BUILDING WITH NATURE
Balancing the urban growth of Kochi’s coastal wetlands with their ecological structures

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part 1: introduction

Fig 1. Water-colour painting of the fort of Cochin from across the back water by an unknown artist, c.1800.
1. Introduction

The World Bank in a 2010 report notes that “Thirteen of the world’s 20 largest cities are located on the coast, and more than a third of the world’s people live within 100 miles of a shoreline. Low-lying coastal areas represent 2 percent of the world’s land area, but contain 13 percent of the urban population (McGranahan et al. 2007). This clearly indicates how attractive coastal areas are for human settlements and urban growth.

But on the flipside, in the light of climate change and natural disasters, these regions stand more to lose than any other. Of these, more than developed countries, the regions in the developing countries seem to be in more danger. A recent study of 136 port cities showed that much of the increase in exposure of population and assets to coastal flooding is likely to be in cities in developing countries, especially in East and South Asia (Nicholls et al. 2008). Due to its high economic value on the national and local scale, coastal areas are developed and inhabited inspite of impending sea-level rise and coastal flooding. Thus development of these areas have to be given special attention and should be more sensitive.

Kochi is one such port city in South Asia. Its economy is driven by the port and oil industry. For the same reason, Kochi is forced to sacrifice to give up its wetlands and natural landscapes for the sake of development. The major challenge in the development of Kochi as a major port city on the western coast in India is finding a way to balance natural landscapes and urban development.

1.1 Project Location and Context

“
A city born in storm, nurtured in rivalry and established as battling ground for European empires “

Kochi, nicknamed the Queen of Arabian Sea, a coastal port city on the south-west coast of India in the state of Kerala is the project location. It is the second largest port city on the west coast of India, the largest being Mumbai. It is the commercial and trade capital of the state of Kerala.

Kochi city on the mainland has a population of 601,574 according to the 2011 Census of India with a density of 6340/sq.km while the population of the metropolitan area is considered to be at 2,117,990. The islands on the west have a density of approximately 2000/sq.km.

1.2 Lagoon, River and City

It lies at a bar mouth of an estuary fed by 10 rivers flowing from the eastern highlands to the Arabian Sea on the west. The 10 rivers including six major rivers of Central Kerala like the Periyar, Achenkovil, Manimala, Meenachil, Muvatupuzha and Pamba flow into the Vembanad Lake before emptying into the Arabian Sea at four outlets - at Munambam, Kochi, Andhakaranazhi and Thottapilly. Munambam and Kochi are perennial while Andhakaranazhi is a seasonal outlet that opens only in the monsoon. At other times, it is a well-used scenic beach. Thottapilly is an artificial spillway that is opened in the monsoons. The lake drains a total area of 15,770 sq.km which accounts for 40% of the area of the state. The annual surface run-off is 21,900 Mm which accounts for 30% of the total surface water resource of the state. Alapuzha and Kodungaloor (old major port cities) are also part of this estuary.
The Kochi estuary as we know today took several millions of years to form though the main estuarine region is not geomorphologically considered old. It is interesting to note that many historic ports are in inland areas now. The sea had receded to form barrier islands later on. In 1341 AD, the Periyar River north of Kochi flooded silting the Kodungalor Port on the north and in the process carved out a natural harbour in Kochi. This catapulted Kochi’s economic growth and attracted the colonial powers.

Later during the British rule, an island was constructed in the harbour and the barmouth was widened by the British to expand the port. Over the years many land reclamation projects were carried out in the name of agriculture. This resulted in a weak coastal system making it susceptible to beach erosion. The last major hazard the coast had to endure was the Indian Ocean Tsunami in 2004. The last map shows how the beach has changed its form and shape due to erosion and accretion.

Fig 5. Evolution of the estuary plotted on map
1.3 History - Princely State to European Colony to Democratic City

The princely state of Kochi was formed in 1102 AD after the breakup of the Kulasekhara Empire. The kingdom was ruled from elsewhere north of Kochi at that time. It was after the 1341 floods when the natural harbour was formed in Kochi that the Royal Kingdom shifted its base to Kochi.

Later in the 1500s, Vasco da Gama arrived in Kochi and established the Portuguese rule. Kochi was the capital of Portuguese India until 1530 and they ruled Kochi until 1663 through the Kochi Raja. The Portuguese rule in Kochi was followed by the Dutch from 1663 to 1773 and the British from 1814 to 1947, when India became independent. Under the colonial kingdoms, Kochi flourished as a port city with spices being the main commodity of trade.

Post Independence, Kochi grew as a port city and at the same time explored other sectors like IT and petrochemical industries. Recently, there has been a renewed interest in the expansion of port and a lot of developments have taken place in this regard.
Fig 11. Old Chinese Fishing Nets and the Modern Port co-exist together

Fig 12. Ernakulam Market

Fig 13. Mattanchery

Fig 14. Cochin Shipyard

Fig 15. Kochi Mainland

Fig 16. New IT Zones

Fig 11. Old Chinese Fishing Nets and the Modern Port co-exist together

Fig 12. Ernakulam Market

Fig 13. Mattanchery

Fig 14. Cochin Shipyard

Fig 15. Kochi Mainland

Fig 16. New IT Zones
2. Problem Statement

The project takes root in the annual monsoon floods that the coast of Kochi is subjected to. In addition to the existing flood scenario is the issue of continued urban growth and ecological destruction. The problem fields are estuarine problems, urban growth and ecological structure.

2.1 Estuaries – Flooding and Sedimentation Issues

The Kochi estuary’s flooding problem is multi-faceted. On one hand, it faces the wrath of the sea while on the other, it takes in the fury of a number of rivers flowing from the eastern highlands. By default, estuaries face three kinds of flooding – rain, river and sea. While the river flooding is restricted to the inland area, coastal flooding mainly affects the barrier islands consisting of coastal villages whose means of defending are limited to mere seawalls.

The coastline is also regarded as highly eroding. This shouldn’t be a surprise as the only measure in place against erosion is ‘seawalls’. These don’t prevent erosion nor encourage accretion. The Shoreline Assessment Map of Kerala show clearly how unstable the coast is. Erosion is a regular and widespread affair on the coast. In one place near Cochin, about two km width of land has been eroded since 1850 (Korakandy, R, 2005). Erosion is very severe during the monsoon months of June - September. The 2004 Indian Ocean Tsunami, left in its wake a new beach at Puthuvype in one of the islands. Though no direct correlation between erosion and fisheries is on record, the socio-economic impact of this environmental phenomenon on the fishermen community through considerable reduction in the traditional shore landing facilities is quite alarming (Expert Committee,1985, pp 351-352) (Korakandy, R, 2005) Climate change will aggrevate both these issues.
2.3 Ecological Structure

The Kochi estuary has a thick vegetation of mangrove forests. They are salt resistant and is a rich breeding ground for fishes, shrimps, clams, mussels etc. These forests are known to be a haven for migratory birds. The Mangalavanam Mangrove Forest in Kochi is one such sanctuary. They are also known to act as barriers against erosions, storm surges and tsunamis. Mangroves play a significant role in coastal stabilisation and promoting land accretion and fixation of mud banks. It also helps in dissipating winds, tidal and wave energy. Mangroves, which absorb carbon dioxide, had to a large extent helped in checking pollution in the district. Ecological structure should be seen as an effective tool to counter climate change.

Developments in the islands of Kochi have resulted in the reclamation of these lands for other uses such as agriculture and agriculture.
3. Project Goals

The project goals are multi-tiered. On the overall scale, the goal of the project is to use the natural landscape for flood management, coastal erosion and be cores of urban development. These will be studied and designed at different scales. The overall goal is broken down into smaller goals at different scales under research and design.

3.1 Scales of Research and Design

There are three scales for research and design:
1. Regional Scale - for flooding and ecological management,
2. Sub-regional Scale – for urban development
3. Local Scale – to test the implications of the regional and sub-regional strategies

The Vembanad Lake system can be divided into saline areas and freshwater areas. Hence the regional scale is restricted to the saline area of the lake. The urban area around Kochi defined by geographical and logistical considerations is taken as the sub-regional scale. A wetland region in Vypin Island which is under immediate threat of development is taken up for detailed study on a local scale. Therefore,

1. Regional Scale: From Periyar River Mouth in the North and the Thaneermukhom Bund and Andhakaranazhi seasonal outlet in the south.
2. Sub-regional Scale: From Njarrakal in the North to Edakochi in the South
3. Local Scale: The mangrove-coconut wetland area north of the Cochin barmouth

2.4 Problem Statement

The problem statement is multi-tiered.

1. Urban development doesn’t follow the natural landscape. Reclamation of wetlands and dominance of infrastructure have resulted in an artificial city landscape.
2. Ecological structures are destroyed for urban development without taking into consideration the benefits and services they have for the city.
3. Urban development takes place in an indeterminate scenario which leaves many a project stalled.
3.2 Research Goals
The goal of the project is to use the natural landscape for flood management, coastal erosion and be cores of urban development. To help reach the goal, certain research questions are framed which will guide the analysis.

3.2.1 Main Research Questions
“How can wetlands help in flood protection, shoreline stabilisation, restore ecological diversity and be cores of urban development?”

3.2.2 Sub Research Questions
The main research question can be better answered if broken down further at different scales.

3.2.2.1 At the Regional Scale
- How can tropical ecosystems be effective flood protection systems?
- How can tropical ecosystems help in giving a stable coast?

3.2.2.2 At the Sub-regional Scale
- How can the ecological structure or the landscape guide the urban development of the city?

3.2.2.3 At the Local Scale
- How can wetlands play the dual roles of flood management and be a core for urban development?

3.3 Design Goals
These research questions are answered through design. The design goals are kept as -

3.3.1 At the Regional Scale
Design a regional flood protection and shoreline stabilisation strategy using tropical ecosystems like mangroves, aquaculture ponds and other wetlands typical of the region.

3.3.2 At the Sub-regional Scale
Design a sub-regional strategy to bring wetlands into the city and plan new developments around wetlands to promote Kochi as a wetland city thereby balancing urban development and natural landscape.

3.3.3 At the Local Scale
Combine the strategies at the two levels to see how those can affect the spatial experience of wetlands.

4. Theoretical Framework and Methodology
Certain principles and guidelines were chosen to guide the author to achieve the above stated goals. These are called frameworks and are divided into two – Research Framework and Design Framework.

4.1 In Research
The Research Framework consists of frameworks for field analysis and theoretical analysis at different scales.

Landscape Urbanism: The project recognises the importance of landscape and indeterminate urban development. For this reason, different concepts and projects which come under the concept of Landscape Urbanism are researched. This is a framework for theoretical analysis. Different tools of the concept were studied, analysed and translated to tangible design concepts.

ARCH: The research framework of TNO called ‘ARCH: Integrated framework for analysis of the lagoon system’ was used to understand the different components in the project and their relation with each other. The framework makes it clear how each component is dependent on the other and how any alteration to one can affect the other. This is a framework for field analysis at the overall scale. The ARCH framework was used to break down the functioning of the lagoon into different parameters which are important for the existence of the ecosystem, region and the city. These parameters are then analysed using the Layers Approach Eg: The ARCH framework implies that ecological structures are important for shoreline stabilisation. The ecological structures are then analysed in layers since not all ecological structures are important to stabilise shorelines. Therefore it is not just the delineation of a parameter that is important, but it is also to come to a precise conclusion of that parameter by analysing it’s different layers.

Layer Approach: The Layer Approach was used in different ways at different scales to understand how different parameters affect the same place in different ways. The place is a result of the interaction between these different layers. This is a framework for field analysis. This was done at the local scale.

In addition to these frameworks, methods like mapping and historical research were also undertaken for the study. Mapping was done extensively to create evolution maps, settlement patterns, structural maps etc to understand the morphological as well as spatial development of the region and the city.
4.2 In Design

The design framework and methodology are a compilation of a structural principle and a design theory that are used for achieving the design. These are:

Building with Nature (BwN): The BwN philosophy is that of taking a stand along with nature to face disasters rather than take an defensive stand like in the past. The methods employed will be soft measures rather than hard ones which cut off the water from the people living along it. As Dr. Ronald Waterman puts it, it is the ‘flexible integration of land-in-sea and of water-in-the-new-land, making use of Materials, Forces & Interactions present in nature, taking into account existing and potential nature values, and the Bio-geomorphology & Geo-hydrology of the coast and seabed’. Though Waterman uses the philosophy for huge land reclamation, I propose to use the philosophy to strengthen the coastline as well as the backwater-front. This philosophy is the base for the regional vision.

The design at the regional scale was targeted for flood management and sedimentation. The design was based on the flood maps created by Centre for Earth Science Studies, Kerala, India (CESS) and shoreline maps created by Institute for Ocean Management, Chennai, India and Ministry of Environment and Forests, India. As the design principle used is Building with Nature, an inventory of available natural landscape was created. This was then used for flood management and prevention of erosion in the design.

Landscape Urbanism: As opposed to architectural forms and buildings deciding the form of the city, in this approach, landscape decides the form of the city. It takes into consideration the natural processes that happen over time and thus is a more realistic approach. As Charles Wadheim puts it, ‘produce urban effects traditionally achieved through construction of buildings simply through the organisation of horizontal surface’.

Taking into consideration, the indeterminate nature of urban development, proponents of Landscape Urbanism puts forward the concept of Designing in Phases. This makes sure that at the end of each phase, the project is complete and ready to use. This way, the vision becomes useful for the city even if the project is stalled over a phase.

At the sub-regional scale, the basic idea of the design is to develop a horizontal surface that can act as a template for urban development. The components of this horizontal surface is derived from the field and theoretical analysis. These components are then integrated into the design. Further design is done in phases as opposed to being done in a single perspective and a single timeline in mind. These phases are determined on the basis of their importance to the cause of flood management and urban development. The first phase being flood management, second being green structure and so on.

The local scale is more or less seen as a scaled down version of the sub-regional vision. Therefore it will follow the same methodology as in the sub-regional scale. The local scale is a wetland location that is most vulnerable to urban development. Therefore it needs an immediate agenda and will therefore be included in the initial phases of the sub-regional vision. From a research perspective, it can be seen as a testing ground for the larger vision.

5. Involved Disciplines

This section explains the disciplines involved in the project other than Spatial Planning and Urban Design. As the project mainly deals with coastal defence and related urban design, hydrology is a very important part of the project. Landscape Architecture is also an important discipline in the project as the project proposes wetlands as an important flood management structure and also to be used to guide urban development.

Studies were also done on fisheries, agriculture, aquaculture and port activities to understand the developmental strategies.
2.1: Literature analysis

Fig 28. Chinese Fishing Net cast in the water. Photo: by Author
part 2: research

2.1: literature analysis

2.2: field analysis

Manufacture nature +
1000 pathways +
Grow the park +
Curate culture +
Sacrifice and save +
Destination and dispersal =
low density metropolitan life

Fig 29. From OMA’s competition entry for Downsview Park, Toronto
Literature analysis was based on the main guiding factors got from primary observations and literature which can be grouped under

1. Flood Management and Sedimentation Strategies
   a. ‘Building with Nature’
   b. Spatial Planning Tools
   c. Landscape and Vegetation
2. Wetland Benefits
   a. Wetland benefits derived from the Ramsar Convention on Wetlands
3. Landscape Urbanism as a concept for Urban Development

6. Flood Management and Sedimentation Strategies

6.1 Building with Nature

Conventional coastal defence measures include hard structures like dams, levees, retaining walls, groynes and sea walls. Huge structures like dams cut off one region from the other interfering in the sedimentation and water circulation processes. This prevents the natural processes from occurring in the ecosystem and consequently results in the deterioration of the ecosystem. This is exemplified in the Delta Works Program in the Netherlands. After the floods of 1953, which cost 2000 lives and destruction of 150,000 hectares of land, a series of dams were built on the country’s south-west region cutting off the sea from inland waters. Though the country lost a substantial amount of its coastline, this ensured that the region was safe from future coastal floods. But cutting off the sea meant cutting off the supply of saltwater which destroyed the aquatic ecosystem that thrived on the intermixing of saltwater and freshwater. This had unforeseen consequences in the local ecological structure. Such ecological disasters have led to a change in the thinking of coastal defence measures and have led to a transition from hard structures to soft structures with lesser impact on the ecological footprint. The concept of ‘Building with Nature’ aims to do the same. As the measures employed by this concept are not always economically viable, cost-effective measures like efficient spatial planning and landscape techniques which were known to mitigate flooding were reviewed.

Concept

This concept works along with nature to face disasters. It is proactive and utilizes natural processes and provides opportunities for nature in the infrastructure development. As Dr. Ronald Waterman, a specialist in chemical, environmental and civil engineering, puts it, it is the ‘flexible integration of land-in-sea and of water-in-the-new-land, making use of materials, forces & interactions present in nature, taking into account existing and potential nature values, and the bio-geomorphology & geo-hydrology of the coast and seabed’. The concepts reviewed in this section are the results of researches done by the Ecoshape consortium in Netherlands.

Traditional approaches involved designing water management infrastructure which served only one purpose. But it is crucial that these should serve more than one purpose and that it is aligned with natural processes rather than working against them, and that is adaptable to cope with changing conditions such as sea-level rise and climate change. Traditional approaches focus on minimizing the negative impacts of infrastructure projects (building in nature) and compensating for any residual negative effects (building of nature) while ‘Building with Nature’ aims to be proactive, utilizing natural processes and providing opportunities for nature as part of the infrastructure development process.’ (De Vriend, H.J. and Van Koningsveld, M, 2012) These solutions are also adaptable as they allow society and environment to respond slowly to climate change and sea-level rise.

Applications

Applications which are useful in tropical estuaries have been reviewed here. These include beach nourishment and preventing erosion of tidal flats which were done in the Netherlands and strategies for tropical coastal areas which were studied in Singapore.

Deffland Sand Engine: This method involves a process of concentrated beach nourishment. The idea is to deposit significant amount of land in one location which will be gradually redistributed along the shore by the wind and the waves. Since it’s a natural process, it will be gradual and will limit the disturbance made to the ecosystem and at the same time provide new areas for nature and recreation. With concentrated depositions, either the footprint is smaller or the frequency of distribution is smaller or both. The project envisaged a hook-shaped peninsula which would provide resting areas for seals at the end of the spit with a shallow lagoon that would offer habitats for flatfish. Some of the sand will be transported to onshore and promote development of dunes.
Tropical Coastal Systems: Singapore where around 20% of the land is reclaimed by destroying mangroves, reefs and seagrass meadows was the location for research on Building with Nature on tropical coastal systems. The envisaged design solution should alleviate the coastal erosion, enhance the potential for recreation and strengthen biodiversity, while also taking into account the proximity of busy shipping lanes and housing developments. (De Vriend, H.J. and Van Koningsveld, M, 2012) According to Tjeerd Bourma, a senior scientist at the Netherlands Institute for Sea Research, ‘rehabilitating an ecosystem may take a long time, even in the tropics’. Therefore it will take time to start seeing the effects of these solutions. But due to limited space, these design solutions cannot be implemented everywhere. To create new ecosystems, the program also made ‘habitat-promoting tiles’ which can be fixed to already existing sea walls to make them conducive for new microhabitats.

6.2 Spatial Planning

In this section, concepts in design of cities and planning instruments like policies and regulations have been reviewed.

Concepts

Water catchment areas: Earth based retention ponds are known to manage storm water. These help substitute the natural absorption of forests or other natural processes that are lost during development. This is recommended in highly urban areas where surface run-off is very high. The efficiency of these retention pond systems is demonstrated in the neighbourhood of Bukit Jelutong housing estate in Malaysia which has helped it to overcome its excess storm water and avoid serious flooding in low lying areas. (Daik, R. M and Shariff, M.K.B.M., 2008) The polders in the Netherlands are also an example of water catchments which store storm water and prevent soil subsidence. They also prevent saltwater seepage during summer droughts.

Accommodation: At accommodation, the difference is that human impacts are minimised by adjusting human use of the coastal zone (Nicholls 2003). This strategy thus uses an altered use of land, including adaptive responses such as elevation of buildings, roads, railways and, modification of drainage systems and land-use change. For natural coastal and estuarine systems, it also includes enhancing the existing natural protection of dunes by vegetation and fencing, or creating and planting upper intertidal areas and salt marshes. The accommodation or planned retreat concept accepts and integrates natural coastline evolution into conservation plans. Also accelerated sea level rise is tolerated here. (Schleupner, C.) Such concepts are useful while planning for unpredictable conditions and futures.

Applications

Accommodation Strategies: In Martinique in the Caribbean Sea, about 18% of the total coastline needs to be protected by hard measures, while 67% of the coastline might serve well with accommodation even if scattered houses or small settlements are found along the coast and within the impacted area. The measure will differ with the vulnerability of the area.
6.3 Landscape and Vegetation

The concepts reviewed are concepts involving purely vegetation but they are almost always used in combination with spatial planning and coastal defence techniques.

Concepts

Coastal vegetation as buffer systems: Protected vegetation, apart from preserving bio diverse species, "emphasize ecosystems as buffers to mitigate flood related impacts" (Adejumo, 2012) Buffers lessen or moderate the impact of floods and storm surges. A buffering coastal forest allows a portion of a wave to pass through the vegetation with its force gradually attenuated, while a solid wall may be broken apart, lifted up, or overtopped. (ProAct, 2008) The ProAct Report of 2008 explains that after a storm surge, partially destroyed mangrove forests will regenerate naturally while the costs for repairing a concrete sea wall is high. After the 2004 tsunami, many studies indicated that mangrove forests played a crucial role in saving human lives and property. Greenbelts of other trees, vegetated coastal dunes, seagrass beds, and intact coral reefs all performed a similar protective function in some areas. Where mangroves and other coastal habitats had been destroyed, often illegally, the waves were able to penetrate far inland, destroying homes, inundating farmland and washing away people and livelihoods. (Environmental Justice Foundation., 2006) ProAct (2008) study shows that a 50 m band of Avicennia species reduced a one meter high wave to just 0.3 meter while a 100 meter buffer of Sonneratia forest reduced wave energy by up to 50 percent. Protected ecosystem constitute coastal and flood plain defence lines safe guarding lives, properties and grey infrastructures. (Adejumo, 2012) Coastal vegetation should be seen as buffers in coastal areas.

Application

Mangrove forests: The coastal defence strategy for Martinique island included both accommodation and landscape strategies. 15 % or about 78 km of the coastline of Martinique that shows vulnerability might adapt to rising sea levels by mangrove forest conservation and regeneration. The measures differ with the vulnerability of the area. The optimal adaptation measure of vulnerable population in the Fort-de-France Bay might be the protection of mangrove forests while for the vulnerable infrastructure along this coastal strip, the optimal adaptation measure would now partly be hard protection.

7. Wetland Benefits

The Convention on Wetlands of International Importance, called the Ramsar Convention, is an international treaty that provides the framework for the conservation and wise use of the wetlands. It is the only treaty in the world that targets a specific ecosystem. There are almost 2000 wetlands which are called Ramsar sites. These sites are considered fragile areas and of international importance. The wetland system of Kochi is one such wetland.

According to the Ramsar Convention, wetland ecosystems have a lot of benefits and services to offer: With increasing global population, there is increasing pressure on water resources and the threats posed by climate change and the need to maximise these benefits has never been greater or more urgent. These benefits are – flood control, groundwater replenishment, shoreline stabilisation & storm protection, sediment & nutrient retention & export, water purification, reservoirs of biodiversity, wetland products, cultural values, recreation & tourism and climate change mitigation. The benefit which the Ramsar Convention doesn’t mention is ‘adding spatial quality to urban areas’ which is an important benefit for the project. The different benefits are shown on the opposite page.
8. Landscape Urbanism

“Landscape Urbanism describes a disciplinary realignment currently underway in which landscape replaces architecture as the basic building block of contemporary urbanism. For many, across a range of disciplines, landscape has become both the lens through which the contemporary city is represented and the medium through which it is constructed.”

- The Landscape Urbanism Reader

8.1 Introduction

In contemporary urbanism and indeterminate scenarios, it became necessary to have an alternative to fixed masterplans which were mostly rooted in modernism. Landscape Urbanism is a concept which does that. It is as much a concept as modernism. It stresses on design as an evolving process taking clues from the natural processes going on in the site, thereby giving into the indeterminate nature of cities.

It is interesting to note the different connotations the word landscape has in the discourse of Landscape Urbanism. It is used as “a metaphor for contemporary urban conditions” as well as to “represent and understand the dynamic systems of the city”. Contemporary urban conditions refer to the fragmented and discontinuous landuses which are prevalent in the cities of today rather than the traditional core model. James Corner and Stan Allen describe these conditions as “field scenarios”, Richard Marshall describes it as “urbanscape” while Rem Koolhaas describes it as “the matrix of landscape”. By “dynamic systems of the city”, they mean the blue and green of a city. In other words, it implies using natural and ecological processes to generate design and landscapes. These are seen in the proposals for Fresh Kills in New York and Downsview Park in Toronto. Thus as mentioned in the quote above the word ‘landscape’ effectively becomes the lens as well as the medium to work with.

USP of Landscape Urbanism

The strength of the concept lies in its acceptance of temporality. Charles Wadheim puts Landscape Urbanism as a process by which designers and planners can “produce urban effects traditionally achieved through construction of buildings simply through the organisation of horizontal surface”. It is the horizontal surface that one can ‘organise’ so as to produce urban effects in time. James Corner in his essay Terra Fluxus applauds Landscape Urbanism as a concept that sees opportunity in indeterminancy, open-endedness, intermixing and cross-disciplinarity. A city is a living ecology. A landscape urbanist constantly looks for opportunities to engage the dynamics of the city. There is always a “propensity for cross-disciplinarity” and a “lust for indeterminancy”.

The cross-disciplinarity of the concept comes from the separation of humans from nature that existed in the past. In contemporary discussions, this separation has clearly blurred. But the significant development might be that in the field of urban ecology. The study of plant and animal communities in the urban landscapes which are subjected to impacts of humans and development has led to new design strategies where these work together rather than as separate entities. Bringing these together is complex and requires a synthesis of factors relating to social, political, economic, urban wildlife and water management.
8.2 Tools of Landscape Urbanism

Methods of Landscape Urbanism are operative and they prioritize the way in which things work and the way in which they are used. A landscape urbanist begins with the given. Five areas of focus according to Corner are horizontality, infrastructure, forms of process, techniques and ecology.

It lays stress on structuring the horizontal surface because the surface collects, distributes and condenses all the forces operating upon it. Structuring the horizontal surface includes division, allocation and demarcation of land as the first step. The second step will be to establish services and pathways. The third step is to ensure sufficient permeability for future permutation, affiliation and adaptation.

Anything that can perform, produce or exfoliate ‘effects’ is termed infrastructure. This includes earthwork, soil cultivation, drainage, vegetation establishment, roads, utilities, bridges, subways/airports and even codes and laws. Of these roads, utilities and bridges have been evaluated solely on technical criteria and over the years have been exempted from having a social, aesthetical or ecological function. A re-examination of infrastructural spaces makes it clear that they are as much a part of public space as parks and squares. Therefore it should stop being a mono-functional realm and designers should start recognizing its role as a part of the formal inhabited city.

Landscape Urbanism suggests that infrastructure be seen together with ecological processes as well as social and cultural needs of the community. Seeing natural systems and infrastructure together suggests a means of developing urban strategies through the development of networks of landscape infrastructure related to ecological systems. The starting point for this is that the most enduring elements of cities are often related to the underlying landscapes of geology, topography, rivers etc. Design of ecological and water networks can be combined with infrastructure as well as public space. Victoria Park in Sydney and Atelier Dreiseitl’s designs for projects at Potsdamer Platz in Berlin are examples of such projects.

Normally, masterplans put out an ‘utopia of form’. Landscape Urbanism puts forward that there should be an ‘utopia of process’ rather than that of form. It should have ‘the advancement of a more socially just, politically emancipating and ecologically sane mix of spatiotemporal production process’.

It also lays an emphasis on the techniques used. There should be a collaboration of techniques. Mapping, cataloguing, triangulating and surface modelling techniques of landscape architects and planning, diagramming, organizing, assembling, allotting, zoning and marketing techniques of an urbanist should be combined. Robert Rauschenberg’s ‘flatbed’ procedures, John Cage’s ‘scorings’, Buckminster Fuller’s ‘projections’ and Michael de Certau’s ‘microtechniques’ could according to Corner be the starting point of a landscape urbanist’s toolbox of techniques.

Lastly, Corner emphasises on ecology. Nature and city are inter-dependent. Nature is part of the urban and not something outside. City and nature exist in a give and take relationship.
8.3 DESIGNING with Landscape Urbanism

Landscape Urbanism seems to be a concept that is more abstract than real, more philosophical than tangible. To get the concepts clear and to see how it can be made practical, a few projects which followed or bordered around the concept of Landscape Urbanism were studied. Boston’s Emerald Necklace is quite old and was done before the birth of the concept of LU. But this project aimed to structure the city through its landscape and was hence chosen to study.

1. Downsview Park

The Downsview Park, Toronto Competition saw a lot of entries which were rooted in the concept of LU. These projects were studied and important design strategies were formulated from these projects.

The competition gave a new equation for ecology with urbanism. It took a different stand from the 1960s where ecology and landscape were understood to be a closed off section in urban areas. Theories of ecology have changed since then. These are the basis of the new dialogues between ecologists and designers and this has manifested in the competition entries for Downsview Park. The most significant change have come in the ways ecologists think about change over time in ecological patterns and processes.

Projects which addressed ecological and hydrological processes as well as celebrating the human use of space have been done before but it has only rarely explored the possibility of simultaneously structuring both hydrological and biological dynamics. The project brief talked about a flexible and adaptable use of space which was interpreted in the entries as a design that included processes and dynamic change.
There were two design strategies that were used – scaffolding (where use of landscape form influenced natural and cultural processes) and juxtaposition. But most teams used the similar ecological and hydrological strategies –

i) long flow paths through riparian vegetation can improve water quality,
ii) wetland areas can be used to increase the diversity of plants on a site,
iii) corridors of wood or grassy vegetation can enhance the ability of wildlife species to move through a landscape.

Ecologically Speaking:
The proposals by Corner and Allen, FOA and Tschumi have used vegetation to build corridors for the movement of people, water and wildlife at the same time enhancing water quality and plant diversity. Both Tschumi and Corner and Allen have used the third principle to connect the park to nearby ravine parks. While the schemes by Brown and Storey and FOA made references to developed open spaces, its scope in terms of regional biodiversity is limited.

References to the past and future:
Corner and Allen tries to bring back the cultural landscape that existed once by using a repeating pattern of large trees that enclose broad fields of grass. Their proposal used a large number of strips which though works well for ecological flows, doesn’t provide an interior habitat for wildlife. Tschumi’s design on the other hand provides large networks for wildlife and a large patch of woodland that can become a relatively undisturbed interior. It tries to recreate the wooded landscape of the past while providing a cultural landscape for the future where there is mutual coexistence among species within urban areas. They intensified the human experience of wildlife through planned encounters and by placing enormous digital screens. There is a feeling that the design accepts the equal importance of both human and non-human uses.

Relationship with Context:
Corner and Allen’s design sits as a natural extension of the surrounding context. The hydrological flows outside the park will have effects on the park itself. Similarly, OMA’s proposal takes cues from the modes of production, construction and expansion of the city. The context is seen as a reservoir of social and environmental possibilities to shape the form and design of the park. Thus the park is exposed to the same vulnerabilities as the environment is. In doing so, the park is exposed to the same kind of openness and flexibility as the environment is. While Corner and Allen dissolves the boundaries of the park for ecological and hydrological productivity and vitality, OMA dissolves the boundary for the park’s survival as a socially relevant place.

Designing for Change:
“A system poised on the edge of chaos is capable of producing an overwhelming response to small, discrete stimuli”.

When designing for unpredictable environmental or programmatic change, the degree of design intervention becomes critical. There has to be an optimal balance in the specification of landscape. Both in the Tschumi and Corner and Allen proposals, different ecological scenarios have been suggested. The Brown and Storey proposal is poised for programmatic emergence around the nodes. The OMA proposal goes one step ahead and proposes the co-evolution of its individual parts which is clear in their phasing diagrams.
Designing in Phases:
The projects have a phasing strategy such that after each phase, the project still remains complete and still flexible in case of uncertainties that may arise in terms of project execution.

Phase 1 of OMA proposes soil amelioration and an evenly distributed web of ‘1000 paths’. This makes the soil fertile and provides the required connectivity for all kinds of future emergences.

Phase 1 of Tschumi proposes cutting of one side of the park with ridges and wetlands to create a future wilderness.

Phase 1 of Corner and Allen regrades the site and inscribes (but not fixing) the circuit path. The result is a vast earthwork that anticipates the future.

Phase 1 of Brown and Storey plants the oak savannah as a move to fix the spatial structure of the park.
Sacrifice and Save
Tree City opts to grow now and build later. It "sacrifices" the construction of costly new buildings in order to "save" funds for an infrastructure of landscape elements. A medium capable of developing mass with greater economy and sustainability, the landscape will be prioritised over the realm officially known as architecture. Stressing the regal and the casual, Tree City makes "the ultimate sacrifice" to save Downsview from overemphasized fiscal disaster with the beauty of nature.
2. Emscher Landscape Park

The aim is to improve the working and living environment for more than 2 Million inhabitants in the region by converting a large number of post-industrial sites to urban public spaces. The five objectives for the Emscher Landscape Park are:

- Preserving the remaining leftover landscape
- Linking up the isolated, separate areas in the agglomeration
- Re-zoning separate areas as parkland
- Reaching agreements both regionally and locally on individual projects with a long-term perspective and
- Maintaining and managing the new open spaces in a permanent regional park association.

Large green footprint is the base of the plan. This green runs along the existing river channels and the planned aquatic expansions. There are green links connecting areas on both the regional and local scales. There is an obvious use of green and blue to create a network. An interesting point here is that roads seldom run along the river. It is the park trails (for biking and walking) that follow the river. These spaces act as landmarks. It is noteworthy that only very few landmarks are along the roads. Most of the landmarks are along park trails. This shows a marked priority for trails compared to roads. The project is realised through a number of smaller projects.
3. Melun-Senart by OMA

The Chinese figure of voids by OMA for the city at Melun-Senart is an example of an open-ended and indeterminate design.

Concept: Urbanism is considered to be chaotic and indeterminate. In such a scenario, it was frivolous to design the urban development itself. Thus the main idea of the project was to identify a template which could ‘surrender to chaos.

How: The project defined areas ‘where not to build’ and not where to build. Through a process of elimination, the design arrived at a Chinese figure of void spaces that could be protected from contamination of urbanism. And the rest could be left for chaos. Through this, a sublime contrast between emptiness and chaos could be generated.

Process of Elimination: An inventory was first made comprising of the River Seine, two forests, existing villages, motorway and the TGV line. And then the process of elimination was started.

a. Motorway near villages. VERDICT: void to protect city from noise
b. Conical strip between forests isolates important landscape elements. VERDICT: void to protect landscape
c. Fringes of forests and River Seine leave these attractions accessible. VERDICT: void
d. Villages and their inter-connections are future cores of development. VERDICT: fill
e. Campus related strip. VERDICT: fill

The strips give rise to residual spaces which are the counterforms to the voids. These are the spaces where new programs and development could come up. This is where chaos would take place.

Conclusion: This city is not organised through built form but through “a system of emptiness that guarantees beauty, serenity, accessibility, identity regardless – or even in spite of – its future architecture.”

Fig 54. Making of the Figure of Voids
Source: S,M,L,XL

Fig 55. Voids as a Chinese Figure in the surrounding landscape
Source: S,M,L,XL

Fig 56. Programming the figure
Source: S,M,L,XL
4. Emerald Necklace, Boston

Franklin Olmsted's Emerald Necklace in Boston consists of multiple smaller projects. On a smaller scale, they served different purposes but on the larger scale, it served Olmsted's vision of having a blue-green structure for Boston along which urban development could take place. These projects were Back Bay Fens, Arnold Arboretum, Franklin Park, Muddy River Improvement and Jamaica Park and were done at different times.

Back Bay Fens was done from 1879-1895. It was carried out to help in flood management and tidal influxes. This was to act as a storage basin for the storm waters of Stony Brook River and restore salt marsh. Footpaths would go along it and city streets over it as bridges. Thus an infrastructural drainage system was brought to the centre of attention and part of the urban form. Water gates were installed at certain points to regulate ebb and tide.

Next project in the necklace was the Arnold Arboretum in 1879. This was done along with the botanist Charles Sprague Sargent. The idea was to have natural vegetation of the region seen when one passes the area in a carriage without having the stiffness of a botanical garden.

The third project was the grand Franklin Park in 1885. This park adhered by Olmsted's principles of screening out surrounding buildings with vegetation and giving an illusion of unlimited space. He divided the park into two - a formal and an informal area by a road. The bigger portion in the South was called Country Park. One could enjoy natural scenery with a gentle valley between rocky wooded hills. There were no elaborate gardening effects. The smaller formal portion was called Ante Park and was a forecourt with sports fields, amphitheatre, a promenade, a deer park and a tot lot. While the Country Park was closed at night, the Ante Park was open and lit at night for matches, concerts etc. Presently, this park is surrounded by large scale recreational facilities like golf and zoo. There is significant competition from other parks in the area.

Franklin Park was followed by the Muddy River Improvement in the 1890s. With the construction of Leverett Park, the Muddy River became stagnant and went from being an inoffensive little stream to a source of disease. From a pleasant valley to a potential slum. The proposal was to clean it up and plant new vegetation along its sides. The last addition to the necklace was the Jamaica Park in 1892. The project was more like a conservation project. It developed a recreational freshwater pond around which one could walk.

The necklace doesn't function in a lot of ways like how Olmsted had envisaged it due to ill maintenance. Damming of the Charles River made Back Bay Fens defunct as a storm water storage basin. Newer roads and interchanges now make this emerald necklace shine less. Failure of the design can be attributed only to newer technology and inefficient authorities.
2.1: literature analysis

2.2 field analysis
9. UNDERSTANDING THE LAGOON

Before starting the major analyses, there should be a clear idea of the lagoon and its different strengths and weaknesses. The lagoon is studied using the ARCH Framework. This starts off the analysis with primary data.

9.1 The ARCH Framework

The ARCH Framework of TNO studies lagoons as an entity of three systems – the Natural System, the Human System and the Human-Nature System. The Natural System consists of hydromorphological status (separately for rivers and lagoons), biological status, physico-chemical status, harm by specific pollutants and dynamics and the vulnerability of the natural system. The Human System consists of the place and its history, developmental drivers within human system, the social structure, governance and the institutional structure, vulnerabilities of the socio-economic system, resources and adaptive capacities of the socio-economic system. The Human-Nature System consists of main pressures and drivers affecting the natural system, exposure of the natural system, forms of nature protection, ecosystem services provided for the benefit of the ‘human system’ and the relations between the lagoon region and the outer world. The framework is used to build a working model which can help understand the positive and negative relations of the various parameters of the system.

9.1.1 Using the Framework

Though the ARCH framework talks about the three systems on the same scale, it is studied at different scales in the project. The Human System on the sub-regional scale is seen as affecting a Natural System on the regional scale. Therefore the effects of the activities on the sub-regional scale can be seen on the well-being of the Natural System on the regional scale. The NATURAL SYSTEM works at the regional scale and provides opportunities for humans to derive benefits from it. These benefits are analysed at the sub-regional scale. But the HUMAN SYSTEM affects the same NATURAL SYSTEM causing imbalance and consequently making it non-sustainable. These relations are better understood by the model.

9.1.1.1 Natural System

The starting points of the variables in the Natural System are the sea, climate change, and rains. These have tangible effects like flooding, erosion and accretion which affects the coastline and the geomorphology of the estuary. The geomorphology of the estuary in turn determines the shape of the natural harbour and other industries that are of importance in the human system.

The sea and rains affect the salinity of the water which affects the ecological structure and natural habitats for fishes. Thus it helps in development of local industries. Another factor that encourages fish breeding is mangroves. Mangroves affect fisheries as well as sedimentation patterns.

9.1.1.2 Human System

Human System utilizes the Natural System to its advantage without knowing what happens at the starting point. Humans converted the natural harbour into a port and set off economic and urban growth. He reclaimed land for urban growth affecting the estuarine stability leading to erosion. He destroys mangroves for urban expansion without realizing they are important for shoreline stability and for fisheries.
9.1.1.3 Human-Natural System Interaction

The model shown in the opposite page explains how the different variables in the two systems affect each other.

10.1.2 Model of Major Variables

Main variables used in the model:

Natural System: climate change, sea, rains, sea-level rise, tidal levels, salinity, flooding, erosion, accretion, geomorphology, sedimentation, beaches, natural harbour, natural habitats, mangroves, ecology.

Human System: port, waterways, oil-terminals, other industries, urban growth, water supply, drainage, fisheries, agriculture, aquaculture, tourism, pollution, reclamations.

From the model, those variables that are understood to have a huge effect on the estuary are singled out. These are shown by the number of lines that follow or lead to it (denoting the importance of the variable), double lines (denoting the adverse effect of it) and a combination of these factors. Keywords like ecology, flood protection, urban growth, traditional stakeholders, beaches and geomorphology were taken and have been made the anchor points of the problem statement.

9.2 Keywords for the Lagoon

The otherwise complex lagoon system and its various attributes have been simplified. Keywords like ecology, flood protection, urban growth, traditional stakeholders, beaches and geomorphology were taken and have been made the guiding factors for the project. The following observations were made of the estuarine region:

1. Urban development and port activities result in reclamations which affects the geomorphology and results in erosion and flooding.
2. Inadequate drainage and flood management measures result in flooding.
3. Flooding effects tourism and urban growth.
4. Climate change implies an aggravated scenario of the above.

Therefore, as a conclusion, we need:

1. sustainable and long lasting methods for flood and erosion
2. put a stop to reclamations for future developments.
10. Morphological Evolution

As was explained before, the estuary is still in its geomorphological infancy. The outline of the estuary has been plotted from maps and informations from various sources including studies done on the coastal morphology, maps made by the Dutch East India Company, maps made by the Kerala State and the present day situation from Google Earth. As can be seen, there has been a considerable change in the form and shape of the estuary. This only leads us to believe that the estuary will keep changing in the future. This changing coastline should be considered while planning something new along the coast.
11. The Blue

11.1 Flooding in the Region

An estuary is subjected to two kinds of flooding – river flooding and coastal flooding, other than flooding during rain. Hazard Maps made by Centre for Earth Science Studies, Thiruvananthapuram, India were used to study this. River flooding occurs in the monsoon season i.e June to August and October to November. The former is known as southwest monsoon and the latter is known as retreating northeast monsoon. During these times the rivers swell resulting in flooding of adjacent floodplains. Areas with poor drainage are also affected by these rain floods.

Coastal flooding cannot be predicted yet never fail to happen at least once a year. Waves overtop the sea-walls and up damaging houses and property. Coastal flooding at the fag end of the monsoon is a regular and accepted affair while the pre-monsoon coastal flooding is a mysterious affair. There has been no scientific explanation to this event. This has been named ‘kala kadal’ in the local language which means the sea comes like a thief (without notice).

The maps on the facing page show the floodable areas at different times of the year. Since they are different types of flood with different types of water, different techniques have to be used to tackle them.
11.2 Sedimentation

The shoreline management maps made for the Kerala Coast clearly show how the state, especially the region, has an eroding coast. The coastal erosion is nothing but the result of human activities. Beaches maintain themselves through the constant supply of sand through wind and water. This is called the littoral drift. At the coast of Kerala, the littoral drift has a southward direction. Thus the beaches receive their sand supply from the north through the movement of wind and waves. If there is an obstruction to this supply, then the beaches start eroding. Two groynes constructed at the Periyar River and the Cochin bar mouths have trapped the littoral drift on the northern side and have left the leeward side starved of sand.

Such groynes are constructed to ensure a clear navigational path for boats and ships and sometimes to create new beaches on the northern side. But little do they realize that the repercussions on the leeward side are far too dangerous. On the leeward side, houses that once stood far away from the sea are right on the sea-front now. Another cause for erosion is the heavy set of waves that hit the coast.

Fig 78. Shoreline Assessment Map of the region

Fig 79. Regional Problem Map
11.3 Flood in the City

Flood scenarios and the flood management systems of the urban area is examined next. The main type of flood that affects the city is the monsoon flooding. Major arteries of the city flood every year with rain. The main infrastructure the city has to manage flood is the canal system.

The canal system consists of primary, secondary and feeder canals. The primary canals run in a N-S direction thereby facilitating thorough movement of water from the estuary. The secondary and feeder canals basically feed the primary canals giving a hierarchy in water drainage. The longest primary canal, the Edappally Canal, in the system is 11km. The total surface area of the canals are $1.22 \times 10^{10}$ sq.m while the area receives a rainfall of $1.1 \times 10^{10}$ cu.m. Though it seems like a flawless system, the canal system of Kochi fails because of its low maintenance. The canals are clogged and polluted thereby prohibiting efficient drainage of the city.

eg: The Edappally Canal is as wide as 75m at its southern junction while in the north, it is as narrow as 5m. Many urban developments on its sides have led to encroachment of the canal. However these urban developments treat the canals as backyards thereby putting them into oblivion. This again results in pollution, eutrophication and loss of a valuable public space in the city.

The first map shows the major canals in the city while the second map shows the depth to the water table. This information is important as it decides the carrying capacity of these canals. In most of the regions, except the sandy islands on the west, the water table is at a depth of 1m from the ground level. According to calculations, the city’s canals have a surface area of $1.22 \times 10^{10}$ sq.m. With the information from the second map, it is safe to assume that the carrying capacity of the canals are $1.22 \times 10^{10}$ cu.m. The area receives an annual rainfall of $1.1 \times 10^{10}$ cu.m thereby making the canals’ capacity as satisfactory.
Fig 83. Canal system of Kochi, made by author based on data

Fig 84. Map of depth to water-table and canal system, made by author based on data
11.4 Flooding in the Local Scale

Much of the marshy area and wetlands are under the threat of flood. Canals can be seen as defining the boundary of the flood area. Previous city scale studies have shown that this area has a depth of 0m to the water table. This increases the possibility of water-logging, in case of flood.

Waterlogging in marshy areas is a method of water retention. It is best that these are left unbuilt and let it do its natural course. These landscaped areas can be used as flood plains with minimum activity. The coastal communities need a flood protection system other than sea-walls and drainage systems as the depth to the water table is found to be 0 m. The problems are summarised in the following pages.
SEDIMENTATION AT THE COAST

PROBLEM
Littoral drift blocked by jetties or groynes to facilitate navigation

CONCEPTUAL SOLUTION
Use mangroves to encourage accretion thereby creating a stable coast

DESIGN SOLUTION
SEEDING AGENT ON THE COAST

FLOODING AT THE COAST

PROBLEM
Waves that hit at the end of the monsoon season erode the beach away. Seawalls don’t do anything

CONCEPTUAL SOLUTION
NEW SOURCE OF SEDIMENT for Littoral Drift

DESIGN SOLUTION
SEDIMENTATION AGENT ON THE COAST

FLOODING IN INLAND AREAS

PROBLEM
Fields remain non-cultivable due to water logging during monsoons

CONCEPTUAL SOLUTION
DRAINAGE SYSTEMS renetworking existing canals

DESIGN SOLUTION
FLOODPLAINS in the monsoon

SALTWATER INTRUSION IN INLAND AREAS

PROBLEM
Saltwater Intrusion during dry season hinders cultivation

CONCEPTUAL SOLUTION
SEASONAL FARMING aquaculture in the dry season

DESIGN SOLUTION
AQUACULTURE in the dry season

Fig 92. Problems and Solutions at the Coast

Fig 93. Problems and Solutions in Inland Areas

Fig 94. Tools for Flood Management and Shoreline Stabilization: Zandmotor, Mangroves and Coastal Vegetation, Wetlands, Drainage System
Fig 95. Coastal wetlands at Puthuvype which are allotted for petrochemical industries.

Fig 96. Chinese Fishing Nets are seen in every nook and corner

Fig 97. Destroyed Mangroves near petrochemical industries

Fig 98. Coconut wetlands like these form a major part of the coastal area

All images are by the author
12. The Green

The green structure of the area consists of mangroves and wetlands. They are mapped through land-use maps and surveys done on mangroves in the area. From the regional map, it becomes clear that the urban area in the region is devoid of any natural green. As can be seen from the diagrams below, the loss of natural green is attributed to urban expansion. The city has expanded by eating up the wetlands. The evolution of the city is investigated to understand how the city has responded to the natural landscape and context.

12.1 Wetlands for Flood Management and Shoreline Stabilization

From these, the wetlands for Flood Management and Shoreline Stabilisation have been mapped. The disparity in the coastal areas come from the fact that there is a sea-wall which counter-effects the benefits of the wetlands.

Fig 99. Wetlands in the region

Fig 100. Wetlands for Flood Management and Shoreline Stabilisation

Fig 101. How the city reclaimed land from wetlands
12.2 How the City ate up the Wetlands

14th – 19th Century

Urbanization started from the west. The westernmost head-shaped landform was the starting point of urbanisation. The early port was located in Mattanchery on the east of the landform. In addition to the port, the eastern waterfront had godowns, shops, markets and the Royal Palace. The Royal Palace and settlements of Jewish traders, Gujarati traders and other trading communities from rest of India settled in this area resulting in a highly dense area with row buildings and inner courtyards. There wasn’t much green space in these areas. The western part of the land, called Fort Kochi, consisted mainly of larger residential buildings, churches, schools and few offices. This grew as a settlement of foreign traders which resulted in an area rich with colonial architecture. Compared to Mattanchery, it was a low density area with green space. A few internal streets have row buildings while the seashore has independent villas.

The area’s spatial development was largely dependent on the waterfront. There is a distinct difference in the typology of buildings and spaces in the two areas because of the difference in the usage of the area.

19th Century

Urbanization crosses the water to the East with the establishment of Market and Broadway. The market and the first commercial street on the mainland Broadway originated from the canal. Broadway was the continuation of the market and was the busiest street in the city. It consisted mainly of row buildings of 1-2 storey height and sloping roof. While the market had a distinct Kerala Style Architecture, Broadway was done in the Indo-European Style of Architecture.

The commercial hub once again developed around water. It had a clear hierarchy of shopping spaces with the market at the inner core and general shopping streets originating from it.
Early 20th Century

Port expands with the construction of Willingdon Island. Willingdon Island was built only for port purposes and so the structure is highly functional. The plan is mostly follows straight lines and there is nothing organic about the development. The main buildings are Indo-European in style while the godowns are industrial.

A hint of modernism is evident in the British planning of the island. It was a function plan and wasn’t site-specific but for the water.

Late 20th Century

The city on the mainland expands further towards the east with urban sprawl along transport corridors like MG Road and Banerjee Road. Canals were soon treated as backyards. While MG Road was built by reclaiming land from wetlands, Banerjee Road was built on top of a canal. Land was reclaimed from the backwaters and paddy fields for urban expansion.

A new fascination towards wide roads and motorways is evident here. There was a shift from canals and waterways to roadways, bridges and railways.
2000 –

Expansion further east with the establishment of Special Economic Zones (SEZ). In the east, where the lowlands start giving way to midlands, there are two kinds of settlement patterns: one triggered by huge actors like Infopark, Cochin SEZ and Industrial Estates and the other by roadways. Development is aided hugely by real estate developers and other private actors. Independent developments on different parts of the city merge to form a continuous cityscape. The irregular internal road network shows how sometimes infrastructure follows residential development.

Private sector plays an important role in urban sprawl. It is necessary to avoid further urban sprawl by adequate planning measures as more expansion on the east would touch independent satellite towns of Kochi. Future planned developments might trigger off the Kakanad settlement prototype for residential development and later the Edapally settlement prototype for organic commercial development.

Expansion on the west with the recent establishment of Special Economic Zones (SEZ) on the islands. Waterfront development takes centre stage again with the construction of bridge connecting three islands to the mainland. The expansion of port facilities and oil storage facilities bring industrial development to the rural areas. Settlement patterns are largely along transportation corridors like road and water and also influenced by natural landscape.

The development was triggered by GIDA, a local governing authority of the islands, who constructed the bridge. Port Trust of India is another key stakeholder in this new urban development. The development of the city has taken a full circle and is again looking at water for its urban growth.
The city has no single structural pattern. The structure keeps changing and will keep changing. There has to be an overall guiding element for the urban development of the city. There was an evident relationship with water and the context in the past. This has changed off late. The city is growing as isolated developments. In the city's expansion over centuries, it has reclaimed more than 50% land from the estuarine waters and wetlands. The urbanisation pressure on the city centre has been the maximum. The pressure is mainly caused by commercial and residential development. This has led to a large scale depletion of wetlands. Wetlands are now limited to just an outer strip around the city.

**Fig 131.** The effect it has on the city

**Fig 132.** City's structure is no longer compact. Ribbon development taking its toll.

**Fig 133.** Existing wetlands in the city

### 12.3 Benefits of the Wetlands

To reinstate the value of wetlands in the city, an inventory was made of the city wetlands and their benefits. The main types of wetlands are mangrove wetlands, coconut wetlands, paddy fields and large sheets of water for fishing and aquaculture. The benefits studied were:

1. Biodiversity and Nutrient Retention
2. Groundwater Retention
3. Cultural Value and Wetland Products
4. Tourism and Recreation

**Fig 134.** Existing wetlands in the city
12.3.1. Biodiversity and Nutrition Retention

Areas rich in Mangrove Forests are known to retain minerals and provide breeding grounds for fishes, crabs and shrimps. They are also known to be an ideal haven for migratory birds. Hence these areas of mangroves are identified as wetlands for Biodiversity and Nutrition Retention. The different species found in these areas are shown in Fig .
Fig 136. List of all species of plants and animals found in the wetlands.
12.3.2 Groundwater Retention

Wetlands are known to retain water but not all water is fit for human consumption. For this, certain variables like pH (acidity), salinity levels, TDS (total dissolved solids) were studied. Areas having a TDS value of lesser than 500mg/L were designated as acceptable areas for groundwater recharging.

Fig 137. Wetlands for Groundwater Retention

Fig 138. Coconut Wetlands in Vypin Island fit for groundwater recharge
12.3.3 Cultural Value and Wetland Products

These wetlands are those that are used by the local stakeholders for cultivating rice or breeding fish and shrimps. They are used for the local socioeconomic benefits. They include:

1. Paddy Fields
2. Aquaculture ponds
3. Fishing through Chinese fishing nets
4. Eco-tourism

Fig 139. Wetland areas that have cultural value and give products like rice and fish

Fig 140. Aquaculture Farms in Kochi

Fig 141. Eco-Tourism in Kumbalanghi
Those wetlands close to recreational areas like beaches, waterfront promenades, lakes in combination with other tourist attractions like the Lighthouse at Vypin or one of the many colonial attractions are defined as recreational wetlands. Not all of these wetlands are used to its full potential.
12.4 Threats to the Wetlands

These same wetlands are also prone to pollution and urbanisation. Hence, such wetlands are also mapped.

12.4.1 Wetlands prone to Pollution

Wetlands close to industries or those that lie downstream of industries are learned as to be the most prone to Pollution. The wetlands on the west are close to the port and petrochemical industries while the ones on the north lie downstream of chemical industries situated on the banks of River Periyar.

12.4.2 Wetlands prone to Urbanisation and Development

Waterfront properties are always hot property in the real estate market and virgin wetlands have poor land value. This combination makes wetlands a very attractive area to develop. All the wetlands shown in the map in the opposite page are demarcated for different developmental activities ranging from cricket stadium to institutes to convention centres to housing to oceanariums.

The wetland at local scale is one such wetland.
12.5 Wetland at the Local Scale

The wetland is a result of the interactions between the surrounding water and the ground. This constitutes the Natural Layer. The area is surrounded by water on three sides - Arabian Sea on the west, Cochin Backwaters on the east and the inlet on the south. Water from these water bodies enter the island through inlets at different points to create the wetland. The wetlands consists of mangroves, coconut trees, paddy fields and aquaculture ponds.

Since the area has a high density of such unique landscape, it should be preserved and be used to guide urban development in the area. Some of these areas like wetlands and mangroves have potential to be used as recreational spaces. Spatial Analysis is also done for these wetlands.
12.5.1 Spatial Analysis

This section analyses the spatial aspects of the wetland region by emphasising on form and composition of elements. The aim is to see how the wetland can be structured to enhance the spatial experience.

AXIS of morphology

The apparent axis is the State Highway but it is not a strong one nor does it create an image. An axis that is hidden but that can create an image is the natural landscape. This will be called the Green Axis from now on.

Role of LANDSCAPE elements

There are different wetland regions with different vegetations. These elements can be used to make a strong purpose, structure and thus a bold and vital image.

COMPOSITION of elements

The elements seem to have a weak relation with each other. The elements can be better composed from within and around for a stronger image and structure.

#vegetation #mangroves #coconut rees #canals #beach #paddy fields #wetlands #large ponds

Fig 156: Sketch of a Birds Eye View of the Wetland
The Green Axis

The natural landscape of the area forms a natural axis in the area. Some wetlands have been broken harshly by roads. These wetlands can be made into a single unit by having bridges over them. This will help in creating a single unified green structure.

Axis as a SEQUENCE of relief positions
Different types of wetland regions with different vegetations give a high scope for the green axis to have a sequence of spaces.

POSITION of axis in the urban pattern
The green axis is now a barrier between the different parts. This barrier can be converted to a seam by active program like recreation and built areas.

VISIBILITY of the Green AXIS
The visibility is minimized by uninteresting bridges and green fences. The opportunity here lies in the N-S canal and the wetland structure that can be developed as an axis. This will also make it more visible.

RELATIONSHIP between green axis, relief and urban structure
Relief makes up the axis but it is not related to urban structure. Better sightlines, linkages and edge conditions between urban structure and relief/axis can make the relationship stronger.

Fig 157. Green Axis
Fig 158. For a Continuous Green Structure
Fig 159. Sequence of Relief
Fig 160. Green Barrier
Fig 161. Visibility Issue _ Relationship with surroundings
13. Finding Additional Tools

13.1 To create a structure for the city - Public Spaces and Post Industrial Sites

In order to create a structure for the city out of the blue and the green, there has to be additional components for it. Public spaces and post-industrial sites which mainly include a few scattered parks, promenades, beaches and abandoned railway lines have been mapped for this purpose. It is clear how most of the public spaces lie on the waterfront and therefore the importance of water for the inhabitants of the city. Making public spaces out of the Green Axis at the local scale will also contribute to the structure. Thanks to centuries of trade, the city now has post-industrial sites which await their own fate. Two railway stations, vaguely in the north and south of the city constitute these post-industrial aspect of the city. Newer railway stations and technology has made these old stations defunct and unused.

As is clear from the mapping, the public spaces are scattered and don’t form part of a single structure. The strength of having a unified public space structure is that it will be less vulnerable to externalities. The advantage of using railway lines as public spaces is that it connects different parts of the city, by default. In this case, it connects parts of the city even over water. Using post-industrial sites as public spaces immediately bring the present inhabitants closer to the history of the city. The western world, has by now, become experts in converting post-industrial sites to attractive public spaces eg. Emscher Landscape Park in Germany, HighLine in New York City etc. Big cities in India like Mumbai have already begun converting old textile mills to shopping malls and public spaces. These post-industrial railway lines and stations of Kochi are ideal for such a conversion. It will add to Kochi’s already illustrious princely and colonial past.
Fig 165. Map of public spaces in the city

Fig 166. Map of post-industrial sites in the main city

Fig 167. Barrier to Seam through public spaces at the Local Scale

Fig 168. Tools to create a Green Structure: Mangroves, Wetlands, Canals, Other Vegetation and Public Space
13.2 To guide Settlement Patterns - Infrastructure

Settlement patterns were studied by doing the Layer Analysis at the local scale. Road network is not strong over marshy areas. Canals go through marshy areas. The beaches on the west are poorly connected. All settlements are on non-marshy land. There are settlements close to paddy fields and wetland areas as they are conducive to settlements. The settlements on the west seem to move away from the sea as one moves south. Natural landscape such as the mangrove and coconut wetlands seem to separate the settlement patterns.

The settlement pattern follows the infrastructure pattern, mostly concentrated on the highway. Few residential settlements are along the canal network while most are along the road network. The settlements along the canals would be older settlements who owned boats while the latter would be those ones who are dependent on motor transport.

Therefore as a tool for urban settlement, the incentives required are infrastructure and economic reasons like industries.
Urban Form in the City

The infrastructure-settlement relationship is investigated at the city scale. Urban form was mapped based on the infrastructure pattern. It was found that the urban form didn’t follow the form of the lagoon i.e infrastructure doesn’t follow the form of the lagoon.

High density of infrastructure was taken as an index of high density of urban settlements. The map shows an urban settlement which follows a pattern which is alien to the city’s natural form. It doesn’t follow the form of the lagoon. This is where there should be focus and attention lest the city loses its identity.

Therefore, to have an urban form that follows the form of the lagoon, the infrastructure has to follow the form of the lagoon.
14. Starting Points for Design

Different conclusions are derived from studying various aspects of the city. Though it is reflected in different ways, the underlying fact remains the same that there is a lack of structural backbone for the city. The starting point of the design is that

i. the canal systems and the wetland structure will be integrated and be part of the flood management structure.

ii. this will be combined with public spaces and infrastructure to guide the urban development of the city.

14.1 Components of a future Structure for the City

The research concludes on a toolkit of tools, systems to achieve and methods to achieve them which can be used to make a flood-proof, ecologically sustainable urban development that respects its natural landscape.

The toolkit consists of TOOLS like zandmotor, mangroves and wetlands, canals, other vegetation, post-industrial sites, public space and infrastructure.

14.2 Systems to Achieve

The main SYSTEMS TO ACHIEVE are blue-green structures for flood management and shoreline stabilisation, a figure of voids which is basically the blue-green structure, a well-connected ecological structure and green structures being the core of development.

14.3 Methods to Achieve

The METHODS TO ACHIEVE are by using the principles of Landscape Urbanism. One is ‘Designing a Horizontal Surface’ which is to design a horizontal template-like structure which can take up urban development around it. The other principle is ‘Designing in Phases’ so that at each phase, the project will be considered complete and useful for the city. This will insure it from any uncertainties that may occur (political or economic).
15. Regional Scale

Secondary data show how natural landscapes can be used for flood management. Therefore the design will involve using wetlands as flood plains. If found lacking in wetlands, then design will involve creating new landscapes like beach and wetlands. The design extensively uses wetlands and mangroves for this purpose. The map shows what is required for such a flood management system.

1. The estuary will be kept open for navigation and hydrological flow.
2. It requires a new source of sediment which will be deposited in the sea and carried by wind and water.
3. There will be a natural sedimentation agent on the coast which can trap these sediments and enlarge the beach. eg: mangroves
4. Wetlands will act as floodplains during coastal flooding or river swelling and will take up other activities during the non-flooding seasons.
5. Drainage systems will be made more efficient.

15.1 Preliminary Design

Based on the conceptual solutions in Fig 229 and 230, a preliminary design was made. This was found to encourage new beaches and make the region fight floods through natural landscape. Floodable landscape or floodplains can be used for other purposes only seasonally. Seasonal activities like aquaculture is an obvious solution to this problem.

Fig 180. Preliminary Design based on Toolkit
Fig 181. Beaches formed as a result of this design
15.2 Final Regional Design

Mangroves and wetlands are the highlight of the design. The dual problem of flooding and erosion are solved through them. The mangroves on the coast will trap sediment and consequently result in a bigger beach. The wetlands and mangroves on the inland will act as floodplains and prevent flood respectively.

The wetlands that are used as floodplains during the monsoons, can serve as aquaculture farms in the dry season. A third use as that of agriculture can also be given to them depending on the water levels. Agriculture mainly consists of Pokkali rice, a salt-resistant variety of rice.
16. Sub-regional Scale

From the regional analysis, there is a broad network of blue and green that has been formed for flood management and shoreline stabilisation. These are denoted as the blue and green strips. OMA’s Melun Senart envisioned a figure of voids that would stand the test of urban development and contribute to the spatial experience of the city. The blue-green structure, which is mainly derived from the regional design, is seen as such a figure of voids which would be left empty for urban development to take place around it.

The design task is to create a structure that can be a figure of voids which will be capable to structure the city and orient it towards wetlands and water and take in its stride urban development. Apart from solving the issue of urban flooding, the structure will

i. integrate drainage systems into natural landscape or vice versa and
ii. use natural landscape and infrastructure to structure the city and its development.
16.1 Components of the Horizontal Surface

The horizontal surface will make use of components like natural landscape (wetlands, mangroves etc), canals (drainage systems) and post-industrial railway sites (heritage). This way, the city will turn towards the natural landscape and hopefully the city starts recognising the natural landscape (which is also important for flood management of the region).

A conceptual green-blue horizontal surface is created from these components.
16.2 Designing in Phases

From the theoretical research, an important conclusion made was the importance of ‘Designing in Phases’. The aim of this methodology is that the project should be complete (in one way or the other) at the end of every phase. In this time of economic slowdown and crisis, such a method will assure that the effects of the project will be seen even if the project is stalled at some phase. In Kochi, where trade unions are powerful, such a theory holds good as projects are stalled due to interference from them. The design was phased depending on the urgency.

Since flood management and wetlands vulnerable to urban development are the most urgent, these will form Phase 01. An integral part of the project is to give the city a green structure. This will form Phase 02. These structures are envisioned to give the city its own urban form and identity. The end result is ideally a built environment that is not planned now. The starting point is a Structure that can give form to this. Urban expansion is believed to be a spin-off by favourable conditions.

Public spaces and infrastructure are the favourable conditions taken here. In order to decide which should come first, two scenarios have been detailed out. A scenario in which public space follows infrastructure and a scenario in which infrastructure follows public space have been worked out. From research, it has been established that urban development follows infrastructure immediately. The first scenario is unlikely to be implemented as urban development would take over probable public space as soon as infrastructure is laid out. Therefore scenario 2 is preferred. Public Space will come before Infrastructure.

These will however be phased together as a long stretch of public space will remain unused if there is no infrastructure. Therefore Phase 03 and 04 will both consist of Public Space and Infrastructure. It will start off from existing infrastructure lines and public spaces along the blue-green structure and this will become Phase 03. Phase 04 will be an extension of Phase 03 and will continue along the blue-green structure.

Phase 01: Blue Structure, Local Project
Phase 02: Green Structure
Phase 03: Public Space and Infrastructure_Pilot
Phase 04: Public Space and Infrastructure_Extension
16.3 Design

Phase 01 - Blue Structure + Local Design of Wetland

Phase 01 involves cleaning up and networking of existing canals for flood management. This ensures a constant water flow through the city making it a very obvious water city even in the interior areas. The city has primary as well as secondary canals. Secondary canals take water from internal areas and empties it into the larger primary canals. As determined before during the research, these canals are sufficient for effective drainage during flood. The canals also ensure ecological flow of fishes and other aquatic systems.

The second part of Phase 01 is the detailed design of a wetland region. This will be explained in detail in the local scale.

Completion of Phase 01 ensures a flood-free water city and a wetland used for other purposes than urban construction.

Fig 191. Scenario I Phase 01: Blue Structure + Design of a local wetland
Phase 02 - Green Structure

Phase 02 is about creating a green structure for the city. This green structure along with the blue structure formed in Phase 01 should act as a structural backbone for the city. This means that this structure should be the underlying base for urban development. This will give the city it’s identity. Abandoned railway lines and canals are used for this purpose. This will ensure an ecological flow of birds and other tree animals through the city.

The green structure is realised by planting trees and plants along existing lines of infrastructure.

LEGEND

PHASE 1
- Existing Wetlands
- National and State Highways
- Functional Railway Lines
- Abandoned Railway Lines
- Existing Beaches

PHASE 2
- Primary Canals
- Secondary Canals
- Mangroves
- Wetlands
- Boulevard of trees connecting isolated wetlands
- New Beach
- Project at the most vulnerable site in the city
Phase 03 - Public Spaces and Infrastructure_Pilot

To make the blue-green structure a part of the urban system and lives of people, the next step taken is to create a continuous structure of public spaces along this blue-green structure. This will put these areas in the mental maps of people. Along with public spaces, infrastructure should also be laid out next to them. The combination of public space and infrastructure will make the place attractive and urban development will follow.
Fig 194. Present day Thevara-Perandoor Canal

Fig 195. Phase 01 Cleaning and Improving the Canal

Fig 196. Phase 02 Greening the Canalfronts

Fig 197. Phase 03 Public Spaces on Canalfronts
Phase 04 - Public Space and Infrastructure_Extension

The corridors established in Phase 03 is extended along the blue-green structure to realise the lagoon and water-based urban form.
Final Design

Following Scenario I, the design prepares a horizontal surface which will help in flood management, create an ecological structure for the city and guide the urban expansion of the city through its natural landscape. The victory of such a flexible design lies in the fact that the design is a success even if there is no urban development as predicted. This is because the horizontal surface plays other important roles besides being a template for urban development.
17. Local Scale

The local scale is a scaled down version of the project at the sub-regional scale. Projects like Downsview Park stress heavily on designing in phases. They also try to set off centres of growth or take cues from around the park about possible trends of growth in the future. The same has been attempted at the Local Scale Design. The design will

1. Investigate how wetlands act as flood management systems and
2. Organise urban development around these wetlands rather than on it.

It will follow the same phasing structure as that at the sub-regional scale. The phases here will be called sub-phases. According to the phases in sub-regional scale, the sub-phases are called

Sub-Phase 01: Flood Management
Sub-Phase 02: Green Structure
Sub-Phase 03: Public Space Structure
Sub-Phase 04: Strategic Infrastructure

Fig 200. Strategy to use wetlands for flood management and recreation

Fig 201. Strategy to balance wetlands and urban development

Fig 202. Wetlands as cores for urban development
17.1 Sub-Phase 01: Flood Management

There are two types of flood this wetland will be subjected to - coastal flooding and flooding due to rain. Both these floods will be dealt with in different ways. During flooding due to rain, the peripheral wetlands don’t have much of a role. It is the internal wetlands that will act as a drainage point for the canals to drain into and act as storage. These wetlands should have the capacity to hold water in times of heavy rain. In the monsoon season, the expected increase in water level is 85 cm. The wetland will be able to hold this water by converting the edges into different levels which can hold different heights of water. Therefore with changing seasons, the edge conditions will also change. Public spaces that border these wetlands will be partially the buffer areas will be flooded during the monsoon.
17.2 Organising the Green Structure: Sub-Phase 02

If Phase 02 is about creating new green links between isolated green areas in the city, Sub-Phase 02 is about organising and structuring the already existing green structure on the basis of its ecological functions. These functions were identified in the previous sections. Based on the ecological function, the edges of the wetlands are determined.

In the maps, wetlands with their special benefits are shown. In the first map, one part of the wetland is omitted as it does not have a highly significant role in any of these benefits. But its strategic placement between the different wetlands give it an important function of being a connection between the wetlands. Its location between ‘tourism wetland’ and the beach on the west and the State Highway on the east makes it an apt location for intense recreational activities. It’s programs will be detailed out in the another section.

The green structure is organised keeping these functions in mind. Type of edges are determined according to the sensitivity of the area. Highly sensitive areas like ecological areas will have hard edges while less sensitive areas like recreational wetlands have softer edges. These have been explained in the table below. The edges are always defined by trees.

<table>
<thead>
<tr>
<th>Edge - Space Chart</th>
<th>Ecological Spaces</th>
<th>Recreational Spaces</th>
<th>Groundwater Points</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Edge</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-open Edge</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed Edge</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 205. Important Wetlands on the basis of their benefits from Research
Fig 206. Addition of a new program for a previously unimportant wetland
Fig 207. Table for edge conditions for the wetlands
17.3 Sub - Phase 03: Wetland as a Seam: Routing System and a Public Space Structure

Better living environment is guaranteed by clean air, water and ample usable open space i.e. public space. Large amounts of green assure clean air. A part of the wetland is identified as a possible groundwater recharge point. This will ensure water supply. The next task is to create vital public spaces that can encourage a healthy living environment. Wetlands are converted to unique public spaces. They are unique because of the natural landscape. This will also give it a social significance.

In the previous chapters, it was seen how these axial wetlands act as a barrier. By programming them, they will be converted to a seam and play a significant role in acting as a connector. It will thus be a strong urban element. Some parts of the wetlands are altered by humans for aquaculture. This landscape has already become an identity of the region. Thus it already has a strong cultural significance.
17.3.1 Routing System

The ill-defined edges of the wetlands are defined by a routing system. Based on landmarks and surrounding wetland types, different routes have been identified along with an exclusively pedestrian pathway. Major landmarks of the area i.e. a 400 year old Portuguese Church 'The Church of our Lady of Hope' and the Lighthouse near Puthuvype Beach are integral parts of this route. The different routes identified are shown in Fig 211. These will go a long way in putting otherwise isolated areas in the mental maps of people, in creating better living environments and thereby making the barrier-like wetland a seam.

According to the types of wetlands and the edges determined before, the spatial experience identified with each part of the route is different. An integral part of this routing is the pedestrian loop which will run on the periphery of the wetlands and at the same time connect these wetlands and surrounding areas. This loop will define the edge of the wetland and determine where people can enter and where they can not. It guides and restricts the movement of the people. The loop goes around all types of wetlands viz. ecological, recreational and groundwater. At the recreational wetland, there are additional spaces for the public. The loop thus gives way to recreational public spaces at this wetland.

In this scenario, certain other edges also come into play. For eg: the edges between existing scenario and the wetlands, the edges between different types of wetlands etc. The edges are so designed so that the existing communities get a benefit from these new development. The recreational space close to existing communities will have spaces for restaurants and kiosks run by the locals. Thus it will become a seam with local people putting up food stalls for the recreational edge happening on the other side. The groundwater area is to be maintained as a clean area and so there will be a semi-barrier where people are not allowed to enter it but at the same time won’t be discouraged from being around the area. The other type of edge that arises is the edge between the different kinds of wetlands. The Ecological – Recreational edge is defined by a bridge and a green buffer space. The buffer space acts as a transition space on one hand and the bridge provides a sense of entrance to the new zone. The Recreational – Groundwater edge is designed as a penetrable barrier to maintain water quality. The existing houses make the barrier while new boardwalks make it penetrable.

Fig 211. Routing the wetland - different routes through the wetland

Fig 212. Spatial experiences through the different routes

Fig 213. Different types of spaces
17.3.2 Public Space Structure

One part of the routing system is converted to pedestrianised public space. This will go around the wetland structure as shown in Fig 214. The presence of this public space structure is based on the defined functions of the wetlands. With this structure, the wetlands will become public and urban development will get an added incentive.

Fig 214. Routes around the main wetland structure

Fig 215. This route can form the main framework for the public space

Fig 216. Sub - Phase 03 - Public Structure
Fig 217. Sections showing how the public space changes around the wetland.
17.4 Sub - Phase 04: Infrastructure

The remaining part of the routing system consists of vehicular routes which connects the landmarks, the main road and the beach. The wetlands will remain vehicle free. This is achieved by building a bridge over the wetlands and having vehicular circulation around the wetlands.

Other than making the wetlands accessible, infrastructure is also expected to set off centres of growth. These centres of growth are expected to expand to huge urban developments, considering the pressure on land.
Fig 221. Sections showing how the public space changes around the wetland as urban development takes place.
The wetland thus becomes an effective flood management system as well as a core for urban development.
part 4: conclusion

Fig 226. Groynes at Munambam and Azhikode at Periyar River.
The main research question of the project was “How can wetlands help in flood protection, shoreline stabilisation, restore ecological diversity and be cores of urban development?” Therefore the aim was to find how there could be an integrated solution for flood management, shoreline stabilisation, ecological structure and at the same time be cores of urban development.

Observations

The major observations made were that the effects of flood management, erosion measures and reclamation at the larger scale are not considered.

A lack of sensitivity to the ecological structure or a purposeful ignorance of the benefits of wetlands was also observed. The natural landscape is totally ignored in the city.

The answer to the question mainly lies in a blue-green centric vision to city planning.

Flood and Erosion

1. Measurements should be taken care of at a regional scale because the systems are inter-connected and the effects are not restricted to one location.
2. Flood can be controlled with an improved ecological structure at the same time not compromising on urban development

Creating a Structure out of Natural Landscape

1. This should have ecological and water structure at the core for a flood and erosion prevention strategy
2. Urban form is guided along this structure by creating public spaces and infrastructure along it.
Designing in Phases

This is an important conclusion and concept while working in indeterminate scenarios. It is important because

1. it makes sure that the design is successful even if some of the later phases are not taken up.
2. even if the predicted urban growth does not take place, the system will work on other levels

This is possible because the design is blue-green centric because of its other commitments. This ensures that the blue and green always remains central to the city. Therefore

1. an urban expansion that takes its cue from the blue-green structure will follow that pattern and will thus have its own structural identity.
2. in case of unpredictable futures like a post-industrial phase, the urban form is still equipped to respect the form of the lagoon
18. Conclusions

By having a blue-green centric vision, multiple problems of the city can be dealt with a single vision. Here, this vision helps in centring the urban development around the water, the canals, wetlands and mangroves. This is essentially also the identity of the city. By using the concepts of Landscape Urbanism, especially 'Designing the Horizontal Surface' and 'Designing in Phases', the design is able to respond to an indeterminate economic and political scenario in a developing democratic country like India.

The conclusions can be broadly summarised as

1. use natural landscapes
   a. for flood management and shoreline stabilisation.
   b. as the core for any city structure.
2. design horizontal surfaces comprising
   a. flood management techniques like canals and wetlands
   b. incentives for urban development like public space and infrastructure
3. design in phases
   a. phase the design and project depending on the function namely flood management, ecology and urban development.

To be precise, design HORIZONTAL SURFACES using NATURAL LANDSCAPES in PHASES.
Fig 238. MATSHAFE aquaculture farms in Malipuram, Kochi
Relationship between Research and Design

Research and design were very dependent on each other. There were two kinds of research - literature study and field study. A brief field study led to a detailed literature study which led to a detailed field study. Conclusions derived from these were used in the design, which itself was seen as a research tool. The research questions are indeed answered at the end of the design.

Relationship between Studio and Graduation Project

The Graduation Project brings together urban development and flood management through ecology. The focus of the studio is integrating flood management interventions spatially in the urban context. The focus of the studio helped me strengthen the spatial component of my project.

Relationship between Approach of Studio and chosen Methodology and Framework

The approach of the studio was quite technical in the beginning as compared to the chosen methodology and framework. The technical approach did help formulate the technical aspects of the methodology and framework.

Relationship between Project and Social Context

As the focus of the project is flood management, it has social relevance beyond measure. Flood management is done through ecological means which doesn’t affect the socio-ecological structure making it more credible in the social context.

Initial Objectives and Final Design Outcomes

The initial objectives of the project were many. They were to control the rapid urbanisation, respect ecological structures, help improve the socio-economic status of the local stakeholders like fishermen and farmers and lastly to create a safe coast. The project started with the aim of protecting the economic means of local stakeholders like the fishermen and farmers in the course of urban development. The goal of the project was to find ways to ensure their socio-economic means wouldn’t be sacrificed in the name of urban development. Spatial design strategies for such a problem were limited other than zoning plans. Strategies were limited to certain areas being zoned for activities that were important for socio-economic reasons.

In the initial stages of the project, wetland types like paddy fields and aquaculture farms were thought to be important for the ecological structure. But further research made it clear that these processes affect the ecological and hydrological structure of the estuary. This consequently put such wetland types into lower priority and the project started focussing on the natural landscape. A clear distinction between the natural landscape and cultural landscape started becoming evident. From then on, focus was given to maintaining or reclaiming the natural landscape. Local stakeholders indeed took a backseat in the project from that point.

The stakeholder co-operation also takes a different turn. In the initial scenario, the interests of the local stakeholders were to be protected from the encroaching interests of the larger modern stakeholders. Both the stakeholders were put on different scales of the balance and the idea was to balance the interests of the two. In the final scenario, the interests of nature or natural landscape were to be protected from the interests of the other stakeholders. So here, nature and other stakeholders are put on the scales.

This project is not the final word for flood management or urban development based on ecological structures. It is only starting a conversation on how ecological structures can be wisely used for flood management and urban development.
Fig 240: Fishing boats docked at the end of the day
Building with Nature
Balancing Coastal Safety Measures with their Ecological Structures

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Abstract: Measures to ensure a safe coast have evolved over time. Conventional measures involved hard engineering solutions like retaining walls, massive concrete channels, dams, levees, sea walls etc. Though efficient in preventing flooding, these hard structures have grave consequences on the ecological structure of the region. A good example for this is the Delta Works in South-West Netherlands. After the devastating 1953 floods that killed around 2000 people and destroyed about 200,000 hectares of land, a series of dams called the Delta Works were constructed to ensure a safe south-west delta. But these dams prevented the mixing of salt and freshwater, resulting in irreparable damage to the ecological system. Such consequences in all parts of the world have made professionals step back and take stock. The situation is more serious in developing countries where money invested for such huge infrastructure ends up not fully serving the purpose. This has resulted in a changing philosophy which looks for softer approaches that work with nature and its ecological planning. Comprehending that the robustness of deltas and estuaries lies in its natural resources and realizing the need to protect them is the first step in this regard. The concept of "Building with Nature" stresses on using natural processes to design water management infrastructure. Land zoning regulations (eg. floodplains) and landscaping are also effective tools for mitigating floods. This literature review paper studies how the concept of "Building with Nature" and spatial and landscape planning tools can be utilized to balance coastal defence and the ecological structure of tropical estuaries with a focus on developing countries. The paper concludes by making a summary of the concepts and gives broad guidelines that can be used for coastal defence of estuaries in developing countries.

Keywords: estuary, coastal defence, ecological structure, Building with Nature, planned retreat, accommodation, coastal vegetation

1. Introduction
Deltas and estuaries are valuable resources for the countries they are located in. They are valuable natural resources and at the same time provide excellent facilities for port and shipping. Thus they play a big role in the economy of their countries. With climate change and consequent rise in sea-level, most of the coastal areas worldwide are subjected to increasing chances of flooding and erosion. This calls for an effective coastal defence strategy.

Conventional coastal defence measures include hard structures like dams, levees, retaining walls, groynes and sea walls. Most of these measures are expensive and in certain cases don’t serve the purpose as expected. Huge structures like dams cut off one region from the other interfering in the sedimentation and water circulation process. This prevents the natural processes from occurring in the ecosystem and consequently results in the deterioration of the ecosystem. This is exemplified in the Delta Works Program in the Netherlands. After the floods of 1953, which cost 2000 lives and destruction of 125,000 hectares of land, a series of dams were built on the country’s south-west region cutting off the sea from inland waters. Though the country lost a substantial amount of its coastline, this ensured that the region was safe from future coastal floods. But cutting off the sea meant cutting off the supply of saltwater which destroyed the aquatic ecosystem that thrived on the intermingling of saltwater and freshwater. This had unforeseen consequences in the local ecological structure.

The paper investigates ecological concepts which can be employed for coastal protection ranging from physical protection to spatial planning and landscape techniques. The concepts are elaborated in the following sections with application. In conclusion, these techniques are then evaluated in the context of developing economies and with respect to the graduation project.

1.1 Ecological Concepts for Coastal Defence

Some incidences have led to a change in the thinking of coastal defence measures and have led to a transition from hard structures to soft structures with lesser impact on the ecological footprint. The concept of "Building with Nature" aims to do the same. As the measures employed by this concept are not always economically viable, cost-effective measures like efficient spatial planning and landscape techniques which were known to mitigate flooding were reviewed. The three broad concepts reviewed across structural, spatial planning and landscape architecture respectively, are -

1.1.1 Building with Nature: This concept works along with nature to face disasters. It is proactive and utilizes natural processes and provides opportunities for nature in the infrastructure development. As Dr. Ronald Waterman, a specialist in chemical, environmental and civil engineering, puts it, it is the "flexible integration of land-sea and water of in-the-new-breed, making use of materials, forces & interactions present in nature, taking into account existing and potential nature values, and the biogeomorphology & geo-hydrology of the coast and coastal ecology."

1.1.2 Spatial Planning: Having a flood-responsive spatial plan can maximize engineering solutions and assist in creating a safe coast. Its advantages are equivalent to that of passive design strategies over active design strategies. Efficient spatial planning like zoning regulations to define floodplains, positioning new development on high land, dagging up retention ponds and accepting unpredictable behaviour from the sea in long term plans go a long way in minimizing the need for active solutions.

1.1.3 Vegetation and Landscape: In recent years, consideration for the use of less expensive ecological engineering alternatives to reduce the threats from many natural hazards is on the increase. It is a "soft" engineering approach, where natural ecosystems or enriched planted degraded wastelands are used as buffers against many flood related natural hazards. (Adaplan, 2012)

2. Building with Nature
The concepts reviewed in this section are the results of research done by the Ecoshape consortium in Netherlands.

2.1. Concept

Traditional approaches involved designing water management infrastructure required only one purpose. But it is crucial that these should serve more than one purpose and that it is aligned with natural processes rather than working against them, and that is adaptable to cope with changing conditions such as sea-level rise and climate change. Traditional approaches focus on minimizing the negative impacts of infrastructure projects (building in nature) and compensating for any residual negative effects (building of nature) while "Building with Nature aims to be proactive, utilizing natural processes and providing opportunities for nature as part of the infrastructure development process." (De Vriend, H.J. and Van Koningsveld, M. 2011) These solutions are also adaptable as they allow society and environment to respond slowly to climate change and sea-level rise.

2.2. Applications

Applications which are useful in tropical estuaries have been reviewed here. These include beach nourishment and preventing erosion of tidal flats which were done in the Netherlands and strategies for tropical coastal areas which were studied in Singapore.

Deflating Sand Engine: This method involves a process of concentrated beach nourishment. The idea is to deposit significant amount of land in one location which will be gradually redistributed along the shore by the wind and the waves. Since it’s a natural process, it will be gradual and will limit the disturbance made to the ecosystem and at the same time provide new areas for nature and recreation. With concentrated depositions, either the footprint is smaller or the frequency of distribution is smaller or both.

The project envisaged a hook-shaped peninsula which would provide resting areas for seals at the end of the spit with a shallow lagoon that would offer habitats for fish. Some of the sand will be transported to enlarge and promote development of dunes. In the first monitoring of the project, the development seems to be going as expected with sediment being deposited along the coast and seals visiting the area.

Outer reef in Eastern Schelde Estuary: The tidal flats of the Eastern Schelde Estuary in South-West Netherlands have been eroding at 2-3 cm per year. Rather than using the silica levels to prevent erosion, ecological solutions to create a reef out of dead oyster shells held together by steel wires and oyster larvae which will attach to these shells were used to expand...
the reef. Once the oysters establish themselves, the steel will corrode and the reef will survive on its own. This has already started to reduce the erosion in the area.

3. Spatial Planning

In this section, concepts in design of cities and planning instruments like policies and regulations have been reviewed.

3.1 Concepts

High land: Living on higher elevation is an obvious solution to the problem of sea-level rise. Many ancient Chinese cities in the Yellow River Plain were built on relatively higher places. In few cities, during flooding, the ground level of the cities became relatively lower because of the silt deposited outside the city. This silt was legally allowed to elevate the submerged land. As a consequence, retention ponds were also formed, which means that when the ground of the city was elevated, water from the waterlogged areas could also be drained to the ponds. (Yu, R., Li, D., and Lai, Z., 2000)

Water catchment areas: Earth based retention ponds are known to manage storm water. These help substitute the natural absorption of forests or other natural processes that are lost during development. This is recommended in highly urban areas where surface run-off is very high.

The efficiency of these retention pond systems is demonstrated in the neighborhood of Bukit Jelutong housing estate in Malaysia which has helped it to overcome its excess storm water and avoid serious flooding in low lying areas. (Dah, R. M and Sharrif, M.K.B.M., 2000) The polders in the Netherlands are also an example of water catchments which store storm water and prevent soil subsidence. They also prevent saltwater seepage during summer droughts.

Planned retreat: Planned retreat means progressively giving up threatened or vulnerable land by moving away from the coastal frontier, or by preventing future developments along the coast that may be affected by sea-level rise. The alternative of defending hundreds of kilometres of shoreline with sea walls or breakwaters would require enormous capital and maintenance costs. (National Institute of Water & Atmospheric Research Ltd. 2001) Hard protection can also cause imbalance in the ecosystem. But allowing beaches, estuaries and marshes to revert naturally with rising sea level will maintain the integrity of these areas as ecosystems.

Accommodation: At accommodation, the difference is that human impacts are minimised by adjusting human use of the coastal zone. (Nicholls 2003). This strategy thus uses an altered use of land, including adaptive responses such as elevation of buildings, roads, railways and modification of drainage systems and land-use change. For natural coastal and estuarine systems, it also includes enhancing the existing natural protection of dunes by vegetation and fencing, or creating and planting upper intertidal areas and salt marshes. The accommodation or planned retreat concept accepts and integrates natural coastal and estuarine evolution into conservation plans. Also, accelerated sea level rise is tolerated here. (Schierup, C.) Such concepts are useful while planning for unpredictable conditions and futures.

4. Landscape and Vegetation

The concepts reviewed are concepts involving purely vegetation but they are almost always used in combination with spatial planning and coastal defence techniques.

4.1 Concepts

Coastal vegetation as buffer systems: Protected vegetation apart from preserving bio-diverse species, "emphasise ecosystems as buffers to mitigate flood related impacts" (Adams, 2011). These lessen or moderate the impact of floods and storm surges. A buffering coastal forest allows a portion of the wave to pass through the vegetation with its force gradually attenuated, while a solid wall may be broken apart, lifted up, or overtopped. (ProAct, 2006) The ProAct Report of 2008 explains that after a storm surge, partially destroyed mangrove forests will regenerate naturally while the costs for repairing a concrete sea wall is high.

After the 2004 tsunami, many studies indicated that mangrove forests played a crucial role in saving human lives and property. Greenbelts of other trees, vegetated coastal dunes, seagrass beds, and intact coral reefs all performed a similar protective function in some areas. Where mangroves and other coastal habitats had been destroyed, often illegally, the waves were able to penetrate far inland, destroying homes, inundating farmland and washing away people and livelihoods. (Environment Justice Foundation, 2006) ProAct (2008) study shows that a 50 meter band of Avicennia species reduced a one
5.2. Relevance to graduation project

The aim of the graduation project is to design a regional coastal defence strategy and an adaptive strategy at the local level for a rapidly changing coastal environment. Planned retreat and accommodation should stand a better chance than zoning regulations since they are more flexible and in fitting to the location of the project. Other strategies which involve landscape techniques can also be used. Given the limited source of finance in developing countries, the strategies explained in this paper can be used to create a city that is safe from coastal floods and sea-level rise. There are more methods which need to be studied. This paper only gives a broad idea of the literature reviewed.

References


Schleppen, C. Regional spatial planning assessments for adaptation to accelerated sea-level rise – an application to Martinique’s coastal zone. Hamburg.

Appendix 3: Miscellaneous Information

CONSEQUENCES OF RAPID DEVELOPMENT

Industrial Development
- effluents pollute the water
  - water shortage
  - loss of biodiversity, fishes
  - creation of slums

Infrastructural Development
- almost always displacing the poor
  - low tidal prism
  - outer delta will shrink

Real Estate Development
- almost always displacing the poor
  - creation of slums

Land Reclamation
- loss of biodiversity, fishes

Port Activities
- almost always displacing the poor
  - creation of slums
- dredging + deposition of dredged material
  - creates siltation or erosion

Fig 241. Consequences of Rapid Development

CLIMATE CHANGE

Intensification of Precipitation
- storm surges
  - beach erosion, (6m width of beach/year) (7125 cu.m/year or 0.3 x10^6 cu.m/year)
- increase in groundwater table
  - water logging
  - drainage problems
  - breeding ground for diseases

Saltwater Intrusion
- unsuitable for aquaculture and fisheries
- shortage of potable water
- low lying barrier islands will become uninhabitable
- on mainland: huge complexes already built where 0.3m-0.6m rise will bring inundation

Higher Tide Levels
- low lying barrier islands will become uninhabitable
- on mainland: huge complexes already built where 0.3m-0.6m rise will bring inundation
- landless poor will be forced out.
- Fishing communities will become non-existant

Higher Waves
- severe wave attack
- higher littoral drift
- beach erosion, (6m width of beach/year) (7125 cu.m/year or 0.3 x10^6 cu.m/year)

Rise in Sea-level (2.27mm/year)
- increase in groundwater table
- saltwater intrusion
- beach erosion, (6m width of beach/year) (7125 cu.m/year or 0.3 x10^6 cu.m/year)

Fig 242. Consequences of Climate Change
The flatbed picture plane makes its symbolic allusion to hard surfaces such as tabletops, studio floors, charts, bulletin boards—any receptor surface on which objects are scattered, on which data is entered, on which information may be received, printed, impressed—whether coherently or in confusion. The pictures of the last fifteen to twenty years insist on a radically new orientation, in which the painted surface is no longer the analogue of a visual experience of nature but of operational processes.

- Leo Steinberg, Other Criteria: The Flatbed Picture Plane

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- Leo Steinberg, Other Criteria: The Flatbed Picture Plane

Fig 244. “Traditional world maps reinforce the elements that separate humanity and fail to highlight the patterns and relationships emerging from the ever evolving and accelerating process of globalization. Instead of serving as “a precise means for seeing the world from the dynamic, cosmic and comprehensive viewpoint,” the maps we use still cause humanity to “appear inherently disassociated, remote, self-interestedly preoccupied with the political concept of its got to be you or me; there is not enough for both.”

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Bibliography


13. de Wit, Saskia, ‘Land out of water’ in F.Hooimeijer, H.Meyer and A.Nienhuis (eds), Atlas of Dutch water cities, SUN: Amsterdam, pg 156 -


15. Department of Town Planning, Kerala, India, Kochi City Development Plan


18. Florence M. A, ‘Sustainability and Livelihood Issues of Vembanad Ecosystem Fisherfolk Communities with Special Reference to Muhamma and Thanneermukkom Villages’, PhD Thesis, Cochin University of Science and Technology, India


24. Hooimeijer, F., ‘Cities in wetlands’ in F.Hooimeijer, H.Meyer and A.Nienhuis (eds), Atlas of Dutch water cities, SUN: Amsterdam, pg 52 -


32. Mary, L, 2012, ‘Strategies To Integrate Landscapes Of Ecosystem Value Into Land Use Planning For Kochi Metropolitan Region’, Master Thesis, School of Planning and Architecture, New Delhi, India


42. Oak Ridge National Laboratory and Cochin University of Science and Technology, 2003, Possible Vulnerabilities of Cochin, India, to Climate Change Impacts and Response Strategies to Increase Resilience.


54. Sathiadas, R and Prathap,S.K, 2007, ‘Socio-Economic Impact of Tsunami on Fisheries and Coastal Communities in Kerala’, The Seventh Indian Fisheries Forum Proceedings, India


61. Thomson, KT, 2003, Economic and Social Management of Estuarine Biodiversity in the West Coast of India: Final Report


