ECOLOGICAL RESTORATION: A CASE OF MUNDERIKKADAVU WETLAND

MASTER OF LANDSCAPE ARCHITECTURE

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2017 MLA 012

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL

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ECOLOGICAL RESTORATION: A CASE OF MUNDERIKKADAVU WETLAND

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Submitted

In partial fulfillment of the requirements for the award of the degree of

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By

DEEPAK T C

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Under the Guidance of

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Declaration

I DEEPAK T C , Scholar No. 2017MLA012

Hereby declare that the thesis entitled ECOLOGICAL RESTORATION: ACASE OF MUNDERIKKADAVU WETLAND , submitted by me in partial fulfillment for the award of Master of Landscape Architecture, in School of Planning and Architecture Bhopal, India, is a record of bonafide work carried out by me. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

07-05-2019 DEEPAK T C

Certificate

This is to certify that the declaration of Mr. DEEPAK T C is true to the best of my knowledge and that the student has worked for one semester in preparing this thesis.

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“You can’t win them all,

But you can try”

-Babe Didrikson Zaharias

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Deepak T C

Abstract

Wetlands are called as “the kidneys of the landscape”. (CST, n.d.). Munderikkadavu is one of the important wetlands in the district of Kannur, Kerala. The wetland is formed by Munderi River which joins with Valapattanam River before it meets Arabian Sea, at Kattampally. The wetland area has already been declared as a Bird Sanctuary by the State Government. The area is highly enriched with varied species of birds, dragonflies, butterflies, grasses, etc. The wetland ecosystem is facing degradation due to human interventions like deforestation, pollution, encroachment, etc. This thesis intends to state the importance of the Munderikkadavu wetland ecosystem and the needs of its restoration. It also goes through the procedure for the restoration and also states how important is the relation between the culture and nature for the successful functioning of an ecosystem.

सार

वेटलैंड्स को "परिदृश्य के गुर्दे" कहा जाता है। (सीएसटी, एन। डी।)। मुंडेरिक्कवडु, केरल के कन्नूर जिले का एक महत्वपूर्ण वेटलैंड है। आर्द्रभूमि मुंडेरी नदी द्वारा बनाई गई है, जो कि कट्टमपल्ली में अरब सागर से मिलने से पहले वालापट्टनम नदी के साथ मिलती है। राज्य सरकार द्वारा आर्द्रभूमि क्षेत्र को पहले ही पक्षी अभयारण्य घोषित किया जा चुका है। यह क्षेत्र पक्षियों, ड्रैगनफली, तितलियों, घास, आदि की विभिन्न प्रजातियों के साथ अत्यधिक समृद्ध है। वेटलैंड पारिस्थितिकी तंत्र वनों की कटाई, प्रदूषण, अतिक्रमण, आदि जैसे मानवीय हस्तक्षेपों के कारण गिरावट का सामना कर रहा है। यह थीसिस मुंडेरिक्कवु वेटलैंड पारिस्थितिकी तंत्र के महत्व को बताती है। और इसके जीर्णोद्धार की जरूरत है। यह बहाली के लिए प्रक्रिया के माध्यम से भी जाता है और यह भी बताता है कि एक पारिस्थितिकी तंत्र के सफल कामकाज के लिए संस्कृति और प्रकृति के बीच संबंध कितना महत्वपूर्ण है।

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CHAPTER 1. INTRODUCTION

Wetlands are considered as “the kidneys of landscape” (CST, n.d.) as it provides many ecological services including water purification, flood control etc. Munderikkadavu wetland is a riverine wetland fed by Kattampally River. Kattampally River meets Valapattanam River, one of the major 44 rivers in Kerala, just 9km before it meets the Arabian Sea. During low tides in the sea, saline water used to intrude into the Kattampally River through Valapattanam River.

Kaippadu Krishi is a special type of organic paddy cultivation practiced in the wetland portions of River in which saline tolerant paddy varieties were used and the paddy grows in deep water. The farmers believed that the saline water is not good for cultivation and had issues like saline water intrusion into the wells and seasonal floods during the monsoon. As per the complaints from the farmers in 1966 Kattampally dam was constructed to check the salt water intrusion into the river and to check the seasonal flooding. The project became a failure in later stages as it failed to meet its objectives.

After the construction of the dam the Kattampally River got converted into Kattampally wetland of which Munderikkadavu wetland is a part. As the saline water intrusion got checked the acidic soil became harder and made it difficult to plough for the cultivation. Along with it the farmers got migrated to cities for a better job option and the rice was available at a cheaper rate from other states like Andhra Pradesh. Gradually the practice of Kaippadu Krishi got extinct.

The site was noted by International Bird life as an Important Bird Area and the Kerala State government has proposed the 4th bird sanctuary of the state over here. But with the extinction of the Kaippadu Krishi the number of birds visiting the site is gradually reducing as birds used to visit the site during sowing and harvesting of seeds to feed on the grains. Along with this, other human interventions like encroachment, pollution, illegal hunting of birds etc. also led to the degradation of wetland ecosystem.

Pandanus sp. (Munda in Malayalam) which was found abundantly in this area, from which the place got its name Munderi – the land of Munda, is at its edge of extinction form the site. The plant is an important wetland species which helps in the water purification, habitat for birds as well as all parts of the plant are edible.

The reduction in the birds visiting, the extinction of agriculture practice, extinction of Pandanus, and the infestation of Acrostichum, a wetland weed along with human interventions caused the degradation of the ecological integrity prevailed over Munderikkadavu wetland.

By this thesis project I am trying to propose a sustainable restoration of the lost ecological integrity of the Munderikkadavu wetland through landscape approach. Considering the importance of birds in this ecosystem and the social condition prevailing in the region instead of a sanctuary, a community reserve is proposed. And for the restoration of the ecosystem the cultural practice of Kaipadu Krishi has to be restored and the cultivation of Pandanus has to be entertained. A scope for eco-tourism also provided to add economic value to the project.

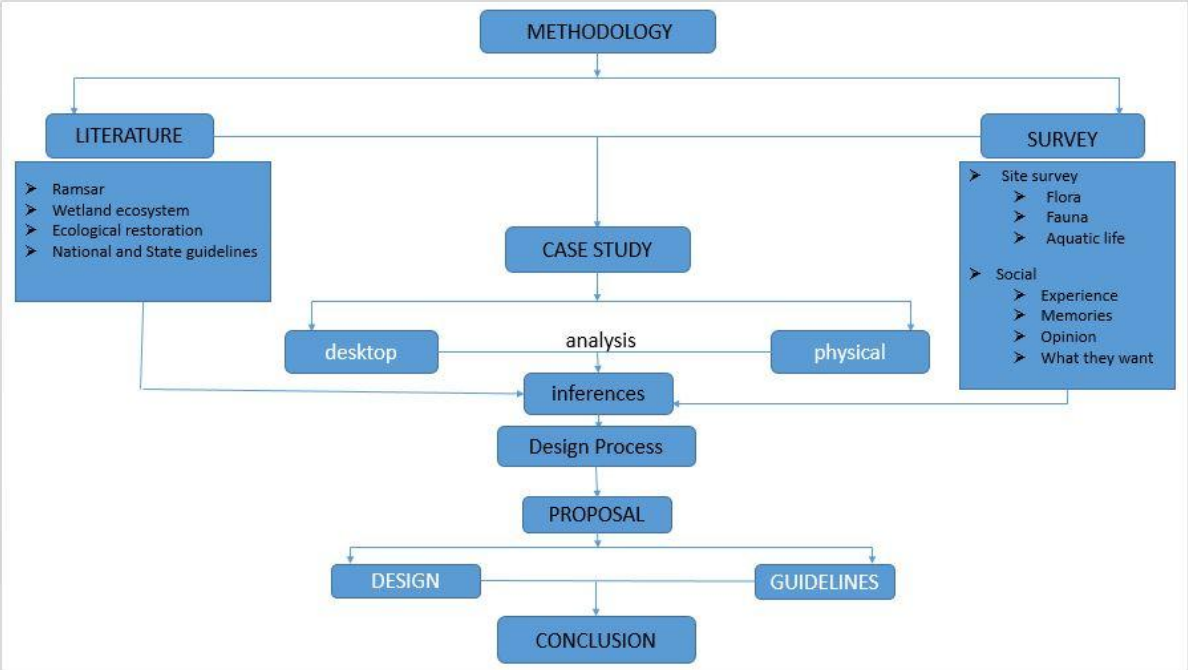
1.1 Aim

To restore the ecological integrity in Munderikkadavu Wetland ecosystem through landscape modifications, giving importance to cultural and ecological importance of the site.

1.2 Objectives

i) To identify the transitions happened in the ecosystem due to human interventions
ii) To establish a symbiotic relation between human and the protected ecosystem.
iii) To resolve the issues facing and enhance the quality of the ecosystem.
iv) To add economic values through eco- tourism.

1.3 Methodology



The whole process was scheduled into two parts, analysis and inferences and design. The analysis and inferences is done by two ways one by onsite surveys, interviews, etc. to identify the social, ecological, economic and cultural aspects of the site. Also the physical survey was conducted to identify the flora and fauna in the area. Alongside the physical surveys, literature study was done to know more about Ramsar convention and guidelines, wetland ecosystem, ecological restoration, national and state guidelines, Kaippadu krishi and community reserve. Two desktop case studies and two physical case studies were done on Bharatpur Bird Sanctuary, Thattekkadu Bird Sanctuary, Deepor Beel Bird Sanctuary and Harry Gibson's Migratory Bird Sanctuary in Canada. Inferences from all these studies were compiled together to propose the Composite Landscape Development Plan. Which is later developed into the design proposal for the project.

1.4 Scope and Limitation

Even though the impact of the wetland will be over a wide range of land area, the area for design interpretation has been restricted to wetland plus 100m buffer area. The field documentation of the existing flora and fauna will be restricted to

the major species. And to quantify the flora the random quadrant method will be used. While incorporating the human as a part of the sanctuary, only a few restricted human activities will be allowed in the protected area without harming the ecosystem like boating, fishing, etc. Some of the human induced issues like encroachment, hunting, etc. can be dealt with strict legal and planning level strategies and policies.

CHAPTER 2. LITERATURE STUDY

2.1 Wetland

WWF defines wetland as a place where the land is covered by water, either salt, fresh or somewhere in between, marshes and ponds, the edge of a lake or ocean, the delta at the mouth of a river, low-lying areas that frequently flood—all of these are wetlands. (WWF, n.d.)

Ramsar convention defines the wetland as the land area which are occasionally covered or saturated with water, where water level does not exceed 6m even at low tide. The flow of water is determined by the climate and configuration and the salinity by the hydrological cycle. And these together determine the flora and fauna that can survive in the wetland ecosystem. (Ramsar Convention, 1971).

In the list of net productivity of an ecosystem, the saline wetland tops the list and just followed by fresh water wetland and then tropical rain forest. The local activities based on the wetland like fishing, sailing, bird watching, other recreational activities, etc. adds to the social and economic value of the ecosystem. And wetlands provide many environmental services like water quality improvement, flood control and ground water recharge. (Matthews, 2013).

2.2 Types of wetlands

Wetlands are classified into different categories according to their origin, geographical location, water-regime, chemistry, dominant plants and soil or sediment characteristics. (Ntaure, classification and distribution of wetlands, n.d.).

The main two categories are Salt water wetlands and Fresh water wetlands. The salt water wetland comprises marine, estuarine, lagoon, and salt-lake wetlands. Freshwater wetlands are comprised of riverine, lacustrine and palustrine wetlands. Other than this aquaculture and agriculture fields, salt exploitation, urban or industrial and water storage areas like reservoirs are considered as man-made wetlands.

As per the location present the wetlands are classified as coastal and inland wetlands. Lakes/ponds, Ox-bow lakes/cut-off meanders, water logged (seasonal) playas, and swamp/marshes are natural inland wetlands. Reservoirs, tanks, waterlogged abandoned quarries, ash-pond/cooling pond are considered as man-made inland wetlands. Estuary, lagoon, creek, back water, bay, tidal flat/mud flat, coral reef, sand/beach/spit/bar, rocky cost and mangrove forest are considered for natural coastal wetlands. Salt pans and aqua-culture ponds are considered as the manmade coastal wetlands.

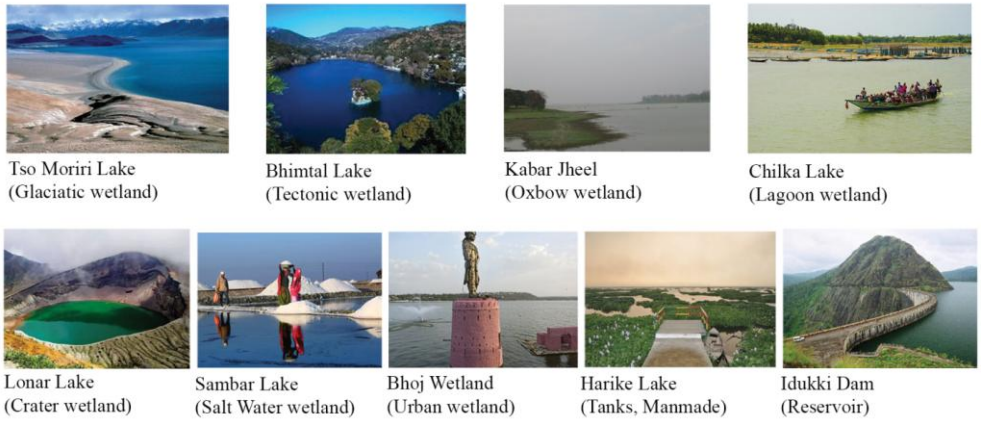


Figure 1 Types of Wetlands

Out of which the Munderikkadavu wetland falls into backwater wetland as the backwater from the Arabian Sea affects it, but it's an inland wetland as per its geographic location and is a riverine wetland by origin.

2.3 Wetland Services

2.3.1 Provisioning

The wetland provides many services to the nature and the human society directly and indirectly. The wetlands act as a prime source of food by the production of fish, wild game, fruits and grains. 60 – 80% of Cambodia's animal protein is provided by Tonle Sap Wetland (IWMI, n.d.). The freshwater stored in the wetland can be used for domestic, industrial and agricultural purposes. Wetlands provide logs, fuel woods, peat and fodder. Wetlands also provide biochemical like extraction of medicines and genetic materials which can be used for resistance to plant pathogens (IWMI, n.d.).

2.3.2 Regulating

Wetlands act as a source and sink for greenhouse gases and influences local and regional temperature, precipitation and other climatic processes. It supports the hydrological flows by recharging and discharging the groundwater. Wetlands help in water purification and waste treatment by retention, recovery and removal of excess nutrients and other pollutants. It acts as a retention pond for the soil erosion and also helps in regulating the flood. As being a prime habitat for the pollinators wetland plays a a major role in the pollination also. (IWMI, n.d.)

2.3.3 Cultural

Many religions attach spiritual and religious values to aspect of wetland ecosystems as you can see the temples and mosques around the Bhoj wetland in Bhopal. Wetlands are also a great source of recreational activities like boating. Wetlands like Dal Lake, Renuka Lake etc, add a value of aesthetics to its surroundings. Wetlands also provide opportunities for formal and informal education and training. (IWMI, n.d.)

2.3.4 Supporting

Wetlands support soil formation by sediment retention and accumulation of organic matters. Wetlands also support storage, recycling, processing and acquisition of nutrients (IWMI, n.d.).

Wetland supports rich and diverse varieties of flora and fauna. Different varieties of birds habitat in wetland ecosystem which includes migratory birds as well as IUCN red listed species. A rich aquatic life including the phyto and zoo planktons, crabs, fishes, aquatic plants, mangroves survive in wetlands. Wetland ecosystem also supports different types of plant species which supports the ecosystem functioning.

2.4 Ramsar Convention, 1971

For the protection of the wetlands, in the year of 1971 at Ramsar, Iran a convention was conducted. The Convention’s mission is “the conservation and wise use of all wetlands through local and national actions and international

cooperation, as a contribution towards achieving sustainable development throughout the world". (Ramsar, The Ramsar Convention and its Missions, n.d.)

The main principles followed by the conventions are:

- Work towards the wise use of all wetlands
- Find out the suitable wetlands and make the list of Wetlands of International Importance (the "Ramsar List") and their proper governance.
- International co-operation for the wellness of wetlands.

There are a total of around 2000 Ramsar sites all around the world. (Ramsar, The Ramsar Sites, 2014). [Figure.2]. Out of them 19 are there in India and 3 in Kerala. 6% of the earth's land area is covered with wetlands.

Figure 2 Ramsar sites around the world

2.5 Ecological restoration

The process of recovering an ecosystem that has been degraded, damaged or destroyed over time is called Ecological Restoration. It also refers to re-establishing a healthy ecological relationship between nature and culture.

Ecological restoration also includes the improvement of human condition. The basic tool of ecological restoration is enhancing the process of **ecological succession.** After a natural incident like forest fire, the succession also happens naturally, but on **an ecosystem damaged by humans, the succession has to be facilitated by human intervention**. Non-native flora and fauna has to be controlled and native species has to be introduced in the ecosystem. And in the end has to ensure the dynamic process of the ecosystem is functioning properly. (Botanic Gardens Conservation International, n.d.)

2.5.1 Principles of wetland restoration (United States Environmental Protection Agency, n.d.)

The United States Environmental Protection agency has defined the principles to be followed for the restoration of a wetland as:

2.5.1.1 Preserve and protect aquatic resources

The biota for and other natural materials are provided by existing biodiversity provides for the recovery of the impaired systems.

2.5.1.2 Restore ecological integrity

Ecological integrity refers to the structure, composition and natural processes of its biotic communities and physical environment. An ecosystem with integrity is a resilient and self-sustaining natural system able to accommodate stress and change. Its key ecosystem processes, such as nutrient cycles, succession, water levels and flow patterns, and the dynamics of sediment erosion and deposition, are functioning properly within the natural range of variability.

2.5.1.3 Restore natural structure

Original physical attributes if the site has to be restored for the successful restoration of other aspects like quality of water and restoration of the native flora and fauna. It can be achieved through the processes like stream channelization, ditching in wetland, disconnection from adjacent ecosystem, shoreline modification and etc.

2.5.1.4 Restore natural function

For a wetland ecosystem natural functions and natural structures are closely linked with each other. Restoration of natural structures will restore the natural functions. For a successful restoration project, the natural functions happening in the site has to be identified, and the list has to be prioritized as per the importance of the functions and the functions to be restore d in the degraded wetland system.

***2.5.1.5** Work within the watershed and broader landscape context*

A restoration project of wetland should be dealt in watershed level as any activity in the watershed area can affect the aquatic resource that is being restored.

2.5.1.6 Understand the natural potential of the watershed

The natural condition of the site before the degradation and what the future could be after the restoration – both these points has to be considered as the potential of the site area for the successful restoration of the ecosystem.

***2.5.1.7** Address ongoing causes of degradation*

The sources of degradation has to be identified and addressed as the if the sources persist the restoration will fail. The sources have to be checked all through the downstream and upstream along with the immediate surroundings of the wetland ecosystem.

***2.5.1.8** Develop clear, achievable and measurable goals*

The goals should be set for the success of the project. The goals should be achieved through ecological processes considering the potential of the area and socio-economic condition of the society depended.

2.5.1.9 Focus on feasibility

In the planning stage of the project the feasibility of the project has to be checked based on the social, financial and ecological parameters. The support from the community affected has to be ensured for the long term success of the project.

2.5.1.10 Use a reference site

Reference sites are those which are similar in structure and function to the proposed restoration site before it started to get degraded. This can be used to measure the achievement of restoration process in each level on comparison.

2.5.1.11 Anticipate future changes

While doing the planning for the restoration the future changes possible on social, economic and ecological conditions also have to be counted. It may include the potential changes in runoff due to developments, and natural changes like plant community succession that influencing the restoration.

2.5.1.12 Involve the skills and insights of a multi-disciplinary team

Since restoration is a process requiring analysis from different disciplinary like ecology, aquatic biology, hydrology, communications, social science and landscape architecture. The stake holders and their interests play a major role in the process. A combined master plan has to be produced from the proposals of different disciplines and the interests of the stakeholders and has to be approved by the authority.

2.5.1.13 Design for self-sustainability

The restoration process has to be planned in a way that it does not require a continuous maintenance of the site. High maintenance will elongate the duration of the process and will depend upon the human activity and cost of the project will go high. So it has to be designes for self-sustainability favoring ecological integrity.

2.5.1.14 Use passive restoration, when appropriate

Passive restoration is totally depended on natural processes. It deals with minimum alterations in the site. For example for a wetland with altered hydrology, restoring the original hydrological regime may be enough for the whole site to reestablish the whole ecological integrity.

2.5.1.15 Restore native species and avoid non-native species

The non-native invasive species substitutes the native species and lead to the extinction of the native species in the area. And the non-native species exploits the available natural resources for their expansion. A special care has to kept to avoid unintentional introduction of any non-native, invasive species in the restoration in the site as the site is highly vulnerable for the invasion.

2.5.1.16 Use natural fixes and bioengineering techniques, where possible

Bioengineering is a method of construction using live plants with inorganic materials to produce a living and functioning system. The method can be used for edge treatments, flood mitigation and water treatment.

2.5.1.17 Monitor and adapt where changes are necessary

The restoration techniques may act differently in different conditions. So monitoring before and during the project is necessary to check the progression of the process and whether the goals are achieved or not. And if the process is not giving the result as planned in the mid-way the required adaptations should be taken to give the required result. Monitoring post project will help to determine whether any additional steps have to be taken or not.

2.6 Community Reserve

The term community reserve was first introduced in the 2002 amendment of 1972 Wildlife Protection Act. A biodiversity abundant land which is privately owned or owned by government and managed by the community can be declared as a community reserve. This allows the community to extract the natural resource to a limit which is governed by a multi-stakeholder Reserve Management Committee. (Wildlife Institute of India, n.d.)

Since the ecosystem of Munderikkadavu is deeply depended on the Kaipadu cultivation practiced in the area, it is a better way to declare the area as a community reserve than a bird sanctuary.

2.7 Kaipadu Krishi

Kaipadu is the shortened version of ‘Kayal Padam’ in Malayalam language in which kayal means ‘salt water area’ and padam means ‘rice field’. The Kaipadu cultivation of rice is an integrated organic farming in which agriculture and aqua-culture goes simultaneously on the same field of coastal brackish water which is rich in organic matter. The practice is intricately linked with culture, history and survival of the Pulaya community. It produces economy from fish capturing which is dominated by prawns, other than paddy. And this special type of paddy cultivation is practiced in the northern part of Kerala especially in the district of Kannur. (The Hindu).

The traditional seeds used for this practice had salt tolerance and adaptive characteristics. Chovvarian, kaymakuthiru, kunjivithu, orthrian, orkayama, orkuthiru and thavalakkannan were some of the seed varieties used for the Kaipadu Krishi practice. These seeds yielded about 2000 kg/ha. And there was no fertilizers or pesticides used for this practice.

In the case of Munderikkadavu wetland the backwater flow from the Arabian Sea makes the water saline. The wetland area/river basin where the saline water intrusion happens, the salt react with the acidic soil and makes it soften and easy to plough.

2.7.1 The Kaipadu Krishi process

The process of the cultivation starts from the month of April onwards when the water level is too low. Many channels are made to drain out the water from the wetland area. During this time women form the Pulaya community used to catch the fish predominantly prawns (chemmeen in Malayalam) and this is known as ‘Chemmeen Thappal’. These fishes are dried and marketed as one of the major way of their income. Dried fields will be loosened with shovels (Figure 3).

Figure 3 loosening the soil with shovels

Due to continuous exposure to the sunlight and heat the soil will become powder. With this soil mounds of 25 – 75 cm high and 1m radius are made. The mounds are called ‘Potta’ in the local language and thus this cultivation practice is also known as ‘Potta cultivation’. In between the pottas small channels are made to facilitate the drenching out of salt from the field with the first rain itself.

Traditional farmers know (instinct knowledge) when will be the next rain and seeds are kept for germination according to that. The water soaked seeds are covered with dry hay and tied by dried coir in a globular shape, known as ‘Pothi’. The pothi is soaked in a nearby artificially made pond for 24 hours and they are brought out and water is drenched out. Seeds start to germinate after 3 days. These germinated seeds are sawn over the pottas after making small depressions which will be covered later to protect it from birds (Figure 4).

Figure 4 germinated seeds are sawn over the pottas

After 40 days of sawing the plants attain a height of 1.5 feet (Figure 5).

Figure 5 plants attain a height of 1.5 feet

The pottas are demolished with shovels. Spread out bunches of rice plants are separated and fixed on the soil by lady folks form the Pulaya community. This procedure is called as ‘Potta Harvesting’ (Figure 6).

Figure 6 potta harvesting

By the time the monsoon is set in full fury and the paddy will grow in deep water (Figure 7).

Figure 7 plants grow in deep water

Harvesting is a tedious process as after getting matured the paddy will fall in water. After 30 days of planting in soil, the paddy will be ready for harvesting. The harvested paddy is brought to the shore by country boats (Figure 8).

Figure 8 harvesting in country boats

2.8 Ecological importance of Kaipadu Krishi

Many of the mangrove species are refugees in the Kaipadu fields. During sowing and harvesting time, many birds, especially Baya weavers, visit the field to feed on the grains. It provides a harmonious balance among all living species. It's a sustainable harvest of prawns, large and small fishes.

CHAPTER 3. AREA OF INTERVENTION - STUDY AND ANALYSIS

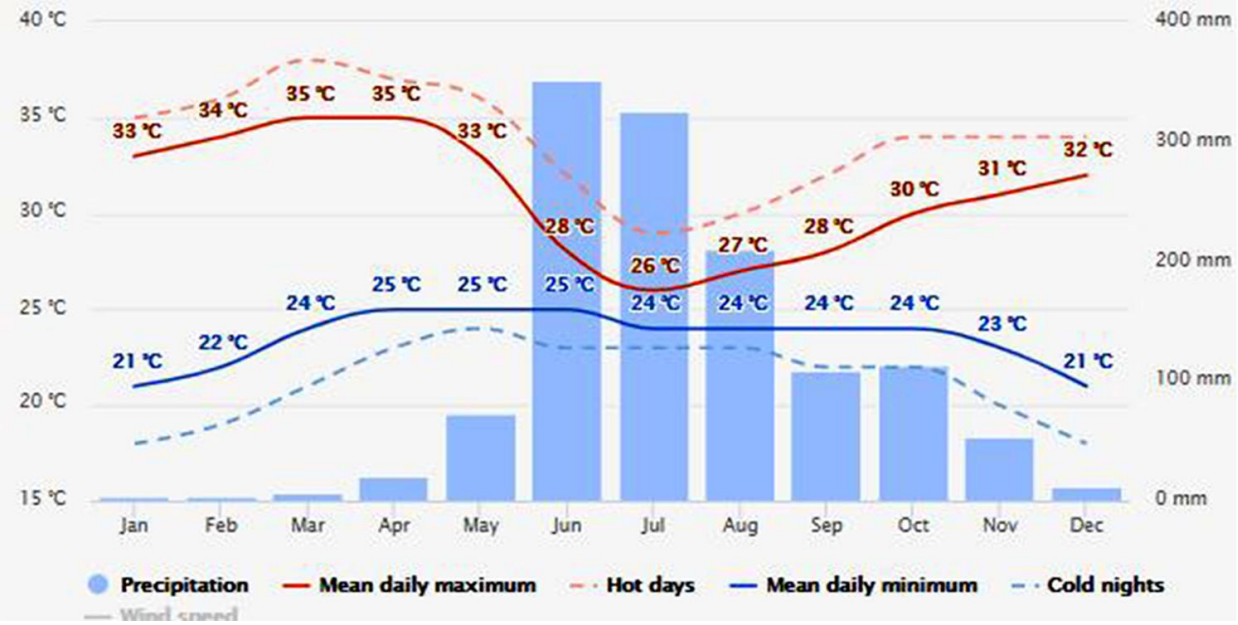
3.1 Kannur

Kannur is one if the maritime districts in North Kerala. It covers an area of 2966 sq. km bounded by Kasargode District on north, Karnataka State on East, Wayanad District on South East, and Calicut District on South and Arabian Sea on West. The District has a population of 2,523,003 (Census Population 2015 Data, 2011). Kannur is the district with longest coastal line. In historical data Kannur has been mentioned as the military capital for foreign invaders like Dutch, Portuguese and French. The only Muslim dynasty rulers in Kerala are from Kannur. The District is famous for its folklore art – Theyyam, its martial art – Kalari, and their culture of handlooms.

Geographically and ecologically, Kannur is highly rich. On the East side is the Western Ghats which has bio-hotspots like Aralam and Kanjirakkolli and tourist spots like Paithal hills and Palakkayamthattu in the district. District has other eco – hotspots like Madayippara and Parassinikkadavu in the middle plains. And the district has many number of small and lasrge beaches including Payyambalam beach, Muzhappilangad beach, Dharmadam beach, etc.

3.2 Climate

Kannur receives a total annual rainfall of around 3438 mm. District experiences heavy rainfall during South West monsoon season followed by North East monsoon. South West monsoon during June to September contributes 70 % of the total rainfall of the year. The northeast monsoon contributes only about 30%. The average mean monthly maximum temperature ranges from 28.4 to 36.90C and minimum temperature ranges from 19.7 to 23.90C.



Graph 1 Temperature and precipitation

3.3 Soil

Temporary or permanent saturation in the upper part of the pedon is strongly influences the Development and properties of wetland soil (Wetering & Moormann, 1985). These are brackish water tracts embellished with high inherent organic matter content and essential nutrients thereby having a high production potential. The ‘Kaipad’ rice which is cultivated in the coastal wetlands of Kerala has been included in the Geographical Indications (GI) registry which is a part of the Intellectual Property regime. (Shanti, Binitha, Suresh, & Ebimol, 2017)

These soils are dominated by the presence of different iron and sulphur containing minerals like pyrite and jarosite. The fine fraction content in the soil increases with depth in horizon. The entry of salt water from the sea during the summer months leads to the salinization of these soils. Further, this salinity gets washed off by the south-west monsoon leading to decline in the salinity levels. The bulk density varied from 1.06 Mgm-3 to 1.17 Mgm-3 with a standard deviation of 0.032. (Shanti, Binitha, Suresh, & Ebimol, 2017)

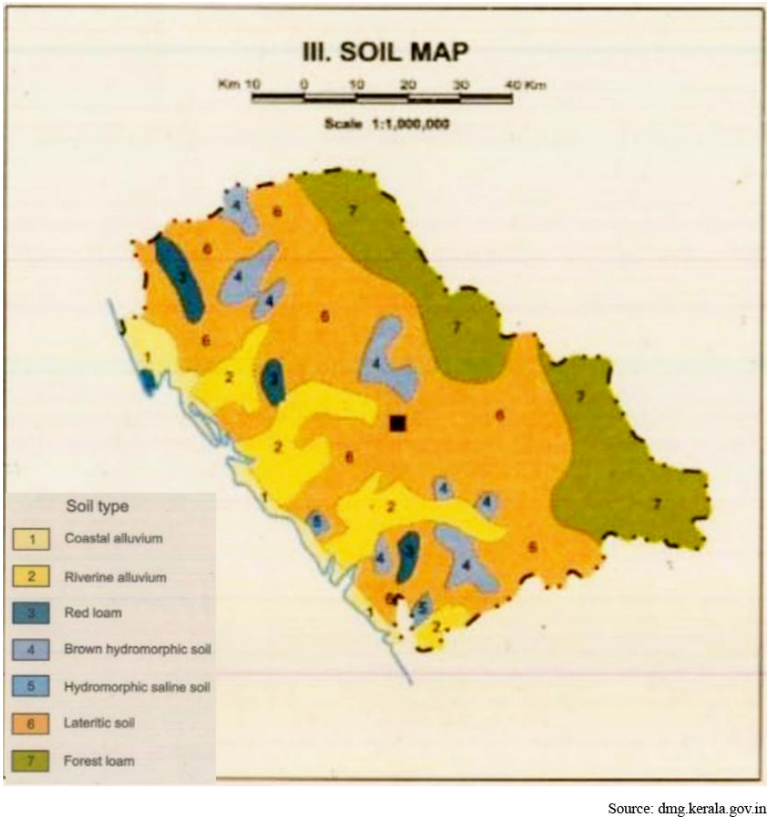


Figure 9 Soil Map of Kannur

3.4 Geomorphology

According to the physiography of the land the district can be divided into 3 geomorphologic sections. In the west, it is coastal plains and lowlands including beaches, estuaries, lagoons and flood plains. It runs till 15 km parallel to the coastal line. The region has maximum elevation of 50 – 60 m from MSL.

Midland in the centre contains undulating terrains. Laterite soil is one of the main characters of midlands, Laterite capped flats, mesasm ridges, spurs and narrow alleviated valleys are the part of this midland. In this region elevation goes to a maximum of 40-100 m from MSL.

In the east it is the high lands of the Western Ghats. Hills with steep slope are the characteristic of this region. In this region the elevation is generally above 500 m from MSL.

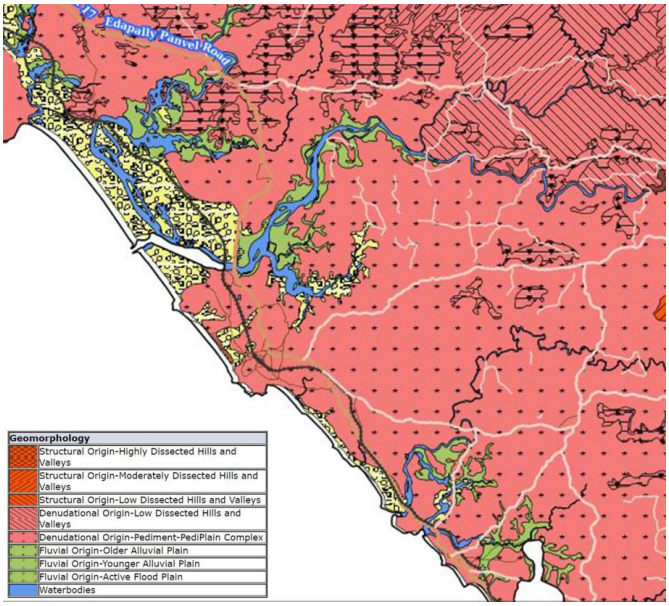


Figure 10 Geomorphology Map (Source: Bhuvan)

3.5 Drainage

The district is mainly drained by the Valapattanam River and Anjarakkandy River along with Kuppam, Mahe and Thalasseri River. Dendritic is the common drainage pattern of Kannur. The Valapattanam River is the longest river in district which originates from Brahmagiri Reserve Forest in Koorg District of Karanataka and drains an area of 1321 sq. km in Kannur and meets the Arabian Sea at Azheekkal. Anjarakkandi River originates from Kannoth Reseve Forest and drains an area of 412 sq. km in the district.

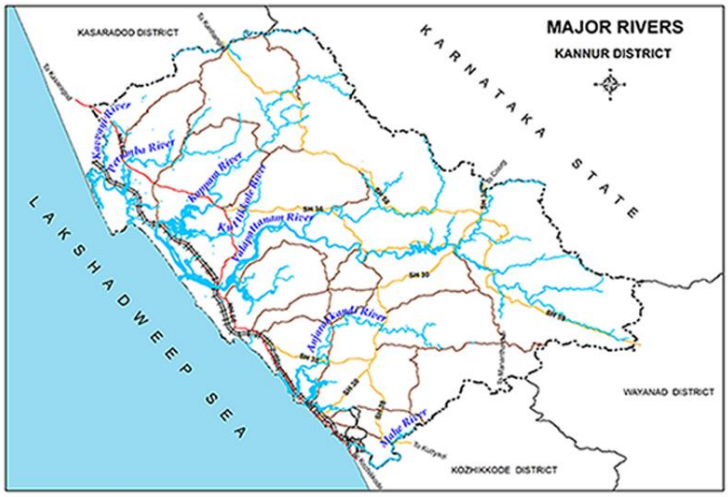


Figure 11 rivers in Kannur (Source: Dpt. Of Town Planning, Kannur)

3.6 Kattampally River and Project (Rajeevan)

Kattampally River is a tributary of Valapattanam River and is 21 km long. 12.8 km from the confluence with Valapattanam River is affected by back - water flow due to tidal effect. It has a catchment area of 135sq.mile and discharges 393 Cumecs (1000 l/s = 1 cumec) of water. The maximum flood level is +2.56 MSL and Water Table is around 1-3 m. The average tidal variation between low and high tides is 85 cm.

The Kattampally River basin has 7.65 percent of its land under Kaipadu land, 4.91 percent under paddy cultivation, 83.03 percent of land is used for mixed trees and crops, 0.11 percent is wooded area, 1.50 percent of barren land and 2.77 percent is covered by water bodies.

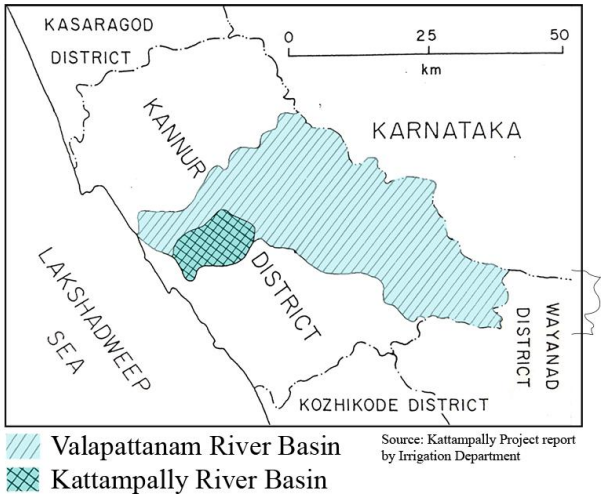


Figure 12 basins of Kattampally and Valapattanam rivers (Source: Kattampally Project report by Irrigation Dpt., Kannur)

In 1966 the State Government of Kerala constructed a barrage across the river at Kattampally on the basis of the complaints from the farmers on crop loss due to salt water intrusion and unexpected seasonal floods. The Kattampally River has a width of nearly 375m at the site proposed for regulator. The purposes of the project were irrigation, mitigate flood and prevent entry of salt water into Kattampally River and to support the Kaipadu cultivation. But due to technical

malfunctions the project failed to meet its objectives. But the bridge has connected the other end of the river to the city.

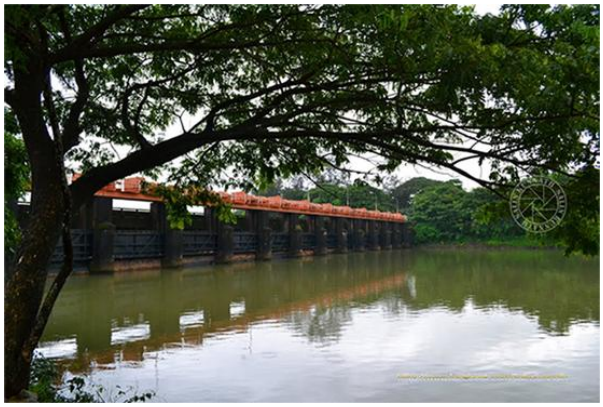


Figure 13 Kattampally Project (Source: Google images)

3.7 Before and After – Kattampally Project

3.7.1 Before

i) Salt water intrusion used to occur

Kattampally River meets the Valapattanam river at just 9 km before it meets Arabian Sea. Salt water intrudes into Kattampally River through Valapattanam River during the tides.

ii) Crop loss due to unexpected floods.

Unexpected continuous rain causes flood in the low lying regions of Kattampally basin due to which the crop loss used to happen.

iii) Flood in monsoon

iv) Used to experience drought in summer

In summers the ground water level has a fall of 0.19m which causes drought in high lands.

v) Salt water in wells

The saline water from the river used to intrude into the nearby wells in the banks, causing drinking water issues for the people.

vi) Salt water neutralized the acidic soil and made it available for cultivation

The soil in the region is acidic and hard in nature; the salt in the

back water reacts with acid in the soil and makes the soil soft and easy to plough.

vii) Agriculture was practiced in all the Kaipadu lands.

Kaipadu Krishi is a special type of organic paddy cultivation practice prevailed in Malabar region, predominantly in Kannur. Saline resistant paddy seeds were used to the cultivation and the plant grows in deep water.

viii) People used the crops which can survive in salt water.

Local varieties suitable for the saline soil like 'Orkkayama' and 'Orkkunhi Nellu' were used and the yield obtained was 2000 kg per Ha.

ix) Major part of Kaipadu area practiced single crop cultivation (Virippu).

x) No chemicals like fertilizers or pesticides were used for the cultivation.

The backwater intrusion has made the soil suitable for paddy cultivation, and also the presence of saline water prevents the attack of pests and insects. So the farmers didn't have to use any chemicals like fertilizers or pesticides.

xi) Other than agriculture the job occupation for the local people were fishing, boat transportation, and handicrafts.

The local people depended on the river for their daily wages, as most of the people were engaged in agriculture, fishing, and transporter across the river. Pandanus sp. was found in abundance in this area which was used for handicraft raw material along with coconut and other items.

xii) Marine fishes used to come to the wetland area through Valapattanam river for breeding.

The marine fishes come to the wetland through Valapattanam River for breeding land laying eggs.

xiii) Birds used to come for feed on the remnants of cultivation and aquatic flora and fauna.

xiv) Birds from North West region like Siberia, and European countries, migrating to South East used the area as a resting spot.

Figure 14 People were engaged in fishing and boating

3.7.2 After

i) The people thought that the prevention of salt water will help for their farming, and requested the Government for a check dam. The dam was constructed in 1966 to check the salt water intrusion, but, the leakage and malfunctioning of shutters led it to a failure and the salt water continued to intrude.

ii) Another purpose of project was to check the flood, but the flood happened in monsoon due to heavy rainfall. And during the monsoon time the regulator were unable to open as the Valapattanam River used to have a higher water level than that of Kattampally River.

iii) Salt water in soil - solved to a greater extent.

iv) Soil become hard due to acidity & made difficult to plough.

The soil in the region is acidic. After the backwater was checked, the soil remained highly acidic and the soil became more herder to plough. Gradually led to the extinction of Kaipadu Krishi. The land was kept unused for cultivation or any other purposes.

v) Kaipadu Krishi got extinct

The backwater intrusion was the major influencing factor of Kaipadu

Krishi practice. The acidic soil is hard to plough for the cultivation. And the yield form the Kaipadu fields got reduced and the practice became economically not feasible. People shifted to other crop cultivation like coconut and other jobs, and gradually the practice of Kaipadu Krishi got extinct in the region.

vi) The modern way of practice is high yielding than Kaipadu practice but is costlier & it alters the soil's character by adding chemicals.

vii) Fishing in the area has become a part of recreation or industrial aquaculture.

After the dam construction the fishes from the sea coming to Kattampally River for breeding got stopped and the fish resource of the river got declined. Nowadays people do fishing in the area for recreation. And also people have started aquaculture for business making small bunds in the river and using artificial food and chemicals.

viii) After the construction of bridges, the people started to depend upon the road transportation than water transportation, boating also became a part of recreation. Before the bridge was there, the people depended on country boats for crossing the river, and many of the people earned their daily wages through it. Kadavu means the boat jetty, from which the name of the place Munderi Kadavu came.

Figure 15 after the dam started to function, more bridges came across the river, and boating became a recreational activity. The fish resource gone down, fishing also became a time pass.

3.8 Munderikkadavu Wetland

Munderikkadavu Wetland is the fourth proposed bird sanctuary in the State of Kerala after Kadalundi, Thattekad and Kumarakom (Correspondent, 2012). It is about 12 kilometres away from district H.Q. The 7.5 sq. km of land is spread across 11 panchayats including Munderi, Koodali, Mayyil, Kuttyattur, Chelora, Elayavur, Chakkarakkal, Pappinisseri, Azheekkode, Narath and Kolacheri (PP & KP, 2013).

The Munderikkadavu wetland (Figure 14) is a destination for more than 100 rare species of birds. According to bird-watchers, around one lakh birds including 60 migratory bird species visit this wetland every year. Eurasian wigeon, black-headed bunting and red-headed bunting are some of the regular visitors. 12 endangered species of eagles are seen in these wetlands. Bombay Natural History Society and the Birdlife International has identified the site as one of the 24 Important Bird Areas (IBA) in the state. (Nair, 2013).

The wetland has a strong relation with the culture of the region as there was a special type of agriculture practiced in the wetland area, known as Kaipadu Krishi. It's organic paddy cultivation where the paddy grows in deep water, and it was practiced by the Pulaya community. (Rajeevan)

Figure 16 Munderikkadavu wetland

3.9 Contour

The region is comparatively free from high fluctuations in contours. It is gradually sloping towards the wetland area. The highest point in the region is 28m from MSL. And the lowest point has gone till -1 in the wetland.

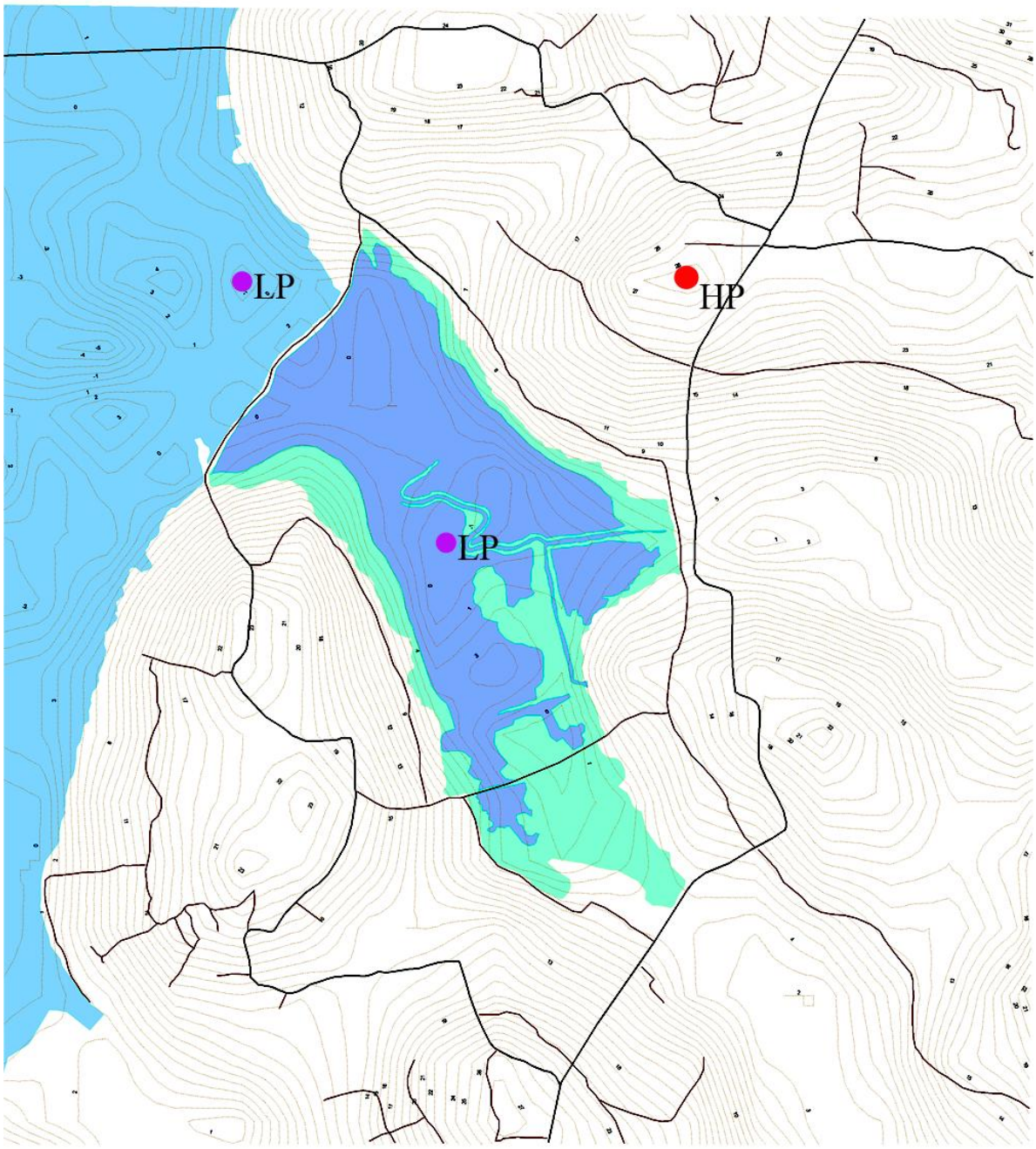


Figure 17 Contour Map

3.10 Site Context

Figure 18 Base Map of the Munderikkadavu Wetland Area

The commercial buildings (Figurer 19) are constructed on the buffer zone of the wetland and the whole locality depends on these shops for their daily needs.

Figure 19 Commercial buildings

The spill over area of the wetland is green throughout the year and the local people depend on this area for graze their cattle.

Figure 20 Spill over area of the wetland

The water from the nearby paddy fields flow to the wetland through a channel, and weeds have infested both edges of the channel and on both side the wetland grass species has grown and the area is also used by the local people to graze their cattle.

Figure 21 Water flows from the paddy fields

There is a small tea shop in the East side of the site from where the people coming from the city enter to the site. In the present situation it is the only hotel in the area.

Figure 22 Country style tea shop

From this entrance point a narrow arterial road of 4m wide runs parallel to the wetland edges and joins the main road near the Munderikkadavu Bridge. Along this road the people has encroached the buffer land of wetland and constructed houses.

Figure 23 Encroachment on the sides of the road

The Govt. has constructed a concrete gateway in this eco sensitive area which itself shows negligence of the authority for the project. And now the structure is in an abandoned condition, the lack of management and involvement of local people is clearly visible on site.

Figure 24 Concrete gateway for the sanctuary

Munderikkadavu Bridge connects either sides of Munderi River. The local people spend time over the bridge in the evenings for gathering, fishing and to enjoy the beautiful vista.

Figure 25 View of wetland from Munderikkadavu Bridge

The wetland area has the best view from the mud bund constructed by the local people to connect either sides of the wetland and it separates the wetland from river. People come here to spend their leisure time, as it has a grand vista of wetland and river from the same spot on your either sides. The coconut trunks are piled in the wetland for the birds to sit. The bund is also the best spot for bird watching as all type of land characters; woodland, grassland, mud dunes, and open water area are clearly visible from here.

Figure 26 on left of the bund is the wetland and right is the river

3.11 Walking experience around the site

Standing on the mud way on the east side of the wetland from where the people coming from the city enter and looking at towards the water body gives a beautiful view of green grasses blending with the blue water. And on the left side the Pandanus sp. standing high making people to remember about its presence. On to the north end of the mud way gives a view of typical Kerala village with small houses and grazing cattle.

Figure 27 View towards the wetland from the mud way at the east entrance of the site

While walking on the road running parallel to the wetland edge, gives a view of the water body through the woods and the trunks make a frame for the scene. The walk also gives an experience of watching birds on the upland vegetation.

Figure 28 View of wetland through the woods

Just beside the constructed gateway for the bird sanctuary on the north side, a narrow trail is running with thick grasses and trees on both sides gives nostalgia of village trails in childhood.

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Figure 29 Village trail

Walking on the mud bund gives a view of wetland and river on the either sides of the bund creating a feel of continuity of water, in the mind of the viewer.

Figure 30 Water on either sides of the bund

The mud bund is the best place to have a glance at the wetland, as it gives an overall view of the water body with the main road in the back drop. From the bund could see the birds in open water as well as on the land.

Figure 31 View of wetland from the mud bund

3.12 Biodiversity of Munderikkadavu wetland

Munderikkadavu wetland ecosystem is very rich in biodiversity. It consists of around 150 species of birds, 45 species of spiders, 34 species of dragonflies, 82 species of butterflies, 68 species of mammals, 150 species of plants, and 16 species of fishes. (Joseph, 2012). Some of them are

Fishes: Etroplus suratensis, Catla catla, Kowala coval, Solea elongate,Puntius ticto, Arius sp, Scylla serrate, Charybdis cruciate

Prawns: Macrobrachium idella, Macrobrachium rosenbergei, Pennacus indicus, Metapenaeus monoceros, Pennaens indicus, Pennaeus monodon

Clams: Meretrix casta, Villorita cyprinodies, Crassostrea gryphoides, Paphia malabarica, Katalysia opima

Plants: Nymphea nouchali, Nymphoides hydrophylla, Nymphoides indica, Premna serratifolia, Wedalia trilobata, Cyperus distans, Cyperus castaneus, Hygrophila schulli, Merremia vitifolia, Mimosa pudica, Morinda citrifolia, Sida acuta, Urena lobata (Prabhakaran & Karakkatt, 2013)

Birds: Anas querquedula, Aythya nyroca, Tadorna ferruginea, Anas penelope, Egretta garzetta, Ardea alba, Ardeola grayii, Ardea cinerea, Anastomus oscitans,

Platalea leucorodia, Himantopus himantopus, Spilornis cheela, Aquila heliacal. (Prabhakaran & Karakkatt, 2013)

The vegetation type, depth of water, quality of water (saline, pollution) human disturbance or alteration due to agricultural practices determines the distribution of birds in a wetland. (Roshnath & Shruthi, 2015)

3.13 Types of vegetation in Munderikkadavu wetland

i) Upland vegetation: in the areas which never get filled with water. Eg.:Macaranga peltata, Peltophorum ferrugineum, Ficus recemosa, Cocos nucifera, Mangifera indica, Helitropium indicum, Mimosa invisa, Mimosa pudica

ii) Lowland vegetation: the marshy area adjoining the water. Eg.: Cymbopogon sp., Axonopus compressus, Derris trifolata, Cyperus castaneus

iii) Emergent vegetation: islet-like patch of lowland vegetation, submerged soil with erect herbaceous hydrophytes which grow upward above the water surface. Eg.: *Fuirena umbellate, Eleocharis dulcis, Eleocharis geniculate*

iv) Paddy fields: moist and marshy cultivable land. Brackish water paddy cultivation (Kaippadu Krishi)

v) Open water: area covered by water having submerged vegetation. Eg.: *Hydrilla verticillata*

Both diversity and number of species was higher in lowland vegetation (46 sp.) followed by upland vegetation (41 sp.) and aerial (38 sp.) then emergent vegetation (22 sp.), paddy fields (21 sp.) and then open water (10 sp.) (Roshnath & Shruthi, 2015)

3.14 Avi – Fauna

Munderikkadavu wetland ecosystem is highly rich in avi-fauna. According to the bird watchers there is around 211 species of birds visiting the site every year. The whole area of the ecosystem is divided into 5 as per the type of vegetation which influences the habitat distribution of birds.

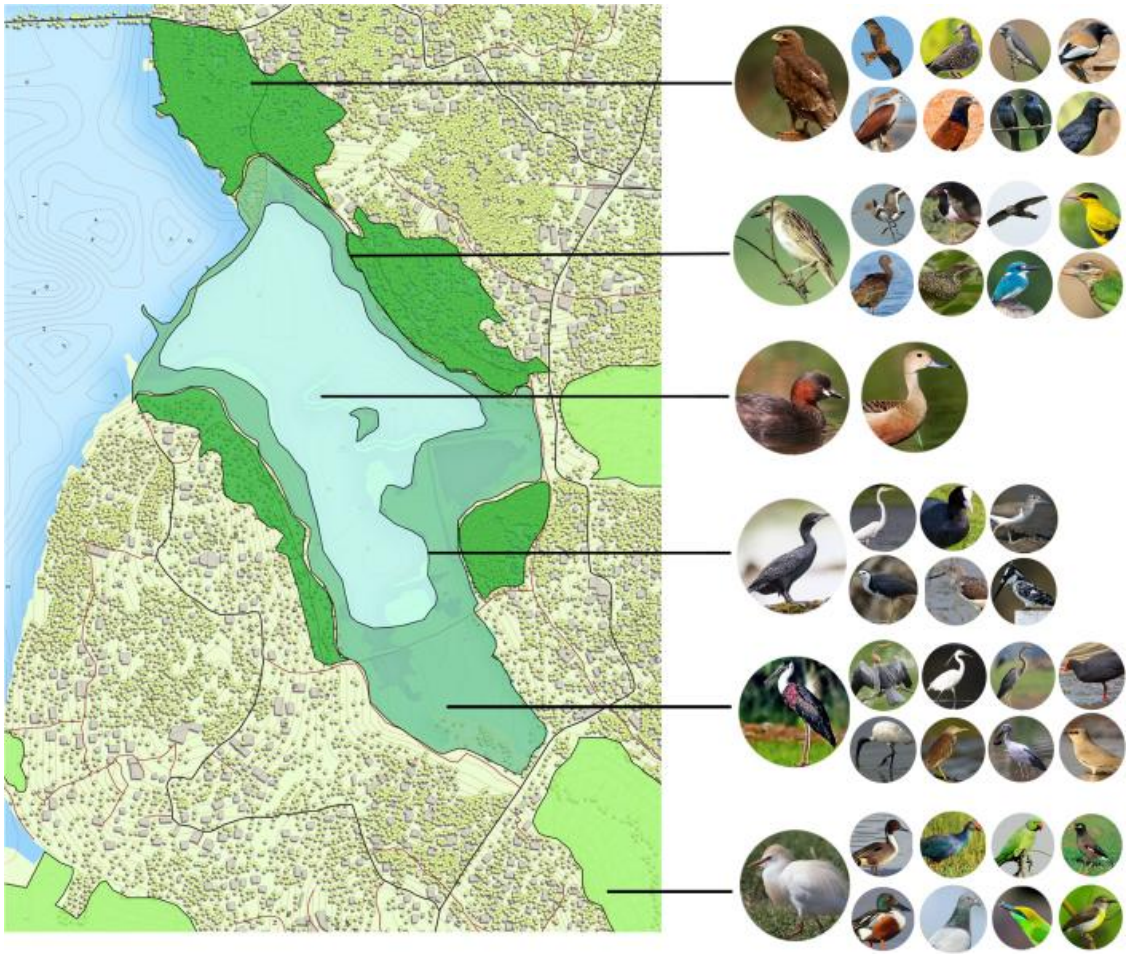


Figure 32 habitat distribution of birds according to the vegetation

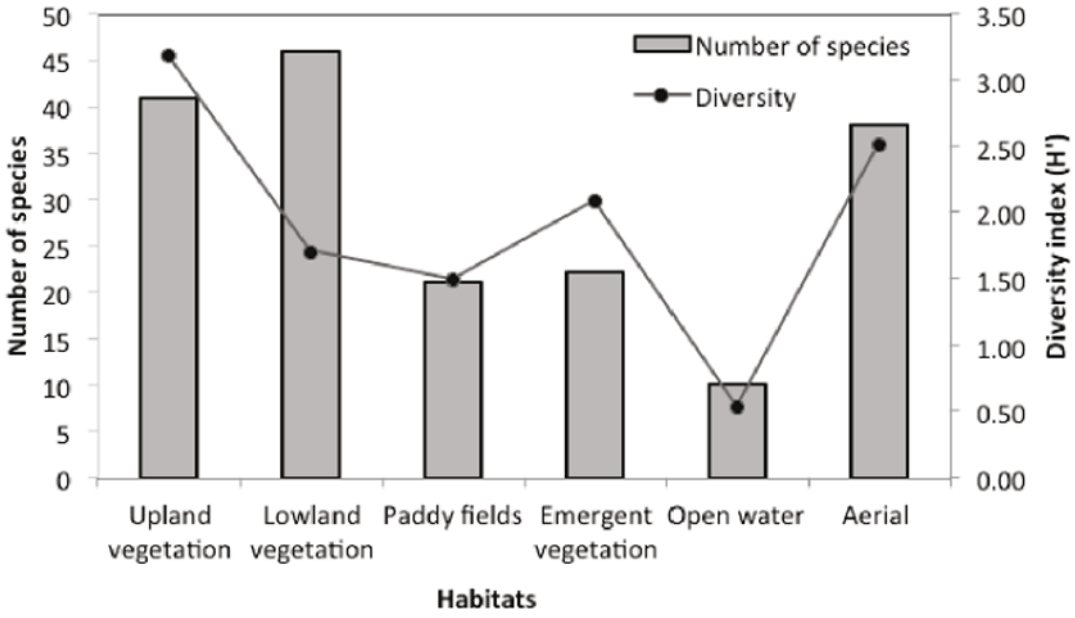
Diversity and number of species is higher in Low land Vegetation followed by Upland Vegetation, then Aerial. The number of species is low in Emergent Vegetation and Open Water is the lowest in species richness. Lowland Vegetation acts as a transitional zone or ecotone between terrestrial and aquatic habitats, thus, can harbor species that occur in both vegetation types.

Purple Moorhen is the most abundant species in Lowland Vegetation. In Paddy Fields flooded with water, dabbling ducks such as Northern Pintail are found abundantly. Species in Emergent vegetation are similar in composition with Lowland Vegetation. The Large Egret is the highest in abundance. Among aerial foragers the Whiskered Tern was the most abundant.

Species overlap is more between Emergent Vegetation and Lowland Vegetation, indicating that bird species composition is similar in both vegetation types. Species overlap among emergent Vegetation, Lowland Vegetation and Paddy fields is due to the persistence of the moist soil which dominates all the three

vegetations. The level of similarities and dissimilarities in the plant communities present in the vegetation types may influence the spatial segregation of bird species and determine the species composition in a wetland ecosystem.

Munderikkadavu Wetland area contains IUCN categorized birds such as “Near Threatened” Oriental Darter, Oriental White Ibis, “Vulnerable” Greater Spotted Eagle and supporting 15 migratory species with large flocks of waterfowl, the area is a priority site for conservation.



Graph 2 Species richness and diversity index

3.15 Issues faced

The Munderikkadavu wetland ecosystem is facing degradation due to human interventions. The wetland was formed as a fresh water wetland but due to the failure of Kattampally irrigation project then it became a saline wetland, which attracted the migratory birds to the spot. In a way it has helped to enrich the biodiversity.

Even though the Munderikkadavu Wetland is a Government protected area, it is facing a lot of threats due to human interventions, such as:

3.15.1 Weed Infestation

Acrostichum aurem, is a wetland invasive tropical wetland species which has substituted the mangroves from the site. The weed has to be removed by hand. The mangrove has to be cultivated and supported so that the weed infestation will not happen again.

3.15.2 Tree felling

The local people are cutting the trees for fuel and construction purposes illegally.

3.15.3 Extinction of Munda

Munda (Pandanus sp.), the major plant prevailed in the region from which the name of the place was evolved is at the edge of extinction from the site. The whole plant is edible and been used as an ingredient for the biriyani. The plant was also used for handicraft making. It also helped to filter the water flowing from the nearby paddy fields to the site.

3.15.4 Decline in biodiversity

As a result of the human intervention in the site, the biodiversity also has changed. The Baya weavers which used to visit the site during the cultivation time, are not found near the area. The number of birds visiting the site is getting reduced gradually. The local people has cleared the natural vegetation and started commercial crops like banana.

3.15.5 Extinction of Kaippadu Krishi

As the salt water intrusion was checked by Kattampally project, the acidic soil became more hard and difficult to plough for the cultivation. Thus the people engaged in the paddy cultivation gradually shifted from it to other commercial crops like banana, coconut, etc.

3.15.6 Shrinkage of wetland

3.15.7 Dumping of wastes

The people visiting the site puts the plastic covers and bottles in the wetland area. Also the butcher shops nearby dumps their waste in the area.

3.15.8 Washing of vehicles

The local people wash their vehicles in the wetland causing oil spill in the water and pollution.

3.15.9 Deterioration of water quality

3.15.10 Lack of management

The protected area lacks a proper management as it is seen at the constructed gate, which is in a ruining condition.

CHAPTER 4. PROPOSAL

4.1 Approach

Like all other cultural ecosystems Munderikkadavu wetland ecosystem also has evolved through the human interventions, some of them affected it adversely and some has enhanced the ecosystem. The people residing around have depended on this water body for daily living as fishing, boating, etc. as the place name itself shows that boating was one of the major activity happened in this area. Kadavu in Malayalam means boat jetty.

The state government has declared the area as a proposed bird sanctuary. The sanctuary should be designed in considering the human inhabitants also as the part of the ecosystem, and supporting their day today activities depended on the wetland, which doesn't harm the ecosystem adversely.

Have to formulate strict rules and implement it as the activities like pollution, encroachment, etc. will be prevented. The common people should be made aware of the importance of the wetland ecosystem, how to be a part of its conservation and enhancement.

After declaring as the bird sanctuary, the govt. has constructed a concrete gate (Figure 3) for the project which is not an environmental friendly approach. Along with this the bird sanctuary could generate income also as a part of the Kannur tourism project which is designed totally eco-friendly way.

4.2 C.L.D.P.

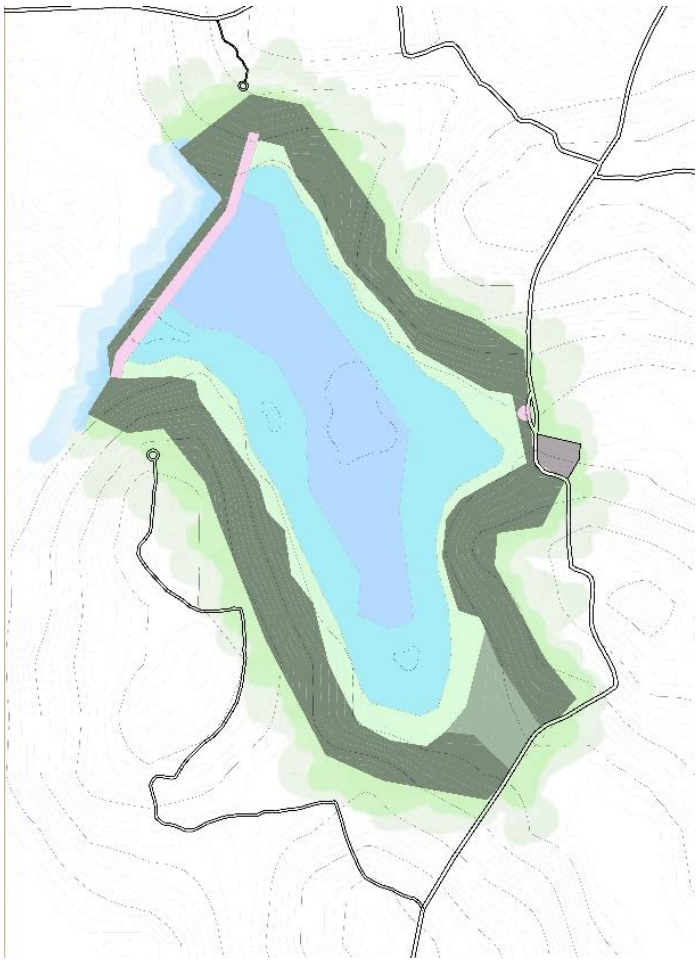


Figure 33 C.L.D.P.

The Composite Landscape Development Plan is done based on the site analysis inferences and inferences from the literature study and information from other sources like interviews and surveys. 124 acres of land has been delineated for intervention, considering a buffer of 75m, stated by National Green Tribunal. The buffer zone has been left as an eco-sensitive area. A second layer of constructed wetlands were created to check the water inflow and purify it, these wetlands acts as sediment tanks also. The area between the constructed wetlands and buffer is used for the growth of wetland species. South east corner is left for the local people to rear their cattle. The character of the prime wetland changes as per the seasons. The existing mud bund is kept as the active zone in the design.

4.3 Design

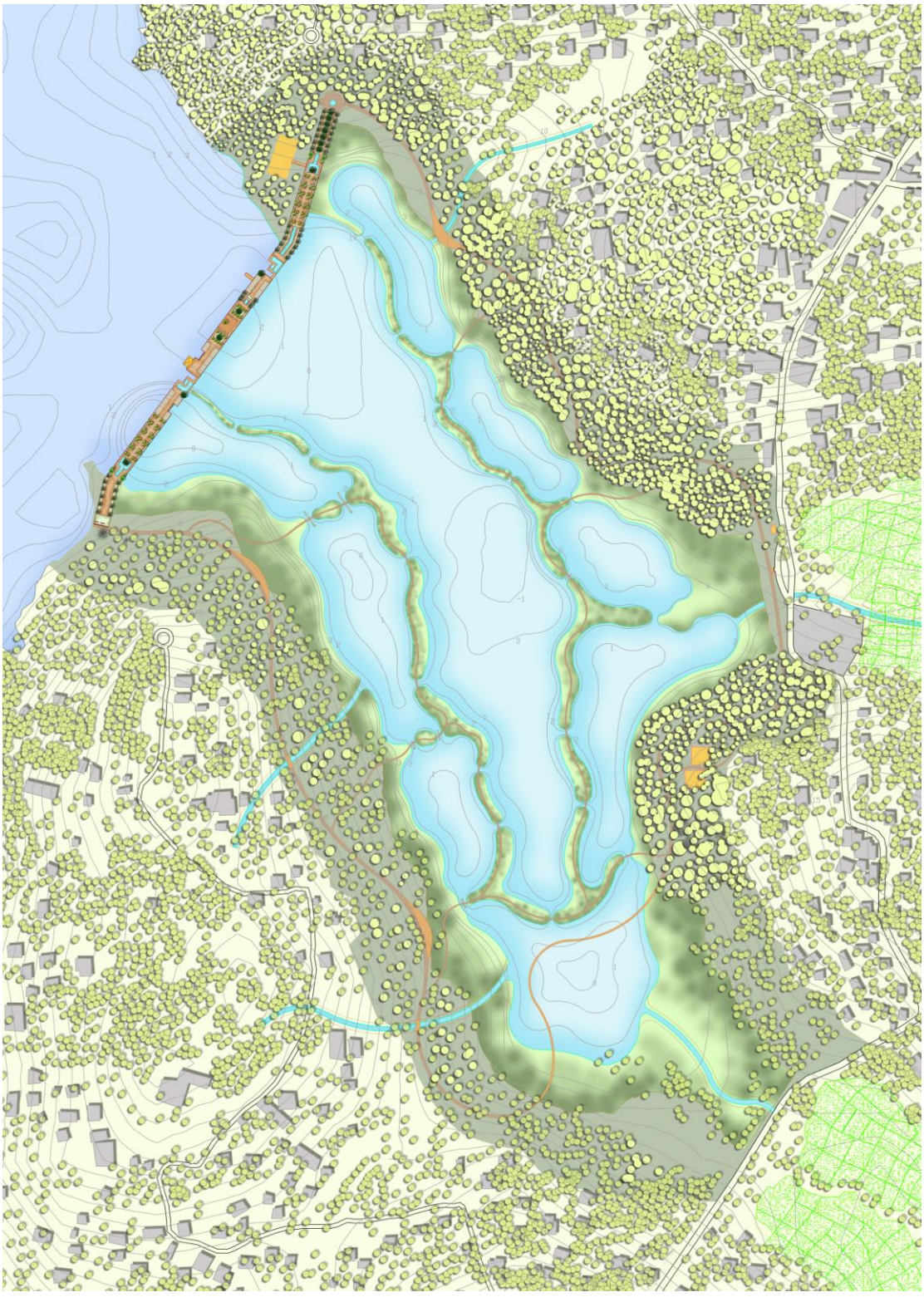


Figure 34 Design Proposal

The design was developed for the restoration of wetland ecosystem keeping proposal for bird sanctuary at the site as a legal support. The 124 acres for intervention is been delineated from the whole area. The programs were planned as an entrance plaza that has a small ticket counter and a small shop to merchandise the handicraft products from the workshops. The entrance has been restricted at one point, that's near to the highway is to avoid the motor vehicles into the buffer area as per the existing design proposal. The entrance avenue with coconut palms on either sides, on its north end as well as south end is leading to the thickly vegetated buffer zone, which is an eco-sensitive zone as per the design proposal. There are two small workshops of 20 x 20 m in the thickly vegetated buffer on south of the entrance.

On the edges of the prime wetland, constructed wetlands were provided. These constructed wetlands act as a sedimentation tank, a purification filter with its plants. Wetlands 4 & 5 are allotted to cultivate pandanus. A board walk is passing through the pandanus field, connecting either sides of the wetland.

And it leads to the thickly vegetated buffer zone on the south of the wetland. The pathway and trails are running through this zone letting the visitors to have a feel of nature and an experience of bird watching for the birds prevailing in upland vegetation. Where the pathway came near to the edges, projected wooden decks are given to enjoy the beauty of wetland as well as watching the birds in open water, emergent vegetation and lowland vegetation.

The mud bund has been redesigned to a linear plaza (Promenade) and all the activities are concentrated on it like, small temporary shops, a boat club with traditional Kerala boat jetty, a small amphi, and sewer gates to control the water flow between the Munderi River and wetland. An interpretation center is given near the plaza.

4.4 Policies

i) No encroachment should be entertained in the buffer area of wetland.

ii) Strict rules has to be implemented against the dumping of waste in the wetland area.

iii) The speed limit has to be restricted in a way that the vibration and noise from the vehicles don't affect the bird life of the area.

iv) Time regulations has to be followed for the functioning of Kattampally dam.

v) The government and non-government bodies should involve in taking care of the ecosystem.

vi) The authority has to make sure that the quality of water and soil is been checked in an equal interval and take necessary actions.

CHAPTER 5. CONCLUSION

The onsite analyses with other sources like, surveys, interviews, literature studies referred to the issues facing by a wetland ecosystem, and how to mitigate them. The studies explains that the restoration of a wetland ecosystem can be achieved by restoring the abiotic conditions that supports and emphasize the biotic succession. Along with these the practices prevailed in the area also has to be restored in order to support ecological restoration.

The infested weed has to be removed by hand, and the native mangrove species has to be reintroduced. The constructed wetlands can be used to cultivate mangroves. And two of the constructed wetlands which receives water from the nearby paddy fields can be used to cultivate pandanus sp. which will help in water purification. The entrance has restricted to one point to avoid unwanted motor vehicles in the eco-sensitive zone. A small work shop has been provided to enhance the handicrafts from pandanus. All other activities are restricted to mud bund redesigned into a linear plaza. Making it a bird sanctuary will add an economic value through eco-tourism. And small area has been left for the local people to rear their cattle, so that they will get benefited from the project. Other regional level impacts are dealt by making new policies and implementing strict rules and regulations. This will enhance the biological succession of the ecosystem and the lost ecosystem balance will be restored over a time.

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