

**RIPARIAN VEGETATION ALONG THE MIDDLE AND
LOWER ZONES OF THE
CHALAKKUDY RIVER, Kerala, India**
(Survey, mapping, community studies and identification of the residual pockets for
conservation.)

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Glossary

Anthropogenic: Caused by human actions directly or indirectly

Arborescent: Resembling a tree in its habitat and nature.

Biogeography: The branch of biology dealing with the geographical distribution of living things.

Ecotone : A narrow and clearly defined transitional zone between two communities or habitats or ecosystems.

Edaphic: Pertaining to the physical environmental condition.

Endemic: Particular to or restricted in distribution to an area or locality.

Eutrophication: Process of nutrient enrichment of a body of water. In advanced state causes severe doxygenation of water body.

Flood plain: Area of valley floor inundated during a flood.

Geomorphology: The origin, development and characteristics of the surface features of the earth.

Ground water: Surface water contained in saturated soils and rocks.

Halophyte : Plant which can tolerate salinity

Liana : A woody climbing plant

Lift irrigation: Usually refers to irrigation using ground water but can include irrigation using water pumped from canals and reservoirs.

Lotic: Referring to running water

Phanerophytes : A life form category of a plant in which the perinnating bud or shoot are born on aerial shoot.

Riparian: Of or relating to or located on the bank of a river. (Stream side)

Riverine ecosystem: Zone of biological and environmental influence of a river and its flood plain.

Salinization: The accumulation of salt in soil or water to a harmful level.

Sediment: Mineral and organic matter transported or deposited by water or air.

Sere : A characteristic stage in a primary or secondary succession

Sluice: Structure with a gate for stopping or regulating flow of water.

Small dam: Defined by ICOLD as dam measuring less than 15 meters from foundation to crest.

Water table: Surface of ground water.

Wet land: Area of land, which is seasonally, intermittently or permanently waterlogged.

1.1. Introduction

The total environmental conditions, availability of basic resources or even cultural diversity and identity of the people are very much related to the physical geography of an area. This fact becomes very crucial in a monsoonal subtropical subcontinent like ours. The Himalayas in the North plays an important role in the overall identity of the subcontinent. Likewise the Western Ghats that starts from Tapti River in the North and ends in the Kanyakumari district of Tamil Nadu in the south (with an average height of 1500m) has a crucial position for the southern region especially for Kerala, because the State is entirely bounded by the Western Ghats on the eastern side. The High Ranges in the southern side up to the Nelliampathies, The Palaghat gap and the continuing Ghats to the north, the western slopes and the foothills, diverse vegetation with evergreen and deciduous forests, grass lands, sholas, bamboo and reed brakes, the riparian habitats, and the 44 rivers with rapids and pools creates a very diverse environment. Along with this, the flood plains, lakes, sacred groves, mangroves, ponds, and the western coast altogether makes this small piece of the subcontinent very rich.

Water is the essential and basic resource of life on earth. The physical features of earth determine the direction of flow of water. In such a geographical unit where water gets regularly and seasonally, weathering of rocks, soil condition and other climatic factors along with availability of water support the growth and development of plant communities. These ecosystems in turn control the temperature, intensity and seasonality of rain, which altogether keep the perenniality of the streams. These forests and rivers provide the basic environmental conditions for the animal and human populations.

The Western Ghats is considered as one of the biodiversity hotspots of the world and the evergreen forest is considered as the climatic climax system. The large canopy of the trees of different layers, which is the

dominant and characteristic community and its multi layered structure, diverse animal and plant species utilize each and every quantum of energy and every drop of water. The deep roots of the trees allow the percolation of the water to recharge the ground water system. The living organisms on earth are in a dynamic process of interactions and interrelationship between each other and the non-living components in the environment. This lead to more efficient, complex and diverse natural systems capable of maintaining the ecological balance of the land and also the livable conditions necessary for the survival and continued evolution of all living beings in the world.

Human civilizations have flourished in the lap of forests and rivers. A large variety of indigenous tribal communities have been living in our forest lands for thousands of years. Their cultural diversity, identity, mode of living, different skills and cultural practices were evolved and sustained by the support of these natural resources. They were living successfully as a part of natural systems and their faith in nature has evolved from the experiences of generations. The survival of these tribal communities is dependent on the stability or balance of natural systems. Hence any sort of activity that leads to the degradation of these ecosystems directly and adversely affects these human communities. Their degradation is an indicator of the impoverished unhealthy condition of our natural resources. Apart from the survival of indigenous human communities, the whole diversity of animal and plant life is also threatened by ecodegradation. Their conditions in an area can also be considered as a measure of the health and dynamics of the natural system.

The change in the vision of the modern human civilization in utilizing their natural resources triggered the degradation of the environment. Human inability to understand the over all complexity and role of these natural systems like forest paved the way for the collapse of our own system. Ecosystem degradation is the major problem created by the modern human 'developmental' culture. Changes in the ideology of utilization of natural resources like water, forest and the changes in the landuse pattern have initiated the degradation. The over exploitation and deforestation in an unbalanced manner has started from the colonial period. Our forest resources were used by the west directly or indirectly for their development and industrialization. The two World Wars and the subsequent shortage of food and basic commodities accelerated the process. Extensive areas of forests

were cleared for raising plantations of tea, coffee and other soft woods like Eucalyptus, Cheeni etc. These are mainly for industrial purposes. The most vulnerable areas of the Western Ghats and other mountains were selected for massive tree felling and raising of plantations. Large-scale consumption of bamboo, reeds etc for paper and pulp industry has deforested extensive areas of forest within a short period. Construction of large and small dams and reservoirs for irrigation and electricity generation has destroyed extensive area of forest and riparian habitats in the catchments of major rivers of Kerala. The human encroachment of the forestlands, occurrence of fire and the conversion of forest areas into monoculture plantations have accelerated this process of destruction.

All these human activities along with the global environmental changes have either destroyed the structure and stability of different forest ecosystems or fragmented the remaining areas in to small patches. Now the rate of these activities has reduced but the occurrence of fire in every year, grazing and small extent of encroachment and reclamation is continuing the activity of ecodegradation. Because the remaining forest areas are very small the impact of these activities become more critical. Catchments and riparian areas of almost all rivers have been destroyed and the perenniality has been lost. Each and every first and second order streams has vanished and the rest have become seasonal. This change in the hydrology of rivers has affected human life and all our activities. Drinking water scarcity, ground water depletion, salinity intrusion, land slides, soil erosion, erosion of river banks, and lack of basic life support resources have all become common problems in Kerala.

People are now become more aware of the environmental disbalances and all 'developmental' thinkers are thinking about 'sustainable development'. They have realized the importance of natural systems within a geographical province. Hence we are planning for the restoration of forest catchments of rivers through watershed management. But till today the real steps needed for the correction of our mistakes are far from becoming reality in the field.

Restoration of our forests, rivers and conservation of our biodiversity need in depth of knowledge and inputs. It needs a lot of investigations of the existing natural systems especially the catchment and riparian areas. Such

collective efforts and compilation of information, study of the remaining natural habitats and their dynamics are needed for an effective watershed treatment and the restoration process. The riparian habitat is highly dynamic being at the meeting zone or ecotone of the flowing river and the riverside land subjected to anthropogenic influences. It can be considered as the stretch of common land which any human community could depend upon for a wide variety of uses including the protection of the riverbank from erosion. But this invaluable natural system is being senselessly destroyed everywhere in Kerala leading to serious ecological problems. In such a background a study about the riparian habitat of a river of Kerala has special importance.

1.2. Riparian Vegetation

The word “Riparian” itself means along the river margin. Plant communities seen along the river margins are commonly referred to as the riparian vegetation. From the beginning to the end of a river, the riparian zone is highly influenced by the quantum and flow of water in the river channel. Usually altitude, total rainfall, duration of rainy season, wind, and temperature along with soil characteristics influenced by climatic factors determine the nature of plant communities (Nair, 1994). In all the cases water availability, humidity becomes a critical factor. Because of this reason the riparian zone is a unique system. Being a transitional zone between the aquatic and terrestrial habitats they have their own unique characteristics like hydric soil, floral and faunal composition, community structure, relationships. The riparian wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstance do support a prevalence of vegetation typically adapted for life in saturated soil conditions (James *et al* 1992). Variations in the environmental conditions provide a diversity of inhabitants, for both aquatic and terrestrial animal community (Pratt 1995).

Due to this availability of watered condition, humidity, and open areas provided by the river, vegetation present in this area will have some unique characteristics. The availability of water, seasonal flooding and sedimentation influences the vegetation and also its development. The plant communities provide shade, which will cool the water, slow the flow, control flooding, and provide microhabitats for a lot of aquatic organisms. This

dynamic but stable environment also provides a unique ecosystem essential for the normal health of the river system.

The unit characteristics of riparian system result from the spatial allocation and configuration. The plant communities in these systems are likely to be affected by both longitudinal (i.e. upstream-downstream) (Vannote *et al* 1980) and transversal (i.e. stream-floodplain or floodplain-basin) (Newbold *et al* 1981) linkages for species recruitment and species diversity (Tabacchi 1996).

Riparian zones have been reported as some of the most species rich and most productive systems and they are also some of the most sensitive to human influence and potentially threatened ecosystems (Malanson 1993).

Plant communities in a riparian zone may include some common elements or may be true riparian plant which can only be seen within this environment, many processes of their lifecycle are supported by this riparian environment for example they need more water, for their growth and seed dispersal, etc. or may need a seasonal availability of water. These plants, their establishment and development depend on the riparian environment. The riparian canopy regulates stream temperature through shadowing and provides organic matter via litter fall, while their root systems stabilize the bank and filter lateral sediment and nutrient inputs, thereby controlling stream sediment and nutrient dynamics: (Naiman and Decamps 1997, Melfield and Naiman 2001). The surfaces of submerged leaves are sites of primary and secondary production by micro algae and bacteria, which can rival that of phytoplankton and bacteriophiles in water column. The community serve as food for grazing invertebrates and protozoa, it contributes to bio-purification of organically polluted watercourses, and can be a substantial source of planktonic microorganism (Goulber and Baker 1991). In the lower reaches the riparian forests act as a buffer between the upland and the river. Rainfall on the watershed is efficiently absorbed by the litter covered forest floor. Evaporation rates are high so that runoff through the forest is generally kept at minimum. Runoff from adjacent uplands flowing across the riparian forest is purified by removal of inorganic nutrients, eroded sediments, and other materials such as agricultural pesticides (James *et al* 1991).

Usually rivers and streams have a one-way downhill flow, and in these lotic environments flow rate is of prime importance in determining the nature of plant and animal community (Osborne 2000). Tropical rivers have a significant interaction with the lining or the riparian zone of the main river channel. Hence the biological species and their diversity will be very unique in these fluctuating environments especially in the floodplains. The floodplains have a significant functional role in the nutrient balance and energy flow within the river system and the relationship between the floodplain and terrestrial system that lines it is both intimate and complex. Rivers differ from other systems mainly in its longitudinal diversity.

From the beginning of a river in the mountains up to the river mouth a continuous change can be observed in the floral and faunal composition with the changing environmental parameters like altitude, humidity, soil conditions and also in the conditions of water like quantum and flow, temperature, pH, salinity. In a tropical country like ours the riparian vegetation in a first order stream in the mountain may be ferns and other associated herbaceous plants in the rock crevices. When coming down, the quantum and the lateral influence of the water increases. So we can observe evergreen forest samples in the riparian zone. Further going down the bed conditions of the river changes from rocky to sandy especially in the floodplains. Here the soil becomes looser, sedimentation rate will be high, and a good amount of alluvium can be found. In these areas the water influence on the vegetation may be more. Herbaceous, grass and hydrophytic plant communities will be abundant in these zones. Coming to the river mouth, the situation changes and the increase in the salinity can be observed by the presence of some halophytic plants in the river margins. The riparian zone is an ecotone, a junction of the aquatic and terrestrial habitat and longitudinal continuity also exist. Hence the riparian zone is a habitat of number of organisms including human populations.

In the context of Kerala ($8^{\circ} 18^1$ to $12^{\circ} 48^1$ North latitude and $74^{\circ} 52^1$ to $77^{\circ} 22^1$ East longitude) having 44 rivers (41 West flowing and 3 East flowing with an average length of 100 km) the riparian zone is a very important habitat. Due to massive destruction of catchments all rivers are striving for their healthy survival. Encroachment and destruction of the riparian habitat is very severe. These river courses are the basis of water

resource of the State. All people directly or indirectly depend on these rivers for their basic needs. Besides these the riparian habitat provides shelter for all wild animals including Elephant, Gaur, Deer, Monkeys in the forest areas and this abundance also attracts predator populations like Leopard and Tiger etc. the availability of reeds and bamboos and other varying micro and macro habitats characterised by different vegetation types support these organisms. Otters and Civets are inhabitants of the riparian forests up to the lower areas. The open spaces above the streams and the riparian vegetation attract a diverse butterfly and bird population because this provides a longitudinal continuity of the water and the vegetation.

Besides these, the riparian forest keeps the continuity of the fragmented forestlands; this acts as a corridor for the migration and movement of animal populations especially for the arboreal species and larger mammals like Elephants. Because of the longitudinal continuity of the streams and the riparian zone the animal and plant population are distributed up and down streams. The river is a continuous entity, which makes many small falls and rapids, and influences the land and biota. These variations in an altitudinal gradient provide different kinds of terrestrial and aquatic microhabitats. So the rivers support a great amount of fish and other aquatic life.

Not only the tribals and the wildlife but also every human being all around the world depend rivers for their survival. In the case of Kerala every water requirement of the people including drinking, domestic, agriculture, industrial are dependant on these rivers. The rivers and the forests maintain the ground water level. Most of the agricultural practices were in the flood plains and riparian zones. Lakhs of people were depending on these forests and rivers for their livelihood, which includes a small tribal community, fishermen communities, the village people and also the people in the cities.

We do not have a good record while dealing with our natural resources. The massive exploitation of the evergreen forests for timber, raising plantations for industrial and agricultural purposes, construction of big dams and reservoirs have all destroyed almost 70% of our natural wealth and the remaining areas became fragmented into islets. They have lost their continuity. All sorts of development activities have destroyed the catchment

forests and hence the rivers. They have lost their continuity (while damming), flow, purity and perenniality. The lower reaches became dead channels filled with chemicals and sewages. The removal of vegetation cover also resulted in the deterioration of the soil wealth and erosion and sedimentation of the topsoil became a common phenomenon. The monoculture plantations in the mountains increased the pace of the process. Removal of the vegetation cover from the riparian zones and increased sand mining has destroyed the stability of the riverbanks. This has resulted in the erosion of the banks and indirectly affects the fish and other populations. Now our state having 44 rivers and 3000mm average rainfall faces serious drinking water scarcity.

2.1. Chalakkudy River and the Basin

Chalakkudy River is the fifth longest river in Kerala ($10^{\circ} 05'$ to $10^{\circ} 35'$ North latitude and $76^{\circ} 15'$ to $76^{\circ} 55'$ East longitude) having a length of 145 km. The total drainage area is 1704 sq km out of which 1404 sq km is in Kerala and the rest 300 sq km in Coimbatore district of Tamil Nadu. It originates from the Anamalais and Nelliampathy ranges of the Western Ghats. In Kerala it flows westward through the Palakkad, Thrissur and Ernakulam districts. A major portion lies in the Thrissur district. When coming to the plains it joins with the northern distributary of Periyar at a place called Elanthikkara just 9 km before they together end in the Lakshadweep sea at Kodungallur estuary.

2.1.1. Physiography

The Chalakkudy river basin contains about 57 sub watersheds and 140 micro watersheds. These sub watersheds are mainly in the catchments and hence the basin becomes narrower towards the west. The river is formed by the confluence of four major tributaries, Sholayar, Parambikulam Ar, Kuriarkutty Ar and Karappara River.

The Sholayar River originates from the Anamalais of the Coimbatore district of Tamil Nadu. This 44 km long tributary joins with the Parambikulam river just upstream at Orukombankutty (455m above MSL) in Kerala, (which originate also from the Coimbatore district of Tamil Nadu and enters into Kerala just north and parallel to the Sholayar river.). The third tributary, the Kuriarkutty River originates from the Anamala ranges of the Kerala region and joins with Parambikulam River at Kuriarkutty (536 m). And the Karappara River originates from the southwestern slopes of Nelliampathy ranges, which lies in the southern boundary of the Palakkad Gap. It joins the main river at Orukombankutty (455m above MSL). These ranges of Western Ghats from where the tributaries originate have more than 1500m altitude above MSL and are perhaps biologically one of the richest areas of the Southern Western Ghats. After the confluence of these main tributaries, the river flows as a single channel and is called the Chalakkudy River. A few smaller streams also join to the main river namely the Anakkayam Thodu, Charpa Thodu, Kannankuzhy thodu, Pillappara thodu and the Arurmuzhy Thodu.

During its journey from the hill ranges to the plains within a short distance, Chalakkudy River unlike other rivers of Kerala is having gentle slope with rocky riverbed. So it makes a number of rapids and falls and the most beautiful and well known falls like the Athirappilly and Vazhachal falls are just 35 km upstream from the Chalakkudy town.

2.1.3. Climate

This river occupies a central position among the rivers of Kerala. Kerala is a monsoonal area. This area experiences a northeast monsoon from November to March (Thulavarsham) and the strong and steady southwest monsoon from June to September (Edavapathi). And have an inter-monsoon April-May and also a second inter-monsoon in October –November. This area of Chalakudy River basin experience more than 3000mm rainfall And the forest areas especially Sholayar region.

The steady and seasonal availability of the two monsoons is a critical factor for the water availability of Kerala. Now the duration of rainy days has reduced and intensity of rain has increased.

2.1.4. Biodiversity Potential and Ecological Importance

About one third length of the river is flowing through natural forestlands and this feature is very important. The Chalakkudy river basin occupies a major portion of the vegetation cover of important wildlife habitats of the southern Western Ghats. The Peechi-Vazhani Wildlife Sanctuary in the north, The Indira Gandhi Wildlife Sanctuary of Tamil Nadu in the east are connected with the forests in the basin. The Parambikulam Wildlife Sanctuary which lies within the basin is the proposed second “ Tiger Reserve” in the State. The Sholayar ranges have some of the remaining evergreen forests of Kerala. The northern region of the basin occupies the famous Nelliampathy hills. This continuity of the forests is maintained towards westward by the Vazhachal and Chalakkudy forests. This tract is having good amount of riparian forests and is ecologically very important.

These areas contain sizeable stretch of Evergreen and Semi-Evergreen forests, the bamboo and reed brakes, deciduous forests predominated by teak, the riparian forests and the plantations. Hence this area supports a major portion of the wildlife and act as a corridor for many animals especially for elephants through maintaining continuity of our fragmented forest habitats.

Forest divisions of the Chalakudy basin.

Forest Divisions

Forest Ranges within the Divisions

Parambikulam Wildlife Division

Vazhachal Division

Chalakudy Division

Nemmara Division

These areas protect many of the endangered and related wildlife like Lion Tailed Macaque, Nilgiri Langur, The Asiatic Elephant, Gaur, Tiger, Leopard and Great Indian Hornbill. And this vegetation cover accounts for the fish diversity in the river. The Chalakkudy River is considered as richest in fish diversity in India (NBFGR, 2000).

2.1.5. Human Interventions

The Chalakkudy River occupies an unique position in the rivers of Kerala. Its wild nature, rapids and falls, importance in the history, wealth of its forests, its water and fish add to this. More than 5 lakhs people in 18 Panchayaths and one Municipality are living in the basin and are dependant on this river now. From the ancient times till today we are exploiting this river and our each and every interventions added to her deterioration. Kadars, Muduvass and Malayas are the three tribal groups found in this basin. Of which the Kadas are a primitive group and are endemic to this basin.

Along with the river and its forests the Kadar people also faced many difficulties. The severe destruction of the richest forests was recorded in 1830's. At that time the Nelliampathy hills and the Valparai areas were clear felled for raising plantations of coffee and tea. These forest catchments even today are plantations with dead streams, and the soil and water became highly polluted with pesticides. After the construction of the Parambikulam Tramway by the British (1901-63) for extraction of timber accelerated the process. The construction of the Anamala road (started in 1942) from Chalakkudy to Valparai has opened the remaining forest areas and accelerated the process of deforestation. This has affected the riparian forests.

Our attitude in the forest policies which paved the way of deterioration of forests, rivers and finally to ourselves through, clearing, clear felling, selection felling, raising of plantations, industrial exploitation, construction of reservoirs etc destroyed more than 70% of the forest wealth. After the construction of Poringalkuthu Dam in 1957 another 5 large dams, The Parambikulam group dams (Thunakadavu, Peruvarepallam and Parambikulam, 1958), The Upper Sholayar in Tamil Nadu (1966), The Kerala Sholayar (1966) and the Chalakkudy River Diversion Scheme meant for the irrigation of 14000 hectares of land were constructed. These constructions have blocked the river in 7 places, and thus the river has lost its continuity. Along with these, treaties like Parambikulam Aliyar treaty for diversion of the waters from the Parambikulam group dams, Sholayar dams and also from dams like Neerur of the periyar river to Tamil Nadu in the east, and

the diversion of water from the Poringalkuthu to the Idamalayar in the Periyar basin to check the salinity intrusion in the industrial areas of Periyar has serious impact on the Chalakkudy River. The diversion of water for Irrigation by the Chalakkudy River Diversion scheme has seriously affected the hydrology of the river.

The change in the landuse of the catchments, clearing of remaining forest areas in the riparian zones for rising plantations of rubber and oil palm by Plantation Corporation of Kerala in the Athirappilly area has added to the degradatory process. Along with these activities the tribals had been displaced from one place to another, they have been transferred from their natural living conditions, most of them became labourers and now they were struggling for their existence. The natural habitats have become fragmented, remaining areas getting depleted with time. Intrusion of unnatural elements in the river and forests, occurrence of fire and overgrazing, aquaculture in land and water, tourism based cultural and physical pollution of river, land and people altogether made conditions worse. But still we can see some beautiful riparian forests, the mountains, water falls, singing birds, presence of animals, fishing by tribals and the flowing water. From the Orukumbankutty to Athirappilly we can see a continuous stretch of riparian evergreen forests, and number of islets with emergent trees and wildlife. This part of the river recorded the maximum number of fish, bird and other animal species. These altogether gives an illusion or a pseudo image of a real river that perhaps symbolically represent the natural conditions of our rivers in the past.

2.1.6 Study Area

For this study entitled 'Riparian Vegetation along the Chalakkudy River' the area selected is the section after Poringalkuthu Dam (400m above MSL) to Elanthikkara (Sea level) where the river joins with the Periyar River. In this area the Chalakkudy River is flowing as a single channel and do not have any major tributaries and obstructions. The Chalakkudy River Diversion Scheme in the Thumboormuzhi for the irrigation of 14000 ha of land and a sluice in the Kanakankadavu to check the salinity intrusion just before the river mouth are the major obstructions. The area from Poringalkuthu to the Thumboormuzhi (50m above MSL) has relics of riparian vegetation, unique among the rivers of Kerala. Besides these, the river has great fish diversity. More than 5 lakhs of people depend on this river. There are relics of riparian vegetation and habitats rich in wildlife. Advice of experts and ongoing studies about the basin and interest in the area, is the basis for choosing this area of the river for investigation. In this study we are considering samples from the upper, middle and lower portions of the river.

The study area covers all riparian local bodies, and the forest areas, under Vazhachal and Chalakkudy forest divisions of Thrissur Circle. The beginning of the study site is just after the Poringalkuthu dam, (the dam is meant mainly for power generation and part of the water is diverted to Periyar basin through a canal). After this area there are no major tributaries, only some streams like Kannankuzhy thodu can be considered as perennial and it becomes almost stagnant in summer. All other streams on either side are either dead or seasonal. Hence the water availability and flow in the river is highly controlled and not natural. The area between the powerhouse and the dam is completely dry because water is released only after power generation.

Almost upto Pariyaram the riverbed is rocky and the remaining part is sandy. Sandmining and allied activities are severe in this river. Industries are very rare except one paper mill (Sreesakthi Paper Mill) and a K.P.C.L Ossein factory after Chalakkudy. The area represents one of the important tourist spot in Kerala the Athirappilly waterfalls, which have been visited by lakhs of people every year.

The Athirappilly-Vazhachal forest is one of the biodiversity rich areas in Kerala. The area have lot of animal, bird, and plant populations. Two tribal settlements of Kadas are also present in the study area.

2.2. Main Objectives

1. Preparation of Map showing the present status of the riparian vegetation, major human interventions and species distribution of some riparian plants along the river.
2. Plant community analysis for the species composition, structure, distribution and dynamics of the riparian vegetation in an altitudinal gradient along the river.
3. Interactions with fishermen and tribal communities to bring out the importance and extent of human dependence to the riparian vegetation.
4. Try to document major human interventions in the riparian zone.
5. From these analyses brings out the significance and status of the remaining riparian vegetation and identify residual pockets for conservation through local level initiatives.

2.3. Materials and Methods

This project can be considered as a multidisciplinary project because it includes scientific assessment and mapping of the vegetation and evaluation of the perceptions of people. So it needs a lot of methods from scientific as well as from social framework. Based on these main objectives, the methodology adopted for the study is follows.

2.3.1. Collection and identification of plant components

Plant components were identified during the field visit. Photographic documentation was also done. For the fieldwork we have got the assistance from the local people especially by the Kadar tribals in the forest areas. After collection the plants were identified by the use of different floras like Flora of Presidency of Madras by J.S. Gamble (1935), Flowering plants of Thrissur Forest, Sasidharan (1996), Identification manual of forest trees by Pascal (1987), and different taxonomic publications. Experts from different backgrounds were also consulted.

2.3.2. Phytosociological analysis

For the analysis, quadrat method was employed. 10m wide and 10m long quadrats were laid on the riparian areas along an altitudinal gradient. Minimum size of the quadrat was determined by species area curve method. In the forest areas the dominant communities i.e the trees and shrubs were given importance. Hence the 10x10 m quadrats were found to be most suitable. The plant components were identified, counted and measured. Girths of all the living trees and lianas $\geq 20\text{cm}$ were measured 1.3 m (Breast height) from the ground. For multi-stemmed trees girths were measured separately and the sum calculated. For buttressed trees the measurement was taken above the buttresses. The Phytosociological characters like Frequency, Density, Abundance, Dominance and Important Value Index were analysed. These characters were analysed by following the methods of Curtis and McIntosh (1950), Stromberg (1995), Misra (1969).

2.3.3. Mapping

A base map of the area was prepared in 1:50000 scale by using river basin map, watershed map and toposheets 58-B7, B8, and B9. A preliminary transect walk was conducted in the beginning of the study throughout the study area and the presence, absence and main physical features and extent of existing riparian vegetation was marked on the map. The data as obtained by direct field observations. Identified riparian zones were studied frequently and Phytosociological characters were measured in the required sites. All these along with landuse of the adjacent areas, major human interventions in the river margins and characteristics of the vegetation in each area were marked in the map with the aid of computers and GIS softwares.

2.3.4. People's Perceptions

Our main focus was on the people who are related directly to the river and the riparian vegetation. The 'Kadar' tribal in the Vazhachal area and the fisherman community in the downstream are the major stakeholders. In different occasions we had interactions with these people and their help were incorporated in all possible occasions. During the survey we had employed some methodologies like semi-structured interviews, historical timeline and seasonal analysis.

Besides these we also had interactions with Sand miners, Fisherman, Farmers, Students, Forest guards, Local body members, officials, merchants and tourists. Their perceptions were also recorded and opinions of experts of different disciplines incorporated in this study.

All these methods were employed for gaining some of the objectives and getting a picture in totality about the structure, dynamics and the human consequences on the riparian vegetation. Besides these important relationships like the vegetation-human-wildlife – river was also recorded during the study period. The secondary information was also collected and incorporated.

2.3.5. Review of literature

This multidisciplinary work requires information from various disciplines. But the main focus is based on the ecology and the taxonomy of the riparian vegetation. In this particular subject especially work on 'Riparian vegetation' is very rare. Our works on plants were mainly for the exploration of the forest and the plant world for exploitation to full fill various human needs. Till today we think only about the economic and medicinal importance of the plants and natural resources. The concepts of ecology developed in recent years in our country and now the pathetic conditions of the natural habitats and difficulties, diseases brought and the global status of the air, Water and Land made some people to think and see the system in a totality. So various taxonomic and ecological studies are available, but particular to the riparian vegetation and riparian ecology are very rare especially from India. It is almost absent in the case of Kerala. We have collected available informations from various sources of the world. Many details about the study area and important plant components were collected from the local resources.

2 . 3 . 5 . a . R i p a r i a n V e g e t a t i o n

Some works related with the riparian vegetation were collected from different research papers from different parts of the world. Papers of Aguiar, F. (1996), Auble, G.T

(1994), Chen, Y.D *et al* (1998), Malansan, G.R. (1993), Stromberg, J.C., Tiller, R. & Richter, B. (1997) were explains the importance of riparian vegetation in controlling the river flow, protection of river, maintaining the water quality, temperature etc. Some other works by Kevin, M. & Carol, K.A. (1999), Maranon, T. & Garcia, L.V. (1997), Rutherford, J.C. *et al.* (1997), Southwood, T.R.E (1987), Tabacchi, E. (1995), Thompson, P.A. (1980) explains in details about the riparian ecology and relationship of riparian vegetation with other organisms.

Penczak, T. *et al* (1994, 1995) in his study on the fish community dynamics related human influence and depletion of riparian vegetation. He has recorded depletion of fish species (17 to 11 in an year) by the removal of 450 m section of riparian vegetation from both sides of the river Warta in Poland. It also explains the increase of fish standing crop with the growth of the riparian trees. Samways, M.J, Steytler, N.S. (1994) explains the importance and need of riparian vegetation (at least 30-20 meters) along the rivers at least for protection of dragonflies, which is a good indicator (*Chlorotestes tessalatus*) of 30 m width of riparian forest in South African rivers.

Some works of Johnson, W.C. (1992), Thomas, D.H.L (1996), Walker, K.F., Boulton, A.J., Thomas, M.C. & Heldon, F. (1994) explains the effect of altered flow of rivers on riparian vegetation induced by dams and rivers. Malansan, G.R. (1993) in his book explain the structre and dynamics of Riparian Landscapes. Books by Mosser, M. (1996) Water Current and Discharges, Muller, E. (1997) Mapping riparian vegetation along rivers, Rosgen Dave (1996) Applied river Morphology etc gave an insight in to the river basin concepts.

2.3.5.b. Plant Taxonomy

The books by Jeffrey, C. (1975) *An introduction to plant taxonomy*, Nicolson, D.H, Suresh, C.R & Manilal, K.S. (1988) *An interpretation of Van Rheedee's Hortus Malabaricus*, Robert Wight. (1853) *Icons Plantarum Indiae Orientalis*, etc gave taxonomic basicsand different floras like Gamble, J.S. (1935) *Flora of the Presidency of Madra*, Manilal, K.S. & Raveendrakumar, K. (1998) additions to the Flora of Kerala since Gamble (1935), Sasidharan, N. & Sivarajan, V. (1996) *Flowering Plants of Thrissur Forest*, Sreekumar, P.V. & Nair, V.I. (1991) *Flora of Kerala Grasses*, Vajravelu, E. (1990) *Flora of Palaghat District-Including Silent Valley National Park*, Pascal, J. P. and Ramesh, B. R. 1987. 'Field of key to the trees and lianas of the

evergreen forests of the Western Ghats (India) etc were used for identification of floristic components.

2.3.5.c. Ecology and Phytosociology

Some basic works by Cottam, G. & Curtis, J.T (1956 and 1962), Hans, M. & Sheriff, D.W. (1975), Kevin, M. & Carol, K.A. (1999), Luisa, S.M. *et al* (1994), Maranon, T. & Garcia, L.V. (1997), Muller, E. (1997), Southwood, T.R.E (1987), Stromberg, J.C., Tiller, R. & Richter, B. (1997), Tabacchi, E. (1995) were used for the evaluation of the methodology and some basic ecological works by Odum E. P, Misra, R. (1969), Cottam, G. & Curtis, J.T, Pratt, C. R. (1995), Osborne (2000), Stomberg, L.P (1995), Weaver, J.E and Clements, F.E. 1973 etc were used for the Phytosociological analysis and for framing the overall concepts.

2.3.5.d. Study area and related information

Major information about the study area i.e the Chalakkudy river were obtained from the works of George .S (1998 & 2000), *Environmental Impact Assessment Report of Athirappilly Hydroelectric Project* (1996), History - Travancore and Cochin States and Forest working plans. The report of National Bureau of Fish and Genetic Resources (2000) reports that the Chalakkudy River is having highest fish diversity among the rivers of India. The works of Ajith Kumar *et al* explain the fish biodiversity of the area. Some publications by Madhusoodhanan P.V gives account of some new species of filmy ferns from the area. Books like The High Ranges, The Southern Western Ghats and some unpublished notes by S. Sathish Chandran Nair (INTACH) gave a deep insight in to the area, ecology and problems of the study area.

2.4. Schedule of Major events

The project was of 18 months duration and the work started from December 2000. In the first 6 months the Literature survey and the preliminary survey and analysis of the vegetation was done. The information was collected from various sources, the libraries of Calicut, Cochin, Mahatma Gandhi and Agriculture Universities, Kerala Forest Research Institute Peechi, Central Marine Fisheries Research Institute Cochin, CDS and other local institutions and libraries..

The study area has been divided into various zones for convenience and each zone was surveyed by walking along the river margin and assistance of local people, forest guards, tribals were used. (December 2000 to May 2001).

The detailed Phytosociological survey and analysis of the riparian vegetation was done after selecting the required areas and done regularly at an interval of almost 2-3 months. Which took about some time for the survey to correct the methodology. In the forest areas the plant collection, quadrat analysis were done and collected materials were identified by analysis and also by the help of experts from the Calicut University.

The field survey, the Phytosociological analysis and photographic documentation were completed at the end of March 2002. After final analysis of data and preparation of map, preparation of the report was done in the remaining two months.

In every 4 months a progress report and the accounts were prepared. During these times many interactions with experts, stakeholders were done and various workshops organized by the KRPLLD were attended. The problem was discussed at various levels and discussed in various educational, awareness programs in the local level.

The present study area includes the lower 440 Sq. Km of the total 1703 sq km area of Chalakudy river basin. The study area starts from Poringal (400m above MSL, $10^{\circ} 8^{\prime}$ N, $76^{\circ} 16^{\prime}$ E) to Elanthikkara (Sea level, $10^{\circ} 18^{\prime}$ N, $76^{\circ} 38^{\prime}$ E) where the Chalakudy river joins with the River Periyar. The length of the river studied is 67 Km i.e. 21.4% of the total river length (144 km). Since the study is focused mainly on the riparian vegetation of the main river channel, (considering 10m width on either side of the river), the actual study area becomes 188.15 ha. (1.88 sq km).

3.1. Zonation

The Chalakkudy River basin includes 18 Panchayaths and one Municipality (total 19 local bodies). Out of these, 12 Panchayaths and Chalakkudy Municipality comes under the present study area. These local bodies are on the banks of the main river channel and hence can be considered as riparian local bodies. Among these the largest is the Athirappilly Panchayath. Approximately 55 Km length of the main river channel comes under this Panchayath. From the preliminary field survey and analysis it was found that about 95% of the riparian vegetation comes under this area (i.e. from Poringal to Thumboormuzhi). But a major part of this riparian vegetation (i.e. Riparian forests, comes under the jurisdiction of Department of Forest, Chalakkudy and Vazhachal division of Thrissur Central Circle.

The vegetation in this area is unique when compared to the surrounding forests and has structural similarities to the wet evergreen forests. The riparian forest of this area especially from the Poringal to Vazhachal waterfalls needs special mention. These forests are evergreen, continuous with comparatively very less disturbed zones.

Based on this aspect and for more convenience, the area has been divided into 3 zones. This will help to get more detailed picture of the riparian vegetation.

3.1.1. Zone 1

This is the upper most zone of the study area. It starts from just below the Poringalkuthu dam (400m above M.S.L.) upto the Athirappilly waterfalls. This zone represents rich low altitude riparian wet evergreen forests. Perhaps this may be the one of the uniqueness of the river Chalakkudy and this zone entirely comes under Dept. of Forest of Vazhachal division. The continuous stretch of riparian vegetation, the river and the Vazhachal and Athirappilly waterfalls makes this zone one of the most beautiful places in South India which attracts lakhs of visitors every year.

At Vazhachal there are no residential areas except two Kadar tribal colonies and Forest Department staff quarters. Hence disturbance in this zone is comparatively less. The main disturbance is from tourism activities and is due to the Anamala road passing through the area.

The river flows making small rapids and falls. This area records maximum biodiversity potential. Tourism and allied activities are mainly located near the Athirappilly, Charpa and Vazhachal waterfalls and hence other areas in this zone is kept comparatively undisturbed. But now a days the intrusion of tourists to the nearby forest areas and riparian zone has increased.

Four large (>1Km² catchment) and 9 small streams drain into the main river from the right bank. Among these is the Charpa Thodu having approximately 11.5 Km² catchment and which joins the Chalakkudy River as a beautiful waterfall just 2 Km downstream of the Vazhachal waterfalls. Likewise 2 large and 7 small streams join the river in this zone from the left bank. Among these one stream draining from the Pokalappara region joins the river just before the Vazhachal bridge. The other is the Minalr thodu joining just above the Athirappilly waterfalls and is the largest of all these 22 streams. But none of these was observed to be totally perennial. The Charpa thodu turns dry by the onset of summer. The Pokalappara Thodu and the Minalr Thodu retain wetness in the summer season as well. Hence these two large streams can be considered perennial to some extent.

The vegetation cover adjoining the riparian forests in this area mainly consists of deciduous forests and plantations of Teak and Bombax. From Poringalkuthu upto just before the Vazhachal waterfalls and 1 Km after the Charpa waterfalls and the adjoining areas of Athirappilly are represented by plantation of teak. In these areas the width of the riparian forest varies from 10-50m. The adjoining land cover of the Charpa area is mainly evergreen and semi evergreen forest. The deciduous patches were also found downstream to Charpa. The Semi evergreen and deciduous forests are formed by deterioration of the evergreen forests due to disturbances. The characteristic of the land adjoining the riparian area is significant and exerts great influence on the riparian vegetation of that area. Small patches of reed brakes are seen near Charpa and bamboo before the Athirappilly water falls.

The river in this area posses many shallow as well as deep, rocky regions. The curves creates many rapids and falls. The River in this area is bounded by beautiful evergreen riparian forests. When the river takes sharp turns the flowing water spreads and due to its influence on the riparian area the riparian forest turns more wet evergreen and beautiful. Deep areas in the river created by sharp turns and rocky regions with surrounding riparian forest makes different microhabitats which support a large extent of aquatic life. Hence these areas are major fishing grounds for the Kadar tribal people of this area. Due to the proximity of the Vazhachal Forest Department office nearby illegal fishing and poaching are more or less under control. This area contributes to a greater portion of the non-wood forest products collection of the tribal people. This collection and fishing are the main livelihood activities of the endemic primitive Kadar tribals.

3.1.2 Zone 11

This is the middle zone and extent from the Athirappilly waterfalls up to Thumboormuzhi (120-50 M.S.L). Geographically this zone is very much similar to the Zone 1. But the continuity of the riparian forests has been lost due to disturbances. The oil palm, rubber and other plantations of Plantation Corporation of Kerala, Tourism activities in the Government and private sector, and the activities of the local peoples have contributed very much to the depletion, and loss of continuity of the vegetation. The riparian vegetation especially in the river margins is highly reduced and is mainly due to the rubber and oil palm plantations. A number of small islets are present upto and just after Thumboormuzhi. These islets have good stretches of riparian vegetation. The riparian forest in these islets is also a unique feature of the Chalakudy River.

The length of the river in this zone is approximately 13.5 Km (14% of the study area.). Altitude ranges between 50-120m above M.S.L. Slope is lower than the zone 1. And the breadth of the river increases. There are very low amount of sandy deposits in some areas. The river has rocky river bed with very few rapids and falls.

Five large and ten small streams are found to join the main river channel on the right bank. Two large and 25 small streams are found to join the river on left bank. Among these the Kannankuzhi thodu joining the river just below the Athirappilly falls is the largest one (about 50 Km catchment). It is the only perennial stream joining the river in the entire study area. The streams in the plantation area (left side) became dry due to the conversion of the forests into plantation. Biodiversity potential of this area is also rich but the disturbance in the adjacent areas restricts the wild life. Residents of these areas depend on the river for their daily activities, and also for livelihood. Illegal fishing by using dynamites is increasing in this area. Entry of tourists to the protected areas is higher and they also use dynamites for fishing. These activities are supported by some of the local people.

Indiscriminate destruction of the riparian forests and cutting of trees in the islets are frequent. Poaching is also detected in this area. One River Diversion Scheme (Chalakkudy River Diversion Scheme) for irrigation of 14000 ha of agricultural lands operates near Thumboormuzhi, which diverts a good amount of water for irrigation purpose.

3.1.3 Zone 111

It is the largest and lowest zone of the study area. It extends from Thumboormuzhi (50m) upto Elanthikkara (sea level) where the river confluences with Periyar River. They together drain into the Kodungallur backwaters to empty into the Arabian Sea at Azheekodu-Munambam. Maximum human interference was noticed in this lower zone of the Chalakkudy river.

This zone has a length of 43 km along the main river and the altitude difference is 50m. Slope is very less when compared to pther zones. The riverbed is rocky in the higher altitude but becomes sandy in the down stream area. Large deposits of sand were noticed in this zone. But indiscriminate sand mining has reduced the sand deposits, which in turn has deepened the riverbed. Legal and illegal sand mining has affected the riverine habitat. The water level has lowered considerably during these years. Indiscriminate sand mining has wiped out large beautiful sand beds and the few

remaining ones are under severe threat. The Arangali sand bed and the Mambra sand bed are the remaining two sand beds in the Chalakkudy River.

Four large and four small streams are found to join the river along the right bank. Two large and six small streams are found to join along the left bank. The major streams like Parayan thodu, Meloor thodu originate by draining vast flood plains. Hence they are perennial and flow through a large area in the flood plains. These streams have considerable length and the people depend on them for various purposes.

Major human activities in the study area are located in this zone. The riparian landuse mainly consists of agricultural practices. Coconut, arecanut, nutmeg and paddy are the main crops. A large area is occupied by banana cultivation. All sorts of water requirements of the people are met from the river and are mainly for drinking, agriculture and other domestic and industrial purposes. Beyond Thumboormuzhi there are a lot of legal and illegal motor pumps operating from the river. Some major drinking water supply schemes like Vainthala supply drinking water to all Panchayaths including the Chalakkudy Municipality. Some Panchayaths outside the basin also depend on this scheme for their drinking water requirement. The coastal Panchayaths like Puthenvelikkara, Eriyard, Methala, and the Kodungallur Municipality have serious drinking water shortage and they also depend on this scheme. The salinity intrusion is increasing every year, due to the reduction in flow, deforestation in the catchments, indiscriminate sand mining etc .A regulator cum-bridge is operating at Kanakankadavu in order to check the salinity intrusion but the inefficiency and unscientific construction has led to the intrusion of saline water beyond the regulator and is found to reach upto Kuzhur.

The main bridges in the river are the two bridges at Chalakudy (One for NH47 and another one for the railway) and another new one at Njaralakkadavu. The last one is the regulator cum bridge at Kanakankadavu. Now a bridge is under construction across the river in the Pulikkakadavu near Annamanada. Industries are comparatively less in this area. One major industry is the K.P.C.L factory situated beyond Chalakudy town which deposits its effluents directly into the river. The major pollution is from domestic sewages and indiscriminate use of pesticides in the agricultural farms and plantations especially in the catchments.

Besides drinking water majority of the people depend on this river for livelihood. This river is considered to be the richest in terms of fish diversity. Puthenvelikkara Panchayath alone has more than 1149 inland fishermen. Various types of inland fishing

activities are in this area. Fishing from the river and flood plain is found to be an important livelihood activity of the local people.

The complex web of life in this area is supported and woven by this river. The livelihood, drinking water needs, potential of the land and people and the various cultures are dependant on this river. The analysis of riparian flora, ecology, human activities, and other major problems become much easier by the zonation of the study area. Hence one can get a clear picture of the problem at micro level and also from a river basin perspective.

4.1. Status of existing riparian vegetation in the study area

Out of the riparian vegetation in the study area (i.e. below 400m altitude up to sea level) of the Chalakudy river 38% of the area has <10m width of riparian vegetation. At least 95% of this is located above (50m altitude) Thumboormuzhi, which represents the forest area (Zone-I and zone-II). A continuous stretch of riparian vegetation in the river margin is found only in zone-I, here 92% of the area possess < 10m-width vegetation.

The riparian vegetation in the zone-II is mainly on the islets. The river margin area is highly disturbed. Here only 3.4 % of the river margin possesses <10m width of vegetation. In the lower region only 3.8% of area possess comparatively undisturbed vegetation.

A Vegetational Map (Map.6. Appendix) gives the status of the existing riparian vegetation, and the main features of the area. The riparian vegetation is mainly evergreen type and based on the status it is marked as undisturbed, completely undisturbed, moderately disturbed and highly disturbed. The area, which is not marked lacks enough vegetation and can be

4.2. Phytosociological analysis

The characteristic of a vegetation type is mainly dependant upon the dominant communities. For example in the case of forests the trees are the dominant species. Any changes in this community immediately affect the entire ecosystem. Any action, which destroys the dominant community, may lead to the complete collapse of the system. Effect of any external or climatic factor on the community can be detected by studying their species composition, structure and their dynamics.

Only 38% of the total area (12% river margin and 26% of the islets.) was found to possess >10m width of riparian vegetation. Atleast 95% of this vegetation is found to be located above 50 - 400m altitude (zone I+II). For the detailed Phytosociological analysis 50 quadrats of 10 x 10m were laid along the river margin. Minimum 0.05% sampling is required for vegetational sampling and more than 0.05% is recommended. (20 quadrats in zone-I and Zone III and 10 quadrats in Zone-II). Maps (7.1 & 7.2) describe the positions of these quadrats in the zone I and Zone II.

For the analysis of the vegetation some analytical quantitative characters have been analysed from the plotted quadrats. From each quadrats number of individuals, total number of species and basal area (i.e. Circumference of the plant at breast height) is measured. From these characters, Frequency, Density, Abundance, Relative frequency,

Relative density, Relative Dominance (Relative Basal Area) and Important Value Index were calculated. A brief discussion follows:

Species Richness : It is a measure of diversity. Is indicated by total number of species in an area. Great value for the species richness indicate greater diversity and importance of the particular habitat or ecosystem. Tropical evergreen forests are considered as richest in species diversity in the terrestrial ecosystems.

Frequency : Is the number of sampling units in which a species occurs. Which indicate how frequent a particular species occur in the study area is measured by

Frequency = $\frac{\text{Number of quadrats of occurrence of the species}}{\text{Total number of quadrats studied}}$

Total number of quadrats studied

Density : It represents the numerical strength of the species in a community. The number of individuals of the species in any unit area is its density.

Density = $\frac{\text{Total no. of individuals of the species in all the quadrats}}{\text{Total no. of sampling units studied}}$

Total no. of sampling units studied

Abundance: This is the number of individuals of any species per sampling unit of occurrence

Abundance = $\frac{\text{Total no. of individuals of the species in all the quadrats}}{\text{No. of sampling units in which the species occurred}}$

No. of sampling units in which the species occurred

The Important Value Index (IVI) Measurement of Dominance :

Based on the quantitative characters like frequency, density and dominance (Basal area or cover) the overall dominance of a species on the entire community is measured by analysing the synthetic character called Important Value Index (IVI). It is calculated by adding Relative frequency, Relative Density and Relative basal area.

Relative Density (RD) = $\frac{\text{Density of the species} \times 100}{\text{Total density of all the species}}$

Total density of all the species

Relative frequency (RF) = $\frac{\text{Frequency of the species} \times 100}{\text{Total frequency of all the species}}$

Total frequency of all the species

Relative Basal Area (RBA) = $\frac{\text{Total basal area of the species} \times 100}{\text{Total basal area of all the species}}$

Total basal area of all the species

Important Value Index = RD+RF+RBA

When the three zones were compared zone-I was found to possess the highest value for the basal area cover, species richness, and the number of individuals. Zone-II falls in the second place. The top 7 quadrats fall under zone-I. The chart 4.1 gives a comparative account of the important Phytosociological characters of the zones. chart 4.2 shows that the species richness and basal area of Zone-I are more than double when compared to the other two zones. The vegetation in the 200- 300m-altitude range (just above the Vazhachal waterfalls) was found to be the richest within zone-I and also in the entire study area. 95% of the river margin of Zone-I consists of this type of vegetation. The species composition and structure of the riparian vegetation in this zone shows similarity to the West-coast evergreen forests. In the altitudinal scale the 200-300m range posses the richest vegetation in the entire study area and the ranges 50-100m and 100-200m fall in the next two positions (Chart4.1-4.3 and Table 8).

A good percentage of the tree species present in the top 3 quadrats come under >100m girth class. Table.5 give the comparison. Almost equal distribution of the middle girth classes and the some increase in the number in the lower girth class are noticeable and has provides a picture of the structure of the vegetation based on the different life forms found in the quadrats. The distribution of different girth classes and the height classes provide a clear picture of the structure of the vegetation. Here the trees and lianas dominate and the medium sized trees dominate the emergent trees in the case of number and species. This explains one of the unique characteristics of the riparian ecology where the riverside always remain open and its influence determines abundance and presence of the medium sized evergreen and riparian tree species.

4.2.1. Species composition and its significance

4.2.1.a. Important Value Index (I. V. I).

The important value index is an analytical Phytosociological index which represents the relative richness in terms of density, frequency and dominance of each species. In the zone-I *Syzygium occidentale* a typical riparian evergreen plant possesses the highest value (Chart .6). Another riparian plant *Barringtonia acutangula* possesses the second position. And the species *Humboldtia vahliana* and species of *Ochlandra* occupies the 3rd and 4th position. These first three tree species and some species like *Madhuca neriifolia*, *Homonoia riparia*, *Mallotus aureo-punctatus* etc were generally considered as evergreen forest species having affinity towards the riparian habitat. . They are usually found near streams. In our observation these species were found only on sides of streams and pools and can be considered as true riparian tree species. The species of *Ochlandra* were also found in highly moist soil and appear in degraded forest areas. Some species have an affinity towards the riparian habitat.

In the zone-II the species of *Ochlandra* possess the highest IVI value. *Barringtonia acutangula* and *Madhuca neriifolia* occupy the second and third positions. (Chart 7). In this zone the riparian vegetation is mainly in small islets. The river margins are highly disturbed. In the islets influence of the change and quantum of flow of water is significant. In these riparian communities the species of *Ochlandra* are abundant. The dominant tree species are represented by *Barringtonia* and *Madhuca*.

The zone-III is the 0-50m-altitudinal ranges and the riparian vegetation was found to be in highly disturbed condition. Only some patches dominated by bamboo were found to retain the richness. So few quadrats were found to possess enough riparian species. In this zone the species of *Bamboo* possess the highest IVI value. (Chart 8). *Saccharam arundinaceum*, *Glyrricedia maculata* and some species of *Ochlandra* follows. The diagram indicates the dominance of the bamboo species. IVI distribution of other species indicates the poorest conditions of the other quadrats.

4.2.2. Dominant species in the Riparian zone

The analysis reveals that the riparian vegetation is dominated by some species like *Syzygium occidentale*, *Barringtonia acutangula*, *Madhuca neriifolia*, *Humboldtia vahliana*, *Mallotus aureo-punctatus*, *Homonoia riparia*, *Hopea*, *Ochlandra*, *Bamboosa*, *Vateria*, *Ficus*. These plants are evergreen species and the first six species are endemic to the riparian habitat

In zone-I the west coast evergreen tree species are dominant. The zone-II is also dominated by the evergreen and semi evergreen tree species. But some deciduous elements also make their appearance. In the zone-III, which is the lower zone and possess few samples and patches of riparian vegetation area is dominated mainly by the species of *Bamboo* and other low altitude species. In the lower areas appearance of some Mangroves and associated species were also noticed.

The dominant evergreen and semi evergreen species found in these zones are *Humboldtia vahliana*, *Barringtonia acutangula*, *Syzygium occidentale*, *Homonoia riparia*, *Madhuca neriifolia*, *Hopea parviflora*, *Vateria indica*, *Xanthophyllum flavescens*, *Elaeocarpus species*, *Aporosa lindleyana*, *Xylia xylocarpa*, *Hydnocarpus alpina*, *Baccaurea courtallensis*, *Olea dioica*, *Entada*, and *Derris*. Of these, most of the species are typical West coast evergreen and semi-evergreen elements. And some plants are typical riparian components. The elements also represent various seral and edaphic communities of the west coast evergreen forests. The species like *Ochlandra* and *Bamboosa*, *Macranga peltata* and some deciduous elements and weeds indicate the disturbances in the riparian forests. The vegetation above 50m altitude (Zone-I and II) found to possess this type of vegetation.

In the lower altitudes the vegetation is very much disturbed. The riparian species in this zone change due to dominance of species of *Bamboosa*. Plants like *Pandanus*, *Saccharum arundinaceum*, and *Ficus* and some halophytic species make their appearance.

4.2.3. Distribution of the species along the river

The chart 9 shows the distribution of various dominant species along the study area. The altitudinal range of the entire study area is between 0-400m MSL. The diagram indicates that the upper limit of the evergreen forest elements is 400m. This distribution can continue into higher altitude but the study area is limited to below 400m. To describe completely one has to study the distribution along the entire basin.

The tract under study represents the lower altitudes of the riparian habitat of the Chalakkudy River. It is observed that the tropical evergreen forest tree species are located at sides comes in to very low altitude (i.e. upto 50-40m.) In the normal condition the

evergreen forest species are detected only at 400m altitudes. These riparian evergreen species are distributed upto 30-40m altitudes. Such a low altitude distribution of the evergreen forest component is an indication of the influence of the riparian habitat and thereby brings out the significance of the riparian vegetation along this river.

Species like *Humboldtia vahliana*, *Homonoia riparia*, *Syzygium occidentale*, and *Madhuca neriifolia* are found only above 50m altitudes. Species like *Aporosa*, *Xanthophyllum flavescens* etc are found only above 200m. Some species like *Vateria* and *Hopea* are recorded from various places upto sea level. They have affinity towards the watered environment. Any way distribution of such species in the lower altitude indicates the importance of the riparian vegetation.

In the lower elevations mangrove species like *Rhizophora mucronata**, *Avicennia officinalis**, and the associated species like *Acrostichum* were detected. The true mangrove species* were recorded very near to the sea and the associated species were found upto the higher points of salinity intrusion in the river.

The Tables 9-11 gives the detailed Phytosociological analysis of the species in the different zones.

4.3. Floristic analysis

For the analysis of the structure, status and dynamism of an ecological unit dominated by tree species (i.e. forest) a detailed study of the existing flora and ecological structure of the community is essential. This in turn can draw a clearer picture of the vegetational characteristics.

From the analysis of the dominant species in the different zones by quadrat method, a total of 85 plants including 70 tree forms, 10 lianas and 5 shrubs were identified in the 50 quadrats. The maximum numbers of trees i.e. 52 species were recorded from the zone-I, zone-II recorded 37 and zone-III recorded the least number i.e. 21 species. This brings out the floristic richness of the zone-I and in the Zone-I the Vazhachal area alone (200- 300 m altitudinal range) recorded 47 species.

A detailed floristic survey of the vegetation in this area (200-300m) was done during the study period. The three rich quadrats in the zone and their surrounding belt of riparian vegetation were surveyed more than four times in an year. We have recorded 166 species of flowering plants. The 166 species include 144 genera of 66 families (57 dicots + 9 monocots). Of these 166 species, 142 belong to dicots and 24 belong to monocots

(Chart.11). The Chart.10 lists the top 10 families, where in Fabaceae, Euphorbiaceae, and Orchidaceae occupy the first 3 positions respectively.

4.4. Ecological analysis of the flora.

The dominance of the tree species especially of evergreen species (Chart 12 &14) and presence of different life forms like herbs, shrubs, climbers, liana, epiphytes and trees in a particular ratio shows clear structural similarity to the wet evergreen forest. The life forms as described by Raunkiaer (1935) were analysed for the area (Chart 13). It is very similar to that of the tropical rain forest systems as mentioned by Osborne (2000). The dominance of the phanerophytes and the ratios of the other life forms are significant.

The abundance of epiphytes and dominance of the evergreen species indicate the richness of the vegetation and its structure. The presence of weeds and some deciduous element indicate the disturbance. These species are mainly found in the edges where the adjacent plantations merge with the vegetation.

4.5. Structure and development of the riparian vegetation.

Jacob in 1988 describes the importance of a profile diagram for analyzing the structure of a tropical rain forest and of other forest ecosystems. Here, in the three zones and within the zones, based on local geography, flow of river, altitude the nature and structure of the existing vegetation shows variations. This can only be analysed by constructing a clear profile picture of different zones. The riparian forests of this zone contains emergent as well as non-emergent evergreen tree species. Some true riparian species also occupies a particular position. The deciduous elements, lianas and weeds, also appear in particular dimension. The profile of a riparian forest along the river margin varies from that of an islet or of a lower altitude, or of a disturbed zone. These variations, alignment and arrangement of different species are formed by the interaction of the system with the environment and other physical stress. This type of response of the system, structural dynamism in response to climate and physical forces gives the trends, direction and dimensions of ecosystem development.

The present vegetation in different zones and different samples gives a profile of the vegetation structure. Putting together these small pieces we get a clear picture of the structural organization of the riparian plant communities. The vegetation in the zone-I and zone-II (50- 400m) is structurally similar to evergreen forests. Vazhachal area of the zone I records the best samples of the riparian vegetation in the islets and in the river margin. These vegetation samples are structurally similar to West Coast evergreen and tropical rain forests.

The true riparian plant elements occupy a position just touching the water body. The seasonal fluctuation of the waterfront is also marked by these species (Diagram1). These true riparian evergreen plants are continued by tropical evergreen forest trees like *Vateria*, *Hopea*, *Hydnocarpus*, and *Xanthophyllum*. Emergent species are also abundant in these zones. Here small samples of climax type of vegetation are detected in this area. On further examination we could find a gradual arrangement of the true riparian component according to their size and shape.

The small shrub species like *Homonoia riparia* are seen on the rocky river bed. They are also found within the rocks between different water flowing areas. Some grasses also occupy such a position. Torrential flow in the monsoon season and seasonal floods exert great pressure on these plants. They become flooded upto more than half their height. And they are always exposed to bright sun light and heat reflection from rocks and water.

Some species like *Syzigium occidentale*, a small evergreen tree also occupies similar position. But these species are larger than the *Homonoia* type. They are also seen in clusters. They associate with other pioneer species. These species are not only seen in the rocky river bed but are also located on the river margins and occupy a second position from the water body (type 2). These species are spreading and drooping type and grow up to 3-meters.

In a horizontal profile the third position is occupied by species like *Barringtonia acutangula* and *Mallotus aureo-punctatus*. These species are small trees of 6-10m height with numerous branches and leaves, which can completely cover the ground. They require some silt and sand for their establishment and are found in association with first two types in various compositions. Usually they are seen on the margins of the river and the islets. They are somewhat erect in shape; girth is maximum (50- 60 cm) and supports the growth of shrubby and herbaceous layers beneath. Usually this zone is highly influenced by seasonal

flooding and here herbaceous elements are very rare. The seedlings of the different species are abundant in this zone. Another important character of the species *Barringtonia acutangula* is it is distributed to very low altitude and presence of water body is essential for its survival. Another species of *Barringtonia* is found along the margins of the brackish and saline water bodies.

The fourth types are some large spreading riparian evergreen trees such as *Madhuca neriifolia*, and *Humboldtia vahliana*. They occupy a very near position to the water body.

They are approximately 10-20m height with a girth near 100 cm. They are broad leaved with closed canopy provide heavy shade and make the soil and the habitat cool and humid. These species occupy a fourth position as described in the diagram. Their roots are wide spreading and always touch the water body. The roots of *Humboldtia vahliana* spread in 75% radius of its crown and attach firmly on rocks. In highly developed vegetation areas aged trees of *Madhuca* and *Humboldtia* are observed first from the river in the horizontal scale. The closed canopy provided by these plants are found to cover almost the entire area of the river and their establishment, growth and development with time wipes out the pioneer light demanding species.

The emergent trees like *Hopea* appears where the riparian vegetation develops to a typical tropical evergreen forest type. In such areas the emergent species were marked by *Vateria* and *Hopea*. Further development of the ecosystem may lead to a normal tropical evergreen climatic climax type. Due to high disturbance in the adjacent lands, mostly from the teak plantations, tourist areas and also from the Anamala road further development of the community in these regions are blocked. The felling of the trees in the recent past and the decrease and irregularity in the water flow due to damming may have crucial roles.

Species of *Ochlandra* and *Bambusa* are abundant mainly in the disturbed area of the riparian zone. *Bambusa* are distributed up to river mouth and species of *Ochlandra* restricted to forest area (above 50m MSL). In one area near 'Vettukadavu' of Chalakkudy some *Ochlandra* was found to grown by a local resident near the riverside.

4.5.1. The structure of the riparian vegetation of the islets

While examining the small to large islets within the river we can find high diversity. The richest and bigger islets were found in the Vazhachal area. The structure is very similar to that explained earlier. The emergent species are also found in these islets. In an islet the entire area is surrounded by the water body. The flowing water influences from all the sides. Hence the species composition is in such a way that the true riparian species encircle the islet. The above-described four types come in different circles. The emergent species occupy a central position. Large islets with fully developed condition with climax emergent species are not found. The lower elevation (< 400m) and disturbance may be the reason for this. (Diagram 2)

In lower areas of zone-I and II large islets were not found. The smaller islets lack the emergent trees and they were found to have a seral community composition. Other islets

represent the lower seral types with structural composition lacking the emergent and the 3rd and 4th types of plant components. (Diagram 3)

Similar types of establishment of the riparian vegetation can be observed at lower altitudes also depending on the altitude, nature of the riverbed, presence of silt, sand and sediments, the species composition varies.

Good samples of riparian vegetation were not observed in the lower zones due to high disturbance caused by various activities like sand mining, encroachment etc. Only small patches were remaining. However, bamboo species were found in abundance in the remaining area. In the lower zones, some *Cyprus*, grass and other herbaceous species were found only in those areas, which have some sediment and silt deposits. Species of *Ficus*, *Saccharam*, *Pandanus* etc occupy the marginal positions in these zones.

In lower saline areas the mangrove associated species and some true mangrove species make their appearance.

The seed dispersal pattern of the riparian plants have significant role in the development of the community. Most of the species are distributed through water. Another important character of riparian forests is that they support lot of epiphytic species. Not only the emergent trees but also species like *Syzigium occidentale*, *Homonoia riparia*, which occupy marginal positions, were found to be abundant. Many epiphytic species mainly Orchids were abundant in these small trees.

The riparian habitat provides microhabitat to a large extent by providing shade, trapping silt and sediments by anchoring roots which in turn supports a number of diverse organisms.

Considering the structure and composition of the existing riparian vegetation in the study area and the climatic factors, the possible climatic climax vegetation in these zones are tropical evergreen forests. In the zones I and II there exists some good samples of such vegetation. Longman and Jerk (1987) describes five microclimatic zones on a forest tree. The temperature inner side of the forest experiences is (7-10⁰) C less than that of the outside. The canopy regulates exposure of the inner side and forest floor from bright sunlight. The plants in the ground level receive only 1% of the light than the outside. In this way the vegetation creates different microclimatic regions, which can support diverse species of plants and animals (From the ground to the upper level on a tree). Different species of animals occupy their niches.

The lowland forests are most luxuriant of all plant communities. But most human activities are concentrated in these lower and mid zones. Such lower and mid altitudinal vegetation are shrinking (Osborne 2000). Since many species are localized in such forests, there is a high degree of endemism.

Unlike other ecosystems the riparian forests have more important role in conserving biodiversity. They can support more diverse organisms than any other forest ecosystems. The riparian forests are tropical evergreen forests. The riparian habitats can also be considered as an ecotone where the terrestrial forest ecosystem and the aquatic environment merges. By providing shade, controlling light and temperature, providing more litter by shedding of leaves, anchoring of roots, by trapping lot of silt and sediments the riparian vegetation supports a lot of aquatic organisms. It provides shelter to most of the animals and bird species. The presence of water, richness of the vegetation, presence of fruiting trees and open area in the river channel that provide an upstream down streams open space attracts and supports lot of bird species including water birds. The importance of the mangrove forests in the conservation of fishes and other aquatic fauna are well known.

In the present study area riparian forests are mainly located in zone-I and zone-II. The lower zones are highly disturbed. Mangrove species are very less. Few plants are recorded. The zone-I records the continuous evergreen riparian forest vegetation.

It is not easy to assess the biodiversity potential of the entire riparian habitat along the study area. Besides these forest areas, the lower areas also have very good biodiversity potential. Many species of fishes are located in the low lands. Many bird species are found in the wetlands. In the low altitude Panchayaths like Puthenvelikkara large number of migratory wetland birds were recorded. Otters are found along the riverbanks upto the lower zones. An attempt is made here to analyse the biodiversity richness of this riparian vegetation area. This richness in the biodiversity brings out the importance of the riparian forests.

5.1. Flora

The riparian forest of the Vazhachal area (zone-I) is well known for its wilderness and beauty. Such a beautiful stretch of low altitude riparian forests is very rare in the entire Western Ghats. In our study from a small area near Vazhachal we have recorded 166 species of flowering plants including 79 species of forest trees of which 71 are evergreen in nature. The family Fabaceae comes first, followed by Euphorbiaceae and records 8 species of orchids.

This area records 329 flowering plants of 260 genera and 97 families including 8 species of orchids. Of which 24 species are endemic to Western Ghats and 10 are rare and endangered species (TBGRI, 1996) These species were recorded from the riparian zone above the Vazhachal waterfalls. Another report by Dr. V.S. Vijayan of SACON indicated that this riparian area possessed 52 endemic plants. In the present study we recorded 42 trees from 19 Quadrat of zone-I, 18 trees from 11 quadrat on zone-II and 29 trees from zone-III (Appendix.1). A complete survey of the riparian vegetation is needed for comprehensive analysis. The Vazhachal Forest Division records 825 species of plants including 220 trees species. This indicates that about 30% of these tree species were found along this 3-4 Km length of riparian forest.

5.2. Fauna

This area records a number of animal species. The Vazhachal Division records 21 species of animals of which 9 are endemic which include the Asiatic elephant, tiger, leopard, gaur, flying squirrels, lion tailed macaque, and nilgiri langur, 19 species of reptiles including one endangered species, the monitor lizard. Amphibian flora of this area record only 5 species. These data are inadequate. Further detailed analysis is needed.

We have experienced a lot of memorable moments during our study process. Elephant groups with young ones resting under the vegetation, moving along and across the river, elephants dung including that of the young ones on the riverbed, large and small foot prints in marshy areas, broken shrubs and reeds in their path, resting places and a lot of dung pitted grounds, trunk marks on the trees.

Besides elephants troupes of Lion tailed macaque on the left side of the river just above the Vazhachal water falls, troupes of Nilgiri langur eating, playing and jumping from one tree to another, troupes of Bonnet macaque over the trees and along the river, their amusing yet interesting efforts especially of young ones to cross the flowing water etc were observed.

Leopard and tiger kills were observed at many occasions in the surrounding areas. Footprints of tiger and cub were recorded many times on the riverbank. sambar deer, Gaur, wild boar etc were found many times along the riverside. The malabar giant squirrel is always seen near the Forest Department quarters and river margin trees. The food markings and footprints of otter were observed along the river. Many reptiles including king cobra, viper, tree snake, flying lizard, chameleons were observed in this area.

5.2.1. Animal corridor

The area just above the Vazhachal waterfalls especially between the Poringal powerhouse and the Vazhachal Bridge is an elephant corridor. This forest tract is bound by the Poringalkuthu dam on the upper side and the Edamalayar reservoir on the southern side. The lower area is bounded by the Vazhachal and Athirappilly waterfalls. Hence this small tract between the Athirappilly waterfalls and Poringal powerhouse is an animal corridor, which connects the Southern Idamala valley forests and the northern Nelliampathy forests. These areas have great conservation value. Elephant cross the river in this area. From our experience and also that of the tribals and forest officers 2-3 groups of elephants cross this area every week. Last summer, a group of elephants with about 20 individuals including different age groups spend half an hour on riverbed just below the Vazhachal Bridge. On each visit to this area, we experience the presence of elephants on the riverside at least once in 3-4 days.

*(Appendix.2)List of animals

5.2.2. Birds and butterflies

C.Sushanth records 231 species of birds in this area. S. Raju records 195 species of birds of which 160 species were recorded from the 2 km riparian area upstream to the Vazhachal waterfalls. Of this 8 species are endemic to Western Ghats and five species are endangered including the Malabar and great pied hornbill, fishing eagle, darter etc. A critically threatened species ie the white backed vulture also has been recorded from here. He records 24 winter visitors and nests of 16 species. Sushanth reports 170 species of butterflies, from this area.

This area is a paradise for birdwatchers. Every morning is welcomed by the call of the whistling schoolboy, Green and ruby throated barbets, cuckoos, whistles of hill myna, refined tunes of the Iora, alarm calls of the racket tailed drongo, and winter songs of magpie robin. We have recorded fishing eagle more than four numbers at a time and witnessed its beautiful activity of catching fish from the river. They are always located around the Vazhachal bridge area where plenty of fish are available. Darters, and other water birds are also recorded here. Four types of hornbills including the Malabar and Great pied hornbill were recorded from here. A family of pied hornbills was found feeding and supporting their young ones to learn to fly at the Charpa area during the previous season. More than 14 pied hornbills were recorded at a time from this area. In a recent study conducted to locate the nests of various hornbill species for conservational aspects the study team has recorded about 24 nests of grey, 4 of the Great Indian and one of the malabar-pied hornbill from this zone. R. Kannan (1993) indicate that hornbills need evergreen habitats with trees having at least 1.43 m average breadth and 43 m height for their nesting. In this area such large trees were present only on the riparian forests.

*List of important birds (Appendix.3)

5.2.3. Fish diversity in the Chalakudy River

The Chalakudy River is richest in the case of fish diversity. A detailed analysis by Ajith Kumar et al (1997) reports 98 (Appendix) species of fishes of which 5 species are new to science. Sixty one species were found in low elevation areas of <75 m 68 species in the midlands. 75-500m, 36 species in the highland (500 - 750m) and 14 species from the high range areas >750m. Out of the 98 species 36 are endemic to the Western Ghats, 10 are endemic to Kerala part of the Western Ghats. Among the 98 species listed, 27 were identified as good edible fishes. About 32 species of fishes were recorded from the Orukumbankutty (500m) just above the Poringalkuthu where the two important tributaries of the Chalakudy river Kuriarkutty and Parambikulam Aar meets. Our present study area 0- 400m altitude represents about 70-80 species of fishes.

The following are the major reasons for the biodiversity richness of the Riparian forests of the area.

1. The low altitude riparian forest of the kind found here are very rare.
2. The riparian habitats are unique, providing a lot of diverse microhabitats in the terrestrial and riverine environment, which can support a lot of organisms.
3. This area is bound by the Peechi Vazhani Wild Life Sanctuary in the north, Idamala Pooyamkuttu valley in the south, and Parambikulam wild life sanctuary in the east so it act as a connecting link with these forests areas.
4. This forest area maintains the continuity between these important wild life sanctuaries.
5. The entire area of this division is mainly plantations and deciduous forests, except some small tracts including the stretch of the riparian vegetation in the Poringal Vazhachal area.
6. After Athirappilly water falls (zone-I) the wild life activities becomes less due to the increase in anthropogenic activities.
7. This river is the only perennial water source in the area especially in the summer when all other streams dries up. All animals depend on this river channel for their water requirements. Some sort of perennality is noticed only in the Kannenkuzhi thodu.
8. This riparian forest provides a good shelter for the wild life.
9. Besides water and shelter these riparian forests provide many food trees for lot of animals and birds including lion tailed macaque, Nilgiri langur and Great Indian hornbill.
10. Presence of office of the forest department and their strict vigilance in the Vazhachal area prevent poaching and felling of trees including threat from fire.

Human perceptions .

Human beings are inseparable and the most dominant species of any natural system. In such an investigation to understand the dynamism of a natural system analysis of the human relationship plays a critical role. From our study area we have selected two groups of people the Kada tribes in the Vazhachal area and the fisherman populations in Puthenvelikkara. Both of these people are unique and are living highly dependant on this river. The experiences of other people were also included.

6.1. Kada tribes of the Vazhachal area and the riparian habitat

In the Vazhachal forest area especially in the riparian area main anthropogenic activities is that of the tourists, and other people from outside. There are no other local residents except two settlements of these 'Kada' tribes and forest department staff at Vazhachal. Being a primitive group they depend the river and the vegetation to a considerable extent.

6.1.1. History and culture

'Kada's' are short, dark skinned, curly haired primitive tribals with curl hairs and platyrrhine noses. They are considered as belonging to Negroid traits and are endemic to Chalakkudy River basin (Palakkad and Thrissur districts of Kerala). They are forest dwellers, living by gathering food from the forests and by fishing. They usually live in huts made by reeds and bamboos and do not have an aptitude for agriculture. According to the 1981 census there were 1503 Kadars (774 males and 729 females) in the state. They live in about 15 settlements in the Parambikulam forest area of Palakkad district and Athirappilly Sholayar region of Thrissur district.

In the study area there are three major settlements of Kadar tribals. Two are permanent settlements. The larger one is the Vazhachal settlement very near to the waterfalls and office of the Forest Department. Another is the Pokalappara settlement near Pokalappara Forest Range office. The third one is located just downstream of the Poringalkuthu dam. Vazhachal and Pokalappara settlements are permanent settlements and the dam site colony consists of few families resettled from the Pokalappara colony. In Vazhachal settlement, there are 160 Kadars with 71 males and 89 females in 55 families. Under different programs they have been provided with many 'modern' facilities including brick walled and roof tiled house and electricity. Pokalappara settlement has 22 families. Their houses are Cement brick walled with concrete roofs. They do not have electricity and water supply but they were transplanted to this place

during the time of powerhouse construction and their settlement is very near to Poringalkuthu powerhouse. These small houses are in very poor condition. In the dam site settlements there are about 17 families. They live in their traditional huts. Tribals of Pokalappara were transplanted from Pokalappara valley to a single settlement near the range office. During the time of the construction of the Poringal powerhouses a group of people moved to the dam site area and settled there making their traditional houses.

6.1.2. Habit and Habitat

Kadar tribals live with their families in huts made usually very close to a river or a stream. Their settlement or 'Ooru' consists of 10-20 families. During the summer season most of the people go to interior forests with their families for collection of Non Wood Forest products like Honey, Damar etc. They make temporary huts during these times and prefer sites very close to a perennial fresh water body. They are partially nomadic and they usually gather food from the forest, and river. Fishing is an important mean for their livelihood. For the collection of Non Wood Forest products they travel with their families to different locations and they always keep dogs with them. They are good trackers and hunters. They collect non-wood forest products like honey, dammar and Shikakai from the forest, which is the major source of their income. They are expert fisherman and usually use pole and line and small nets for fishing. Usually do not go for large-scale fishing.

6.1.3. Traditional Skills

Traditional huts or 'Pathy' made by them using bamboo and reeds are very strong, beautiful and suitable to the mountain environment. The main skeletons of the huts were built with bamboo poles. Mats and sheets made by reeds or made by flattened bamboo stems were used for doors and other such structures. The exoskeleton made by bamboo poles is then covered with clay-based mud. According to them this structures exist without damage for 15-25 years. Skeleton of the roofs were made mainly by bamboo poles and reeds were also used at required positions. Between this closely placed elongated bamboo pieces leaves of reeds (Usually broad leaved *Ochlandra travancorica*; commonly called "Eetta") were placed from bottom to upper side in such way that leaf tips of the upper row came above the lower rows and which make draining of water much easier. They usually use mats made by bamboo and reed and whatever structures needed inside their houses they make with bamboo and reeds. After building houses they 'smoke' from inside and ash content from the smoke or produced while cooking protect the bamboo and reed stems from insects. After few months roofs become black with

coating of ash and smoke particles from inside. This method of “pukayidal” or smoking is a common practice among various communities all over Kerala especially for the protection of seeds and corns from insects. One of the important feature of these houses is that these are most suitable to the mountain environment and can withstand high rain fall in the monsoon (more than 3000 ml.) and clay based mud floor and walls make environment very cool during summer season. For making traps and equipments for hunting and fishing they depend on these local materials.

Upto recent past we were using the tribals for extraction of timber and clearing of forests and also for raising plantations, building dams and for clearing forests by many administrations starting from the British. Deterioration of their habitats can be detected from the analysis of the present living condition of the Kadar tribals in the basin.

6.1.4. Water requirements

They directly depend on the river and forest streams for their water requirements. For bathing, drinking, and washing of clothes and plates they use the nearby streams and river. Usually their settlements and also their temporary huts will be very close to the river and there will not be any problem for access to clean water. Only in their permanent settlements as in Vazhachal and Pokalappara they take and store water from the river in pots. According to residents of Vazhachal, increased tourism activities create problems by polluting nearby riversides and also affect their privacy. Due to this they have to travel a long distance for securing unpolluted water and for privacy especially for ladies. Both men and women of the Kadar are very shy people. Nowadays they carry out their daily activities especially bathing in the early morning hours or late in the night or go to thick riparian forests in the Vazhachal bridge area.

6.1.5. Food

According to them nowadays their food habits has changed and now are similar to that of the other people. They are basically food gatherers and were not agriculturally oriented. This may be one reason for the deterioration of their cultural identity. They would be the worst affected people by this habitat destruction. Presently they depend on the markets and shops for their food requirements mainly rice, cowpea, and tapioca. Fishing and hunting had played a vital role in ensuring their survival till today.

According to members of older generation like Kochuvelayudhen, they had the habit of collecting different type of tubers, including Colocasia, Amorphophallus, Dioscorea,

Curcuma and storing for the monsoon season. They also used to collect various fruits including jackfruits, mango, Syzigium, Ficus, and gooseberry and also collect and use honey. They used to hunt small animals and birds like Jungle Fowls, Hornbills, Mynas, Hare and small Deer. These collected foods were preserved by drying and used in the summer months. According to them wild tubers were used after some sort of treatments for removing sour and bitter taste. Fishing plays an important role in their food and livelihood economy.

Presently the collection of food resources has become difficult due to deterioration in the evergreen character of the vegetation. According to Vasanthan a 22year-old youth, the riparian forests are more important for them as only these habitats retain the evergreen nature and possess resources. Some items like gooseberry and medicinal plants were usually collected from the deciduous forests. The riparian habitats are their most welcomed option for temporary migration during the summer season for the collection of forest resources because as it provides shelter, water and fishing facilities. He said that most of the bird species and animal species are located near the perennial stream and swamps covered by forests.

6.1.6. Fishing

According to them fishing is one of the main food gathering activity and nowadays has turned into a good source of income. This river is very rich in fish resources. The shallow as well as deep pools in the river nurture different type of fishes. According to Kochuvelayudhan and Vasanthan, experts in fishing and forest gathering, these nearby areas of Vazhachal Bridge and area just after the Vazhachal waterfalls are the important fishing grounds in the Vazhachal. Areas near Ittiani and Athirappilly falls also have importance. Most important place for them is the stretch between the Poringal powerhouse and Vazhachal water falls. According to Vasanthan and others like Jaliyan and Kumaran, fishes weighing upto 7-12 kg have been collected from this area. During favorable seasons they can collect fishes upto 5-15 kg at a time. They usually catch fishes including Chooru, Pachilavetti, Modan, Aral and Tilapia. People from all groups are engaged in fishing activity including women.

They usually use pole and line (Choonda) for fishing. Long narrow stems of bamboo and reeds were used for making pole. According to them various types of hooks and baits were used for catching different types of fishes. They usually do not go for large-scale fishing. 'Catching for a meal' is their life principle. Those who were employed in Vana Samrakshana Samithi and other forest related jobs rarely go for

fishing. But the majority of people including woman and children do fishing. Old people mainly use pole and line and using nets is not a common practice. Some people especially in the reservoir area were found to use gill nets. Very rarely some people use the cast nets. Using dynamites (Thotta) for fishing is becoming frequent during nowadays. In many occasions from this area to downstream areas we have noticed the use of dynamites. Among tribals, youngsters are interested in using dynamites and catching fish in large quantity for their economic needs. But most of the tribal people are aware of the impact of dynamite blasting on the fish fauna and know that it is illegal. In Vazhachal area it was noticed in very rare occasions.

6.1.7. Non-Wood Forest Products.

Collection of non-wood forest products is a main source of income. They are good gathers and their collections include honey, bee wax, Entada (Kakkumkai), shivakai, kashurimanjal, maramanjil, black damer, white damar and gooseberry. Tribal Welfare Society receives these collected NWFP from the tribals through their collection centres. **Sholayar Scheduled Tribal Co-operative Society, Malakapara** is the functioning society in this area. Their areas of operation include the Forest Ranges namely Sholayar, Vazhachal, Kollathirumedu, Charpa and Athirappilly. This co-operative society was started in 1981-82 as a part of the Western Ghat Development Programme. The society was formed for the sake of tribals for preventing exploitation from external agencies and their agents. Vazhachal has one collection centre. Tribals from the Pokalappara and Vazhachal settlements are linked with the Vazhachal society. In the upstream areas like Vachumaram and the Sholayar there are other collection centres. They have fixed rates for each product and also give financial support to the tribal people. The NWFP collected in the Vazhachal society is exclusive to Kada's since there are no other tribal group settlements in this area. These collections account for the one major part of their income (Table.15).

This table gives an approximate proportion and quantity of each product in a year. Honey, Kasthuri Manjal, Cheevakai and Dammar are obtained in larger quantities. Honey is an important product that ensures the quantity and money.

The approximate yearly collection of non wood forest produce of this Malakkapara Tribal Society is as follows: 500 Kg of Bees wax, 4 to 8 tonnes of honey, 1.5 tonnes of Kattupathry, 12 tonnes of Manjakuva, one tonne of Kakkumkaya. The maximum collection is obtained from the Sholayar Collection Centre. From the table it can be observed that Vazhachal collection centre receives less than ¼th of the total

collection. But only 40 members are there under the Vazhachal collection centre and all of them are Kadar tribals. Collection prices for these produce are: Honey Rs.50/kg, Bees wax Rs.50/kg, Pathripoo or Kattupathry Rs. 120/Kg. Black dammar Rs.20/kg, White dammar 27/kg, Manjakuva Rs.19/kg, Kakkumkaya Rs.5/kg and Chevakai Rs. 10/Kg.

According to them, most of the old people used to go for collection of NWFP. The main season for collection of NWFP starts from February and ends with starting of rain in June. 90% of the all products were obtained in this season. When the season begins tribal people move into the interior of the forests with their families or groups of 2 or 3 men. After locating products that they want they make temporary huts in suitable locations and go out for collection this. Sometimes this lasts for weeks and months. According to them collection of honey needs special skills; they locate bees hives usually on large trees or steep rocks and make suitable arrangements for climbing the trees and rocks. Usually they hammer small bamboo sticks like a ladder on the barks of large trees or use large bamboo stems as ladder to climb up the rocky surfaces. We have located such ladders on the rocky cliffs of Ittiany area. In order to prevent the attack of bees collection of honey from the locations is usually at night and they also use “Pantham” or fire.

Unlike other tribes of Kerala they do not collect medicinal plants from the forests and hence their income is very limited and mainly depend upon these materials like honey, and dammar. The resources are very limited and most of these products are of evergreen and semi-evergreen forests. In this areas evergreen character of the forests were remained only on the riparian areas and on some mountaintops and are usually along the sides of the hill streams. 90% of the remaining forest areas are teak and softwood plantations. This limits their collection, and according to them nowadays they have to travel long distances for collection of these materials. This not only threatens their livelihood but also increase the pressure on the remaining evergreen and riparian forests. Lack of knowledge about the vulnerability of these riparian forests and critical conditions of the resources is found to be an important problem. At many occasions their collection methods causes deterioration of trees for example collection of honey of small bees it become detrimental to the host trees. Likewise collection of dammar and other resins from the trees, cutting of stems of “Kakkumkai” and “Shivakai” etc also causes deterioration of the habitat. Today things are changing and most of the people know seriousness of the problem. But they are the people of the forest and river and every activity of their life are related with nature. With the deterioration of the habitat healthy survival of these community is becoming a big question.

6.1.8. Other income resources

From the past period, the tribal have been brought to different labor works under changing administrations. And in these days also labour works mainly related with forest is a major part of their income. They engage in different daily wage labors under the Department of Forests and Kerala State Electricity Board. Tribals in the Vazhachal colony were getting more jobs under Departments of Forests. In order to use their skills in forestry activities and also in tourism promotion a society called Vana Samrakshana Samithi has been formed under Department of Forests. The major types of work include the activity of forest protection, cleaning the tourist area, giving guidance to the tourists and keep vigilance in the tourism concentrated zones, fire protection etc. The Samithi gives more the 10 jobs daily and tribals are selected in rotation so that all people will get a minimum job in all seasons. A portion of the ticket fee collected from the tourists is ensured for this purpose. Besides ensuring a minimum all season jobs the V.S.S. has succeeded in bringing good relationship between the Forest Department and the tribals. Engaging the tribals in such activities related with forest protection has created more awareness among the tribal people. Besides these jobs the fire line keeping, forest watch, weeding, planting, tracking etc also giving a support to the tribal people.

K.S.E.B also provides jobs and these are mainly reserved for the settlers near the powerhouse area. These people were transplanted from other areas during the construction of the dam and had been used for labour jobs related with dam and powerhouse construction. After the construction period job opportunities have decreased and also the major forest areas has been drowned or cleared. Survival is becoming a major problem for the tribes of this area. They are getting few jobs like fire keeping and weeding, and people from outside are engaged in various jobs under the Electricity Department on different contract basis.

Considering income generation these activities play an important role but this does not mean that they are fully dependant on these jobs because the tribesmen say that most of the people gather food, catch fish and collect NWFP's and are struggling for their survival.

They are generally illiterate and only few people among the younger generation have attained secondary education. Only one girl from the Pokalappara colony secured admission to higher education i.e nursing and now has got a job. According to them, they are not interested in seeking their livelihood away from their natural habitats and are not interested in jobs not related with forests. According to the older people the

inconveniences in educating their children creates problems and this kind of education is not proper for them and they have the opinion that this system has spoiled their natural skills and hence usually the children do not continue their education.

Every activity in their life and their survival is very much related with the river and forest. Being a nomadic group these tribals retain their links to the riparian habitat. The forest, the forest products and the river has a significant role in their life. The major activities in their life are very much related to this environment.

6.1.9. Dynamics of change

As a general rule availability of food, water, and shelter determines the degree of freedom. Purity and availability of the resources is another factor determining the wealth of a tribal community. These factors and their living with nature and degree of freedom obtained from this only can keep their cultural identity. Here in the case of Kadar they are becoming more market oriented and dependent on the external community for their survival due to lack of food. This condition brings changes in the attitude of the new generation. They are also becoming more dependent on the external society for financial resources due to the habitat destruction.

If the forest resources and riverine habitats are rich enough and abundant they could have attained more freedom than any other tribes because of the nomadic nature and non-agriculture based economy. From the past they were used for destruction of their own habitats and the deterioration of the forests especially of the riparian habitat. This has become a critical factor in their cultural as well as social deterioration.

The houses in the Pokalappara colony are cement bricked and the roof concreted. With its small size and lack of ventilation it looks like a bathroom or a shed. They do not like this type of houses. Some people make traditional huts near these concrete houses and use it for sleeping. Now very few people live in this colony.

Older people go in to the forest with their families for the collection of forest resources. They live inside the forest, with family upto the end of the season. Most of the youngsters do not like to go for collection of forest products and for fishing. They are more interested in other money earning works and are attracted to modern market oriented consumer life. Nowadays consumption of alcohol has increased especially among the youngsters.

Some young people also like to live a nomadic life. They like to fish, live in forest, like to going for search of food and other forest products than doing other work like construction, and forest clearing.

All the forest tribes in Kerala depend on these rivers and riverine habitat for their existence. Their mode of living, culture, livelihood and agricultural practices are

very much linked with these habitats. Most of the tribes depend directly on the natural streams of the Ghats for their water requirement. Those who live permanently in hamlets usually select a place very near to natural stream. Most of them find their food from the forest or by fishing. Their agricultural practices were dependent on the streams and the weather. Those who are nomadic make their temporary huts very near to rivers. Fishing and collection of non-timber forest resources is an integral part of their lives. The most interesting part of their life is the knowledge and faith in the totality of the system. This has led them to take the minimum from the surroundings. Their collectiveness and lack of individual possessive mentalities help them live in harmony. But this mode of living in the modern world, characterised by maximum exploitation and depletion of natural systems, becomes impossible. They lose their cultural identity and perish. This loss in human cultural diversity is yet another impact of ecosystem degradation. We believe it is an inevitable “part of socialization”. Depletion of natural systems can be observed from the reflections and changes in the normal life patterns of every individual organism of that system. So the pathetic state of all tribal communities indicates the critical conditions of our environment especially that of rivers and forests. In such conditions each and every stretch of forestland is very important and hence the riparian habitat in Kerala have great importance to be conserved and used carefully.

It is very obvious that the conservation of these forest and river has critical role in preserving this endemic cultures. Any sort of development seen in the lives of Vazhachal tribals than any other Kadar group is very much related to this remaining stretch of riparian habitats and resource of the river. Any significant change in these conditions will have a negative impact.

- The endemic Kadar tribals especially within this area are found to prefer the riparian habitat. Their nomadic gathering lifestyle is very much dependant on the forests and river.
- Fishing and collection of minor forest products are major activity for their livelihood and they are found to dislike agriculture.
- Most of them dislike going outside the forests for a long time and always wanted to keep themselves within their territory. Majority of them wanted to live in their traditional houses.
- Considering the examples of Vazhachal they were more interested in forest related jobs than any other construction and labour works
- The attempt like V.S.S has succeeded to a considerable in making a good relation between the forest department and tribes.
- It is evident that the conservation of the forests especially the riparian habitats are necessary for the healthy survival and preservation of their cultural identity. The

process of making them aware about the importance of the habitat and its critical condition is very important for the conservation of these last remaining riparian forests.

- We cannot consider their life separately from their habitat i.e from the forest and river. These people are the people of the forest and river. They are living with the forest and every activity in their life has evolved from a lot of experiences and contains all message of conservation. We cannot find any activity that destroys or overexploits the river or forests in their life. They won't block the flowing water and allow the river to flow, seeds to germinate, allow seedlings to grow. Their footsteps do not damage the seedlings and they take very less from the river and forest.

6.2. Fishermen in the lowlands

The Chalakudy River has enough inland fisheries resources. Many people depend on these resources for their livelihood. Most of them are traditionally engaged in fishing. They have adopted and evolved many different traditional and modern techniques for catching fishes. These activities range from single to group activities and men, women, children, younger and old people were engaged. Chalakudy River with Periyar have lot of inland fresh and backwater bodies. These diverse environments are found to support large diversity of economically valuable fish species. People are found to travel a long distance and catch fishes in the inland water bodies of the river.

Diverse fishing methods and high production was observed in the lower region where the brackish and fresh water body merges. These environment support lot of marine, brackish as well as fresh water fishes and the vast wetlands are habitat for many fishes. The Puthenvelikkara Panchayath alone has 1149 people in 245 families engaged in inland fishing included 570 males and 579 females (George 2001).

6.2.1. Methods of fishing

They have adopted various types of fishing methods including modern as well as traditionally involved techniques. Fishing methods vary from simple ones like pole and line to banned large nets with small mesh size (Adakkam Kolly Vala's). Some methods are highly species specific. These methods vary according to the nature of fishes, season, habitat, size of the fishes and quality of catch. These methods were evolved by careful scientific observation and development of their skills.

It ranges between highly specific methods for catching some particular fishes to large-scale fishing. For example the former type includes methods for catching small fishes like pearl spot with the use of two poles from the shallow regions, catching prawns in single numbers using thread and loop and use of different baits for specific species of fishes. For catching 'Varal' (snake head) usually small fishes and earthworms are used as bait. But during breeding seasons this fishes do not take these baits. So they use some larvae feeding fishes like "Manathukanni or Pochutti" (*Aplochiles lineatus*) or cockroaches and other insects, with which catching becomes easy.

Many experienced fishermen from the Puthenvelikkara shared their experiences and discussed their problems. Their visions and knowledge were evolved from years of experiences and have strong scientific basis. Important ones were listed below in order to

bring out the significance of the riparian vegetation in preserving such natural habitats and supporting marginalized communities.

6.2.2. Perceptions of the people

Thomas

Thomas is a 60-year-old fisherman, living near Choukkakadavu of Elanthikkara where the Chalakkudy River and the Periyar meets. He has the opinion that the fish catch is decreasing every year. Increased sand mining has resulted in the erosion of the riverbanks and the vegetation and has increased the time span of salinity intrusion.

He recollects that the confluence point of the two rivers was very shallow, and can be easily crossed by walking and many people including women were engaged in fishing, mussel collection and various related activities there. There were lot of common riparian lands with large trees of 'Kandal' (Mangrove) and 'Pooparuthi' (*Thespesia populnea*). Now this area has become 40-50 feet deep due to indiscriminate sand mining. The riverbanks are eroded, common lands and sandbanks have disappeared and erosion of the banks has become a major problem. People were protecting their land by making cement walls individually or by with the help of local bodies and which need lot of money and found non-sustainable.

There is ban on sand mining but unfortunately this activity is increasing with time. The police and concerned departments are not taking any efforts. Now a strong effort from the local people and subsequent change in the attitude of the local body has found some results. But he said that the area is irreversibly damaged by these activities. Very big criminal gangs were working behind this indiscriminate sand mining and the local people have lost their hopes.

Lalu .K.P

A 24-year-old youngster, running a hairdressing saloon in the Kanakkankadavu shared his thoughts. Before taking up this job he was engaged in fishing. He resides in the Kozhithurthu located just upstream to Elanthikkara and downstraem to the Kanakkankadavu regulator-cum bridge. He said that fishing became more difficult due to increased sandmining and changes in the regularity of the stream flow and salinity intrusion. And now is mainly due to the failures in the construction of the regulator. He said that due to the vigorous flow in the monsoon the concreted parts below the shutter of the regulator has been damaged. Now the saline water intrudes beyond the regulator through the damaged area. Many temporary attempts were made every year to check this

by spending lot of money for fixing sand filled plastic bags below the shutters. He also indicated that the functioning of the shutter is not proper. At many times shutters was raised during the summer season and the intruded saline water has destroyed acres of paddy cultivation and affected fisherman and now this has become a common phenomenon.

Radhakrishnan

A resident of the Kozhithuruthu had similar opinion and he said that fishing is becoming more difficult in these areas. He recollected that they were used to make temporary sand barriers on either side of the thuruthu (islet) keeping the thuruthu on the middle. At that time there was no problem of saline intrusion. Since the upper part of the Kozithuruthu was getting freshwater and all wells on the eastern side of the Koazhithuruthu had obtained fresh water throughout the year.

When the attractive 'Developmental' concept of a regulator cum bridge came into reality it was planned just above the thuruthu. But after the thuruthu becomes completely surrounded with saline water during the summer season and drinking water scarcity has become a major problem.

Krishnan

A middle-aged man residing just upstream of Kanakankadavu regulator said that the inefficiency of the regulator has resulted in salinity intrusion and has seriously affected many drinking water and irrigation schemes. They have made some temporary sand barriers in the smaller streams for checking the intruding saline water. Upto very recent times *Pandanus* and *Thespesia* plants were abundant in the riparian zone and that was very good barriers for the riverbank erosion. Most of the mud and sand banks were destroyed due to increased sandmining and further deepening of the main river has affected the water table especially on the riparian lands. Lowering of the water table in the river also affected traditional and modern irrigation facilities. He believes that indiscriminate sandmining as the major reason behind their problems and planting more trees like *Thespesia* and bamboo can protect the eroding riverbanks.

Vishwambaran

A 50 year old fisherman in the Puthenvelikkara Panchayath has shared his experiences. He said that amount of fish becoming less and many fishes were not seen nowadays. Some fishes, which were found in these areas in early times, were not coming in the seasons.

He has mentioned a lot of economically valuable fishes and also mentioned decrease in the amount of fishes during the monsoon season. He explained a particular fishing activity during the monsoon season called 'Oothal' i.e. during the beginning of the monsoon large quantity of fresh water flows from the highlands and this will flood the riparian areas and wetlands. Many fully-grown fresh water and brackish water fishes spread out and reaches these shallow wetland and ponds through this shallow flooding water. It is regarded as a seasonal phenomenon for the migration of the fishes for breeding. This happens 2-4 times in a monsoon season depending upon the strength and duration of rain. In these 3-4 days of flood the fishermen will get a good collection of 'Oothal' fish. They are mainly 'Vala, Konchu, kolan, Karimeen, Kanambu, Varal, and Koory and Manja Koori'. From the shallow regions of the wetlands, paddy fields and small streams they catch fishes using various method including fishing by hand. Cast nets and other nets were used sometimes. Gill nets were used mainly because large fishes can be easily trapped in it. But a main feature of this during "Oothal" fishing majority of the fishing take place by simple methods like hand fishing, by knife and arrows, luring by torches at night and also by pole and line. Fishes can be easily caught by hand searching from the holes and litter in the bushes of riparian plants and paddy fields or wetlands. Pandanus bushes are important hiding places for the fishes. All men and women of all ages engaged in this 'Oothal' fishing. He indicated that these 'Oothal' fishes were mainly found in the paddy fields and associated streams and ponds especially near thick vegetation.

According to him this sort of fishing and other livelihood activities like agriculture, and traditional aquaculture were very much dependant upon the seasonal flooding in the river. Now a days decrease in the runoff of water during the monsoon and deepening of the main river has adversely affected the seasonal flood. He accounts deforestation in the catchments and damming of the water in the highlands for the irregularity of the river flow. Thick vegetation like Pandanus, Mangroves and even other small grasses found along the banks and wetlands play an important role in the productivity. He believes that reclamation of wetlands, paddy fields, ponds and streams, clearing and cutting of the riparian vegetation mainly mangroves, reclamation of the 'Common lands' has serious impacts on the fish population and affected balance of the river. He indicated that indiscriminate sand mining has deepened the river and now it is very below sea level and so the salinity intrusion in lower water exist during the monsoon also. And this has affected seriously the fish population. The growing of weeds like Eichornia in the

shallow waters due to eutrophication and water pollution is another important problem for the fishermen.

Job kallarakkal & Valsan

Two middle-aged fishermen residing in Pannjipalla area of Puthenvelikkara explained traditional method of aquaculture in the wetlands and different catching methods. They were engaged in this activity for many years. According to them with the starting of monsoon season (June) seasonal flooding occurs in the wetlands and paddy fields. Then fishes migrate to the wetlands for breeding and then they close the main entrances by making temporary barriers of mud and sand and it is called 'kettu' usually 'Chemmeenkettu' (traditional prawn culture farm) and they allow natural growth of these fishes. They capture this fishes after 3-6 months period. Starting from the August-September harvesting begins. Based on the growth rate and maturity period of various fish species they capture them during different periods. They use different captive methods and gears including castnets, Ottal, and so on. Some of the people engage in this activity, which is regarded as a group activity. It needs high care and labour of more than half a dozen people. The changes of epidemics are not rare especially for the valuable species of prawns. They said that they have to feed the fishes and mangroves and other vegetation with their litters are very productive than any other food. Final harvesting is after 6 months i.e. usually during November and 'Kettu' will be opened after this. They said that many large scale captive methods used with in the river decrease in the quantity of fresh water during flood season and increased sand mining has reduced the migration of fishes. They also noted that some chemicals used in modern aquaculture farms also account for the decrease in the native fishes. The main fishes include different prawns (njaren, kara, konchu, poovalan), kanambu, chempally, prayil, viral, paithy, thirutha, kolan, etc.

Job explained in detail about a method off catching 'oothal' fish with use of up to 40 m long Ottel like barriers made by thin elongated pieces of bamboo or stems of Aarecanut palm.

Antony and Babu

They were practicing this traditional method of aquaculture and shared similar experiences and said that they were engaged in this activity from their childhood. They have got these experiences from their parents. They explained these methods as a collective activity. Now they were doing this in 28 acres of land and 5 people were engaged in this activity. They said that they prefer this traditional farming method than

the modern aquaculture. The modern aquaculture farms were yielding profit only up to a maximum of 5 years and the production becoming less and less every year. The chances for epidemics are also greater. They have the experience that many chemicals used in the modern aquaculture farms for clearing and killing of all other species before seeding is a serious threat to the natural fishes in this area. These chemicals were washed off into the natural streams and were affecting many native fishes. Clearing of all plants including mangroves and Pandanus patches were severe in the modern aquaculture farms and that has serious impact on the natural productivity.

They indicated that destruction of the wetlands and riparian habitat through increased cutting of vegetation and mining of clay and sands threatens their livelihood activities. Reclamation of paddy fields and streams were blocking the connection with the main river and other larger captive methods in the main river have serious impact on the migration of fishes and now threaten their livelihood.

Bhaskaran

A 55-year-old man residing in Elanthikkara of Puthenvelikkara Panchayath has years of experience in fishing. He is a good observer. According to him not only the river but also inland water bodies including the streams, connected ponds, Pokklai farm and the marshy traditional aquaculture farms play a significant role in the availability of fishes. He explained that the availability of fishes has been reduced so much and number of fishermen increased in the recent years. Migrating fishes from the sea and brackish water have an important role. They migrate from sea and brackish water to inland based on season, salinity and tidal changes. Large-scale fishing in the river mouth with the use of modern nets, negligence, and much destruction in river including regulators and bridges prevent their seasonal migration.

He was of the opinion that the depth of the river in this area is more than the sea level and hence the saline water intrusion has increased and the seasonal stability and equilibrium has been lost which has a negative impact on the availability of fish fauna.

Mini

A 28-year-old housewife said that many women from this area were engaged in fishing and mussel collection (Kakka) activity especially in the shallow regions. And most of the women go for selling fishes. Decrease in the fisheries resources and increased sand mining has threatened their livelihood.

Availability of fresh water in the wells during the summer season has become very rare especially in the riparian areas. She resides very near to the river and the community has been facing serious drinking water shortage. They had access to drinking water in their wells in the older times and now increased sand mining and deepening and subsequent lowering of the water table has resulted in drying up of wells with starting of monsoon and salinity in the wells is increasing year by year.

She also noted that due to increased depth and salinity in the river in all seasons they could not use the river for bathing and washing of clothes. Irrigation has also become a major problem due to lack of availability of fresh water.

Latha

She also shares similar experiences and mentioned that production of mats with the use of Pandanus leaves and grasses were one main livelihood activity of the people especially for the women. This Pandanus was abundant in the riparian areas of the main river and also along the small streams in the wetlands. Grasses were also obtained from these areas. Increased riverbank erosion, reclamation of the common riparian lands, clearing of vegetation for the aquaculture farms, clay and sand mining has destroyed the vegetation and threaten their livelihood. Deepening of the river has created problems in using the river and increased salinity has stopped the use of river for their water requirements. Collection of fishes and mussels has become very difficult especially for the women due to increased depth of the river.

Shajan

Shajan, member of Puthenvelikkara Panchayath shared his experiences and indicated major threats to the riverine habitat. He indicated the sandmining activity as the key factor behind major problems affecting the people. Nowadays the Panchayath has brought regulations for the illegal mining of sand from the river. But according to him criminal mafias are behind these activities, Very few people from local areas support this activity and police is not taking any serious actions against the sandmining mafias.

According to him indiscriminate sandmining has resulted in deepening of the riverbed more than 5 meters during the past 5 years. This has resulted in lowering of the water table, salinity intrusion, and riverbank erosion and has increased drinking water shortage. He pointed out the decrease in the ground water table and indicated that this has seriously affected fresh water resources. He indicated that their Panchayath and near by areas are facing serious drinking water scarcity.

He also pointed out the unscientific planning and implementation of various projects the Kanakankadavu regulator. Salinity intrusion by the leakage of the regulator is a problem today. Its inefficiency has created many problems for the fishermen and farmers. He pointed out that fishing and allied activities are the main livelihood means for the local people and his Panchayath alone contributes major proportion of inland fishery products of the area. Now these fishing activities, collection of mussels and crabs are under serious threats. He is very enthusiastic about increasing awareness among the local residence and also hopeful about bringing in many activities.

Suseelan

An enthusiastic social worker residing in the banks of Chalakudy River near Elanthikkara shared his thoughts. He had a long history of legal battle against the sand mining activity. He has explained the indiscriminate sand mining as the root problem behind major problems of the area including drinking water scarcity, depletion of riparian habitat and vegetation and reduction in the fisheries.

He point out the importance of riparian vegetation for stabilizing the riverbanks. According to him the riparian vegetation especially the mangrove and associated flora has great importance in the fisheries products. He has indicated about the clearing of the riparian lands. According to him large trees of Thespesia, mangroves, Pandanus and bamboo were abundant in the riparian areas. They have been cleared for various activities. Indiscriminate sand mining has resulted in the serious riverbank erosion and every san and mud banks have disappeared from the region.

Some isolated patches of vegetation were pointed out by him especially some protected areas near temples and indicated the possibility for the regeneration of riparian vegetation. He believes that an engineering structure cannot replace the riparian habitat.

Interaction with fishermen revealed a list of about 52 economically valuable fish species. About 15 species were purely fresh water and others were of brackish water. They have a common opinion that the amount of fishes are becoming very less. Some older species are not seen today. Some introduce cultivating varieties are found in very less quantities.

6.2.3. Relation with riparian vegetation

All fishermen indicated that vegetation rich areas are good fishing grounds. In their opinion fishes are usually found attached to shady and cool areas rather than bright sunlight. They usually cast their nets or use pole and line in vegetation rich areas. They

have the opinion that these trees and bushes (pontha) provide shelter for some large and small fishes. They also provide food by shedding their leaves and fruits and by trapping slit and sediments. Due to the shallow nature of the riparian and wetland areas and also due to availability of shades and food these areas are their breeding sites.

They depend the vegetation for fire wood, mat making and making fishing equipments. The pole of pole and line were made usually with stems of reeds, bamboos and rachis of 'olettipana' palm. Various gears used in fishing are made with use of bamboo and wood of Arecanut palm. Different types of 'ottels' differing in size and shapes were made by bamboo or Aarecanut palms. 'Kuda' is used for the collection of fishes usually made with coconut leaves or thin pieces of reed or bamboos. Many species of mangroves and *Thespesia* were used for making boats. The fishermen use wood of 'Punna' (*Callophyllum inophyllum*) or that of mangroves for making Chinese dip nets or 'Cheenavala'. Some common luring methods include attracting fishes by putting mangrove and other riparian vegetating are a common practice.

During summer season fishermen put stems and branches of mangroves and other vegetation as round bunches in the shallow waters. This gives a temporary shade and protection. Fishes especially prawns including larger ones "Attukonchu" (*Macrobrachium roxenburghii*) are attracted towards the temporary habitats. After few months before the rainy season the fishermen surround these temporary nests of vegetation with large 'ottels' made by elongated pieces of bamboo and remove the branches. Then the fishes established in these temporary nests become trapped and they catch the fishes using small nets. They have the opinion that the mangrove and other riparian trees and bushes were very suitable for this temporary nets. This is an evidence about the relationship of fishes with vegetation especially for breeding.

Most of the fishermen are of the opinion that the riparian vegetation and the wetlands play a significant role in the fisheries production. Now destructive activities were decreasing their resources and threatening their livelihood.

6.3. Major human interventions in the riparian zone

About 4 lakhs of people within 18 Panchayaths and 1 municipality are directly dependant on this river. They depend mainly for their water requirements including drinking water, irrigation and also for other livelihood means like fishing, food, and transportation entertainment. This ranges from the small tribal groups to distant populations depending for the drinking water and food requirements. Human interventions at various levels and overexploitation of the resources play an important role in the deterioration of the riverine habitat. Lack of awareness, unscientific planning and implementation of projects, greed, lack of social responsibility, improper functioning of the various institutions and delays in the implementation of laws plays an important role. These factors were becoming detrimental to the riverine ecosystem, and threaten the sustainability of these basic resources. Major human interventions and its impacts were analysed and described below. These interventions vary in scale and style with changes in the topographic and demographic features of the area.

6.3.1. Reclamation of the riparian and adjacent landuse

Reclamation of the riparian area is a major problem found throughout the study area. This is mainly for raising plantations, agriculture practices and also for construction of other developmental projects and also for overexploitation of resources like sandmining. This has resulted in severe fragmentation of the riparian vegetation and has seriously affected its structural composition. The plantations were seen mainly in the (zone I and II (400-50m) Poringal to Thumboormuzhi areas. Agricultural activities are concentrated mainly in the middle and lower areas i.e. After Thumboormuzhi (Zone III). The construction and related activities were seen throughout the river sand and clay mining was severe in the lower areas.

6.3.1.a. Plantations

Plantations in the study are mainly of the Department of the Forests and the Plantation Corporation of Kerala. These plantations bound the entire riparian area from the Poringalkuthu upto Thumboormuzhi (Zone I and Zone II). The plantations of the Department of Forests are mainly Teak and soft woods (Teak+ Elavu+ Eucalyptus.). The entire study area comes mainly under Chalakudy, Malayattoor and Vazhachal divisions of the Forest Department. These plantations are located from Poringal upto 4 km downstream just below the Athirappilly waterfalls (Zone I and small part of the Zone II). Majority of the area were coming under Athirappilly and Charpa ranges of Vazhachal division. Table .17.

The table indicates that these plantations account for the 21.4% of the total area in the divisions. The plantations are found lining the entire riparian vegetation from the Poringal up to Athirappilly on either side of the river except some natural forest areas in the Charpa region on the right side of the river. These plantations are found to evade the riparian zone at many places, near Poringal powerhouse, near Vazhachal Bridge and near Ittiany. Map.9.

The map gives an idea of the plantations and the fragmentation of the riparian vegetation in the zone-I. Only a single line of natural trees occurs at the left upper side of the Athirappilly waterfalls. Teak plantations and destruction of under story vegetation has caused severe soil erosion on the right side. The riparian vegetation in the Ittiany area is also damaged severely. The plantations have invaded the riparian zones and severe soil erosion and occurrence of fire has noticed in this region. The dry deciduous nature of the plantations and high amount of heat reflections by the teak leaves and high risk of forest fire has seriously damaged the remaining riparian vegetation. The streams in the plantations hardly possess any kind of riparian vegetation and every stream has lost their perenniality.

Kalady group of plantation

4260.965 ha area of Chalakudy Malayattoor and Vazhachal division was leased to Plantation Corporation Kerala Ltd, Kottayam. These plantations are mainly of rubber, Cashew and Matti and were raised under three estates Athirappilly, Vettilappara and Kallala in the period of 1961-77. The Vazhachal division alone has 3545.510 ha of these plantations. Rubber account for the largest area and now they have converted large area of rubber in to oil palm plantations.

These plantations in the riparian zone begin just after the teak plantation near Kannankuzhi area below Athirappilly waterfalls. Almost all river margins were invaded by these plantations on either side of the river except small areas like a patch of deciduous forest on the right side of the river just above the Thumboormuzhi River Diversion Scheme. They have planted oil palm just downstream of the Athirappilly waterfalls (near Kannankuzhy) and now the riparian areas in the zone I (i.e from the Kannankuzhy upto the Thumboormuzhi) and upto some areas below Ezhattumugham are completely invaded by the oil palm and rubber plantations. The rich evergreen forests in this area have been destroyed indiscriminately. Some patches remain only in the small islets. Destruction of the riparian forests has resulted in high degree of soil erosion in the area.

6.3.1.b. Agricultural practices

Agricultural practices were found mainly in the residential area. It was noticed only after Athirappilly and its impact is severe in the lower regions. In the zone- II agricultural practices are noticed in small areas up to Ezhattumugham. Local people were growing Tapioca, Banana in the riparian areas including many islets. In this area mainly Tapioca, Banana and other seasonal crops were noticed. Perennial crops like coconut and nutmeg found mainly after the Ezhattumugham area. The topographical features restrict paddy cultivation to the lower areas. Banana cultivation is found in extensive areas in the riparian zones. These activities have caused serious impact on the remaining riparian vegetation. Clearing of the riparian vegetation has been noticed at many occasions.

Motor pumps operating directly from the river both legally and illegally were disrupting the continuity of the remaining vegetation at more than hundreds of location in the middle and lower regions.

6.3.1.c. Constructions and allied activities

Two large projects within the study area are the Poringalkuthu dam and Thumboormuzhi river diversion scheme. The Poringalkuthu dam owns 220.15 ha of area in the upstream. The river diversion schemes divert water for irrigating 14000 ha of land. Another important construction activity are the bridges and the bunds. Bridge in the Vazhachal, railway and national highway bridges at Chalakudy, bridges at Muzhikkulam and new bridges at Njaralakadavu and Pulikakadavu, and a regulator cum bridge at Kanakkankadavu are the major bridges across the river.

The major problems related with these constructions are not only the reclamation of the riparian area but are mainly due to problems created by the unscientific construction and due to lack of care. Blockage of the river at many places has resulted in the alteration of flow of river and serious damage to the riverbanks. One incomplete barrier across the river at Vettukadavu of Chalakkudy municipality caused massive flow on one side of the river and has resulted in serious erosions of the banks on the opposite side. The same thing was noticed in left side of Njaralakkadvu Bridge where the continuity of the river has been blocked using clay and other materials and left a small area on the left side. They did not remove the clay after the construction and has deposited waste of construction material in that region. Consequent blockage of the river and increased flow on the left side has seriously damaged the left bank and destroyed the houses. And now local bodies are funding for the construction of walls for the protection of the riverbanks. Same thing was noticed in the Kanakankadavu regulator. Here the big construction

materials including large beams were deposited at the centre of the river and increased flow on either side caused severe land erosion. Due to unscientific construction the regulator did not function properly. The people said that the saline water is intruding beyond the regulator. According to them this permanent bund blocked the movement of boats and also affected the fish species. Accumulations of many weeds like *Ichornia* have become a menace for the fisherman. Change from the traditional temporary sand bund to a permanent one on the upper side of the 'thuruthu' has resulted in the complete salination of the ground water in the Kozhithuruthu.

6.3.2. Encroachment

Encroachment and reclamation of riparian area and vegetation for various purposes are another important anthropogenic impact on the riparian vegetation. This was noticed at many places. These are mainly for the agricultural and other private purposes including construction of private farms, resorts and parks related with tourism activities.

6.3.2.a. Agricultural related encroachment

This was noticed mainly in the residential areas i.e. which starts from the Athirappilly and found up to the Elanthikkara. In the Kannankuzhi, Chiklai and Vettilappara areas many riparian habitat were found to be invaded by the local residents. In the Plantation Corporation area i.e. on the left side of the river there is maximal encroachment. Some islets are also found to use up by the local people for agricultural purposes. After Ezhattumugham up to the lower areas the riparian land uses were represented by coconut and mixed crops of private ownership. In most of these areas agricultural practices including banana cultivation has completely destroyed the riparian vegetation. In some area the farmers who have recognized the value of riparian trees for stabilizing the river banks have retained, and preserved at least a thin line of vegetation. Some people in this zone planted some riparian trees including species of *Bamboo* and *Ochlandra*. This protected and planted trees are the only remaining vegetation in the riparian zone. The riverbanks in this vegetation less area is highly eroding. Seasonal agricultural practices of Paddy, Banana, Legumes, Tapioca, are found at many sites throughout the area and in some places within the river.

6.3.2.b. Encroachment for tourism and related purposes

Private individuals and groups are found to construct hotels, resorts, parks and farms in the river margin. Tourism related activities are mainly located in the Athirappilly and Vettilappara areas. There are many resorts in the riparian area after Athirappilly. The Plantation Corporation of Kerala has also encroached about 400-500m of riparian land on

the right bank of the river just after the Athirappilly for the construction of the resort which has completely destroyed the natural vegetation in the river margin. Many similar cases were found in this area. Encroachment and construction for making private farms were noticed in the middle areas, for e.g. in the Chalakudy municipal area many private land holdings and farms including the 'divine' and new tourism resorts just aside the national highway, found to invade and have constructions in the river margin zone. In the same way some local people also invaded the area at many places. In the lower zones the floodplain wetlands and the brackish water bodies has reduced so much due to reclamation for various destructive purposes. These encroachments not only destroyed a major portion of the riparian vegetation but also raise many questions of social significance. One significant thing is that a majority of the riparian lands were either encroached or has been destroyed or eroded. Starting from Athirappilly most of the riparian lands were under private ownership.

6.3.3. Sand mining

Sand mining is the most destructive and problematic human activity on the river. The condition of Chalakudy River is not much better than other rivers of Kerala in this aspect. Sand mining in the river has been located at many places just below Ezhattumugham and continuously seen up to Elanthikkara. A study conducted by Centre for Earth Science Studies (CESS) has indicated about 34 authorized sand mining locations in 9 local bodies. Besides these many illegal unauthorized sand mining Kadavu were located throughout the river. In every year about 420800 m³ of sand has been mined from 34 stations of 9 Panchayaths. Mining from unauthorized Kadavu were more than four times than mining from the authorized stations. Local bodies have brought more regulations after the year 2001 considering the pathetic conditions of the river. But after that illegal sand mining has increased very much. According to the local people illegal sandmining activity is under the control of the criminal mafias. It is taking place mainly at nighttime. Local men from Vainthala have explained that every day more than 20 boats were engaged in sandmining from the kadavu. A single boat carry 3 loads of sand at a time and each boat usually take 2-3 loads per day. They usually work at night starting from 5 p.m in the evening. Local people complained against this criminal activity to the police and local bodies. They said that police is not taking any action against the mafia gang. The local body members including the president also have the same voice that the police and the responsible agencies were not taking necessary actions. At many occasions they have given details and complained and nothing has happened. Sand mining from this Vainthala Kadavu has been banned by the Panchayath due to the

presence of drinking water supply schemes. Similar things were noticed throughout the river. The riparian areas and the riverbanks were eroded seriously and the common riparian lands were disappeared. People were struggling for the protection of their lands from erosion.

Sand mining Kadavus are locations for piling up and transport of the collected sand. Sand mining takes place almost uniformly from all areas. In the Edathrakkavu area people had made a Lorry track with use of sand and rocks through the middle of the river. This has totally changed the structure of the river.

Our survey brings out the fact that about 32 large sand beds covering approximately 260 ha of area have been disappeared during 1976-2000 period. Only two sand beds one at Arangali Kadavu and another at the Mambra- Annamanada area have retained. Aranagli is protected mainly due to the strong vigilance of the local people. And the Mambra sand bed is related with Siva temple of Annamanada and famous 'Sivarathri' rituals. Data of the hydrology section of the Irrigation Department at Chalakkudy indicated that riverbed has lowered up to 5 meters in many locations since 1976 and 1998. After 1998 the sand mining activity is continuing and now conditions has become more critical. This has resulted in soil erosion of the river banks subsequently causing serious damaged to the riparian vegetation. This has also affected the physiochemical properties of the water, increase turbidity, salinity intrusion, destroy microhabitat and cause serious impact on the aquatic organisms especially of fishes. In the lower areas in the Elanthikkara the sand mining is severe and the riverbed has lowered considerably. Lowering of the riverbed affected the ground water table and increased drinking water scarcity. People from the lower areas like Puthenvelikkara Panchayath pointed out decrease in water level, drying up of wells with the starting of summer and increased salinity intrusion. Experiences of the people from the middle areas like Chalakkudy are not much different. A study conducted by K.S.S.P in 1991 indicated drying up 70% of wells in the summer season. People also indicated that this phenomenon has started in recent years after 1980s, which clearly indicate the direct relationship of the indiscriminate sandmining for industrial purposes.

Local people said that criminal gangs control most of these activities. Many local residents had history of encounters at various levels. According to them the bed level has lowered seriously at many places. In the lower areas the bed level is below sea level. According to some fishermen in the Puthenvelikkara this has resulted in high salinity intrusion and adversely affect the fish availability. They also said that the lowered water level had drained underground water from the surrounding areas and all most all fresh

water resources especially wells have become seasonal. Acute drinking water scarcity was located in the riparian areas.

One traditional sand mining labourer called Antony living in Puthenvelikkara narrated a clear story of the sand mining. This he described the evolution of the sand mining methods by the increase in the activity and lowering of riverbed. The 67 years old man recollect that he is doing this work from the age of 13 i.e from 1959. At that time very few people were engaged in this activity. They usually collect sand from various sites on demand by any local people. He said that they collect different type of sands of various grain sizes for various requirements from different places. Salinity intrusion was not severe in that time. He recollected that many places in the river including the confluences of Chalakkudy and Periyar at Elanthikkara could be crossed easily by mere walking. Now it has become more than 40-50 feet deep. He described various methods used by them at many occasions. In the early times they simply lifted sand with buckets and collected. Lot of sand beds were present at that time and areas were very shallow. Now it has evolved into using a 35 feet long bamboo stem and a connected net at the tip for the collection of sand. He said that he is very healthy and only have some problems related with hearing and breathing caused by continuous drowning in water. But the modern technique of using bamboo stem nets causes serious back pain and every man engaged in the sandmining activity is becoming seriously injured within 5-10 years time. (Diagram.4.)

Most of the people including Antony indicate sandmining as the prime reason for the clearing of riparian habitats. He recollected that many large riparian trees including *Thespesia* were cut down in these times. He believes that only vegetation especially riparian and mangroves can stabilize the riverbanks.

6.3.4. Quarrying and clay mining

Clay mining is severely located in the wetland and paddy fields. It was not severe in this basin in the early times and now from the Periyar and Karuvannur basins they have shifted to Chalakkudy basins and that has increased the thrust. Clay mining is mostly located in the paddy fields. It is mainly for two reasons. One is the availability of clay and they can easily access paddy fields because the people were not very much interested in agriculture. Most of them sell clay from the paddy fields for making money.

Granite quarrying in 50 ha of 3 Panchayaths, laterite quarrying in three Panchayaths and clay mining in six Panchayath were observed (George 2001).

6.3.5. Felling of the trees and clearing of the riparian forest

Cutting of the riparian trees were observed not only in the residential areas but also in the islets of the upper region. In the forest areas of the zone-1 and II tree felling was not observed seriously. In some region in the Vettilappara trees in the islets are found to cut down by the local community. Local people said that they cut and use these trees for various purposes including agricultural, fishing and other personal purposes. The local community also uses up species of Bamboo and Ochlandra. These areas are under the jurisdiction of Department of Forests. But now it is not severely seen. Some people are found to cut down large amount of small reeds for making bags and handles for 'bigshoppers'. These people come from the plantation area. These areas are away from the vigilance of the local people and Forest Department. This type of increased activity is also a threat to the riparian vegetation. In the forest areas cutting of the riparian trees for firewood, by tourists and cinema shooting were observed. Strict actions of the Forest department are needed to control this activity.

In the lower areas almost all-riparian vegetation were found to be cut down by local people for different purposes. This ranges from localized collection of wood for fishing purposes, cutting for firewood, agricultural and other allied activities and up to clearing of the areas for economic needs. Large private firms and individuals are clearing the riparian vegetation for various purposes.

6.3.6. Over use of resources

Local people depend on this vegetation and river for many livelihood activities. In the forest area collection of firewood especially by the people from outside is found to cause damage to the existing vegetation. Due to the decrease in the resources and evergreen character of the vegetation collection of no-wood forest products by the tribesmen also causes problems. Some residents from nearby locations are found to collect firewood from the riparian areas. They damage the trees or tree parts and then the plant would die and they can collect it as firewood. This has serious impact on the vegetational structure by opening up of the trees. Cutting down of living trees for firewood were observed in the lower region also.

6.3.7. Poaching and illegal fishing

Poaching has been reduced by the strict vigilance of the forest officers. But we have located signs of pouching at three times in the riparian forests of the Athirappilly Vazhachal areas during our trips. Skins of Sambar deer after the removal of flesh was found buried in the riparian forest of the Athirappilly –Vazhachal area. Illegal fishing is also observed in many areas. Many local people are found to fish from the forest areas

using large nets. For fishing many people use dynamites in this zone. In the Vazhachal and Athirappilly areas dynamiting was observed at many occasions.

Dynamiting for fishing is found to be a common activity after the Athirappilly region. Now tourists are also engaged in such illegal activities. We have counted 37 blasting during a 3-4 hour transect walk from Athirappilly to Thumboormuzhi in 2001 March. Collection of small hill stream fishes was also noticed in these areas. Young people and children were engaged in this activity. This is very frequent in the lower areas. On further investigation it is found that these people collect these fishes and sell them to some agency located in Eranakulam. Forest officials had strictly warned locals against doing such activities in the forest areas.

The activity of dynamiting and over fishing was severe in the lower areas. Dynamiting is become a common practice and we have observed this at many occasions. Locals had indicated that many people were injured during this activity. Illegal large-scale fishing by use of banned nets with small mesh sizes were also recorded from many places in the lower region.

6.3.8. Fire

Serious damage due to fire on the riparian area and in the adjacent lands was noticed at many locations. Fire damages were severely noticed in the plantation areas and areas near to residential zones. During every summer season people put fire and destroy the vegetation. The staff of the Department of Forests, members of V.S.S and members of the Participatory Forest Management are engaged in fire protection. Fire linings were made on either side of the roads in each season. This has succeeded in protection of the forests from fire upto a controlled level. But in the lower areas and plantation areas damages due to fire is high. And the local people in that area do not care. At many vulnerable locations we have spotted forest fire in the last summer. The fire is found to spread from the teak, rubber and oil palm plantations and from previously fire degraded secondary dry deciduous forests. It was noticed in the Poringal powerhouse area, lower side of Vazhachal, Ittiany area, Athirappilly and plantation areas, and Thumboormuzhi and lower areas. Occasional fires in the summer season destroy the understory vegetation, kill the trees, destroy the herbaceous layer and destroy the seedlings. This changes the evergreen nature of the riparian vegetation and increase soil erosion.

Clearing vegetation in many areas by using of fire is a common practice. This is found not only in the upper region but also noticed in many agricultural lands in the

lower region. This causes a serious loss to the quality of land and resulting in erosion of the topsoil.

6.3.9. Grazing

Grazing is also noticed throughout the area. The riparian zones are always rich with herbs, grasses and seedlings. This attracts the cattle. In the lower region many cattle were freely allowed to graze in the riverbanks and sand beds. These activities were mainly located in the sand beds and are a part of livelihood activities of local people. In a normal condition the grazing will not adversely affect the region. But the highly degraded condition of the riverbank vegetation and decrease in the sand beds for grazing has increased the stress on the remaining vegetations. In the Vazhachal Athirappilly forest area cattle mainly from Vettilappara and Poringalkuthu region were allowed to graze on the forest. This has found to damage remaining beautiful riparian forests.

6.3.10. Tourism

Throughout the riparian zone in the study area tourism activities create more problems. Reclamation of remaining patches of riparian vegetation was noticed in the upper and lower zones. In the tourism zones like Athirappilly and Vazhachal areas intrusion of tourists to the riparian forests and their activities like, bathing, fishing, and cooking are found to damage the riparian vegetation. Uses of liquors were noticed highly in these areas. The broken bottles, littering wastes including plastics has become a big problem. The Anamala road passing through this area supports such activities of the tourists. Through the road they can approach any site upto Sholayar. At many sites in the upstream areas of Vazhachal tourists makes their entry and destroys the vegetation and litter plastic, liquor bottles and other wastes in the river. We can find decayed wastes and bunches of plastic plates, glasses and carry bags starting from the Vazhachal Bridge. The Forest Department has initiated many awareness programs and strict vigilance. But protecting the important areas from tourism activity and restriction of such activities within the tourist zones is a necessity in a conservational point of view.

Findings and Discussion

This short-term research carried out to analyse the present status of the riparian vegetation in the middle and lower reaches of the Chalakkudy River brings out many significant features of the riparian vegetation. This enables the analysis of factors relevant to river protection, biodiversity conservation and other social, economic and ecological dependence. The remaining vegetation patches were identified, mapped and its status was analysed in detail. Ecological as well as social significance of the riparian vegetation was analysed through scientific sampling methods and by relating it with social aspects.

7.1. Structure, composition and configuration of riparian vegetation

The structure and status of riparian vegetation was found to vary according to the topographical and demographical features of the area. Most of the riparian lands and vegetation in the lower elevations has been lost. The zone-I area from Poringalkuthu upto Vazhachal is found to possess continuous stretch of >10m width of riparian forest along the riverbank. Atleast 92% of this area contains >10m width of evergreen forest, which accounts for 49.7% of the riparian vegetation in the total study area.

The zone-II extends from the Athirappilly waterfalls to Thumboormuzhi (100-50m) holds second position. In this zone the river margins are highly damaged and which account for only 3.4% of >10m width riparian vegetation and the riparian areas of the islets account for 53.6%. Altogether 57% riparian area of this zone represent >10m width of evergreen riparian vegetation which account for 46.13% of the total riparian vegetation.

Riparian forests in these two zones fall under the jurisdiction of Department of Forests and away from the main residential areas. These two zones together account for the 95.2% of the total riparian vegetation in the study area. The lower zone contains only 4.7% of >10m width riparian vegetation. Most of the riparian zone in the lower area is highly degraded. A thin layer of highly disturbed and low diversity (<10m width) vegetation was seen throughout and this remaining vegetation was dominated by species of *Bamboo*, *Pandanus*, and *Saccharam*.

Species composition in the zone-I and II are similar to that of wet evergreen forests and are dominated by species like *Hopea*, *Madhuca neriifolia*, *Syzigium occidentale*, *Vateria indica*, *Xanthophyllum flavescens*, *Cinnamom riparium*, *Dimocarpus longum*, *Humboldtia vahliana*, *Elaeocarpus*, and *Homonoia riparia*. Area between Poringal powerhouse and Vazhachal waterfalls records maximum diversity of these

species. Species composition is very similar to that recorded from wet evergreen forests of different areas of Western Ghats including Nelliampathy, Sholayar, and Kalakkad. Moderately and highly disturbed areas in this zone also possess these species. Some deciduous species like *Terminalia*, *Xylia xylocarpa*, *Erythrina* appear in disturbed areas. The lower regions are also represented by evergreen species mostly of *Bamboo*, *Pandanus*, and *Thespesia*.

Species richness in the zone-I and zone-II correlates with that recorded at many sites of Western Ghats. Highest value for species richness was recorded in Vazhachal area (200-300m altitude) 13-species/0.01 ha (>30 cm girth) and 39 tree species/0.1ha (>20cm girth) of zone I. This is higher than that recorded in the 30 species ha⁻¹ in Nelliampathy, Kerala, and to 64-85 species ha⁻¹ that observed in the high elevation forests of Kalakad. In the wet evergreen forests of tropical regions tree diversity ranges from 20 species ha⁻¹ in Rio Xingu in Brazil to 307 species ha⁻¹ in Amazonian Ecuador. On that account the species richness in this riparian forest is intermediate. Local climatic factors, geographical peculiarities and extent of external stress may be the reason for these variations.

The presence of some light demanding species like *Macranga peltata*, *Mallotus*, *Terminalia* and *Homonoia* is due to open areas on the riverside and also on the adjacent plantations. Tree diversity of these zones is similar to that recorded in wet evergreen forests of Western Ghats. Mean tree density of Vazhachal area 200-300m elevations CUD (Comparatively Undisturbed Zone) is higher 11.9/0.01 ha is greater than that of 419 trees/ ha reported as mean tree density for Western Ghats closed-canopy evergreen forest. Highest basal area recorded 18.22m²/0.01 ha (>30 cm girth of quadrat 12 of zone I(200-300m)) ranges between that observed in tropical wet forest of Rio Xingu Brazil 25.5m²/ha and 82.76m²/ha in tropical rain forest of Reunion Islands. These riparian forests are dominated by species of Lauraceae, Euphorbiaceae, Myrtaceae, Rubiaceae families.

The islets in zone-I just above the Vazhachal waterfalls and the riparian area represent maximum value in species richness, density and abundance. The islet of zone-II also represents similar vegetation. In the lower zone the vegetation shows less species richness and abundance. Species like *Barringtonia acutangula*, *Humboldtia vahliana*, *Syzigium occidentale*, *Homonoia riparia*, *Madhuca neriifolia*, *Elaeocarpus*, etc are the true riparian species found abundantly in the CUD and MD zones and is above 50m altitude (zone-I and II). The lower areas are mostly represented by the species of *Bamboo*, *Pandanus*, *Saccharam*, *Thespesia*, etc. Species of bamboo and *Ochlandra* are

abundant in the disturbed zones throughout the river margin. The I.V.I for *bamboos* in all zones are very high and follow a uniform distribution from the high lands to the sea level along the riverbank. The I.V.I values for *Pandanus*, *Saccharam*, and *Thespesia* were high in the lower quadrats. Only available small patches of riparian vegetation in the lower areas are dominated by these species. The lower quadrats were low in species diversity and density. The lowest region extent from Kuzhoor to Elanthikkara is posses very few plants of *Thespesia*, *Ficus*, and few species of mangroves like *Avicennia*, *Acrostichum*.

Many wet evergreen species like *Xanthophyllum flavescens*, *Hydnocarpus dpina*, *Vateria indica*, *Hopea parviflora*, were distributed up to 100-200m lower elevations. Plants like *Elaeocarpus*, *Madhuca neriifolia*, *Barringtonia acutangula*, *Humboldtia vahliana etc* are located up to 50m altitudes. Inspite of the human interventions and consequent destructive landuse in the adjacent lands the riparian vegetation distributed upto very lower elevations. This is a unique feature of this riparian vegetation

7.2. Importance of riparian vegetation

Observations and analysis of vegetation in the riparian zones of the study area brings out the following ecological and social significance of the riparian vegetation.

7.2.1. Ecological significance

7.2.1.a. Influence on the microclimate and protection and stabilization of river margin

Any plant species need a particular microclimatic condition for its establishment. The climatic climax type of natural vegetation for tropical regions having high rainfall is the wet evergreen forest and is usually found above 500-600m altitudes. In this study area many such tree species were distributed upto very lower elevations (100-50m Above M.S.L). These species are distributed along with riparian plant communities and shows variations with the presence and absence of riparian plant communities. Orchids are also very sensitive to microclimatic conditions and are usually found on the trees of wet evergreen forests. About 8 species of orchids were found on these riparian trees. The presence and abundance of orchids in small riparian trees (for example *Syzigium occidentale*, *Homonoia riparia*, etc) are also indications of the influence of the river and the riparian plant communities on the microclimatic features.

The riparian vegetation rich zones are protected from erosion of soil and degradation of riverbanks. Conditions of damaged riparian areas of Vazhachal, Vettilappara, Ezhattumugham and lower areas are examples. The protected riverbanks by the riparian

vegetation in many places, inspite of other obstructive factors like sand mining can be taken as examples. Many local people were protecting their land with the use of bamboo and other available tree species.

7.2.1.b. Importance in watershed regeneration

The perenniality of the first order and second order streams has great significance in the regeneration of watersheds. In the study area about 61 small (<1km² catchment) and 19 large streams drain into the river. Of which 51 small and 13 large streams were above 50 m altitude (Zone I and II). Only a single stream, the Kannankuzhi thodu joining just below the Athirappilly waterfalls is found to be perennial and it is the largest stream in the study area (about 50 km² catchment). The dry nature of the plantations is the major reason behind the degradation of these streams. Areas of Plantation Corporation of Kerala on the left side of the river alone has 27 streams and are in totally degraded conditions. Almost all-riparian vegetation in this area has been destroyed.

Watershed regeneration aims mainly on conservation and regeneration of water, soil and biomass of an area. Regeneration of the streams is an immediate need. The evergreen forests are important for maintaining the perenniality of streams and for improving the ground water recharge and local climate. Riparian plant species are more important for the regeneration of the first order and second order streams. Bamboo and *Ochlandra* are commonly used for this purpose. Watershed regeneration attempts can be accelerated by protecting and planting suitable riparian plants, based on the topography, soil condition, altitude, and other conditions of an area.

7.2.1.c. Biodiversity conservation

The most important character of the riparian vegetation is their role in biodiversity conservation. The riparian forests present throughout the area are found very diverse in their floristic composition and support a lot of terrestrial as well as aquatic fauna. In the zone-I and II the vegetation supports significant wildlife including many endangered and endemic species like *Asiatic elephant*, *Tiger*, *Liontailed macaque*, *Nilgiri langur* and so on.. More important, the riparian vegetation supports both terrestrial as well as aquatic animals. The degraded remaining patches of vegetation near the lower residential areas also support local gene pools. They support wild species of resident birds like *King fishers*, *Night heron*, *Storks*, *Owls* and small mammals including *Otters*, *Civet* (As reported by the fishermen).

The riparian forest of the zone I from Poringalkuthu to Athirappilly and the islets of zone-II have great conservational value. The 2-3 km areas upstream of Vazhachal

waterfalls can be considered as the core area because this area record maximum species diversity and support maximum wildlife in the study area. The riparian forest of this area recorded maximum number of evergreen tree species. In the present study we have recorded 39 trees from 20 quadrats (0.1ha) of zone-I. This area records 329 flowering plants of 260 genera and 97 families including 8 species of orchids. Of which 24 species are endemic to Western Ghats and 10 are rare and endangered species (TBGRI, 1996) . Dr. V.S. Vijayan (SACON, 2002) reported 52 endemic species from this riparian forest. From riparian forests of 300-400m elevations in the Vazhachal area (50% area survey) we have identified 168 plants of 144 genus of 66 families including 79 tree species and two remain unidentified. The families Fabaceae, Euphorbiaceae, Orchidaceae and Rubiaceae were dominant. This account for about 30% of tree species recorded in the entire Vazhachal forest division.

Inspite of the plantations in the surrounding region this small stretch of evergreen riparian forest recorded 21 species of mammals including 9 endemic species like *Asiatic Elephant*, *Tiger*, *Lion tailed macaque*, *Nilgiri langur*. The avifauna in this area recorded up to 195 species including 6 endangered and 8 species endemic to Western Ghats (Raju, 2002) of which 160 species recorded from the 2 km stretch of riparian forests just above the Vazhachal waterfalls. This includes the *Great Indian* and *Malabar Pied Hornbills*, *Fishing Eagle*, *Darter* and a critically endangered species i.e the *White Backed Vulture*. Sushanth (2002) records 231 species of birds and 170 species of butterflies from this Athirappilly Vazhachal area (i.e. Zone-I). In a recent study of the Forest Department located nests of 24 *Grey*, 4 *Great Indian* and 1 *Malabar Pied Hornbills* from these riparian forests. R. Kannan (1993) indicate that hornbills need evergreen habitats with trees having at least 1.43 m average breadth and 43m height for their nesting. In this area such large trees are present only on the riparian forests.

Ajith Kumar *et al* (1999) recorded about 71 species of fishes from these zones. The Chalakkudy River recorded maximum number of fishes perhaps in India i.e. 104 species (NBFGR, 2001) . This area is important for the livelihood activities of primitive endemic Kadar tribals especially for fishing.

Many species located here are having very important conservational values at national and international level. Many projects like Project tiger, Project elephant, and efforts for conserving species like *Lion tailed macaque*, *Nilgiri langur* and *Hornbills* are examples.

Many tree species listed in this riparian forest are keystone species of these important animals and birds. Species like *Hopea parviflora*, *Terminalia bellirica*, *Pongamia pinnata*, *Mangifera indica* and *Syzigium species* etc are food plants of Nilgiri langur . Many plants like *Ficus hispida* and other species of *Ficus*, *Syzigium*, etc are food plants of Hornbills. Wesley *et al*, (2001) report the importance of riparian forests and their continuity for the conservation of *Nilgiri langur*.

7.2.1.d. Forest Continuity and Ecological corridor

This forest area lies in between the Nelliampathies in the North, Parambikulam-Anamalais in the East and Idamala-Pooyamkutty valley in the South. These areas are few important biodiversity rich evergreen forest areas of the Western Ghats (Nair, 1991) . The unique riparian forest in the Vazhachal area support and maintains continuity of these forests.

The continuity of the forests is important for biodiversity conservation. Many animal species require this continuity atleast for their seasonal migration. The Vazhachal area is an important elephant corridor that connects the Idamala-Pooyamkutty valley to the Parambikulam area, which is of great value in the conservation of elephants. These areas including Vazhachal come under Anamala Elephant Reserve – 9 of Project Elephant meant for the conservation of *Asiatic Elephant* by MoEF.

This factor brings out the significance of this small but important area. As mentioned by the Forest Department in their Conservation Plan, protection of this zone by raising its level to a Wild Life Sanctuary is essential. In turn this can contribute very much to the watershed, forest and wild life conservation activities of the entire area.

7.2.2. Social significance

The riparian vegetation has great social significance as they provide direct and indirect economic and livelihood support. Most of the well-maintained riverbanks were protected by riparian vegetations present in each area. They also decrease soil erosion and support silt, sediment and nutrient deposits and is important for fish diversity.

Fishing is a major means of livelihood in the study area. Thousands of people including tribals depend on this river for fishing. The primitive endemic Kadar tribals of the Vazhachal and Pokalappara area used to fish from the river and fishing is an important livelihood activity of this tribe. According to them the area near Vazhachal Bridge and some areas in between Vazhachal and Athirappilly are their major fishing grounds. They have been collecting fishes weighing upto 12 kg, from this area and their

catch at a time vary from 5-20 kg. Important economically valuable fishes in this area are 'Kuyil, Chooru, Pachilavetti, and Moden'. Most of this species found to eat leaves and fruits of riparian plants. According to the tribals they use fruits and flowers of *Hopea*, *Madhuca* and *Ficus*, as baits for catching these fishes and these fishes are available plenty in waters below this riparian plants especially in the fruiting season.

The Puthenvelikkara Panchayath alone has about 1149 people including 570 males and 579 females engaged in inland fishing activities (George, 2000). According to them the vegetation rich areas are major fishing grounds. The vegetation in the riparian zones and also on floodplains is essential for seasonal migration of fishes especially during summer. They have listed about 42 edible, economically valuable fishes, 3 crabs, 4 molluscs and 5 types of prawns. Of which 19 fishes were freshwater species. Ajith Kumar *et al* (1999) recorded 104 species of fishes from this Chalakkudy River and have recorded about 72 species from the Vazhachal Athirappilly area.

The tribals depend on this riparian vegetation for collection of Non Wood Forest Products. They also depend this vegetation for materials used for making their huts (Mainly *Bamboo* and *Ochlandra*). In the lower regions many riparian plant species are economically valuable ones. The *Pandanus* and *sedges* are used for cottage industry. This *Pandanus* mat is an important economic resource of women in the costal areas. Most of the fishing gears are made by *bamboo* and other tree species. The species of *Thespesia* 'pooparathy' is used for making boats and gears. The 'Punna', *Calophyllum inophyllum* is extensively used for 'Cheenavala ' Chinese-dip net and boat making.

The majority of the population depends on this river for their drinking water and agricultural requirements. Many people are found to be engaged in inland fishing activities, which more than its production value support many human communities by providing livelihood. Local people are found to depend on this riparian vegetation for stabilizing the riverbanks and protecting from riverbank erosion induced by various human activities including sand mining. Most of the people are found to depend this vegetation for their basic requirements as tribals in the upper areas and fishermen and other local people in the lower areas.

7.3. Factors affecting vegetation

Fragmentation and clearing of riparian forests, changes in the hydrological and physiochemical parameters of water and changes in the terrestrial and aquatic environment mainly due to human activities are the major factors influencing riparian vegetation. The changes in the quantum and availability of water due to changes in the

flow, irregular regulation and flushing out of water controlled by dams, uptake and diversion of water for various purposes, indiscriminate sand mining and subsequent lowering of water level etc has great influence.

7.2.1. Fragmentation

Fragmentation of the riparian vegetation through clearfelling and encroachment has affected seriously the entire riparian vegetation. Loss of continuity, deterioration in the species composition and structure are main effects of fragmentation. In the lower areas only 4.7% of the riparian area possess >10 m width riparian vegetation.

Encroachments and reclamation of the riparian area for agriculture, tourism and other related activities are the main problems. Local residents have invaded riparian areas at many places beyond Thumboormuzhi for various agricultural purposes. In the Vettilappara, Ezhattumugham areas agriculture activities are noticed on riverbanks, sand beds and also in the islets. The riparian areas just beyond the Athirappilly are destroyed and invaded by oil palm and rubber plantations of Plantation Corporation of Kerala. The riverbanks of Chalakkudy area retained a thin layer of vegetation mostly Bamboos in the vicinity of local residents. The lower riparian areas are almost completely destroyed.

Private groups and individuals have constructed many farms, hotels and resorts in the riparian zone. In these areas the river margins were invaded and natural vegetation has been destroyed. The farm of 'Divine' and a tourism resort in Chalakudy, resort of PCK other private ownership in Athirappilly are examples.

Serious fire damage to riparian vegetation has been located in many areas. Due to dry nature of plantations chances for fire damage is very high. We have recorded fire in many degraded location like Poringalkuthu powerhouse, Plantation areas of Athirappilly, and Vettilappara. fire degradation and subsequent clearing of riparian vegetation is noticed in many agricultural dominated zones.

7.3.2. Dams and other constructions

Usually rivers and streams have a one-way downhill flow, and in these lotic environments flow rate is of prime importance in determine the nature of plant and animal community (Osborne 2000) .

The deterioration in the species composition and structure of riparian vegetation due to decrease in the flow of water can be observed in the riparian area just below Poringalkuthu dam. Where species composition is very less (3 species/ 0.01 ha in quadrat 1) there are deciduous plants (*Lagerstroemia*, *Terminalia*, and *Ochlandra*) with very less

basal area 2.5m^2 . Soil in this area is highly eroded and forest fire is also noticed. This is because water is diverted from the dam to the powerhouse through tunnels. The flow in the river is maintained only beyond the powerhouse area. Hence the river in between the dam and powerhouse becomes almost dry and flow is noticed only in the summer season.

Similar things can be observed beyond the Chalakkudy River Diversion Scheme, where water is being diverted for irrigating 14,000 ha of land. One incomplete barrier across the river at Vettukadavu of Chalakkudy municipality caused massive flow on one side of the river and has resulted in serious erosion of the riverbanks. The same thing has happened due to deposition of wastes of construction materials near Njaralakkadavu bridge of Kadukutty Panchayath and Kanakkankadavu regulator cum-bridge of Puthenvelikkara Panchayath. Salinity intrusion beyond the Kanakkankadavu regulator is noticed and these things are mainly due to unscientific planning and implementation of the projects.

7.3.3. Overuse of resources

The riparian zones are generally common lands. Overuse of this vegetation and the river is a major problem. Indiscriminate felling of riparian trees was located at many sites mainly for fire wood (Vazhachal, Athirappilly) timber use (Vettilappara and lower region) and for other purposes like agriculture, basket making, illegal fishing and poaching destroys the riparian habitat. Increased uptake of water for irrigation and related purposes along with sand mining has affected the water table, which indirectly has great influence on the riparian vegetation.

7.3.4. Sandmining

Sandmining is the most destructive anthropogenic activity on the riverine habitat. Chalakkudy River is not an exception, here about 420800m^3 of sand was mined from 34 stations within 9 local bodies. These sandmining locations (Kadavu) extend from Pariyaram to Elanthikkara. Many other small sandmining locations were also noticed. Actually these sandmining Kadavus are locations for piling up and transport of collected sand. Sandmining takes place almost uniformly throughout the river. About 32 sand banks covering 260 ha of area have disappeared from this river during 1976-2000 (Map-9). Only two sand beds, one in Arangaly and another in Annamanada have been retained due to strong vigilance of the local people and also due to their aesthetic and devotional value. The riverbed level has lowered alarmingly in many places. Fishermen are of opinion that the bed level in many lower areas is below sea level and this is the main reason for salinity intrusion. An old sandmining laborer narrated evolution in the

sandmining activity with time and lowering of riverbed, from simple methods to modern methods using 35-40 feet long bamboo stems and attached nets.

As a result the riverbanks were seriously eroded, damaged and most of the riparian lands have disappeared. Older folks recollected presence of abundant riparian vegetation of bamboos, wild trees including Hopea, mangroves, and large trees of Thespesia in the lower zones. Lowering of riverbed drains ground water nearby and cause drying up of wells (upto 32%) during summer months (George, 2001). The depletion of ground water level, removal of sand and sediment deposits has serious impact on the riparian as well as floodplain ecology. This in turn has seriously affected the livelihood activities of river dependent people.

7.3.5. Tourism

Many developmental activities along with tourism has serious impact on the riparian vegetation. The riparian forest of Vazhachal and the three waterfalls are famous for their aesthetic value and is one of the most important tourist places in South India. Increased tourism activities have serious impact on the riparian as well as riverine habitat. The following are the important problem located in the tourism zone.

1. Littering the river and forest with plastics and other waste materials.
2. Intrusion of tourists into the riparian forests throughout the area.
3. Use of dynamites for fishing.
4. Cooking of food within the area.
5. Damaging the trees, rocks and lands of the riparian zone.
6. Destruction of understorey vegetation especially seedlings.
7. Poaching and disturbance to wildlife.
8. Reclamation of natural riparian forest for various tourism purposes in the areas.
9. Use of this area for cinema production resulting in serious damage and waste disposal in the zone.

are highly degraded. Oil palm and rubber plantation have replaced the river margin vegetation. Many construction activities related with tourism also occupied the riparian zone. Plantation Corporation of Kerala has serious stake in the degradation of the riparian vegetation of the area.

Important problems and Recommendations

- Starting from Athirappilly the riparian area has been bounded by Oil palm and Rubber plantations of P.C.K.
- Riparian area in these zone have been completely destroyed
- Remaining vegetation samples are in the islets.
- Diversion of water for irrigation by the Chalakkudy River Diversion Scheme has been found to affect the steam flow and also on the riparian vegetation below Thumboormuzhi
- Plantations have been found up to the river margins at many sites including Chiklai, Vettilappara, Kannankuzhi, and Thumboormuzhi area.
- Illegal activities like dynamiting, overfishing, cutting and clearing of forests, and encroachment of the area were observed in this zone.
- The Department of Forest should identify the problems in these area and along with the participation of the local people and Panchayath necessary steps should be forwarded.
- P.C.K should identify the violation in the riparian areas and should take necessary steps.
- These two zones are coming from the Department of Forests. They should take care of the problem and necessary action should be initiated immediately.
- A separate treatment plan for the riparian zones should be started.
- Entry of tourists and littering of wastes in the river should be terminated.
- Necessary treatment of the degraded area should be started.
- At least 30m width for the regeneration and protection of the riparian forests are recommended for this zone.

Important areas, its status and recommendations based on identified problems

8.1. Zone-I (Poringalkuthu dam to Athirappilly waterfalls:)

400-100m altitude; length 10.5km

This area represents about 49% of the total remaining riparian vegetation in the study area. 92.8% of this zone is having >10m width of riparian forests. There exist longitudinal continuity of the riparian forests upto the Poringalkuthu dam site except some areas. This area represents highly diverse and most dense riparian vegetation in the study area. Great biological diversity was observed and river is also very rich in biological diversity especially in the case of fish fauna. Area near the Vazhachal Bridge is the last remaining elephant corridor and this area is the habitat for the Kadar tribes. Two important water falls of Kerala the Athirappilly and Vazhachal are in this area and are regarded as one of the important tourist spots in south India.

Important areas and their status

8.1.1. Area from Poringalkuthu dam upto the powerhouse

The flow in the river is very less and almost nil during the summer season because the water is diverted from the dam to the powerhouse through the tunnels for power generation. This has affected considerably the characteristics of the riparian vegetation in this area. This is in a highly degraded condition. The density of the trees is very low and diversity is also very less 3 species in the quadrat no. 1, Basal area is also very low 2.65 m and most of the trees are deciduous ones. Fire damage was also located from the area. Soil erosion during monsoon is very high. Nearby forest areas has been degraded into moist and dry deciduous conditions.

Recommendations for conservation

- Ensuring a minimum flow of water in the river is needed for the regeneration of the river and the vegetation.
- Other disturbances are very low in this area and so careful treatment could accelerate the process of regeneration.
- This area is very vulnerable because the slopes in riparian areas are very high and further degradation would lead to complete destruction. The vegetation in the slopes have to be stabilized.
- Possibilities for the regeneration lie upon the existing moist nature of the adjacent forests. Continuous fire and degradation of the riparian vegetation and changes in

the river flow has affected these forests adversely. Immediate treatments are necessary.

- Some degraded patches of riparian vegetation and seedling are found along the banks. Not only the Forest Department but also the K.S.E.B should take such initiatives.

8.1.2. Area just after Poringal powerhouse to the Vazhachal waterfalls.

There is continuous flow in this area because water is released after power generation. This area represents very rich samples of riparian vegetation. Two islets in this area and the riparian areas represent most dense and diverse riparian forests of the study area. They are very much similar to evergreen forests in their species composition and abundance. More than 25-meter width of riparian forests are also present in some areas especially near the islets and the before the bridge. This area is the elephant corridor and most of the animals from the surrounding forests were recorded here especially during summer months. Large riparian trees greater than 10m were recorded here. Maximum diversity in the flora (15-20 species of evergreen trees and lianas per 10 x10 m quadrat) and fauna (Birds 195 species) reported from this area.

Major problems and recommendations

- Disturbance due to the Anamala road passing through this area and which promotes the entry of the tourists other people into the forests areas.
- Entry of tourists to the river and riparian forests were intense and were observed at more than five locations starting from the left side of the river before the bridge, either sides of the bridge, two sites after the bridge including the swampy area, the proposed dam site and the riverside near parking ground and the tourism spot.
- Littering of plastics and other wastes were observed in these sites and decayed materials found to pollute the water. This could be the reason for spread of epidemics like pneumonia and typhoid among the department staffs and tribals during this year.
- Cutting of the trees for fire wood and grazing in the riparian areas were observed and is mainly by the non-tribal people and also by the tourists.
- Invasion of the plantation and weeds like Mikania and eupatorium in the disturbed area like proposed dam site and areas near bridge.
- Strict actions against the entry of the tourists into the river and the forests other than tourism sites are needed.
- Protection and treatment of the degraded areas can bring results.

- Protection of the river from pollution is an urgent necessity.

8.1.3. Area from Vazhachal to the Ittiany

Steep rocky region just after the Vazhachal water falls on the right side and also the Ittiany areas are highly degraded. The evergreen species have been replaced by deciduous plant element, other areas represent the evergreen riparian forests but the adjacent lands are Teak plantations. Riparian areas just after the Vazhachal waterfall especially on the left side and up to Charpa falls is very rich. Soil erosion is very high in the degraded areas.

Recommendations

1. Regenerating samples of riparian vegetation were found after the degraded areas of Ittiany especially at the place where river makes a left turn. The forest of these areas contains regenerating seedlings. Sediment deposition is also very high and which can support the regeneration.
2. An immediate treatment of the degraded zone is necessary for the regeneration.
3. Entry of tourists to the river in the steep area of Ittiany is frequent and has caused human death in the previous year. It should be terminated.
4. Poaching also noticed in these areas.
5. Necessary treatment for the degraded zone and adjacent forest areas is a necessity.

8.1.4. Area from Ittiany to the Athirappilly waterfalls

These areas also have relics of riparian forests. Moderately dense and diverse samples are present. Nearby areas of Athirappilly water falls on either sides of the river is highly degraded. Herbaceous and shrubby layers have been lost. Plantations of Teak are found to invade the riparian area. Soil erosion is severe especially in the area on the right side before the Athirappilly waterfalls. The riparian vegetation present on the left upper sides of waterfalls was represented by a single line of riparian trees and is lined by Teak plantations.

Recommendations

- Rich samples of riparian vegetation are present on the river turnings. This has to be given top priority and conserved.
- Other areas were highly degraded.
- Entry of tourists and their waste disposal is the major problems
- Entry of tourists into the interior area should be terminated.
- Regular programmes should be initiated with the help of V.S.S

8.2. Zone-II Athirappilly water falls to the Thumboormuzhi (100-50m)

This zone possesses about 46% of the total riparian vegetation. 57% of the zone represent the >10m width of rich riparian vegetation and are concentrated in the islets. The river margin areas are highly degraded. Oil palm and rubber plantation have replaced the river margin vegetation. Many construction activities related with tourism also occupied the riparian zone. Plantation Corporation of Kerala has serious stake in the degradation of the riparian vegetation of the area.

Important problems and Recommendations

- Starting from Athirappilly the riparian area has been bounded by Oil palm and Rubber plantations of P.C.K.
- Riparian area in these zone have been completely destroyed
- Remaining vegetation samples are in the islets.
- Diversion of water for irrigation by the Chalakkudy River Diversion Scheme has been found to affect the steam flow and also on the riparian vegetation below Thumboormuzhi
- Plantations have been found up to the river margins at many sites including Chiklai, Vettilappara, Kannankuzhi, and Thumboormuzhi area.
- Illegal activities like dynamiting, overfishing, cutting and clearing of forests, and encroachment of the area were observed in this zone.
- The Department of Forest should identify the problems in these area and along with the participation of the local people and Panchayath necessary steps should be forwarded.
- P.C.K should identify the violation in the riparian areas and should take necessary steps.
- These two zones are coming from the Department of Forests. They should take care of the problem and necessary action should be initiated immediately.
- A separate treatment plan for the riparian zones should be started.
- Entry of tourists and littering of wastes in the river should be terminated.
- Necessary treatment of the degraded area should be started.
- At least 30m width for the regeneration and protection of the riparian forests are recommended for this zone.

8.3. Zone-III Area after Thumboormuzhi to Elanthikkara (50-sea level)

The riparian zone of these areas comes under the jurisdiction of different Panchayaths. This is the lower most area of the river in the study area. Maximum human interaction in the riparian zone and also on the river occurring in this zone. Sand mining has seriously affected the water table and all most all riparian lands has been wiped out.

32 sand beds covering 260 ha of area has been lost since 1976- 2000 due to indiscriminate sand mining. Now erosion of riverbanks has become a major problem. The loss of common riparian lands and high erosion ensues since riparian areas are bounded by private land holdings. Some people have retained samples of riparian vegetation and they are protecting this area from the severe erosion. People throughout the area complain about the illegal and uncontrolled sand mining by criminal “mafia” gangs. This has become a great problem in these areas.

Major problems and intensive areas

1. Sand mining is the main problem found throughout the area. The local Panchayath has declared altogether 34 sand mining locations (Kadavu) in 9 local bodies and license has been given to allow sand mining in a controlled level by the recommendation of the Centre for Earth and science studies, (CESS) Thiruvananthapuram. But now illegal sand mining by criminal mafias are continuing vigorously and the local people and the Panchayath itself had complained to the police but they said that Police and concerned authorities are not taking much efforts. Every night about more than 120- 180 loads of sand is smuggling from the Vainthala Kadavu alone.
2. Erosion and encroachment of the riparian area is severe.
3. Clearing of riparian vegetation: - riparian vegetation in these zones is very low in diversity and composition. They are found in very few sites.

8.3.1. Area from Thumboormuzhi up to Chalakudy

- Degraded patches of mixed vegetation found after Thumboormuzhi. This continues up to Kanjirapilly. In this area soil erosion is high.
- At one place near Edathrakavu temple of Melur sand mining take place so vigorously that a track has been made through the middle of the river with the use of the sand and rocks. And river is flowing through one side causing high degree of erosion to that side.
- At Ezhattumugham many islets have been formed due to spreading of river into more than 7 channels. And people have cleared the riparian vegetation and are practicing banana, tapioca, and other cultivation.
- In some areas of Pariyaram, Melur and Chalakudy bamboo breaks have been found to retained by the local people. These have been found mainly in the Kanjirapilly, Kunnapally, Kuttikad, Pulani and Pariyaram. This is also found in small quantities in the river turning of Elanjipara, Melur, opposite sides of the

Kudapuzha, right side after Chalakudy bridge, near Arangali sandbeds, Vainthala and Annamanada.

- Erosion of river banks have been noticed throughout the area and is intensive on Kudapuzha, Vettukadavu of Chalakudy, opposite sides of the Arangali of Annanadu Panchayath and Elanthikkara temple Kadavu.

8.3.2. Area after Chalakudy upto Elanthikkara of Puthenvelikkara Panchayath.

Sand mining is severe in these area some patches of Bamboo breaks had been found up to Vainthala and Annamanada Panchayath .

8.3.2.a. After Annamanada and Valur

- Riparian areas are highly degraded and only some degraded patches of Bamboo, small trees of Ficus, Thespesia, Screwpine (Pandanus) Saccharam (Njangana) and some grasses have been found.
- Salinity intrusion is noticed in the summer months so the vegetation shows the affinity towards the mangrove associated flora especially in the very lower reaches like Kundur and Elanthikkara.
- Mangroves are not seen along the main river and only some plants like Acanthus ilicifolius, Avicennia and Acrostichum (A bushy halophyte) are found in very low numbers.
- In the lower region near Kozhithuruthu and Kanakkankadave riverbanks have been protected with laterite and granite blocks.

Recommendations and Conclusion

9.1. Recommendations and plans for conservation and regeneration of the riparian vegetation for the protection of the riverbanks.

Being one of the rich rivers of Kerala, the Chalakudy River support more than ten lakhs of people. Keeping aside its problems, this river has maximum resource to support the life of the people in and around its vicinity. Now indiscriminate sand mining, riverbank erosion, clearing of riparian vegetation and the radiation in the fisheries resource have become a serious problem.

This has reduced the quality of water and caused lowering of water table and has affected the water availability. Protection of riverbanks from erosion and protection of our resources means ensuring our future. Any activity to protect this river would be a step towards our cultural wisdom that has been lost from our minds and culture to protect all lives and all life supporting habitats around us.

Based on the available information, some localized specific action is needed for the rehabilitation of the residential pockets of the riparian habitats and its regeneration. We have put forward all available information, problems and recommendation in this report. This chapter focuses only on the possibilities for the rehabilitation of residual pockets of riparian habitat and also on planting of the vegetation at least for the protection of riverbanks.

9.1.1. Important riparian plant species for replanting

9.1.1.a. Pioneer species

1. *Barringtonia acutangula* (Neer pezhu): - a short 5-8m high tree seen abundantly along the banks of river. It can be planted up to the lower region, very easy to establish, is a pioneer associates in the riparian forests. It needs some soil and wetness for the establishment. After establishment it will support the establishment and growth of other riparian tree species. Seeds and seedlings can be collected during April- May. Another species *B. racemosa* (Samudraksham) found to grow on the brackish water areas. This species can be used in the saline riparian areas.

2. *Homonoia riparia* (Kattarali): - It is rheophyte, a small dwarf tree and a pioneer species most common among small rocks of hill streams, along banks and rocky riverbeds and can withstand extreme climatic conditions. This is usually found above 50-100m above MSL and is having capacity to grow on the open spaces. Fruits are very small and germination of the seeds in the nursery needs future studies and experiments. Seedlings can be easily collected. Fruiting season is March-May. It has strong ability to withstand high intensity of light exposure, strong river flow and flood, and can trap and collect sand and silt among the rock crevices and can further support the establishment of grasses, herbs and finally other dominant riparian plant species.

3. *Syzigium occidentale* (Neer Chamba)

An evergreen small tree commonly seen on the bank of hill streams and rivers usually above 100m above MSL, 4-5m in height. Narrow elliptic leaves with white showy typical "Chamba" of flowers. Fruits are small usually seen on march-may. Some times found in

clusters in evergreen areas. This plant found in varying places including Rocky River beds, on islets and usually associated with Homonoia and thus can be regarded as a second sere after the Homonoia type pioneer plant species. They also found on the river margins lining the margins of evergreen patches. Near Charpa and other site we found islets dominated by this species and also found associated with other riparian tree species like Humboldtia and Madhuca. So it can be regarded as a second plant component, which need minimum soil, moisture and evergreen support to establish. Seedlings can be collected and seeds can be germinated. Further investigation needed for successful planting.

4. Mallotus aureo-punctatus

This is also a riparian small tree usually found along the banks of hill streams and rivers. This needs some soil and moisture. This species usually seen on banks of river, sand bed on an intermediate position in between the pioneer species, or river and large tree species like Syzigium occidentale. This grows up to 5- 10m and provides more shade than other pioneer species. Fruits are very small, seen on March- May. Seedlings can be collected. Found only above 100m in the river. It can be planted on the riverbanks of hilly areas having some sand.

5. Humboldtia vahliana (Attuvanchi)

It is a large evergreen tree with dark coloured bark and similar to “Ashoka” tree in appearance. It is found very close to the river along with other riparian trees and evergreen plants above 100m altitudes. This species attains 10- 20m height and girth average more than 100cm. These are abundantly found on the rocky regions having some soil and it always need a touch of water. A single tree found to spread 5-10m in diameter and its root also spreads and cover the ground about 75 % of area of its canopy. Small coral like roots are found to cover the rocks near on the flowing water. It is a leguminous plant, flowering and fruiting in Feb-May period. Fruits are large and can be collected. This tree highly specific to its microclimatic region or niche. Here germination of seeds on nursery condition needs special care and further experiments. Seedlings can be collected from the riverside especially from the area of Vazhachal and Athirappilly. Riparian vegetation having this tree can be considered as some what stabilized or have potential to survive. It can be successively establish near other shrubby and evergreen vegetation and have strong capacity to trap sediments and silt and protect from soil erosion.

6. Madhuca neriifolia (Attu elippa)

It is also a median sized tree found only on the river margins. It is having thick leaves and small round fruits about 3 cm across. Madhuca in some areas known as a “Attuvanchi’ It attains 10 m height and the girth is usually more than 100m. More than 4m girth has been measured for some plants in and after the Vazhachal waterfalls. This species is specific to the riparian habitat and found through out Kerala along banks of rivers above 50-100m altitudes. Seeds can be collected from the areas.

7. Cinnamomum riparium (Vayana -small)

It is an evergreen shrub-tree, usually found along the riverbanks above 200m. Leaves and stems possess an odor similar to Cinnamomum. Leaves are narrow acute. Seeds can be collected during Feb- March period. Usually seen as an undergrowths of evergreen and semi evergreen vegetation along the riverside.

8. Crateva magnum (Nirmathalam)

A small tree with tripinnate leaves and bunches of white, pink tinted flower with clawed petals. Fruits can be collected in March April. This species is also found in the lower reaches.

4. Pandanus (screwpine, Kaitha)

It is an important plant species usually found along the riverbanks in all elevations. In the hill streams species like *Pandanus thwaitesii* are abundant and in the lower regions people were cultivating this for its leaves which are used for mat making. This species is also planted along the river margins and margins of streams and ponds for protection against erosion. Its stem cuttings are used for propagation. The commonly used species is *P. oederotissimus*

10. Ochlandra wightii (Eetta)

It is the common species of Ochlandra found in the riparian areas of Chalakudy River. This differs from the common species *O. travancorica* in its leaf size (smaller breadth in *O. wightii*). Culms upto 7m tall, 2.5-4cm in diameter. This species of Ochlandra are economically very valuable because this is used in making mats, bamboo ply, traditional huts and houses and other required materials. Mostly Ochlandra and other bamboo species are found in the disturbed riparian areas. Species of Ochlandra are found in the upper areas (above 50m altitude) but at many places like Kanjirapilly and Pariyaram people have planted Ochlandra along the riverbanks.

11. Ochlandra scriptoria

This is another species of *Ochlandra* found along the riverbanks of Chalakkudy river (above 50m altitude). This species is less than 5m tall and leaves are very narrow (1.2 cm broad) and have an appearance of a short Bamboo. Internode 45 cm long and 2.5cm in diameter. Commonly called as Reed bamboo and 'Ammei' in Malayalam. This species is also used by the local people for many purposes.

12. *Pseudoxytenanthera bourdillonii*

A moderate sized straggling bamboo forming open clumps. Culms upto 10m tall, internode 45-50cm long, 8-2.5cm diameter, wall thickness varies from 0.8cm to 1.6cm. Endemic to Kerala part of Western Ghats.

12. *Bambusa bambos* (Mula)

It is the common species of bamboo found in the study area. Commonly called as 'Mula'. Densely tufted bamboo, Culms strong, cylindrical, erect, hollow dark green coloured upto 30m tall and 18-25cm in diameter. Bamboo species are found abundantly in some disturbed and dry areas, and this species is found up to the lower reaches of the river. In the lower areas (after Ezhatumukham up to Elanthikkara) the remaining riparian vegetation samples are represented by Bamboo because it protects river banks from soil erosion. It is economically very valuable and the local people are depending on this species for variety of purposes in their life. Another introduced species of Bamboo is found occasionally on the riverbanks. The yellow Bamboo (Manjamula) *Bambusa vulgaris* has been found planted near the Arangali sand bed.

Local people especially the tribes and fishermen extensively use the species of Bamboo and *Ochlandra* for variety of purposes. It is an important part of their life. They use it for making every part of their traditional houses, gears, mats, and also for agricultural activities.

In the forest area, beside the above stated true riparian species many evergreen semi evergreen plants were found abundantly. Most of these species are very valuable and their evergreen nature and affinity towards the water environment could support the regeneration of the riparian vegetation for stabilization of the riverbanks and reconstruction of riparian and riparian ecosystem.

9.1.1.b. Other tree species that can be planted mainly in the forest area are listed below.

1. *Hopea parviflora* (Thambakam)

Commonly known as 'Thambakam', a large evergreen tree having small fruits with two fan leaf like wings. Valuable timber yielding tree, occasionally found in evergreen and semi evergreen forests usually near stream and riverbanks. This species found to grow in low lands up to sea level. Another species *Hopea wightiana* (Kambakam) is also found there.

2. Elaeocarpus munroii (Kara)

A medium sized evergreen tree with 3-4cm long berry. Commonly called as 'Kara' and its fruits are edible. Older leaves become reddish before falling. This species occurs upto the lower region near sea level. Other two wild species are found along the riparian forest of Vazhachal *E. tuberculata* and *E. serratus*. Seeds can be collected during April-May and can be germinated.

3. Aporosa lindleyana (Vetti)

Small evergreen tree commonly known as 'Vetti' usually found in evergreen and semi evergreen forest. Another species *Aporosa acuminata* is known as 'Neer vetti' is found in the Vazhachal area. These species is more suitable to the forest areas.

4. Baccaurea courtallensis (Muttilthuri)

It is an evergreen tree species commonly known as 'Muttilthuri'. Fruits are edible found only in the evergreen forests usually in the riparian areas above 200m. It is found abundantly in the Vazhachal area.

5. Carallia brachiata (Vaalbham)

It is an evergreen tree similar to mangroves and commonly known as 'Karakandal'. Occasionally found in the evergreen semi evergreen forest and riparian forest and also found in areas up to sea level.

6. Ficus sps (Athi)

Numerous species of *Ficus* found in the study area of which *Ficus racemosa* found along the river margins and another species *Ficus glomerata* (thondi) is also abundant. These species are more suitable for the riparian environment.

7. Hydnocarpus sps (Marotti)

Two species of *Hydnocarpus* were found along the river banks of which *H. alpina* (Malamarotti) is found in the forest areas and *H. pentandra* is the common Marotti found occasionally along the riverbanks up to the sea level.

8. Terminalia sps

Many species of Terminalia were found in the study area of which *T. arjuna* (Neer maruthu) is found in the riparian forest. Other species like *T. chebula* (Kadukka), *T. paniculata* (maruthu), *T. crenulata* (Thembavu) are also found in the riparian forest. Another species *T. bellirica* (Thani) found growing up to sea level. It is a deciduous forest tree and seedlings were widely distributed throughout the state as a part of afforestation programme by the Department of Forests.

9. Pongamia pinnata (Vungu, Venga)

A medium sized tree commonly known as 'Venga' occasionally found in the riparian forest and also in areas up to sea level. Seeds are large and can easily collected in the March-April months. This can grow easily and have the capacity to establish in the dry areas.

10. Syzigium species (Chamba)

Beside the true riparian Syzigium occidentale other two rare species *S. malabaricum*, are found in the riparian forest of Vazhachal. The common species *S. cumini* (Njaval and Njara) are found in the forest and vegetation rich areas up to sea level. Many garden varieties of Syzigium are available nowadays.

11. Vateria indica (Vellapine, Pinum)

It is a large leaved large evergreen tree commonly found in the evergreen and semi evergreen forest and also found in the sacred grooves and riversides up to sea levels. The seeds can be easily collected and germinated. The tree has the potential to grow in varying habitat, extreme sunlight especially in the presence of some moisture. So it can be considered as a key species for the regeneration and protection of riparian forest.

Beside these many valuable forest trees not only for their ecological properties but also have economic importance were found in the riparian forests. Most of these species can be successfully used for regeneration of riparian forest.

9.1.1.c. Riparian species found only in the lower area

1. Trema orientalis (Amathali)

Commonly known as 'bird cherry' or 'ami' is found abundantly in the lower areas of Chalakudy river having fresh water especially near Chalakudy and surrounding areas. Can be grown easily.

2. Glyrricedia maculata (Seema konna)

It is abundantly found through out the river margin and is used for fencing, and also for organic manuring. The stem cuttings can be used for propagation.

3. *Saccharum arundinaceum* (Njangana, Iringana)

It is similar in appearance to sugar cane and is found abundantly in the very lower areas of Chalakudy River. Usually grow in groups and is planted by local people for the conservation of riverbanks from erosion. Stem cutting can be easily used for propagation.

4. *Pandanus* species (Screw pine, “Kaitha”)

It is very economically valuable species found through out the river margin and also along the margins of streams and ponds. Mainly cultivated for protection of stream banks and also for its leaves. After drying leaves are extensively used for making mats (Thazhapaya), bags, purses and baskets. This is an important livelihood activity of the coastal areas. This plant can protect the riverbank from heavier soil erosion and provide suitable habitat for the aquatic organisms.

5. *Thespesia populnea* (Pooparuthi)

It is a strong timber-yielding tree found in the lower areas of river. It can grow near saline waters and is used for making furniture, boats, and fishing gears.

6. *Hibiscus tiliaceus* (Veli paruthi)

It is also a tree similar in appearance with *Thespesia* and are usually used for fencing. It also grows along and near water bodies especially in the lower reaches. along the banks of streams and river. Commonly used for fencing.

7. *Polyalthia longifolia* (Aranamaram)

Is a tall evergreen tree commonly growing in the gardens as ornamental tree mostly seen in the lower elevations. Can be grown associated with other riparian plant species.

8. *Lawsonia inermis* (Henna “Mailanji”)

It is also small tree found up to sea level extensively used for fencing. Leaves are used as henna. Stem cuttings can be used for propagations.

9. *Casurina* sps (Kattadi, Choola)

Casuarina has been extensively used for planting in the severely damaged banks of brackish water bodies especially in the sandy areas. This plant is not a supporter for the improvement of soil and other vegetation but can be used in severe conditions of bank erosion.

9.1.1.d. Mangrove and associated species.

1. *Avicennia officinalis* (Kandal or Upputha)

Is an evergreen true mangrove species found in the mangrove forests and disturbed saline areas. This species is one of the true mangrove species having wider distribution and are found in the riparian areas of Chalakkudy River.

2. *Rhizophora mucronata* (Vallikandal)

It is an evergreen halophytic tree with long pendulous viviparous fruit. Is a true mangrove species, represented only by a single small young plant located in Elanthikkara.

3. *Acrostichum aureum*

It is a rhizomatous shrub found abundantly in the banks of streams and rivers in the saline areas. It is an indicator of salinity intrusion and has the ability to bind the soil from erosion and stabilize river and stream banks.

4 *Derris trifolia*.

It is a woody climber found along the riverbanks of saline areas. These two plants *Acrostichum* and *Derris* are mangrove-associated species. Many other plants including grasses and trees like *Thespesia populnea*, *Lawsonia inermis*, *Ficus* and *Morinda citrifolia* also can be used for planting in the saline areas.

9.1.2. Plan for the regeneration of riparian vegetation

Depending upon the area different strategies may be needed for the rehabilitation and planting of the riparian plants. Selection of the plant varies with the topography, altitude, area, conditions of the riverbanks and conditions of the existing vegetation.

We have identified two main regions in the study area one in forest area (above 50m altitudinal area) before Thumboormuzhi and the second is the lower residential areas under the jurisdiction of local bodies. Plant component also vary in these areas.

1. Topography and altitude

Natural plant component in the riparian habitat vary with the topographical and altitude features. Here most of the forest species found above 50m altitudes. Species growing in the rocky or forest red soils vary from that growing in the sandy areas or that of the saline areas of lower altitudes.

2. Conditions of the riparian areas.

Usually all riparian lands are “common lands” and will be under the legal control of local bodies. But forest areas are under the control of Department of Forests. In the lower areas the riparian areas are under the jurisdiction of local Panchayath or municipalities. But indiscriminate sand mining has vanished the common lands and most of the riparian areas are private land holdings. So based on these conditions different approaches should be needed for the conservation and regeneration activities.

3. Conditions of riverbanks and existing vegetation.

Depending upon the condition of riverbanks and also on the existing vegetation different plant component may be needed for the regeneration processes. For a highly degraded area some quickly growing and soil binding plants like *Pandanus*, *Bamboo*, *Ochlandra* and *Saccharam* may be needed initially for the stabilization of the riverbanks. In some less degraded areas where riverbank erosion is not severe, some pioneer species like *Homonoia*, *Syzigium*, *Barringtonia* and some quickly growing species like *Macranga* and *Vateria* may be used. In the lower reaches some evergreen, quick growing trees and pioneers like *Saccharam*, *Pandanus* would be more suitable.

If some plants were existing in the selected area our intervention would not destroy the existing vegetation. The existing vegetation is an indicator of the overall condition of an area, which gives an indication of the physical stress, soil condition and also the human or other interference. (Some good samples of vegetation in the similar or nearby areas can be taken as a benchmark for the necessary development). If any species is existing in the area identification of their ecological position or ecological niche is important because our intervention should not be retrogressive or negative. We should not destroy existing vegetation except weeds.

4. Nursery building

Department of Forest has nurseries (as in Vazhachal and Chalakkudy) especially meant for forest plants. So this riparian plant species can be germinated in these nurseries. Individuals or groups of people with the support of local bodies or kudumbaseva units or local bodies itself and NGO'S can initiate building a nursery. This can support the lively hood of some interested people.

Selection of plants

Plants having large distribution and local or economic utility from the riparian plant species should be selected for large scale propagation for eg: *Bamboo*, *Ochlandra*, and valuable tree species like *Vateria*, *Xylia*, and *Hopea*. Exotic species should not be selected or supported. Species should be selected depending upon the area (forest species

and lower elevation) the need of the project (pioneer species, tree species, mangrove, fastly growing, soil binding should be selected).

5. Detailed observation and identification of the area

Observation and recording of the conditions of soil, and riverbanks, existing vegetation are needed. This can be discussed with experts and activities and main objectivities of the planting process can be identified.

6. Selection of the plant component

Plant component should be selected according to the above stated details mainly based on the conditions of the areas, riverbanks, and existing vegetation. for example If a bare area is selected then pioneer species are needed and if some pioneer species exists in the area then some other evergreen species that could be contribute to the development of the vegetation should be needed and should not affect the system negatively. For highly eroding areas species that can easily establish and bind the soil from erosion should be selected.

7. Season.

Most of the plant species were fruiting at the Feb-May season and so the collection of seedlings would be easier. Seedlings also can be collected after the first heavy rain in the June- July. So the seedlings can be collected in this season. In the monsoon season there would be a torrential flow in the river so planting in the beginning of the rain need care and should not be done in large scale. Planting after the heavy rain and their protection up to a year is very important. These need further experiments for evolving a perfect methodology. In the nearby seasons highest water flow in the Chalakudy river has been recorded in the August September and October months (4.2 meter, 9-8-96, 4.6m, 23.9.96, 4.320, 25-7-97 and 4.540, 4-8-99. Arngaly)

8. Assessment of the development

Monitoring and assessment of the development plant species are needed for successful establishment of the process. Some good samples present new to the planting areas could be regarded as a benchmark. Some simple methods like counting the plant seedlings and stocks, measuring the growth, arrival of new species, presence of animal, bird, and fish population. should be adopted. Flowering and growth of the planted species, presence of small animal, bird population and fish species are good indicators. Germination and growth of the seedlings indicate the importance of soil quality.

The presence of weeds grazing and clearing should be controlled. So the awareness and participation of local people is very important. From the observations necessary steps like weeding, watering in the dry period, growing fast growing trees for shade, making some temporary mechanical support to decrease the intensity of riverbank erosion.

9.2. Important areas and initiative steps for the rehabilitation and regeneration of riparian vegetation on along the Chalakudy River

Various peoples, institutions, have serious stakes in the utilization, destruction and protection of natural system in an area. So the identification of these stake holder groups and their roles based on the dependence is an important step. For a rehabilitation and regeneration processes the priority and importance of the stakeholder groups vary depending upon their power, dependence, and legal measures. here we have identified two major zones 1. The forest area (zone-I & II, Poringal to Thumboormuzhi) 2. Lower areas under the jurisdiction of local bodies.

9.2.1. Zone –I and II forest areas

Important stakeholders

1. Department of Forest of Vazhachal division
2. Plantation Corporation of Kerala.
3. Kerala State Electricity Board.
4. Athirappilly Grama Panchayath and other riparian panchayaths.
5. Tourism department
6. Tourism resorts including KTDC hotels, tourist resorts of PCK other resorts Dream world and Silver storm water theme park.
7. Tourist, businessmen
8. Local people including tribals
9. NGO's like VSS of tribal people, PFM samithies, Kudumbasree units, AWARD, Chalakkudy Puzha Samrakhana Samithy and Nature clubs in the schools.

9.2.1.a. Necessary actions required.

9.2.1.a. Role of Forest Department.

About 95% of the existing riparian forests come under the jurisdiction of Department of Forests and hence they have a serious stake in the conservational aspects. Strict vigilance of the forest staff and programmes like Vana Samrakshana Samithi (V.S.S) and nature

education facilities provided in Vazhachal has succeeded to a large extent in promoting the idea of conservation.

1. Separate treatment plan for riparian areas are needed (including planting, protection and maintenance of the continuity of vegetation). Atleast 20-30m width is recommended for the riparian vegetation in the forest areas.
2. Tourism activities are a major threat to the conservation of the area. Restriction of tourism activities to important tourism zones is a necessity. Entry of tourists to the riparian area should be prohibited.
3. Awareness generation and strict implementation of law should be attempted with local participation for conservation.
4. Necessary steps shall be attempted for the conservation and regeneration of the degraded riparian zones.
5. Creating awareness among tribals and local people about importance of the riparian vegetation and impact of various activities on riparian vegetation including overuse of the resources is also essential.
6. Considering the importance of the riparian vegetation in the Vazhachal area various steps and dialogues may be started for raising the level of this forest area to that of a wildlife sanctuary.
7. Regeneration of natural forests shall be attempted atleast in the adjacent areas of the riparian forests, which can help and protect the existing riparian vegetation.
8. No other developmental and infrastructural activities should be allowed in the riparian zone.
8. Strict implementation of law is necessary against activities that could affect existence of the riparian habitat.
9. Growing riparian plant species in the nursery.
10. Identification of encroachment and other violations in the riparian zone by Institutions like PCK, KS.E.B, Tourism Department, Tourism resorts and individuals.

9.2.1.b. Local bodies.

1. Creation of awareness within the institution and among individuals with active participation of local people.
2. Eco-restoration programmes for the conservation and regeneration of riparian vegetation in the sensitive areas can be initiated as a component in their watershed management programmes.
3. As an initial step, survey of the riparian areas for knowing the extent of encroachment and violation of existing laws should be conducted.
4. The conservation and regeneration programmes and enforcement of laws should be initiated only after discussions and planning of the processes with local participations.
5. Any type of reclamation of the riparian vegetation should be permitted and protection of riparian zone and natural vegetation should be ensured during the implementation of developmental projects.
6. Encroachment of the riparian zone by individuals and institutions should be identified and necessary preventive measures shall be taken. Regeneration programmes shall be attempted with the participation of these institution and local bodies.
7. Convene meeting of different stakeholders and initiate the process of protection and regeneration.

9.2.1.c. Plantation Corporation of Kerala

Riparian vegetation and streams in the areas owned by Plantation Corporation of Kerala have almost vanished and the PCK activities have contributed very much to their deterioration. In many locations riparian zones were invaded by plantations. Such areas should be identified and necessary steps should be initiated for the regeneration. Watershed based programmes shall be attempted for the conservation and regeneration of riparian vegetation and also for the regeneration of streams.

9.2.1.d. Role of local people

1. Awareness on importance of riparian vegetation among the local people especially living on the riverbanks should be initiated.
2. Dialogues between the local people and local bodies shall be initiated and a participatory approach is most essential.

3. Planting ecologically and economically valuable riparian plants like species of *Bamboo*, *Ochlandra*, *Thespesia*, *Mangroves* and other evergreen riparian forest trees can be attempted with local participation.
4. Necessary steps should be taken to decrease the problem of sand mining, clear felling etc.
5. Local bodies have a major role in arranging awareness programmes in a river basin basis among the local people.

9.2.1.e. Role of NGO's

Non-Governmental Organizations have a serious stake in the conservational aspects. Lack of awareness and responsibility of the local people and institutions is a major problem in conservation. Sudden implementation of law and orders may create problems, widen the gaps and may increase conflicts between institution and local people. In the conservational point of view a complete participatory approach is essential.

The experiences of **V.S.S** can be taken as an example. Many other NGO's including **Chalakkudy Puzha Samrakshana Samithi** has already started dialogues by conducting seminars with the participation of local body members and individuals. Plan to implement the **Athirappilly Hydroelectric Project** without adequate study and planning was questioned and temporarily stopped by the involvement of these NGO's and locals through the initiative of Chalakkudy Puzha Samrakshana Samithi. This project can completely destroy the remaining riparian vegetation in the Vazhachal area and could cause serious ecological and social damage.

9.2.2. Lower area (zone-III from Thumboormuzhi to Elanthikkara)

Important stakeholders

1. Local bodies: - about 9 riparian local bodies including Chalakkudy municipality are the important stakeholders.
2. Local people: - mainly people who have live and land on the riparian area.
3. Institutions like Forest Department, Water Authority, Irrigation Department, Agricultural Department.
4. Private institution like 'Divine', tourism resorts water theme park and factories like Sree Shakthi Paper mill.
5. Local people like fishermen, farmers, and sand mining labourer, NGO's like Kudumba sree units, River Protection Council, local clubs, nature clubs, in the schools and colleges etc.

6. Department of Police.

Necessary steps

1. Formation of a samithi or samithies including all stakes holder groups atleast with in a Panchayath or atleast for 2-4 neighboring Panchayath especially Panchayaths on the either sides of the river.
2. Identification of riparian areas and its condition
3. Identification of individual or private landholders of the riparian areas in each Panchayath.
4. Insurance of the participation of the local people in the samithy is necessary.
5. Initiation of awareness programmes, nursery building, and regeneration and conservation.
6. Panchayath and Kudumbasree units and other institution like a student group, River Protection Council etc.
7. Identification of major problem in the riparian zone and the analysis of gaps in the local level should be initiated by the local Panchayath, with the active participation of local people and NGO's.

9.3 Conclusion

The riparian forest is a unique and rich natural ecosystem which has great influence on the adjacent aquatic as well as terrestrial systems. In addition to stabilizing and safeguarding the river bank from erosion, the riparian ecosystem increases the biotic productivity and the biodiversity potential of the river. They also have a major role in influencing the water quality of the river. In the highly degraded condition of forest ecosystems in our state, the remaining riparian forests have a significant role as they support human life especially of the majority of ordinary people including the marginalized indigenous communities.

The emphasis of this study is on the status of the remaining riparian vegetation in the middle and lower reaches of the Chalakudy river and the major human interventions on the riparian zone. Some remaining riparin forests are located above the 50m altitudes. They are extremely fragmented and their conservation is an urgent need. Almost all riparian vegetation have been lost in the lower areas due to various anthropogenic activities. After studying the species composition and ecological importance of this ecosystem, the most prominent plant components and their peculiarities have been listed. Based on a detailed analysis of the remaining patches of relatively undisturbed riparian vegetation and the various threats they face, four different zones are delineated.

In view of the acute scarcity of all natural resources, especially of drinking water and the unchecked degradation of the river system, in depth and location specific studies are needed for corrective action. Regeneration of forest areas,

afforestation of the barren or dry hills, conversion of dry forests and plantations to more wet and evergreen areas and stabilization of river banks all require relevant information about the suitable plant components and their plant community composition for varying conditions. Only on the basis of detailed studies and field experiments on afforestation and ecorestoration, successful watershed management programmes can be planned and put into practice at the river basin level.

Degradation of natural resources and ecosystems is the biggest threat to human survival. Conservation and regeneration of life support natural ecosystems are indispensable for a healthy and viable human society. But our present land use practices are unscientific leading to the degradation of the whole system, both natural and man-made. Fortunately many attempts are being made all over the world and also in Kerala for correcting our past mistakes and conserving our natural resources.

This study is a preliminary attempt and needs a lot more of scientific investigations, long-term observations and documentation. Extension of this study to the river basin level, detailed studies on the catchment areas and field experimentations on the regeneration process at least in some locations are needed as the next step.

following are some important concluding points

1. Such low altitude riparian forests are very rare in the rivers of Kerala and its protection is an important thing. The remaining vegetation has to be protected as it is and degraded riparian zone should be regenerated based on the information gained from this and similar studies.

2. The study points out that about 10m width of the riparian vegetation is needed for maintaining the normal health of the riparian zone in the low altitudes and for the forest areas more than 20-30 m is recommended.

3. In highly degraded conditions of our forest the remaining riparian vegetation is important for the conservation wildlife and fisheries resource. The vegetation by maintaining the normal health of the river system is contributing to the water conservation and the conservation and planting in the riparian zones can be taken as the initiative long-term steps in the watershed treatment programs.

4. The remaining riparian vegetation in the Athirappilly-Vazhachal regions is one of the last remaining low altitude riparian forests in Kerala and is very important for its biodiversity richness. This area is one of the last remaining elephant corridor, which connect the Edamala-Pooyamkutti valley to the Parambikulam- Nelliampathi regions. This area acts as a buffer zone for the Parambikulam Wild Life Sanctuary and to the Sholayar forests.

5. This riparian vegetation and the famous waterfalls in the Athirappilly and Vazhachal are well known for its ethnic beauty and is one of the important tourist spots in south India. Now these are under threat of submergence and destruction by the proposal for construction of a dam just upstream to the Vazhachal waterfalls. The remaining

riparian vegetation, the elephant corridor will be submerged and damming and diversion of water will dry up the Vazhachal and Athirappilly waterfalls.

6. Conservation of this riparian vegetation can support the livelihood means of the tribals, fisherman communities and other local people depending on the river system.

7. In the areas where the forests lands were given under the control of Kerala State Electricity Board and that leased to Plantation Corporation of Kerala etc are the seriously damaged areas and many threats to the wildlife and forests found frequent here. So they are responsible for the damage and the department of forests should ensure the protection of riparian lands, forests and wild life in these areas and take necessary actions. The departments of forests with the participation of local bodies should pressurize these departments for initiation of programs for the conservation of the riparian lands and remaining forests under these leased areas.

8. Control of the tourism activities in the riparian areas is necessary and tourism activities should be planned based on the objectives of conservation.

9. The activities of the private firms operating in the riparian areas should be monitored and controlled and should ensure the freedom of the local people for the healthy use of their natural resources in their day-to-day activities.

10. Water uptake from the river by private firms should be controlled and monitored. Waste deposition into the river should be prevented and ensure installation and working of proper waste treatment plants.

11. A proper awareness about these activities and its impact on the river system should be initiated among these institutions, local people and among student groups. As compensation such programs and proper conservation activities with consultation of expert authorities should be demanded from the private firms.

12. Riparian zone regeneration programs can be initiated in each local body with the participation of riparian landowners. Planting of indigenous tree species along the river margins can protect and stabilize the river margins and by proper planning it can be developed into economically benefited programs in the private land holdings.

13. In the lower areas the riparian vegetation acts as a gene pool for the wildlife relevant in each area.

14. The department of forests and the local bodies should initiate such afforestation programme for the development and conservation of riparian forests in the degraded areas.

15. Sandmining is found as most destructive human activity on the river margin. Illegal sand mining is the main problem and in order to check this activity the local bodies should (a). They should develop a system to directly mine the sands in prescribed quantities from the allowed areas and sell directly to the consumers rather than giving license for sandmining through auction. This can prevent the activities of sandmining mafias and the illegal sandmining to a considerable extent. (b). The quantity of the sands that is to be mined from each area should be regulated based on the rate of deposition of

sand in each area and that should ensure a minimum deposition and development of sand deposition year after year. The Chalakudy Puzha Samrakshana Samithy, an NGO working for the conservation of river has put forward detailed suggestion on this sandmining issue.

16. These above mentioned human activities on the river is increase day by day man illegal points exist already to check these activities and the is not functioning properly. This indicates a gap in the monitoring system on the activities on the river system. The NGOs and individuals working for the conservation of river have pointed out it many times. So it is necessary to have a body with participation of all stakeholder groups with the leadership of District collectors, local bodies, responsible departments and active participation of NGOs, scientists and senior citizens from the local people. The body should be given powers to monitor the activities on the river and to take necessary steps for control of the destructive activities. The body/forum should study and develop programs for the conservation of the river system in each region.

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