Ecological Management Plan
Indian Institute of Technology – Palakkad

Care Earth Trust
Biodiversity. People. Conservation

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Contents

List of Tables

List of Figures

List of Maps

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1. Introduction

The need to pursue development within a framework of environmental and social responsibility and justice is no longer an option. Conditions and systems that facilitate the integration of environmental and social dimensions into the mission and vision of any development, irrespective of its scale have become mandatory. Evidently, this has led to a situation where there are many environmental and social codes and standards that are defined by law. Presumably, these exist as a generic template that needs to be adapted on a case by case basis. Academic institutions such as the Indian Institute of Technology (Madras, Tamilnadu and Mandi, Himachal Pradesh, and more recently, the upcoming Tirupati campus) have pioneered this framework not only as a procedure for compliance to the statutory laws and regulations, but have expanded the scope to incorporate measures such as development of campus specific sustainability plans, design and development of the campus, setting up of monitoring mechanisms etc.

In continuation of this practice, Indian Institute of Technology, Palakkad has commissioned Care Earth Trust, a Chennai based institution that was responsible for developing Ecological Management Plans (EMP) for the Madras, Tirupathi and Mandi Campuses to develop an EMP for its upcoming campus at Kanjikode, Palakkad district, Kerala.

1.1 The Framework

The framework for the Ecological Management Plan for the Indian Institute of Technology, Palakkad campus is entrenched on the notion that it is a management system that outlines a set of processes and practices to meet the institute's objectives of sustainable growth while also functioning as a robust system to follow, review, undertake mid-course corrections, improving and foster a green agenda.

It is also the recognition by IIT that institutional campuses have served as repositories of biological diversity (commonly defined as the variety and variability of life forms and the systems that they sustain) throughout the world and can serve as the last abode (or even a refugium) to some of the threatened plants and animals that forms the basis of the current EMP. A good example of this is the campus of IIT-Madras where recent

studies have established the presence of plants like *Garcinia spicata* which has locally disappeared as also *Typhonium trilobatum*, a new record for Tamil Nadu.

The EMP is hence defined on the understanding that the complex and dynamic nature of environmental problems requires flexible and transparent decision-making that embraces a diversity of knowledge and values. An EMP looks at existing scenarios, as also the possible impacts of projects and interventions and describes the different measures that can be taken to mitigate those impacts. It also identifies parties or departments that are responsible for following up on the recommended procedures and then monitoring the area on a continued basis for any warning signs that those procedures are not working.

EMPs in India are normally developed as part of the Environmental Impact Assessment process, to meet the statutory requirements of the Environmental (Protection) Act, 1986. They are not generally viewed as being essential for urban or habitation planning, and hence there are no standardised procedures or templates of EMPs especially for institutions or urban planning.

EMPs are ideally based around two main ideas: natural resource conservation and pollution reduction. This could include pollution of all kinds: liquid effluents, air contamination, solid wastes, and even control of noise and vibration levels. Negative impacts on the social and cultural of any affected human communities are also inherent components of an EMP.

There could hence be several necessary components to an EMP – such as,

1) Summary of impacts, both environmental or ecological and social.
2) Description of mitigation measures, where each measure is described and connected with its related impact, as well as the project design and operating procedures.
3) Description of monitoring procedures, connecting the impacts from the EIA report, measurement indicators, detection limits, and defining the warning thresholds measurements when countering actions would need to be done.

4) Assignment of responsibilities, as well as outlining communication and co-operation between the different departments involved.
5) Schedules with timing, frequency, and length of each mitigation measure, as well as directions for reporting progress.
6) List of cost estimates and sources of funding.

1.2 Scope and purpose of an EMP

EMPs, as stated earlier, are usually built off of data collected in the environmental impact assessment (EIA). An EIA has the same goal as an EMP: creating a balance between conserving natural resources and sustaining development in order to ensure the survival of the affected community and economy. EIAs began to be used in India in between 1977-1978 when the Department of Science and Technology began preparing for river valley projects. The purpose of an EIA is to identify potential impacts (both negative and positive) that a project could have on an ecosystem, including possible social and cultural impacts. Then, methods for mitigating and managing these impacts are suggested. These impacts and suggestions provide the basis for the EMP. An EMP alone will not ensure the health of the ecosystem during a project. It must be followed and respected. A good, well written plan will increase efficiency across the board. Defining the limitations of the EMP – what it will and will not cover, will also help in the beginning to determine the focus of the proposed work. It will help avoid time and energy being spent on areas outside the purview of the EMP, as well as avoid possible conflicts with outside parties.

It is important to remember that EMPs can be updated and revised as time goes on, and more data are gathered. Changes can be made along the way in response to monitoring results to help improve procedure techniques and make the project successful. The following conditions have been identified as essential for the successful implementation of an EMP.

- Proponent and key partner commitment.
- Participation of all stakeholders in EMP development.

- Providing adequate lead time and support to develop appropriate institutional capacity for EMP implementation.
- Giving EMPs formal status in project documents, agreements, permits and contracts.
- Including full EMP costs in project costs, economic and financial analyses, and budgets.
- Systematic supervision and monitoring; this requires the design, funding and implementation of rigorous supervision programmes to check on EMP implementation and effectiveness and to advise on corrective actions required
- Ensuring that EMPs are flexible and adaptive so as to be able to react to new situations and to Ensuring comprehensiveness and quality.

In summary, EMPs are excellent tools that help projects generate sustainable development while minimizing damages to the surrounding environment as well as any affected human communities. An EMP is necessary for all stages of a project. At the beginning, it informs about the expected budget and informs all involved parties about their responsibilities. During and after project activity, an EMP informs monitoring procedures and warning threshold levels. When written well, EMPs can help all involved parties work together effectively to help make development projects successful and sustainable.

1.3. Project Site

The campus of Indian Institute of Technology, Palakkad is spread over an extent of 529.52 acres at Puduserry West Village, Kanjikode, Palakkad district, Kerala in the near vicinity of the Cochin-Coimbatore Highway.

1.4. Objectives

To provide guidelines for the preparation of the master plan for the campus. Specific tasks include:

1. Development of the baseline ecological map with checklists of flora and fauna typically found within the campus and its immediate environs.
2. Identification and characterization of broad habitat types and their conditions within the campus and the immediate environs.
3. Identify and characterize ecological zones within the campus, also providing details of the best use for each of the zones.
4. Identify zones for protection/conservation and detail the guideline for the greening programme.
5. Assessment the drainage pattern and identification of threats, if any, to the downstream
6. Documentation of the ecological history of the landscape.
7. Any other related information

1.5 Methodology

The methodology for developing the EMP included:

a) review and study of secondary literature pertaining to the landscape: specifically, the landscape of Palakkad district, human habitations in the near proximity of the campus, past research studies and Survey of India toposheets/satellite imageries of the landscape.
b) field assessments: comprising of all out search, transects of varying lengths and duration, sample plots, camera traps to assess the habitat and its constituent species in the IIT – P campus.
c) field assessments: comprising of interviews, non-participant observations and focus group discussions on parameters identified as being critical through the secondary literature review. Identification of a set of flora/fauna as bio-indicators of the campus.

d) geo-spatial analysis of the habitat for various parameters: highlighting ecological zonation of the campus, edge with the adjacent Protected Area, human habitations, hydrology etc.

e) consolidation of the results through discussions with IIT-P administration and development of the final report.

2. Results and Discussion

The results of the assessment have been organized as follows:

1. Section 2.1 provides an overview of the largest administrative unit viz, highlighting key ecological features / issues
2. Section 2.2 provides an overview of the natural features of the district within which IIT-P is to be located.
3. Section 2.3 discusses the ecology and biodiversity of the campus, highlighting significant parameters

Section 2.1 : The State of Kerala

Kerala lies along the coastline, to the extreme south west of the Indian peninsula, flanked by the Arabian Sea on the west and Western Ghats on the east. It is located between northern latitudes 8°18' and 12°48' and eastern longitudes 74°52' and 77°22' and coastline of 580 km with a varying width of 35 to 120 km. Spread over 38,863 km^2, it is bordered by Karnataka to the north and northeast, Tamil Nadu to the east and south, and the Arabian Sea to the west. According to 2011 census the population of Kerala was 33,387,677. It is the thirteenth largest state by population and is divided into 14 districts with the capital being Thiruvananthapuram.

The topography and physical characteristics distinctly change from east to west. The nature of the terrain and its physical features divides the state into three distinct regions- hills and valleys, midland and plains and the coastal region. The Western Ghats, bordering the eastern boundary of the State, are almost continuous, except near Palakkad where there is a natural mountain pass known as the Palakkad Gap. The average elevation of the Ghats is about 1500 meters above sea level, occasionally soaring to peaks of 2000 to 2500 m. From the Ghats, the land slopes to the west on to the plains, into an unbroken coastline. There are 44 rivers in the state, of which 41 originate from the Western Ghats and flow westwards into Arabian Sea. Only three tributaries of the river Cauvery originate in Kerala and flow east into the neighbouring States. In the Midland Plains of central region, the hills are not very steep and the

valleys are wide. The valleys have been developed as paddy fields and the elevated lands and hill slopes converted into estates of rubber, fruit trees and other cash crops like pepper, areca nut and tapioca (https://en.wikipedia.org/wiki/Kerala; https://kerala.gov.in/about-kerala).

Palakkad district lies in the east-central part of the state between 10°19′ and 11°15′N latitudes and 76°01′ and 76°55′E longitudes. It is bordered by Malappuram district in the northwest, Thrissur district in the southwest and Coimbatore district of Tamil Nadu in the east, covering a geographical area of 4480 sq. km. The district is 24.4% urbanized according to the census of 2011 (http://ecourts.gov.in/kerala/palakkad). The district accounts for about 11.5% of the total land area of the state of Kerala, with the population share of 8.2%. There are five Taluks (Ottappalam, Palakkad, Alathur, Chittur and Mannarkad) and 163 villages in the district. There are four Municipal towns and ninety one Panchayats in the district. The district is divided into 13 Community Development Blocks. The Forest land of the district covers an area of 136257 ha (www.ecostat.kerala.gov.in/docs/pdf/district/pkd.pdf).

2.1.1 Geomorphology

a) The Palghat Gap

The east-west trending Palghat Gap is a prominent physiographic break in the Western Ghats. The rock-floored Gap is about 13 km wide and has a maximum elevation of 300 m above mean sea level. On either sides of the Gap the Western Ghats attain heights of more than 2500 m above MSL (Sheth, 2007). The steep hills in the north (Nilgiris and Biligirirangan) and south (Palni and Cardamom hills) are characterized by high level plateau landforms. Many researchers suggest the formation of the gap due to fluviatile erosion consequent to crustal unwarp while others consider it to be formed due to tectonic activity (Singh et al. 2011; Valdiya, 2011).

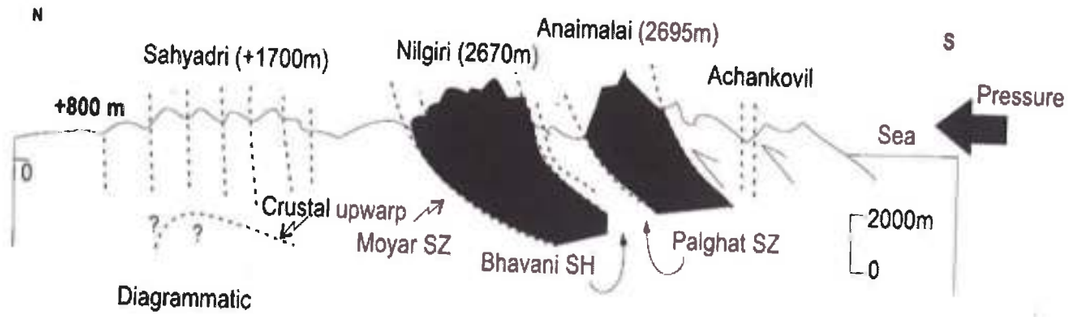


Figure 1: The northward directed pressure on the Indian crust caused the breaking and squeezing up of the faulted blocks resulting in the emergence of Nilgiris and the Anaimalai. The block between the two high mountains failed to rise up and resulted in the formation of Palghat Gap (Valdiya, 2011).

b) Seismicity in vicinity of Palghat Gap

Low to moderate seismicity has been detected within the Palghat Gap. The region around Wadakkancheri, Thrissur District, Kerala, is known for microseismic activity, since 1989. An ML 4.3 earthquake recorded in 1994 near Wadakkancheri in Thirssur district was reported to be located within the confines of this feature. Further, historic records exhibit the occurrence of two earthquakes near Coimbatore on the northern extremity of the gap. Continued low level seismic activity, originating from this area, has also been recorded. This analyses of regional seismicity by Rajendran and Rajendran (1996) points to presence of active structures and enhanced stress concentration within the Palghat Gap. Subsequent studies have identified a south dipping active fault (Desamangalam Fault) that may have influenced the course of Bharathapuzha River. The ongoing seismicity is concentrated on southeast of Wadakkancheri. A study by Singh et al (2016), identified the northwestern continuity of NW-SE trending Periyar lineament, which appears to have been segmented in the area. Morphometric analysis showed that the NW-SE trending lineaments appear to be controlling the sinuosity of smaller rivers in the area, and most of the elongated drainage basins follow the same trend. A number of brittle faults that appear to have been moved are consistent with the

present stress regime and these are identified along the NW-SE trending lineaments. The current seismic activities also coincide with the zone of these lineaments as well as at the southeastern end of Periyar lineament. These observations suggest that the NW-SE trending Periyar lineaments/faults may be responding to the present N-S trending compressional stress regime and reflected as the subtle readjustments of the drainage configuration in the area.

On the basis of topography, geology, soils, climate and natural vegetation, Palakkad district consists of four regions- (i) Pattambi undulating plain, (ii) Mannarkad-Palakkad forested hills, (iii) Palakkad Gap and, (iv) Chittur forested hills. Physiographically, the district can be divided into two parts- Highland and Midland.

Table 1: Terrain units in Palakkad District

Terrain unit	Area %
Low lying terrain including flood plain and terrace	27
Moderately undulating mid land terrain with flood plain	26
Highly undulating terrain	12
Hilly area including scrap slope	35

(Source: cgwb.gov.in/District_Profile/Kerala/Palghat.pdf)

The eastern region of the district comprises of high mountains, extensive ravines and dense forests. Land slopes upwards from west to north and north-east to south. The altitude varies between 15 m in the west and 2500 m in the north-east. While Ottappalam Taluk lies completely in the Midland region, all other Taluks in the District lie in the Midland and Highland regions. The Mannarkad - Palakkad forested hills region comprises of parts of Mannarkad and Palakkad Taluks, bounded by Tamil Nadu in the north and the east, Palakkad gap in the south and Nilambur forested hills in the west. This table-land is the continuation of the neighbouring Coimbatore plateau and it generally slopes towards the south and west. The north-east portion of this region slopes towards the east which influences the flow of the Bhavani River towards the east. This region also forms the catchment area of Thuthapuzha River, a tributary of the Bharathapuzha. There is a predominance of semi evergreen forest (composed mainly of

teaks, sandalwood and bamboo). Malampuzha Reservoir is located at its southern extremity and its waters irrigate vast areas of Palakkad District.

The Palakkad Gap region comprising of parts of Palakkad, Ottappalam, Mannarkad, Chittur and Alathur Taluks, is bounded by Mannarkad-Palakkad forested hills in the north, Tamil Nadu in the east, Chittur forested hills in the south and Pattambi undulating plain in the west. The highest elevation (394 m) is observed in the central portion of this region and the minimum (61 m) in the western portion of Keralassery village of Palakkad Taluk. The Palakkad gap has the average width of 30 km. This region is mainly drained by the Bharathapuzha and its tributaries- Kalpathypuzha, Walayar, Koraiyar, etc. Thoothapuzha River also drains the region and joins Bharathapuzha downstream. Kalpathypuzha originates from Chenthamarakulam in hills north of Walayar formed by four streams viz. Korayar, Varattar, Walayar and Malampuzha. Korayar and Varattar both originate in Anamalai Hills and flow westwards before being joined by Walayar near Thampalam. This combined river is known as Korayar, flowing again in the same direction, till it is joined by Malampuzha stream at about 5 km down Malampuzha dam. This region also has a number of isolated residual hills (Palakkad district handbook- www.censusindia.gov.in/2011census/dchb/3206_PART_B_PALAKKAD.pdf).

There are 12 reservoirs in the district associated with two major rivers and its tributaries - Parambikulam, Peruvaripallam, Thoonakadavu, Chulliyar, Pothundi, Moolathara, Meenkara, Walayar, Malampuzha, Gayathri, Kanjirapuzha and Mankulam. There are also a number of irrigation projects, major ones being Malampuzha, Chittoorpuzha, Kuriar Kutty, Karapara, Kanjirapuzha and Attappady Valley Irrigation Project. The main crops grown under the irrigation scheme are paddy, coconut, areca nut, plantain, grams, vegetables etc. (cgwb.gov.in/District_Profile/Kerala/Palghat.pdf).

2.1.2 Groundwater

Palakkad district is underlain by rocks of Archaean metamorphic complex. Groundwater occurs in all the geological formations- from Archaean crystallines (hard rock) to recent alluvium (soft rock). Groundwater occurs in phreatic condition in the laterite, alluvium

and weathered crystallines. It is in semi confined to confined condition in the deep fractured rocks. Along the middle portion of the district which includes the Palakkad Gap, the thickness of weathering is more than 10 m. The major hard rock aquifer is hornblende biotite gneiss here and the yield ranges from 2 to 30 lps. The water level in bore wells of the region is going down considerably and the yield of bore well in this zone is site specific. Along the E-W and NW-SE fractures, the bore wells are better yielding. Common abstraction structures feasible in the area are dug well, dug cum bore well and bore well. The yielding fracture zones, in general, are encountered generally within 125 m and in exceptional cases up to 175 m (cgwb.gov.in/District_Profile/Kerala/Palghat.pdf).

The status of future water demands (after 2025) calculated based on the crop water requirement calculations for the entire cropped area for irrigation and for the other sectors (domestic and industrial) of Palakkad district works out to be 3841 MCM, showing a large deficit in water resources, when compared to the available water resources (Surendran et al. 2015).

Table 2: Categorization for groundwater development as on 31st March, 2009 in Malampuzha Block

Net Ground Water Availability (Ham)	Ground Water Draft for all Uses (Ham)	Stage of GW Development	Is there a significant decline of pre-monsoon water table	Is there a significant decline of post monsoon water table	Categorization for future GW development
6372.36	5771.99	90.58	No	No	Critical

Source: cgwb.gov.in/District_Profile/Kerala/Palghat.pdf

Four soil types can be observed in the district- (i) Laterite soil, (ii) Virgin forest soil, (iii) Black cotton soil and, (iv) Alluvial soil. Laterite soil is mostly observed in Palakkad taluk.

2.1.3 Climate

The Palghat Gap plays a critical role in determining the climate of Kerala, especially that of the Palakkad plain. Owing to its specific geographical location, its climate is highly

influenced by the humid climate of Kerala as well as the more arid climate condition of the Coimbatore plains of Tamil Nadu. The gap shapes the moderate climate of Coimbatore and provides notable rainfall in the region than other parts of Tamil Nadu by allowing the moisture laden monsoon winds to pass through during the south–west monsoon season. On the other hand, the summer temperature of the Palakkad plain of Kerala is also greatly influenced by the gap (Raj and Azeez, 2010).

The average rainfall in Palakkad is lower than the average rainfall in Kerala state. The annual rainfall in Palakkad district varies from 1883 to 3267 mm based on long term normal. The district receives an average rainfall of 2362 mm annually. Major rainfall is received during June to September in the southwest monsoon (71%), while northeast monsoon contributes about 18%. The western part of the district around Pattambi receives the maximum rainfall whereas the rain shadow area of Chittur in the eastern part receives minimum rainfall (cgwb.gov.in/District_Profile/Kerala/Palghat.pdf). A study by Raj and Azeez (2010) examined the general rainfall pattern in the Palakkad plains using the historical rainfall data available at four rain–gauge stations located at Mannarkkad, Palakkad, Chittur and Malampuzha. Among the stations, the south–west monsoon rainfall showed a decreasing trend in all the stations, which was found to be statistically significant only in the case of Malampuzha and Mannarkkad. The winter rainfall in all the stations also showed a decreasing trend which however was not statistically significant, except in the case of Malampuzha. The decrement in the total rainfall in the region was found to be highly related with the decrease in the seasonal rainfalls (Raj and Azeez, 2010). Another study by Krishnakumar et al. (2009) also showed significant decrease in southwest monsoon rainfall while increase in post-monsoon season in Kerala. Rainfall decline was more predominant in June and July but not so in August and September within the monsoon season.

Near the Palghat Gap over a distance of 30 km the increase is from 5 to 8 dry months owing to absence of relief. Further, regions situated in the east experience two dry periods per year, one in summer and other in winter (Pascal, 1988). Here the maximum temperature ranges from 28.1 to 37.4°C whereas the minimum temperature ranges from 22.2 to 25.3°C. The average annual maximum temperature is 32.3°C and the average annual minimum temperature is 23.4°C. The wind predominantly blows from west and east during morning as well as evening hours, reaching highest speed during

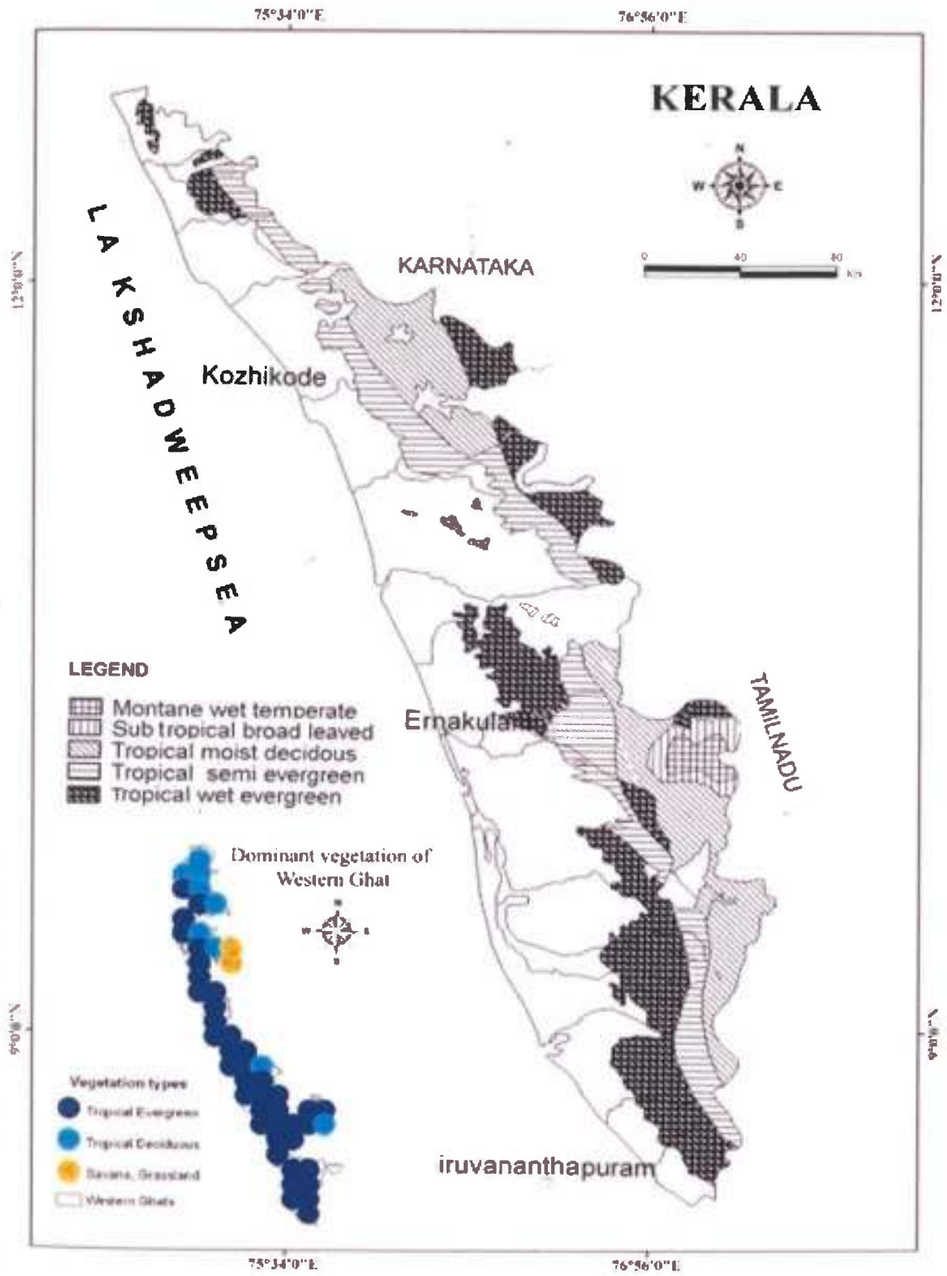
August (13.6 kmph). The humidity is higher during the monsoon period i.e. from June to September (cgwb.gov.in/District_Profile/Kerala/Palghat.pdf). During the dry season (December to March) the dominant winds are essentially from east in Palghat, while the winds from west and south-west are dominant from April onwards (Pascal, 1988; Pascal et al. 2004).

2.2 Palakkad district

2.2.1 Forests of Palakkad district

Even though the land area of Kerala is only 1.2 percent of India, the forest cover is 2.30 percent of the national average. According to the Forest Survey of India report 2015, the forest cover in Kerala has increased to 19239 sq. km from 17922 sq. km in 2013 assessment (http://www.kerenvis.nic.in/Database/FOREST_819.aspx). Kerala forests fall in two biogeographic provinces- Western Ghats and the Western Coast, and are rich in biodiversity and considered to be a repository of rare and endangered flora and fauna. The western slopes of the Ghats have a natural cover of evergreen forest, which changes to moist and then dry deciduous types as one moves to the eastern slopes. The vegetation of South of Palghat Gap regions is more heterogeneous and the most spatially heterogeneous Western Ghats South of Palghat Gap region has the maximum number of irreplaceable sites.

The forest of Palakkad district can be classified as tropical wet evergreen forests, shola, and tropical moist deciduous forests. Of these, shola forests are seen in the Silent Valley and in some blocks of Attappady reserves at an elevation of 1500 m. The temperate forests (Sholas) are found in higher areas of Attappady valley. The tropical moist deciduous forests grow in the plains up to 500 m on westerly or southerly slopes of Chanet Nair Reserve, Puliampulli Reserve and the Kumrid slopes in Attappady block I and II. In Palakkad District, there are Five Forest Divisions - Mannarkad, Silent Valley National Park (Wildlife), Palakkad, Parambikulam Tiger Reserve and Nemmara. (District census handbook: www.censusindia.gov.in/2011census/dchb/3206_PART_B_PALAKKAD.pdf).



Map 1: Forest types in state of Kerala (Kerala State Biodiversity Board)

Table 3: Forest cover in Palakkad district (Area in sq. km)

Geographical area (GA)	Very Dense Forest	Mod. Dense Forest	Open Forest	Total	% of GA	Change	Scrub
4480	317	677	767	1761	39.31	133	26

(Source: http://www.kerenvis.nic.in/Database/FOREST_819.aspx)

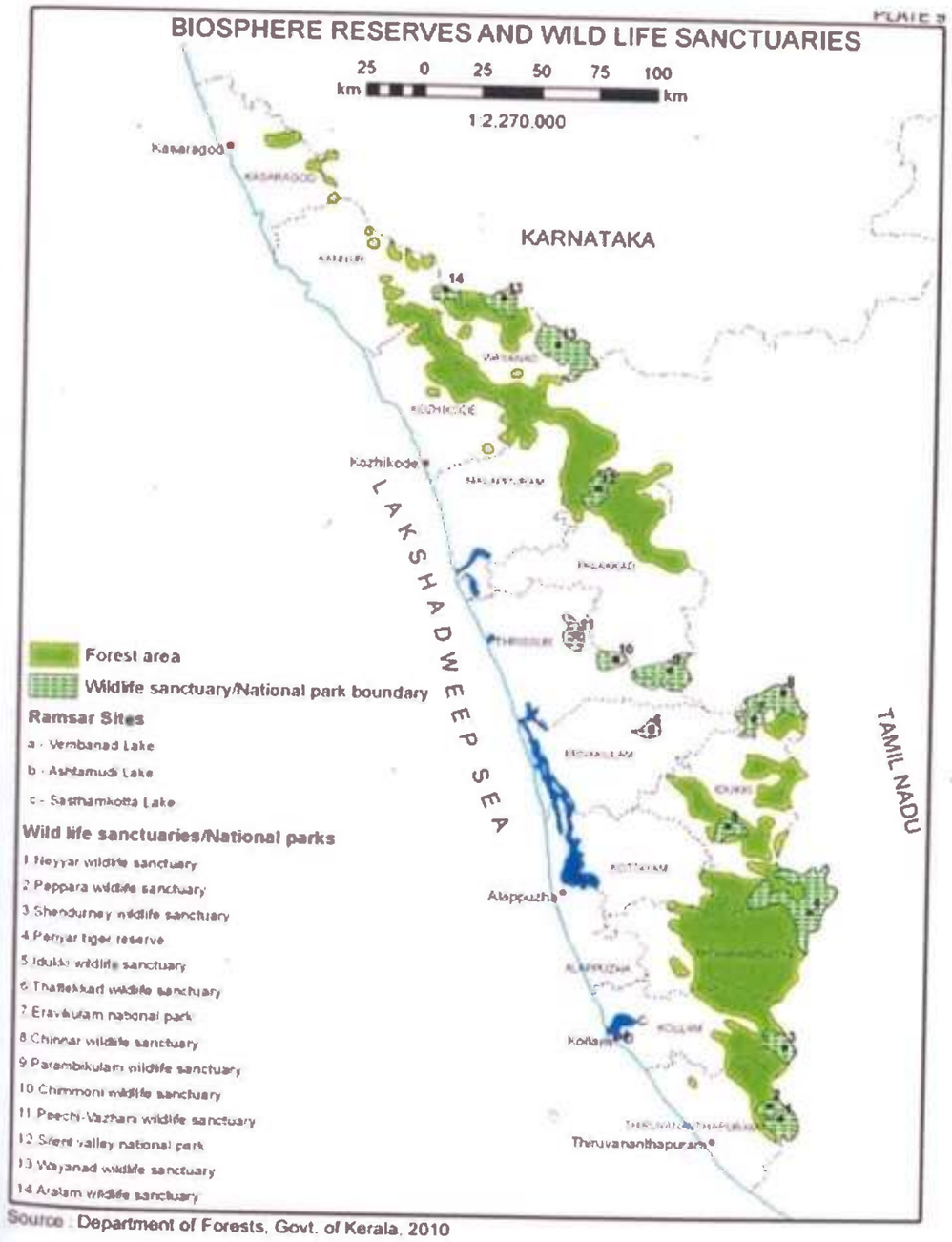
Table 4: Details of Palakkad Forest division area

Name of Range	Total Extent (sq. km)	Reserve Forest Extent (sq. km)	Vested Forest Extent (sq. km)	EFL Extent (sq. km)
Walayar	145.439	11.7173	18.4285	23.82
Olavakkode	81.5543	61.6927	33.4471	1.4611
Ottappalam	37.5683	-	33.4471	4.1208

(Source:http://circle.forest.kerala.gov.in/tcpalakkad/index.php?option=com_content&view=article&id=106&Itemid=28)

2.2.2 Protected areas of Palakkad district

Silent Valley National Park is situated in Palghat district and is one of the core areas of the Nilgiri Biosphere Reserve. The National Park area is 90 km^2 and it forms part of the westerly sloping Silent Valley-New Amarambalam. Kunthipuzha, a tributary of Bharathapuzha, originating from the northeastern hill ranges of the National Park, drains the area. The altitude varies from 658 to 2,383 m. Silent Valley forests are one of the areas of highest rainfall in the entire Western Ghats, averaging 6000 mm per year, and the annual mean temperature is around 20ºC. The vegetation is tropical wet evergreen. The highly diverse flora of Silent Valley includes 966 species belonging to 134 families and 559 genera (Joseph et al. 2003). Another protected area located in the district is Parambikulam Tiger Reserve spread over an area of 275 km^2. The Palghat gap lies to the north of this sanctuary. It is a part of the contiguous larger area of the forest comprising of Anaimalai, Nelliampathy, Sholayar and Palni Hills. Here the average temperature is 30°C and rainfall is 2300 mm. The vegetation includes evergreen, semi-evergreen, moist deciduous, dry deciduous, wet temperate forests and teak plantations. It is also a Tiger Reserve (Joseph et al. 2007).



Map 2: Map showing protected areas in Kerala (http://www.kerenvis.nic.in/)

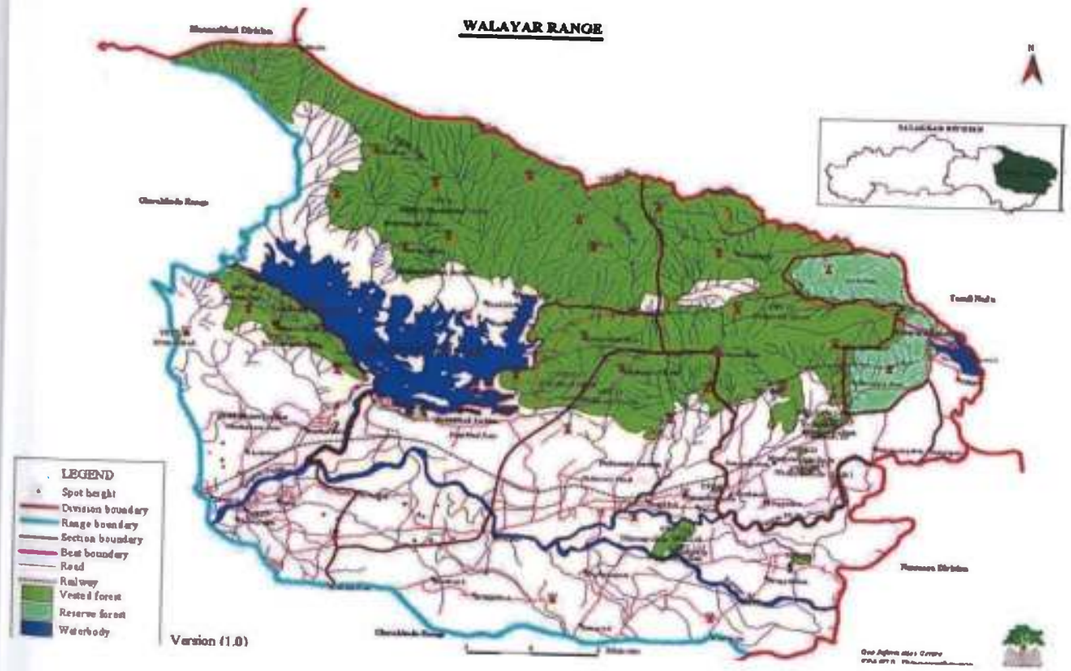
The IIT site is located near the Walayar Range, in Palghat district, which covers an area of 125.65 sq.km and is divided into six sections- Akathethara, Pudussery North, Pudussery South, Walayar, Akamalavaram and Kottekkad. Pudussery North and Pudussery South are the two Beats of the respective Pudussery North and Pudussery South Sections. Malampuzha and Kottekkad are the two Beats of Malampuzha Section and Poolampara and Varali are the two Beats of Walayar Section of Walayar Range (http://circle.forest.kerala.gov.in). Walayar Valley, located in lower Western Ghats of Coimbatore district, Tamil Nadu and Palghat district, Kerala and the Palghat gap of both States covers an area of ca.12500 ha (ca. 4200 ha in Tamil Nadu and 8300 ha in Kerala) between the altitude 370 and 450 m above msl. The geographical location of Walayar valley is 10° 77′ 0-3″ N and 76° 51′ 06-10″ E. In this landscape, nearly 55% of the geographical area is occupied by moist tropical semi-evergreen forest dominated by *Chloroxylon swietenia* tree species and it is a protected forest. The Walayar River runs across the valley. The agricultural land around the forests in this valley spreads over an area of approximately 40% of total geographical area. Annual rainfall ranges between 1500 and 2200 mm. Madukkarai – Walayar reserve forest is located within the Nilgiri Biosphere reserve area. These forest sites are contiguous, bordering north of Palghat gap, in the Kerala-Tamil Nadu state border and south of the Bolampatti II Reserve Forests. The Walayar valley is swept by strong winds during the monsoons as well as in months of January and February. Tropical dry deciduous forests can be seen in the Walayar reserves (Prithviraj et al. 2011; Venkatachalapathi et al. 2016).

This area is prone to ground fire every year as local people use fire for various reasons, major reason being to collect seeds of the Silk Cotton Tree (Ramachandran and Remesh, 2016).

2.2.3 Palakkad district Eco sensitive zones

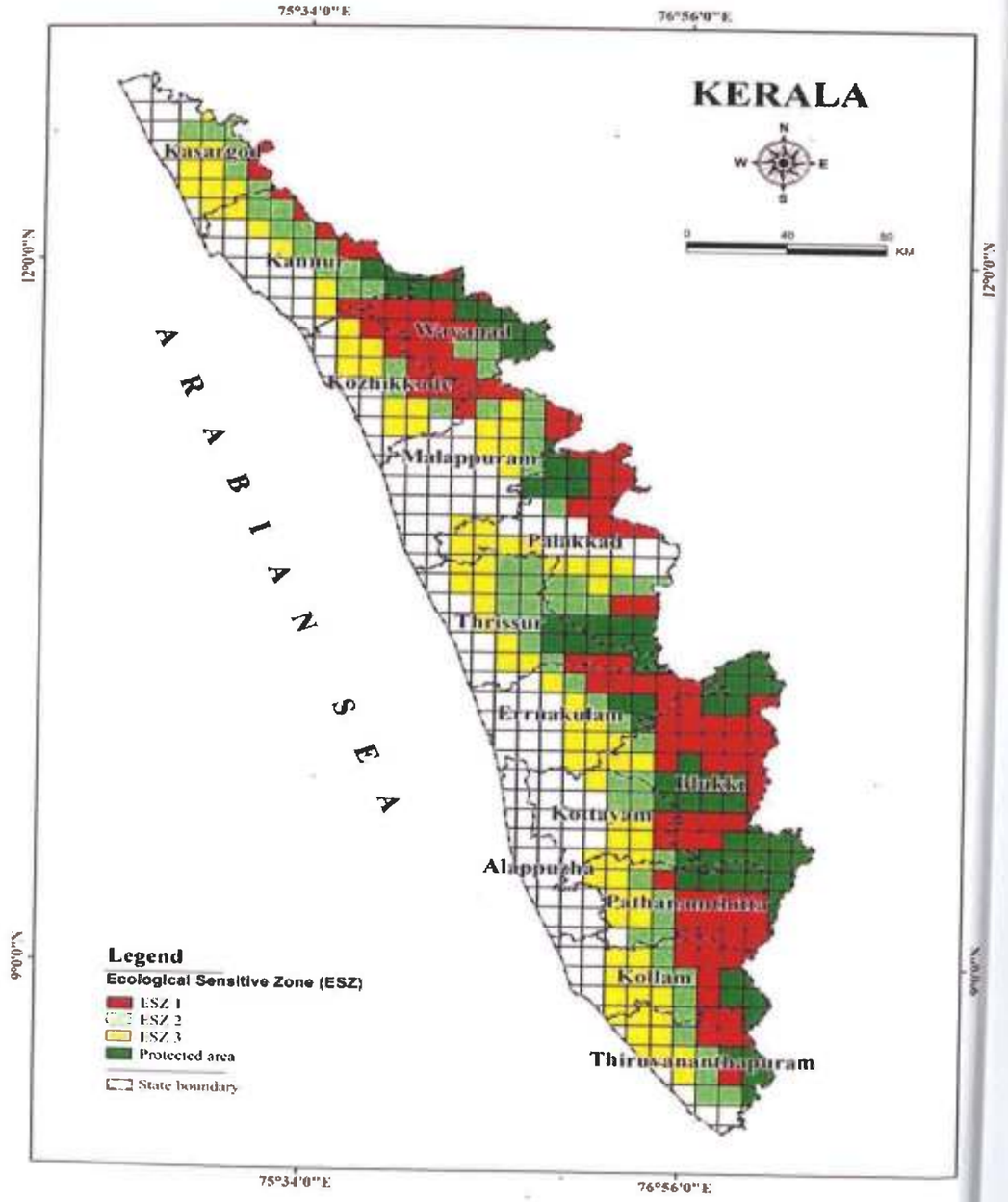
Eco sensitive areas or ESA's are those areas that are ecologically and economically very important, but, vulnerable to even mild disturbances and hence demand conservation. A set of attributes with the criteria to be used for each of them and methodological process were evolved to use these criteria in demarcating ESA. They include biological attributes, (richness, species rarity, habitat richness, productivity,

estimate of biological/ecological resilience, cultural and historical significance), geo-climatic layers attributes, (topographic features, climatic features, hazard vulnerability), stakeholders valuation. Western Ghats Ecology Expert Panel (WGEEP) recommends the adoption of a graded or layered approach, and suggests that the entire Western Ghats be characterized as comprising (1) Regions of highest sensitivity or Ecologically Sensitive Zone 1 (ESZ1), (2) Regions of high sensitivity or ESZ2, and the remaining (3) Regions of moderate sensitivity or ESZ3.



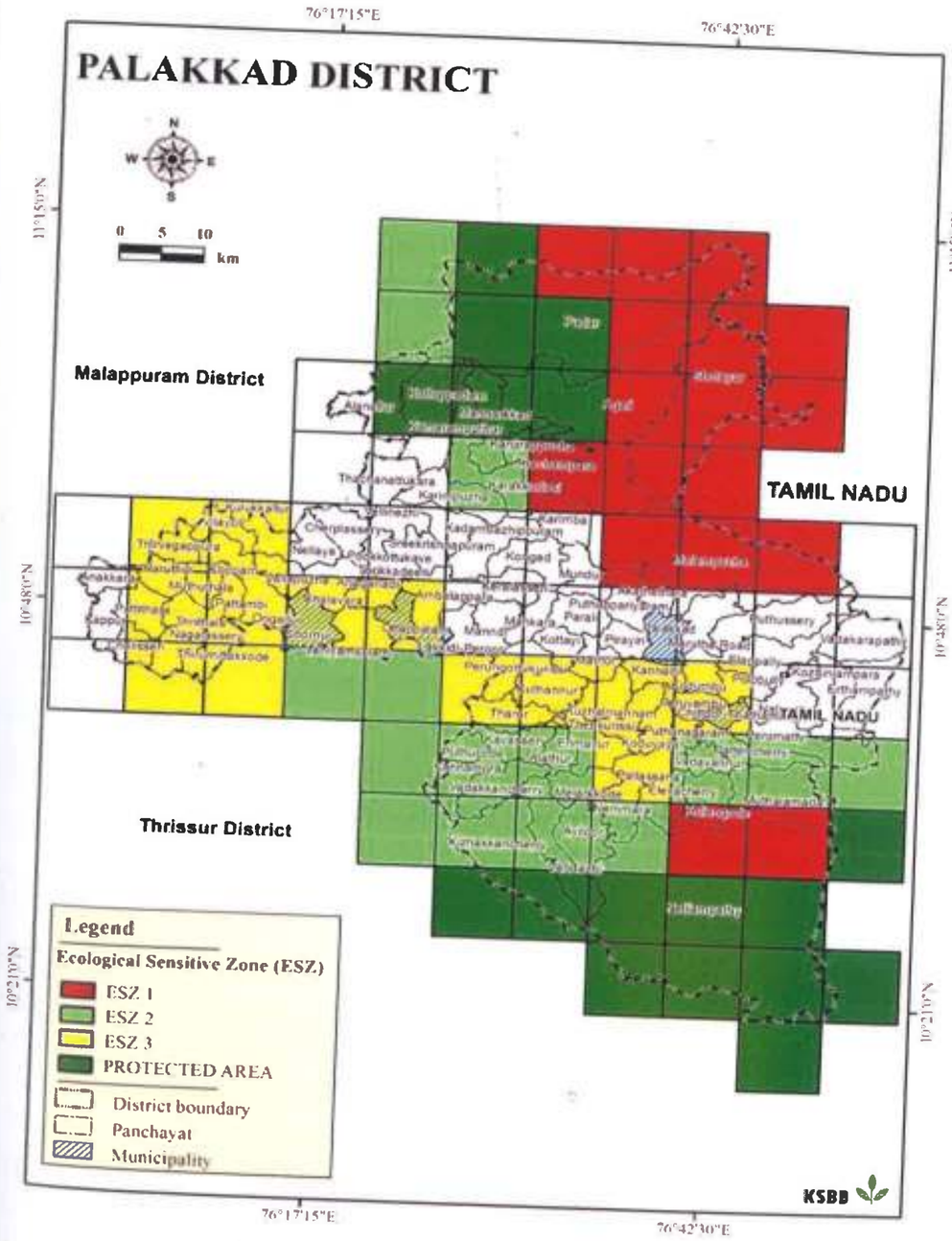
Map 3: Walayar Forest Range

(source:
http://circle.forest.kerala.gov.in/tcpalakkad/index.php?option=com_content&view=article&id=124&Itemid=119)



Map 4: Eco-sensitive zones in Kerala: modified after WGEEP report

Source: Kerala State Biodiversity Board



Map 5: Eco-sensitive zones of Palakkad district (Kerala State Biodiversity Board)

Table 5: Proposed assignment of various Western Ghats Talukas to ESZ1, ESZ2 and ESZ3.

District	Talukas assigned to ESZ1	Talukas assigned to ESZ2	Talukas assigned to ESZ3
Palakkad	Mannarkkad, Chittur		Alattur

(www.keralabiodiversity.org/images/pdf/wgeep.pdf)

Table 6: Proposed ESZ1, and ESZ2 assignment of various Western Ghats talukas for which less than 50% area is within the Western Ghats boundary.

District	Talukas assigned to ESZ1	Talukas assigned to ESZ2
Palakkad	Palghat	Palghat, Ottappalam

(www.keralabiodiversity.org/images/pdf/wgeep.pdf)

The maps reveal that a large part of Palakkad district lies in ESZ1 category which is highly ecologically sensitive zone. It can be observed that while Pudussery Panchayat does not lie in any of the ecologically sensitive zones, it is surrounded by highly sensitive (ESZ1) Malampuzha Panchyat on the northern side and Kodumbu and Elapally (ESZ3) Panchayats on the south-western side.

2.3 Ecology of the Campus and its adjacent habitats

The permanent campus of the Indian Institute of Technology (IIT), is to be developed within the Pudussery West village, near the Kochi-Coimbatore National Highway. As per the plan, the State was to allot about 500 acres of land close to the Kanjikode industrial belt in Pudussery West village to the Ministry of Human Resources Development, Government of India. This was largely enabled through a negotiable purchase of private land.

Table 7: Land acquired for IIT-Palakkad

Pvt. Land	367.87 acres
Pudussery Panchayat land	21.84 acres
Government land (DIC)	70.02 acres
Forest land	44.81 acres
Total land:	504.54 acres

Discussion with Forest Department revealed that in the past, private forests were taken over by the State through The Kerala Private Forests (Vesting and Assignment) Act, 1971. Of such forests, nearly 44 acres of Nellissery Mallavaram vested forest (VF) has been diverted to IIT under item number 34. The rest was Emur Devaswom land.

Out of 367.87 acres of Pvt. Land, 317.77 acres had been purchased and nearly 50.10 acres is yet to be purchased. It was recorded that agriculture was not very profitable owing to the water scarcity in the region. The water level was observed to be low especially during summer season and famers were unable to cultivate a second crop of paddy. Further, the farmers were being impacted due crop losses following crop raiding by elephants. Additionally, there are issues of seasonal forest fires and man-animal conflict in the region. The problem of human-elephant conflict is reported to be severe in the monsoon season and the elephants normally returned to the forests only after the cropping season.

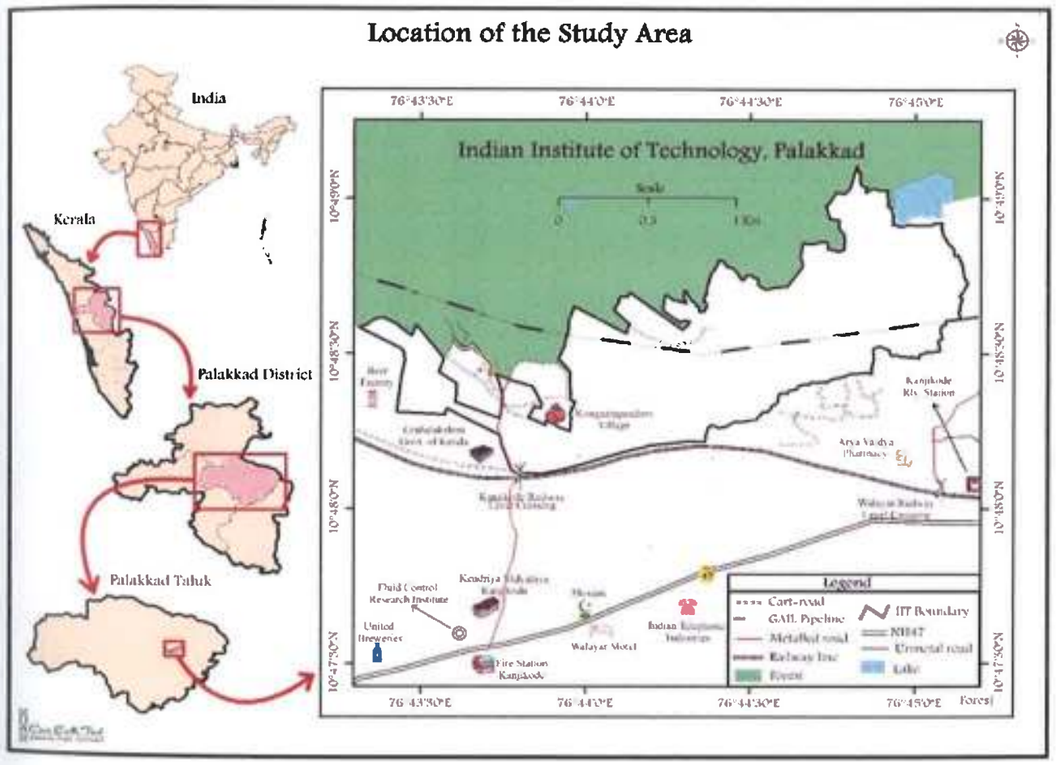
2.3.1 Location

The proposed IIT campus site is located in Pudussery Panchayat covering an area of 529.52 acres. The elevation of the site ranges from 106 m to 142 m amsl. Pudussery west village is located 10 km east of the Palakkad town, close to the Kanjikode industrial cluster. Many industries are located in the Kanjikode Industrial Area, which is termed as the second biggest industrial area in Kerala. The project site is located at about 7 - 8 km from National Highway 47. The access road to IIT site from the Highway is lined with industries and institutes like United Breweries, Fluid Control Research Institute and Kendriya Vidyalaya, Kanjikode as well as small shops and paddy fields. The IIT boundary begins after crossing the Kanjikode Railway Crossing on the south-western side. The railway track runs parallel to some distance along the southern boundary of IIT site. The northern and western boundaries of Palakkad site is highly undulating. As nearly 44 acres of vested forest in the north were diverted for IIT, its northern boundary is contiguous with the Walayar Forest Range. There is a large wetland located outside the north-eastern boundary of the project site. A brewery and Grama Lakshmi Mudralayam are located outside the western boundary of the site. Kongaatupaadam village is nestled between the IIT boundary and the forest on the northern side. The village is linked to the National Highway by a metalled road that runs through the project site on the western side. The Kanjikode railway station is located near the project site. GAIL pipeline traverses from west to east through the project site for a length of 2157.6 meters.

It is important to mention that in the absence of the AutoCAD Land Survey map being available during the survey, field survey over a period of 15 days and GIS tools had to be deployed to define the area and its features: the comparative table is as under:

Table 8: Length and Area assessment of the campus

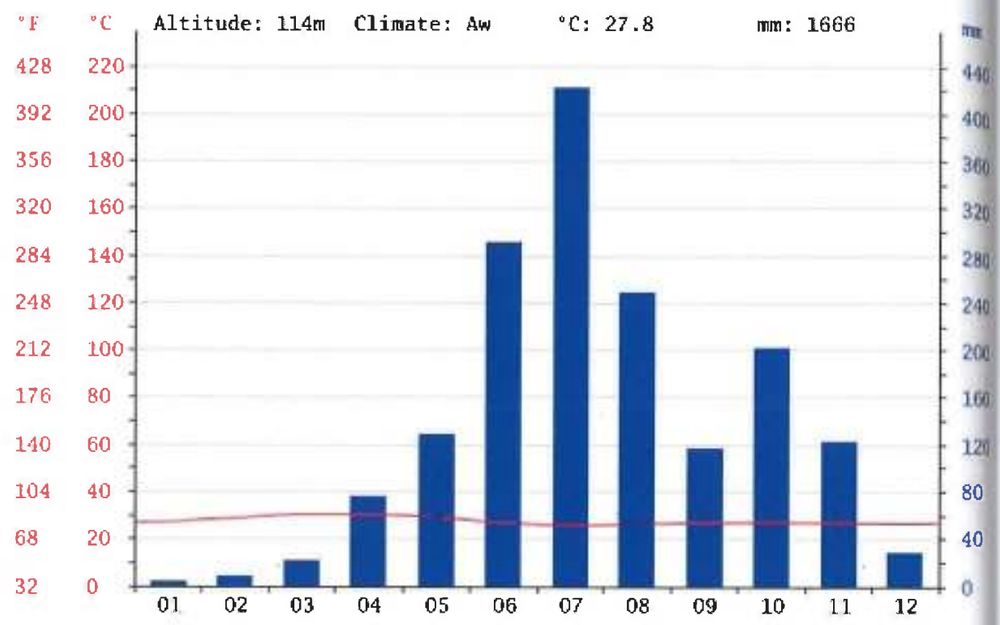
S. No.	Feature	Current Assessment	Land Survey by IIT P
1	Total Perimeter	13.02 Km	13.33 Km
2	West - East length in the Nothern boundary	8.30 Km	8.28 Km
3	Total area of IIT Palakkad campus	526.13 Acres	506.12 Acres



Map 6: Location of the Study Area

2.3.2 Climate

Kanjikode's climate is classified as tropical. It receives more rainfall during the south-west monsoon season in comparison to north-east monsoon. The average annual



temperature in Kanjikode is 27.8 °C and the rainfall here averages 1666 mm.

Figure 2: Graph showing the climate features in Kanjikode

Source: http://en.climate-data.org/location/767104/

In July, the precipitation reaches its peak, with an average of 421 mm. At an average temperature of 30.5 °C, March is the hottest month of the year. Between the driest and wettest months, the difference in precipitation is 417 mm. The variation in annual temperature is around 4.7 °C (http://en.climate-data.org/location/767104/).

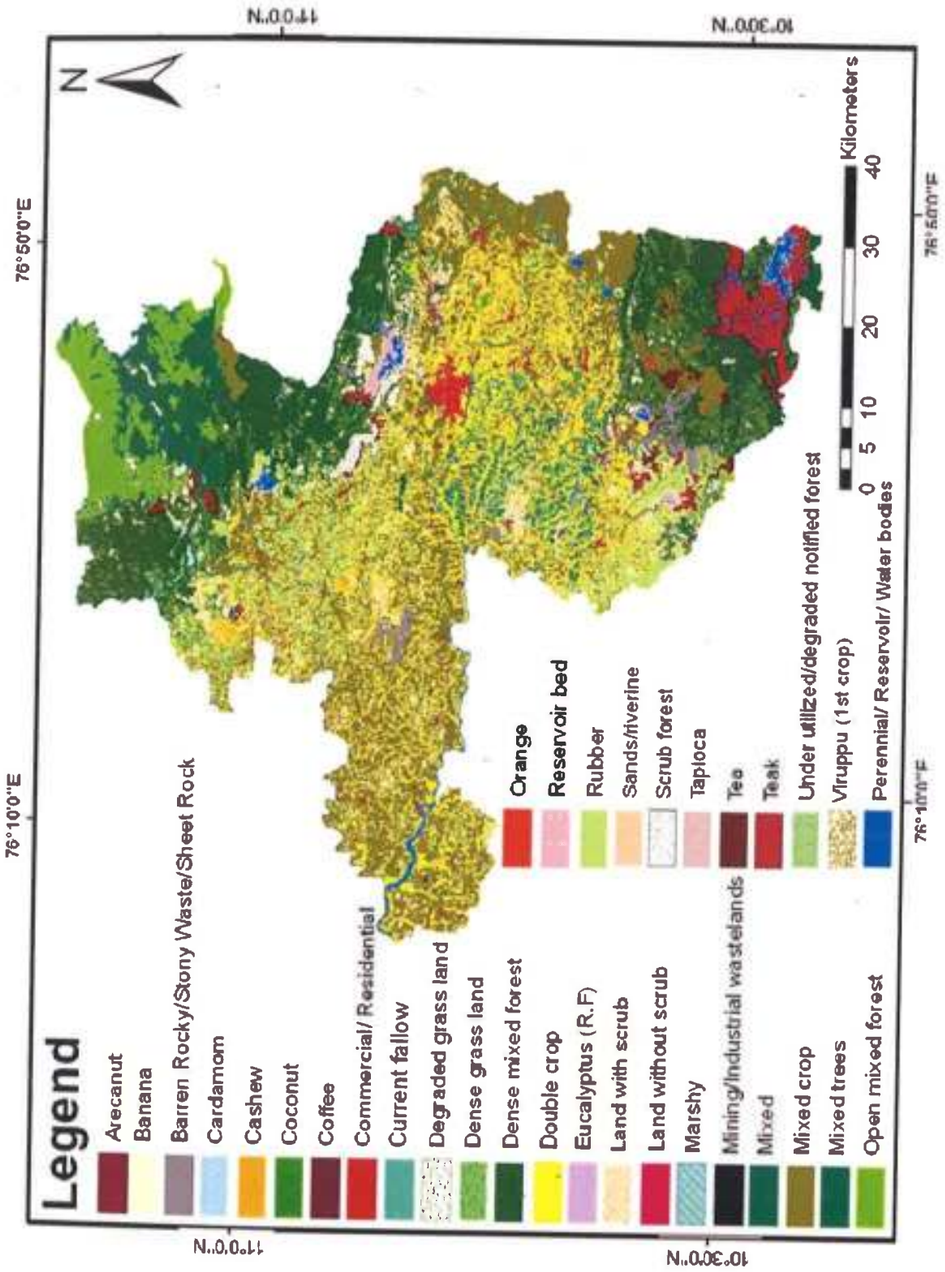
2.3.3 Land use land cover

Palakkad district is known as "the granary of Kerala state". Agriculture is the dominant land use in the district. Paddy, coconut, vegetables, rubber, fruits and spices and condiments are the principal crops cultivated in the district.

Table 9: Land use pattern in Palakkad district (2011)

S. No.	Land use category	Area (Lakh ha.)
1	Geographical area	4.47
2	Forest area	1.36
3	Land under nonagricultural use	0.45
4	Permanent pastures	-
5	Cultivable wasteland	0.29
6	Land under misc. tree crops and groves	0.017
7	Barren and uncultivable land	0.032
8	Current fallows	0.10
9	Other fallows	0.09

(Source: Agriculture Contingency Plan for District: Palakkad, 2011)



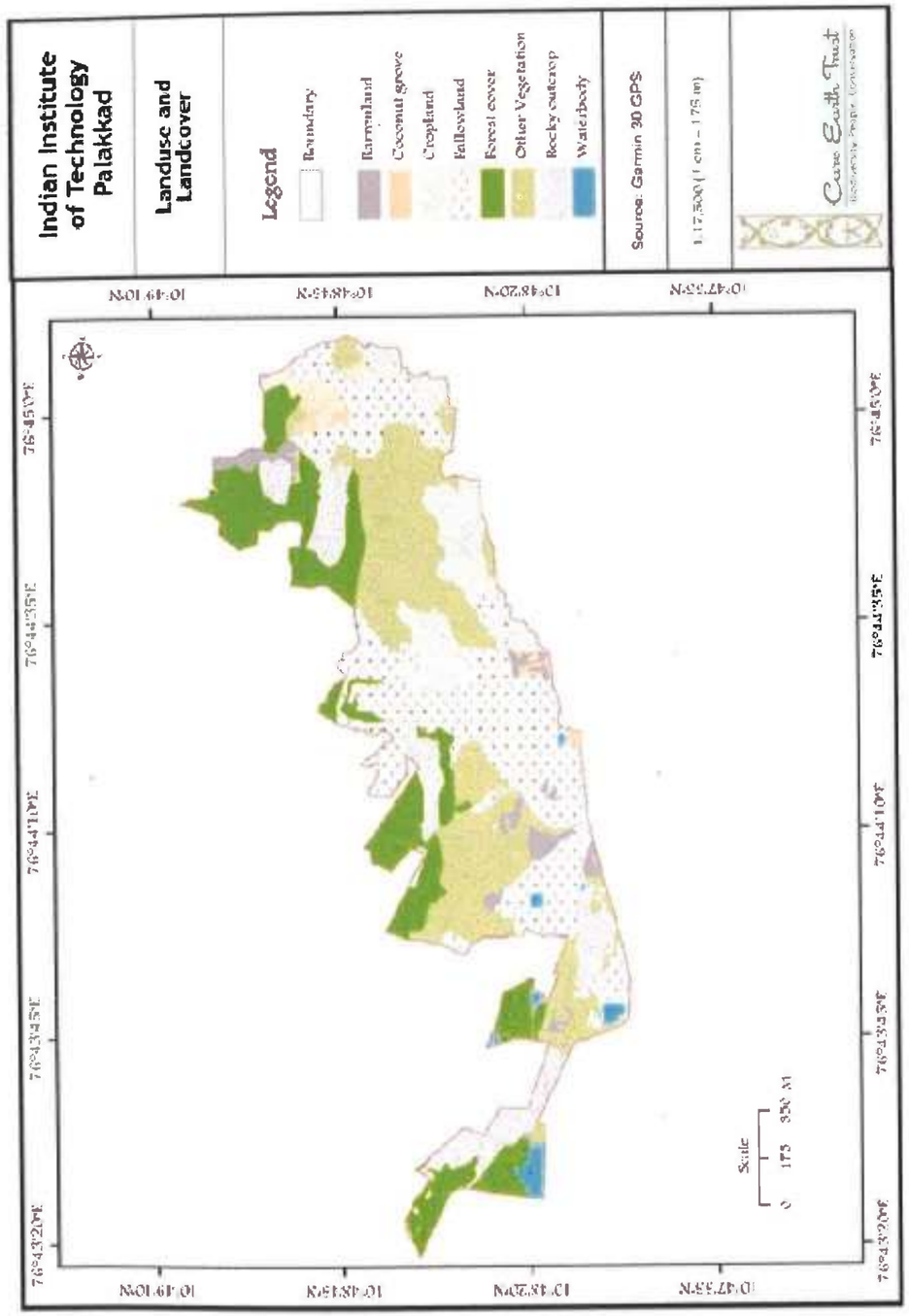
Map 7: Land Use/Land Cover Map of Palakkad district (Gopinath et al. 2014)

2.3.4 Land Use Land Cover of the Study Site

The land use within the study site is dominated by fallow land (30.67%) distributed mainly in the eastern and central portions of the project site. Dense vegetation is observed mostly along the northern boundary of the site as this side is adjacent to vested forest. Moderate to sparse vegetation was recorded throughout the site interspersed with other land cover types. Crop lands covering 49.83 acres, and groves of about 8.80 acres was noted largely in the central and eastern periphery of the project site. A substainal portion of the site is typified by green cover, which are remnants of the historical forests of the landscape and these are present as two large parcels in the central portion of the study site. Rocky portions were found to largely dominate the north-eastern and western sides of the project site. There are a few waterbodies/wetlands at the site including some water filled abandoned quarries. A canal from Periya eri located outside the north-eastern boundary of the project site passes through the site which was used for irrigating paddy fields. The canal is characterised by natural seepage across its length.

Table 10: Land Use Categories in the Project Site

S.No	Landuse	Area in acres	Percentage
1	Fallowland	162.42	30.67
2	Forest	99.16	18.73
3	Waterbody	6.93	1.31
4	Rocky outcrop	47.71	9.01
5	Barren	19.57	3.70
6	Green cover	135.09	25.51
7	Coconut grove	8.80	1.66
8	Cropland	49.83	9.41
	Total:	**529.52**	**100.00**

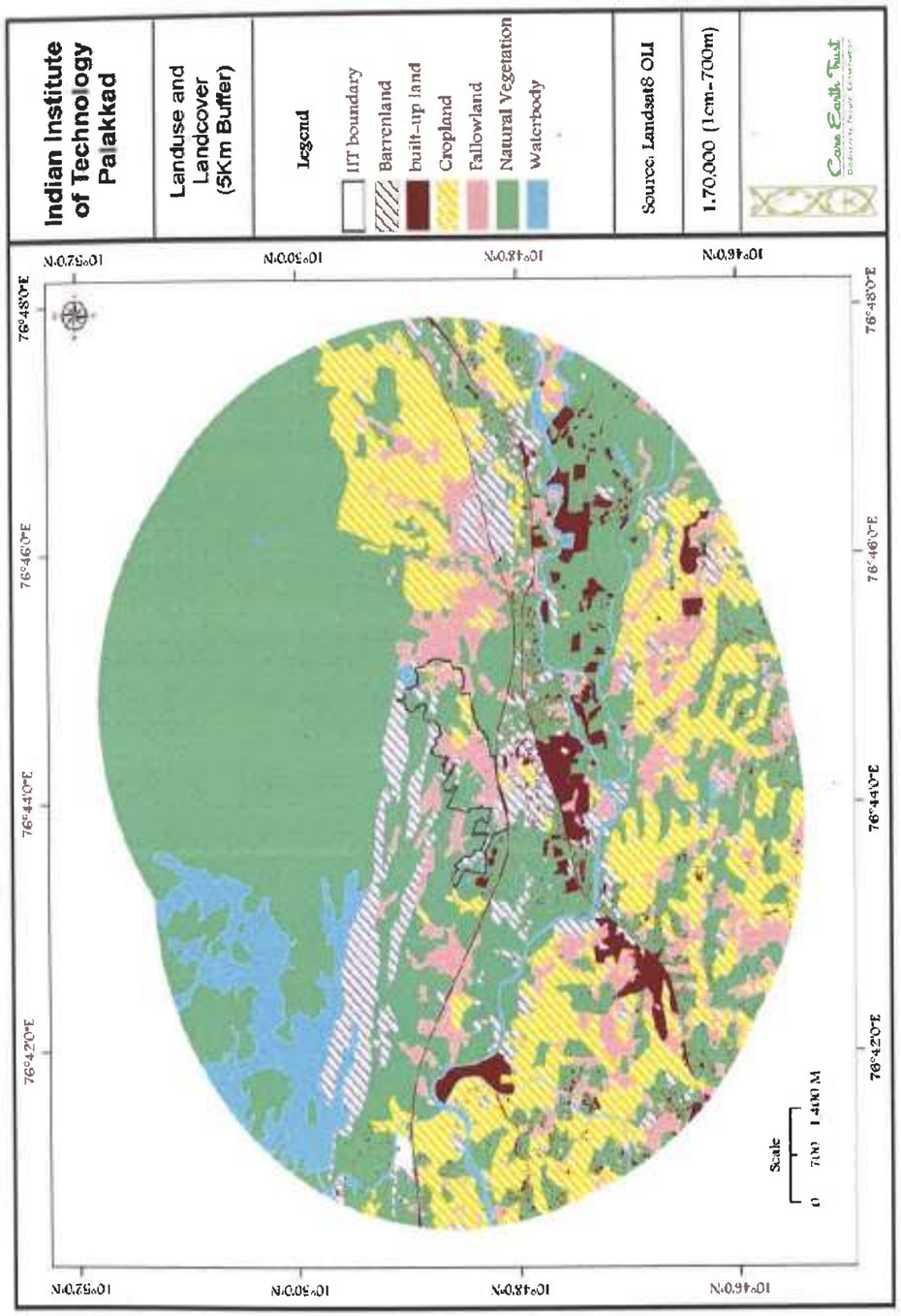


Map 8: Land Use/Land Cover within the proposed Campus

Analysis of land use land cover around the IIT campus site (5 km buffer) showed that the area is largely dominated by forest on the northern side, as also the Malampuzha Reservoir. Cropland can be observed mostly on the eastern and southern side interspersed with fallow land. Despite the overall impression that one gets in the landscape of area under agriculture reducing, it is interesting to note that areas in the immediate vicinity of the streams, especially the higher order streams, continue to be cultivated. Likewise, the southern segment of the landscape (south of the National Highway) seem to reflect more areas under agriculture as opposed to the northen segment where there are larger tracts of barren land: a possible reflection of human animal conflict, or rocky terrain, or a simple conversion of agriculture to other land uses, or presence of seasonal cultivation. The barren land observed on the north-western and western side is mostly rocky hillocks devoid of vegetation. The built-up land largely composed of industrial clusters are noted in the southern side of the landscape.

Table 11: Landuse around the campus (five km buffer)

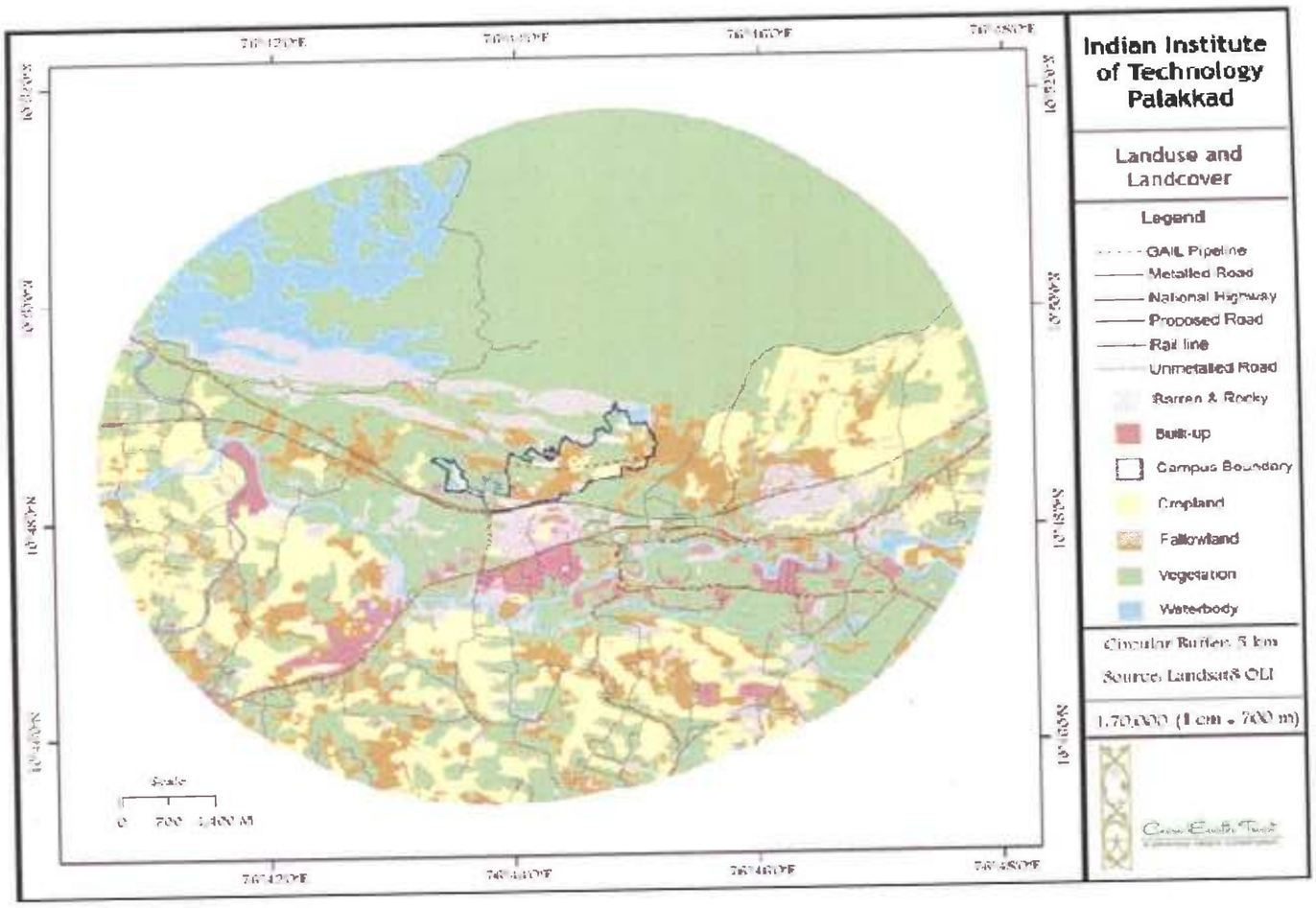
Land use	Area in km^2	Area in Hectare	Percentage
Barrenland	9.43	943.00	7.67
Built-up land	4.84	484.00	3.93
Cropland	21.04	2104.00	17.10
Fallow land	10.82	1082.00	8.80
Natural vegetation	68.07	6807.00	55.33
Waterbody	8.82	882.00	7.17
Total	**123.02**	**12302.00**	**100.00**



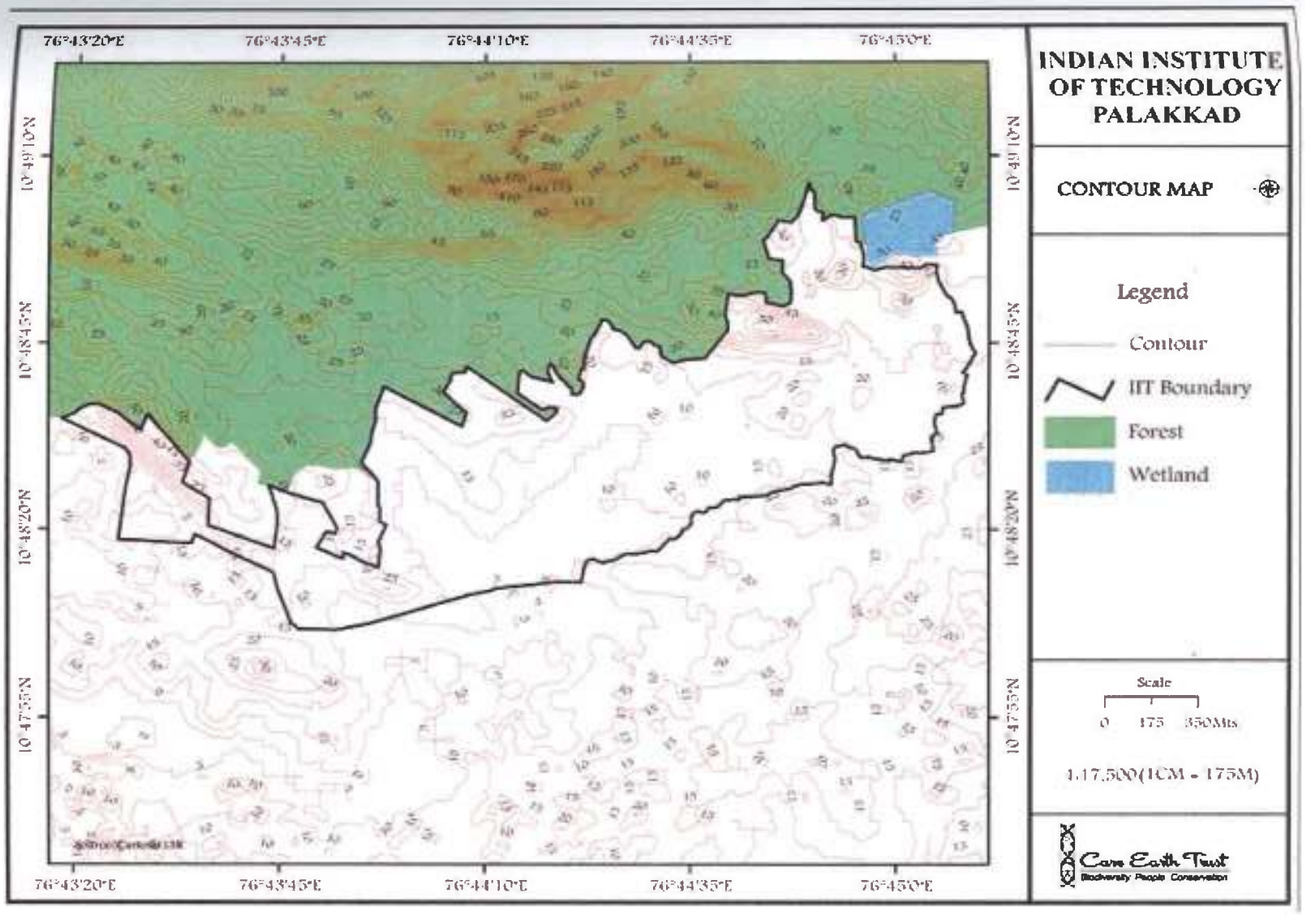
Map 9: Land Use/Land Cover in and around (5 km buffer) the proposed Campus

2.3.5 Access roads for villages around the project site

The proposed IIT Palakkad campus is well connected to other parts of the state as also major access facilities since it is in the immediate proximity of the National Highway 47 which connects Cochin to Coimbatore. Similarly, it is also well connected to Palakkad (the district headquarters) which is about 10 km west of the campus. It is however the roads that actually lead to the campus, as also the roads that provide access to the local villagers that need to be planned with care. Currently, the campus is accessed through a road through its eastern periphery, which also is the primary road of connectivity to the village. As the road leads towards the northern periphery of the campus, it is largely a mud road, and is frequented by elephants that move from the higher elevation forests to the plains. Further, the new road that has been laid to provide access to the small group of 25-28 households that are trapped within the eastern periphery of the large campus, is a point of contention in view of the fact that is longer to traverse, but more importantly is frequented by elephants. This needs to be reviewed and addressed as part of the campus development.



Map 10: Land Use/Land Cover around (5 km buffer) with road connectivity



Map 11: Contour profile of the study site

2.4 Hydrology

Palakkad district is drained largely by two rivers- Bharathapuzha and Bhavani. Of these Bhavani is east flowing and is a tributary of Cauvery River. The landscape around IIT site is largely drained by Koraiyar River. Koraiyar River is one of the tributaries of the river Kalpathipuzha, which in turn is a main tributary of the Bharathapuzha River (cgwb.gov.in/District_Profile/Kerala/Palghat.pdf). The rivers of this region including Koraiyar drain into Bharathapuzha River which ultimately flows into Arabian Sea. Bharathapuzha is therefore a west flowing river which originates in the Western Ghats. In recent years, the basin is facing severe water scarcity and drought, especially due to anthropogenic pressures. Unsustainable exploitation of water, instream sand mining and clay mining for brick kilns are among the threats to the flow of the river (Raj and Azeez, 2009).

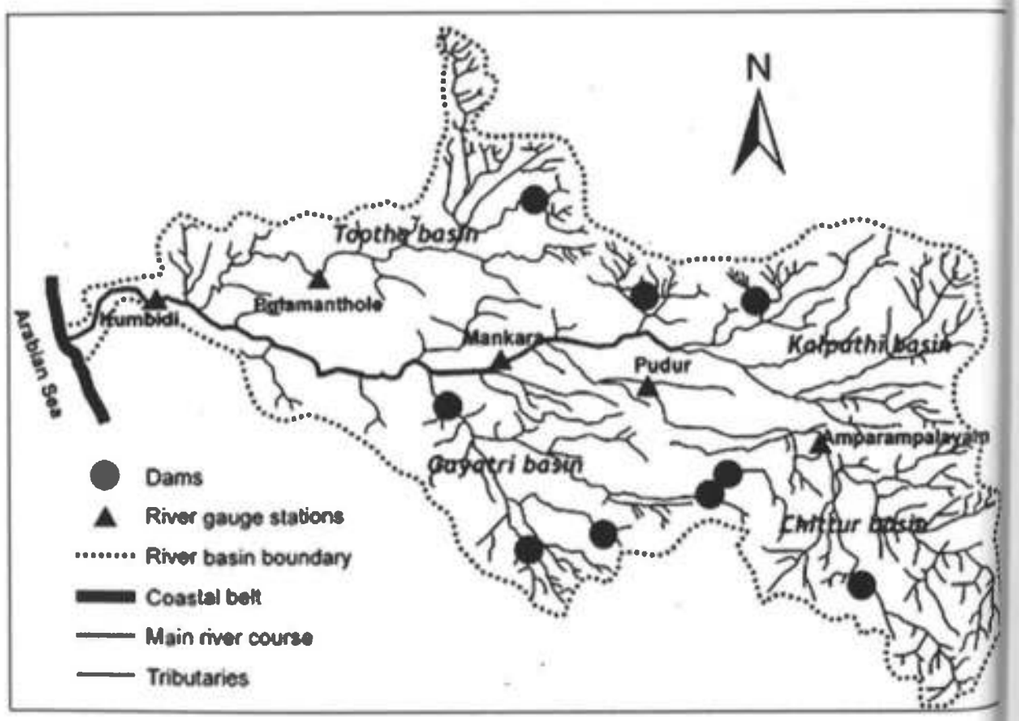
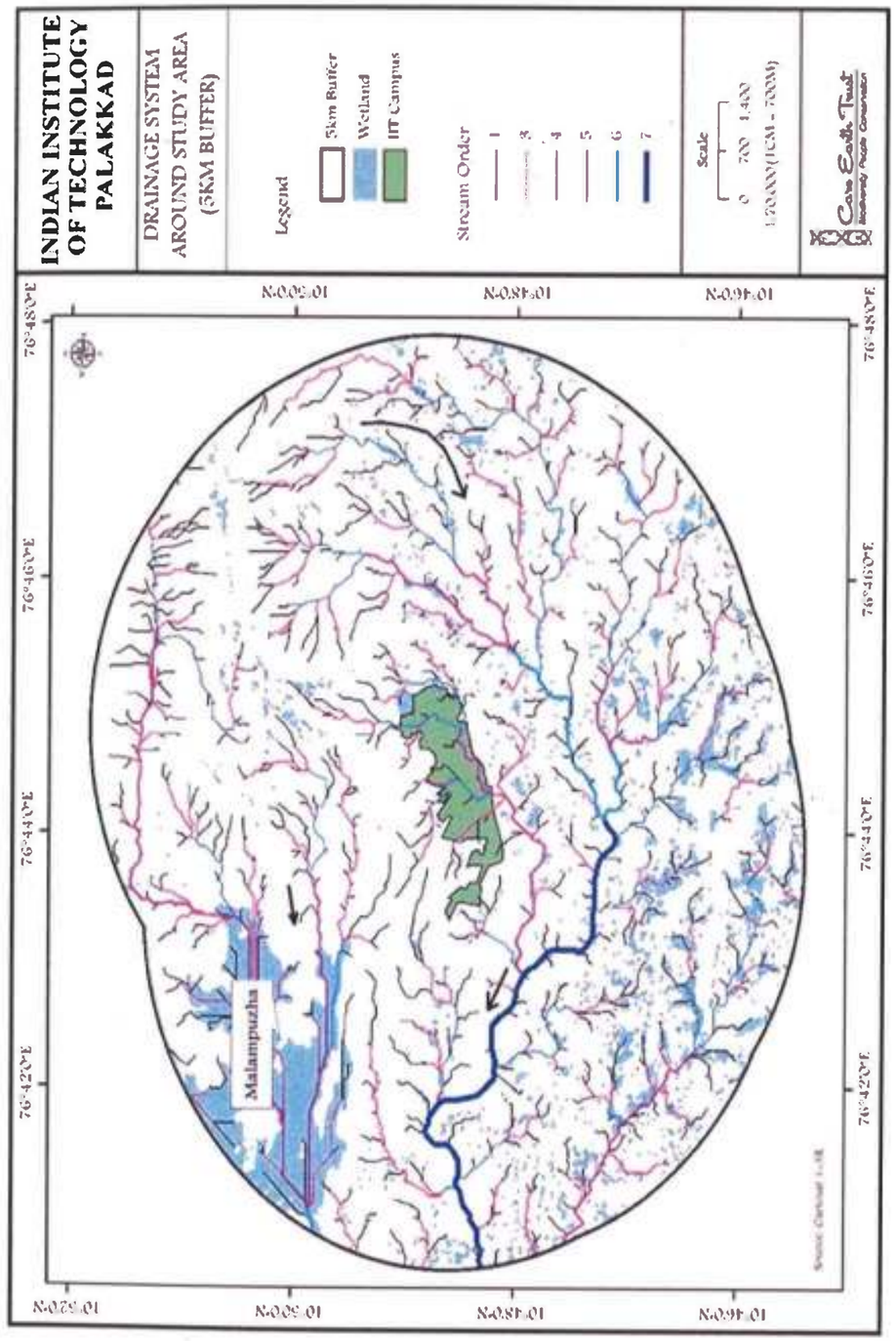


Figure 3: Bharathapuzha River Basin Map (Raj and Azeez, 2009)

Hydrological studies are basic to understanding the patterns of drainage and water storage (surface and underground) in any terrain, and is an inherent component in defining the ecology of the landscape. Hydrological profiles form the basis for planning the schematic of a campus, and are in many ways are the fundamental of sustainable resource management.

In this section the hydrology of the Campus is presented at the scale of the landscape as well as the local scale. The map of the drainage system was created using Cartosat-1. Carto DEM-3R DEM (Digital Elevation Model) data downloaded from bhuvan.nrsc.gov.in with a spatial resolution of 2.5 m. The following hydrological techniques were systematically followed in order to extract the stream flow. Initially filling technique was utilized that fills sinks in a surface raster to remove small imperfections in the data. Secondly the technique of flow direction was utilized that creates a raster of flow direction from each cell to its steepest down-slope neighbour. Thirdly, flow accumulation technique was utilized that creates a raster of accumulated flow into each cell. A weight factor can optionally be applied; the output is further analyzed using the conditional techniques where it performs a conditional if/else evaluation on each of the input cells of an input raster. The second technique evolves from Strahler method of stream ordering proposed by Strahler in 1952. Stream order only increases when streams of the same order intersect. Therefore, the intersection of a first-order and second-order link will remain a second-order link, rather than creating a third-order link. The final step in the hydrological analysis is the "stream to feature" where it Converts a raster representing a linear network to features representing the linear network.



Map 12: Drainage pattern around the campus

The hydrological analysis of the drainage system of IIT project site landscape showed that the drainage is largely east to west. On the higher elevation, northern periphery, it is interesting to note that there are number of wetlands scattered especially on the western periphery. The Malampuzha reservoir dominates on the western periphery. What is interesting however is the absence of networks of smaller order streams in the higher elevation zones that normally trigger large scale erosion, but the presence of well defined streams that drain in the south-westerly direction. Most of the streams ultimately consolidate into the Koraiyar River. If the IIT Campus is considered as the mid point, it is evident tht the southern segment of the 5 km buffer is well watered, not just by stream networks but also by a number of wetlands (largely man made). And this could be the single most determining factor for continued cultivation, as also the foray of elephants into the landscape for crop raiding.

The IIT Campus is drained by two fourth-order streams which consolidate into a single fifth order stream near the southern periphery of the campus. This is the region which forms the catchment of the campus and in the subsequent sections of the report where potential designs for campus development have been detailed, this section has been earmarked as a constructed wetland. The moot point is that this section needs to be dedicated to harvest and conserve water for direct and associated uses within the campus.

The IIT Campus is well drained, and there are number of perennial streams (more like seepage) in the landscape. This is further reiterated by the local tradition of digging out shallow, small ponds (ooranis) for domestic water requrirement. A number of small wetlands were recorded at the site in the western and south-western sides. These wetlands included small ponds and water filled abandoned quarries. A canal from Periya eri located outside the north-eastern boundary of the project site passes through the site which was used for irrigating paddy fields. Seepage water was also observed at the site coming from the canal running inside the site. Discussion with engineers at IIT Palakkad revealed the plan to transfer water from Malampuzha reservoir to IIT project site through a pipeline. The Malampuzha Irrigation Project, located on the north western periphdery of the landscape is the first large-scale irrigation system in Kerala. The

project consists of a dam constructed across the river Malampuzha, a tributary of Bharathapuzha and network of canal system to irrigate an area of 21,245 ha. The capacity of the reservoir is 226 mm^3 at Full Reservoir Level (FRL) + 115.06 m and a water-spread area of 22 sq.km. There is a network of two canal systems that serve the dam's reservoir of 42,090 ha. The canal systems serve to irrigate farm land while the reservoir provides drinking water for Palakkad Municipality and 6 adjacent panchayats. The dam was conceived as a multi-purpose project to provide water for irrigation, drinking, industries, power generation, fish farming and water transport.

The left bank is designed for discharge at head of 21.24 cumec to serve 17050 hectare and the length is 31.60 km. The canal with its network empties its residual water into Gayathri River to be used by Cheramangalam scheme about 5 km downstream of the river. The scheme was completed in the year 1951 and irrigates an ayacut of 1205 hectare. The right bank canal has a length of 32 km irrigating an area of 4299 hectare (http://india- nris.nrsc.gov.in/wrpinfo/index.php?title=Malampuzha_Major_Irrigation_Project_JI02667)

2.4.1 Water crisis

According to agriculture contingency plan for Palakkad district (2012), the district is prone to drought as well as heat wave conditions

(agricoop.nic.in/Admin_Agricoop/Uploaded_File/KER6-Palakkad-30-02011.pdf).
According to a report (dated October, 2016), a 34% decrease in average rainfall between June and September in 2016 was recorded in Palakkad district resulting in a major drinking water scarcity and agricultural loss. Although Palakkad has a number of irrigation dams with good canal connectivity, catchment areas of the dams were now remaining dry because of lack of sufficient rainfall. Malampuzha, the largest drinking water reservoir in the State, reportedly had low drinking water levels. In April, 2016, it was reported that the depleting water level in the Malampuzha reservoir posed a threat to water availability in areas coming under Palakkad municipality and the surrounding Gram panchayats of Malampuzha, Akathethara; Puthupariyaram, **Pudussery**, Pirayiri and Marutha Road. According to another news report several firms like Pepsico, United Breweries, Amrut Distilleries, United Spirits and Empee Distilleries, which dot the

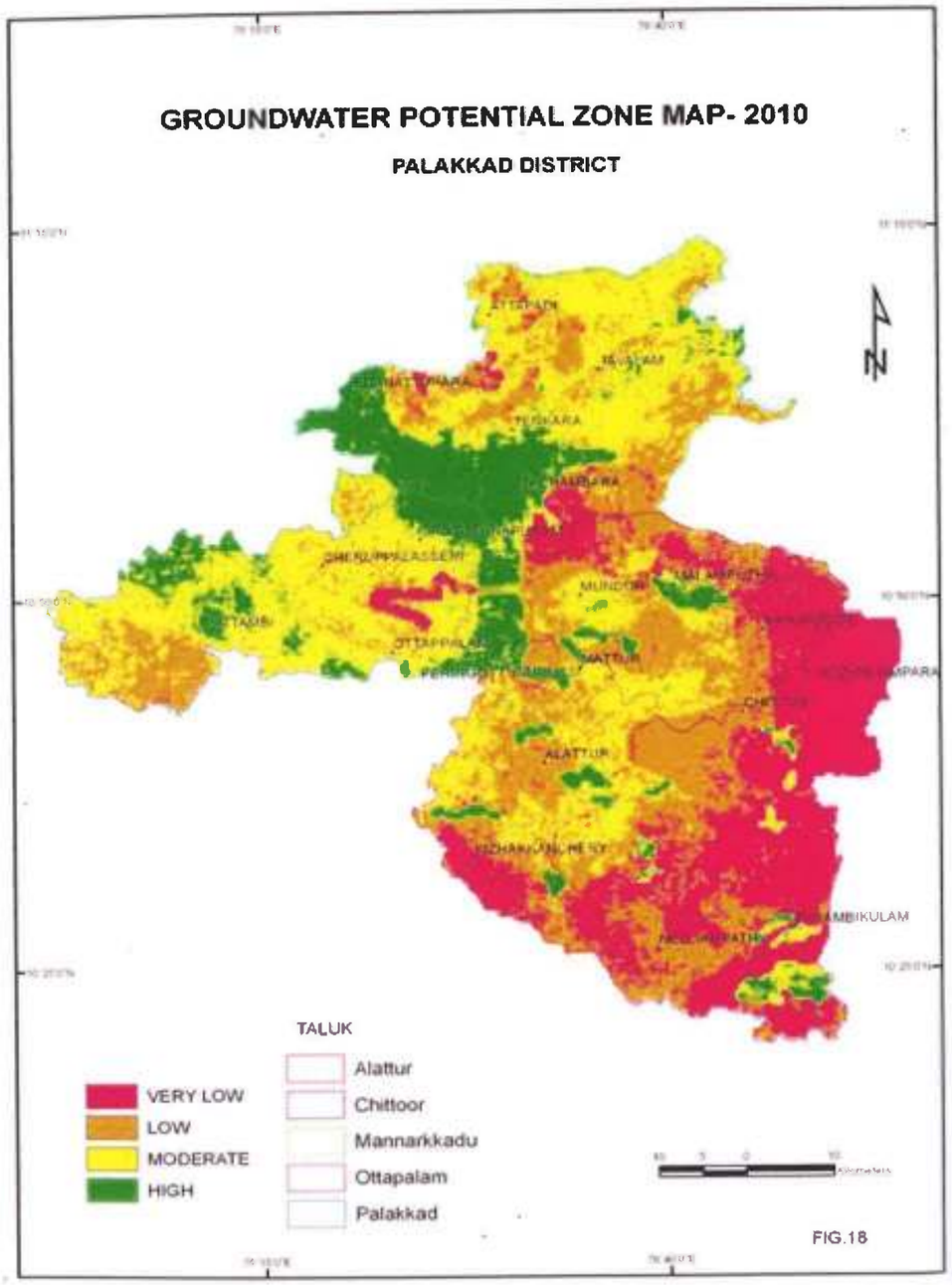
Kanjikode landscape, consume lakhs of litres of water every day, resulting in over-extraction of groundwater. Pudussery Panchayat also wanted PepsiCo to shut down its plant due to water crisis in the region. On the basis assessment of groundwater utilization pattern, across Kerala, Malampuzha block of Palakkad district has been categorized as 'Critical' (CGWB, 2012).

(http://www.thehindu.com/todays-paper/tp-national/tp-kerala/severe-water-crisis-grips-palakkad/article9242518.ece;

http://www.thehindu.com/news/national/kerala/palakkad-on-the-brink-of-a-water-crisis/article8469067.ece;

http://articles.economictimes.indiatimes.com/2016-05-11/news/72987643_1_pepsico-india-pepsi-co-india-water-exploitation;

http://www.newindianexpress.com/thesundaystandard/2016/may/01/Corporates-Make-a-Killing-as-Villagers-Cry-for-Water-931497.html)



Map 13: Groundwater potential map for Palakkad district -2010 (Jose et al. 2012)

In the 1960s, the Industries Department acquired about 130 acres in Pudussery West Village for an Industrial Development Area. Later the department acquired about 500 odd acres of land in Pudussery Central Village for a new industrial development area. Further, large quantity of limestone deposits are found in Walayar forest area where the Malabar Cement Factory is located. A number of major industries including textile and soft drink giants set up units in Kanjikode due to the availability of cheap land, power and proximity to the fast growing industrial centres of Coimbatore and Tiruppur. About 48 industries of various sectors are established in the Kanjikode area like distilleries, petroleum, steel, cement, paint colour, beer and soft drinks companies, fertilizers and chemicals manufacturing industries, etc. Kanjikode is one of the largest industrial areas in Kerala and companies like Indian Telephone Industries (ITI), Instrumentation Limited (ILP), Fluid Control Research Institute (FCRI), Carborundum International, Patspin India Ltd, Pepsi, PPS steel (Kerela) Pvt Ltd, United breweries, Empee Distilleries, Marico, Bharath Earth Movers Ltd, Rubfila International Ltd, Arya Vaidya Pharmacy (AVP) etc. have production facilities here (Nisha et al. 2010; http://www.thehindu.com/2003/05/18/stories/2003051801940500.htm).

According to a news report (dated November, 2015), chemical contamination caused by a number of factories, including steel rerolling mills and iron smelting factories, in the Kanjikode industrial belt was posing a threat to Koraiyar River. Fishes had been found dead in the river near the check-dam at Koralaru. This tributary, which joins the Bharathapuzha through Kalpathi, is one of the major sources of drinking water across the Bharathapuzha river basin. Chemical contamination had affected the quality of water being supplied to large parts of Palakkad, Thrissur, and Malappuram districts. According to people living close to the river in the Kanjikode area, chemical contamination had polluted the water in the wells. Other than chemical contamination, illegal sand-mining was also posing threat to the river, which once was the lifeline of the Walayar-Kanjikode belt. Close to the Walayar forests, the river is the main source of drinking water for animals, including elephants in Walayar, Akkara and Anikkad forests. It also helps irrigate vast stretches of paddy fields in the region. (http://www.thehindu.com/news/national/kerala/chemical-contamination-posing-threat-to-korayar/article7848857.ece;

http://cmsenvis.cmsindia.org/newsletter/enews/NewsDetails.asp?id=71157). As per a report submitted by the district administration, a dyeing unit and a liquor bottling plant were primarily responsible for polluting the river and causing the death of large number of fishes. Preliminary tests found that sulphur and sulphite levels were more than the permissible level in the river water. The oxygen level in the river water had also come down significantly.

(http://www.saconenvis.nic.in/e_bulletin_NOV_2015_files%5CKorayar.htm).

A study by Nisha et al. (2010) revealed deteriorating water quality in Kanjikode, possibly as a result of rapid and over- exploitation of water and effluent disposal into the water reservoirs from various industries. Most of the water samples from the area had total alkalinity, total hardness, chlorides, salinity, oxygen, iron, and sulfates significantly higher than desirable limits.

According to Shaji (2007), industrial pollution in the Kanjikode industrial park in Kerala had assumed alarming proportion. As many as 42 iron-smelting factories along with the soft drink giant Pepsi's bottling unit were violating the pollution control measures and industrial safety norms. Almost all the residents near the park were suffering from bronchitis, asthma, cancer and kidney diseases ever since the establishment of these units. Further, many of these polluting units were located on the banks of Korayar, a major tributary of Kerala's largest river Bharathapuzha. Due to the direct dumping of industrial wastes into the river, water had turned arsenic and about a kilometer stretch of its bank was deposited with the solid wastes. Further, a sponge iron unit, had recently been established close to the Malampuzha drinking water and irrigation project site in Bharathapuzha. Once operational, the factory's waste and fly ash was expected to contaminate the water source of over five lakh people. According to Pudussery Panchayat, parts of missiles, tanks, chemical equipment and even nuclear wastes were being imported from overseas to be re-cycled there. According to a study by the Central Pollution Control Board, no such factory was permissible in Palakkad district considering its demographic aspects. Most factories do not possess the panchayat's license to smelt iron (www.countercurrents.org/shaji100807.htm).

According to Kerala State Action Plan on Climate Change, the major climate change hotspot districts in Kerala were Alappuzha, Palaghat and hilly districts of Wayanad and Idukki. Overall, Palakkad had higher composite vulnerability index as social economic vulnerability index was an important determinant in this district (Kerala State Action Plan on Climate Change).

2.4.2 Hydrological Management

The following activities can be undertaken to maintain sustainability in the campus and coping with water scarcity.

i. Rainwater harvesting- Since the area is prone to water stress especially during the summer months, it is suggested to install appropriate rainwater harvesting structures while designing the campus. This would include a dedicated effort to protect, develop and convert a constructed wetland in the zone that has been identified as the catchment area by the current assessment.
Localized rainwater harvesting systems around the impervious rocky section located on the north-eastern and north-western sides of the project site in the form of check dams could be effective through their ability to channel rainfall runoff into the underground aquifer. Percolation tanks could also be constructed around the rocky outcrops to capture runoff and recharge groundwater. It would also check erosion and prevent evaporation losses. Percolation tanks are to be normally constructed in natural depression on second or third order streams, as the catchment area of such streams would be of optimum size (www.wrmin.nic.in/writereaddata/ModelDesignsforRainWaterHarvesting.pdf).

ii. Preventing over-extraction of groundwater- As indicated by some studies the groundwater potential is low in the area, it is suggested to prevent over-extraction of groundwater. Further, digging up of bore wells in the campus along the stream drainage may lead to drying up of small order streams and wetlands.

iii. Water recycling- Waste water in the campus can be recycled by re-using treated wastewater for beneficial purposes such as landscape irrigation, toilet flushing, and replenishing groundwater. Wastewater treatment can be tailored to meet the

water quality requirements of a planned reuse. Recycled water for landscape irrigation would require less treatment.

iv. Water quality monitoring- As the project site is located near the Kanjikode industrial belt with reports of existing water pollution it is suggested to monitor the water quality in the campus on a regular basis to check for signs of pollution or contamination.

v. Water efficient landscape design- One of the best means of conserving water is to design or modify the campus landscape to reduce its water requirements. The landscape design could take into account the local climate as well as soil conditions. Focus should be on preserving as many existing trees and shrubs as possible, because established plants usually require less water and maintenance. Plants native to the region should be selected as native plants, once established, would require very little to no additional water beyond normal rainfall. Also, because they are adapted to local soils and climatic conditions, native plants commonly would not require the addition of fertilizers. The regional and microclimatic conditions of the site, existing vegetation, topography, intended uses of the property, and the grouping of plants by their water needs, can also be taken into account while designing. Also the plants' sun or shade requirements and preferred soil conditions should be considered. Lawns require a large amount of supplemental water and generally greater maintenance than other vegetation. Hence if necessary, select a type of grass that can withstand drought periods and become dormant during hot, dry seasons (www.epa.gov/watersense/outdoor).

2.5 Vegetation

Flora

Plants are the organisms that give every landscape its unique character. Plants are also fundamental to the creation of terrestrial habitats. It is therefore important to study the diversity of plants in any landscape for conservation planning and sustainable development. The following section describes the landscape, vegetation diversity and plant species diversity of the Campus.

The Landscape

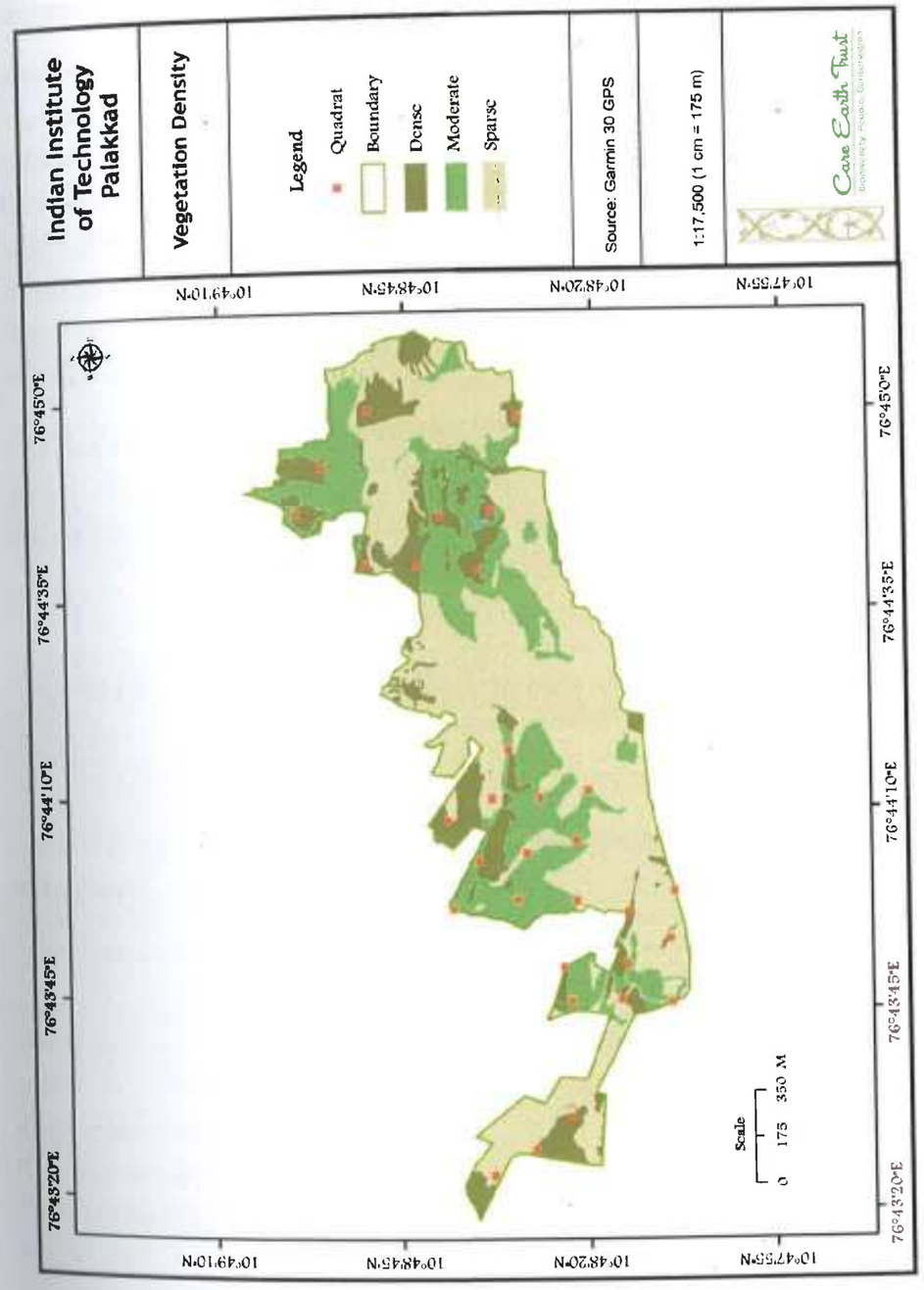
The campus is a mosaic of habitats with remnants of dense forests, agricultural fallows, rocky outcrops, human habitation and water bodies. The forests represent the lowland moist deciduous to semi-evergreen types as described by Champion and Seth (1968). These forests are mostly confined to the northern and north-eastern sides and are characterized by the presence of evergreen trees. The western segment is topographically diverse having a linear hillock with a thin strip of moist forests along the foothills. This segment is also home to many wetland herbs. Rest of the Campus is comprised of recent fallow lands with human habitation at the center. Paddy is the predominant crop cultivated in this landscape.

2.5.1 Methodology for assessing the plant species richness, density and dominance

Since the landscape is highly variable in topography and types of habitats, intensive field work was carried out in an all-out-search mode for the documentation of plant species richness. Inventory of all the Angiosperm plants was made by visiting every possible location within the Campus. The initial ground survey suggested that, transect method, if applied to collect plant data would be biased since the major land use within the campus is fallow-land and the occurrence of dense vegetation (forests) was localized and patchy. We therefore used 10x10m quadrats. A total of 31 quadrats were sampled. Plant species richness is thus estimated and presented in the form of a checklist and also based on quadrat data.

Plants were classified into different life-forms such as trees, shrubs, saplings, liane, herbs, grasses, etc. Saplings were counted to understand the dynamics of plant species recruitment in the landscape. Woody plants having a girth at breast height (GBH) of more than 15 cm and taller than 1.5 m are considered as trees.

Herbaceous plants such as grasses, sedges, creepers were also recorded in the inventory. However, counting of individual herbs and grasses was avoided due to the difficulty in quantifying them as most of them are runners, occurring as clumps and ephemerals. Slender stemmed plants like climbers and creepers have been recorded individually. Invasive alien species (IAS) or any other proliferating non-native species in the quadrats were also recorded as this will be helpful in finding the potential threat from such plant-invaders to the landscape.



Map 14: Vegetation density and distribution of Quadrats

Density, frequency, and abundance of woody angiosperm species were determined as per Curtis and McIntosh (1950).

(a) Species Density

Density is the expression of the numerical strength of a species where the total number of individuals of each species in all the quadrats is divided by the total number of quadrats studied. Density is calculated by the equation:

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

(b) Frequency (%)

This term refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence. It was calculated by sampling the study area at several places and by recording the occurrence of the species in each sampling unit. It is calculated by the equation:

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which the species occurred X 100}}{\text{Total number of quadrats studied}}$$

(c) Degree of dispersion

Degree of dispersion is calculated by dividing the frequency of a species by the total number of quadrats studied. It is a measure of how widely a species is distributed.

2.5.2 Plant species richness

The overall richness of Angiosperms as inferred by the all-out-search method is 383 species (Table 1). These 383 species represent 256 genera and 86 families. 39 families are represented by single species. The flora is dominated by herbaceous species (more than 50%) with 163 species of herbs and 24 species of grass. In comparison only 73 species are trees (Table 2). Only 40% of the plants species (150 species) were represented in the quadrats. However, the quadrats enabled us to estimate the numerical abundance and spatial segregation of the 150 species of plants.

2.5.3 Plant Density and Dominance

Xylia xylocarpa ('Iruli' in Malayalam) is the most abundant native woody angiosperm in the Campus (Table 16). The estimated density is 4.065 (saplings) and 2.258 (mature trees) per 100 sq.m. *Morinda* and *Calycopteris floribunda* also show high density (1.677 & 1.516 respectively) among the native species. Other smaller shrubby plants dominating the landscape in terms of density are the *Hyptis, Mimosa diplotricha* and *Chromolaena*. The dominance of these non-native species poses a threat to the natural vegetation and native biodiversity in the Campus apart from creating a weed management problem in future.

Table 12. Checklist of Angiosperms in the Campus

No.	Family	Species	Habit
1	Acanthaceae	***Andrographis echioides*** Nees	Herb
2	Acanthaceae	***Blepharis repens*** (Vahl) Roth	Herb
3	Acanthaceae	***Dipteracanthus prostratus*** (Poir.) Nees	Herb
4	Acanthaceae	***Hygrophila schulli*** (Hamilt.) M.R.Almeida & S.M.Almeida	Herb
5	Acanthaceae	***Justicia adhatoda*** L.	Shrub
6	Acanthaceae	***Justicia diffusa*** Willd.	Herb
7	Acanthaceae	***Justicia procumbens*** L.	Herb
8	Acanthaceae	***Rungia pectinata*** (L.) Nees	Herb
9	Acanthaceae	***Stenosiphonium russellianum*** Nees	Shrub
10	Acanthaceae	***Thunbergia fragrans*** Roxb.	Twiner
11	Alangiaceae	***Alangium salvifolium*** (L.f.) Wang.	Tree
12	Amaranthaceae	***Achyranthes aspera*** L.	Herb
13	Amaranthaceae	***Aerva lanata*** (L.) Juss. ex Schultes	Herb
14	Amaranthaceae	***Allmania nodiflora*** (L.) R. Br. ex Wight	Herb
15	Amaranthaceae	***Alternanthera paronychioides*** A.St.	Herb
16	Amaranthaceae	***Alternanthera philoxeroides*** (C. Martiu) Griseb.	Herb
17	Amaranthaceae	***Alternanthera sessilis*** (L.) R.Br. ex DC.	Herb
18	Amaranthaceae	***Amaranthus spinosus*** L.	Herb
19	Amaranthaceae	***Amaranthus viridis*** L.	Herb
20	Amaranthaceae	***Gomphrena globosa*** L.	Herb
21	Amaranthaceae	***Gomphrena serrata*** L.	Herb
22	Anacardiaceae	***Lannea coromandelica*** (Houtt.) Merr.	Tree
23	Anacardiaceae	***Semecarpus anacardium*** L.	Tree
24	Annonaceae	***Annona reticulata*** L.	Tree
25	Annonaceae	***Annona squamosa*** L.	Tree

26	Annonaceae	***Artabotrys hexapetalus*** (L. f.) Bhandari	Straggler
27	Apocynaceae	***Catharanthus pusillus*** (Murr.) G.Don	Herb
28	Apocynaceae	***Holarrhena pubescens*** (Buch. - Ham) Wall. ex G. Don	Tree
29	Apocynaceae	***Ichnocarpus frutescens*** (L.) R.Br.	Climber
30	Apocynaceae	***Wrightia tinctoria*** (Roxb.) R.Br.	Tree
31	Aponogetonaceae	***Aponogeton natans*** (L.) Engler	Herb
32	Araceae	***Amorphophallus paeoniifolius*** (Dennst.) Nicolson	Herb
33	Araceae	***Amorphophallus sylvaticus*** (Roxb.) Kunth	Herb
34	Araceae	***Colocasia esculenta*** (L.) Schott	Herb
35	Arecaceae	***Borassus flabellifer*** L.	Tree
36	Arecaceae	***Cocos nucifera*** L.	Tree
37	Aristolochiaceae	***Aristolochia indica*** L.	Twiner
38	Asclepiadaceae	***Calotropis gigantea*** (L.) R.Br.	Shrub
39	Asclepiadaceae	***Holastemma ada-kodien*** Schultes	Climber
40	Asclepiadaceae	***Pentatropis capensis*** (L.f.) Bullock	Climber
41	Asclepiadaceae	***Pergularia daemia*** (Forrsk.) Chiov.	Climber
42	Asclepiadaceae	***Tylophora indica*** (Burm.f.) Merr.	Climber
43	Asclepiadaceae	***Wattakaka volubilis*** (L.f.) Stapf	Twiner
44	Asparagaceae	***Asparagus racemosus*** Willd.	Climber
45	Asphodelaceae	***Aloe vera*** (L.) Burm.f.	Herb
46	Asteraceae	***Blainvillea acmella*** (L.) Philipson	Herb
47	Asteraceae	***Blumea obliqua*** (L.) Druce	Herb
48	Asteraceae	***Chromolaena odorata*** (L.) King & Robinson	Shrub
49	Asteraceae	***Eclipta prostrata*** (L.) L.	Herb
50	Asteraceae	***Emilia sonchifolia*** (L.) DC.	Herb
51	Asteraceae	***Epaltes divaricata*** (L.) Cass.	Herb
52	Asteraceae	***Lagascea mollis*** Cav.	Herb
53	Asteraceae	***Mikania micrantha*** Kunth.	Climber
54	Asteraceae	***Parthenium hysterophorus*** L.	Herb
55	Asteraceae	***Synedrella nodiflora*** (L.) Gaertn.	Herb
56	Asteraceae	***Tagetus erecta*** L.	Herb
57	Asteraceae	***Tridax procumbens*** L.	Herb
58	Asteraceae	***Vernonia cinerea*** (L.) Less.	Herb
59	Asteraceae	***Wedelia chinensis*** (Osbeck) Merr.	Herb
60	Balsaminaceae	***Impatiens balsamina*** L.	Herb
61	Barringtoniaceae	***Careya arborea*** Roxb.	Tree
62	Bignoniaceae	***Spathodea campanulata*** Beauv.	Tree
63	Bignoniaceae	***Stereospermum colais*** (Buch.-Ham. ex Dillw.)Mabberley	Tree
64	Bombacaceae	***Bombax insigne*** Wall.	Tree
65	Boraginaceae	***Carmona retusa*** (Vahl) Masamune	Shrub

66	Boraginaceae	***Cordia obliqua*** Willd.	Tree
67	Boraginaceae	***Heliotropium indicum*** L.	Herb
68	Boraginaceae	***Heliotropium scabrum*** Retz.	Herb
69	Burseraceae	***Garuga pinnata*** Roxb.	Tree
70	Cactaceae	***Cereus pterogonus*** Lem.	Shrub
71	Caesalpiniaceae	***Bauhinia racemosa*** Lam.	Tree
72	Caesalpiniaceae	***Bauhinia tomentosa*** L.	Shrub
73	Caesalpiniaceae	***Cassia fistula*** L.	Tree
74	Caesalpiniaceae	***Cassia siamea*** Lam.	Tree
75	Caesalpiniaceae	***Chamaecrista absus*** (L.) H. Irwin & Barneby	Herb
76	Caesalpiniaceae	***Chamaecrista mimosoides*** (L.) Green	Herb
77	Caesalpiniaceae	***Chamaecrista pumilla*** (Lam.) K. Larsen	Herb
78	Caesalpiniaceae	***Delonix regia*** (Boj. ex Hook) Rafin.	Tree
79	Caesalpiniaceae	***Peltophorum pterocarpum*** (DC.)	Tree
80	Caesalpiniaceae	***Senna auriculata*** (L.) Roxb.	Shrub
81	Caesalpiniaceae	***Senna occidentalis*** (L.) Link	Shrub
82	Caesalpiniaceae	***Senna tora*** (L.) Roxb.	Herb
83	Caesalpiniaceae	***Tamarindus indica*** L.	Tree
84	Capparidaceae	***Capparis zeylanica*** L.	Liane
85	Capparidaceae	***Cleome felina*** L.	Herb
86	Capparidaceae	***Cleome rutidosperma*** DC.	Herb
87	Capparidaceae	***Cleome viscosa*** L.	Herb
88	Ceratophyllaceae	***Ceratophyllum demersum*** L.	Herb
89	Colchicaceae	***Gloriosa superba*** L.	Herb
90	Colchicaceae	***Iphigenia indica*** (L.) A. Gray ex Kunth	Herb
91	Combretaceae	***Calycopteris floribunda*** Lam.	,Tree
92	Combretaceae	***Combretum albidum*** G. Don	Liane
93	Combretaceae	***Terminalia bellirica*** (Gaertn.) Roxb.	Tree
94	Combretaceae	***Terminalia chebula*** Retz.	Tree
95	Combretaceae	***Terminalia cuneata*** Roxb.	Tree
96	Combretaceae	***Terminalia paniculata*** Roth	Tree
97	Combretaceae	***Terminalia elliptica*** Willd.	Tree
98	Commelinaceae	***Commelina benghalensis*** L.	Herb
99	Commelinaceae	***Commelina diffusa*** Burm	Herb
100	Commelinaceae	***Cyanotis axillaris*** (L.) D. Don	Herb
101	Commelinaceae	***Cyanotis cristata*** (L.) D. Don	Herb
102	Commelinaceae	***Murdannia semiteres*** (Dalz.) Sant.	Herb
103	Commelinaceae	***Murdannia simplex*** (Vahl.) Brenan	Herb
104	Convolvulaceae	***Argyreia nervosa*** (Burm.f.) Boj.	Climber
105	Convolvulaceae	***Ipomoea aquatica*** Forssk.	Herb
106	Convolvulaceae	***Ipomoea carnea*** Jacq.	Shrub

107	Convolvulaceae	***Ipomoea marginata*** (Desr.) Verdc.	Twiner
108	Convolvulaceae	***Ipomoea obscura*** (L.) Ker-Gawl.	Twiner
109	Convolvulaceae	***Ipomoea pes-tigridis*** L.	Climber
110	Convolvulaceae	***Ipomoea quamoclit*** L.	Twiner
111	Convolvulaceae	***Ipomoea staphylina*** Roem. & Schultes	Twiner
112	Convolvulaceae	***Merremia aegyptia*** (L.) Urban	Twiner
113	Convolvulaceae	***Merremia emarginata*** (Burm.f.) Hall.f.	Herb
114	Convolvulaceae	***Merremia tridentata*** (L.) Hall.f.	Herb
115	Cornaceae	***Mastixia arborea*** (Wight) Bedd.	Tree
116	Cucurbitaceae	***Coccinia grandis*** (L.) Voigt	Climber
117	Cucurbitaceae	***Luffa acutangula*** (L.) Roxb.	Climber
118	Cucurbitaceae	***Momordica charantia*** L.	Twiner
119	Cucurbitaceae	***Mukia maderaspatana*** (L.) M. Roem.	Climber
120	Cucurbitaceae	***Solena amplexicaulis*** (Lam.) Gandhi	Climber
121	Cucurbitaceae	***Zehneria maysorensis*** (Wight & Arn.) Arn.	Climber
122	Cyperaceae	***Bulbostylis barbata*** (Rottb.) Clarke	Sedge
123	Cyperaceae	***Cyperus compressus*** L.	Sedge
124	Cyperaceae	***Cyperus corymbosus*** Rottb.	Sedge
125	Cyperaceae	***Cyperus difformis*** L.	Sedge
126	Cyperaceae	***Cyperus distans*** L.	Sedge
127	Cyperaceae	***Cyperus exaltatus*** Retz.	Sedge
128	Cyperaceae	***Cyperus iria*** L.	Sedge
129	Cyperaceae	***Cyperus rotundus*** L.	Sedge
130	Cyperaceae	***Cyperus tenuispica*** Steud.	Sedge
131	Cyperaceae	***Fimbristylis argentea*** (Rottb.) Vahl	Sedge
132	Cyperaceae	***Fimbristylis bisumbellata*** (Forssk.) Bubani	Sedge
133	Cyperaceae	***Fimbristylis complanata*** (Retz.) Link	Sedge
134	Cyperaceae	***Fimbristylis cymosa*** R. Br.	Sedge
135	Cyperaceae	***Fimbristylis dichotoma*** (L.) Vahl	Sedge
136	Cyperaceae	***Fimbristylis miliacea*** (L.) Vahl	Sedge
137	Cyperaceae	***Fimbristylis triflora*** (L.) Schum. ex Engler	Sedge
138	Cyperaceae	***Kyllingia nemoralis*** (J. R. & G. Forst.) Dandy	Sedge
139	Cyperaceae	***Pycreus polystachyos*** (Rottboell) Beauv.	Sedge
140	Cyperaceae	***Pycreus pumilus*** (L.) Nees ex Clarke	Sedge
141	Cyperaceae	***Schoenoplectus articulatus*** (L.) Palla	Sedge
142	Dioscoreaceae	***Dioscorea bulbifera*** L.	Climber
143	Dioscoreaceae	***Dioscorea oppositifolia*** L.	Climber
144	Dioscoreaceae	***Dioscorea pentaphylla*** L.	Climber
145	Droseraceae	***Drosera burmannii*** Vahl	Herb
146	Droseraceae	***Drosera indica*** L.	Herb
147	Ebenaceae	***Diospyros ebenum*** Koen.	Tree

148	Ebenaceae	***Diospyros melanoxylon*** Roxb.	Tree
149	Eriocaulaceae	***Eriocaulon quinquangulare*** L.	Herb
150	Eriocaulaceae	***Eriocaulon xeranthemum*** Mart.	Herb
151	Euphorbiaceae	***Acalypha fruticosa*** Forssk.	Herb
152	Euphorbiaceae	***Breynia retusa*** (Dennst.) Alston	Shrub
153	Euphorbiaceae	***Bridelia retusa*** (L.) Spreng.	Tree
154	Euphorbiaceae	***Bridelia scandens*** (Roxb.) Willd.	Shrub
155	Euphorbiaceae	***Cleistanthus collinus*** (Roxb.) Benth. ex Hook.f.	Tree
156	Euphorbiaceae	***Croton bonplandianum*** Baill.	Herb
157	Euphorbiaceae	***Croton hirtus*** L'Herit	Herb
158	Euphorbiaceae	***Euphorbia antiquorum*** L.	Tree
159	Euphorbiaceae	***Euphorbia corrigioloides*** Boiss.	Herb
160	Euphorbiaceae	***Euphorbia heterophylla*** L.	Herb
161	Euphorbiaceae	***Euphorbia hirta*** L.	Herb
162	Euphorbiaceae	***Euphorbia indica*** Lam.	Herb
163	Euphorbiaceae	***Flueggea leucopyrus*** Willd.	Shrub
164	Euphorbiaceae	***Givotia rottleriformis*** Griff.	Tree
165	Euphorbiaceae	***Manihot glaziovii*** Muell.-Arg.	Tree
166	Euphorbiaceae	***Micrococca mercurialis*** (L.) Benth.	Herb
167	Euphorbiaceae	***Pedilanthus tithymaloides*** (L.) Poir.	Shrub
168	Euphorbiaceae	***Phyllanthus amarus*** Schum. & Thonn.	Herb
169	Euphorbiaceae	***Phyllanthus debilis*** Klein ex Willd.	Herb
170	Euphorbiaceae	***Phyllanthus emblica*** L.	Tree
171	Euphorbiaceae	***Phyllanthus polyphyllus*** Willd.	Shrub
172	Euphorbiaceae	***Phyllanthus reticulatus*** Poir.	Shrub
173	Euphorbiaceae	***Phyllanthus virgatus*** Forst.	Herb
174	Euphorbiaceae	***Tragia involucrata*** L.	Climber
175	Fabaceae	***Abrus precatorius*** L.	Climber
176	Fabaceae	***Aeschynomene aspera*** L.	Shrub
177	Fabaceae	***Aeschynomene indica*** L.	Herb
178	Fabaceae	***Alysicarpus monilifer*** (L.) DC.	Herb
179	Fabaceae	***Alysicarpus ovalifolius*** (Schumac) J. Leon.	Herb
180	Fabaceae	***Alysicarpus vaginalis*** (L.) DC.	Herb
181	Fabaceae	***Butea monosperma*** (Lam.) Taub.	Tree
182	Fabaceae	***Butea parviflora*** Roxb.	Liane
183	Fabaceae	***Butea purpurea*** (Benth. ex Baker) Blatter	Climber
184	Fabaceae	***Canavalia gladiata*** (Jacq.) DC.	Shrub
185	Fabaceae	***Centrosema pubescens*** Benth.	Climber
186	Fabaceae	***Clitoria ternatea*** L.	Climber
187	Fabaceae	***Crotalaria calycina*** Schrank	Herb
188	Fabaceae	***Crotalaria pallida*** Dryand.	Herb

189	Fabaceae	***Crotalaria verrucosa*** L.	Herb
190	Fabaceae	***Dalbergia lanceolaria*** L.	Tree
191	Fabaceae	***Dalbergia paniculata*** Roxb.	Tree
192	Fabaceae	***Dalbergia volubilis*** Roxb.	Climber
193	Fabaceae	***Desmodium triflorum*** (L.) DC.	Herb
194	Fabaceae	***Flemingia macrophylla*** (Willd.) Prain ex Merr.	Shrub
195	Fabaceae	***Gliricidia sepium*** (Jacq.) Kunth ex Walp.	Tree
196	Fabaceae	***Indigofera linifolia*** (L.f.) Retz.	Herb
197	Fabaceae	***Indigofera tinctoria*** L.	Herb
198	Fabaceae	***Indigofera uniflora*** Buch. - Ham. ex Roxb.	Herb
199	Fabaceae	***Macroptilium atropurpureum*** (DC.) Urban	Herb
200	Fabaceae	***Pongamia pinnata*** (L.) Pierre	Tree
201	Fabaceae	***Rhynchosia aurea*** (Willd.) DC.	Herb
202	Fabaceae	***Rhynchosia minima*** (L.) DC.	Climber
203	Fabaceae	***Sesbania bispinosa*** (Jacq.) W. F. Wight	Shrub
204	Fabaceae	***Stylosanthes fruticosa*** (Retz.) Alston	Herb
205	Fabaceae	***Tephrosia purpurea*** (L.) Pers.	Herb
206	Fabaceae	***Tephrosia villosa*** (L.) Pers.	Herb
207	Fabaceae	***Zornia diphylla*** (L.)	Herb
208	Flacourtiaceae	***Casearia graveolens*** Dalz.	Tree
209	Flacourtiaceae	***Flacourtia indica*** (Burm.f.) Merr.	Shrub
210	Gentianaceae	***Canscora diffusa*** (Vahl) R.Br. ex Roem. & Schultes	Herb
211	Gentianaceae	***Canscora heteroclita*** (L.) Gilg	Herb
212	Gentianaceae	***Enicostema axillare*** (Lam.) Raynal	Herb
213	Hydrocharitaceae	***Hydrilla verticillata*** (L. f.) Royle	Herb
214	Hypoxidaceae	***Curculigo orchioides*** Gaertn	Herb
215	Lamiaceae	***Anisochilus carnosus*** (L.f.) Wall. ex Benth.	Herb
216	Lamiaceae	***Hyptis suaveolens*** (L.) Poit.	Shrub
217	Lamiaceae	***Leucas aspera*** (Willd.) Link	Herb
218	Lamiaceae	***Leucas diffusa*** Benth.	Herb
219	Lamiaceae	***Ocimum americanum*** L.	Herb
220	Lamiaceae	***Ocimum basilicum*** L.	Herb
221	Lamiaceae	***Ocimum basilicum*** L.	Herb
222	Lamiaceae	***Ocimum tenuiflorum*** L.	Herb
223	Lamiaceae	***Plectranthus mollis*** (Ait.) Spreng.	Herb
224	Leeaceae	***Leea macrophylla*** Roxb. ex Hornem.	Shrub
225	Lemnaceae	***Lemna gibba*** L.	Herb
226	Lemnaceae	***Lemna perpusilla*** Torrey	Herb
227	Lemnaceae	***Spirodela polyrhiza*** (L.) Schleiden	Herb
228	Lentibulariaceae	***Utricularia graminifolia*** Vahl	Herb
229	Loganiaceae	***Strychnos nux-vomica*** L.	Tree

230	Loganiaceae	***Strychnos potatorum*** L.	Tree
231	Lythraceae	***Ammania baccifera*** L.	Herb
232	Lythraceae	***Ammania baccifera*** L.	Herb
233	Lythraceae	***Lagerstroemia reginae*** Roxb.	Tree
234	Lythraceae	***Lawsonia inermis*** L.	Shrub
235	Lythraceae	***Rotala indica*** (Willd.) Koehne	Herb
236	Malvaceae	***Abelmoschus ficulneus*** (L.) Wight & Arn.	Shrub
237	Malvaceae	***Abelmoschus manihot*** (L.) Medicus	Shrub
238	Malvaceae	***Sida acuta*** Burm.f.	Shrub
239	Malvaceae	***Sida cordifolia*** L.	Herb
240	Malvaceae	***Sida rhombifolia*** L.	Shrub
241	Malvaceae	***Urena lobata*** L. subsp. ***lobata***	Shrub
242	Malvaceae	***Urena lobata*** L. subsp. ***sinuata*** (L.) Borssum	Shrub
243	Martyniaceae	***Martynia annua*** L.	Shrub
244	Melastomataceae	***Osbeckia aspera*** (L.) Blume	Shrub
245	Meliaceae	***Azadirachta indica*** A. Juss.	Tree
246	Menispermaceae	***Cocculus hirsutus*** (L.) Diels	Climber
247	Menispermaceae	***Pachygone ovata*** (Poir.) Miers ex Hook. f. & Thoms.	Climber
248	Menispermaceae	***Stephania japonica*** (Thunb.) Miers	Climber
249	Menispermaceae	***Tiliacora acuminata*** (Lam.) Hook. f. & Thoms.	Climber
250	Menispermaceae	***Tinospora cordifolia*** (Willd.) Miers ex Hook. f. & Thoms.	Climber
251	Mimosaceae	***Acacia caesia*** (L.) Willd.	Shrub
252	Mimosaceae	***Acacia catechu*** (L.f.) Willd.	Tree
253	Mimosaceae	***Acacia leucophloea*** (Roxb.) Willd.	Tree
254	Mimosaceae	***Albizia chinensis*** (Osbeck.) Merr.	Tree
255	Mimosaceae	***Albizia lebbeck*** (L.) Willd.	Tree
256	Mimosaceae	***Albizia saman*** (Jacq.) F.v. Muell.	Tree
257	Mimosaceae	***Desmanthus virgatus*** Willd.	Shrub
258	Mimosaceae	***Leucaena leucocephala*** (L.) Gills	Tree
259	Mimosaceae	***Mimosa diplotricha*** C. Wright ex Sauvalle	Straggler
260	Mimosaceae	***Mimosa intsia*** L.	Liane
261	Mimosaceae	***Mimosa pudica*** L.	Herb
262	Mimosaceae	***Mimosa rubicaulis*** Lam.	Liane
263	Mimosaceae	***Neptunia prostrata*** (Lam.) Baill.	Herb
264	Mimosaceae	***Xylia xylocarpa*** Taub.	Tree
265	Molluginaceae	***Glinus oppositifolius*** (L.) A. DC.	Herb
266	Molluginaceae	***Mollugo cerviana*** (L.) Ser.	Herb
267	Molluginaceae	***Mollugo disticha*** Ser.	Herb
268	Molluginaceae	***Mollugo pentaphylla*** L.	Herb
269	Moraceae	***Ficus elastica*** Roxb. ex Hornem.	Tree

270	Moraceae	***Streblus asper*** Lour.	Tree
271	Myrsinaceae	***Embelia ribes*** Burm.f.	Shrub
272	Najadaceae	***Najas indica*** (Willd.) Cham.	Herb
273	Nyctaginaceae	***Boerhavia diffusa*** L.	Herb
274	Nyctanthaceae	***Nyctanthes arbor-tristis*** L.	Tree
275	Nymphaeaceae	***Nymphaea pubescens*** Willd.	Herb
276	Olacaceae	***Olax scandens*** Roxb.	Liane
277	Onagraceae	***Ludwigia adscendens*** (L.) Hara	Herb
278	Onagraceae	***Ludwigia hyssopifolia*** (G. Don) Exell	Herb
279	Orobanchaceae	***Rhamphicarpa fistulosa*** (Hochst.) Benth.	Herb
280	Oxalidaceae	***Biophytum sensitivum*** (L.) DC.	Herb
281	Passifloraceae	***Passiflora foetida*** L.	Climber
282	Pedaliaceae	***Pedalium murex*** L.	Herb
283	Pedaliaceae	***Sesamum indicum*** L.	Herb
284	Pedaliaceae	***Sesamum prostratum*** Retz.	Herb
285	Periplocaceae	***Hemidesmus indicus*** (L.) R.Br.	Herb
286	Poaceae	***Apluda mutica*** L.	Grass
287	Poaceae	***Aristida adscensionis*** L.	Grass
288	Poaceae	***Aristida hystrix*** L.	Grass
289	Poaceae	***Bothriochloa pertusa*** (L.) A. Camus	Grass
290	Poaceae	***Brachiaria ramosa*** (L.) Stapf	Grass
291	Poaceae	***Brachiaria reptans*** (L.) Gard. & Hubbard	Grass
292	Poaceae	***Cymbopogon flexuosus*** (Nees ex Steud.) Wats	Grass
293	Poaceae	***Cyrtococcum trigonum*** (Retz.) A. Camus	Grass
294	Poaceae	***Dactyloctenium aegyptium*** (L.) Willd.	Grass
295	Poaceae	***Dendrocalamus strictus*** (Roxb.) Nees	Grass
296	Poaceae	***Desmostachya bipinnata*** (L.) Stapf	Grass
297	Poaceae	***Dichanthium annulatum*** (Forssk.) Stapf	Grass
298	Poaceae	***Digitaria ciliaris*** (Retz.) Koeler	Grass
299	Poaceae	***Eragrostiella bifaria*** (Vahl) Bor	Grass
300	Poaceae	***Eragrostis gangetica*** (Roxb.) Steud.	Grass
301	Poaceae	***Eragrostis riparia*** (Willd.) Nees	Grass
302	Poaceae	***Eragrostis tenella*** (L.) P. Beauv ex Roem. & Schultes	Grass
303	Poaceae	***Eragrostis viscosa*** (Retz.) Trin.	Grass
304	Poaceae	***Heteropogon contortus*** (L.) P Beauv	Grass
305	Poaceae	***Isachne globosa*** (Thunb.) Kuntze	Grass
306	Poaceae	***Ischaemum indicum*** (Houtt.) Merr.	Grass
307	Poaceae	***Ischaemum rugosum*** Salisb.	Grass
308	Poaceae	***Oplismenus compositus*** (L.) P. Beauv	Grass
309	Poaceae	***Perotis indica*** (L.) Kuntze	Grass
310	Pontederiaceae	***Monochoria vaginalis*** (Burm. F.) Presl	Herb

311	Portulacaceae	***Portulaca pilosa*** L.	Herb
312	Portulacaceae	***Portulaca quadrifida*** L.	Herb
313	Portulacaceae	***Talinum triangulare*** Willd.	Herb
314	Rhamnaceae	***Ziziphus mauritiana*** Lam.	Tree
315	Rhamnaceae	***Ziziphus oenoplia*** (L.) Mill.	Liane
316	Rubiaceae	***Canthium coromandelicum*** (Burm. F.) Alston	Shrub
317	Rubiaceae	***Catunaregam spinosa*** (Thunb.) Tirvengadum	Tree
318	Rubiaceae	***Haldina cordifolia*** (Roxb.) Ridsdale	Tree
319	Rubiaceae	***Hedyotis corymbosa*** (L.) Lam.	Herb
320	Rubiaceae	***Hedyotis herbacea*** L.	Herb
321	Rubiaceae	***Hedyotis puberula*** (G.Don) Arn.	Herb
322	Rubiaceae	***Hymenodictyon orixense*** (Roxb.) Mabberley	Tree
323	Rubiaceae	***Ixora pavetta*** Andr.	Tree
324	Rubiaceae	***Mitracarpus villosus*** (Sw.) DC.	Herb
325	Rubiaceae	***Mitragyna parvifolia*** (Roxb.) Korth.	Tree
326	Rubiaceae	***Morinda pubescens*** J.E. Smith	Tree
327	Rubiaceae	***Morinda umbellata*** L.	Shrub
328	Rubiaceae	***Mussaenda frondosa*** L.	Shrub
329	Rubiaceae	***Spermacoce articularis*** L.f.	Herb
330	Rubiaceae	***Spermacoce hispida*** L.	Herb
331	Rubiaceae	***Spermacoce ocymoides*** Burm.f.	Herb
332	Rutaceae	***Limonia acidissima*** L.	Tree
333	Rutaceae	***Murraya paniculata*** (L.) Jack	Shrub
334	Rutaceae	***Naringi crenulata*** (Roxb.) Nicolson	Tree
335	Rutaceae	***Toddalia asiatica*** (L.) Lam.	Liane
336	Rutaceae	***Chloroxylon swietenia*** DC.	Tree
337	Sapindaceae	***Cardiospermum halicacabum*** L.	Climber
338	Sapotaceae	***Madhuca longifolia*** (Koen.) Macbr.	Tree
339	Scrophulariaceae	***Bacopa monnieri*** (L.) Pennell	Herb
340	Scrophulariaceae	***Dopatrium junceum*** (Roxb.) Buch.-Ham. ex Benth.	Herb
341	Scrophulariaceae	***Dopatrium lobelioides*** (Retz.) Benth.	Herb
342	Scrophulariaceae	***Limnophila heterophylla*** (Roxb.) Benth.	Herb
343	Scrophulariaceae	***Limnophila indica*** (L.) Druce	Herb
344	Scrophulariaceae	***Lindernia ciliata*** (Colsm.) Pennell	Herb
345	Scrophulariaceae	***Lindernia crustacea*** (L.) F.v.Muell.	Herb
346	Scrophulariaceae	***Mecardonia procumbens*** (Mill.) Small	Herb
347	Scrophulariaceae	***Scoparia dulcis*** L.	Herb
348	Scrophulariaceae	***Sopubia delphiniifolia*** (L.) G.Don	Herb
349	Scrophulariaceae	***Striga asiatica*** (L.) Kuntze	Herb
350	Solanaceae	***Physalis angulata*** L.	Herb
351	Solanaceae	***Physalis lagascae*** Roem. & Schult.	Herb

352	Solanaceae	***Physalis peruviana*** L.	Herb
353	Solanaceae	***Solanum torvum*** Sw.	Shrub
354	Sterculiaceae	***Helicteres isora*** L.	Shrub
355	Sterculiaceae	***Melhania incana*** Heyne ex Wight & Arn.	Herb
356	Sterculiaceae	***Sterculia urens*** Roxb.	Tree
357	Tiliaceae	***Corchorus aestuans*** L.	Herb
358	Tiliaceae	***Muntingia calabura*** L.	Tree
359	Tiliaceae	***Triumfetta rhomboidea*** Jacq.	Herb
360	Trapaceae	***Trapa natans*** L.	Herb
361	Ulmaceae	***Holoptelea integrifolia*** (Roxb.) Planch.	Tree
362	Urticaceae	***Pouzolzia auriculata*** Wight	Herb
363	Verbenaceae	***Clerodendrum inerme*** (L.) Gaertn.	Shrub
364	Verbenaceae	***Clerodendrum paniculatum*** L.	Shrub
365	Verbenaceae	***Clerodendrum serratum*** (L.) Moon	Shrub
366	Verbenaceae	***Lantana camara*** L.	Shrub
367	Verbenaceae	***Phyla nodiflora*** (L.) Greene	Herb
368	Verbenaceae	***Premna tomentosa*** Willd.	Tree
369	Verbenaceae	***Stachytarpheta jamaicensis*** (L.) Vahl	Herb
370	Verbenaceae	***Tectona grandis*** L.f.	Tree
371	Verbenaceae	***Vitex altissima*** L.f.	Tree
372	Verbenaceae	***Vitex negundo*** L.	Shrub
373	Violaceae	***Hybanthus enneaspermus*** (L.) F. v. Muell.	Herb
374	Vitaceae	***Ampelocissus latifolia*** (Roxb.) Planch.	Liane
375	Vitaceae	***Cayratia pedata*** (Lam.) Juss. ex Gagnep.	Climber
376	Vitaceae	***Cayratia trifolia*** (L.) Domin.	Climber
377	Vitaceae	***Cissus quadrangularis*** L.	Climber
378	Vitaceae	***Cissus repanda*** Vahl	Liane
379	Vitaceae	***Cissus vitiginea*** L.	Climber
380	Vitaceae	***Tetrastigma leucostaphylum*** (Dennst.) Alston	Climber
381	Xyridaceae	***Xyris pauciflora*** Willd.	Herb
382	Zingiberaceae	***Curcuma aromatica*** Salisb.	Herb
383	Zingiberaceae	***Curcuma aurantiaca*** Zijp	Herb

Table 13. Plant life-form diversity

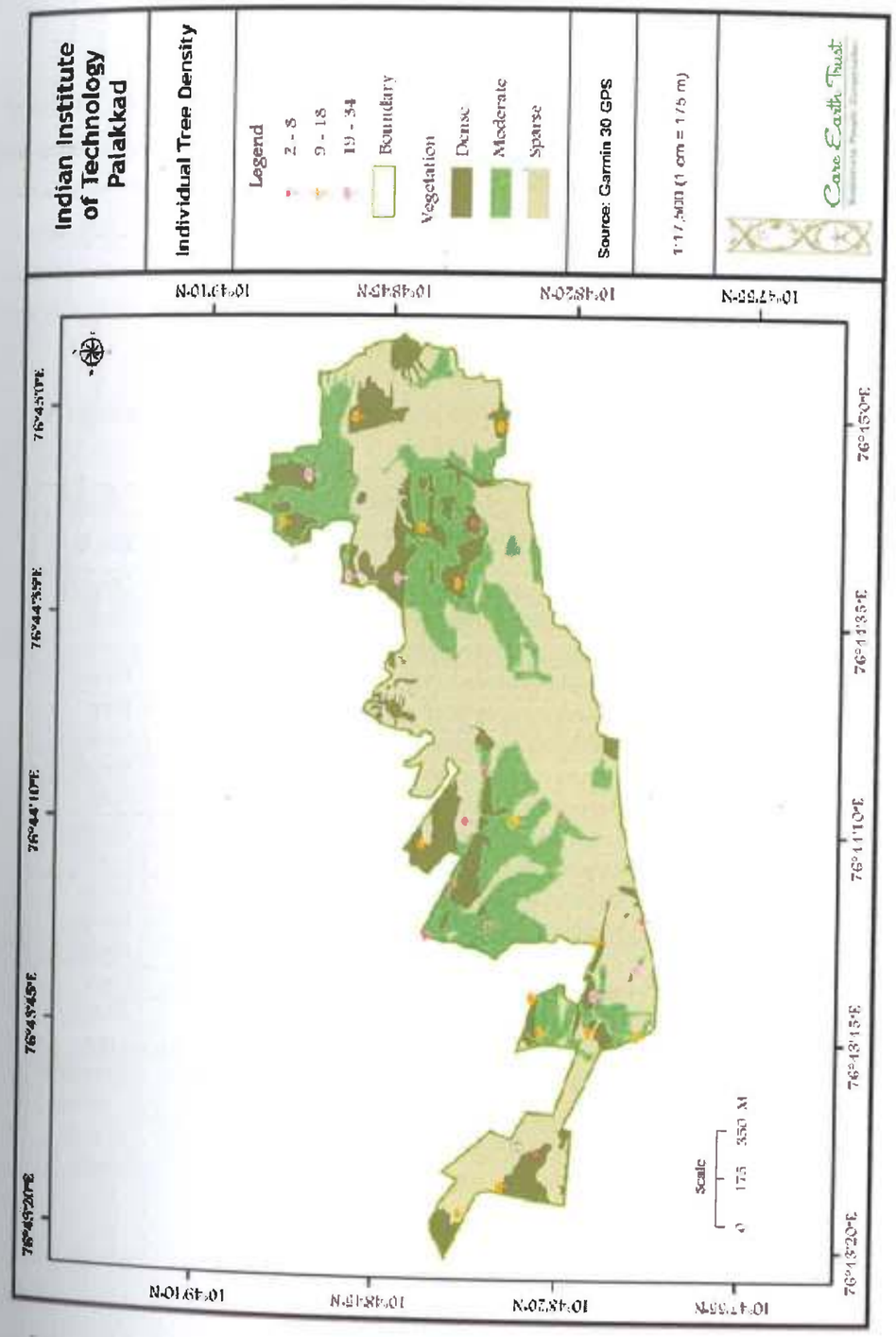
Life-form	No. of Species
Tree	73
Shrub	46
Liane	10
Straggler	2
Climber	36
Twiner	9
Herb	163
Grass	24
Sedge	20

2.5.4 Distribution of Tree Density

Table 14 summarizes the density of woody plants, the number species and density of trees in the 31 quadrats. As evident in the Table 14 and the Map, trees are rather clumped in distribution.

Table 14. Consolidated list of density and species richness in the Quadrats

Quadrat No.	No. of Individuals	No. of Species	No. of Trees
P1	43	9	11
P2	40	9	14
P3	42	16	8
P4	49	15	13
P5	44	20	11
P6	59	13	16
P7	81	11	18
P8	49	15	22
P9	35	22	21
P10	27	13	6
P11	50	16	10
P12	19	8	0
P13	23	10	6
P14	35	10	7
P15	45	11	5
P16	15	11	0
P17	26	13	0
P18	37	16	3
P19	43	11	10
P20	26	13	2
P21	62	10	11
P22	46	12	4
P23	31	9	18
P24	74	16	27
P25	45	14	34
P26	26	9	11
P27	23	9	3
P28	41	5	16
P29	26	9	11
P30	49	11	22
P31	48	18	18



Map 15. Uneven distribution of tree density in the Campus

2.5.5 Invasive Species of Plants

At least 21 species of plants that have been identified in the Campus have t
of being invasive (Table 15). While *Chromalaena odorata* (Siam weed) and *Parthenium*
hysterophorus are invasive alien species, widespread aquatic plants such as *Lemna*
spp. and *Spirodela* sp. (Duckweeds) have the potential of covering entire stretches of
water thus reducing the oxygenation of the water bodies. *Parthenium* (Famine weed)
poses a human health risk. Others like *Mikania* sp. (Minute-a-mile vine) have a great
'nuisance' values adding to the costs of weed management in the Campus.

Table 15. List of non-native plant species that are highly invasive and others that are potentially invasive

No.	Family	Species	Habit
1	Asteraceae	***Chromolaena odorata*** (L.) King & Robinson	Shrub
2	Asteraceae	***Mikania micrantha*** Kunth.	Climber
3	Asteraceae	***Parthenium hysterophorus*** L.	Herb
4	Asteraceae	***Wedelia chinensis*** (Osbeck) Merr.	Herb
5	Caesalpiniaceae	***Cassia siamea*** Lam.	Tree
6	Caesalpiniaceae	***Delonix regia*** (Boj. ex Hook) Rafin.	Tree
7	Caesalpiniaceae	***Peltophorum pterocarpum*** (DC.)	Tree
8	Caesalpiniaceae	***Senna occidentalis*** (L.) Link	Shrub
9	Caesalpiniaceae	***Senna tora*** (L.) Roxb.	Herb
10	Convolvulaceae	***Ipomoea carnea*** Jacq.	Shrub
11	Euphorbiaceae	***Croton bonplandianum*** Baill.	Herb
12	Euphorbiaceae	***Croton hirtus*** L'Herit	Herb
13	Lamiaceae	***Hyptis suaveolens*** (L.) Poit.	Herb
14	Lemnaceae	***Lemna perpusilla*** Torrey	Shrub
15	Lemnaceae	***Spirodela polyrhiza*** (L.) Schleiden	Shrub
16	Martyniaceae	***Martynia annua*** L.	Herb
17	Mimosaceae	***Leucaena leucocephala*** (L.) Gills	Tree
18	Mimosaceae	***Mimosa diplotricha*** C. Wright ex Sauvalle	Straggler
19	Passifloraceae	***Passiflora foetida*** L.	Herb
20	Verbenaceae	***Lantana camara*** L.	Shrub
21	Verbenaceae	***Stachytarpheta jamaicensis*** (L.) Vahl	Herb

Table 16. Density and Frequency of woody plants recorded from the Quadrats

Family	Species	Habit	Total nos.	Frequency	Degree of Dispersion	Density
Mimosaceae	***Xylia xylocarpa*** Taub.	Sapling	126	10	0.323	4.065
Lamiaceae	***Hyptis suaveolens*** (L.) Poit.	Shrub	116	13	0.419	3.742
Mimosaceae	***Mimosa diplotricha*** C. Wright ex Sauvalle	Straggler	90	7	0.226	2.903
Mimosaceae	***Xylia xylocarpa*** Taub.	Tree	70	10	0.323	2.258
Asteraceae	***Chromolaena odorata*** (L.) King & Robinson	Shrub	57	8	0.258	1.839
Rubiaceae	***Morinda pubescens*** J.E. Smith	Tree	52	10	0.323	1.677
Combretaceae	***Calycopteris floribunda*** Lam.	Sapling	47	6	0.194	1.516
Apocynaceae	***Holarrhena pubescens*** (Buch. - Ham) Wall.	Sapling	39	8	0.258	1.258
Verbenaceae	***Tectona grandis*** L.f.	Sapling	38	6	0.194	1.226
Euphorbiaceae	***Manihot glaziovii*** Muell.-Arg.	Tree	32	3	0.097	1.032
Vitaceae	***Ampelocissus latifolia*** (Roxb.) Planch.	Liane	27	9	0.290	0.871
Rhamnaceae	***Ziziphus oenoplia*** (L.) Mill.	Shrub	27	8	0.258	0.871
Euphorbiaceae	***Phyllanthus reticulatus*** Poir.	Shrub	26	6	0.194	0.839
Verbenaceae	***Tectona grandis*** L.f.	Tree	26	5	0.161	0.839
Verbenaceae	***Lantana camara*** L.	Shrub	23	7	0.226	0.742
Combretaceae	***Calycopteris floribunda*** Lam.	Tree	22	5	0.161	0.710
Mimosaceae	***Acacia catechu*** (L.f.) Willd.	Tree	19	4	0.129	0.613
Euphorbiaceae	***Manihot glaziovii*** Muell.-Arg.	Sapling	18	3	0.097	0.581
Rubiaceae	***Morinda pubescens*** J.E. Smith	Sapling	15	5	0.161	0.484
Barringtoniaceae	***Careya arborea*** Roxb.	Sapling	15	4	0.129	0.484
Dioscoreaceae	***Dioscorea bulbifera*** L.	Liane	14	3	0.097	0.452
Apocynaceae	***Wrightia tinctoria*** (Roxb.) R.Br.	Sapling	14	1	0.032	0.452
Apocynaceae	***Holarrhena pubescens*** (Buch. - Ham) Wall. ex G. Don	Tree	11	3	0.097	0.355
Fabaceae	***Gliricidia sepium*** (Jacq.) Kunth ex Walp.	Sapling	11	2	0.065	0.355

Rutaceae	***Chloroxylon swietenia*** DC.	Sapling	11	2	0.065	0.355
Combretaceae	***Terminalia cuneata*** Roxb.	Tree	10	2	0.065	0.323
Rubiaceae	***Catunaregam spinosa*** (Thunb.) Tirvengadum	Shrub	10	2	0.065	0.323
Cucurbitaceae	***Mukia maderaspatana*** (L.) M. Roem.	Climber	9	6	0.194	0.290
Meliaceae	***Azadirachta indica*** A. Juss.	Tree	9	4	0.129	0.290
Unknown	Kaanakam	Tree	9	2	0.065	0.290
Asteraceae	***Mikania micrantha*** Kunth.	Climber	9	2	0.065	0.290
Fabaceae	***Dalbergia paniculata*** Roxb.	Sapling	8	3	0.097	0.258
Euphorbiaceae	***Cleistanthus collinus*** (Roxb.) Benth. ex Hook.f.	Sapling	8	2	0.065	0.258
Fabaceae	***Dalbergia lanceolaria*** L.	Sapling	8	2	0.065	0.258
Verbenaceae	***Vitex negundo*** L.	Sapling	8	2	0.065	0.258
Sterculiaceae	***Helicteres isora*** L.	Shrub	8	1	0.032	0.258
Vitaceae	***Cissus vitiginea*** L.	Climber	7	5	0.161	0.226
Fabaceae	***Gliricidia sepium*** (Jacq.) Kunth ex Walp.	Tree	7	4	0.129	0.226
Menispermaceae	***Tinospora cordifolia*** (Willd.) Miers ex Hook. f.	Climber	7	3	0.097	0.226
Fabaceae	***Dalbergia lanceolaria*** L.	Tree	7	2	0.065	0.226
Martyniaceae	***Martynia annua*** L.	Shrub	7	2	0.065	0.226
Caesalpiniaceae	***Delonix regia*** (Boj. ex Hook) Rafin.	Sapling	7	1	0.032	0.226
Bombacaceae	***Bombax insigne*** Wall.	Tree	6	4	0.129	0.194
Arecaceae	***Borassus flabellifer*** L.	Tree	6	3	0.097	0.194
Combretaceae	***Terminalia elliptica*** Willd.	Tree	6	2	0.065	0.194
Mimosaceae	***Albizia saman*** (Jacq.) F.v. Muell.	Tree	6	2	0.065	0.194
Euphorbiaceae	***Flueggea leucopyrus*** Willd.	Shrub	6	1	0.032	0.194
Malvaceae	***Urena lobata*** L.	Shrub	5	4	0.129	0.161
Vitaceae	***Tetrastigma leucostaphylum*** (Dennst.) Alston	Liane	5	3	0.097	0.161
Apocynaceae	***Wrightia tinctoria*** (Roxb.) R.Br.	Tree	5	2	0.065	0.161
Cornaceae	***Mastixia arborea*** (Wight) Bedd.	Tree	5	2	0.065	0.161
Ebenaceae	***Diospyros melanoxylon*** Roxb.	Tree	5	2	0.065	0.161
Mimosaceae	***Acacia leucophloea*** (Roxb.) Willd.	Sapling	5	2	0.065	0.161
Fabaceae	***Pongamia pinnata*** (L.) Pierre	Tree	4	3	0.097	0.129
Vitaceae	***Cayratia pedata*** (Lam.) Juss. ex Gagnep.	Climber	4	3	0.097	0.129
Euphorbiaceae	***Bridelia retusa*** (L.) Spreng.	Tree	4	2	0.065	0.129
Euphorbiaceae	***Cleistanthus collinus*** (Roxb.) Benth. ex Hook.f.	Tree	4	2	0.065	0.129
Mimosaceae	***Acacia leucophloea*** (Roxb.) Willd.	Tree	4	2	0.065	0.129
Sapotaceae	***Madhuca longifolia*** (Koen.) Macbr.	Tree	4	2	0.065	0.129
Mimosaceae	***Acacia catechu*** (L.f.) Willd.	Sapling	4	2	0.065	0.129
Moraceae	***Streblus asper*** Lour.	Tree	4	1	0.032	0.129
Combretaceae	***Terminalia cuneata*** Roxb.	Sapling	4	1	0.032	0.129
Cucurbitaceae	***Momordica charantia*** L.	Climber	3	3	0.097	0.097
Sterculiaceae	***Sterculia urens*** Roxb.	Tree	3	2	0.065	0.097
Ebenaceae	***Diospyros melanoxylon*** Roxb.	Sapling	3	2	0.065	0.097
Asclepiadaceae	***Calotropis gigantea*** (L.) R.Br.	Shrub	3	2	0.065	0.097
Annonaceae	***Annona squamosa*** L.	Tree	3	1	0.032	0.097
Combretaceae	***Terminalia paniculata*** Roth	Sapling	3	1	0.032	0.097
Convolvulaceae	***Argyreia nervosa*** (Burm.f.) Boj.	Climber	3	1	0.032	0.097
Ebenaceae	***Diospyros ebenum*** Koen.	Tree	2	2	0.065	0.065
Loganiaceae	***Strychnos potatorum*** L.	Tree	2	2	0.065	0.065
Asclepiadaceae	***Holastemma ada-kodien*** Schultes	Climber	2	2	0.065	0.065
Burseraceae	***Garuga pinnata*** Roxb.	Tree	2	1	0.032	0.065
Ulmaceae	***Holoptelea integrifolia*** (Roxb.) Planch.	Tree	2	1	0.032	0.065
Meliaceae	***Azadirachta indica*** A. Juss.	Sapling	2	1	0.032	0.065
Myrtaceae	***Syzygium cumini*** (L.) Skeels	Sapling	2	1	0.032	0.065
Boraginaceae	***Carmona retusa*** (Vahl) Masamune	Shrub	2	1	0.032	0.065
Fabaceae	***Butea parviflora*** Roxb.	Liane	2	1	0.032	0.065
Mimosaceae	***Mimosa rubicaulis*** Lam.	Liane	2	1	0.032	0.065
Annonaceae	***Artabotrys hexapetalus*** (L. f.) Bhandari	Straggler	2	1	0.032	0.065
Fabaceae	***Canavalia gladiata*** (Jacq.) DC.	Climber	2	1	0.032	0.065
Sapindaceae	***Cardiospermum halicacabum*** L.	Climber	2	1	0.032	0.065

Vitaceae	***Cissus quadrangularis*** L.	Climber	2	1	0.032	0.065
Anacardiaceae	***Lannea coromandelica*** (Houtt.) Merr.	Tree	1	1	0.032	0.032
Barringtoniaceae	***Careya arborea*** Roxb.	Tree	1	1	0.032	0.032
Boraginaceae	***Cordia obliqua*** Willd.	Tree	1	1	0.032	0.032
Caesalpiniaceae	***Tamarindus indica*** L.	Tree	1	1	0.032	0.032
Fabaceae	***Dalbergia paniculata*** Roxb.	Tree	1	1	0.032	0.032
Loganiaceae	***Strychnos nux-vomica*** L.	Tree	1	1	0.032	0.032
Mimosaceae	***Albizia chinensis*** (Osbeck.) Merr.	Tree	1	1	0.032	0.032
Annonaceae	***Annona reticulata*** L.	Sapling	1	1	0.032	0.032
Arecaceae	***Borassus flabellifer*** L.	Sapling	1	1	0.032	0.032
Fabaceae	***Pongamia pinnata*** (L.) Pierre	Sapling	1	1	0.032	0.032
Sapotaceae	***Madhuca longifolia*** (Koen.) Macbr.	Sapling	1	1	0.032	0.032
Unknown	Kanakam	Sapling	1	1	0.032	0.032
Verbenaceae	***Vitex altissima*** L.f.	Sapling	1	1	0.032	0.032
Cactaceae	***Cereus pterogonus*** Lem.	Shrub	1	1	0.032	0.032
Caesalpiniaceae	***Bauhinia racemosa*** Lam.	Shrub	1	1	0.032	0.032
Euphorbiaceae	***Phyllanthus polyphyllus*** Willd.	Shrub	1	1	0.032	0.032
Lythraceae	***Lawsonia inermis*** L.	Shrub	1	1	0.032	0.032
Asclepiadaceae	***Wattakaka volubilis*** (L.f.) Stapf	Liane	1	1	0.032	0.032
Acanthaceae	***Thunbergia alata*** Boj. ex Sims	Climber	1	1	0.032	0.032
Apocynaceae	***Ichnocarpus frutescens*** (L.) R.Br.	Climber	1	1	0.032	0.032
Asclepiadaceae	***Tylophora indica*** (Burm.f.) Merr.	Climber	1	1	0.032	0.032
Cucurbitaceae	***Coccinia grandis*** (L.) Voigt	Climber	1	1	0.032	0.032
Fabaceae	***Abrus precatorius*** L.	Climber	1	1	0.032	0.032
Fabaceae	***Dalbergia volubilis*** Roxb.	Climber	1	1	0.032	0.032
Passifloraceae	***Passiflora foetida*** L.	Climber	1	1	0.032	0.032
Rubiaceae	***Morinda umbellata*** L.	Climber	1	1	0.032	0.032
Vitaceae	***Cissus repanda*** Vahl	Climber	1	1	0.032	0.032

2.5.6 Forest Fire Management

According to a news report (dated March, 2014), large tracts of forests in parts of Palakkad district such as Kunchiyarpathy in the Alathur forest range, Ananganmala, Kottoppadam and **Kanjikode** in Walayar forest range were destroyed in fire (http://www.thehindu.com/news/national/kerala/vast-tracts-of-palakkad-forests-perish-in-fire/article5803955.ece). Discussion with the officials of Palakkad Forest Division also revealed that there was a problem of forest fire in the forest range adjacent to IIT project site. A combination of factors including high temperature and lack of summer rain contributed to incidents of forest fire in this region in addition to human activities (http://www.thehindu.com/news/cities/Kochi/scorching-sun-sets-palakkad-wayanad-forests-ablaze/article8431427.ece). The following management strategies can be implemented to manage the impacts of possible forest fires in the region.

i. Maintenance of fire lines along the northern boundary of the project site adjacent to the forest range. Roads can also function as a potential firebreak and fuel break. The width of the fire break will vary with the slope.

   Slope/Width of Fire break

   0 - 5% 30 m

   5 - 15% 40 m

   > 15% 50 m

ii. Engagement of fire watchers during the fire season. Collaboration with the Forest Department can be made to set up an alarm or information transfer system for fire monitoring.

iii. Early warning and real time monitoring systems can be designed and installed in collaboration with the Forest Department.

iv. Establishment of in-house firefighting equipment and fire tenders. A dependable and substantial source of water is the most effective firefighting resource. Therefore, water storage capability (accessible by firefighters) using tanks, ponds, pools, or underground tanks could be developed.

v. Conducting regular fire safety drills in the campus.

vi. Management of combustible debris in and around the campus including dry grass, garbage, combustible substances, etc.

vii. Use of fire-proof building materials to prevent the spread of fire.

viii. Overhead distribution power lines are a possible source of ignition for interface fires. Major accumulations of vegetation under the power lines may also contribute to ignitions. Hence, appropriate clearances between vegetation and conductors should be maintained while planning.

ix. Vegetation management inside the campus. Ground litter, over mature, dead and dying trees, and downed trees which have the potential to ignite and carry fire should be managed regularly.

x. Maintaining vegetation within the campus composed of less fire prone species according to the local ecology. The most flammable plants include those that rapidly accumulate quantities of dead foliage and branches, dead and diseased trees, vegetation with high oil or resin content, and plants that dry quickly in arid weather. When planting a new landscape, choosing a species with these characteristics can be avoided.

Table 17: Characteristics of fire-resistant vegetation

Characteristics	Example
Accumulates minimal dead vegetation	Sparsely branched trees and shrubs
Non-resinous plants	Deciduous trees and shrubs
Plants with low volumes of vegetation	Younger, sparse growing trees and shrubs
Plants with high live fuel moisture	Succulent plants that retain a large amount of water
Drought-tolerant plants	Deeply rooted plants with thick, heavy leaves
Low maintenance vegetation	Slow-growing plants requiring little care
Plants with thick woody stems	Require prolonged heating to ignite

(Source: Vicars, 2003)

2.6 Fauna

2.6.1 Amphibians and Reptiles

Amphibians and reptiles are cold-blooded vertebrates. These animals are important indicators of the health of the ecosystem for the following reasons; 1) Many species are habitat specialists, 2) They have small home ranges and 3) They are sensitive to changes in the micro-habitats. It is therefore important to assess the diversity and conservation status of the amphibians and reptiles when any ecological management plan is drawn up.

During the survey of the proposed Campus area a total of 44 species including 13 amphibians and 31 reptiles were observed. This number suggests that there is a good diversity of amphibians and reptiles in the Campus. The 44 species includes two species that are endemic to the Western Ghats (Jerdon's Bush Frog and Coastal Day Gecko). There are also endangered species like the Indian Rock Python and the Bengal Monitor Lizard.

Three species of venomous snakes including the Common Indian Krait, Spectacled Cobra and Russell's Viper occur in the Campus. While they do not pose any serious threat to human lives in the Campus, in the absence of careful habitat management the chances of these species coming into conflict with humans are high. The same may be said of the Indian Rock Python, the largest reptile in the Campus.

The community of amphibians observed is a mixture of terrestrial and aquatic species. Most of the species have wide geographical range and can be commonly seen in human-impacted landscapes both within and outside the Western Ghats. The general observation suggests that the family of tree frogs that is very diverse in the Western Ghats is represented by just a single species (Jerdon's Bush Frog). This may be due to under-sampling as these species are most active during the nights and when it rains. It may therefore be said that the 13 species observed may only be indicative of the diversity of amphibians in the Campus. As the Campus falls within the zone of humid low-elevation tropical forests, the overall diversity of amphibians may in fact be much higher. The elusive amphibians, apart from some species tree frogs and bush frogs, may also include the burrowing caecilians (legless amphibians).

Reptiles are well-adapted to the warm and humid conditions as that experienced by the Campus. Thirty-one species of reptiles is suggestive of the diversity. More than half the reptiles observed in the Campus are snakes. Of the rest, one is a freshwater turtle and the others lizards. The domination of the community by snakes is a pattern generally observed in the Western Ghats. As with amphibians, and with the exception of a few species, the reptiles observed in the Campus are largely widespread in India. Some obvious absentees in the present survey are pit vipers. Pit vipers are generally common in the low elevation forests of the Western Ghats. Due to their small size and cryptic habits, it is possible they have been overlooked during the survey. In addition to pit vipers, there may also be a few species of the burrowing shield-tail snakes in the Campus.

Like amphibians, reptiles are also vulnerable to habitat loss and transformation. Sustaining the diversity in these lower vertebrate species requires careful planning. Some patches of natural vegetation in the Campus may have to be preserved to conserve the amphibians and reptiles. Natural ponds and streams are also critical breeding habitats of amphibians. As amphibians and reptiles are animals that are important links in the food chain, special attention has to be paid in the conservation of amphibians and reptiles.

Table 18: List of Amphibians recorded from the site

Family	Scientific Name	Common Name	END	IUCN	WPA	CITES
Order: Anura						
Bufonidae	*Duttaphrynus melanostictus*	Common Indian Toad		LC		
Bufonidae	*Duttaphrynus scaber*	Ferguson's Toad		LC		
Dicroglossidae	*Sphaerotheca breviceps*	Indian Burrowing Frog		LC		
Dicroglossidae	*Hoplobatrachus tigerinus*	Indian Bullfrog		LC	Sch. IV	App. II
Dicroglossidae	*Hoplobatrachus crassus*	Jerdon's Bullfrog		LC	Sch. IV	
Dicroglossidae	*Euphlyctis cyanophlyctis*	Skittering Frog		LC	Sch. IV	
Dicroglossidae	*Fejervarya* sp.					
Ranidae	*Hydrophylax malabarica*	Fungoid Frog		LC	Sch. IV	

Microhylidae	*Microhyla ornata*	Ornate Narrow-mouthed Frog		LC		
Microhylidae	*Microhyla rubra*	Reddish Narrow-mouthed Frog		LC		
Microhylidae	*Uperodon taprobanica*	Painted Frog		LC		
Microhylidae	*Uperodon variegata*	Variegated Balloon Frog		LC		
Rhacophoridae	*Pseudophilautus wynaadensis*	Jerdon's Bush Frog	WG	EN		

Table 19: List of Reptiles recorded from the site

Family	Scientific Name	Common Name	END	IUCN	WPA	CITES
Order: Testudines						
Geoemydidae	***Melanochelys trijuga*** (Schweigger, 1812)	Indian Black Turtle		NT		App. II
Order: Squamata						
Agamidae	***Calotes calotes*** (Linnaeus, 1758)	Common Green Forest Lizard		NE		
Agamidae	***Calotes rouxii*** (Duméril & Bibron, 1837)	Roux's Forest Lizard		LC		
Agamidae	***Calotes versicolor*** (Daudin, 1802)	Indian Garden Lizard		NE		
Agamidae	***Draco dussumieri*** (Duméril & Bibron, 1837)	South Indian Flying Lizard		LC		
Agamidae	***Psammophilus dorsalis*** (Gray, 1831)	South Indian Rock Agama		LC		
Gekkonidae	***Cnemaspis littoralis*** (Jerdon, 1854)	Coastal Day Gecko	WG	DD		
Gekkonidae	***Hemidactylus brookii*** (Gray, 1845)	Brook's House Gecko		NE		
Gekkonidae	***Hemidactylus frenatus*** (Schlegel, 1836)	Asian House Gecko		LC		
Gekkonidae	***Hemidactylus leschenaultii*** (Duméril & Bibron, 1836)	Bark Gecko		LC		
Scincidae	***Eutropis carinata*** (Schneider, 1801)	Common Keeled Skink		LC		
Scincidae	***Eutropis macularia*** (Blyth, 1853)	Bronze Grass Skink		NE		
Scincidae	***Lygosoma punctata*** (Gmelin, 1799)	Spotted Supple Skink		NE		
Varanidae	***Varanus bengalensis*** (Daudin, 1802)	Bengal Monitor		LC	Sch. I	App. I

Typhlopidae	***Indotyphlops braminus*** (Daudin, 1803)	Brahminy Worm Snake		NE	Sch. IV	
Pythonidae	***Python molurus*** (Linnaeus, 1758)	Indian Rock python		LC	Sch. I	App. I
Erycidae	*Eryx conicus* (Schneider, 1801)	Common Sand Boa		NE	Sch. IV	App. II
Colubridae	***Coelognathus helena*** (Daudin, 1803)	Common Trinket Snake		NE	Sch. IV	
Colubridae	***Ptyas mucosa*** (Linnaeus, 1758)	Indian Rat Snake		NE	Sch. II	
Colubridae	***Oligodon arnensis*** (Shaw, 1802)	Common Kukri Snake		NE	Sch. IV	
Colubridae	***Dendrelaphis tristis*** (Daudin,1803)	Common Bronzeback Tree Snake		NE	Sch. IV	
Colubridae	***Lycodon travancoricus*** (Beddome ,1870)	Travancore Wolf Snake		LC	Sch. IV	
Colubridae	***Lycodon aulicus*** (Linnaeus, 1754)	Common Wolf Snake		NE	Sch. IV	
Colubridae	***Boiga ceylonensis*** (Günther, 1858)	Ceylon Cat Snake		NE	Sch. IV	
Colubridae	***Ahaetulla nasuta*** (Bonnaterre, 1790)	Common Vine Snake		NE	Sch. IV	
Colubridae	***Ahaetulla pulverulenta*** (Duméril & Bibron, 1854)	Brown Vine Snake		LC	Sch. IV	
Natricidae	***Amphiesma stolatum*** (Linnaeus, 1758)	Striped Keelback		NE	Sch. IV	
Natricidae	***Xenochrophis piscator*** (Schneider, 1799)	Checkered Keelback		NE	Sch. II	App. III
Elapidae	***Bungarus caeruleus*** (Schneider, 1801)	Common Indian Krait		NE	Sch. IV	
Elapidae	***Naja naja*** (Linnaeus, 1758)	Spectacled Cobra		NE	Sch. II	App. II
Viperidae	***Daboia russelii*** (Shaw & Nodder, 1797)	Russell's Viper		NE	Sch. II	App. III

Conservation Status

END = Endemic

IUCN = International Union for Conservation of Nature

WPA = Wildlife (Protection) Act 1972, India

CITES = Convention on International Trade in Endangered Species

NE = Not Evaluated

NT = Near Threatened

LC = Least Concern

DD = Data Deficient

2.6.2 Birds

One hundred and four species of birds were observed during the survey of the Campus suggesting a high local avifaunal richness. The avifauna is however dominated by birds that are common in most parts of south India. Less than 20% of the avifauna is comprised of species more typical of the Western Ghats. The domination of common birds is the result of habitat degradation that the Campus has experienced during the recent past.

Since the study-season did not coincide with the winter months migratory birds are scarcely represented in the avifaunal list. Three species viz., Grey Junglefowl, Blue-winged Parakeet and White-cheeked Barbet are endemic to southern India. Large-bodied arboreal birds include the Indian Grey Hornbill and Crested Serpent Eagle. Of these two, the Crested Serpent Eagle was observed nesting in the Campus. The small lakes created by the abandoned quarries have attracted a handful of water birds including species of ducks, cormorants, herons, egrets, coot and the Little Grebe.

Sustaining the diversity of birds on the Campus is dependent on habitat conservation and management. Birds like the Indian Grey Hornbill, barbets and woodpeckers are obligate hole-nesting birds. They require mature trees to breed successfully. The hornbill and barbets are also fruit-eating birds. They need trees that bear fleshy fruits for their continued survival.

The avifauna as a whole is comprised of birds that have diverse breeding habits. Its composition varies from aquatic breeding birds to those that nest in the ground and those that nest in tree-holes and yet others like the Crested Serpent Eagle that nests in the canopies of tall trees. As majority of these are resident birds, their long-term survival in the Campus depends on the availability of suitable nesting sites.

Birds are easy to observe, identify and monitor. Continuous monitoring of the avifauna will shed light on the overall health of the environment in the Campus.

Table 20: List of avifauna recorded from the Campus

S.no	Family	English Name	Scientific Name
Order: Galliformes			
1	Phasianidae	Grey Francolin	*Francolinus pondicerianus*
2	Phasianidae	Jungle Bush Quail	*Perdicula asiatica*
3	Phasianidae	Grey Junglefowl*	*Gallus sonneratii*
4	Phasianidae	Indian Peafowl	*Pavo cristatus*
Order: Anseriformes			
5	Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*
6	Anatidae	Indian Spot-billed Duck	*Anas poecilorhyncha*
Order: Podicipediformes			
7	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*
Order: Pelecaniformes			
8	Ardeidae	Cinnamon Bittern	*Ixobrychus cinnamomeus*
9	Ardeidae	Indian Pond Heron	*Ardeola grayii*
10	Ardeidae	Eastern Cattle Egret	*Bubulcus coromandus*
11	Ardeidae	Grey Heron	*Ardea cinerea*
12	Ardeidae	Western Great Egret?	*Ardea alba*
13	Ardeidae	Little Egret	*Egretta garzetta*
Order: Suliformes			
14	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*
15	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*
Order: Accipitriformes			
16	Accipitridae	Black Kite	*Milvus migrans*
17	Accipitridae	Brahminy Kite	*Haliastur indus*
18	Accipitridae	Crested Serpent Eagle	*Spilornis cheela*
19	Accipitridae	Shikra	*Accipiter badius*
20	Accipitridae	Besra	*Accipiter virgatus*
Order: Falconiformes			
21	Falconidae	Common Kestrel	*Falco tinnunculus*
Order: Gruiformes			
22	Rallidae	Purple Swamphen	*Porphyrio porphyrio*
23	Rallidae	Common Moorhen	*Gallinula chloropus*
24	Rallidae	Eurasian Coot	*Fulica atra*
Order: Charadriiformes			
25	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*
Order: Columbiformes			
26	Columbidae	Common Pigeon	*Columba livia*
27	Columbidae	Spotted Dove	*Spilopelia chinensis*
28	Columbidae	Laughing Dove	*Spilopelia senegalensis*
Order: Psittaciformes			
29	Psittacidae	Vernal Hanging Parrot	*Loriculus vernalis*
30	Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*
31	Psittacidae	Plum-headed Parakeet	*Psittacula cyanocephala*
32	Psittacidae	Blue-winged Parakeet*	*Psittacula columboides*
Order: Cuculiformes			
33	Cuculidae	Blue-faced Malkoha	*Phaenicophaeus viridirostris*
34	Cuculidae	Asian Koel	*Eudynamys scolopaceus*
Order: Strigiformes			
35	Strigidae	Spotted Owlet	*Athene brama*
Order: Caprimulgiformes			
36	Caprimulgidae	Indian Nightjar	*Caprimulgus asiaticus*
Order: Apodiformes			
37	Hemiprocnidae	Crested Treeswift	*Hemiprocne coronata*
38	Apodidae	Asian Palm Swift	*Cypsiurus balasiensis*
39	Apodidae	House Swift	*Apus nipalensis*
40	Apodidae	Alpine Swift?	*Tachymarptis melba*
41	Apodidae	House Swift	*Apus nipalensis*
Order: Coraciiformes			
42	Coraciidae	Indian Roller	*Coracias benghalensis*

43	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*
44	Alcedinidae	Common Kingfisher	*Alcedo atthis*
45	Alcedinidae	Pied Kingfisher	*Ceryle rudis*
46	Meropidae	Blue-bearded Bee-eater	*Nyctyornis athertoni*
47	Meropidae	Green Bee-eater	*Merops orientalis*
Order: Bucerotiformes			
48	Upupidae	Eurasian Hoopoe	*Upupa epops*
49	Bucerotidae	Indian Grey Hornbill	*Ocyceros birostris*
Order: Piciformes			
50	Megalaimidae	Brown-headed Barbet	*Megalaima zeylanica*
51	Megalaimidae	White-cheeked Barbet*	*Megalaima viridis*
52	Megalaimidae	Coppersmith Barbet	*Megalaima haemacephala*
53	Picidae	Brown-capped Pygmy Woodpecker	*Dendrocopos nanus*
54	Picidae	Streak-throated Woodpecker	*Picus xanthopygaeus*
55	Picidae	Lesser Goldenback	*Dinopium benghalense*
Order: Passeriformes			
56	Tephrodornithidae	Common Woodshrike	*Tephrodornis pondicerianus*
57	Aegithinidae	Common Iora	*Aegithina tiphia*
58	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*
59	Laniidae	Bay-backed Shrike	*Lanius vittatus*
60	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*
61	Oriolidae	Black-hooded Oriole	*Oriolus xanthornus*
62	Dicruridae	Black Drongo	*Dicrurus macrocercus*
63	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*
64	Dicruridae	White-bellied Drongo	*Dicrurus caerulescens*
65	Dicruridae	Bronzed Drongo	*Dicrurus aeneus*
66	Rhipiduridae	White-throated Fantail	*Rhipidura albicollis*
67	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*
68	Corvidae	House Crow	*Corvus splendens*
69	Corvidae	Large-billed Crow	*Corvus macrorhynchos*

70	Alaudidae	Jerdon's Bush Lark	*Mirafra affinis*
71	Alaudidae	Ashy-crowned Sparrow-Lark	*Eremopterix griseus*
72	Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*
73	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*
74	Pycnonotidae	White-browed Bulbul	*Pycnonotus luteolus*
75	Hirundinidae	Barn Swallow	*Hirundo rustica*
76	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*
77	Cisticolidae	Zitting Cisticola	*Cisticola juncidis*
78	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*
79	Cisticolidae	Ashy Prinia	*Prinia socialis*
80	Cisticolidae	Plain Prinia	*Prinia inornata*
81	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*
82	Timaliidae	Tawny-bellied Babbler	*Dumetia hyperythra*
83	Leiothrichidae	Large Grey Babbler	*Turdoides malcolmi*
84	Leiothrichidae	Jungle Babbler	*Turdoides striata*
85	Leiothrichidae	Yellow-billed Babbler	*Turdoides affinis*
86	Sylviidae	Yellow-eyed Babbler	*Chrysomma sinense*
87	Sittidae	Chestnut-bellied Nuthatch	*Sitta cinnamoventris*
88	Sturnidae	Common Myna	*Acridotheres tristis*
89	Sturnidae	Brahminy Starling	*Sturnia pagodarum*
90	Muscicapidae	Oriental Magpie-Robin	*Copsychus saularis*
91	Muscicapidae	Indian Robin	*Saxicoloides fulicatus*
92	Muscicapidae	Asian Brown Flycatcher	*Muscicapa dauurica*
93	Chloropseidae	Jerdon's Leafbird?	*Chloropsis jerdoni*
94	Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*
95	Nectariniidae	Purple-rumped Sunbird	*Leptocoma zeylonica*
96	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*
97	Nectariniidae	Loten's Sunbird	*Cinnyris lotenius*
98	Passeridae	House Sparrow	*Passer domesticus*
99	Ploceidae	Baya Weaver	*Ploceus philippinus*

100	Estrildidae	Indian Silverbill	*Euodice malabarica*
101	Estrildidae	White-rumped Munia	*Lonchura striata*
102	Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*
103	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*
104	Motacillidae	Paddyfield Pipit	*Anthus rufulus*

? Ambiguous
*Endemic

Endomic Birds:

1. Grey Junglefowl – Endemic to peninsular India
2. White-cheeked Barbet - Endemic to Western Ghats
3. Blue-winged Parakeet - Endemic to Western Ghats

Birds Nomenclature and order is based on "Indian country Birdlist IOC Ver. 2.7"

Out of the total 104 species, most commonly sighted birds include Little Egret, Eastern Cattle Egret, Spotted Dove, and Common Myna. The commonly seen Raptor Crested Serpent Eagle is found to be breeding in the campus; nest of this species has also been noted. The abandoned quarry acting as water pools serve as foraging ground for the Grebes and Ducks.

2.6.3 Mammals

Fourteen species of mammals were observed in the Campus during the survey. These mammals vary in size from the small Three-striped Palm Squirrel to the Asian Elephant. The fourteen species observed are only indicative of the diversity of mammals in the Campus. As mammals are generally shy and many species are strictly nocturnal, it is inferred that some more species that are likely to exist in the Campus may have been missed during the brief survey. This is particularly true of bats and smaller rodents.

Two to three small herds of elephants were observed using the Campus. Whether these are resident can only be confirmed after round-the-year observations on their movements and herd size. Nevertheless, that the Campus is habitat for the elephant poses a conservation challenge. Unless the boundaries of the Campus are carefully defined and managed there will be long-term conflicts with the elephant.

The Campus is also habitat to three other species of large mammals. These are the Sambar (deer), Spotted Deer and Barking Deer (Indian Muntjac). Large herbivorous

mammals including the elephant and deer require vast areas of forage. These along with the Indian Wild Pig are candidates for future human-wildlife conflicts in the Campus. Surprisingly, no primate was observed during the study.

Table 21: Mammals recorded in the campus

S. No.	Family	Common name	Scientific Name
Order: Proboscidea			
1	Elephantidae	Asian Elephant $^{+EN}$	*Elephas maximus*
Order: Artiodactyla			
2	Cervidae	Indian Muntjac	*Muntiacus muntjak*
3	Cervidae	Sambar $^{+VU}$	*Rusa Unicolor*
4	Cervidae	Spotted Deer	*Axis axis*
6	Suidae	Indian Wild pig	*Sus scrofa*
Order: Carnivora			
7	Viverridae	Common Palm Civet	*Paradoxurus hermaphroditus*
8	Herpestidae	Grey Mongoose	*Herpestes edwardsii*
Order: Rodentia			
9	Hystricidae	Indian Crested Porcupine	*Hystrix indica*
10	Sciuridae	Three-striped Palm Squirrel	*Funambulus palmarum*
11	Muridae	Indian Mole Rat	*Bandicota bengalensis*
Order: Chiroptera			
12	Pteropodidae	Indian Flying Fox	*Pteropus giganteus*

+Threatened Species (IUCN ver. 3.1)

EN - Endangered

VU – Vulnerable

Mammals Nomenclature and order is based on "Indian Mammals A Field Guide" by Vivek Menon

2.7 Conservation Strategy for the Asian Elephant

In view of the fact that the proposed site of IIT Palakkad is located in what has been designated as the Elephant Landscape, and is a known zone for human-elephant conflict, it is imperative that a well entrenched conservation strategy for the Asian Elephant is evolved and made a part of the Campus development and functionality. It is important that as the campus becomes fully functional, the residents (faculty, support staff, students and the families) are made fully aware of the fact that the campus is part of the elephant landscape. This would entail that a comprehensive 'Do's and Dont's' manifesto is developed for the campus and the same is instilled amongst the members of the campus. It is also critical to emphasise that certain cherished provisions such as laying of lawns, establishing gardens similar to those found in other IIT campuses etc, may have to be abandoned in the IIT Palakkad campus. Most importantly, the orientation programme for students needs to include a component of Elephant Ecology and Behaviour with specific reference to the landscape.

The establishment of IIT Palakkad Campus can be an opportunity for the conservation of the Asian Elephant, only if the requisite sensitivity to this charismatic animal is demonstrated at every stage of the development of the campus. It is therefore suggested that the advice of senior Wildlife Biologists with specialisation in the management of Elephant Landscapes, be obtained at every stage of the development of the campus.

It is also an opportunity if IIT Palakkad refrains from demanding additional infrastructure for connectivity and improved mobililty, specifically with reference to Line B railway track that runs throught the Walayar Forests. This has been the zone where a number of elephants have been ploughed down by speeding trains.

In the same context, it would be extremely important that IIT Palakkad considers devolving a part of its development and annual budget to developing and implementing a conservation strategy for the Asian Elephant. This could be carried out in partnership with the Kerala Forest Department and can emerge as a pioneering initiative for mitigating human-elephant conflict. The technological capability that IIT as an institution has could be oriented to provide robust interventions that could mitigate elephant and human casualities. This would ensure

that in addition to traditional measures/mechanisms and infrastructure such as watch towers, anti poaching systems etc, recent learnings and success stories could be explored for implementation. For example, an alert system that could inform people of elephant movement, an auto speed reduction system for trains that traverse through Line B, drone-based system that track crop raiding incidences etc. In terms of the functionality of the campus, it may be advisable to train and build capacities of the security personnel in elephant management, with the active collaboration of the Kerala Forest Department. In what would perhaps be a pioneering initiative anywhere in the world, IIT Palakkad could actively consider financially and technically supporting the creation and functioning of a Rapid Response Force for the Conservation of the Asian Elephant – that could liaison with the major stakeholders of the landscape and provide on group, real time support to protect India's charismatic speices.

It is also to be highlighted that the additional focus on the Asian Elephant should not be at the cost of according a lower value / importance to the other fauna and flora of the campus and the landscape.

2.7.1 Habitat management for elephants

Field observations indicated the presence of 6 elephants in the area while interaction with the locals revealed the presence of 13 elephants, in three herds, visiting the campus site. It was also stated by the locals that the herd of 3 males was largely responsible for crop raids and conflict with humans. Discussion with Forest Officials revealed that the problem of human-elephant conflict was severe during the monsoon season and the elephants returned to the forest after the cropping season. The **Asian Elephant** *(Elephas maximus) is commonly observed* in Walayar and Bolampatty Valleys, Anaikatty R.F., Gopinari R.F., Hulical, Jaccanare slopes and Nilgiris Eastern Slope R.Fs. During the rainy season they are observed in Sholakkarai, Singapathy and Iruttupallam blocks. Elephant paths in this division passes through Mannarkad (Kerala State) – Kodunagaraipallam – Anaikatty – Pillur – Nellithorai – Hulical – Kallar – Odanthorai (and Bhavanisagar, Mudumalai – Moyar – Bhavanisagar – Odanthorai – Kunjapanai and Walayar – Mangalapalayam – Sigarapathy – Thanikandy) (http://www.coimbatoreforests.org/overview.htm). The elephant population in Nilambur South, Silent Valley and Attappady and Mannarkkad

forests is also contiguous with the Coimbatore Division of Tamil Nadu. The Palakkad population ranges over Muthikulam, Walayar, Olavakkode and up to Attappadi through a narrow corridor in Tamil Nadu (Ghosh and Baskaran, 2007). According to news reports and articles, a large number of elephants were reported to have been killed/injured due to speeding trains between Kanjikode and Madukkarai (a 30 km stretch of dense forest) in this section. Though both the Railway and the Forest departments claimed that the entire track was cordoned off by electric fencing, and the elephants were safe, the fencing was found to be breached at places by the elephants by pushing huge teak trees onto it. The B-line, which has been laid through the Walayar Reserve forest, bisects an elephant corridor (http://www.conservationindia.org/gallery/walayar-walking-on-a-knifes-edge).

A broad definition of human-elephant conflict is "any human-elephant interaction which results in negative effects on human social, economic or cultural life, on elephant conservation or on the environment". Elephants have the potential to damage large areas of crops, destroy property, and cause injury and death. Hence it is important to reduce the conflict through proper land-use planning to reduce habitat fragmentation and human elephant conflict. The following strategies can be considered for reducing the conflict.

i. Physical barriers, although an expensive option, are seen by many people as potentially a permanent solution to an elephant problem. An encircling fence layout is considered most useful since it avoids 'funneling' elephants around the open end of a fence. Maintenance of fence has been identified as a critical problem with any type of wildlife fencing. Stone walls, although expensive to build, have been quite effective as an elephant barrier in parts of the world particularly if used as a strong base for a simple electric fence. However the building of stone walls in many other areas is limited by insufficient quantities of usable stone (Hoare, 2003). Thouless & Sakwa (1995) suggest that stone walls with a concreted top, or an electrified wire running along the top of them might be viable alternatives.

   Other types of strong, non-electrified fences have been used to restrict elephant movements in many parts of Africa and Asia. These fences are usually built with wooden or steel poles driven vertically into the ground. Heavy gauge wire or cable is strung between the poles and drawn tight. While

these fences have met with some success, they can be expensive to erect and maintain, as there is a large labour investment required and expert advice is needed (Parker et al. 2007).

ii. Electric fencing- Electrified fences are commonly employed to protect farm lands from elephants and by governments and conservation agencies to restrict elephants to particular areas. If maintained properly it can be the most successful barrier against elephant. Electric fences carry a high voltage at low amperage as a pulsed current. They do not cause physical harm to elephants but give a powerful electric shock upon contact. Elephants tend to be wary of it and not adapt to it easily. However, some elephants eventually adapt with prolonged exposure. Constant high voltages will deter most elephants, but low voltage, a common symptom of poor maintenance, will render the fence ineffective, and may only serve as an irritant, resulting in elephants destroying sections of fence. Elephants have been known to breach electric fences by using tusks which do not conduct electricity, pushing or kicking down fence posts and stepping over the fence using the thick soles of their feet to depress the wires. Use of high quality components such as porcelain or UV stabilized insulators and other hardware, non-corroding wires etc. make fences long lasting if constructed with quality materials coupled with good maintenance. Good maintenance requires daily inspection of fence for wire breaks, loosening, current leakage from objects or plants touching the wires, replacing damaged posts, inspection of batteries, powering energizer etc. Clearing vegetation from underneath the fence is essential to prevent current leakage from plants touching the wires especially where live wires run close to the ground. Potential theft of vital components also needs to be taken into account (Nelson et al. 2003; Fernando et al. 2008).

As the northern boundary of the IIT project site is contiguous with the Walayar forest range which is an important elephant habitat, it is suggested afforest the northern site with plants that do not attract elephants. A number of plants can be planted along the northern boundary that deter the movement of the animals and at the same time stabilize the slope designed. A number of thorny plant species such as agave, cacti and bougainvillea can be planted as 'Biological Fences'.

The food choice of elephants ranges from grass, bamboo, tree bark, paddy, fruits and other kind of palatable vegetation (Chatterjee, 2016). Hence, it is important to note that plants like bamboo, palms and other fruit trees are not planted inside the campus.

Discussion with Forest Department officials revealed that the Forest Department needs to be financially supported, especially to devise and install mechanisms that would prevent accidents along the Line B Railway Track. Options such as establishing an underpass for elephant movement, installation of speed regulation systems combined with warning/alert systems, regular patrolling, watch towers equipped with communication equipment etc. have been suggested, but are not implemented for want of financial support. This would be a gap that IIT Palakkad could consider addressing. Additionally, the Forest Department needed railway track CCTV cameras so that railway stations could be informed; manpower, rubber bullets; a maintenance fund (8 lacs per year) for maintenance of fence and watchers. It would also be important to improve elephant habitat management in the adjoining Walayar Forest Range.

2.7.2 Labour Protection during construction period

Since elephants and other mammals frequent the project site it would be important to undertake measures for labour safety. It is suggested that erection of a temporary electric fence on the northern side should be one of the first works to be undertaken at the site followed by the construction of the stone wall as recommended in the design. It is also recommended to construct housing camps for labourers outside and away from the project site from where they can be transported using buses. They can also be equipped with drums, fire crackers, lighted fuel-woods or other handy objects that are used in dealing with raiding elephants.

2.7.3 Management of Solid and Liquid Waste

In addition to the statutory provisions that define the handling, disposal and management of soild and liquid waste, it is important that adequate care is accorded to the same even during the construction phase, especially with reference to labour sheds in view of the faunal presence and movement in the landscape.

3. GAIL Pipeline

The Kochi-Kootanad-Bengaluru-Mangalore pipeline is a project initiated in 2007 by Gas Authority of India Limited (GAIL), aimed at connecting the southern states of Kerala, Tamil Nadu and Karnataka to the national gas grid. Gail had planned to lay pipelines from Kochi to Bangalore through Kanjikode and Coimbatore. Accordingly, out of the 900 km pipeline, about 300 km would have to pass through Tamil Nadu and 100 km through Karnataka. The land acquisition for laying of pipelines is being done under the Petroleum and Mineral Pipelines (Acquisition of Right of User in Land) Act, 1962. Under the Act, the owner will retain the ownership rights over the land and cultivation, other than planting of trees (http://www.thehindu.com/news/national/kerala/gail-calls-off-pipeline-work-in-tamil-nadu/article5934658.ece; http://economictimes.indiatimes.com/articleshow/51070472.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst. The GAIL pipeline traveses through the campus (West to East) over a length of 2157.6 meters. The local forest officials who were part of the survey stated that a width of 20 meters (see Figure) is proposed as the land required for installing the pipeline, which renders about 43,152 sq. meters of land as inviolate/ unavailable. More importantly, the pipeline creates an additional edge within the campus.

To avoid gas pipeline accidents, appropriate measures and periodic monitoring should be undertaken including corrosion rate of the pipeline. Approved means of leak detection would be employed as per the provisions. Regular and adequate surveillance of pipeline should be done particularly at crossing locations and settlements. There should be regular monitoring of pressure, coating conditions and cathodic protection (Hubert Enviro Care Systems (P) Ltd., Chennai, 2013; http://indianexpress.com/article/india/india-others/22-would-not-have-died-in-pipeline-blast-had-gail-installed-safety-features-as-it-had-promised-probe-report/).

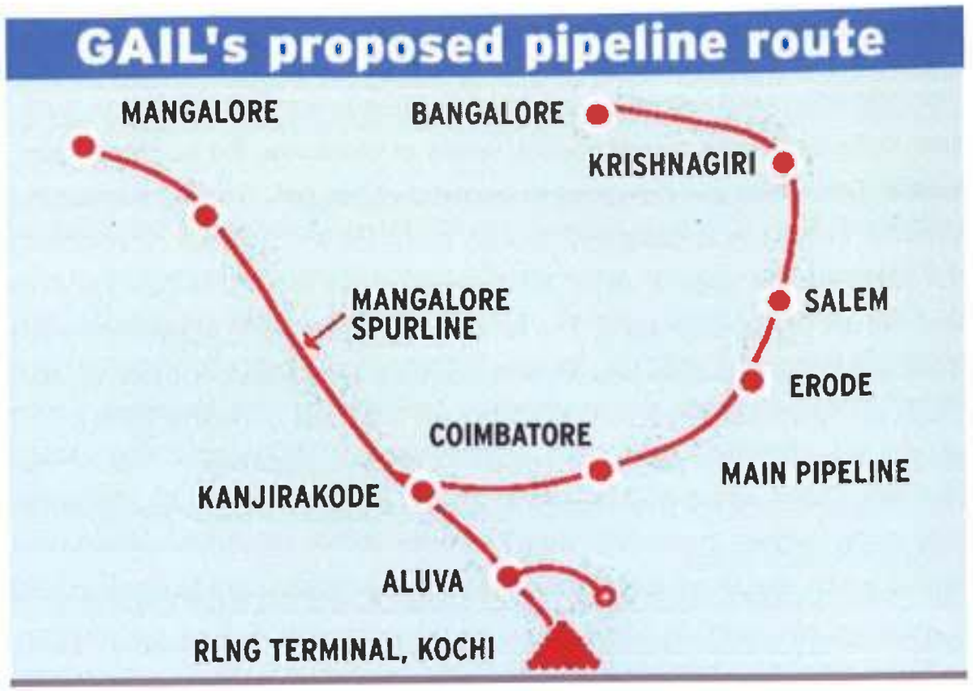


Figure 4: GAIL pipeline's proposed route

Source: http://www.thehindu.com/news/national/kerala/gail-calls-off-pipeline-work-in-tamil-nadu/article5934658.ece

Figure 5: GAIL Right of User are being marked as 20m in the map

Source: Valayar Forest Range office, Kerala Forest Department

4. Overall Recommendations

As mentioned in the earlier sections of the report, the current study has estimated the area of the campus as 526.13 acres, with a perimeter of 13.02 km. The West to East length along the Northern boundary is 8.30 km. The campus is spread as a rectangle, and the 8.30 km northern perimeter is a factor that needs to be addressed with caution in view of the potential Edge Effect that it could cause with the adjacent Protected Area.

Edge effects- In addition to the conventional meaning of edge effect – namely the increased number of species encountered where two major habitat types inter-grade, the use of edge effect here is also concerned with changes occurring in previously undisturbed forests by the abrupt creation of a very sharp edge as that in a Protected Area margin. The following major markers of habitat change may result owing to,

a) Microclimatic changes- following isolation the understory interior is exposed to drastically different microclimatic conditions; fire and grazing
b) Plants- Previous studies show a marked increase in tree mortality and leaf fall subsequent to isolation; tree falls due to climate vagaries more along edges

That edge effects penetrate to around 5 km into fragmented Protected Areas is based on studies in neotropical forests. According to Janzen (1986), "Within a tropical forested habitat, expect edge effects anywhere within 5 km of the preserve boundary. However, for wide-ranging vertebrates and seeds they carry, the edge effect will be much greater." Hence an upper limit of 5 km from the edge of the Protected Forest is being considered as the vulnerable zone.

4.1 Layout and Infrastructure Development of the Campus

The upcoming campus of IIT Palakkad presumably would have the following functional zones: academic zone, residential zone and recreation zone. Evidently each of these zones would be designed to maximize the purpose of the zone, while being modular to allow future expansion. Overlaying this with the overall character and integrity of the earmarked habitat as well as the landscape of which it is an inherent part, the following recommendations are being made.

Land use and campus development should be guided by ecosystem princples (see Hamilton and McMillan, 2004) and the fragility of the landscape. This fragility is human induced through pressures of grazing and fire, and exacerbated by the low rainfall-extended dry conditions.

The sharp slope conditions on the northern periphery of the campus influence the campus site in not only keeping it wet in patches, but also supplementing the same with enriched top soil in a limited manner. Hence in addition to a micro-climate friendly architectural design (which competent architects are better equipped to handle), it is important for the campus to designate an additional zone while deciding the layout of the campus. This zone needs to be a Blue-Green Zone that accords equal weightage to greening that would conserve elements of the remnant vegetation as also protect, restore, create and conserve wetlands within the campus.

On ground, this would be that those areas that could be earmarked for afforestation and water catchment. The Blue Green Zone would define the sustainability of the campus, and should ideally follow a dedicated conservation plan and programme. As with such initiatives elsewhere, the conservation programme should constitute the following components: protection, restoration and conservation. This however does not imply a focus on inviolate or species/landscape specific protection plan that is normally practised within Protected Areas. The plan would while keeping the purpose and scope of IIT–Palakkad as the primary focus would be evolved to ensure that prudent utilisation of natural resources is facilitated while making concerted efforts to repudiate detrimental use/abuse of natural resources.

The following design components have been proposed for IIT Palakkad Campus site.

I. Afforestation- Afforestation has been proposed for 10% of the total campus area along the northern and eastern edges of the project site. As nearly 44 acres on the northern side of the campus site was diverted from vested forest, further enrichment of this side as well as the eastern side is proposed to be maintained as a green belt. This would also help in preserving existing dense vegetation sites on the northern side.

II. The drainage of the project site is largely east to west, hence, on the basis of water drainage, a low-lying area on the south-western side has been proposed to be developed as a constructed wetland for storing surface runoff and recharging groundwater. This would also improve the microclimate of the region and serve as a source of water in the campus.

III. Maps and visualizations for campus infrastructure development:

Design A: The entrance of the IIT campus is suggested to be near the south-western side from the main highway. An 18 m wide main road is proposed which runs through the middle of the campus acting as an axis along which infrastructure development is aligned. This design proposes the location of guest house on the western side of the site closer to the entrance. The residential block is located on the left side of the axial road between the afforested zone on the northern side and constructed wetland on the southern side.

The hostel block is located on the eastern side, bound by afforested zones on all the sides except west to provide peaceful learning environment for the students. The academic block is situated on both sides of the axial road, to the west of hostel block. This would ensure easy accessibility for the students from the hostels. Administrative block and parking site have been proposed near the entrance of the campus towards the south-western side.

Apart from the main road, two other road types have been proposed- a 15 m wide sub-main road which runs as a ring-road around the building blocks and 10 m wide streets that connect main road to the sub-main roads. Additionally, all the roads have been designed to have cycle track and pedestrian walkway.

Design B: According to this design while the location of guest house and administrative blocks remain the same as design A, the residential area is located on the eastern side of the campus surrounded by the afforested zone for a tranquil environment and the hostel zone is located on the western side of the residential block. The academic block is spread out around the proposed wetland on either side of the main axial road. Road specifications proposed are similar to design A, with a change in alignment according to the placement of various blocks as can be seen the image.

IV. Compound wall design

A retaining wall of 4 m and a compound wall of 3 m supported by flying buttress have been proposed at the end of the afforestation belt resulting in a strong wall. A steep slope of ratio 1:5 has been proposed at the forest edge of the site which would hinder the movement of the elephants towards the campus and also prevent the fatal consequences of a trench.

V. Rocky Area Landscape design

Rocky terrains provide habitat for many diverse organisms and hence should be preserved. There are three such rocky outcrops in the campus which have been proposed to be preserved and landscaped. Zone 1 is located on the north-western corner while zone 2 lies towards north eastern edge. Wooden ramps, stairs and decks are suggested for these zones causing minimum damage to the existing terrain and facilitating interaction of the students with surrounding nature. The following types of design are proposed:

i. Seating areas on the rocks as a relaxation space around existing wetlands.
ii. On the steeper side of the terrain, wooden decks suspended by cables can be built for use as semi-private space for discussions.
iii. The top surface of the rocky areas can be developed as an outdoor gallery using semi-open covered structures.
iv. The top area can also be developed into a student activity centre.

4.2 Restoration: Goals and Targets

While restoration can be broadly defined as "the act of restoring to a former state or position ... or to an unimpaired or perfect condition", in the context of IIT – Palakkad, it can be operationally defined to fulfill the following purposes:

(a) to restore highly degraded but localized sites,

(b) to improve production capability in degraded but localized production lands,

(c) to enhance conservation values in protected/productive landscapes.

The principles of Restoration can be applied at various spatial and temporal scales; for instance, ecosystems, habitats, communities, species, water or soil quality or

some other characteristic of the degraded area. In the case of IIT – Palakkad it is at the scale of habitat: which is operationally defined as the dwelling place of an organism or community containing the particular combination of resources and environmental conditions that are required by individuals of a given species or group of species to carry out life processes. Habitat is not equivalent to 'habitat type' which refers to the type of vegetation association in an area.

Habitat restoration is a term that is frequently used to cover the general topic of restoring ecosystems for the specific purpose of providing habitat- either for an individual or a group of species found in an area. Habitat restoration lays more emphasis on the area where organism lives rather than ecological functions.

A restoration goal is a description of the desired outcome of restoration. The restoration goals identified should be specific, measurable, agreed upon, realistic and time bound, developed in consultation with the stakeholders. Following considerations should be taken into account for restoration.

1. Identification of target species

As habitat is a species-specific concept its restoration involves identification of a particular target species. The needs of the target species determine the desired composition and structure of the site and accordingly place importance on the components to be restored. The target species for restoration can include, (a) Threatened species, (b) Focal species, (c) Functional response groups, (d) Keystone species (e) Umbrella species and (f) Flagship species. In cases where data regarding particular species is lacking, landscapes can be modelled to identify groups of species associated with a particular habitat that are in active decline. All the above approaches have their advantages and disadvantages and no single approach can effectively conserve all species in an area.

Evidently, the campus is part of the Elephant Landscape, and de facto the target species for restoration would be the Asian Elephant which is designated as a Threatened, Focal, Keystone, Umbrella, and Flagship species. Additionally, the Elephant is protected as a Schedule I species, which is the highest protection accorded by the Wildlife Protection Act, 1972.

For the ecosystem functioning, certain processes like water and nutrient cycling, energy flow, soil formation, pollination etc. are desirable and Functional groups are groups of species that perform a role in ecosystem functioning, helping create a self-sustaining system. For e.g. pollinators, seed dispersers, nitrogen fixers, primary producers etc. The greater the number of functional groups greater would be the likelihood to cope with disturbance. Hence functional species, which in the current case are the 375 plant species also need to become a part of the restoration goal.

2. Habitat heterogeneity

A model to define the level of habitat modification in a landscape has been developed by McIntyre and Hobbs (2000) which categories habitats under the following categories:

- intact - >90% of habitat intact or with low levels of modification
- variegated - 60 to 90% habitat intact and/or low to high levels of modification of remaining habitat
- fragmented - 10 to 60% habitat intact and low to high levels of modification
- relictual - <10% habitat intact and most remaining habitat highly modified

In the intact and variegated landscapes, the habitats are well connected and they require only maintenance and improvement of integrity and resilience. In fragmented and relictual landscape, habitats are severely modified and fragmented and restoration in these cases involves checking degradation and restoring the function of degraded patches like improving habitat connectivity and quality. The vegetation profile of the IIT Palakkad campus characterizes it as a variegated habitat: restoration of such habitats focusses on ensuring the continued condition of the habitat, supported by strategic interventions to minimise any degradation, which in the case of IIT – Palakkad would be the Blue Green Zone. In other words, it would mean no establishment of 'gardens' within the Blue Green Zone, but the management of the same as 'Constructed Wildnerness' which is practiced rather effectively in IIT Madras campus. Other aspects of habitat restoration such as habitat elements, adequacy and requirement are not of relevance in the current context.

Ecological restoration is not by any means an easy exercise. Critical habitats will regenerate rather quickly when fire is controlled and the soil moisture is conserved.

The use of grassy meadows as a biological support mechanism to prevent fires is also recommended on the Northern periphery. It is also recommended that the native vegetation (however degraded) especially along the slopes, ridges and wetlands are not disturbed. The need to have a two layered porus protection mechanism for the Northern periphery, as stated in the earlier sections is critical. This mechanism needs to be further strengthened by establishing fire lines that run parallel.

As stated in the section on hydrology, the possibility of establishing checkdams, percolation ponds and groynes on the southern periphery to maximise surface water capture should be explored. The flip side of this would be that the habitat would become more conducive for wildlife especially during summer.

The Campus cannot be managed as an island insulated from the rest of the landscape. The existing streams and low lying areas should not be burdened with the task of waste disposal.

Discharge of waste water and management of solid wastes is an important component of campus development. It is normal to establish a centralised oxidation pond and solid waste management facility and it is best that this facility is created and maintained as close to the southern periphery. This is to minimise the foray of wild animals into the campus since composting would attract and influence their movement.

Evidently a comprehensive solid waste management programme that commences operations right from the time of construction needs to be evolved. All organic wastes need to be segregated at source and composted, and more importantly fed back into the conservation of the Blue Green Zone. Any surplus can be provided to the local panchayat as part of the social outreach programme of IIT Palakkad.
Decentralized collection and treatment of waste water will certainly reduce the burden on the habitat. Ideally, the proposed infrastructure needs to be segregated and clustered in such a manner that there would be a waste water collection and treatment facility for each building complex.

With the exception of the proposed waste water collection and treatment facility –that will contain inorganic (laboratory and workshop wastes) and medical wastes, all others will only generate organically enriched (largely domestic) sewage that can be locally treated using soak pits and natural filters. The topography will help in the use of gravitational flow to a large extent and the filtration technique adopted should take advantage of this.

It is proposed that the filtered domestic sewage is used for restoring the vegetation (and also preventing forest fires during summer) on the slopes through a network of sprinklers. Surplus treated domestic sewage can be provided for irrigation of crops in the adjoining villages during summer. Waste water from the facilities need to be completely removed of toxins, oils and diesel, etc before sending it into the oxidation ponds. There must be a provision through which all the waste water collection and treatment units are linked to the oxidation ponds.

The topography of the Campus does not permit creation of a walled or insulated space. Home gardens, especially when vegetables are grown, will attract the Wild Pig and also the Hare. While fencing the gardens might keep the animals out, it is better to avoid home gardens that attract wild animalsso that conflicts are minimized. Free-ranging dogs on the Campus, however, are a sure cause for trouble. Residents should adhere to a strict code of conduct by not feeding and maintaining free-ranging dogs (and cats).

It is recommended that no plant species other than that identified and listed in the Checklist be planted on the Campus. Conventional 'landscaping' can be detrimental and should not be entertained. Alternately, natural avenues, hedges and meadows can be created and maintained using native grasses and the plants listed in the report.

The natural vegetation on the Campus, when conserved can be quite attractive and unique. Natural vegetation can also be effectively used on slopes to prevent soil erosion and landslides.

The institution needs to invest effort on making itself relevant to the local population. The rather nascent aspirations that the local population harbour in being able to send the children to a good school needs to be furthered by not only ensuring access to

good schooling, but also by devoting time and effort to elevate capabilities. Apart from ensuring that the local population is given the opportunity to enroll their children in the school that IIT would establish, it would also be beneficial to make available the services of resource persons to the local middle school. Similarly, the local balwadi (kindergartens) would also benefit with expertise on preschool pedagogic training and capacity building.

An Ecological Monitoring Cell (EMC) should be set up such that infrastructure development is monitored right from its inception. In this context, it is also rather important to sensitise the students and staff on the ecological merit of the landscape. That the services provided by the ecosystem need to be respected and conserved is required to be made part of the student orientation programme. For instance, seemingly harmless acts as throwing garbage or a cigarette butt can wreck havoc in terms of increased human animal conflict or forest fires. This would also dissuade students, staff and families from making demands such as establishing lawns or landscaped gardens.

In the event labour needs to be brought from other places, the contractors should provide identification cards and domicile facilities to the labourers. This is to address the fear of theft or robbery. Likewise, LPG or Kerosene stoves need to be provided so that the migrant labour does not engage in felling of trees. The migrant labour should not also be allowed to soil (especially defecate) and abuse the wetlands.

Similarly, in the event of allowing trade units such as grocery shops, tailors, photocopying facilites to be established within the campus, or engaging transport services, local inhabitants could be given priority. Quality medical care is a major requirement of the landscape, and a referral based system could be made available to local inhabitants.

In summary, the Ecological Management Plan when operationalized would help in establishing a vibrant campus of IIT Palakkad that effectively reconciles the goal of conserving local ecology and the pursuit of academic excellence.

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Clerodendrum serratum

Anisochilus carnosus

Chamaecrista pumilla

Abelmoschus ficulneus

Vernonia cinerea

Cleome rutidosperma

Clerodendrum paniculatum

Catharanthus pusillus

Eriocaulon xeranthemum

Monochoria vaginalis

Nymphaea sp.

Trapa natans

Murdannia semiteres

Utricularia graminifolia

Aponogeton natans

Dopatrium junceum

Mimosa diplotricha

Croton hirtus

Lagascea mollis

Blainvillea acmella

Lantana camara

Mikania micrantha

Givotia rottleriformis - Habit

Givotia rottleriformis - Fruit

Manihot glaziovii -with fruits

Holarrhena pubescens - Fruits

Manihot glaziovii

Cleistanthus collinus - Fruits

Sterculia urens - Habit

Sterculia urens – dehised capsule

Hymenodictyon orixense

Premna tomentosa

Xylia xylocarpa - Leaf

Xylia xylocarpa – a dehised pod

Embelia ribes

Tetrastigma leucostaphylum

Olax scandens

Dioscorea bulbifera

Ampelocissus latifolia

Calycopteris floribunda – small tree

Bridelia scandens

Mimosa intsia

Common Picture Wing

Baronet

Common Gull

Angled Castor

Chocolate Pansy

Oriental Garden Lizard

Red-Wattled Lapwing

Grey Francolin

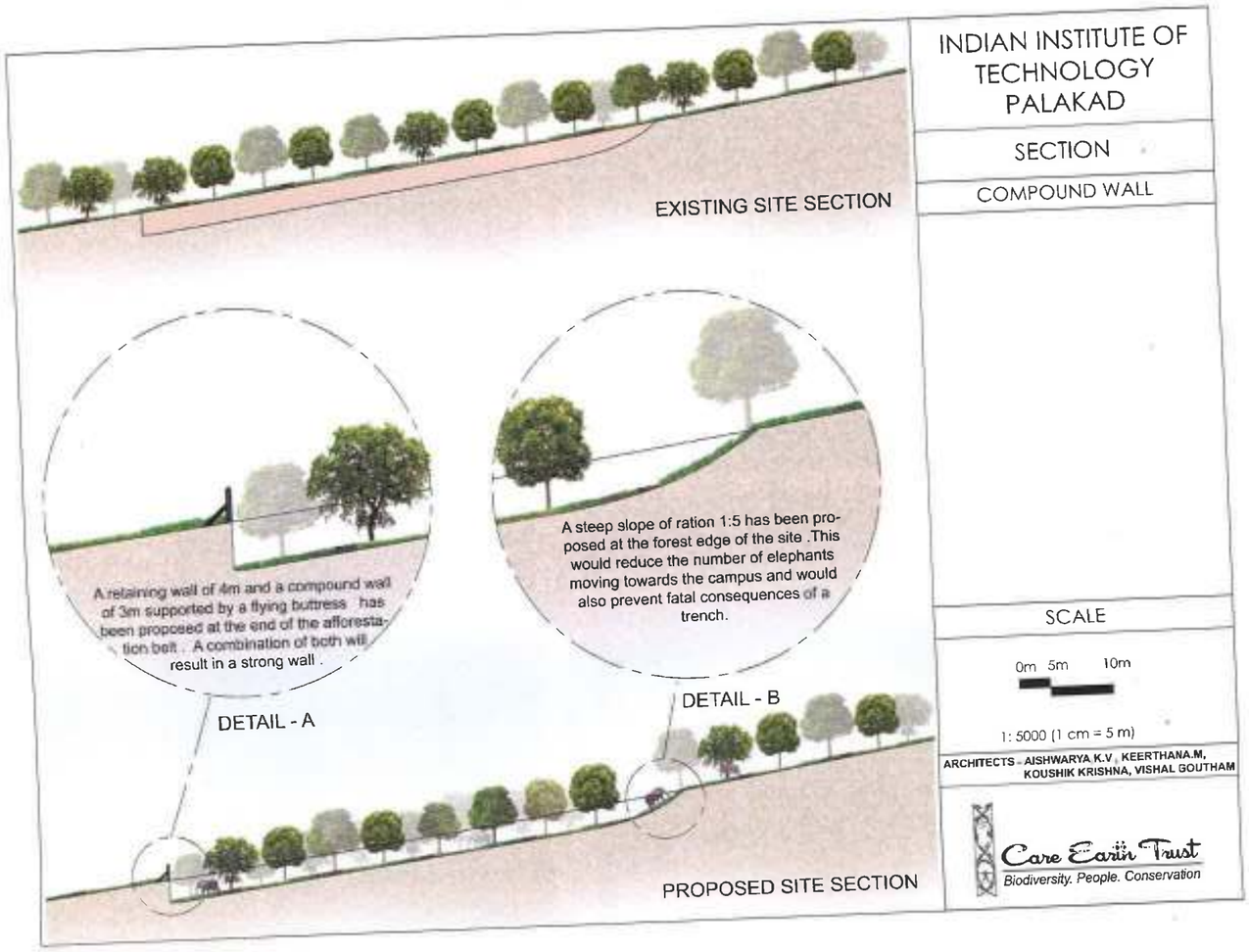
Common Kingfisher

Indian Peafowl

Crested Serpent Eagle

Asian Elephant

Annexure II



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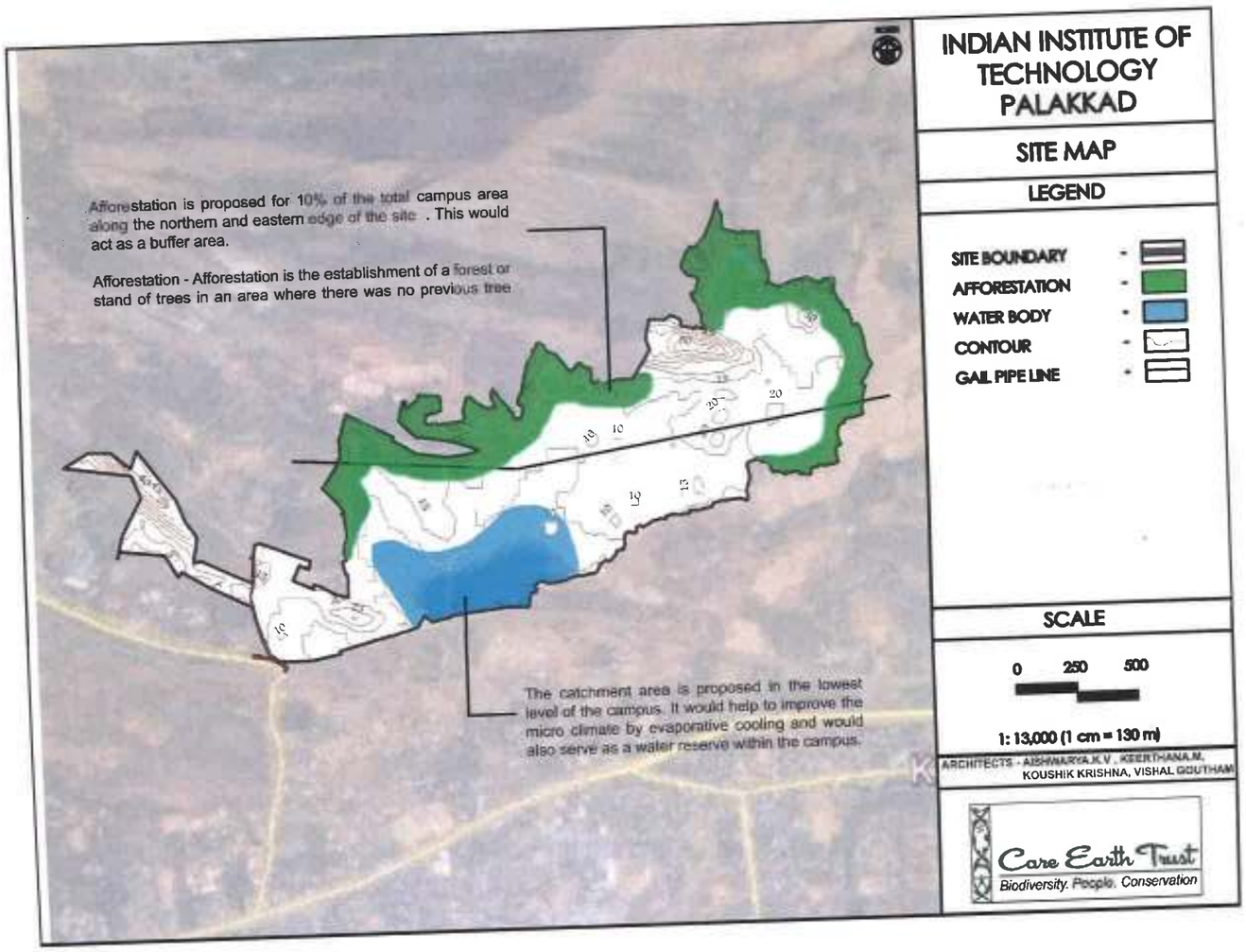
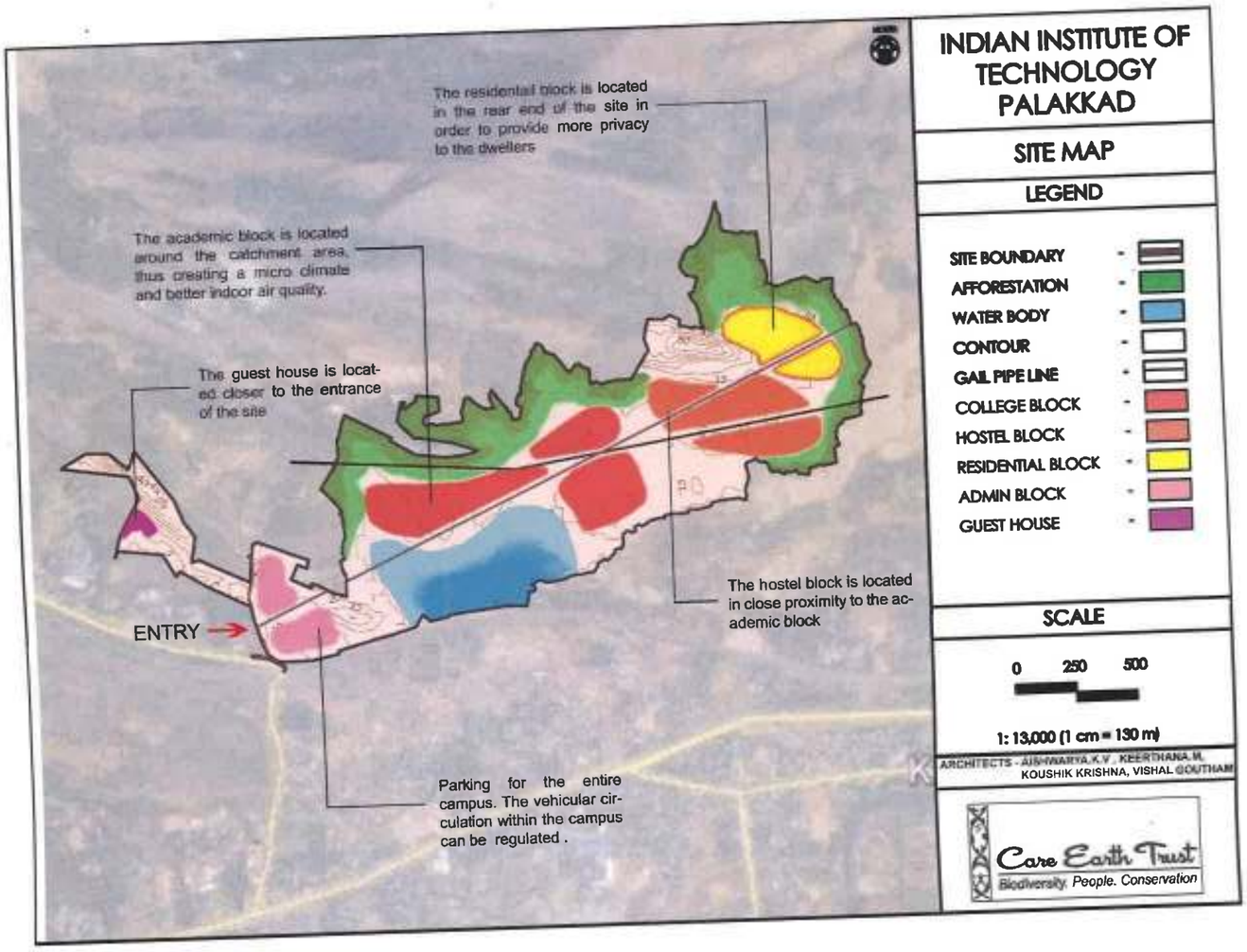
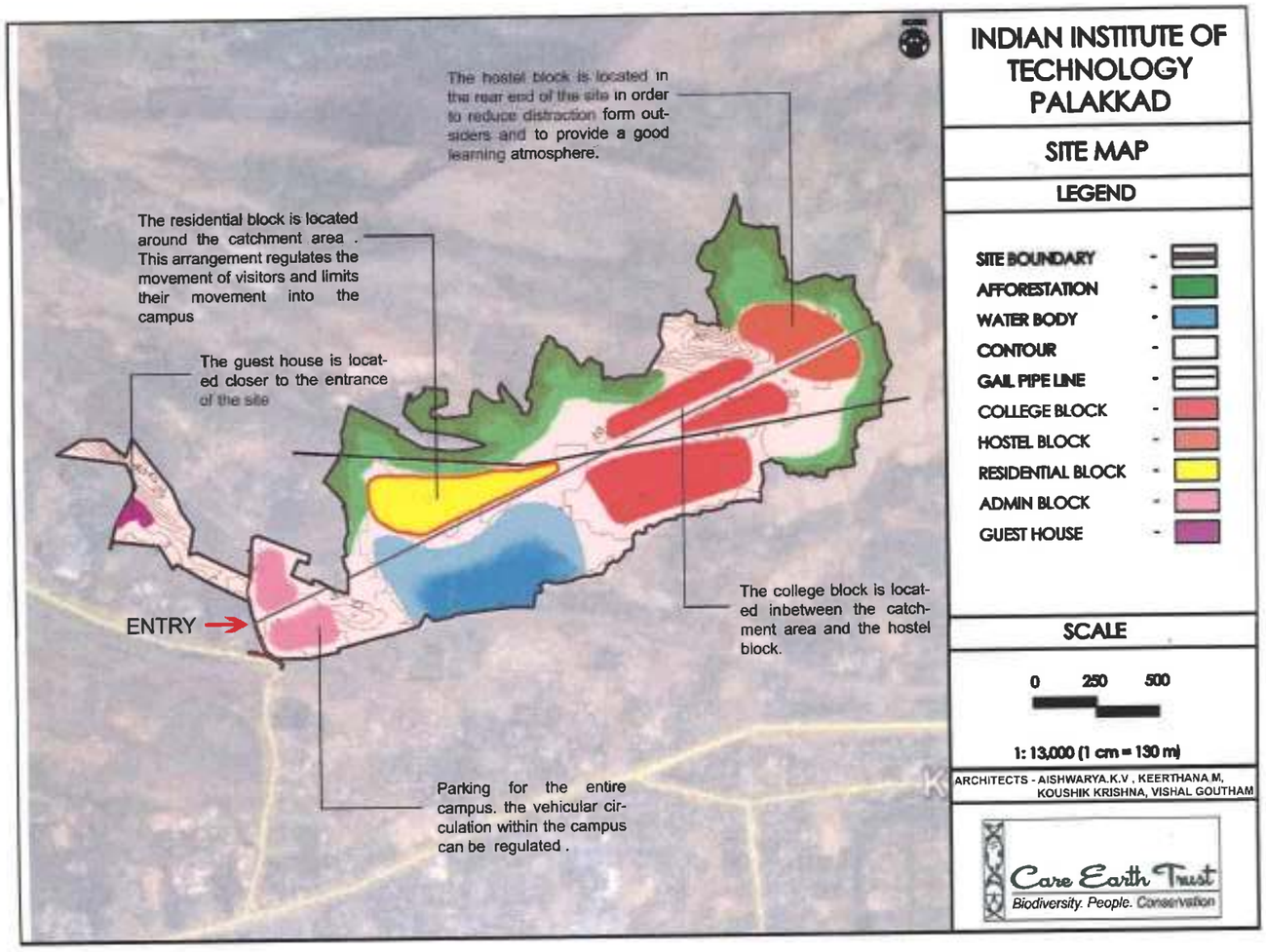



The residential block is located in the rear end of the site in order to provide more privacy to the dwellers
The academic block is located around the catchment area, thus creating a micro climate and better indoor air quality.
The guest house is located closer to the entrance of the site
ENTRY
The hostel block is located in close proximity to the academic block
Parking for the entire campus. The vehicular circulation within the campus can be regulated .
INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD
SITE MAP
LEGEND
SITE BOUNDARY
AFFORESTATION
WATER BODY
CONTOUR
GAIL PIPE LINE
COLLEGE BLOCK
HOSTEL BLOCK
RESIDENTIAL BLOCK
ADMIN BLOCK
GUEST HOUSE
SCALE
0 250 500
1: 13,000 (1 cm = 130 m)
ARCHITECTS - AISHWARYA.K.V , KEERTHANA.M, KOUSHIK KRISHNA, VISHAL GOUTHAM
Care Earth Trust
Biodiversity. People. Conservation


The hostel block is located in the rear end of the site in order to reduce distraction form outsiders and to provide a good learning atmosphere.
The residential block is located around the catchment area . This arrangement regulates the movement of visitors and limits their movement into the campus
The guest house is located closer to the entrance of the site
ENTRY
The college block is located inbetween the catchment area and the hostel block.
Parking for the entire campus. the vehicular circulation within the campus can be regulated .
INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD
SITE MAP
LEGEND
SITE BOUNDARY
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