NATIONAL WETLAND ATLAS:

KERALA

Sponsored by

Ministry of Environment and Forests

Government of India

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015

This publication deals with the updated database and status of wetlands, compiled in Atlas format. Increasing concern about how our wetlands are being influenced has led to formulation of a project entitled “National Wetland Inventory and Assessment (NWIA)” to create an updated database of the wetlands of India. The wetlands are categorised under 19 classes and mapped using satellite remote sensing data from Indian Remote Sensing Satellite: IRS P6- LISS III sensor. The results are organised at 1: 50, 000 scales at district, state and topographic map sheet (Survey of India reference) level using Geographic Information System (GIS). This publication is a part of this national work and deals with the wetland status of a particular State/Union Territory of India, through text, statistical tables, satellite images, maps and ground photographs.

The atlas comprises wetland information arranged into nine sections. How the NWIA project work has been executed highlighted in the first six sections viz: Introduction, NWIA project, Study area, Data used, Methodology, and Accuracy. This is the first time that high resolution digital remote sensing data has been used to map and decipher the status of the wetlands at national scale. The methodology highlights how the four spectral bands of LISS III data (green, red, near infra red and short wave infra red) have been used to derive various indices and decipher information regarding water spread, turbidity and aquatic vegetation. Since, the aim was to generate a GIS compatible database, details of the standards of database are also highlighted in the methodology.

The results and finding are organised in three sections; viz: Maps and Statistics, Major wetland types, and Important Wetlands of the area. The Maps and Statistics are shown for state and district level. It gives details of what type of wetlands exists in the area, how many numbers in each type, their area estimates in hectare. Since, the hydrology of wetlands are influenced by monsoon performance, extent of water spread and their turbidity (qualitative) in wet and dry season (post-monsoon and pre-monsoon period) are also given. Similarly the status of aquatic vegetation (mainly floating and emergent types) in two seasons is also accounted for. Status of small wetlands are also accounted as numbers and depicted in maps as points. Wetland map also show important ancillary information like roads/rail, relevant habitations. False Colour Composite (FCC) of the satellite image used (any one season) is shown along with the derived wetland map to give a feeling of manifestation of wetlands in remote sensing data and synoptic view of the area. The status of some of the important wetlands like Ramsar sites, National Parks are shown with recent field photographs.

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Ministry of Environment and Forests, Government of India

As a part of the project on National Wetland Inventory and Assessment (NWIA)

Space Applications Centre (ISRO), Ahmedabad

and

Kerala State Remote Sensing & Environment Centre, Thiruvananthapuram

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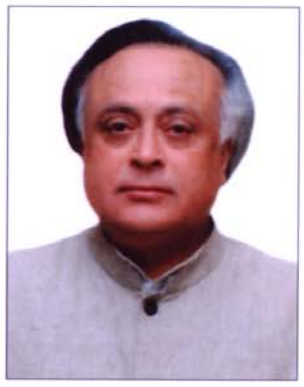
जयराम रमेश
JAIRAM RAMESH



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MESSAGE

It gives me great pleasure to introduce this Atlas, the latest in a series, prepared by Space Applications Centre, Ahmedabad in connection with the National Wetland Inventory and Assessment Project.

This Atlas maps and catalogues information on Wetlands across India using the latest in satellite imaging, one of the first of its kind. Wetlands are areas of land critical ecological significance that support a large variety of plant and animal species adapted to fluctuating water levels. Their identification and protection becomes very important.

Utility-wise, wetlands directly and indirectly support millions of people in providing services such as food, fiber and raw materials. They play important roles in storm and flood control, in supply of clean water, along with other educational and recreational benefits. Despite these benefits, wetlands are the first target of human interference and are among the most threatened of all natural resources. Around 50% of the earth's wetlands are estimated to already have disappeared worldwide over the last hundred years through conversion to industrial, agricultural and residential purposes. Even in current scenario, when the ecosystem services provided by wetlands are better understood - degradation and conversion of wetlands continues.

Aware of their importance, the Government of India has formulated several policies and plans for the conservation and preservation of these crucial ecosystems. Realising the need of an updated geospatial data base of these natural resources as the pre-requisite for management and conservation planning, National Wetland Inventory and Assessment (NWIA) project was formulated as a joint vision of Ministry of Environment & Forestry, Govt. India, and Space Applications Centre (ISRO). I am told that the latest remote sensing data from Indian Remote Sensing satellite (IRS P6) have been used to map the wetlands. The present atlas is part of this project and highlights the results of the study state in terms of statistics of various types of wetlands, extent of water, aquatic vegetation and turbidity in pre and post monsoon period. I also note that special efforts are made to provide detailed information of important wetlands like Ramsar sites, National Parks etc.

I am certain that this Atlas will raise the bar in developing such database and will be of great use for researchers, planners, policy makers, and also members of the general public.

(Jairam Ramesh)

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FOREWORD

Wetlands defined as areas of land that are either temporarily or permanently covered by water exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry. Wetlands are one of the most productive ecosystems and play crucial role in hydrological cycle. Utility wise, wetlands directly and indirectly support millions of people in providing services such as storm and flood control, clean water supply, food, fiber and raw materials, scenic beauty, educational and recreational benefits. The Millennium Ecosystem Assessment estimates conservatively that wetlands cover seven percent of the earth's surface and deliver 45% of the world's natural productivity and ecosystem services. However, the very existence of these unique resources is under threat due to developmental activities, and population pressure. This calls for a long term planning for preservation and conservation of these resources. An updated and accurate database that will support research and decision is the first step towards this. Use of advanced techniques like Satellite remote sensing, Geographic Information System (GIS) is now essential for accurate and timely spatial database of large areas. Space Applications Centre (ISRO) took up this challenging task under the project "NWIA" (National Wetland Inventory and Assessment) sponsored by Ministry of Environment & Forests. To account for numerous small yet important wetlands found in the country, mapping at 1:50,000 scales has been taken up. Two date IRS LISS III data acquired during pre and post monsoon season are used for inventory to account for wet and dry season hydrology of wetlands. The map outputs include the status of water spread, aquatic vegetation and turbidity. Ancillary layers like road/rail, habitations are also created. Very small wetlands below the mappable unit are also identified and shown points. The results are complied as Atlases of wetlands for states/Union Territories of India. This Atlas highlights results for a particular state/UT and hopes to improve our understanding of the dynamics and distribution of wetlands and their status in the area.

I congratulate the team for bringing out this informative atlas and sincerely hope that this will serve as a useful source of information to researchers, planners and general public.

January 25, 2010

(Ranganath R. Navalgund)

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This project has benefited from the wisdom of many people**.** It is a pleasure to acknowledge the contributions made by the wetland experts especially to Prof. C.K. Varshney, Former Dean, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, Prof. A.R. Yousuf, The University of Kashmir, Srinagar, Prof. Pradeeep Shrivastava, Head, Wetland Research Centre, Barakatullah University, Bhopal, Dr. Prikshit Gautam, Director, WWF-India, Dr. S. Narendra Prasad, Salim Ali Centre for Ornithology and Nature, Coimbtore and Dr. R.K. Suri, Additional Director, Ministry of Environment and Forests, Govt. of India, New Delhi, and the database experts from ISRO who participated in the peer Review meeting to finalise the “Wetland Classification System” followed in this project

We acknowledge the positive role played by 16th SC-B (Standing Committee on Bioresources and Environment) of NNRMS (National Natural Resources Management System) meeting in formulating this project. We are extremely thankful to the members of the“Steering Committee” of the project, under the chairmanship of Dr E J James, Director – Water Institute, Karunya University, for their periodical review, critical comments and appreciation of the efforts by the project team. We are thankful to SC-B under the chairmanship of Secretary, MoEF, for periodic review of the progress of the project and guidance towards timely completion of the work. We acknowledge the valuable contributions made by Dr J K Garg, the then scientist of SAC for his active role in formulation of this project, co-authoring the procedure manual document.

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1.0 INTRODUCTION

It is increasingly realized that the planet earth is facing grave environmental problems with fast depleting natural resources and threatening the very existence of most of the ecosystems. Serious concerns are voiced among scientists, planners, sociologists, politicians, and economists to conserve and preserve the natural resources of the world. One of the difficulties most frequently faced for decision making is lack of scientific data of our natural resources. Often the data are sparse or unconvincing, rarely in the form of geospatial database (map), thus open to challenges. Thus, the current thrust of every country is to have an appropriate geospatial database of natural resources that is based on unambiguous scientific methods. The wetland atlas of Kerala, which is part of the National Wetland Atlas of India, is an attempt in this direction.

1.1 Wetlands

Wetlands are one of the crucial natural resources. Wetlands are areas of land that are either temporarily or permanently covered by water. This means that a wetland is neither truly aquatic nor terrestrial; it is possible that wetlands can be both at the same time depending on seasonal variability. Thus, wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics. Because of their transitional nature, the boundaries of wetlands are often difficult to define. Wetlands do, however, share a few attributes common to all forms. Of these, hydrological structure (the dynamics of water supply, throughput, storage and loss) is most fundamental to the nature of a wetland system. It is the presence of water for a significant period of time which is principally responsible for the development of a wetland. One of the first widely used classifications systems, devised by Cowardin *et al.,* (1979), was associated to its hydrological, ecological and geological aspects, such as: marine (coastal wetlands including rock shores and coral reefs, estuarine (including deltas, tidal marshes, and mangrove swamps), lacustarine (lakes), riverine (along rivers and streams), palustarine ('marshy'- marshes, swamps and bogs). Given these characteristics, wetlands support a large variety of plant and animal species adapted to fluctuating water levels, making the wetlands of critical ecological significance. Utility wise, wetlands directly and indirectly support millions of people in providing services such as food, fiber and raw materials, storm and flood control, clean water supply, scenic beauty and educational and recreational benefits. The Millennium Ecosystem Assessment estimates conservatively that wetlands cover seven percent of the earth's surface and deliver 45% of the world's natural productivity and ecosystem services of which the benefits are estimated at $20 trillion a year (Source : www.MAweb.org). The Millennium Assessment (MA) uses the following typology to categorise ecosystem services:

Provisioning services: The resources or products provided by ecosystems, such as food, raw materials (wood), genetic resources, medicinal resources, ornamental resources (skin, shells, flowers).

Regulating services: Ecosystems maintain the essential ecological processes and life support systems, like gas and climate regulation, water supply and regulation, waste treatment, pollination, etc.

Cultural and Amenity services: Ecosystems are a source of inspiration to human culture and education throughout recreation, cultural, artistic, spiritual and historic information, science and education.

Supporting services: Ecosystems provide habitat for flora and fauna in order to maintain biological and genetic diversity.

Despite these benefits, wetlands are the first target of human interference and are among the most threatened of all natural resources. Around 50% of the earth's wetlands is estimated to already have disappeared worldwide over the last hundred years through conversion to industrial, agricultural and residential developments. Even in current scenario, when the ecosystem services provided by wetlands are better understood - degradation and conversion of wetlands continues. This is largely due to the fact that the 'full value' of ecosystem functions is often ignored in policy-making, plans and corporate evaluations of development projects.

1.2 Mapping and Geospatial technique

To conserve and manage wetland resources, it is important to have inventory of wetlands and their catchments. The ability to store and analyse the data is essential. Digital maps are very powerful tools to achieve this. Maps relating the feature to any given geographical location has a strong visual impact. Maps are thus essential for monitoring and quantifying change over time scale, assist in decision making. The technique used in the preparation of map started with ground survey. The Survey of India (SOI) topographic maps are the earliest true maps of India showing various land use/cover classes including wetlands. Recent years have seen advances in mapping technique to prepare maps with much more information. Of particular importance is the remote sensing and geographic information system (GIS) technique. Remote sensing is

now recognized as an essential tool for viewing, analyzing, characterizing, and making decisions about land, water and atmospheric components.

From a general perspective, remote sensing is the science of acquiring and analyzing information about objects or phenomena from a distance (Jensen, 1986; Lillesand and Keifer, 1987). Today, we define satellite remote sensing as the use of satellite borne sensors to observe, measure, and record the electromagnetic radiation (EMR) reflected or emitted by the earth and its environment for subsequent analysis and extraction of information. EMR sensors includes visible light, near-, mid- and far-infrared (thermal), microwave, and long-wave radio energy. The capability of multiple sources of information is unique to remote sensing. Of specific advantage is the spectral, temporal, and spatial resolution. Spectral resolution refers to the width or range of each spectral band being recorded. Since each target affects different wavelengths of incident energy differently, they are absorbed, reflected or transmitted in different proportions. Currently, there are many land resource remote sensing satellites that have sensors operating in the green, red, near infrared and short wave Infra red regions of the electromagnetic spectrum giving a definite spectral signature of various targets due to difference in radiation absorption and reflectance of targets. These sensors are of common use for land cover studies, including wetlands**.** Figure 1 shows typical spectral signature of few targets from green to SWIR region. Converted to image, in a typical false colour composite (FCC) created using NIR, red and green bands assigned as red, green and blue colour, the features become very distinct as shown in Figure 2. In FCC, the vegetation thus appears invariably red (due to high reflection in NIR from green leaves).

Since the early 1960s, numerous satellite sensors have been launched into orbit to observe and monitor the earth and its environment. Most early satellite sensors acquired data for meteorological purposes. The advent of earth resources satellite sensors (those with a primary objective of mapping and monitoring land cover) occurred, when the first Landsat satellite was launched in July 1972. Currently, more than a dozen orbiting satellites of various types provide data crucial to improving our knowledge of the earth's atmosphere, oceans, ice and snow, and land. Of particular interest to India is the indigenous series of satellites called Indian Remote Sensing satellites (IRS-Series). Since the launch of the first satellite IRS 1A in 1987, India has now a number of satellites providing data in multi-spectral bands with different spatial resolution. IRS P6/RESOURCESAT 1 is the current generation satellite that provides multi-spectral images in spatial resolution of 5.8 m (LISS IV), 23.5 m (LISS III) and 56m (AWiFS). Over the past few decades, Indian remote sensing data has been successfully used in various fields of natural resources (Navalgund et al. 2002).

Development of technologies like Geographic Information System (GIS) has enhanced the use of RS data to obtain accurate geospatial database. GIS specialises in handling related, spatially referenced data, combining mapped information with other data and acts as analytical tool for research and decision making. During the past few decades, technological advances in the field of satellite remote sensing (RS) sensors, computerized mapping techniques, global positioning system (GPS) and geographic information system (GIS) has enhanced the ability to capture more detailed and timely information about the natural resources at various scales catering to local, regional, national and global level study.

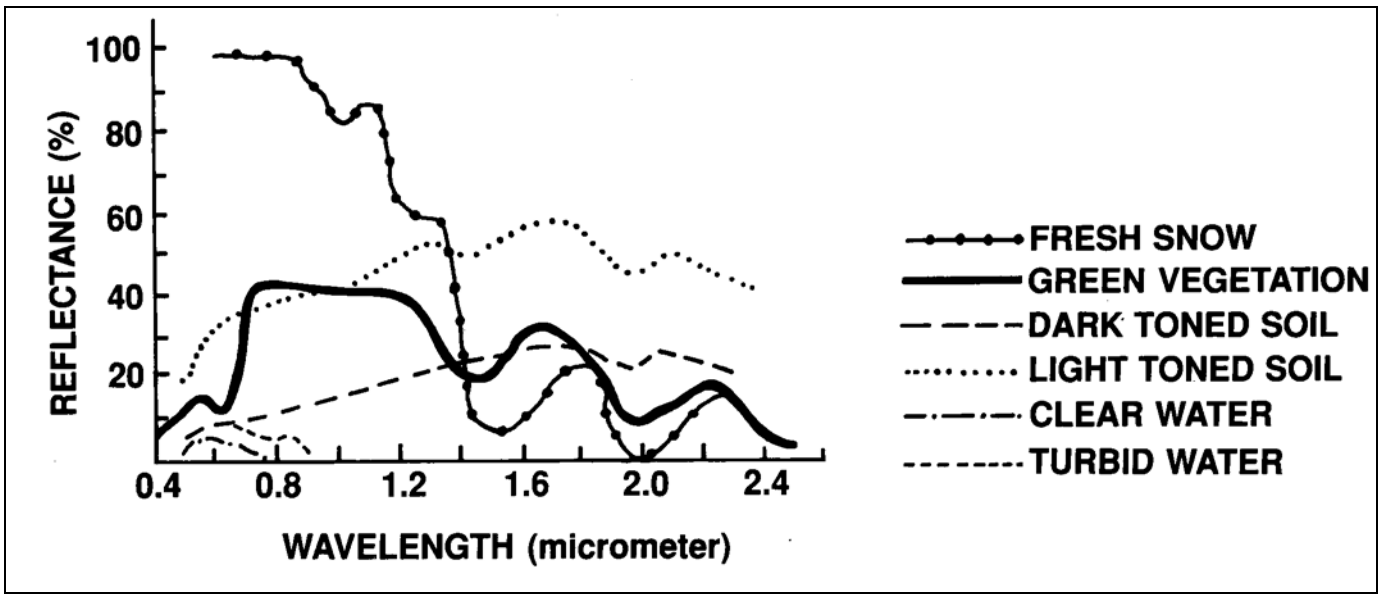


Figure 1: Spectral Signature of various targets

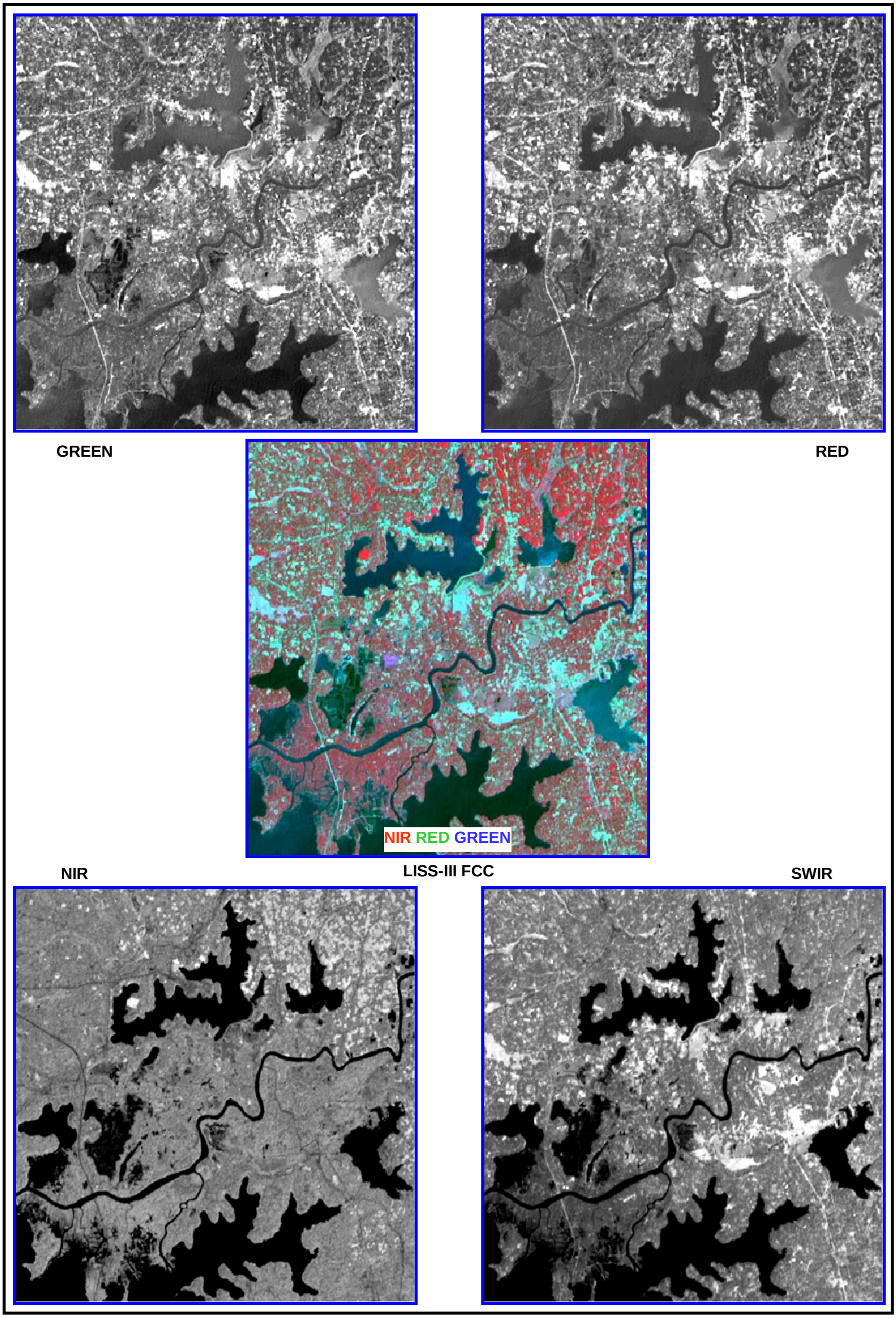


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC.

1.3 Wetland Inventory of India

India with its large geographical spread supports large and diverse wetland classes, some of which are unique. Wetlands, variously estimated to be occupying 1-5 per cent of geographical area of the country, support about a fifth of the known biodiversity. Like any other place in the world, there is a looming threat to the aquatic biodiversity of the Indian wetlands as they are often under a regime of unsustainable human pressures. Sustainable management of these assets therefore is highly relevant. Realising this, Govt. of India has initiated many appropriate steps in terms of policies, programmes and plans for the preservation and conservation of these ecosystems. India is a signatory to the Ramsar Convention for management of wetland, for conserving their biodiversity and wise use extending its scope to a wide variety of habitats, including rivers and lakes, coastal lagoons, mangroves, peatlands, coral reefs, and numerous human-made wetland, such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans reservoirs, gravel pits, sewage farms, and canals. The Ministry of Environment and Forests has identified a number of wetlands for conservation and management under the National Wetland Conservation Programme and some financial assistance is being provided to State Governments for various conservation activities through approval of the Management Action Plans. The need to have an updated map database of wetlands that will support such actions has long been realized.

Mapping requires a standard classification system. Though there are many classification systems for wetlands in the world, the Ramsar classification system is the most preferred one. The 1971 Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat is the oldest conservation convention. It owes its name to its place of adoption in Iran. It came into being due to serious decline in populations of waterfowl (mainly ducks) and conservation of habitats of migratory waterfowl. Convention provides framework for the conservation and 'wise use' of wetland biomes. Ramsar convention is the first modern global intergovernmental treaty on conservation and wise use of natural resources (www.ramsar.org). Ramsar convention entered into force in 1975. Under the text of the Convention (Article 1.1) wetlands are defined as:

"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".

In addition, the Convention (Article 2.1) provides that wetlands:

"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands".

The first scientific mapping of wetlands of India was carried out during1992-93 by Space Applications Centre (ISRO), Ahmedabad, at the behest of the Ministry of Environment and Forests (MoEF), Govt. of India using remote sensing data from Indian Remote Sensing satellites (IRS-Series). The mapping was done at 1:250,000 scale using IRS 1A LISS-I/II data of 1992-93 timeframe under the Nation-wide Wetland Mapping Project. Since, no suitable wetland classification existed for comprehensive inventory of wetlands in the country at that time, the project used a classification system based on Ramsar Convention definition of wetlands. The classification considers all parts of a water mass including its ecotonal area as wetland. In addition, fish and shrimp ponds, saltpans, reservoirs, gravel pits were also included as wetlands. This inventory put the wetland extent (inland as well as coastal) at about 8.26 million ha. (Garg et al, 1998). These estimates (24 categories) do not include rice/paddy fields, rivers, canals and irrigation channels.

Further updating of wetland maps of India was carried out by SAC using IRS P6/Resourcesat AWiFS data of 2004-05 at 1:250000 scale. In recent years, a conservation atlas has been brought out by Salim Ali Centre for Ornithology and Natural History (SACON, 2004), which provide basic information required by stakeholders in both wetland habitat and species conservation. Space Applications Centre has carried out many pilot projects for development of GIS based wetland information system (Patel et al, 2003) and Lake Information system (Singh et al, 2003).

2.0 NATIONAL WETLAND INVENTORY AND ASSESSMENT (NWIA) PROJECT

Realising the importance of many small wetlands that dot the Indian landscape, it has been unanimously felt that inventory of the wetlands at 1:50,000 scale is essential. The task seemed challenging in view of the vast geographic area of our country enriched with diverse wetland classes. Space Applications Centre with its experience in use of RS and GIS in the field of wetland studies, took up this challenging task. This is further strengthened by the fact that guidelines to create geospatial framework, codification scheme, data base structure etc. for natural resources survey has already been well established by the initiative of ISRO under various national level mapping projects. With this strength, the National Wetland Inventory and Assessment (NWIA) project was formulated by SAC, which was approved and funded by MoEF.

The main objectives of the project are:

- To map the wetlands on 1:50000 scale using two date (pre and post monsoon) IRS LISS III digital data following a standard wetland classification system.
- Integration of ancillary theme layers (road, rail, settlements, drainage, administrative boundaries)
- Creation of a seamless database of the states and country in GIS environment.
- Preparation of State-wise wetland atlases

The project was initiated during 2007. The first task was to have a classification system that can be used by different types of users while amenable to database. An expert/peer group was formed and the peer review was held at SAC on June 2007 where wetland experts and database experts participated and finalized the classification system. It was agreed to follow the classification system that has been used for the earlier project of 1:250,000 scale, with slight modification. Modified National Wetland Classification system for wetland delineation and mapping comprise 19 wetland classes which are organized under a Level III hierarchical system. The definition of each wetland class and its interpretation method was finalized. The technical/procedure manual was prepared as the standard guideline for the project execution across the country (Garg and Patel, 2007). The present atlas is part of the national level data base and deals with the state of Kerala.

2.1 Wetland Classification System

In the present project, Modified National Wetland Classification system is used for wetland delineation and mapping comprising 19 wetland classes which are organized under a Level III hierarchical system (Table 1). Level one has two classes: inland and coastal, these are further bifurcated into two categories as: natural and man-made under which the 19 wetland classes are suitably placed. Two date data pertaining to pre-monsoon and post monsoon was used to confirm the classes. Wetlands put to agriculture use in any of the two dates are not included as wetland class. Definitions of wetland categories used in the project is given in Annexure-I.

2.2.1 Spatial Framework and GIS Database

The National Spatial Framework) (NSF) has been used as the spatial framework to create the database (Anon. 2007). The database design and creation standard suggested by NRDB/NNRMS guidelines is followed. Feature codification scheme for every input element has been worked out keeping in view the nationwide administrative as well as natural hierarchy (State-district- within the feature class for each of the theme. All data elements are given a unique name, which are self explanatory with short forms.

Following wetland layers are generated for each inland wetland:

- Wetland extent: As wetlands encompass open water, aquatic vegetation (submerged, floating and emergent), the wetland boundary should ideally include all these. Satellite image gives a clear signature of the wetland extent from the imprint of water spread over the years.
- Water spread: There are two layers representing post-monsoon and pre-monsoon water spread during the year of data acquisition.

- Aquatic vegetation spread: The presence of vegetation in wetlands provides information about its tropic condition. As is known, aquatic vegetation is of four types, viz. benthic, submerged, floating, and emergent. It is possible to delineate last two types of vegetation using optical remote sensing data. A qualitative layer pertaining to presence of vegetation is generated for each season (as manifested on pre-monsoon and post-monsoon imagery).
- Turbidity level of open water: A layer pertaining to a qualitative turbidity rating is generated. Three qualitative turbidity ratings (low, medium and high) is followed for pre and post-monsoon turbidity of lakes, reservoirs, barrages and other large wetlands.
- Small wetlands (smaller than minimum mappable unit) are mapped as point features.
- Base layers like major road network, railway, settlements, and surface drainage are created (either from the current image or taken from other project data base).

In the case of coastal wetlands only wetland extent is given.

Table 1: Wetland Classification System and coding

Wettcode*	Level I	Level II	Level III
1000	Inland Wetlands		
1100		Natural	
1101			Lakes
1102			Ox-Bow Lakes/ Cut-Off Meanders
1103			High altitude Wetlands
1104			Riverine Wetlands
1105			Waterlogged
1106			River/stream
1200		Man-made	
1201			Reservoirs/ Barrages
1202			Tanks/Ponds
1203			Waterlogged
1204			Salt pans
2000	Coastal Wetlands		
2100		Natural	
2101			Lagoons
2102			Creeks
2103			Sand/Beach
2104			Intertidal mud flats
2105			Salt Marsh
2106			Mangroves
2107			Coral Reefs
2200		Man-made	
2201			Salt pans
2202			Aquaculture ponds

* Wetland type code

3.0 STUDY AREA

Kerala is located on the southernmost tip of India and embraces the coast of Arabian Sea on the west and is bounded by the Western Ghats in the east extending from 8^0 17' and 12^0 48' north latitude and 74^0 51' and 77^0 20' east longitude (Figure 3). Kerala also encloses Mahe, Pondicherry's coastal exclave. With 14 districts and other cities the total area of Kerala is 38, 916 sq km. This South Indian state stretches from north to south along the coast line of 580 kms with an approximate breadth of 35 to 120 km.

Though small in size, Kerala is a land affluent in water sources. 44 rivers drain the land, of which 41 are west flowing and 3 flow east. Apart from these 44 rivers, their tributaries and distributaries and a countless number of streams and rivulets crisscross the land making it green and fertile and also serves as inland waterways. Major rivers include Pampa, Periyar, Achenkovil, Manimala, Bharathapuzha, Chalakudy, Valapatanam, Kallayi, Meenachil, Muvattupuzha, Mogral.

Beside these rivers, Kerala is bestowed with a number of lakes and backwater lagoon which add to the beauty of the land. The important wetlands of Kerala are Ashtamudi Lake, Vembanad Lake and Sasthamkotta Lake. Vembanad backwater lake is the largest in the state while Sasthamkotta lake is the largest natural fresh water lake. The other important backwaters are Anjengo, Veli, Edava, Kadinakulam, Nadayara, Kayamkulam, Paravoor, Kowai and Chotwa.

Kerala has the finest beaches like Kovalam, Shangumugham, Varkala, Cherai, Fort Cochin, Kappad, and Bekkel. Reservoirs are the major wetlands that form the source of hydroelectricity. Major reservoirs include Neyyar,Peppara, Kallar, Kakki, Idukki, and Walayar.

Kerala has hot and humid climate during April-May and pleasant, cold climate in December-January. Summer extends from the month of April to June when the temperature reaches to a maximum of 37^0. Summer is followed by Southwest monsoon that starts pouring in the month of June and continues till September. Winter in Kerala lasts from November to January or February. Southwest monsoon and retreating monsoon (Northeast monsoon) are the main rainy seasons. Kerala receives an average rainfall of 118 inches (3,000 mm) annually.

The state has fourteen districts and is covered in 86 Survey of India topographical maps on 1:50,000 scale that form the spatial frame work for mapping (Figure 4). The spatial framework was prepared using 15' x 15' grid.

A detail of district information followed in the atlas is given in Annexure-II.

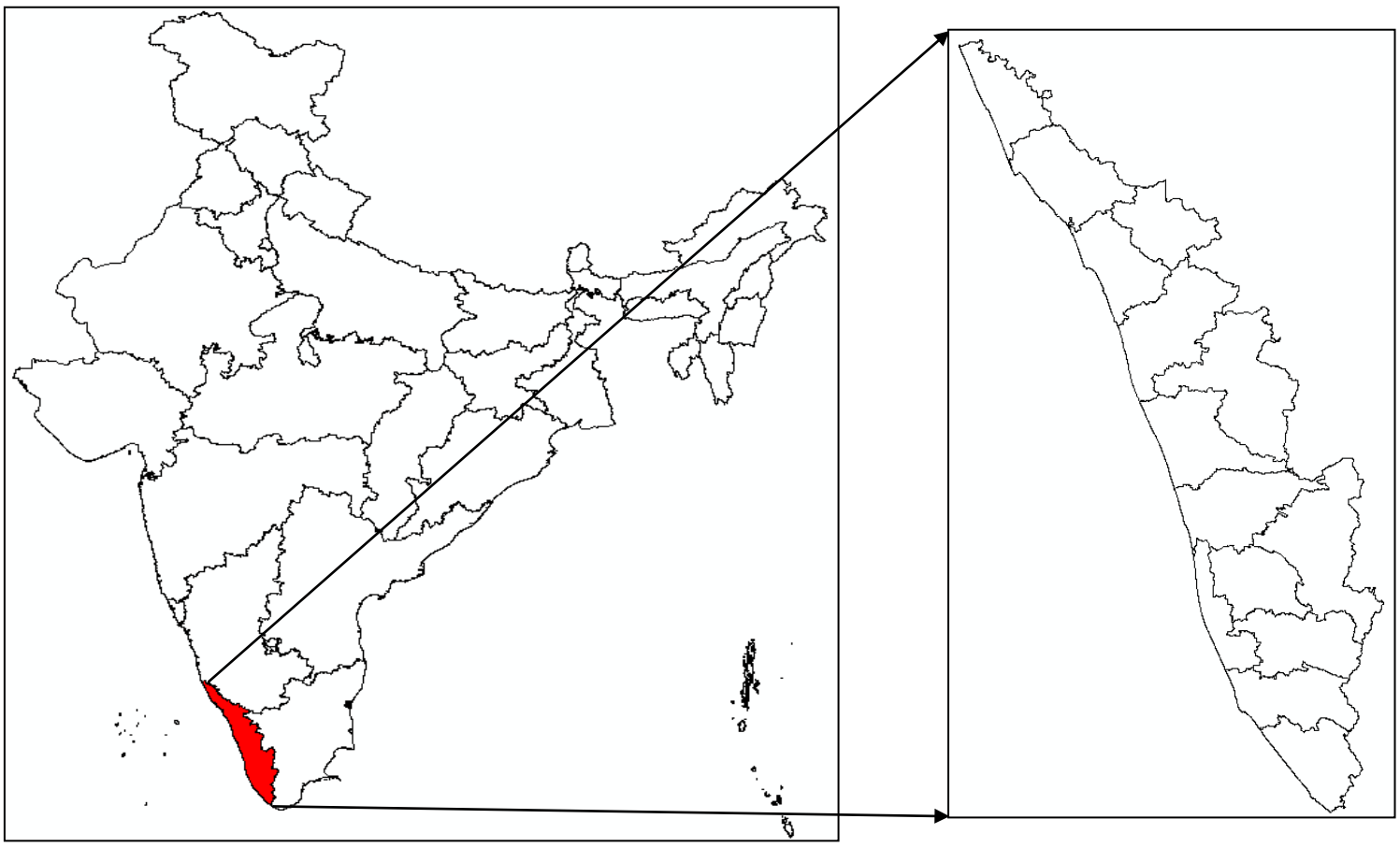


Figure 3: Location Map

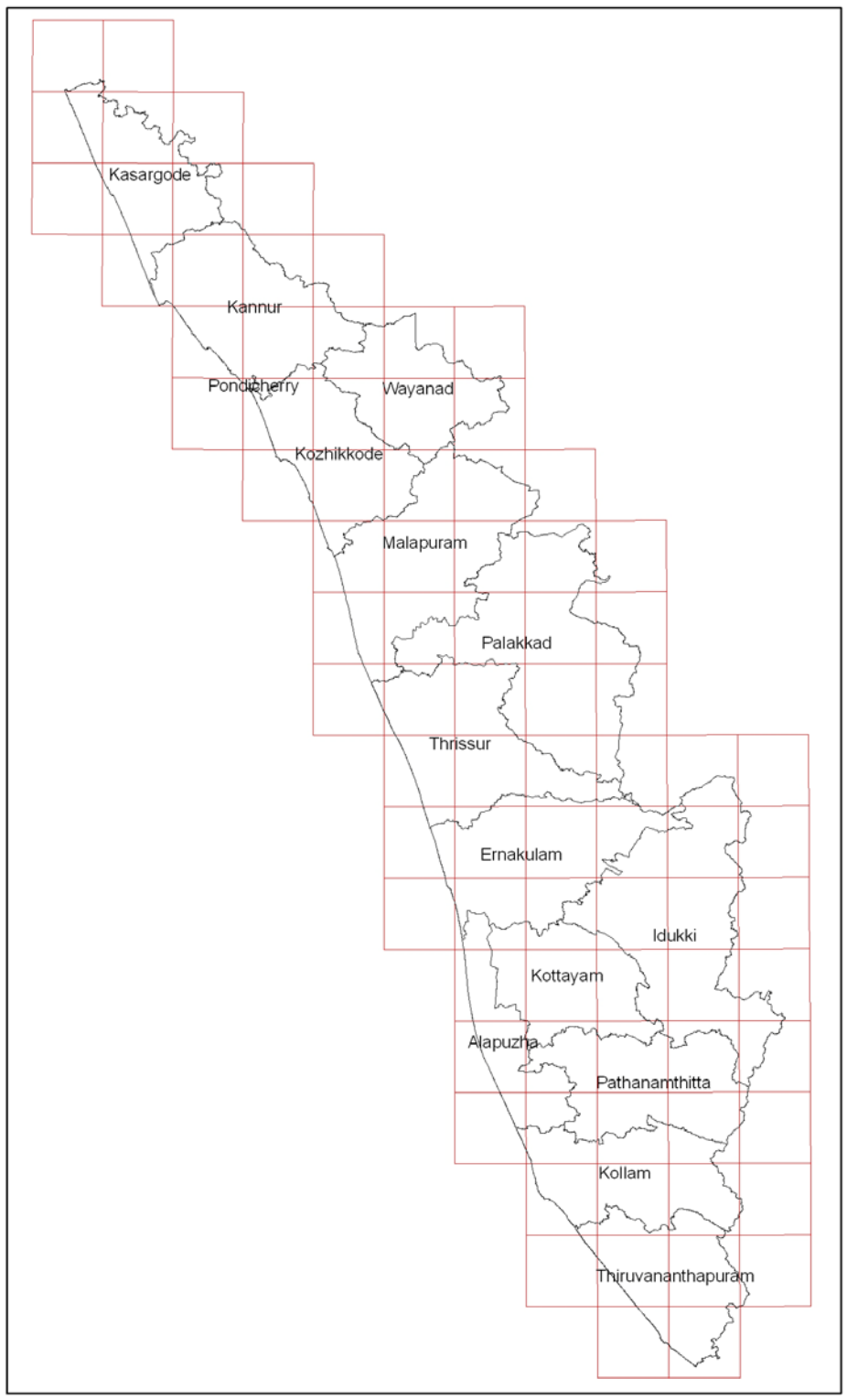


Figure 4: Spatial Framework of Kerala

4.0 DATA USED

Remote sensing data

IRS P6 LISS III data was used to map the wetlands. IRS P6 LISS III provides data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23.5 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The state of Kerala is covered in 9 IRS LISS III scene (Figure 5). Two date data, one acquired during March and another during January were used to capture the pre-monsoon and post-monsoon hydrological variability of the wetlands respectively (Table-2). Figure 5 shows the overview of the part of Kerala as seen in the LISS III FCC of post- monsoon pre-monsoon data respectively.

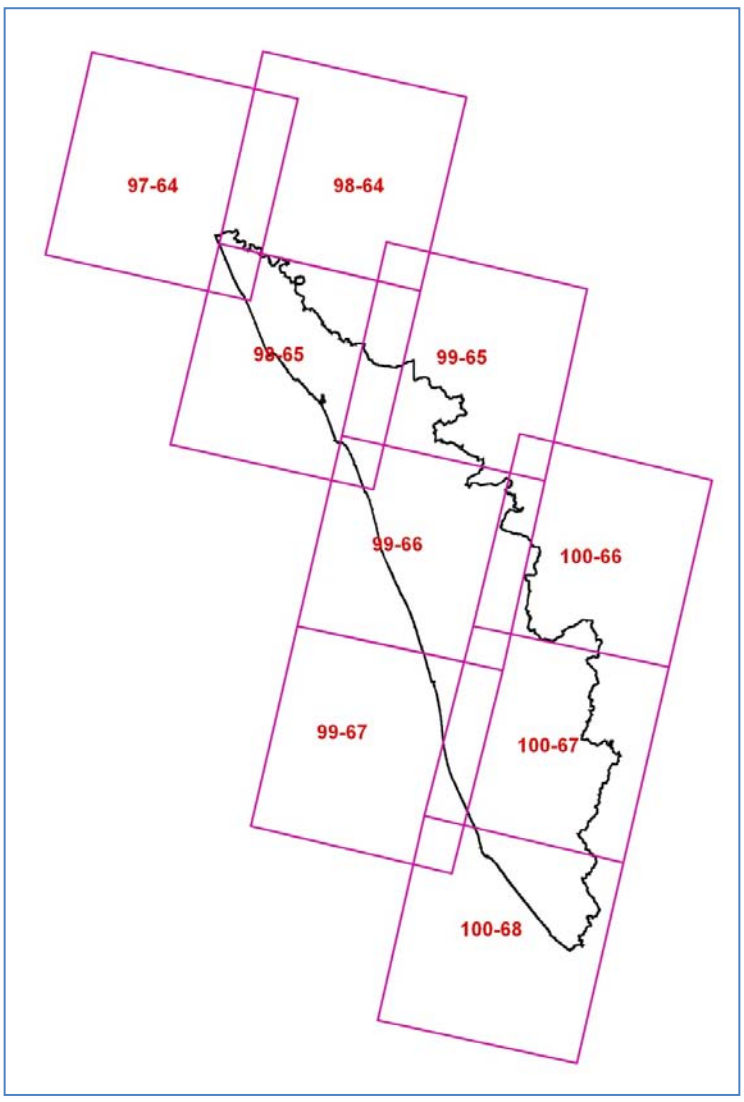


Figure 5: IRS P6 LISS-III coverage (path-row) of Kerala

Table-2: Satellite data used

Sr. No	Resourcesat LISS III Path Row	Post-Monsoon	Pre-Monsoon
1	97-64	January 5, 2007	March 13, 2006
2	98-64	December 7, 2006	May 10, 2005
3	98-65	December 7, 2006	January 5, 2007 & January 29, 2006
4	99-65	December 17, 2005	February 27, 2006 & March 23, 2007
5	99-66	January 5, 2007	February 27, 2006
6	99-67	February 27, 2006	February 27, 2006
7	100-66	March 23, 2007	March 28, 2006
8	100-67	February 13, 2005	March 23, 2007
9	100-68	February 13, 2005	March 28, 2007

Ground truth data

Remote sensing techniques require certain amount of field observation called “ground truth” in order to convert into meaningful information. Such work involves visiting a number of test sites, usually taking the satellite data. The location of the features is recorded using the GPS. The standard proforma as per the NWIA manual was used to record the field data. Field photographs are also taken to record the water quality (subjective), status of aquatic vegetation and water spread. All field verification work has been done during October and November 2008.

Other data

Survey of India topographical maps (SOI) were used for reference purpose. Lineage data of National Wetland Maps at 1:250,000 scale was used for reference.

5.0 METHODOLOGY

The methodology to create the state level atlas of wetlands is adhered to NWIA technical guidelines and procedure manual (Garg and Patel, 2007). The overview of the steps used is shown in Figure 7. Salient features of methodology adopted are

- Generation of spatial framework in GIS environment for database creation and organisation.
- Geo-referencing of satellite data
- Identification of wetland classes as per the classification system given in NWIA Manual and mapping of the classes using a knowledge based digital classification and onscreen interpretation
- Generation of base layers (rail, road network, settlements, drainage, administrative boundaries) from satellite image and ancillary data.
- Mosaicing/edge matching to create district and state level database.
- Coding of the wetlands following the standard classification system and codification as per NWIA manual.
- Preparation of map compositions and generation of statistics
- Outputs on A3 size prints and charts for atlas.

Work was carried out using ERDAS Imagine, Arc/Info and Arcgis softwares.

5.1 Creation of spatial framework

This is the most important task as the state forms a part of the national frame work and is covered in multiple map sheets. To create NWIA database, NNRMS/NRDB standards is followed and four corners of the 1:50,000 (15' x 15') grid is taken as the tics or registration points to create each map taking master grid as the reference. Spatial framework details are given in NWIA manual (Garg and Patel 2007). The spatial framework for Kerala state is shown in Figure 4.

5.2 Geo-referencing of satellite data

In this step the raw satellite images were converted to specific map projection using geometric correction. This is done using archived geometrically corrected LISS III data (ISRO-NRC-land use / land cover project). Standard image processing software was used for geo-referencing. First one date data was registered with the archived image. The second date data was then registered with the first date data.

5.3 Mapping of wetlands

The delineation of wetlands through image analysis forms the foundation for deriving all wetland classes and results. Consequently, a great deal of emphasis has been placed on the quality of the image Interpretation. In the present study, the mapping of wetlands was done following digital classification and onscreen visual interpretation. Wetlands were identified based on vegetation, visible hydrology and geography. There are various methods for extraction of water information from remote sensing imagery, which according to the number of bands used, are generally divided into two categories, i.e. Single-band and multi-band methods. Single-band method usually involves choosing a band from multi-spectral image to distinguish water from land by subjective threshold values. It may lead to over- or under-estimation of open water area. Multi-band method takes advantage of reflective differences of each band. In this project, five indices known in literature that enhances various wetland characteristics were used (McFeetres, 1986; Xu Hanqiu, 2006; Lacaux *et al*, 2007; Townshend and Justice, 1986; Tucker and Sellers, 1986) as given below:

i) Normalised Difference Water Index (NDWI) = (Green-NIR) / (Green + NIR)

ii) Modified Normalised Difference Water Index (MNDWI) = (Green-MIR) / (Green + MIR)

iii) Normalised Difference Vegetation Index (NDVI) = (NIR - Red) / (NIR + Red)

iv) Normalised Difference Pond Index (NDPI) = (MIR – Green / MIR + Green)

v) Normalised Difference Turbidity Index (NDTI) = (Red – Green) / (Red + Green)

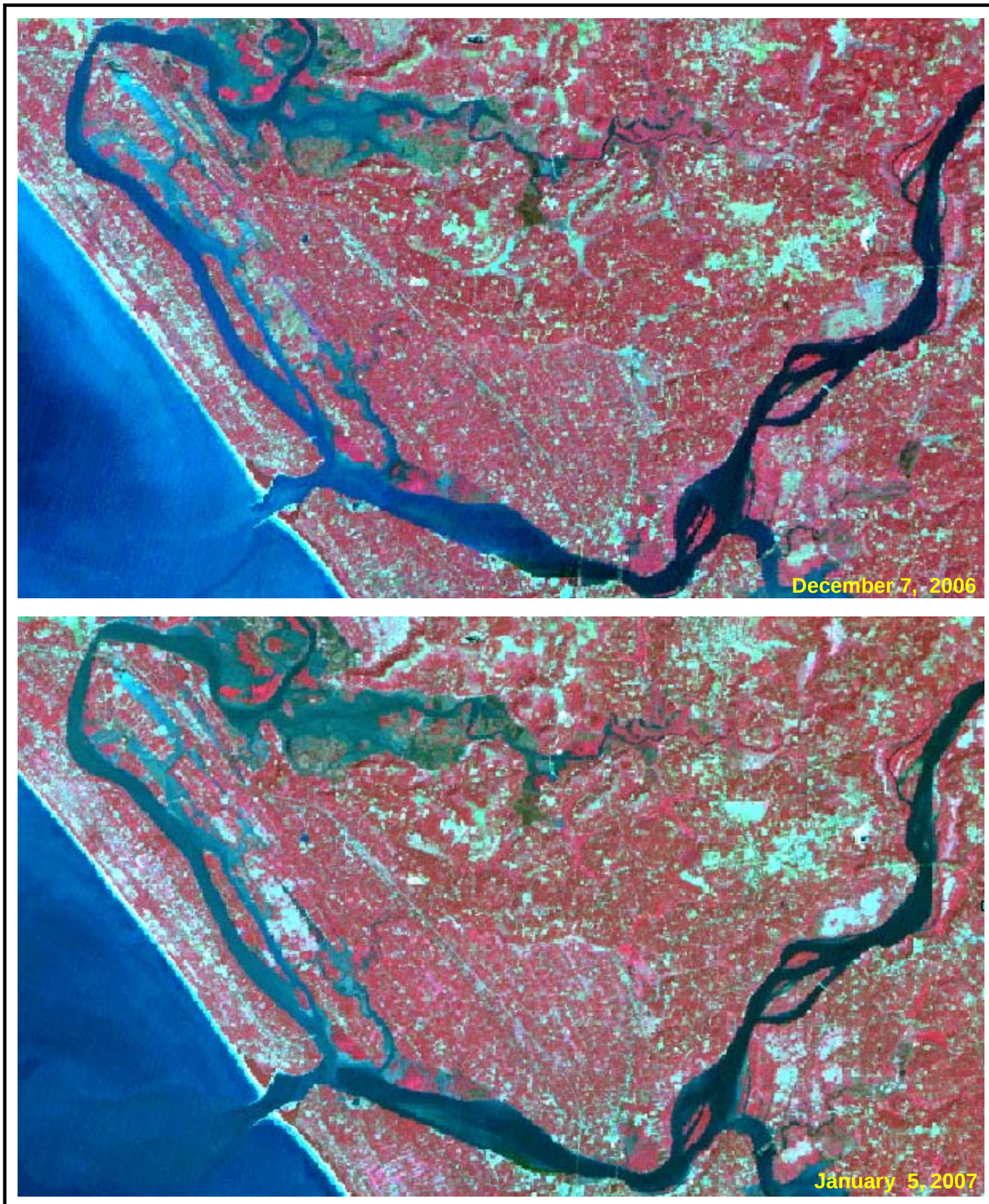


Figure 6: IRS LISS-III FCC: Part of Kerala state

The indices were generated using standard image processing software, stacked as layers (Figure 8). Various combinations of the indices/spectral bands were used to identify the wetland features as shown in Figure 9. The following indices were used for various layer extractions:

- Extraction of wetland extent :

  MNDWI, NDPI and NDVI image was used to extract the wetland boundary through suitable hierarchical thresholds.

- Extraction of open water :

  MNDWI was used within the wetland mask to delineate the water and no-water areas.

- Extraction of wetland vegetation :

  NDPI and NDVI image was used to generate the vegetation and no-vegetation areas within a wetland using a suitable threshold.

- Turbidity information extraction :

  NDTI and MNDWI image was used to generate qualitative turbidity level (high, moderate and low) based on signature statistics and standard deviations. In the False Colour Composite (FCC) these generally appear in different hues (Table-3).

Table 3: Qualitative turbidity ratings

Sr. No.	Qualitative Turbidity	Conditional criteria	Hue on False Colour Composite (FCC)
1.	Low	> $+1\sigma$	Dark blue/blackish
2.	Moderate	> -1σ to <= $+1\sigma$	Medium blue
3.	High/Bottom reflectance	<= $\mu - 1\sigma$	Light blue/whitish blue

5.4 Conversion of the raster (indices) into a vector layer

The information on wetland extent, open water extent, vegetation extent and turbidity information was converted into vector layers using region growing properties or on-screen digitisation.

5.5 *Generation of reference layers*

Base layers like major rail, road network, settlements, drainage are interpreted from the current image or taken from other project database. The administrative boundaries (district, state) are taken from the known reference data.

5.6 Coding and attribute scheme

Feature codification scheme for every input element has been worked out keeping in view the nationwide administrative as well as natural hierarchy (State-district-taluka) within the feature class for each of the theme. All data elements are given a unique name/code, which are self explanatory with short forms.

5.7 Map composition and output

Map composition for atlas has been done at district and state level. A standard color scheme has been used for the wetland classes and other layers. The digital files are made at 1:50,000 scale. The hard copy outputs are taken on A3 size.

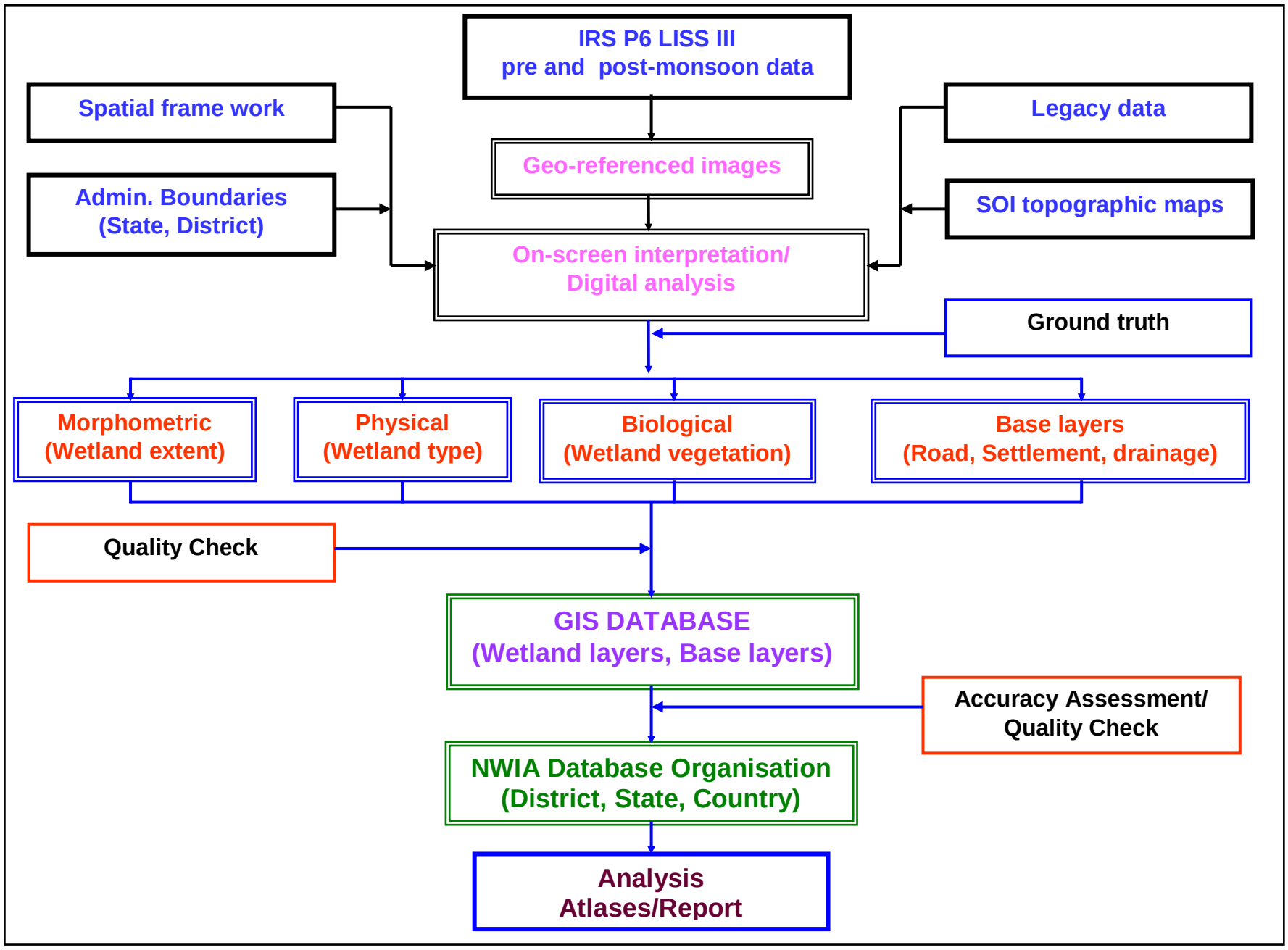


Figure 7: Flow chart of the methodology used

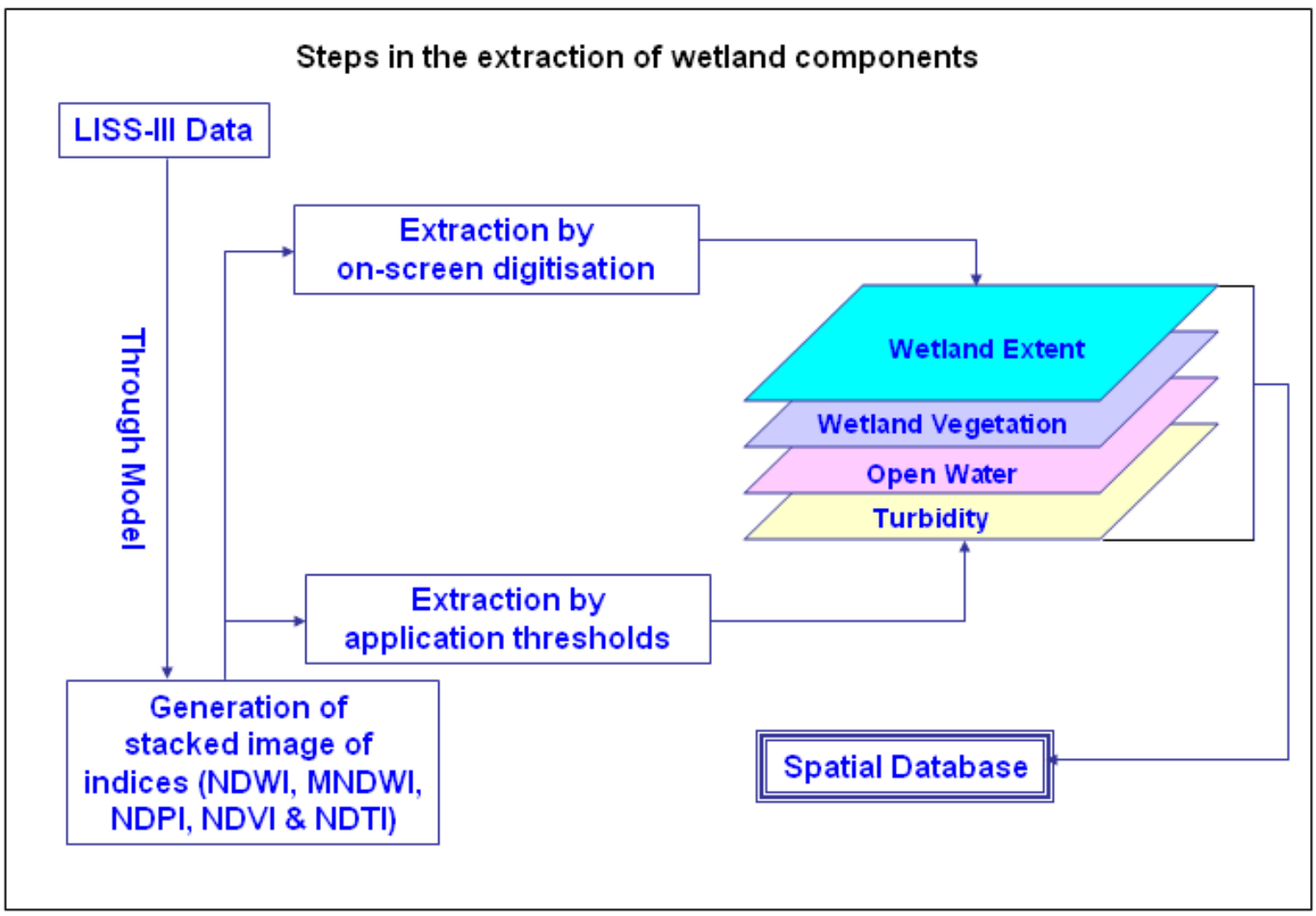


Figure 8: Steps in the extraction of wetland components

6.0 ACCURACY ASSESSMENT

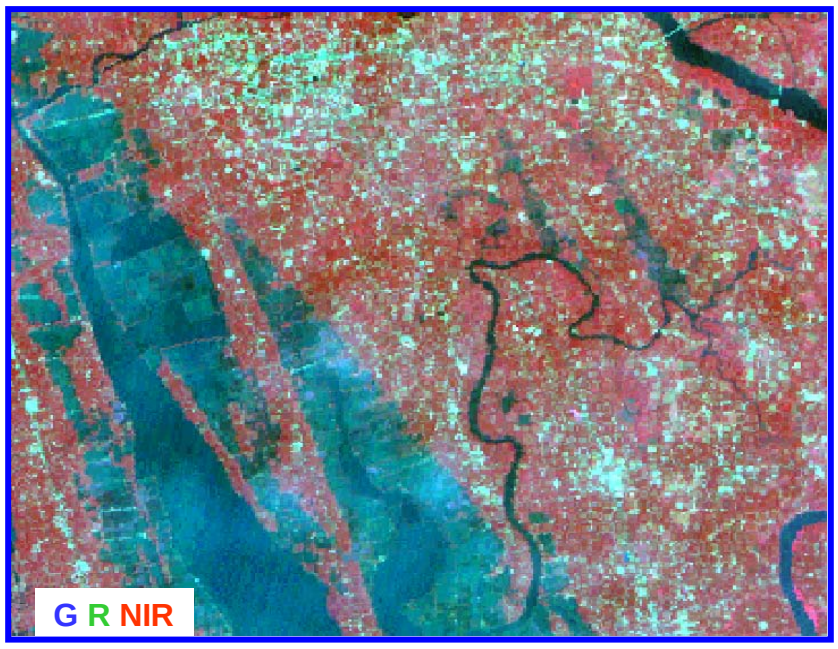
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as locational accuracy. In addition, GIS database(s) contents have been also evaluated for accuracy. To ensure the reliability of wetland status data, the project adhered to established quality assurance and quality control measures for data collection, analysis, verification and reporting.

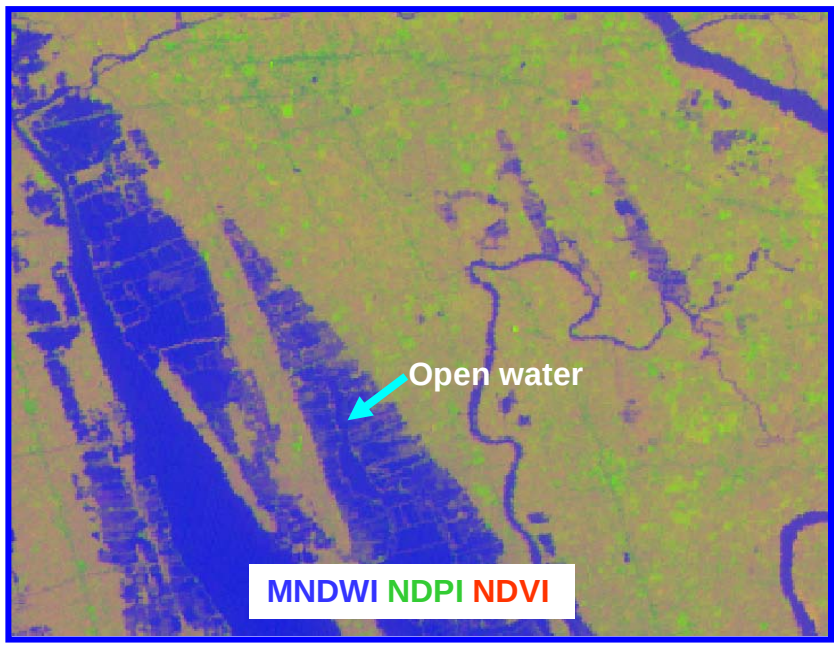
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imageries were reviewed by technical expert team for accuracy and code. The reviewing analyst adhered to all standards, quality requirements and technical specifications and reviewed 100 percent of the work. The various stages of quality check include:

1. Image-to-Image Geo-referencing/Data generation
2. Reference layer preparation using NWIA post monsoon and pre-monsoon LISS-III data.
3. Wetland mapping using visual/digital interpretation techniques.
4. Geo-data base creation and organization
5. Output products.

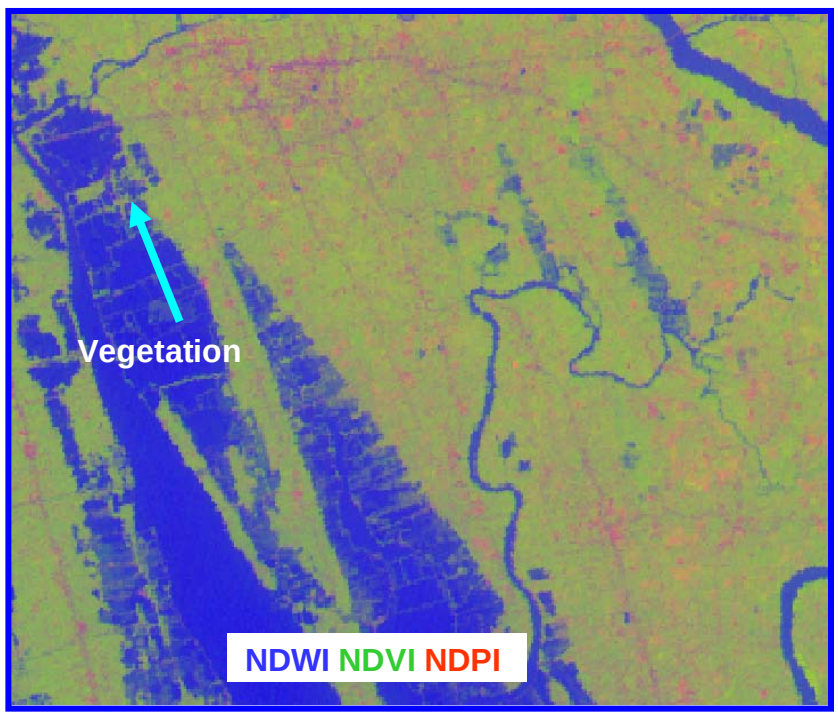
6.1 Data verification and quality assurance of output digital data files

All digital data files were subjected to rigorous quality control inspections. Digital data verification included quality control checks that addressed the geospatial correctness, digital integrity and some cartographic aspects of the data. Implementation of quality checks ensured that the data conformed to the specified criteria, thus achieving the project objectives. There were tremendous advantages in using newer technologies to store and analyze the geographic data. The geospatial analysis capability built into this study provided a complete digital database to better assist analysis of wetland change information. All digital data files were subjected to rigorous quality control inspections. Automated checking modules incorporated in the geographic information system (Arc/GIS) were used to correct digital artifacts including polygon topology. Additional customized data inspections were made to ensure that the changes indicated at the image interpretation stage were properly executed.



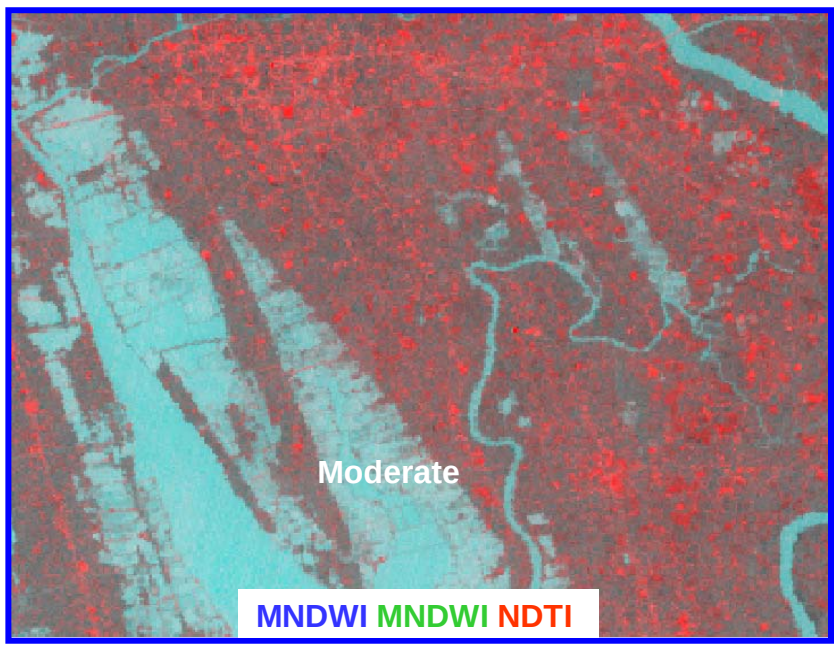


Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features

IRS LISS III data, 07 January, 2007



Useful for qualitative turbidity delineation

Figure 9: Various combinations of the indices/spectral bands used to identify wetland components

MAPS AND STATISTICS

7.0 WETLANDS OF KERALA: MAPS AND STATISTICS

Area estimates of various wetland categories for Kerala have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. In the state of Kerala 1762 wetlands have been delineated. In addition, 2592 wetlands smaller than 2.25 ha have also been identified. Total wetland area estimated is 160590 ha (Table 4). The major wetland types are River/Stream (65162 ha), Lagoons (38442 ha), Reservoirs (26167 ha) and waterlogged (20305 ha). Graphical distribution of wetland type is shown in Figure 10.

Analysis of wetland status in terms of open water and aquatic vegetation showed that around 88 and 83 per cent of wetland area is under open water category during post monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 8 and 6 per cent of wetland area during post and pre-monsoon respectively.

Table 4: Area estimates of wetlands in Kerala

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	3	2643	1.65	2259	2125
2	1104	Riverine wetlands	18	410	0.26	410	410
3	1105	Waterlogged	922	20305	12.64	11495	7771
4	1106	River/Stream	172	65162	40.58	61853	60338
	1200	**Inland Wetlands -Man-made**					
5	1201	Reservoirs/Barrages	39	26167	16.29	24583	23421
6	1202	Tanks/Ponds	439	2435	1.52	1466	530
		Total - Inland	**1593**	**117122**	**72.93**	**102066**	**94595**
	2100	**Coastal Wetlands - Natural**					
7	2101	Lagoons	39	38442	23.94	36819	35796
8	2102	Creeks	19	80	0.05	77	77
9	2103	Sand/Beach	111	2354	1.47	0	0
		Total - Coastal	**169**	**40876**	**25.45**	**36896**	**35873**
		Sub-Total	**1762**	**157998**	**98.39**	**138962**	**130468**
		Wetlands (<2.25 ha), mainly Tanks	2592	2592	1.61	-	-
		Total	**4354**	**160590**	**100.00**	**138962**	**130468**

Area under Aquatic Vegetation	13364	8925

Area under turbidity levels		
Low	102026	94722
Moderate	36501	35119
High	435	627

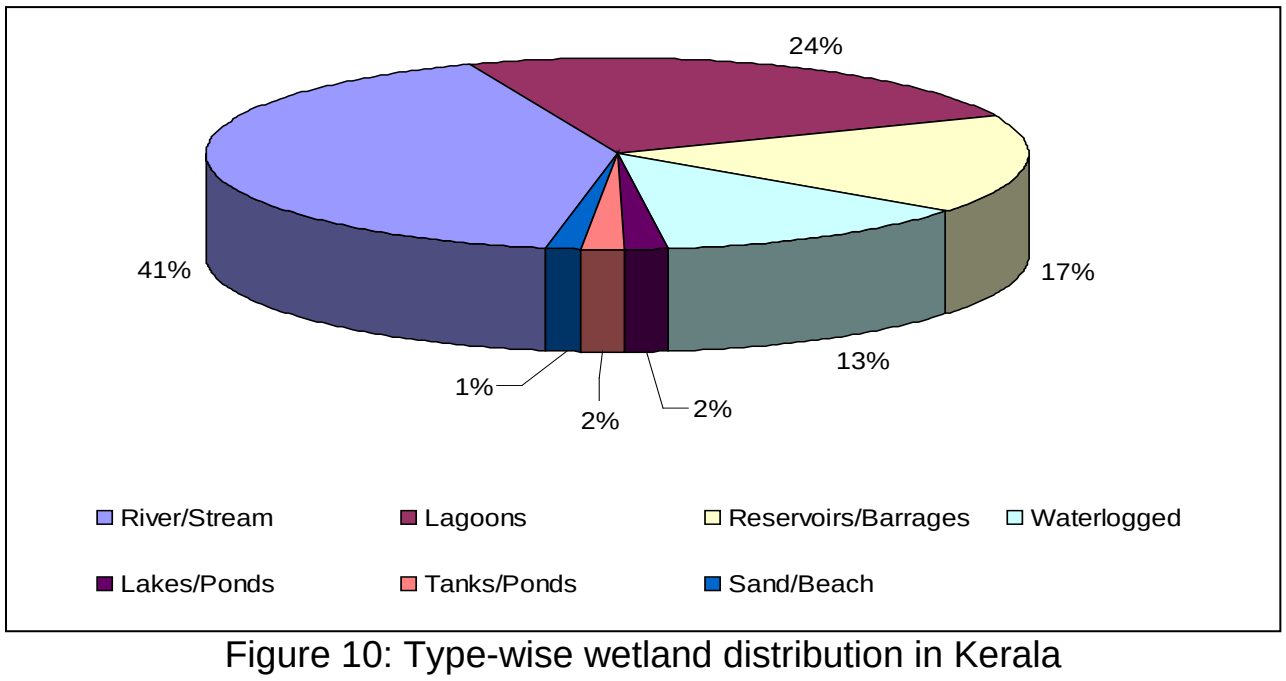


Figure 10: Type-wise wetland distribution in Kerala

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has fourteen districts. District-wise distribution of wetlands showed that four districts can be called as wetland rich. Alappuzha has highest concentration with 26079 ha area under wetland. This is mainly due to the location of the famous Vembnad kol wetland. The other three districts are Ernakulam (25065 ha), Kollam (13703 ha) and Thrissur (13285 ha). Wayanad district has the lowest area under wetland (3866 ha). District-wise wetland area estimate is given in Table-5. Figure 11 shows district-wise graphical distribution of wetlands.

Wetland statistics followed by wetland map and corresponding satellite data for each district is given to have a fairly good idea about the distribution pattern and density of wetlands in the district.

Table-5: District-wise wetland area

Sr. No.	District	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of district geographic area
1	Kasaragod	1961	7561	4.71	3.86
2	Kannur	2997	10870	6.77	3.63
3	Wayanad	2132	3866	2.41	1.81
4	Kozhikode	2345	7690	4.79	3.28
5	Malappuram	3548	9511	5.92	2.68
6	Palakkad	4480	11892	7.41	2.65
7	Thrissur	3032	13285	8.27	4.38
8	Ernakulam	2408	25065	15.61	10.41
9	Idukki	4998	10655	6.63	2.13
10	Kottayam	2204	9523	5.93	4.32
11	Alappuzha	1256	26079	16.24	20.76
12	Pathanamthitta	2731	4948	3.08	1.81
13	Kollam	2579	13703	8.53	5.31
14	Thiruvananthapuram	2192	5942	3.70	2.71
	Total	**38863**	**160590**	**100.00**	

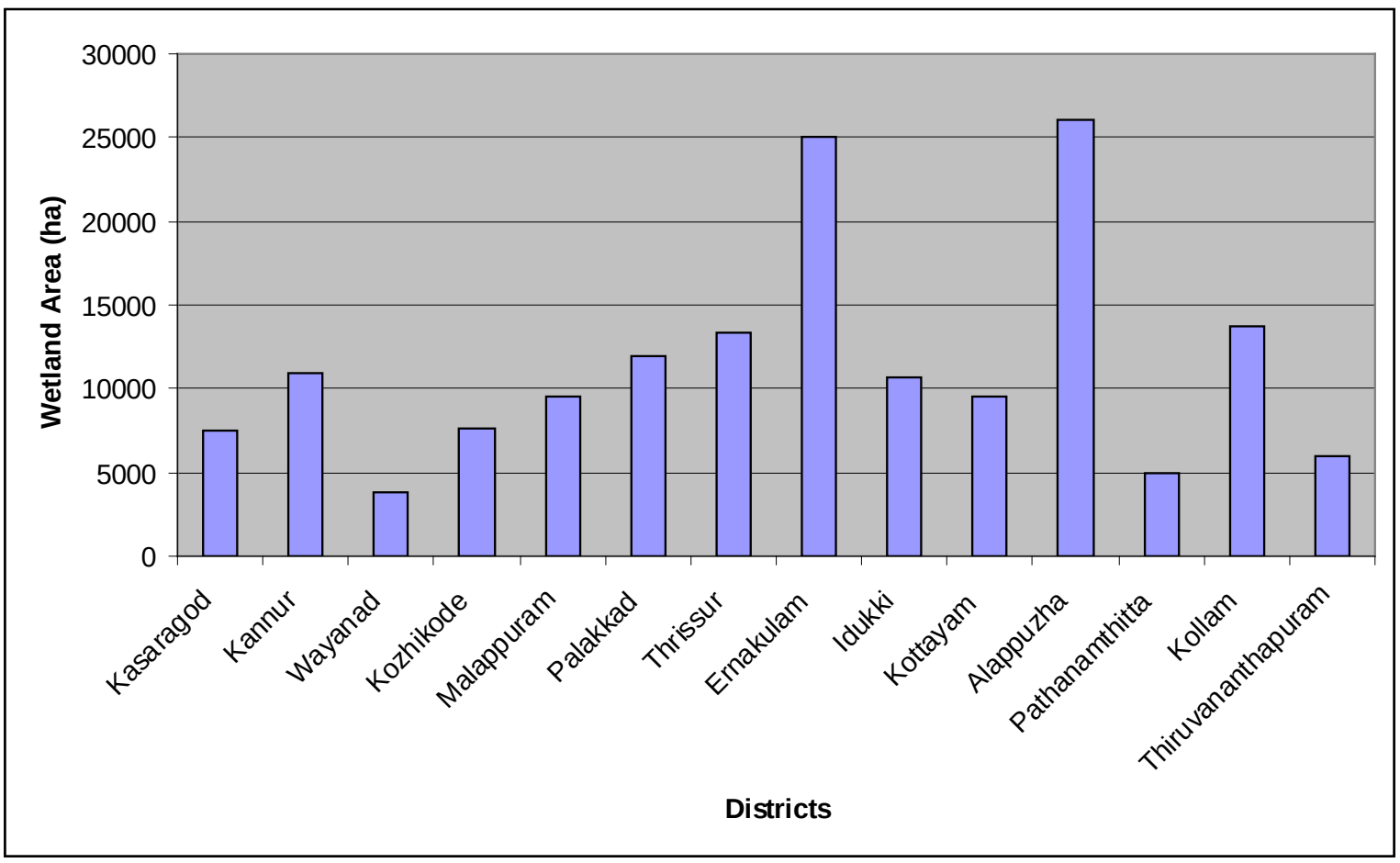
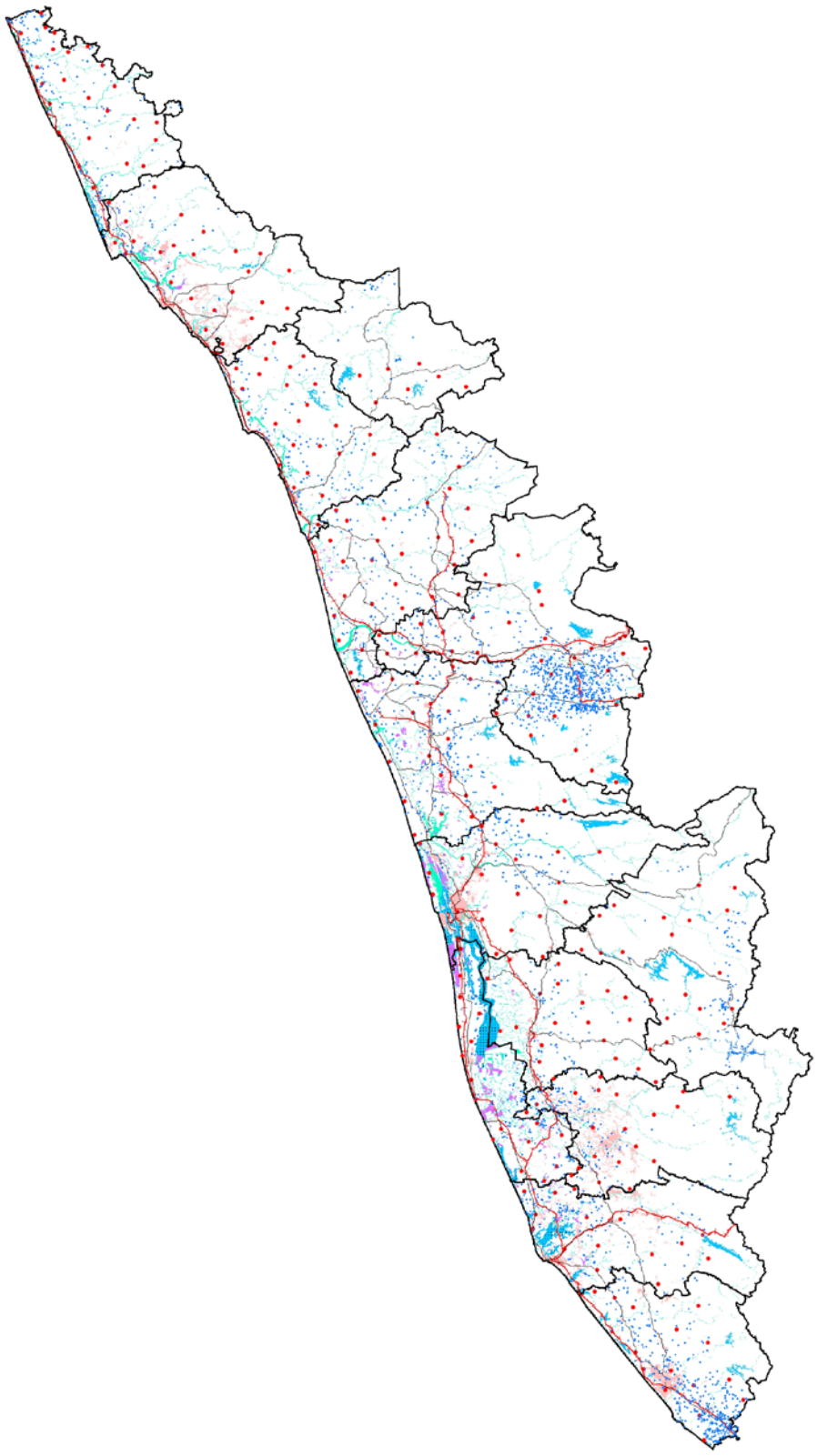


Figure 11: District-wise graphical distribution of wetlands

State : Kerala

WETLAND MAP



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

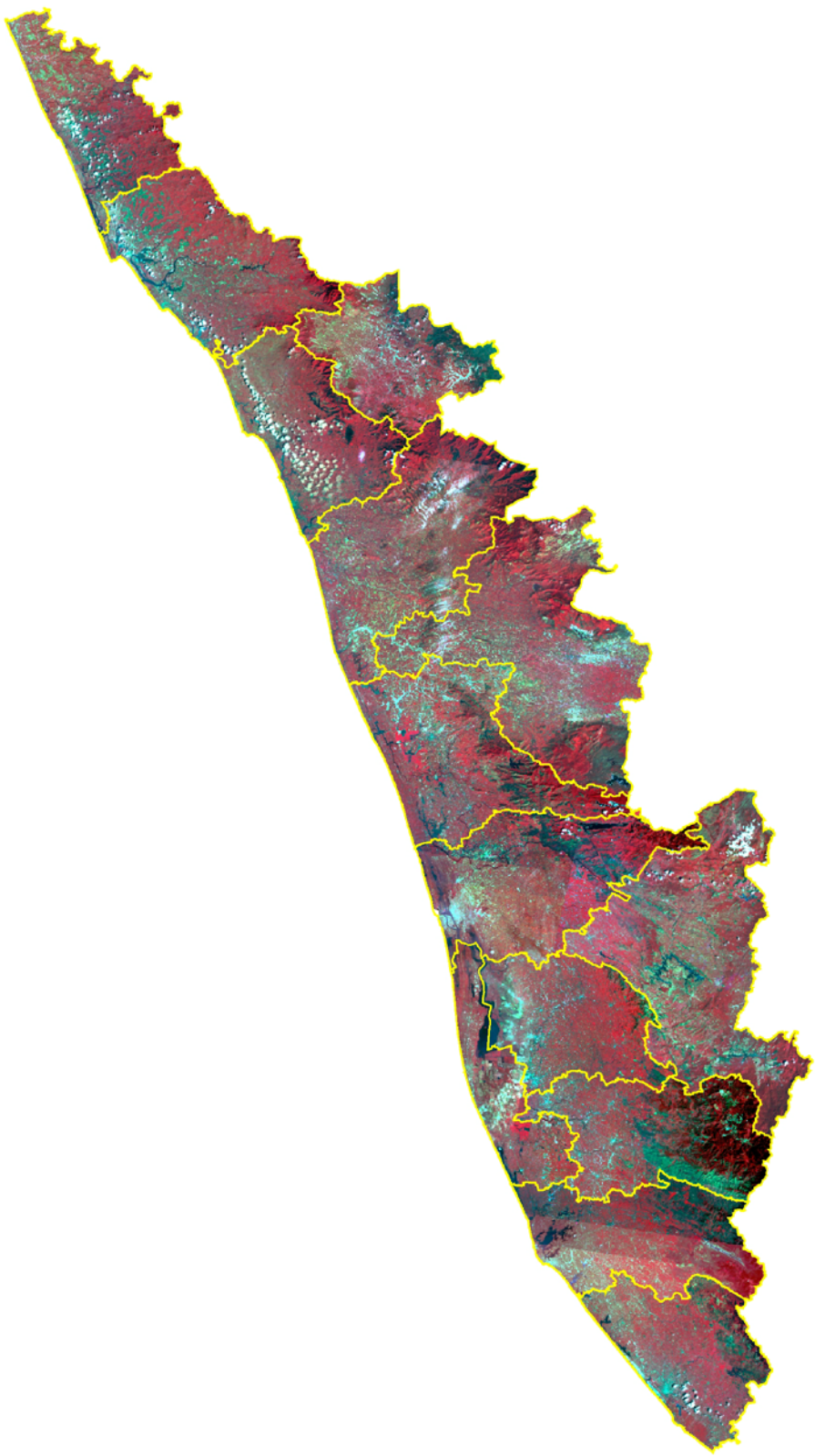
Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala



IRS P6 LISS-III post-monsoon data (2006)

7.1.1 Kasaragod

This is the northern most district of Kerala and is named after Kasaragod Town which is the administrative headquarters of the district. To its south lies Kannur District and to the north the Dakshina_Kannada district of Karnataka state. The total geographic area of Kasaragod district is 1961 sq km. The district has Arabian sea to the west and Western ghats to the east. Kasaragod lies between latitudes 12° 2′ to 12° 48′ N to logitudes 74°51′ to 75° 26’ East. It has an average elevation of 19 metres (62 feet). As of 2001 India census, Kasaragod had a population of 12,04,078. Males constitute 49% of the population and females 51%. Kasaragod has an average literacy rate of 79%, higher than the national average of 59.5%: male literacy is 82%, and female literacy is 76%.

The wetland area estimated is 7561 ha which includes 146 small wetlands (< 2.25 ha). Details of the wetland statistics of the district is given in Table 6. The major wetland types are river/stream, lagoons and sand/beach. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 87 and 80 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 2 and 1 per cent of wetland area during post-and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 6: Area estimates of wetlands in Kasaragod

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	25	155	2.05	57	30
2	1106	River/Stream	55	5007	66.22	4751	4244
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	8	35	0.46	1	1
		Total - Inland	**88**	**5197**	**68.73**	**4809**	**4275**
	2100	**Coastal Wetlands - Natural**					
4	2101	Lagoons	1	1775	23.48	1632	1626
5	2103	Sand/Beach	14	443	5.86	0	0
		Total - Coastal	**15**	**2218**	**29.33**	**1632**	**1626**
		Sub-Total	**103**	**7415**	**98.07**	**6441**	**5901**
		Wetlands (<2.25 ha), mainly Tanks	146	146	1.93	-	-
		Total	**249**	**7561**	**100.00**	**6441**	**5901**

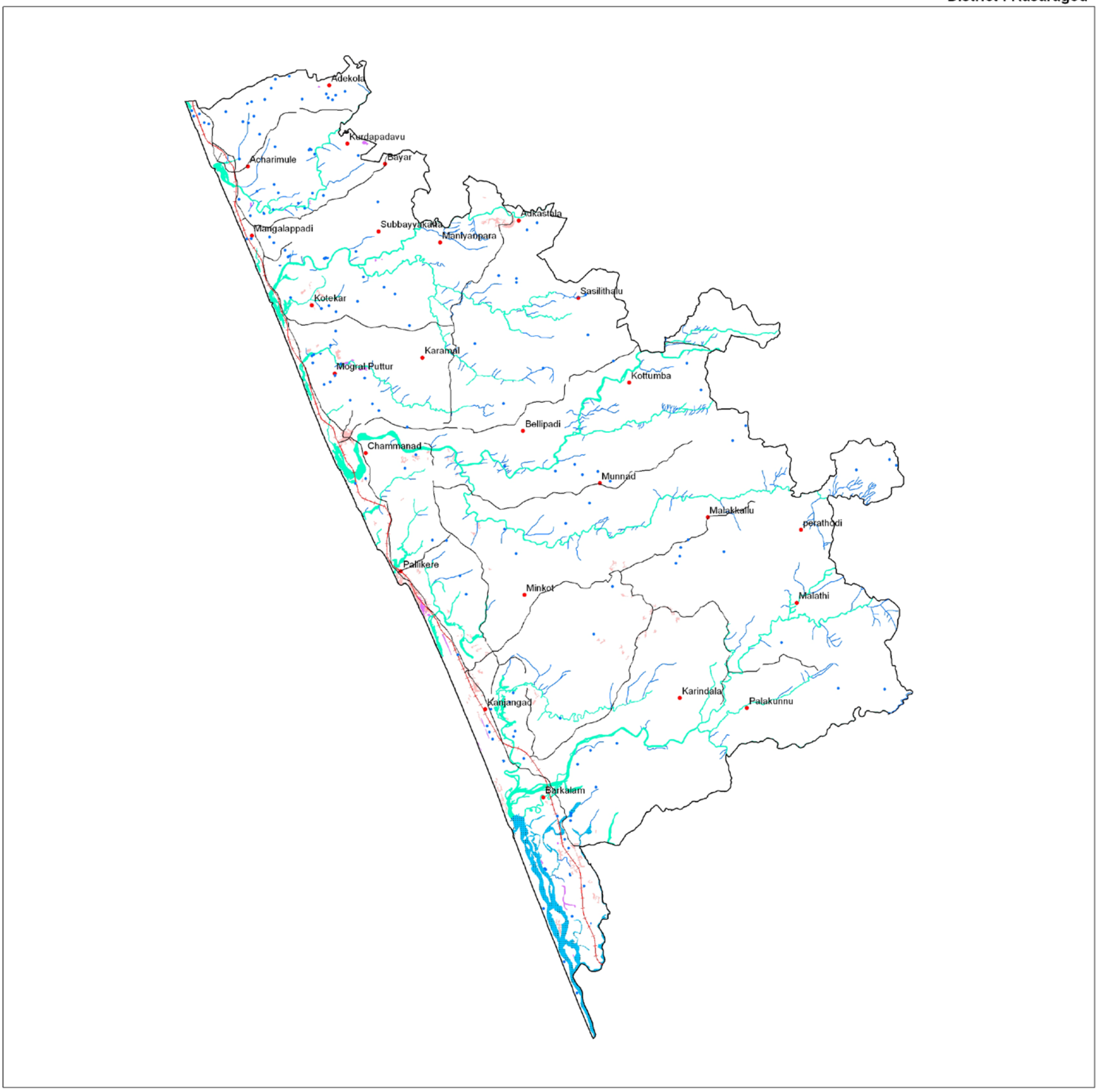
Area under Aquatic Vegetation	159	93

Area under turbidity levels		
Low	411	253
Moderate	6032	5647
High	-	-

State : Kerala

WETLAND MAP

District : Kasaragod

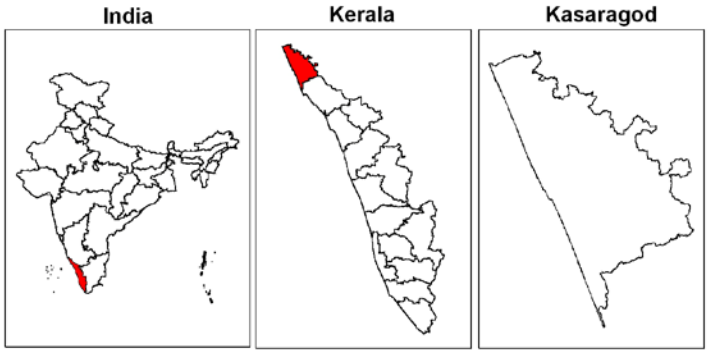


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

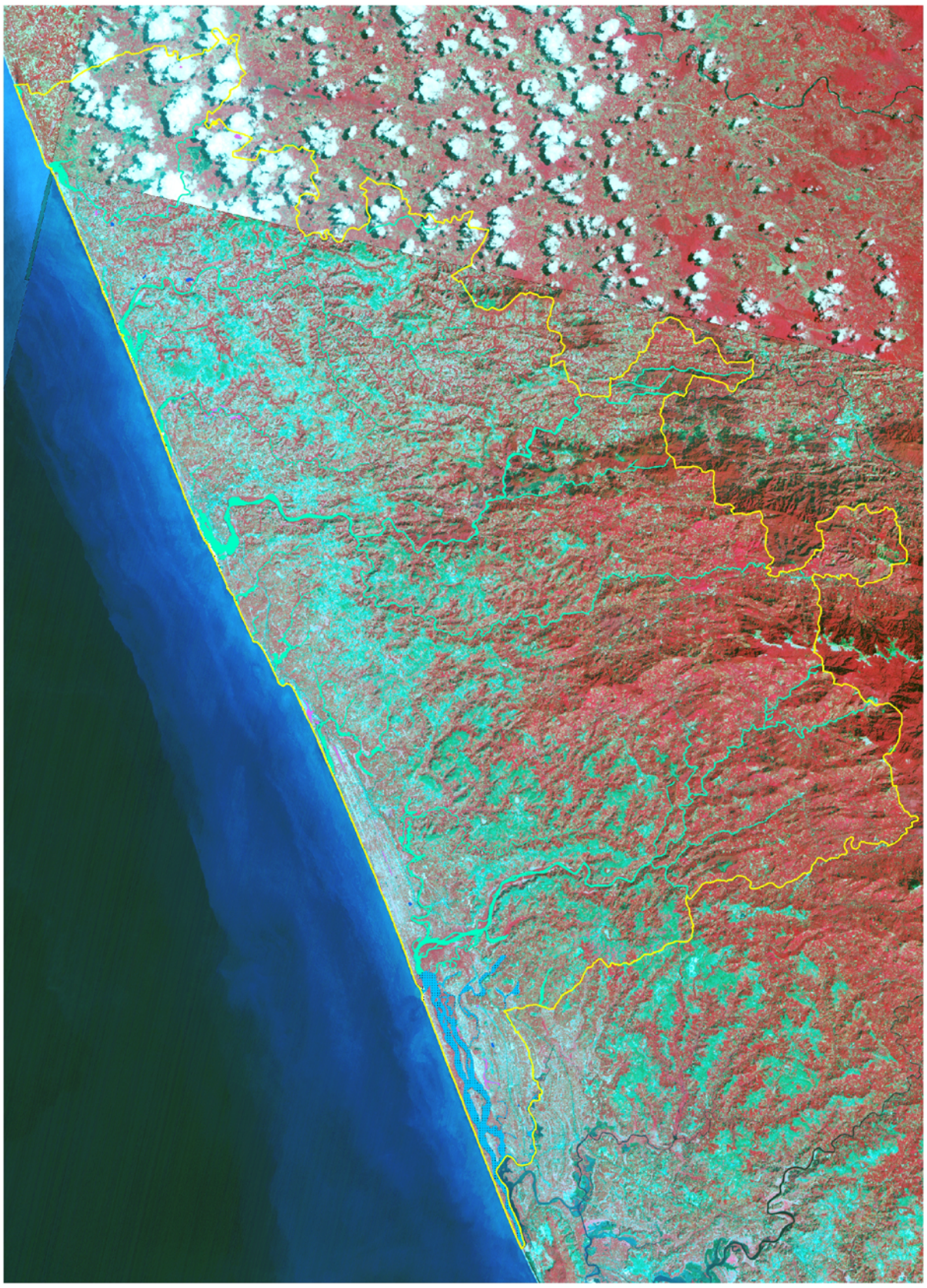
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Kasaragod



IRS P6 LISS-III pre-monsoon data (2007)

7.1.2 Kannur

Kannur town is the district headquarters, and gives the district its name Kannur. The total geographic area of Kannur district is 2,997 sq km, has an urban population of 12,12,898, which is the second largest in Kerala after Ernakulam district with 50% of its residents living in urban agglomerations and total population of 23,87,468 (2001 census). Literacy as per the 2001 census is put at 88.61%. The district lies between latitudes 11° 40' to 12° 48' North and longitudes 74° 52' to 76° 07' East. Six rivers drain Kannur district, the longest being the Valapattanam river with a length of 110 km. Other rivers flowing through the district are Kuppam, Mahe River, Anjarakandi, Thalassery, Ramapuram and district has several beaches, some of which are Payyambalam , Muzhappilangad Drive-in Beach, Dharmadam Island.

The wetland area estimated is 10870 ha which includes 57 small wetlands (< 2.25 ha) in the district. Details are given in Table 7. The major wetland types are River/Stream, waterlogged, lagoons and riverine wetlands. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 85 and 83 percent of wetland area is under open water category during post monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 11 and 6 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 7: Area estimates of wetlands in Kannur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1104	Riverine Wetlands	14	316	2.91	316	316
2	1105	Waterlogged	67	1544	14.20	384	210
3	1106	River/Stream	55	7590	69.83	7444	7400
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/Barrages	1	553	5.09	543	544
5	1202	Tanks/Ponds	9	66	0.61	38	45
		Total - Inland	**146**	**10069**	**92.63**	**8725**	**8515**
	2100	**Coastal Wetlands - Natural**					
6	2101	Lagoons	2	434	3.99	433	433
7	2103	Sand/Beach	20	310	2.85	0	0
		Total - Coastal	**22**	**744**	**6.84**	**433**	**433**
		Sub-Total	**168**	**10813**	**99.48**	**9158**	**8948**
		Wetlands (<2.25 ha), mainly Tanks	57	57	0.52	-	-
		Total	**225**	**10870**	**100.00**	**9158**	**8948**

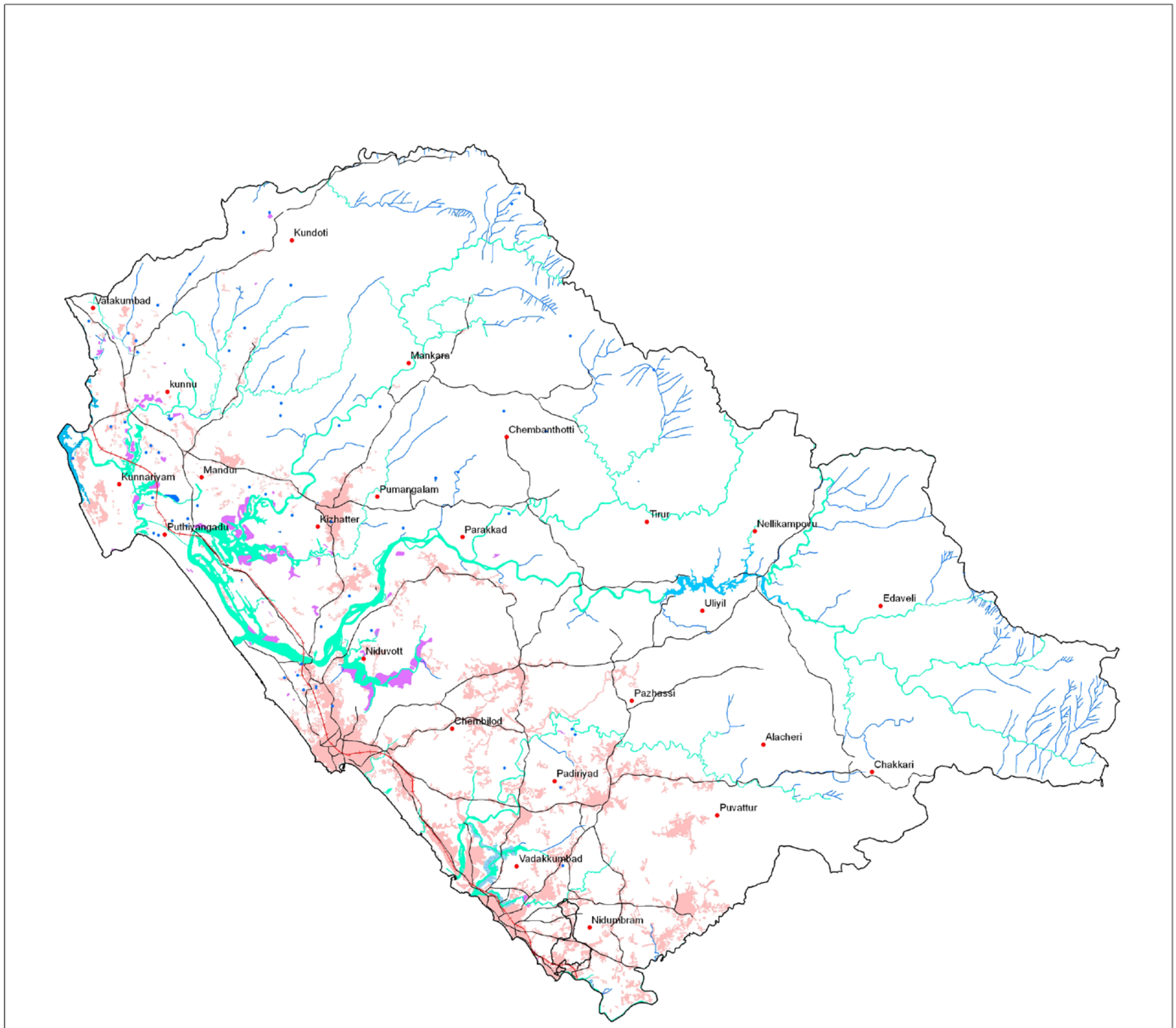
Area under Aquatic Vegetation	1194	639

Area under turbidity levels		
Low	7186	7138
Moderate	1972	1810
High	-	-

State : Kerala

WETLAND MAP

District : Kannur

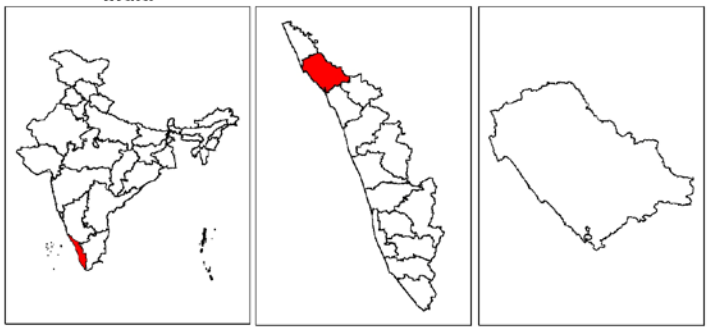


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

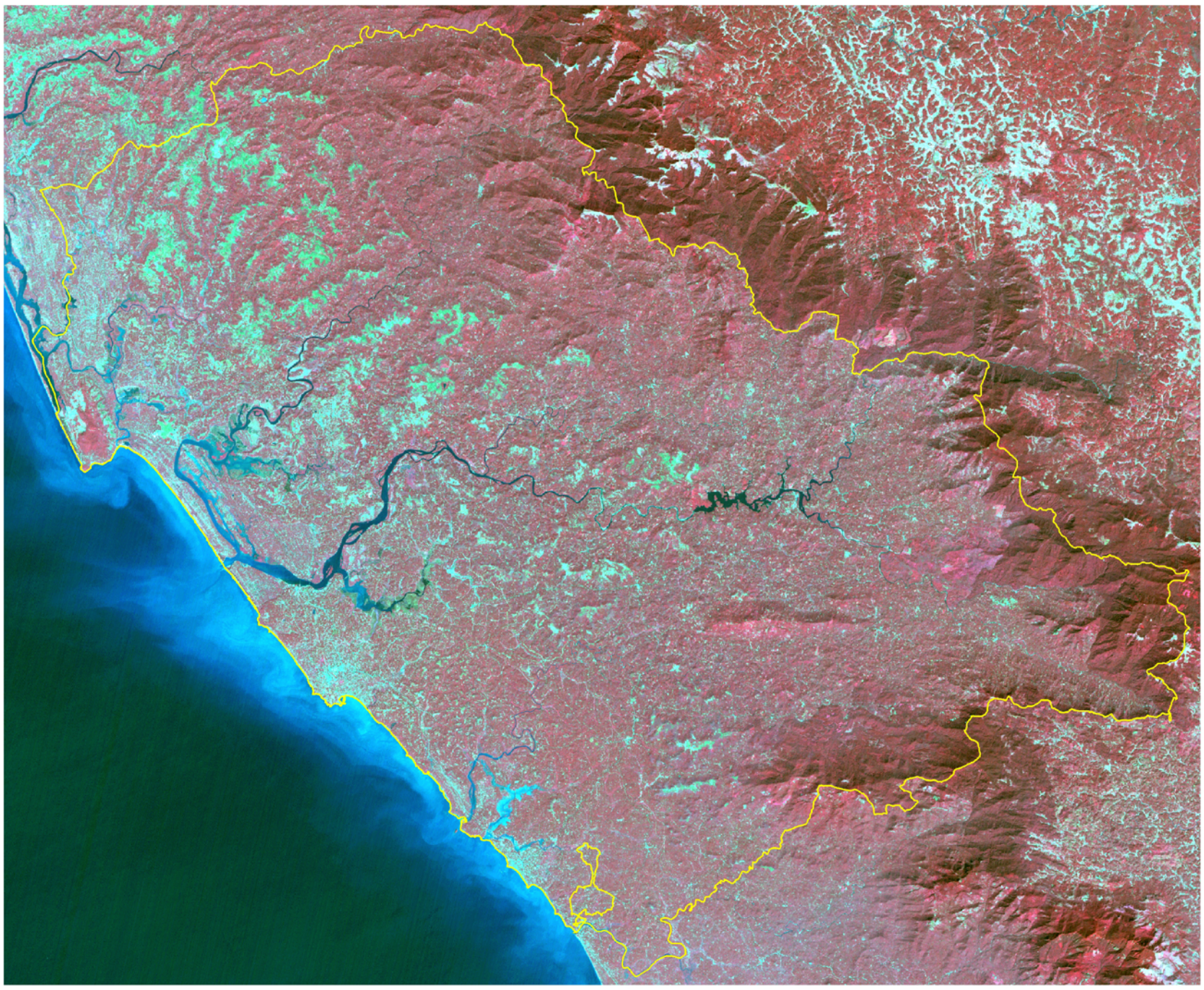
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Kannur



IRS P6 LISS-III post-monsoon data (2006)

7.1.3 Wayanad

Wayanad district stands on the southern top of the Deccan plateau and its chief glory is the majestic rugged terrain of the Western ghats, with lofty ridges interspersed with dense forest, tangled jungles and deep valleys. Quite a large area of the district is covered by forest but the continued and indiscriminate exploitation of the natural resources point towards an imminent environmental crisis. The total geographic area of Wayanad district is 2132 sq km, has a population of of 7,73,924 (2001 census). The Kabini River, one of the three east flowing rivers of Kerala, is an important tributary of the Kaveri River. Almost the entire Wayanad district is drained by Kabini and its three tributaries, the Panamaram, Mananthavady, and Kalindy rivers. The Banasura Sagar Dam is built on one of tributaries of the Kabini River.

The wetland area estimated is 3866 ha. which includes 36 small wetlands (< 2.25 ha). Details are given in Table 8. The major wetland types are River/Stream, tanks/ponds and lagoons. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 92 and 84 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 9 and 4 per cent of wetland area during post and pre-monsoon respectively.

Table 8: Area estimates of wetlands in Wayanad

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	4	10	0.26	6	0
2	1106	River/Stream	17	1837	47.52	1822	1741
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	2	1946	50.34	1650	1483
4	1202	Tanks/Ponds	14	37	0.96	30	0
		Sub-Total	**37**	**3830**	**99.07**	**3508**	**3224**
		Wetlands (<2.25 ha), mainly Tanks	36	36	0.93	-	-
		Total	**73**	**3866**	**100.00**	**3508**	**3224**

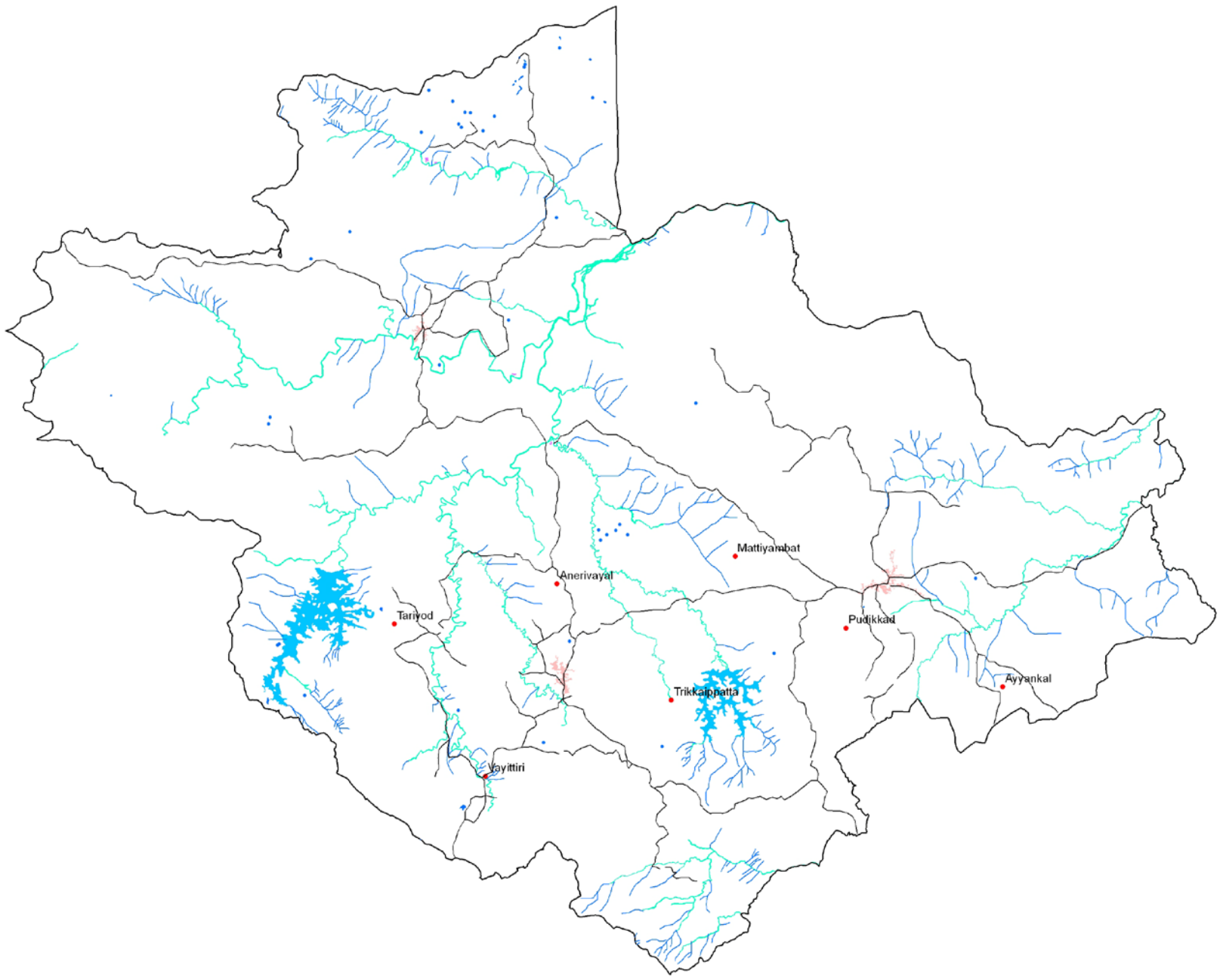
Area under Aquatic Vegetation	328	163

Area under turbidity levels		
Low	3502	2733
Moderate	6	491
High	-	-

State : Kerala

WETLAND MAP

District : Wayanad

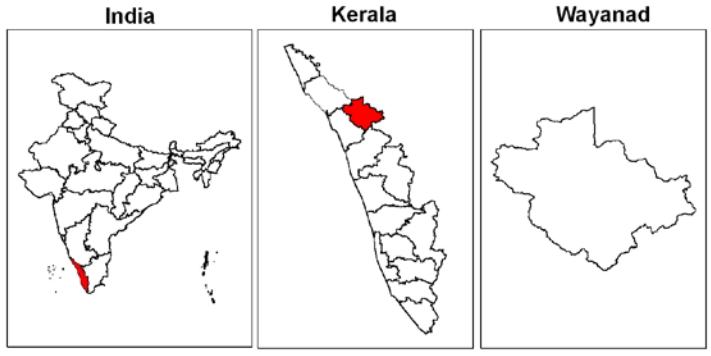


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

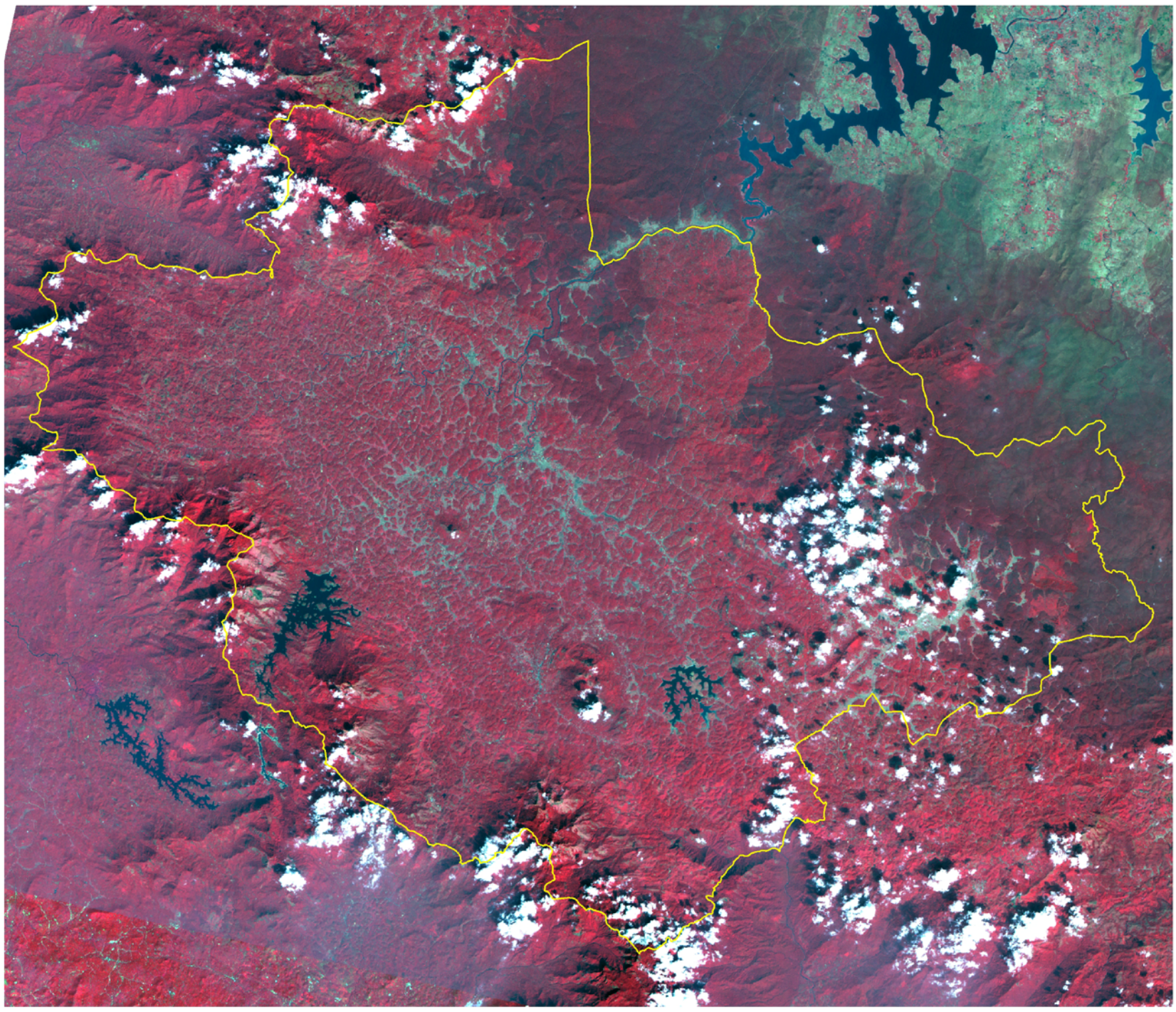
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Wayanad



IRS P6 LISS-III post-monsoon data (2006)

7.1.4 Kozhikode

Kozhikode District is a district of Kerala state, situated on the southwest coast of India. The city of Kozhikode, also known as Calicut, is the district headquarters. The district is 38.25% urbanised. Kozhikode district is bordered by the districts of Kannur to the north, Wayanad to the east, and Malappuram to the south.The Arabian Sea lies to the west. It is situated between latitudes 11° 08'N and 11° 50'N and longitudes 75° 30'E and 76° 8'E. The total geographic area of Kozhikode district is 2,345 sq km, has a population of 65,18,673 (2001 census) with an extended metropolitan population of about 0.9 million, making it the third largest urban agglomeration in Kerala. There are a number of rivers and lakes in the district. Chaliyar puzha, Kallayi Puzha, Korapuzha, Poonoor puzha, and Iravanjhi puzha are some among them. Kozhikode has an average literacy rate of 92.24%, higher than the national average of 59.5%: male literacy is 96.11% and female literacy is 88.62%.

The wetland area estimated is 7690 ha. which includes 117 small wetlands (< 2.25 ha). Details are given in Table 9. The major wetland types are River/Stream, Reservoirs/Barrages, and tanks/ponds. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 91 and 90 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 5 and 3 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 9: Area estimates of wetlands in Kozhikode

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1104	Riverine wetlands	4	94	1.22	94	94
2	1105	Waterlogged	17	161	2.09	90	63
3	1106	River/Stream	27	5514	71.70	5507	5503
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/Barrages	2	1261	16.40	1034	1082
5	1202	Tanks/Ponds	30	277	3.60	159	83
		Total - Inland	**80**	**7307**	**95.02**	**6884**	**6825**
	2100	**Coastal Wetlands - Natural**					
6	2102	Creeks	5	18	0.00	17	17
7	2103	Sand/Beach	24	248	0.00	0	0
		Total - Coastal	**29**	**266**	**3.46**	**17**	**17**
		Sub-Total	**109**	**7573**	**98.48**	**6901**	**6842**
		Wetlands (<2.25 ha), mainly Tanks	117	117	1.52	-	-
		Total	**226**	**7690**	**100.00**	**6901**	**6842**

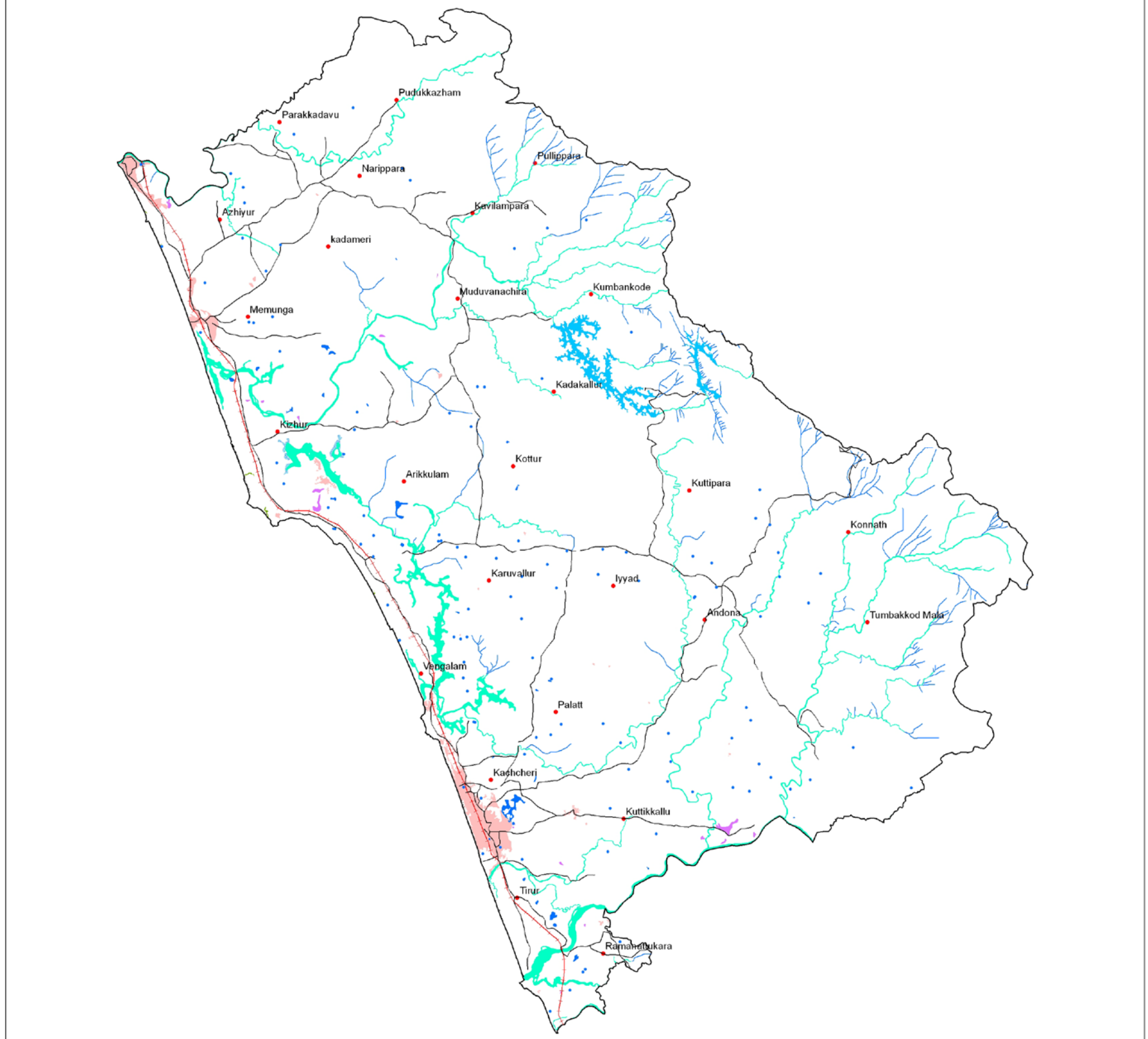
Area under Aquatic Vegetation	388	249

Area under turbidity levels		
Low	6699	6666
Moderate	202	176
High	-	-

State : Kerala

WETLAND MAP

District : Kozhikode

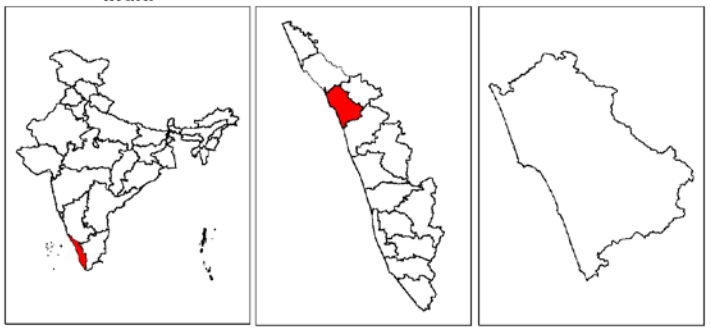


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

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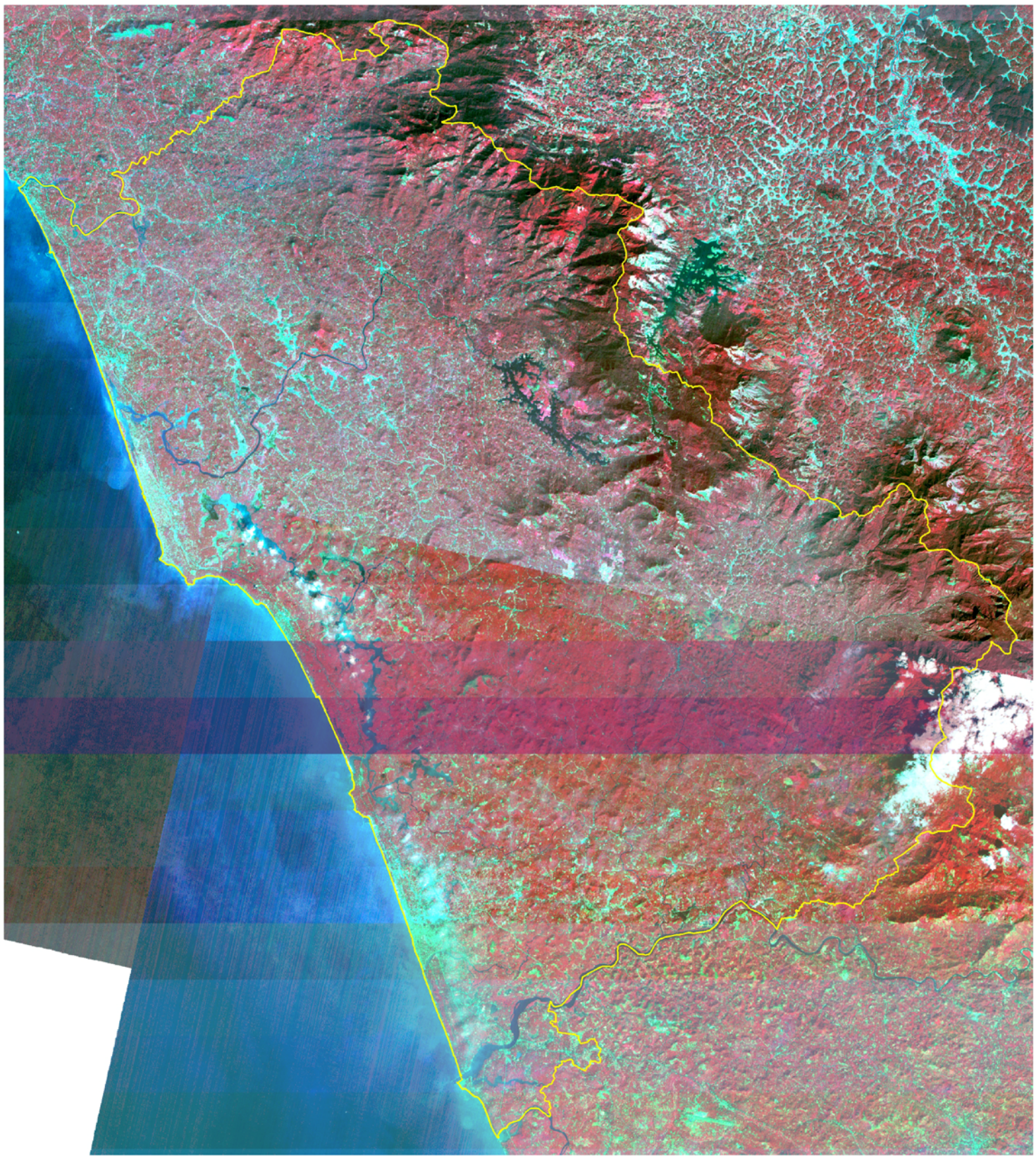


IRS P6 LISS-III post-monsoon data (2006)

7.1.5 Malappuram

Malappuram District district lies in northern Kerala, and is bounded on the north by Wayanad and Kozhikkode districts, on the northeast by Tamil Nadu, on the southeast and south by Palakkad District, on the southwest by Thrissur District, on the west by the Arabian Sea, and on the northwest by Kozhikode District The total geographic area of Malappuram district is 3,548 sq km, has a population of 36,29,640 (2001 census). The male: female ratio of 1063 females for every 1000 males (higher than the state average of 1058 females for 1000 males). Four important rivers of Kerala, flow through Malappuram district. They are Chaliyar (Beypore river), Kadalundipuzha, Bharathapuzha and Tirurpuzha. Chaliyar has a length of 169 km and originates from Illambalieri hills in Tamilnadu, important tributaries of this river are Chalipuzha, Punnapuzha, Pandiyar, Karimpuzha, Cherupuzha and Vadapurampuzha. Chaliyar traverses through Nilambur, Mampad, Edavanna, Areekade, Vazhakkad and flows into the sea at Beypore in Kozhikode district. Kadalundipuzha is formed by the confluence of two rivers, the Olipuzha and Veliyar. Olipuzha originates form Cherakomban hill and Veliyar from Erattakomban hill. They flow through the Silent Valley and traverse through Ernad and Valluvanad regions, before flowing into the sea at Kadalundi Nagaram. It passes through places like Melattur, Pandikkad, Malappuram, Pankkad, Parappur, Kooriyad and Tirurangadi. Kadalundipuzha has a circuit course of 130 km. Of these rivers, only Chaliyar is perennial. The other rivers dry up in summer. This is one of the reasons that Malappuram district is prone to draught.

The wetland area estimated is 9511 ha. Small wetlands, which are less than minimum mapable units, are 175 in the district. Details are given in Table 10. The major wetland types are River/Stream, Waterlogged and lagoons.

Analysis of wetland status in terms of open water and aquatic vegetation showed that around 73 and 63 per cent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 10 and 11 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 10: Area estimates of wetlands in Malappuram

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	46	832	8.75	366	106
2	1106	River/Stream	65	6979	73.38	5715	5679
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	35	232	2.44	49	2
		Total - Inland	**146**	**8043**	**84.57**	**6130**	**5787**
	2100	**Coastal Wetlands - Natural**					
4	2101	Lagoons	1	1012	10.64	721	119
5	2103	Sand/Beach	12	281	2.95	0	0
		Total - Coastal	**13**	**1293**	**13.59**	**721**	**119**
		Sub-Total	**159**	**9336**	**98.16**	**6851**	**5906**
		Wetlands (<2.25 ha), mainly Tanks	175	175	1.84	-	-
		Total	**334**	**9511**	**100.00**	**6851**	**5906**

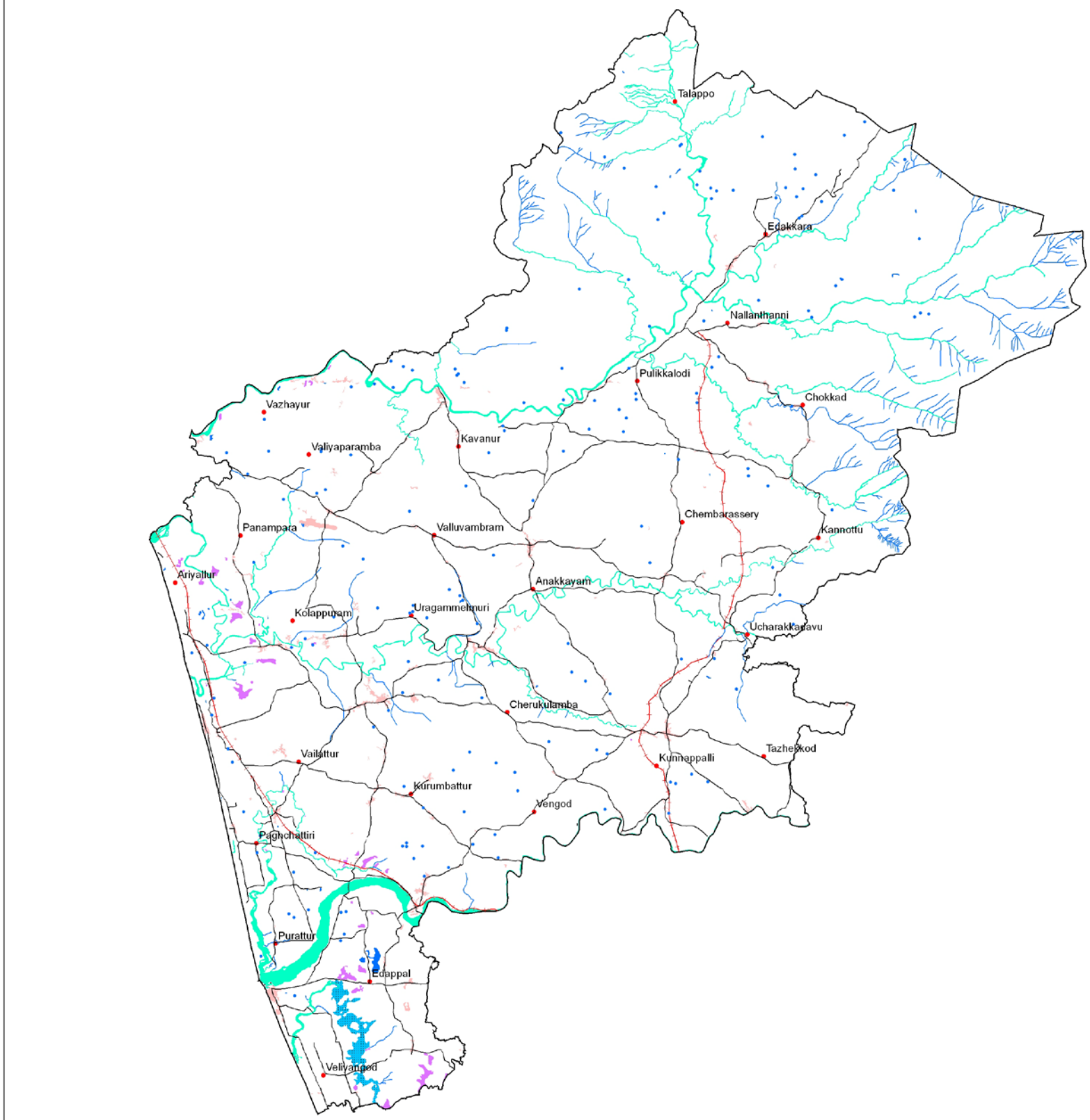
Area under Aquatic Vegetation	948	1086

Area under turbidity levels		
Low	6293	5609
Moderate	558	297
High	-	-

State : Kerala

WETLAND MAP

District : Malappuram



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map

India | Kerala | Malappuram

0 2.5 5 10 15 20 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

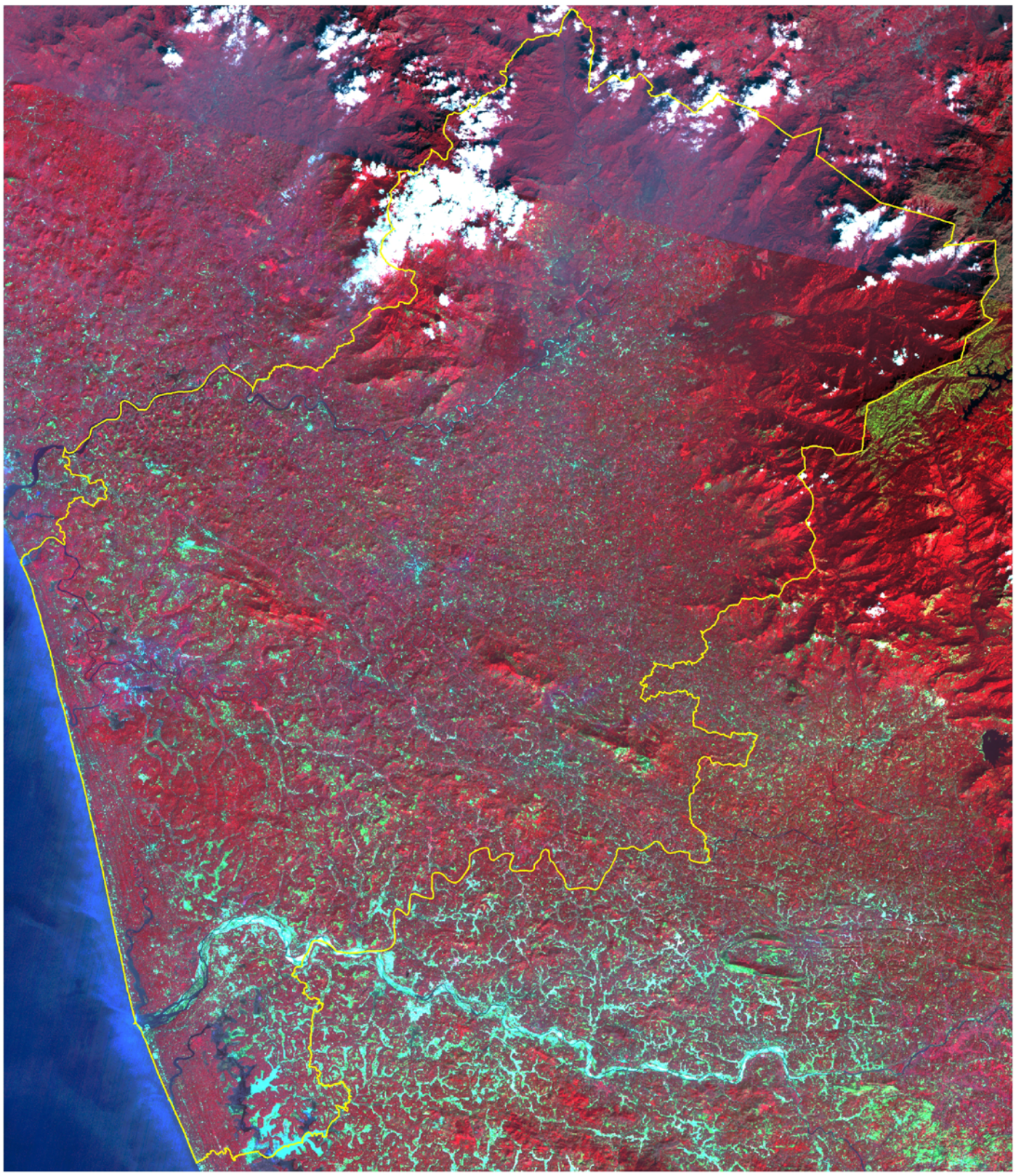
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Malappuram



IRS P6 LISS-III post-monsoon data (2006)

7.1.6 Palakkad

Palakkad district is one of the 14 districts of Kerala state in South India. The city of Palakkad is the district headquarters. Palakkad is bordered on the northwest by the Malappuram district and on the southwest by the Thrissur district. To the east lies the Coimbatore District of Tamil Nadu. It is a predominantly rural district. Palakkad is the gateway to Kerala due to the presence of Palakkad Gap, in the Western Ghats. The total geographic area of Palakkad district is 4480 km² which is 11.5% of the state's area and has a population of 26,17,232 (2001 census). The district is nicknamed "the granary of Kerala". The Bharatha Puzha river originates in the Palakkad Gap from rivulets and tributaries feeding from steep escarpment slopes along the flanks of Palakkad Gap is a 30-40 kilometers (19-25 miles) wide low mountain pass in the Western Ghats, near Palakkad town in the South Indian State of Kerala. Most parts of the district fall in the midland region (elevation 75–250 m), except the Nelliampathy-Parambikulam area in the Chittur taluk in the south and Attappadi-Malampuzha area in the north, which are hilly and fall in the highland region (elevation >250 m). Some of the notable peaks in the district are Anginda (2325 m), Karimala (1998 m), Nellikotta or Padagiri (1585 m) and Karimala Gopuram (1439 m).The climate is hot and humid for most part of the year. The district is blessed with many small and medium rivers, which are tributaries of the Bharathapuzha River. A number of dams have been built across these rivers, the largest being Malampuzha dam. The largest in volume capacity is the Parambikulam Dam.

The wetland area estimated is 11892 ha. which includes 722 small wetlands (< 2.25 ha). Details are given in Table 11. The major wetland types are River/Stream, Reservoirs/Barrages and tanks/ponds. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 89 and 81 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 2 and 1 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 11: Area estimates of wetlands in Palakkad

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	14	245	2.06	93	5
2	1106	River/Stream	29	5270	44.32	4216	4217
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	11	5477	46.06	5384	4771
4	1202	Tanks/Ponds	73	178	1.50	284	60
		Sub-Total	**127**	**11170**	**93.93**	**9977**	**9053**
		Wetlands (<2.25 ha), mainly Tanks	722	722	6.07	-	-
		Total	**849**	**11892**	**100.00**	**9977**	**9053**

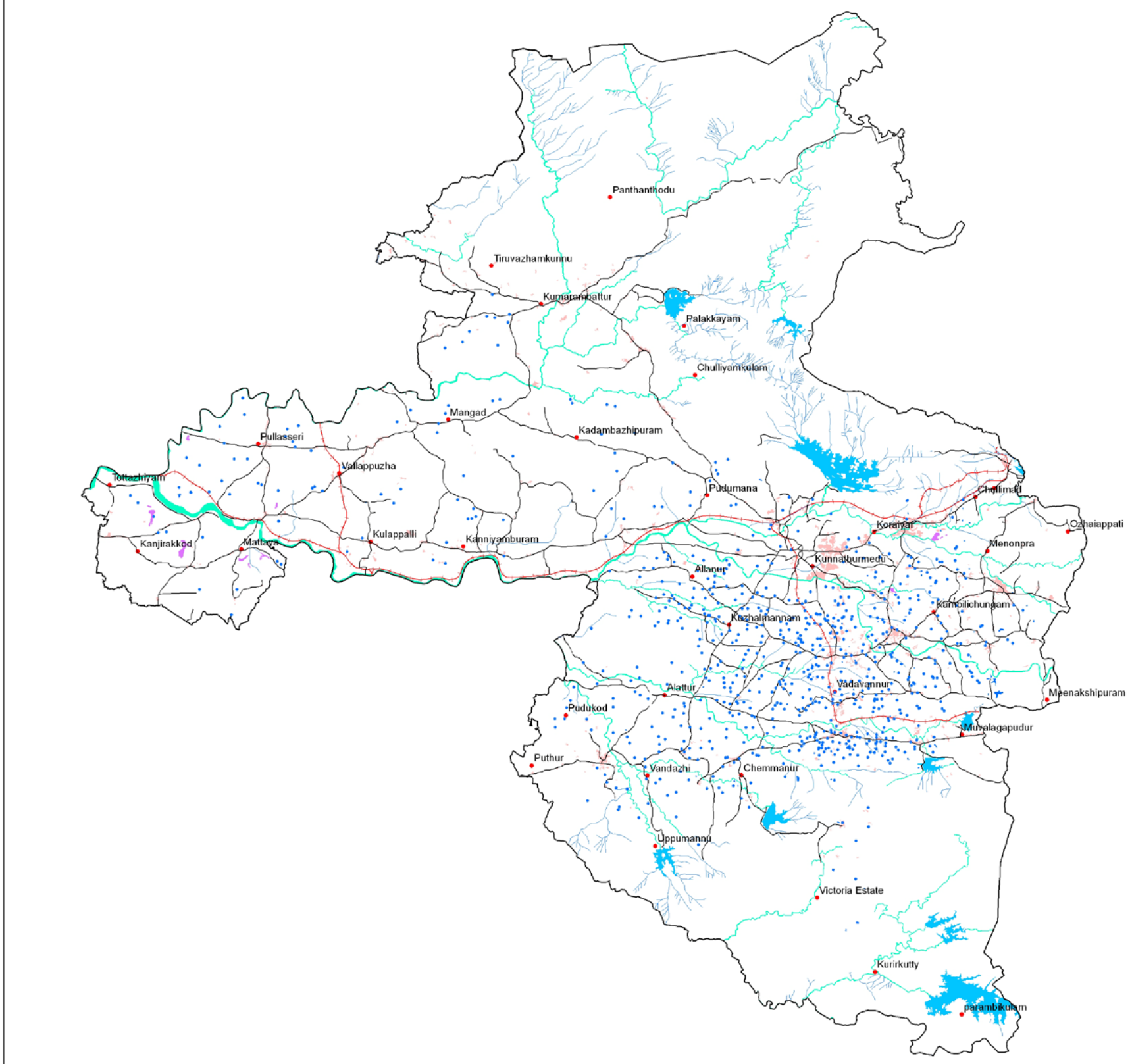
Area under Aquatic Vegetation	247	161

Area under turbidity levels		
Low	8829	7847
Moderate	948	1006
High	200	200

State : Kerala

WETLAND MAP

District : Palakkad

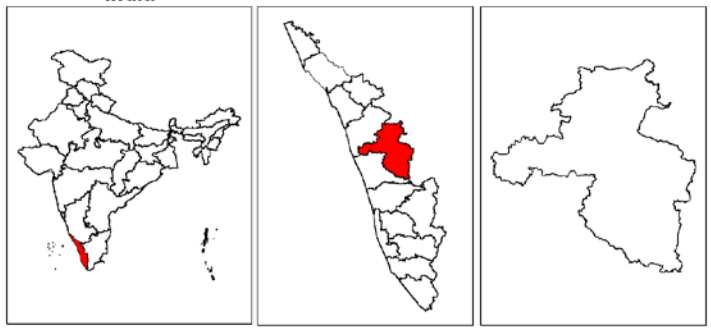


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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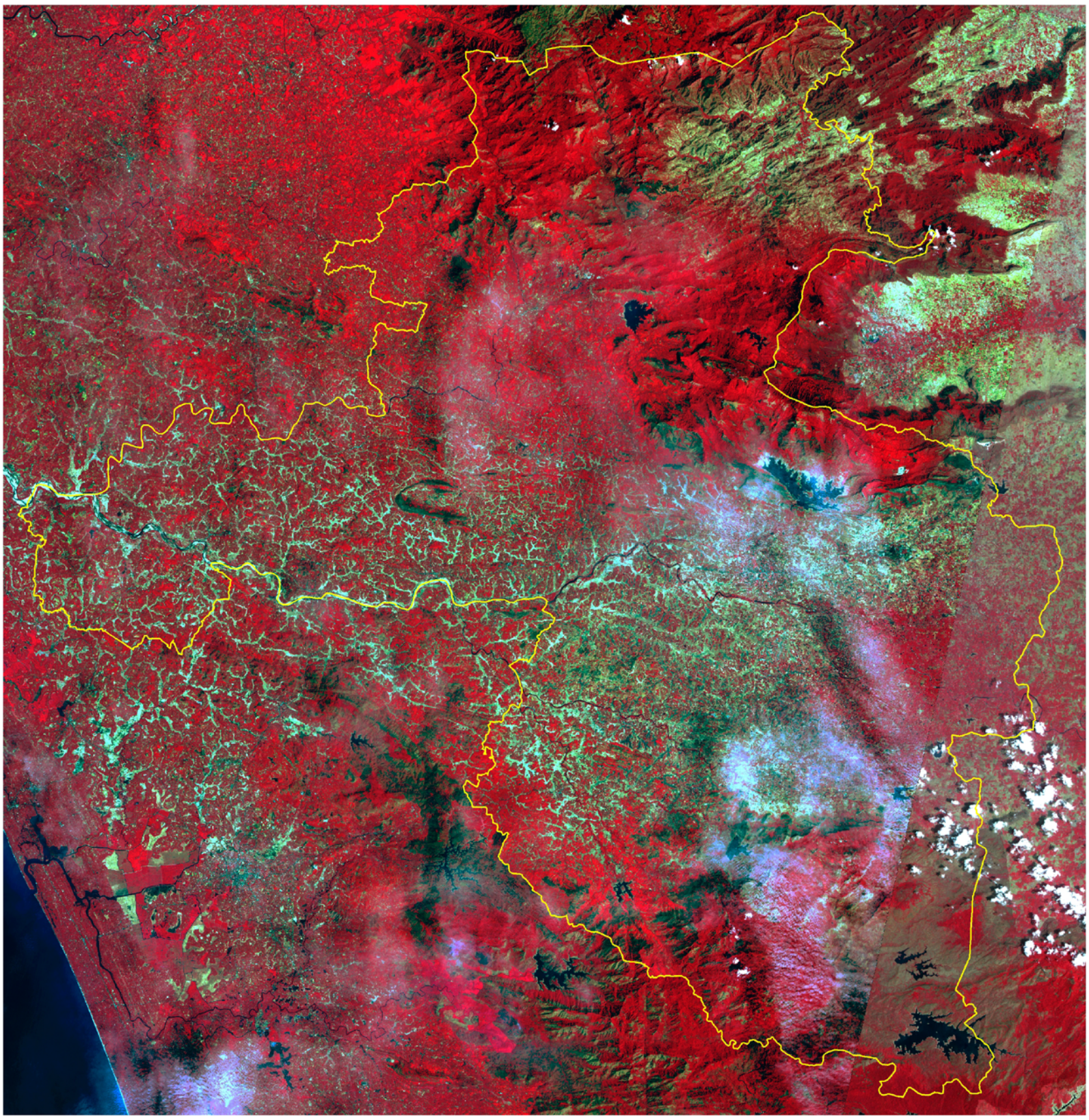
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Palakkad



IRS P6 LISS-III post-monsoon data (2006)

7.1.7 Thrissur

Thrissur district is situated in the central region of the state of Kerala. The total geographic area of Thrissur district is 3,032 sq km, has a population of 29,74,024 (2001 census). Males constitute 48.6% and females constitute 51.4% of the total population.

The wetland area estimated is 13285 ha. Small wetlands, which are less than minimum mapable units, are 271 in the district. Details are given in Table 12. The major wetland types are River/Stream, Reservoirs/Barrages, Waterlogged and sand/beach. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 84 and 69 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 12 and 5 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 12: Area estimates of wetlands in Thrissur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	126	2990	22.51	1668	560
2	1106	River/Stream	26	6451	48.56	6108	5967
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	7	3027	22.79	2988	2429
4	1202	Tanks/Ponds	91	294	2.21	184	14
		Total - Inland	**250**	**12762**	**96.06**	**10948**	**8970**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	1	4	0.03	0	0
6	2103	Sand/Beach	7	248	1.87	0	0
		Total - Coastal	**8**	**252**	**1.90**	**0**	**0**
		Sub-Total	**258**	**13014**	**97.96**	**10948**	**8970**
		Wetlands (<2.25 ha), mainly Tanks	271	271	2.04	-	-
		Total	**529**	**13285**	**100.00**	**10948**	**8970**

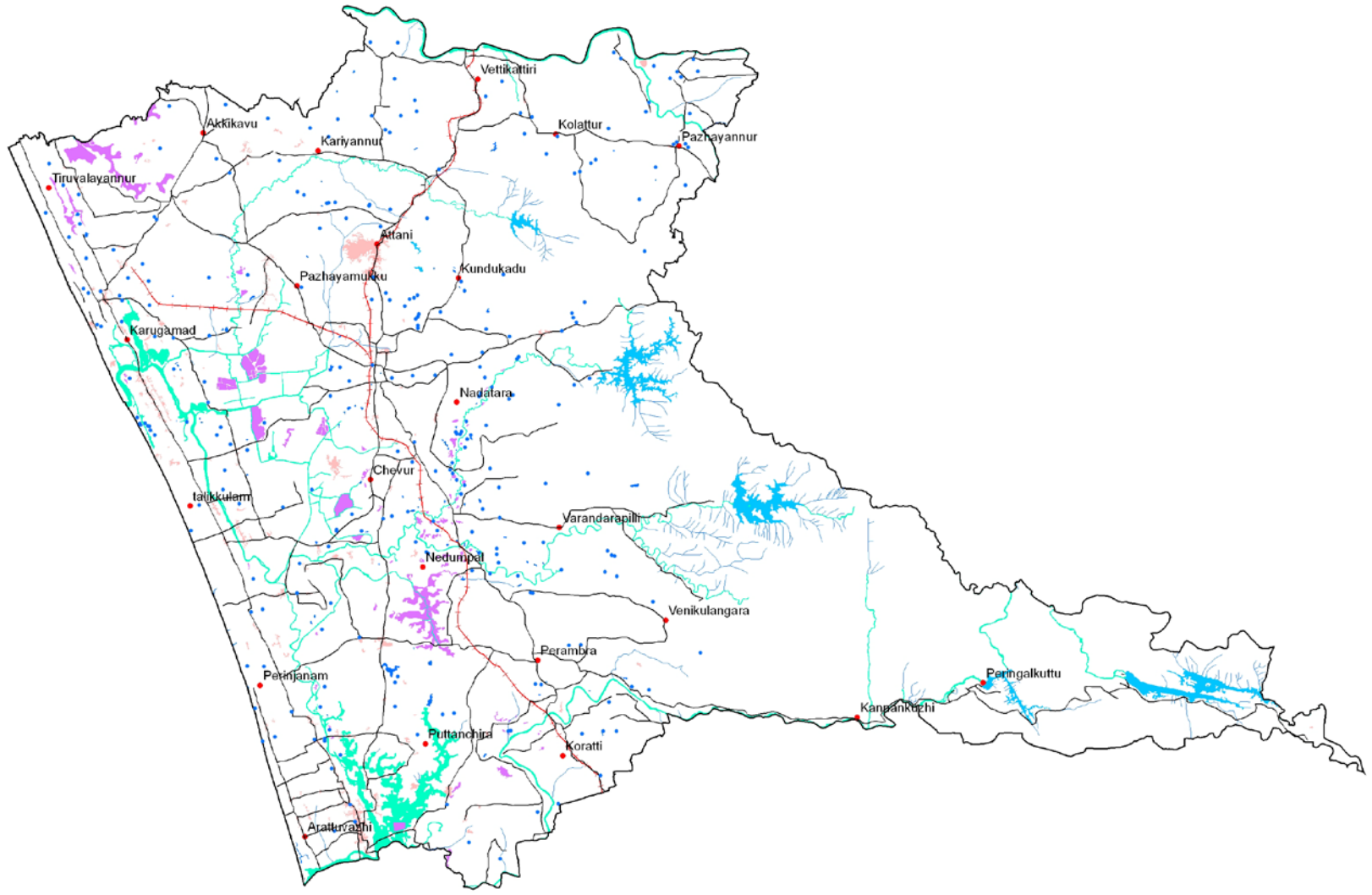
Area under Aquatic Vegetation	1504	595

Area under turbidity levels		
Low	8933	7491
Moderate	2015	1479
High	-	-

State : Kerala

WETLAND MAP

District : Thrissur

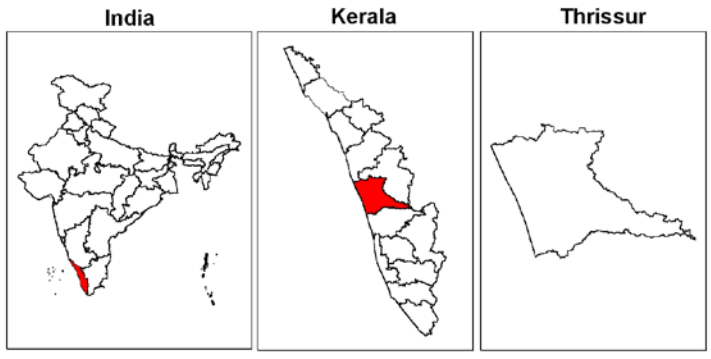


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

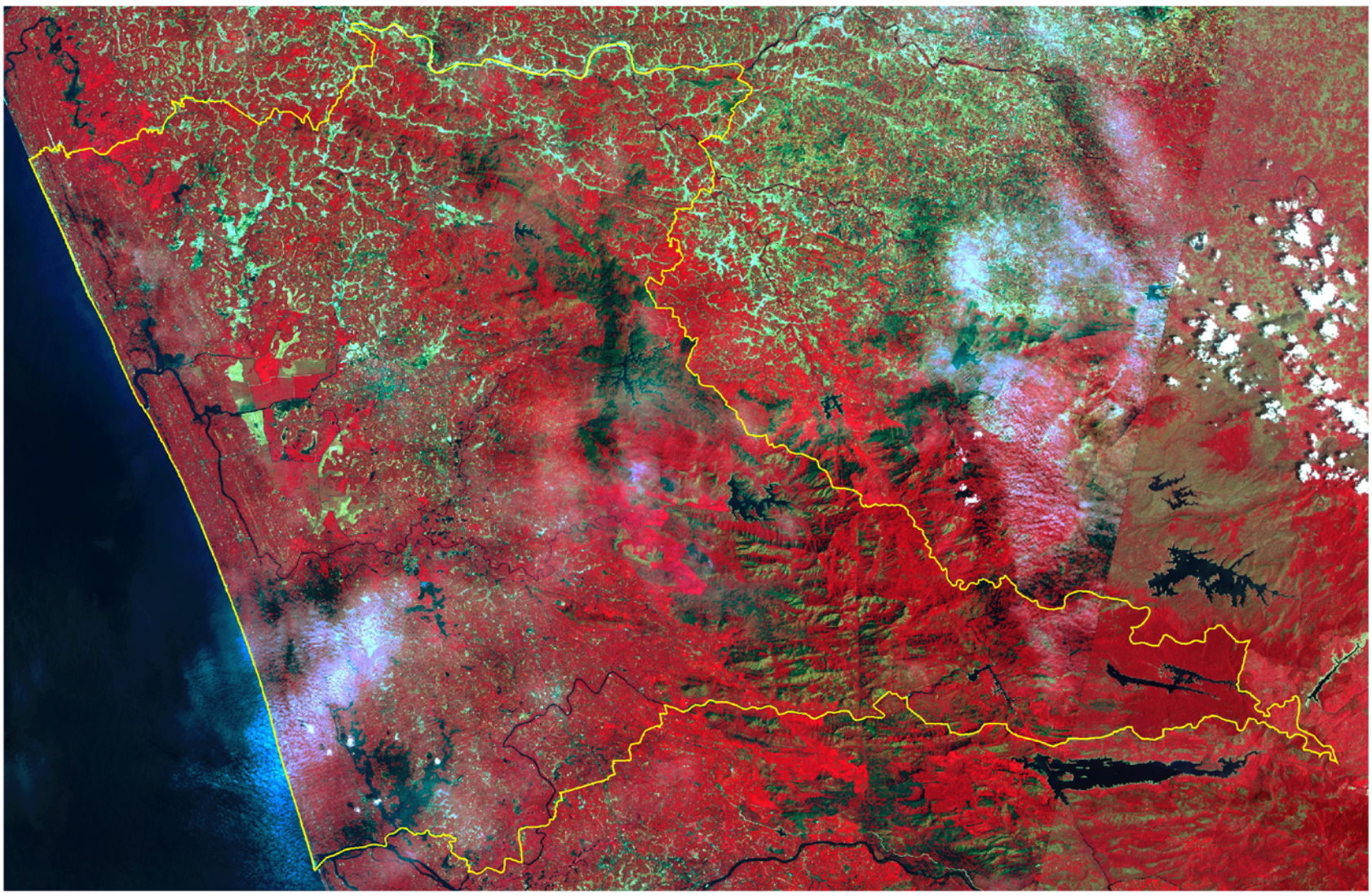
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Thrissur



IRS P6 LISS-III post-monsoon data (2006)

7.1.8 Ernakulam

The total geographic area of Ernakulam district is 2,408 sq km, has a population of 30,36,009 (2001 census). District can be divided geographically into highland with altitude of about 300 m, midland, low land with 20 percent of the total area region and coastal area. is. The midland consists mainly of plain land having natural facilities of drainage via backwaters and canals. The hilly or eastern portion is formed by a section of Western Ghats. Muvattupuzha, Kothamangalm and Aluva can be called the highlands.The borders of the district are the Arabian Sea in the west, Thrissur District in the north, Idukki District in the east, and Alappuzha and Kottayam districts in the south. The Periyar River, Kerala's second longest river, flows through all the taluks except Muvattupuzha. The Muvattupuzha River and a branch of Chalakkudy River also flow through the district. Muvattupuzha and Periyar are the main rivers of which the latter flows through Thodupuzha, Muvattupuzha, Aluva, Kunnathunadu and Parur taluks. During rainy season these rivers are full and heavy floods affect the low-lying areas on the banks, but in the summer season they generally go dry and narrow. The Periyar is stretched over a length of 229 km.

The wetland area estimated is 25065 ha. which includes 133 small wetlands (< 2.25 ha) in the district. Details are given in Table 13. The major wetland types are River/Stream, Reservoirs/Barrages, Waterlogged and Lagoons. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 94 and 91 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 5 and 6 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 13: Area estimates of wetlands in Ernakulam

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	145	4662	18.60	3628	3426
2	1106	River/Stream	44	8729	34.83	8683	8567
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	2	3448	13.76	3361	3274
4	1202	Tanks/Ponds	18	84	0.34	66	2
		Total - Inland	**209**	**16923**	**67.52**	**15738**	**15269**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	8	7898	31.51	7593	7507
6	2103	Sand/Beach	4	111	0.44	0	0
		Total - Coastal	**12**	**8009**	**31.95**	**7593**	**7507**
		Sub-Total	**221**	**24932**	**99.47**	**23331**	**22776**
		Wetlands (<2.25 ha), mainly Tanks	133	133	0.53	-	-
		Total	**354**	**25065**	**100.00**	**23331**	**22776**

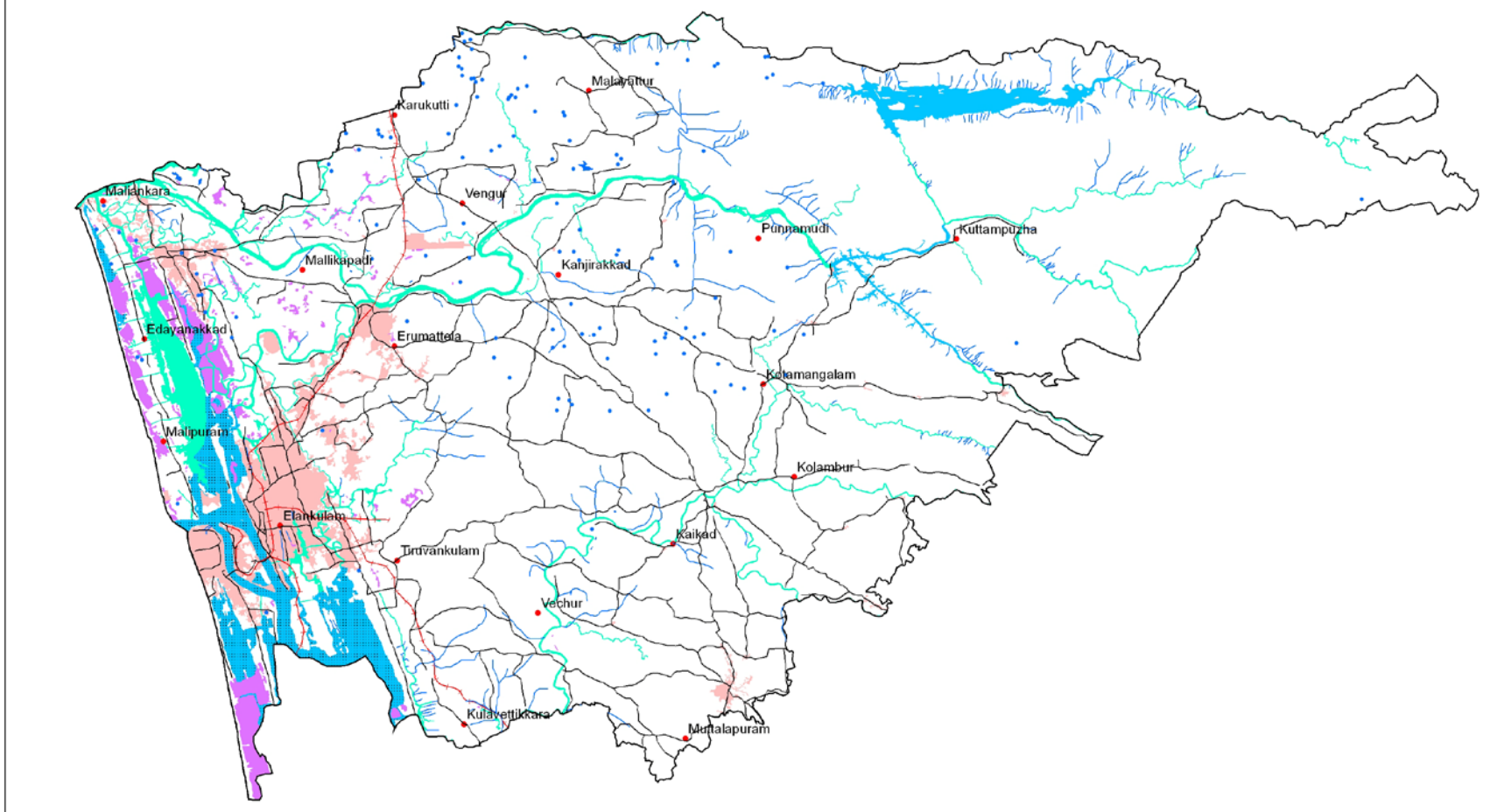
Area under Aquatic Vegetation	1334	1450

Area under turbidity levels		
Low	18736	15782
Moderate	4595	6994
High	-	-

State : Kerala

WETLAND MAP

District : Ernakulam

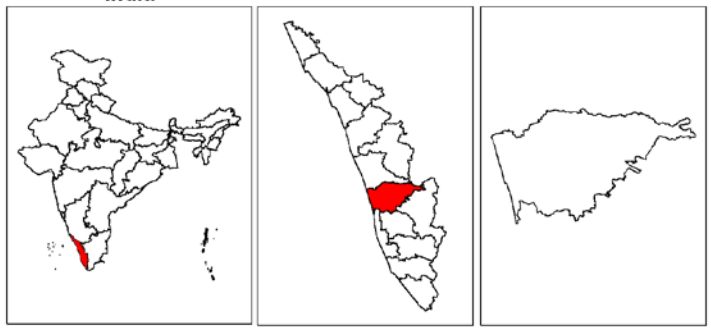


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

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Sponsored By:

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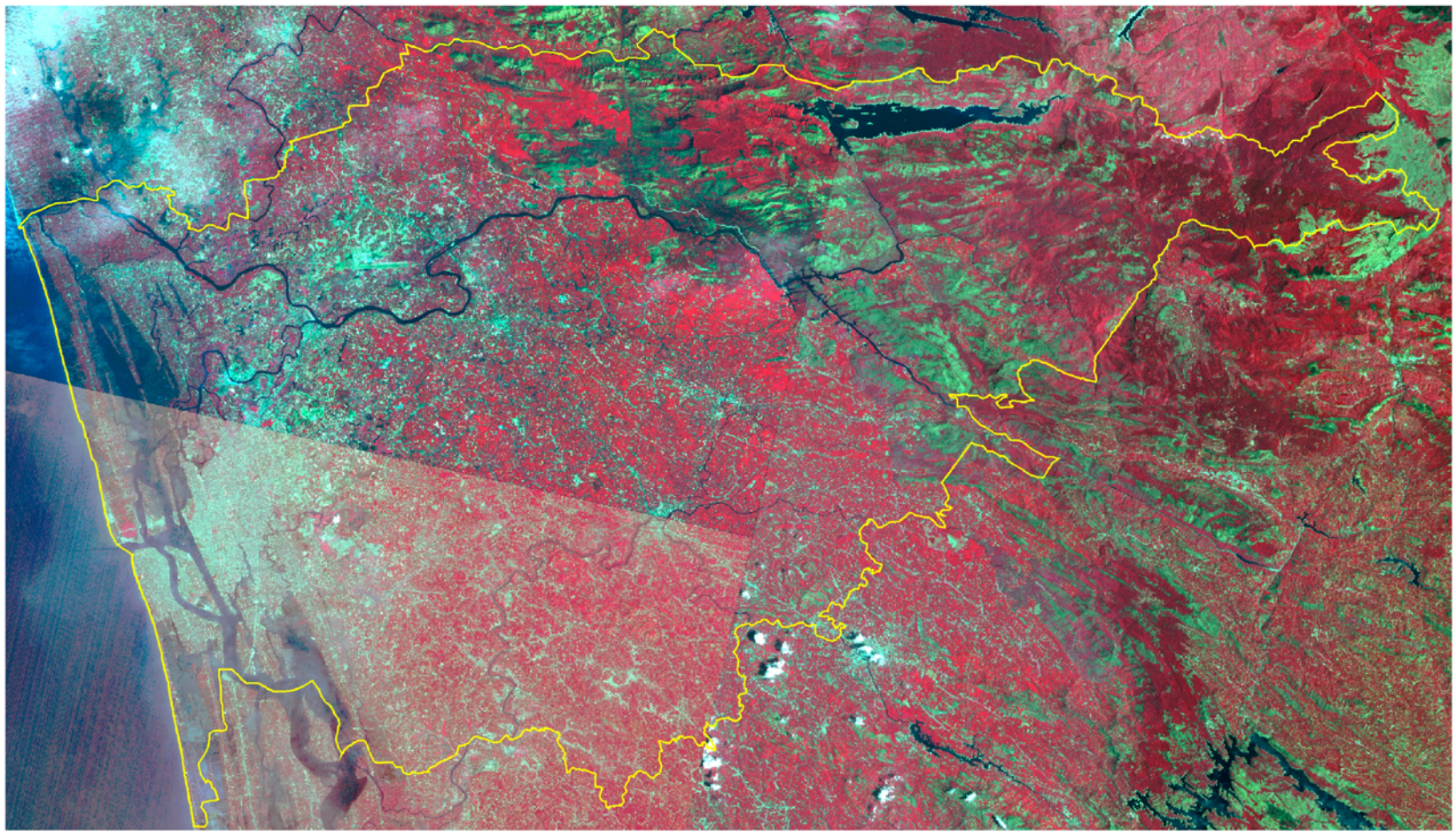
State : Kerala

District : Ernakulam



IRS P6 LISS-III post-monsoon data (2006)

7.1.9 Idukki

The total geographic area of Idukki district is 4,998 sq km and is the second largest District of Kerala with total population of 11,28,205 (2001 census). Rugged mountains and forests cover about 97 per cent of the total area of the district. The district borders Pathanamthitta to the south, Kottayam to the southwest, Ernakulam to the northwest and Thrissur to the north and Coimbature, Dindigul and Theni districts in Tamilnadu to the east. Anamudi, the highest peak is in the Kuttampuzha Panchayat of Adimali Block, in the K.D.H Village of Devikulam taluk. 13 other peaks in the district exceed a height of 2,000 m (6,562 ft). The Periyar, Thodupuzhayar and Thalayar are the important rivers of the district. Idukki the hilly district of the state, has many unique topographical and geographical characteristics. It is also known spice bowl of South India.

The wetland area estimated is 10655 ha. which includes 92 small wetlands (< 2.25 ha) in the district. Details are given in Table 14. The major wetland types are River/Stream, Reservoirs/Barrages, and Lakes/Ponds. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 96 and 93 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 5 and 1 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 14: Area estimates of wetlands in Idukki

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	2042	19.16	1658	1525
2	1105	Waterlogged	7	25	0.23	25	16
3	1106	River/Stream	34	2776	26.05	2770	2769
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/Barrages	7	5613	52.68	5550	5500
5	1202	Tanks/Ponds	29	107	1.00	93	6
		Sub-Total	**78**	**10563**	**99.14**	**10096**	**9816**
		Wetlands (<2.25 ha), mainly Tanks	92	92	0.86	-	-
		Total	**170**	**10655**	**100.00**	**10096**	**9816**

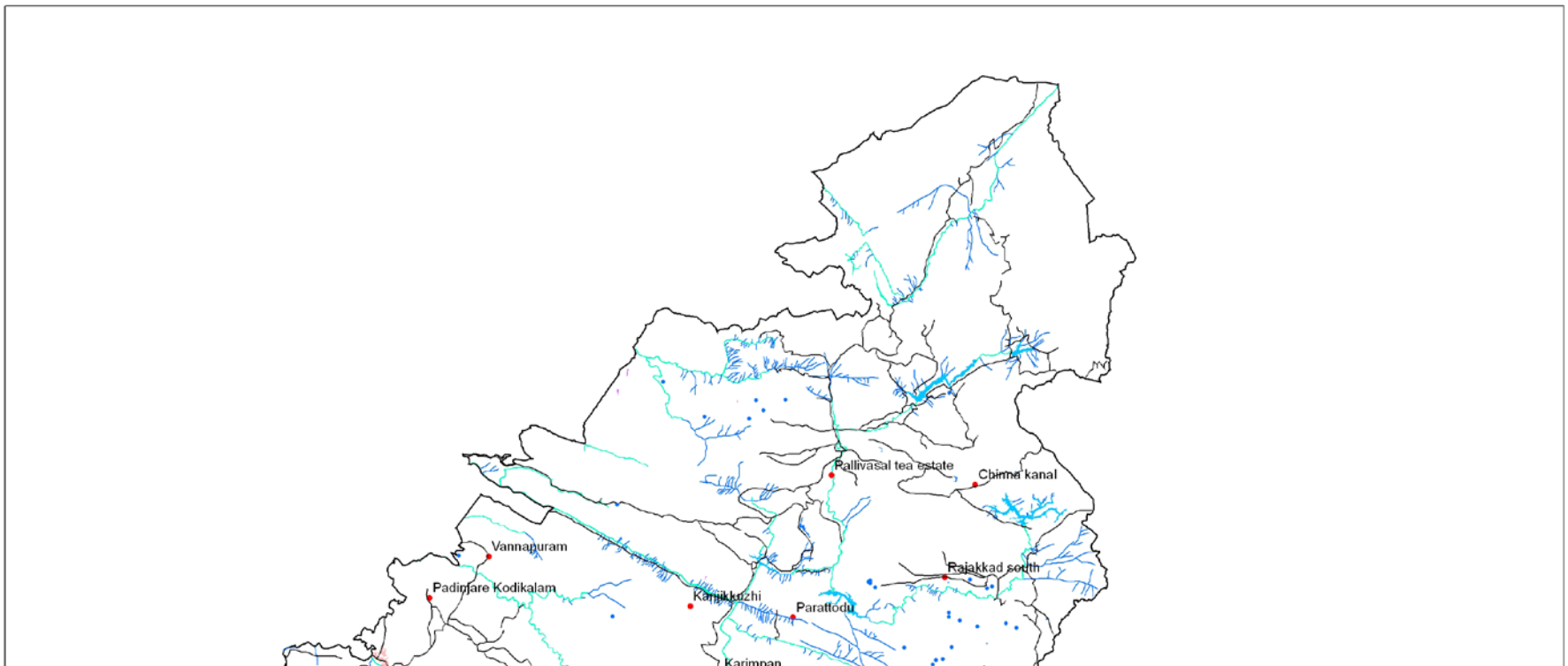
Area under Aquatic Vegetation	469	133

Area under turbidity levels		
Low	7153	7034
Moderate	2943	2782
High	-	-

State : Kerala

WETLAND MAP

District : Idukki

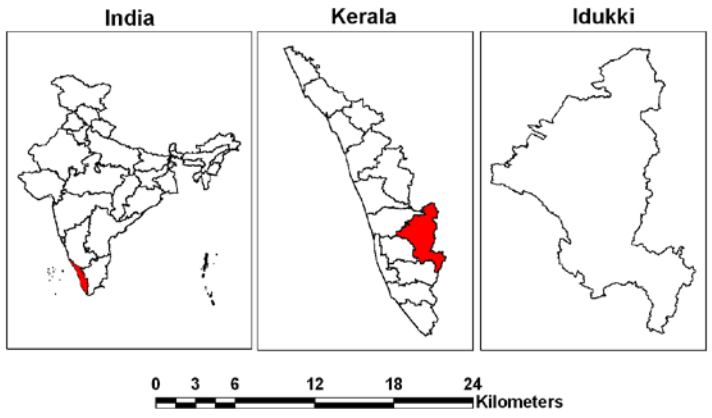


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

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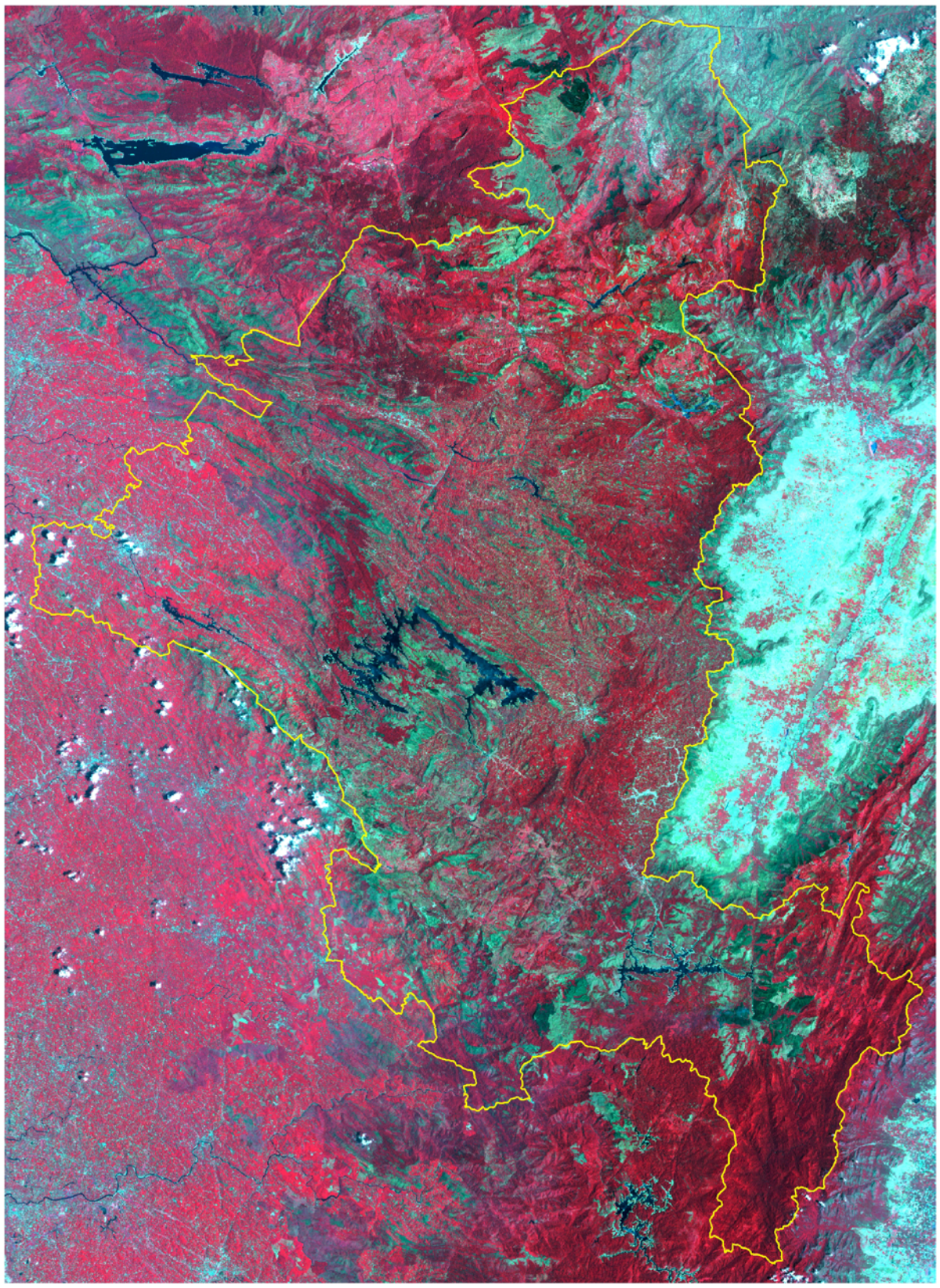
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Idukki



IRS P6 LISS-III pre-monsoon data (2007)

7.1.10 Kottayam

The district has its headquarters at Kottayam town and lies between latitudes 9.36° N and longitudes 76.17° E. The total geographic area of Kottayam district is 2,204 sq km. Bordered by the Western Ghats on the east and the Vembanad Lake and paddy fields of Kuttanad on the west, Kottayam has many unique characteristics. Panoramic backwater stretches, lush paddy fields, highlands, hills and hillocks, rubber plantations. Kottayam town is situated in the basin of the Meenachil River which is formed from several streams in the Western Ghats in Idukki district. It flows through Kottayam district and joins Vembanad Lake. It is the first district to achieve highest literacy rate in the whole of India. The district is 15.35% urbanised. As of 2001 India census, Kottayam Urban Agglomeration had a population of 1,72,878, while Kottayam district had a population of 19,52,901. It is one of the very few places which witnessed a negative population growth from 1991 to 2001. This district has marked lowest decadal population growth rates of 6.76% compared to 9.42% for Kerala.

The wetland area estimated is 9523 ha. which includes 66 small wetlands (< 2.25 ha). Details are given in Table 15. The major wetland types are Lagoons, River/Stream and Waterlogged. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 96 and 95 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 4 and 1 per cent of wetland area during post and pre-monsoon respectively.

Table 15: Area estimates of wetlands in Kottayam

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	60	405	4.25	54	74
2	1106	River/Stream	24	3826	40.18	3824	3800
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	18	30	0.00	21	0
		Total - Inland	**102**	**4261**	**44**	**3899**	**3874**
	2100	**Coastal Wetlands - Natural**					
4	2101	Lagoons	3	5196	54.56	5187	5168
		Total - Coastal	**3**	**5196**	**54.56**	**5187**	**5168**
		Sub-Total	**105**	**9457**	**99**	**9086**	**9042**
		Wetlands (<2.25 ha), mainly Tanks	66	66	0.69	-	-
		Total	**171**	**9523**	**100**	**9086**	**9042**

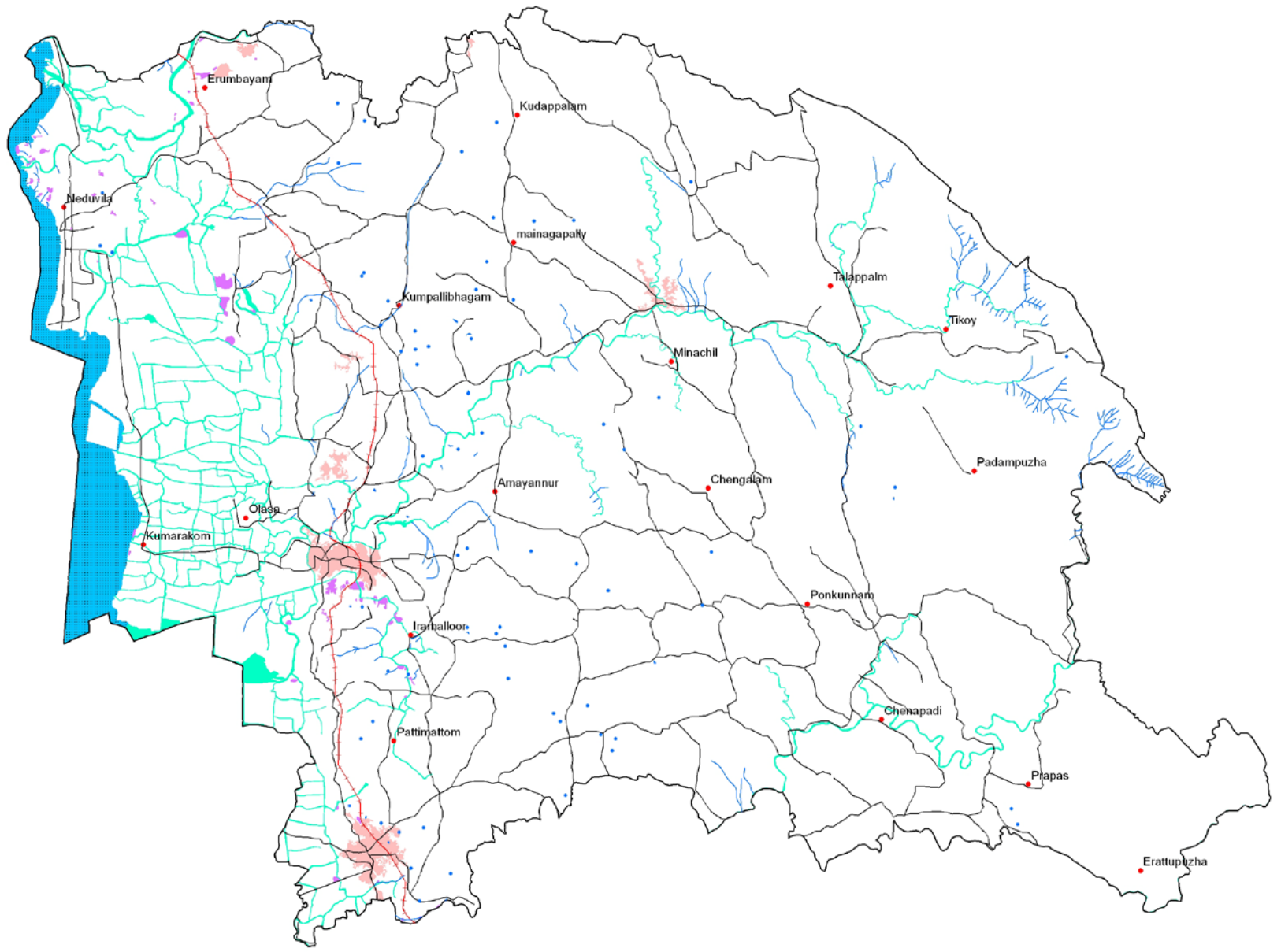
Area under Aquatic Vegetation	401	129

Area under turbidity levels		
Low	6894	6852
Moderate	2192	2190
High	-	-

State : Kerala

WETLAND MAP

District : Kottayam

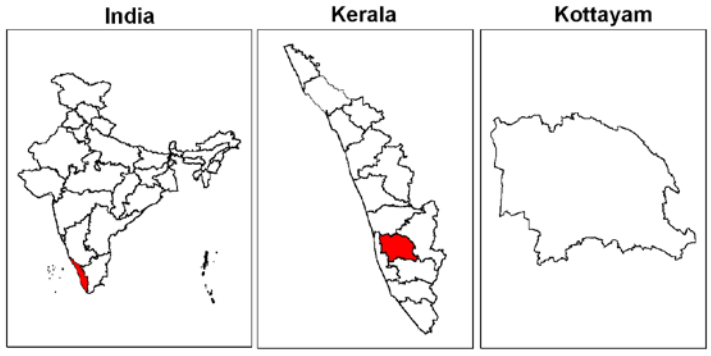


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 1.5 3 6 9 12 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

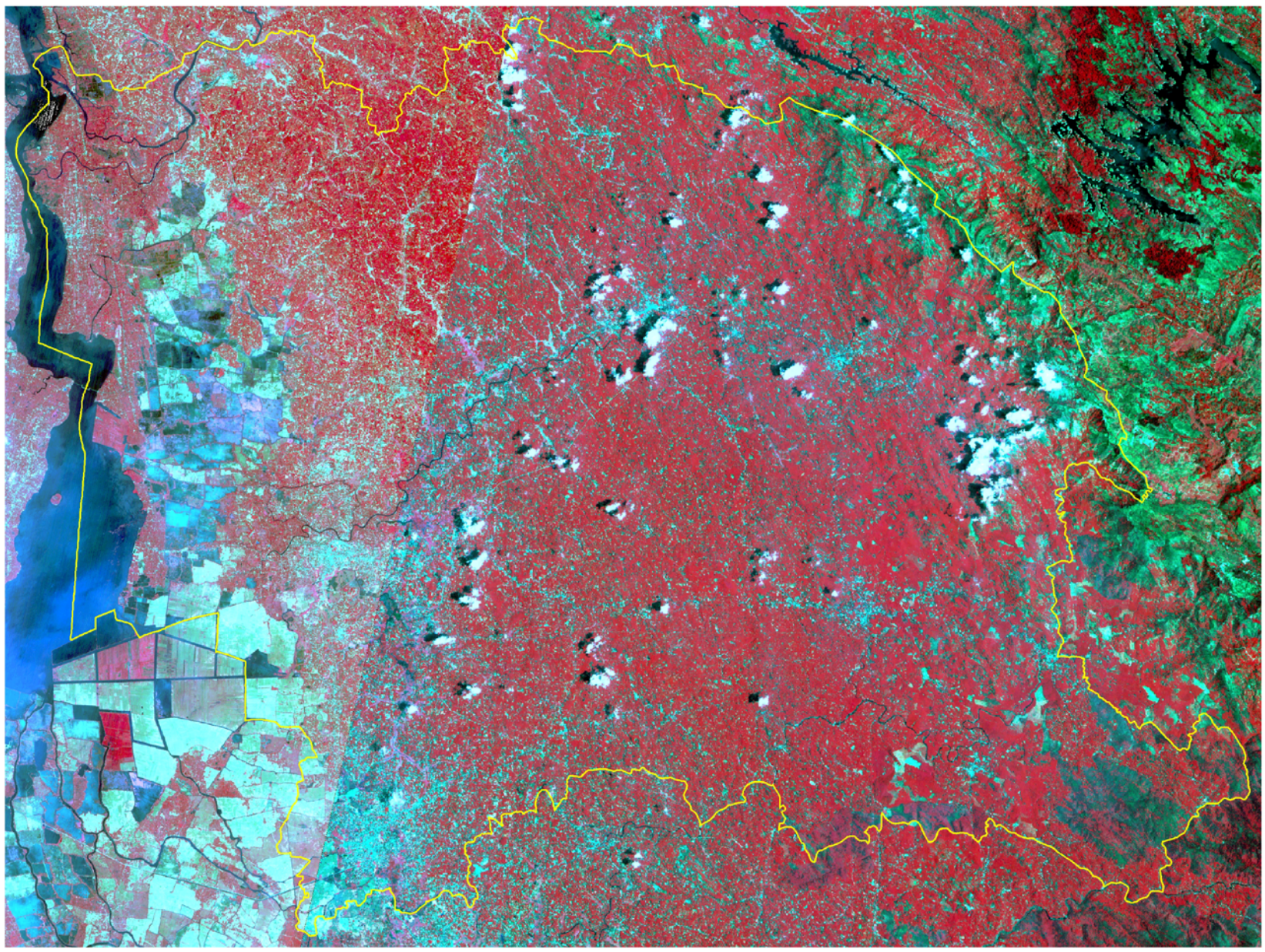
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Kottayam



IRS P6 LISS-III post-monsoon data (2006)

7.1.11 Alappuzha

Alappuzha, also known as Alleppey, is a town in Alappuzha district of Kerala state. A town with canals, backwaters, beaches, and lagoons. Kuttanad, the rice bowl of Kerala with the unending stretch of paddy fields, small streams and canals with lush green coconut palms, was well known even from the early periods of the Sangam age. The total geographic area of Alappuzha district is 1,256 sq km. As of 2001 India census, Alappuzha had a population of 20,63,491. Alappuzha has an average literacy rate of 84%, higher than the national average of 59.5%. It has the highest population density among all districts of the state. The city is located between 9.50° North Latitude and 76.33° East Longitude. The geography of Alappuzha is diverse. Alleppey is gifted with immense natural beauty with the Arabian sea on its west. The city has a vast network of lakes, lagoons and fresh water rivers.

The wetland area estimated is 26079 ha. which includes 129 small wetlands (< 2.25 ha). Details are given in Table 16. The major wetland types are Lagoons, Waterlogged, River/Stream and Tanks/Ponds. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 84 and 76 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 16 and 10 per cent of wetland area during post and pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail.

Table 16: Area estimates of wetlands in Alappuzha

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	223	7753	29.73	4443	2834
2	1106	River/Stream	25	4558	17.48	4546	4445
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	25	476	1.83	211	166
		Total - Inland	**273**	**12787**	**49.03**	**9200**	**7445**
	2100	**Coastal Wetlands - Natural**					
4	2101	Lagoons	16	13017	49.91	12496	12248
5	2102	Creeks	14	62	0.24	60	60
6	2103	Sand/Beach	5	84	0.32	0	0
		Total - Coastal	**35**	**13163**	**50.47**	**12556**	**12308**
		Sub-Total	**308**	**25950**	**99.51**	**21756**	**19753**
		Wetlands (<2.25 ha), mainly Tanks	129	129	0.49	-	-
		Total	**437**	**26079**	**100.00**	**21756**	**19753**

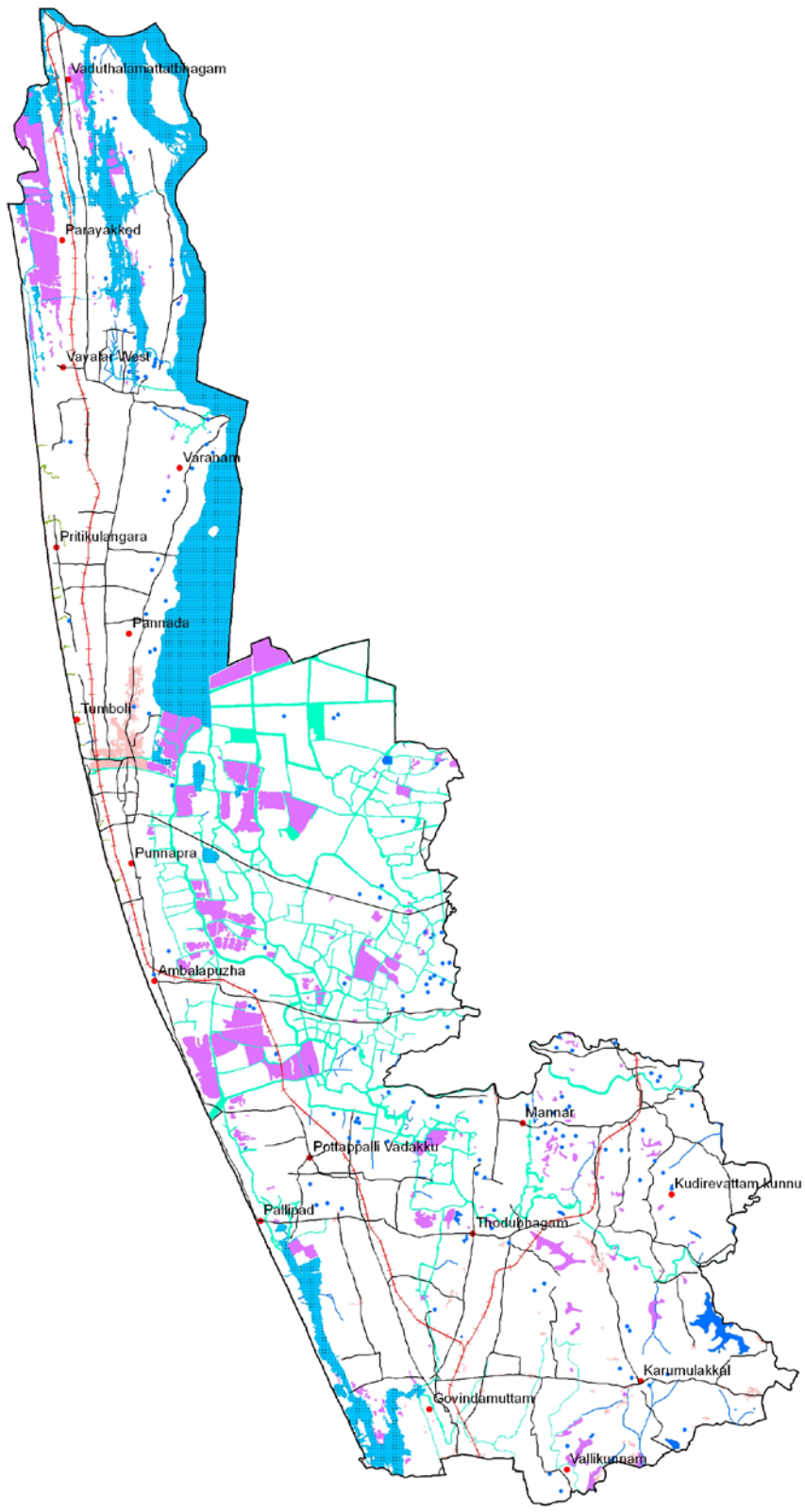
Area under Aquatic Vegetation	4182	2642

Area under turbidity levels		
Low	11768	11438
Moderate	9988	8315
High	-	-

State : Kerala

WETLAND MAP

District : Alappuzha

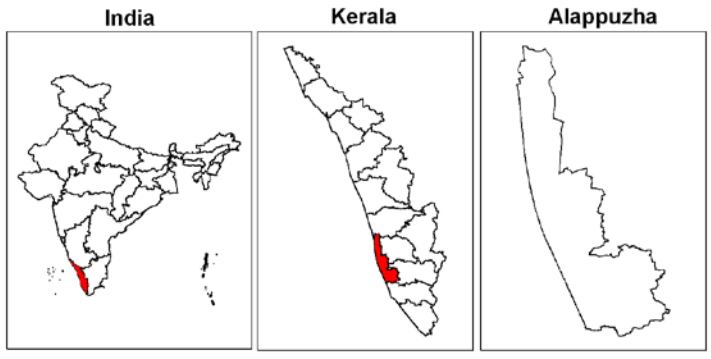


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

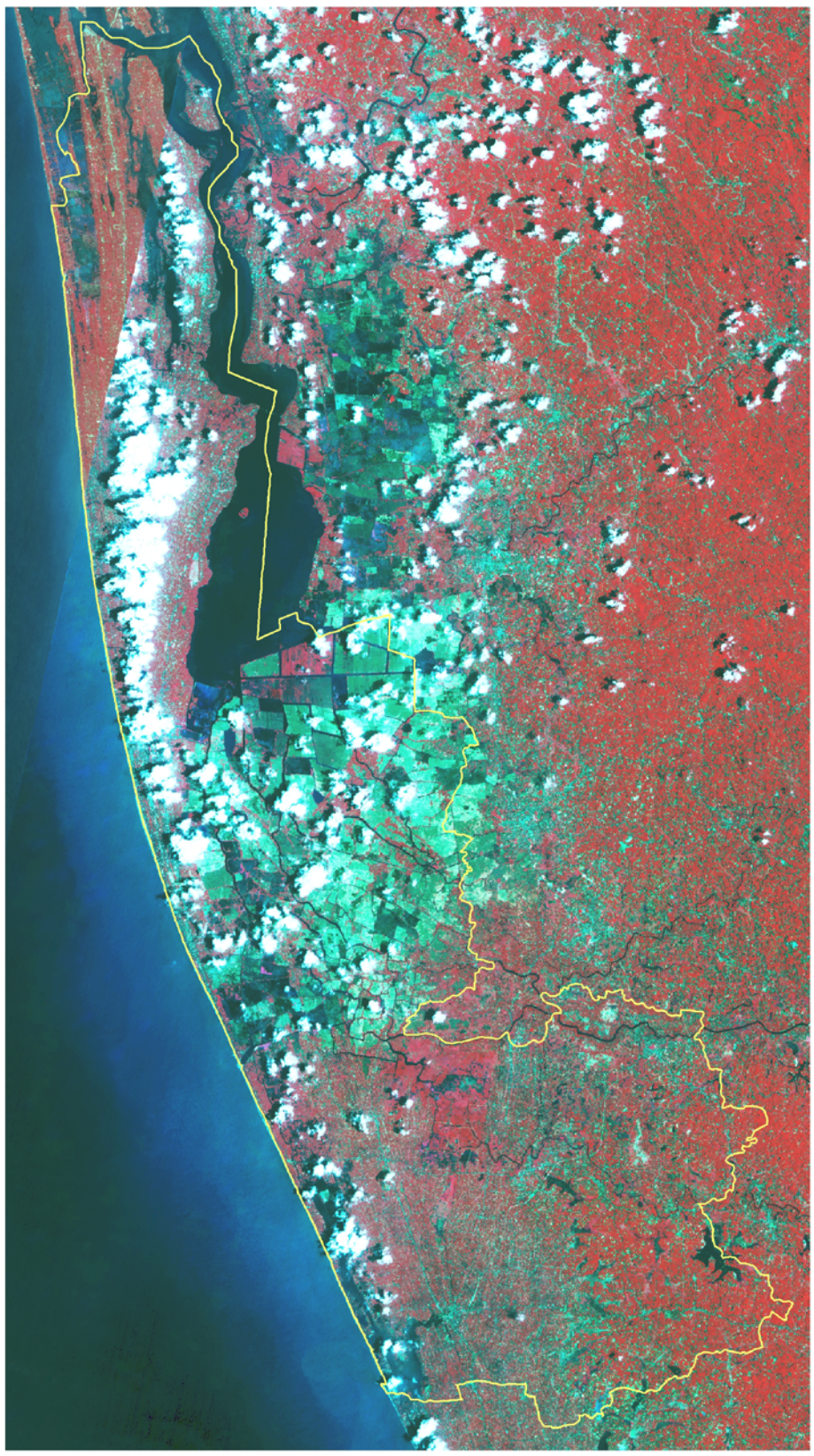
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Alappuzha



IRS P6 LISS-III postmonsoon data (2006)

7.1.12 Pathanamthitta

Pathanamthitta is a town situated in the very heart of the Central Travancore region of Kerala State. The total geographic area of Pathanamthitta district is 2,731 sq km. Pampa and Kakki reservoir and the famous Lord Ayappa temple in the nelimala inside periyar tiger reserve is in this district. As of 2001 India census, Pathanamthitta had a population of 12, 34,000. Pathanamthitta has an average literacy rate of 93%, higher than the national average of 59.5%.

The wetland area estimated is 4948 ha. Small wetlands, which are less than minimum mapable units are 129 in the district. Details are given in Table 17. The major wetland types are River/Stream, Reservoirs/Barrages, Tanks/Ponds and Waterlogged. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 90 and 83 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 9 and 5 per cent of wetland area during post and pre-monsoon respectively.

Table 17: Area estimates of wetlands in Pathanamthitta

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1105	Waterlogged	52	201	4.06	89	6
2	1106	River/Stream	42	2955	59.72	2894	2771
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	2	1440	29.10	1319	1211
4	1202	Tanks/Ponds	27	223	4.51	43	12
		Total - Inland	**123.00**	**4819.00**	**97.39**	**4345.00**	**4000**
		Total - Coastal	**0**	**0**	**0.00**	**0**	**0**
		Sub-Total	**0**	**4819**	**0.00**	**4345**	**4000**
		Wetlands (<2.25 ha), mainly Tanks	129	129	2.61	-	-
		Total	**129**	**4948**	**2.61**	**4345**	**4000**

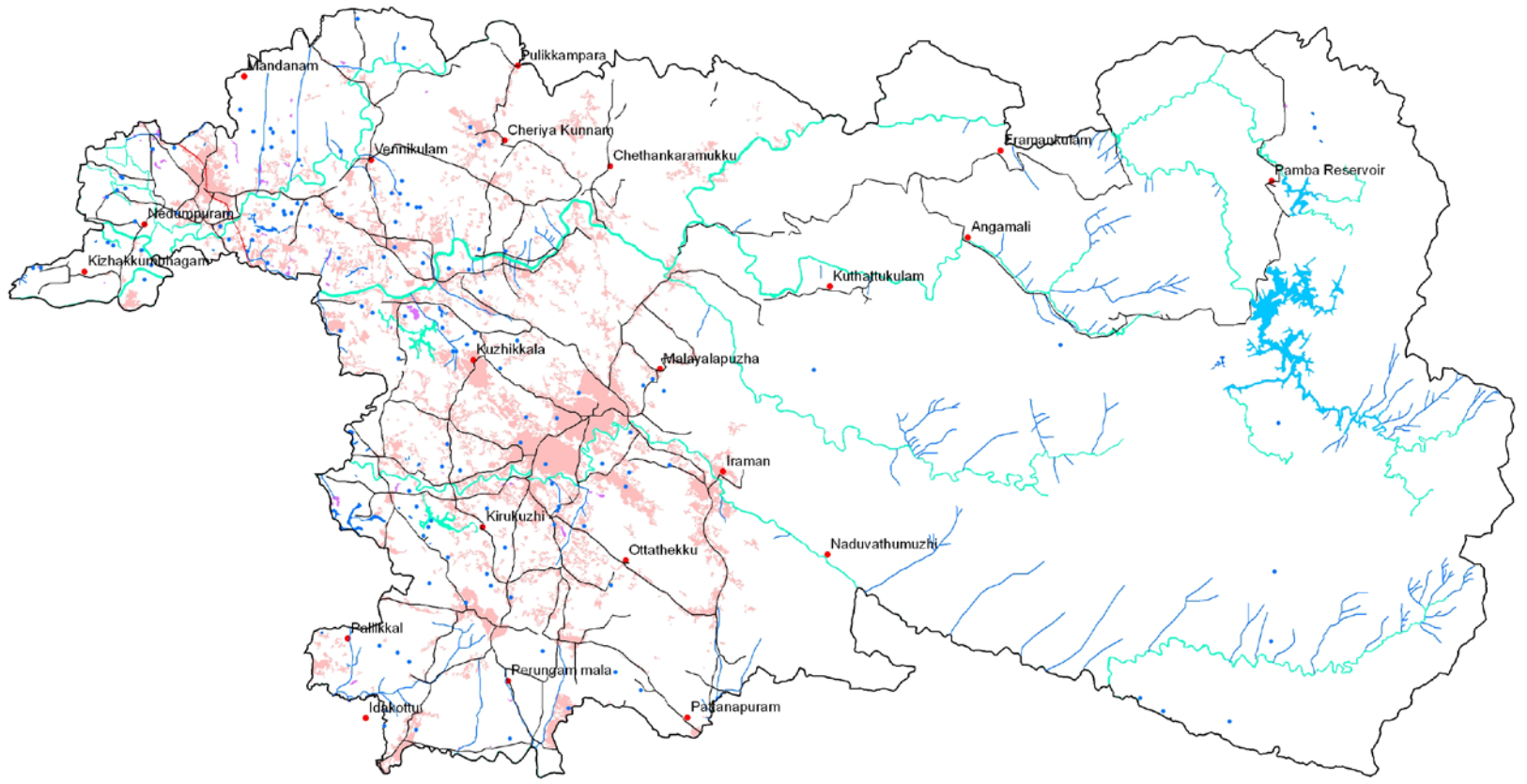
Area under Aquatic Vegetation	413	246

Area under turbidity levels		
Low	3343	3179
Moderate	1002	821
High	-	-

State : Kerala

WETLAND MAP

District : Pathanamthitta

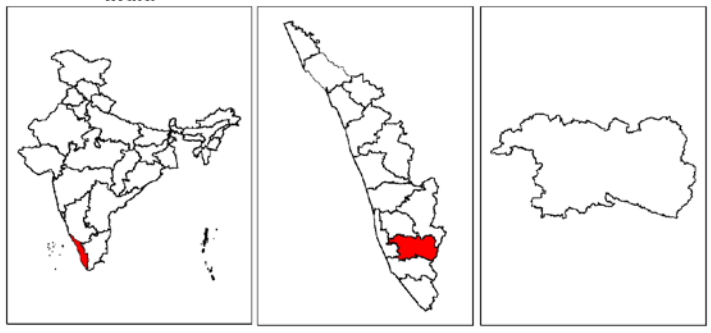


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

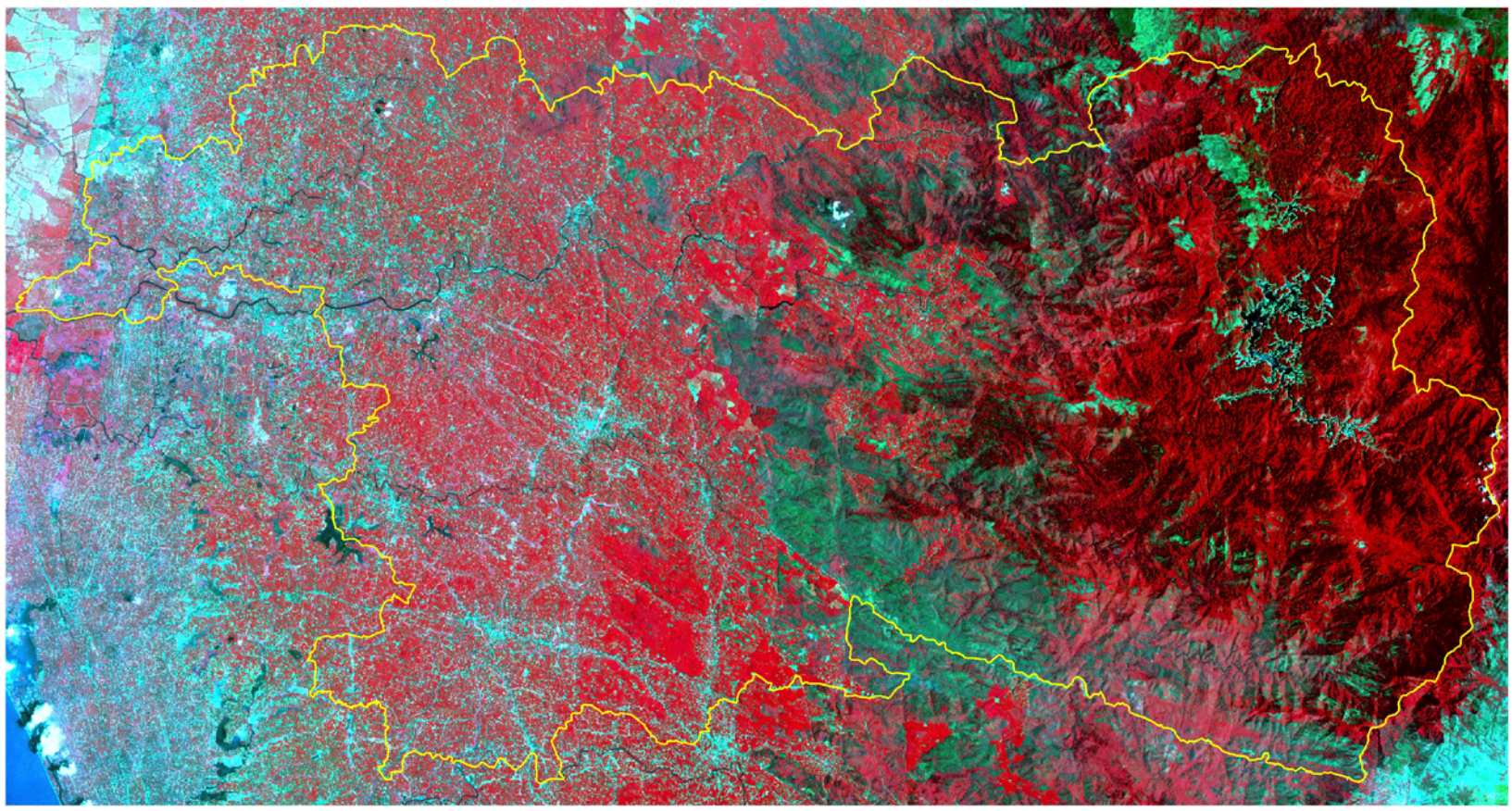
Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Pathanamthitta



IRS P6 LISS-III post-monsoon data (2006)

7.1.13 Kollam

Kollam Is one among the 14 districts in the state of Kerala. The total geographic area of Kollam district is 2,579 sq km. As of 2001 India census, Kollam had a population of 25,83,945. It lies north of the state capital Thiruvanathapuram. It is bound on the south by Thiruvananthapuram district, on the north by Pathanamthitta and Alappuzha, on the east by Tamil Nadu and on the west by the Arabian Sea. It is the southern gateway to the backwaters of Kerala, and a prominent tourist destination. About thirty percent of this district is covered by the Ashtamudi Lake. The Kallada river, which originates near Ponmudi from the Kulathupuzha hills Western Ghats in Thiruvananthapuram district, is formed by the confluence of three rivers, viz., Kulathupuzha, Chenthurnipuzha, and Kalthuruthipuzha, and after traversing a distance of about 121 km through virgin forests finally debouches into the Ashtamudi wetland at Neendakara (a fishing harbour) near Kollam as it enters the Lakshadweep Sea, part of the Arabian Sea with a maximum depth of 6.4 m at the confluence. It is Kerala's deepest estuary.

The wetland area estimated is 13703 ha. which includes 134 small wetlands (< 2.25 ha). Details are given in Table 18. The major wetland types are Lagoons, River/Stream, Reservoirs/ Barrages and Waterlogged. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 90 and 90 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 10 and 8 per cent of wetland area during post and pre-monsoon respectively.

Table 18: Area estimates of wetlands in Kollam

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes	1	354	2.58	354	354
2	1105	Waterlogged	134	1281	9.35	568	416
3	1106	River/Stream	30	2080	15.18	2067	2003
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/ Barrages	1	1901	13.87	1555	1896
5	1202	Tanks/Ponds	14	292	2.13	246	117
		Total - Inland	**180**	**5908**	**43**	**4790**	**4786**
	2100	**Coastal Wetlands - Natural**					
6	2101	Lagoons	13	7575	55.28	7365	7371
		Total - Coastal	**24**	**7661**	**56**	**7365**	**7371**
		Sub-Total	**204**	**13569**	**99.02**	**12155**	**12157**
		Wetlands (<2.25 ha), mainly Tanks	134	134	0.98	-	-
		Total	**338**	**13703**	**100.00**	**12155**	**12157**

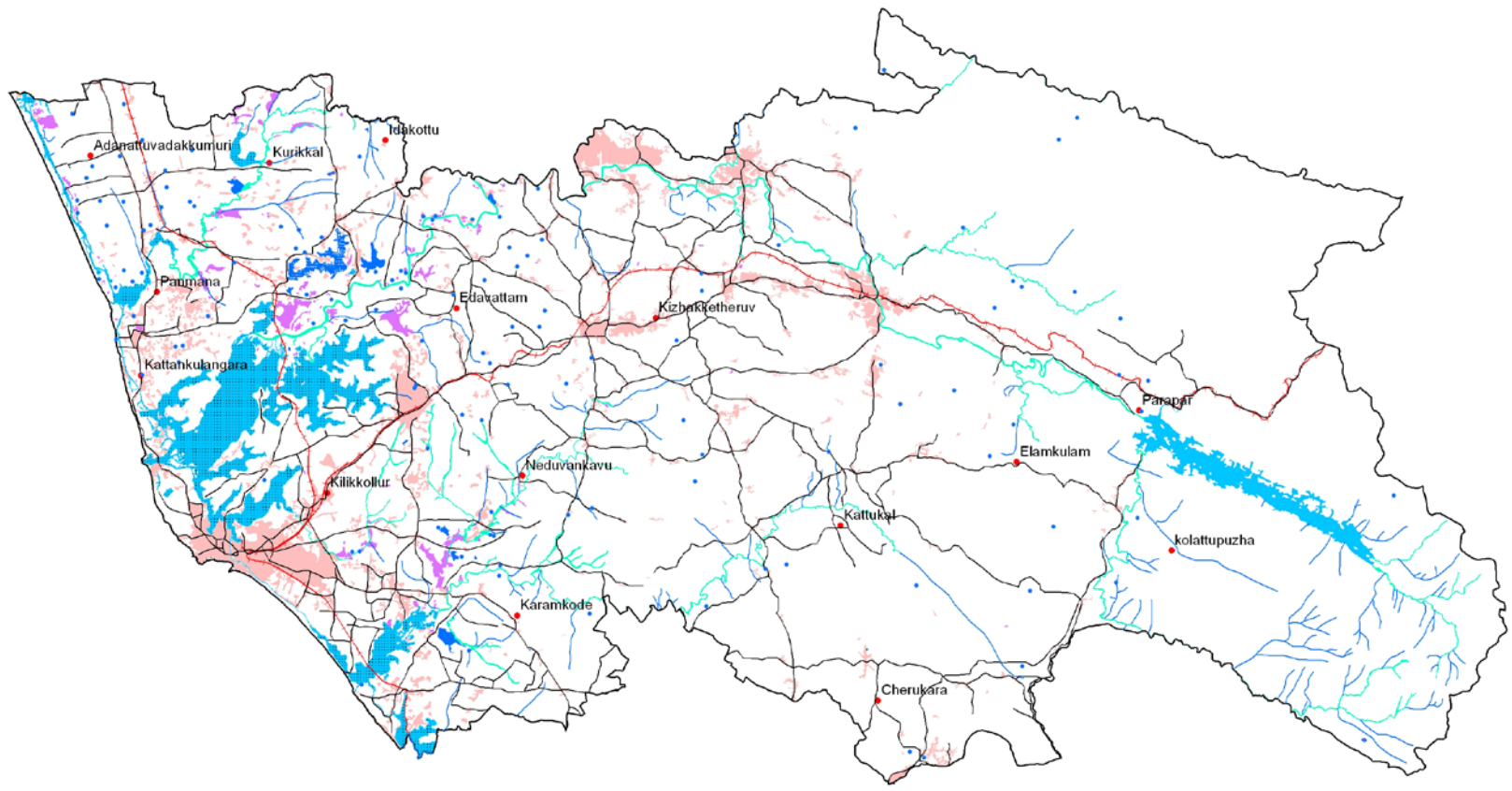
Area under Aquatic Vegetation	1301	1050

Area under turbidity levels		
Low	10174	10260
Moderate	1981	1814
High	0	83

State : Kerala

WETLAND MAP

District : Kollam

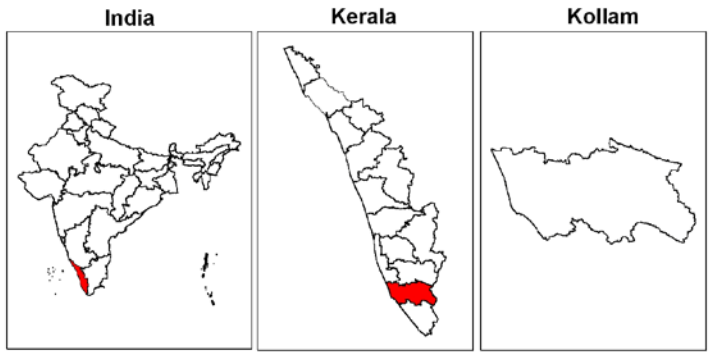


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 2 4 8 12 16 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

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Sponsored By:

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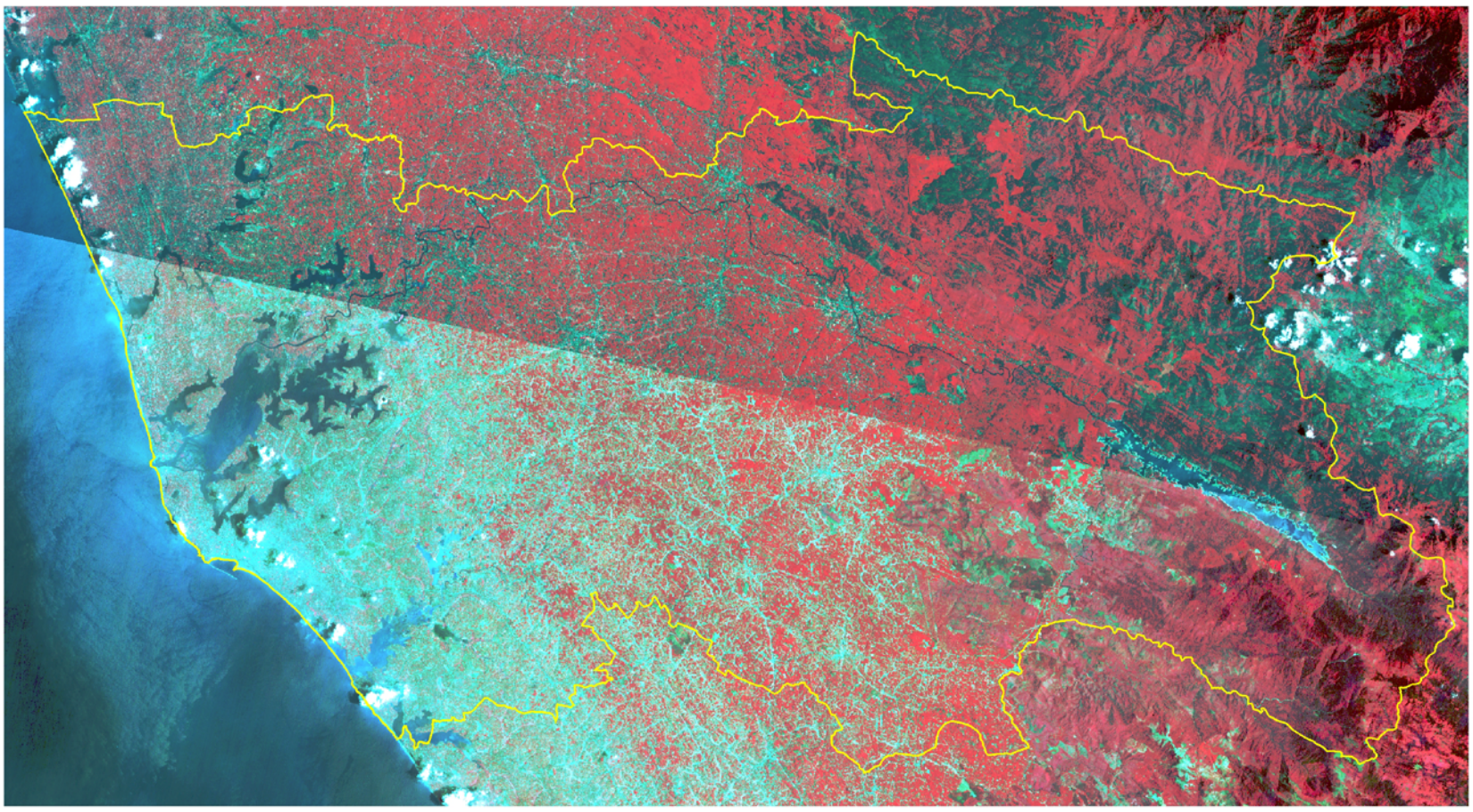


IRS P6 LISS-III post-monsoon data (2006)

6.1.14 Thiruvananthpuram

Trivandrum is the capital of the Indian state of Kerala and the headquarters of the Thiruvananthapuram District. The district is situated between North latitudes at 8°17’ to 8°54’ and East longitudes 76°41’ to 77°17’. The district stretches 78 km along the shores of the Arabian Sea on the West, Kollam district lies on the North with Tirunelveli and Kanyakumari districts of Tamil Nadu on the East and South respectively. The district is characterized by its undulating terrain of low coastal hills and busy commercial alleys. The total geographic area of Thiruvananthapuram district is 2,192 sq km with a population of 32,34,356. as per the 2001 census, Among the three rivers in the district, the Neyyar (56 km), the southernmost river of the Kerala state, has its origin in the Agasthyamala, the second highest peak in the Western Ghats. Karamana river (67 km) originates from Vayuvanthol (vazhuvanthol), another mountain in Western Ghats and the Vamanapuram River have their origin from Chemunji Mottai of the Western Ghats. There are 10 major back waters in the district. The major ones are Veli, Kadinamkulam, Anchuthengu(Anjengo), Kaappil, Akathumuri and the Edava-Nadayara. Besides these, there is a fresh water lake at Vellayani in Thiruvananthapuram taluk, which has the potential to become the major water sources of the Thiruvanthapuram city in future.

The wetland area estimated is 5942 ha. which includes 385 small wetlands (< 2.25 ha). Details are given in Table 19. The major wetland types are Lagoons, River/Stream, Reservoirs/Barrages, Waterlogged and Sand/Beach. Analysis of wetland status in terms of open water and aquatic vegetation showed that around 79 and 73 percent of wetland area is under open water category during post-monsoon and pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 9 and 5 per cent of wetland area during post and pre-monsoon respectively.

Table 19: Area estimates of wetlands in Thiruvananthpuram

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	247	4.16	247	246
2	1105	Waterlogged	14	41	0.69	24	25
3	1106	River/Stream	24	1590	26.76	1506	1232
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/Barrages	4	1501	25.26	1199	1231
5	1202	Tanks/Ponds	51	104	1.75	41	22
		Total - Inland	**94**	**3483**	**58.62**	**3017**	**2756**
	2100	**Coastal Wetlands - Natural**					
6	2101	Lagoons	19	1531	25.77	1392	1324
7	2103	Sand/Beach	15	543	0.00	0	0
		Total - Coastal	**34**	**2074**	**34.90**	**1392**	**1324**
		Sub-Total	**128**	**5557**	**93.52**	**4409**	**4080**
		Wetlands (<2.25 ha), mainly Tanks	385	385	6.48	0	0
		Total	**513**	**5942**	**100.00**	**4409**	**4080**

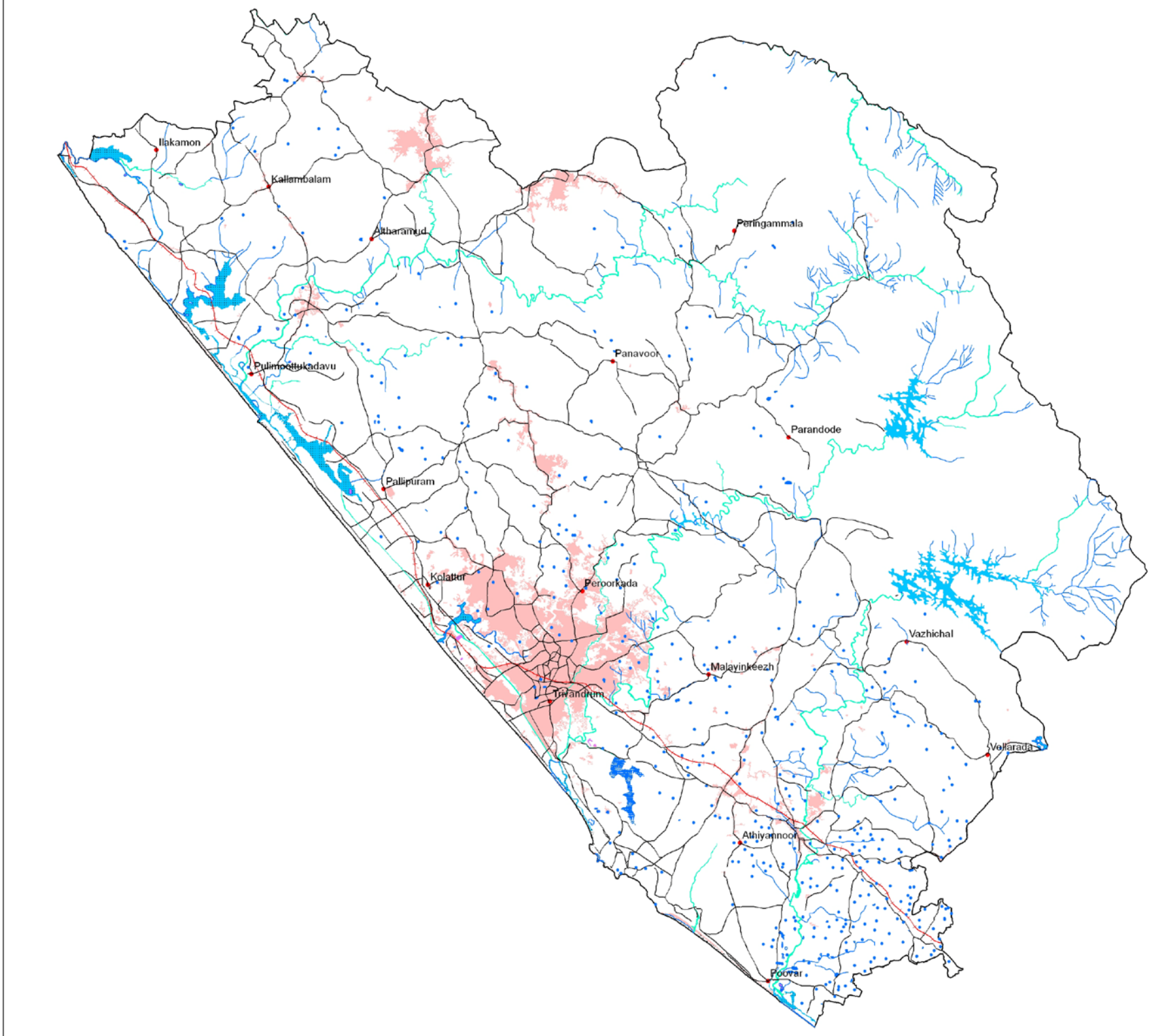
Area under Aquatic Vegetation	496	289

Area under turbidity levels		
Low	2105	2439
Moderate	2069	1297
High	235	344

State : Kerala

WETLAND MAP

District : Thiruvananthpuram

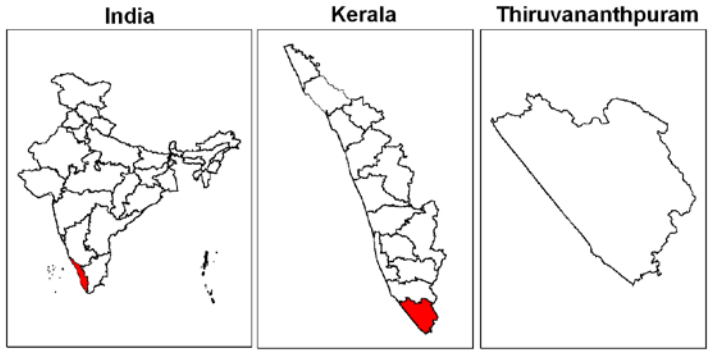


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary

Location Map



0 1.5 3 6 9 12 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

District : Thiruvananthpuram

IRS P6 LISS-III post-monsoon data (2006)

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF KERALA

Major wetland types observed in the state are Rivers, Lagoons and Reservoirs. Details are given in Plate-1. Ground truth data was collected for selected wetland sites. The standard Performa was used to record the field data. Field photographs are also taken to record the water quality (subjective), status of aquatic vegetation and water spread. The location of the features was recorded using GPS. Field photographs of different wetland types are shown in Plates 2a, 2b, 2c and 2d.

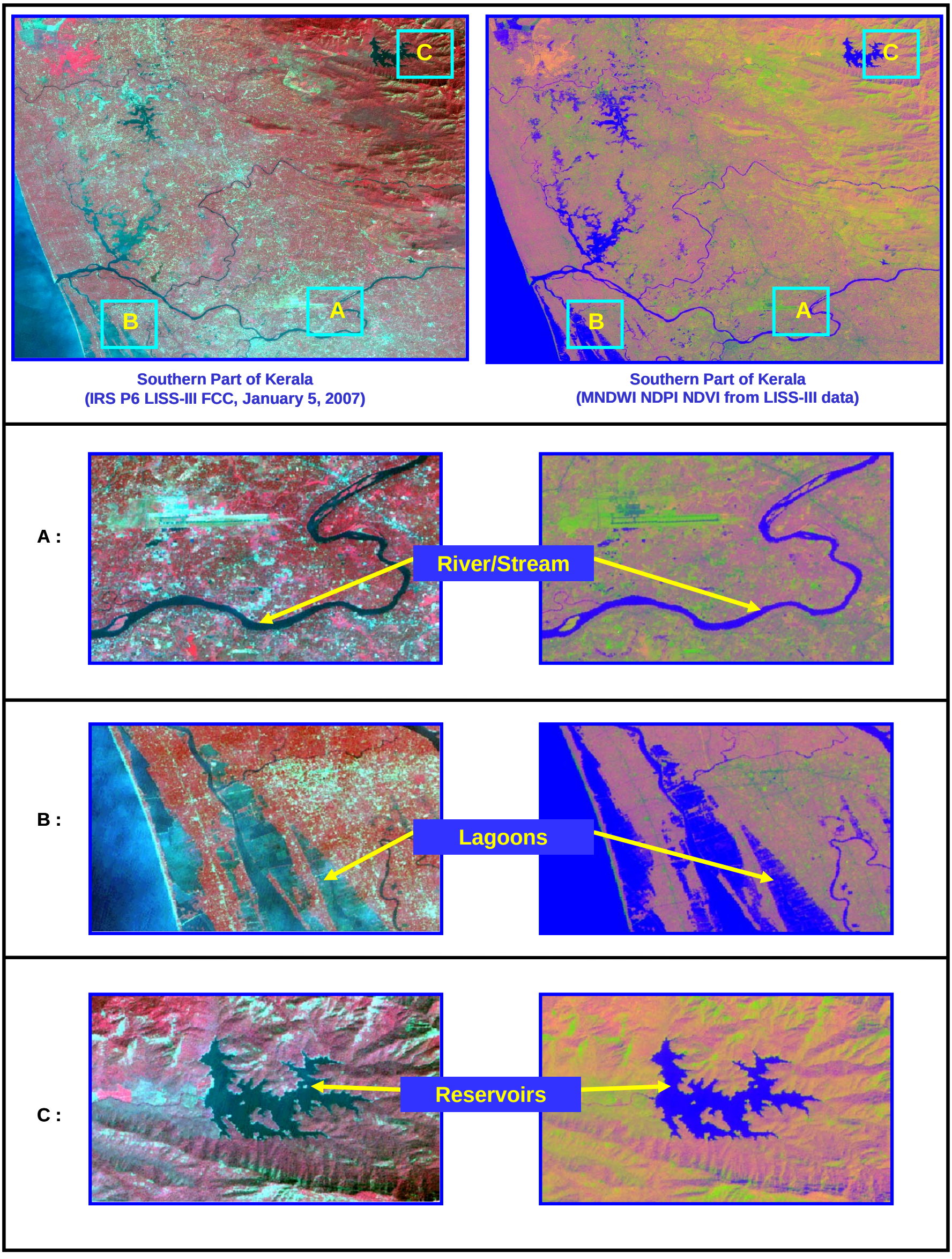


Plate - 1: Major wetland types of Kerala

Sr. No.	Description	Field photograph
1.	**Wetland Type**: Lagoon **Location**: Longitude: 76^0 24’ 2.56” E Latitude : 09^0 40’ 25.27” N **Turbidity**: Low **Aquatic vegetation**: Absent	
2.	**Wetland Type**: Reservoir/Barrage **Location**: Longitude: 76^0 45’ 54.26” E Latitude : 10^0 35’ 36.27” N **Turbidity**: Low	
3.	**Wetland Type**: Sand/Beach **Location:** Longitude : 75^0 52’ 4.39” E Latitude : 10^0 58’ 37021” N **Turbidity**: NA **Aquatic Vegetation:** NA	
4.	**Wetland Type**: Lake **Location**: Longitude: 76^0 59’ 34.72” E Latitude : 08^0 25’ 43.56” N **Turbidity**: Low **Aquatic vegetation**: Present	

Plate 2a: Field photographs and ground truth data of different wetland types in Kerala

Sr. No.	Description	Field photograph
5.	**Wetland Type**: Pond **Location**: Longitude: 76^0 19’ 2.90” E Latitude : 09^0 46’ 5.58” N **Turbidity**: Low **Aquatic vegetation**: Present	
6.	**Wetland Type**: River **Location**: Longitude: 74^0 57’ 19.45” E Latitude : 12^0 33’ 36.65” N **Turbidity**: Moderate	
7.	**Wetland Type**: Riverine Wetland **Location:** Longitude : 76^0 01’ 11.61” E Latitude : 10^0 50’ 31.89” N **Turbidity**: Moderate **Aquatic Vegetation:** Present	
8.	**Wetland Type**: Waterlogged **Location**: Longitude: 76^0 40’ 58.81” E Latitude : 09^0 18’ 53.79” N **Turbidity**: Moderate **Aquatic Vegetation:** Present	

Plate 2b: Field photographs and ground truth data of different wetland types in Kerala

Sr. No.	Description	Field photograph
9	**Wetland Type**- River **Location**- Longitude : 76º48´29.16“E Latitude: 9º15´40.43“N **Turbidity**- High	
10.	**Wetland Type**- Pond/Tank **Location**- Longitude : 77º3´18.14“E Latitude: 9º57´42.18“N **Turbidity**- Low	
11.	**Wetland Type-** Lagoon **Location-** **Longitude:** 75º58´43.24“E **Latitude:**10º45´50.36“N **Aquatic Vegetation-** Present (Weeds, Lotus)	
12.	**Wetland Type-** Waterlogged **Location-** Longitude : 76º42´13.96“E Latitude : 9º19´16.49“N **Aquatic Vegetation:** Present (Weeds, Lotus)	

Plate 2c: Field photographs and ground truth data of different wetland types in Kerala

IMPORTANT WETLANDS OF KERALA

9.0 IMPORTANT WETLANDS OF Kerala

Ashtamudi WetlandSasthamkotta Lake, Vembanad-Kol Wetland are three Ramsar sites in Kerala, Other than these wetlands , Parambikulam Dam, Periyar Lake, Kaway Lagoon, Kumbalangi kayal, Malampuzha Reservior, Koltapuzha kayal, Vayalar lake, Kayamkulam Kayal, and Peechi Dam Reservoir are some of the important wetland sites. Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of each wetland sites. Location map of important wetland sites is shown in Plate 3. Details of each wetland and wetland map of 5 km buffer area are shown in plates 4 to 18.

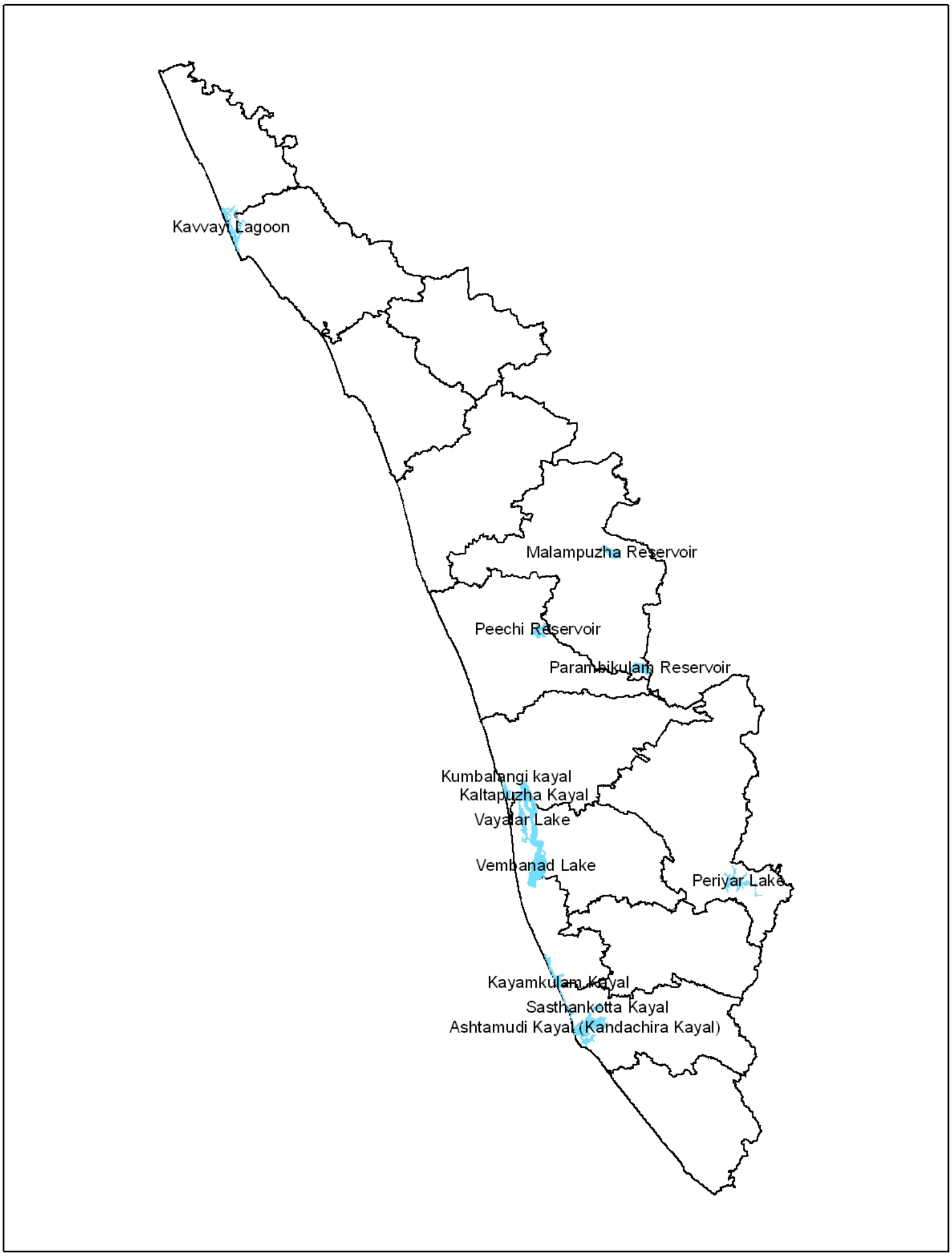
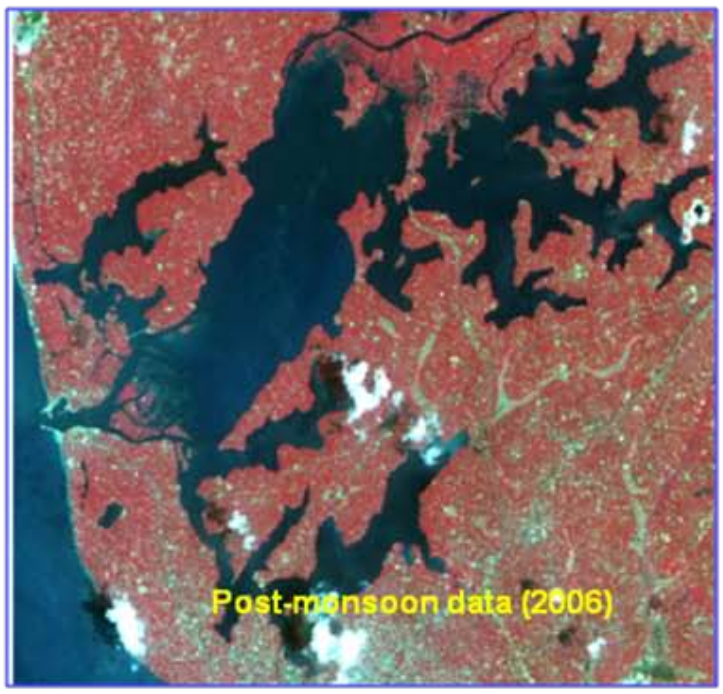


Plate – 3: Important Wetland sites of Kerala

9.1 Ashtamudi Wetland

Name: Ashtamudi Wetland

Location:
Latitude: 8º 53′ 14" N to 9º 0′ 57" N
Longitude: 76º 31′ 54" E to 76º 40′ 2" E
1 km north of Kollam Town
Area: 5598 ha
Wetland type: Lagoon
Average Annual Rainfall:
2400 mm, mostly occurring during June to September
Declared as Ramsar site on *19/08/02*. An extensive estuarine system, the second largest in Kerala State, which is of extraordinary importance for its hydrological functions, its biodiversity, and its support for fish. The site supports a number of mangrove species as well as over 40 associated plant species, and 57 species of birds have been observed, including six that are migratory. Nearly 100 species of fish sustain a lively fishing industry, with thousands of fishermen depending directly upon the estuary for their livelihood. Population density and urban pressures pose threats to the site, including pollution from oil spills from thousands of fishing boats and from industries in the surrounding area and conversion of natural habitat for development purposes.
Principal Vegetation:
Ashtamudi Estuary has mangroves *Avicennia officinalis*, *Brugiera gymnorrhiza* and *Sonneratia caseolaris* as also 43 species of marshy and mangrove associates including two endangered species *Syzygium travancoricum* (endangered species according to the Red Data Book of Indian Plants) and *Calamus rotang* in the Terrestrial system. These species offer excellent scope for development of marine bioreserve to promote eco-tourism in the estuarine of the lake.
Fauna:
The lake supports 57 species of avifauna, of which 6 are migratory and 51 resident species. Terns, plovers, cormorants, and herons are most abundant birds in the lake.



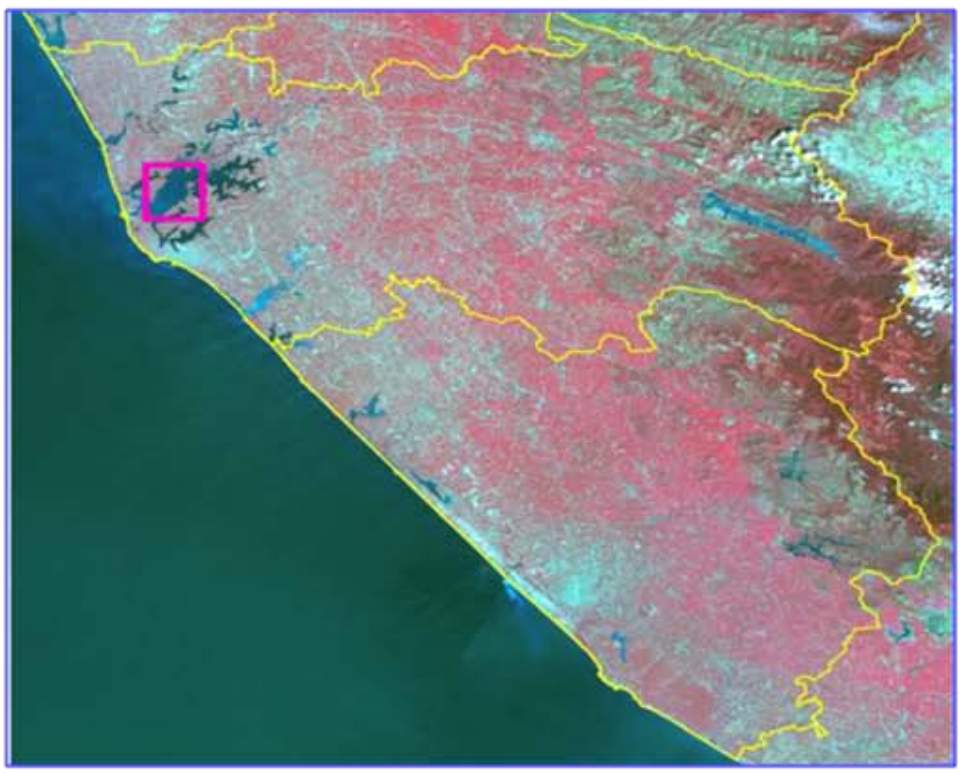
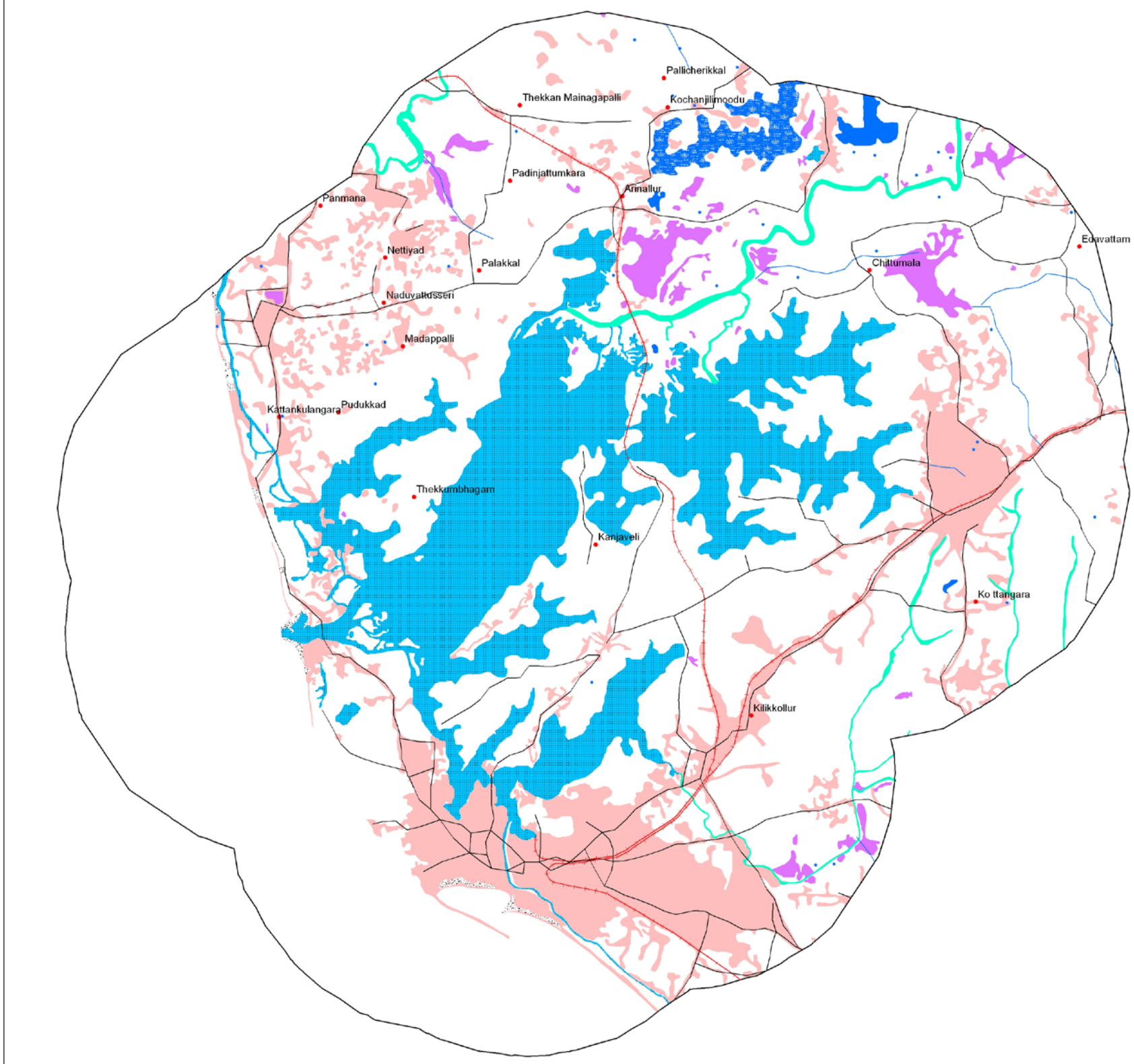


Plate 4: Ashtamudi wetland

State : Kerala

WETLAND MAP

Ashtamudi Wetland



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary
- 5 km buffer area

Location Map

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 5: Wetland map - 5 km buffer area of Ashtamudi wetland

State : Kerala

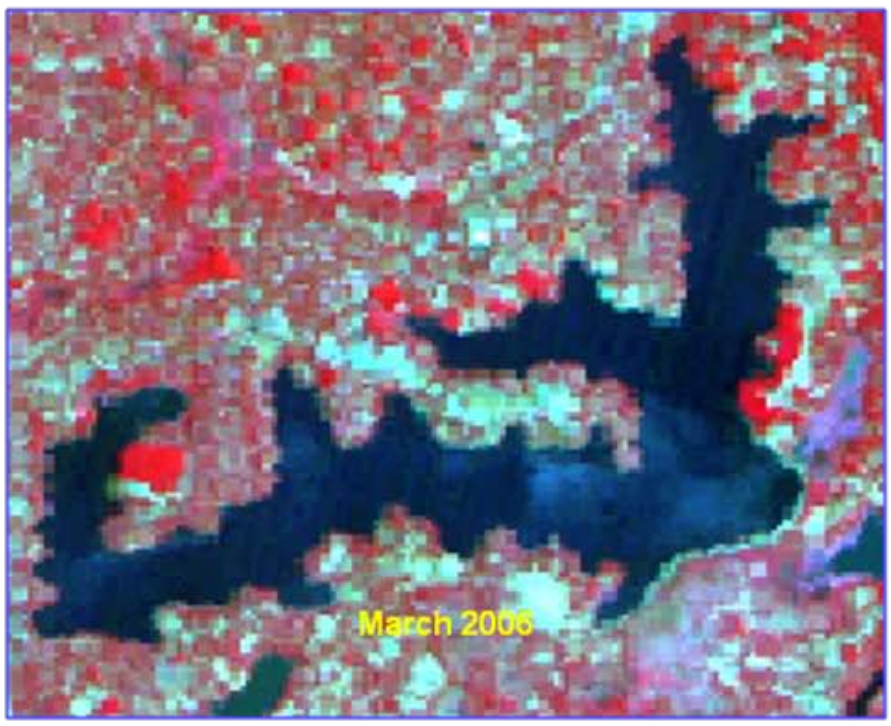
Ashtamudi Wetland

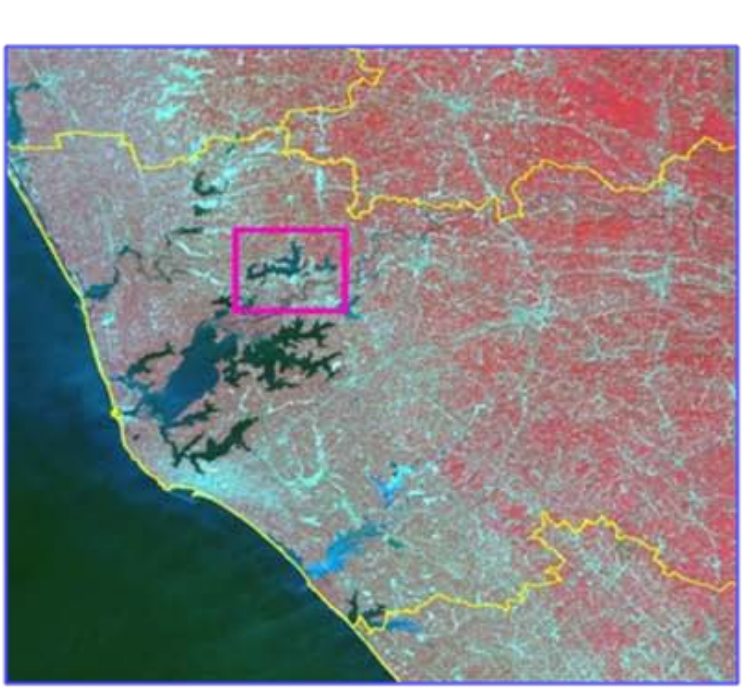
IRS P6 LISS-III post-monsoon data (2006)

Plate 6: IRS LISS-III FCC - 5 km buffer area of Ashtamudi wetland

9.2 Sasthamkotta Lake

Name: Sasthamkotta Lake
Location:
Latitude : 9º 1′ 35" N to 9º 3′ 17" N
Longitude: 76º 36′ 42" E to 76º 38′ 41" E
Located in Kollam district and thirty kilometers away from Kollam town.
Area: 354 ha
Wetland type: Lake
Average Annual Rainfall:
2540 mm, mostly occurring during June to September
Description:
Declared as Ramsar site on *19/08/02*. The water contains no common salts or other minerals and supports no water plants; a larva called "cavaborus" abounds and eliminates bacteria in the water, thus contributing to its exceptional purity. Overall turbidity is low.
Largest rain-fed, freshwater lake in Kerala. The lake is surrounded by hills on all sides, except the south where a bund has been constructed. The average depth is 6.8 m and maximum depth is 15.2 m. The lake provides drinking water to the people in its environs.
Fauna and Flora:
27 species of freshwater fishes include pearl spot {*Etroplus suratensis*} and catfish, two genera of prawns, 21 species of herrings and sardines of the family Clupeidae. The Common Teal or dabbling duck is the smallest migartory bird found in the lake. The insectivorous plant, *Drosera sp.* is found on the eastern shore of the lake.
Principal Vegetation:
Vegetation is very scant, floating and rooted plants are negligible.





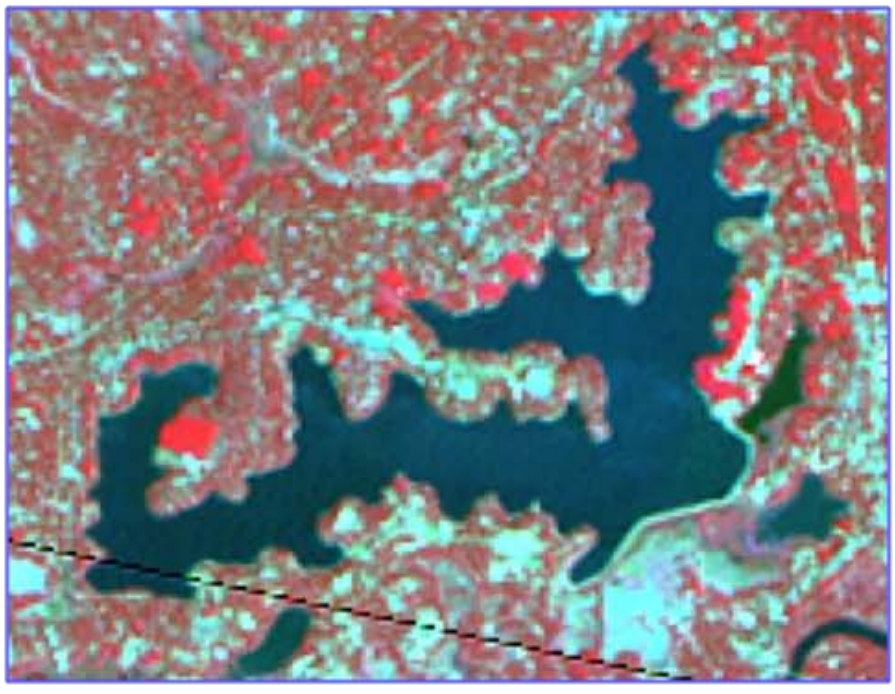
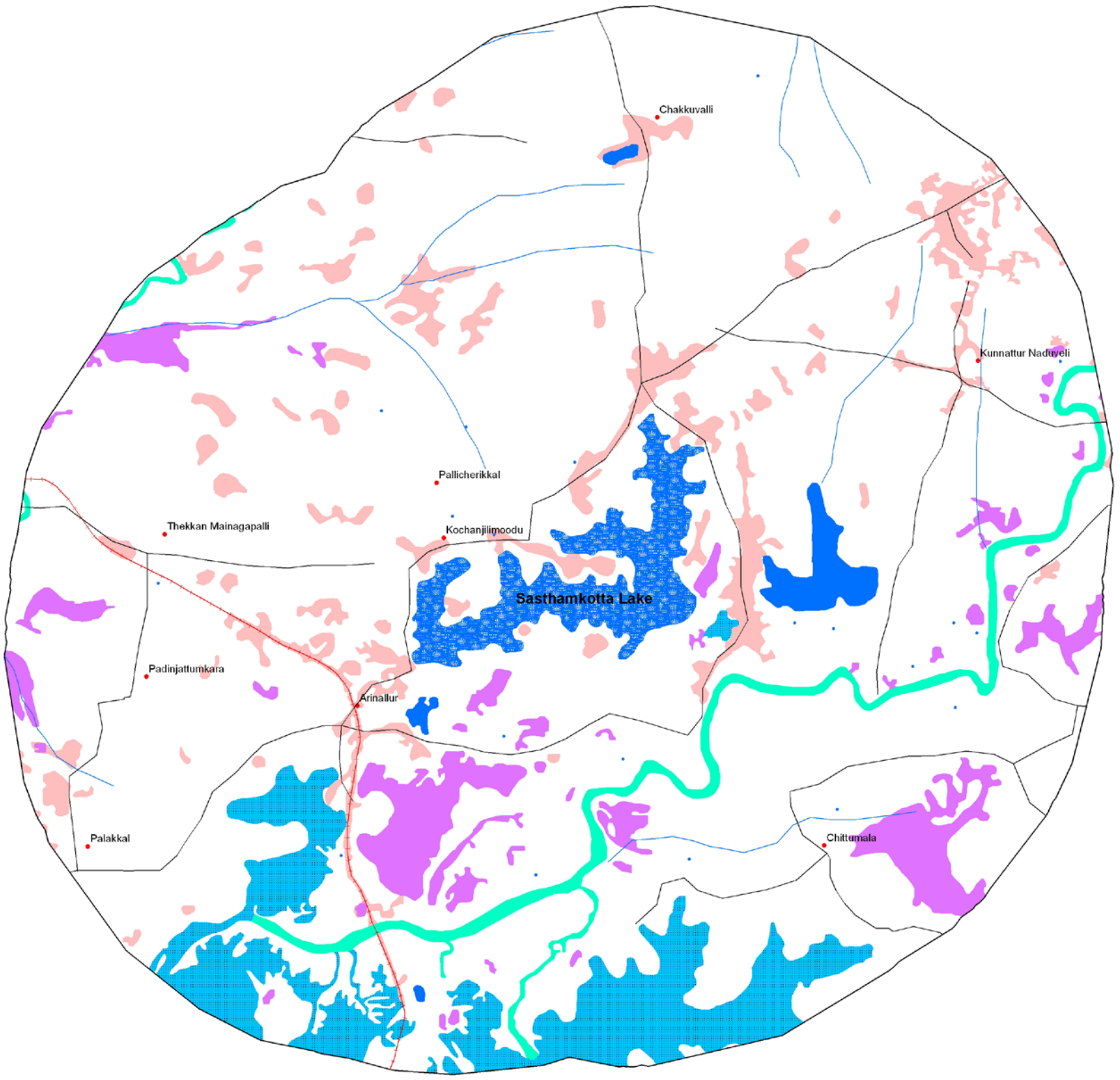


Plate 7: Sasthamkotta Lake

State : Kerala

WETLAND MAP

Sasthamkotta Lake

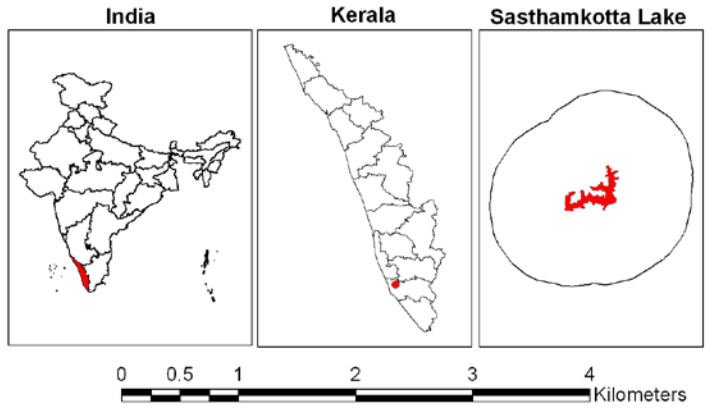


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary
- 5 km buffer area

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

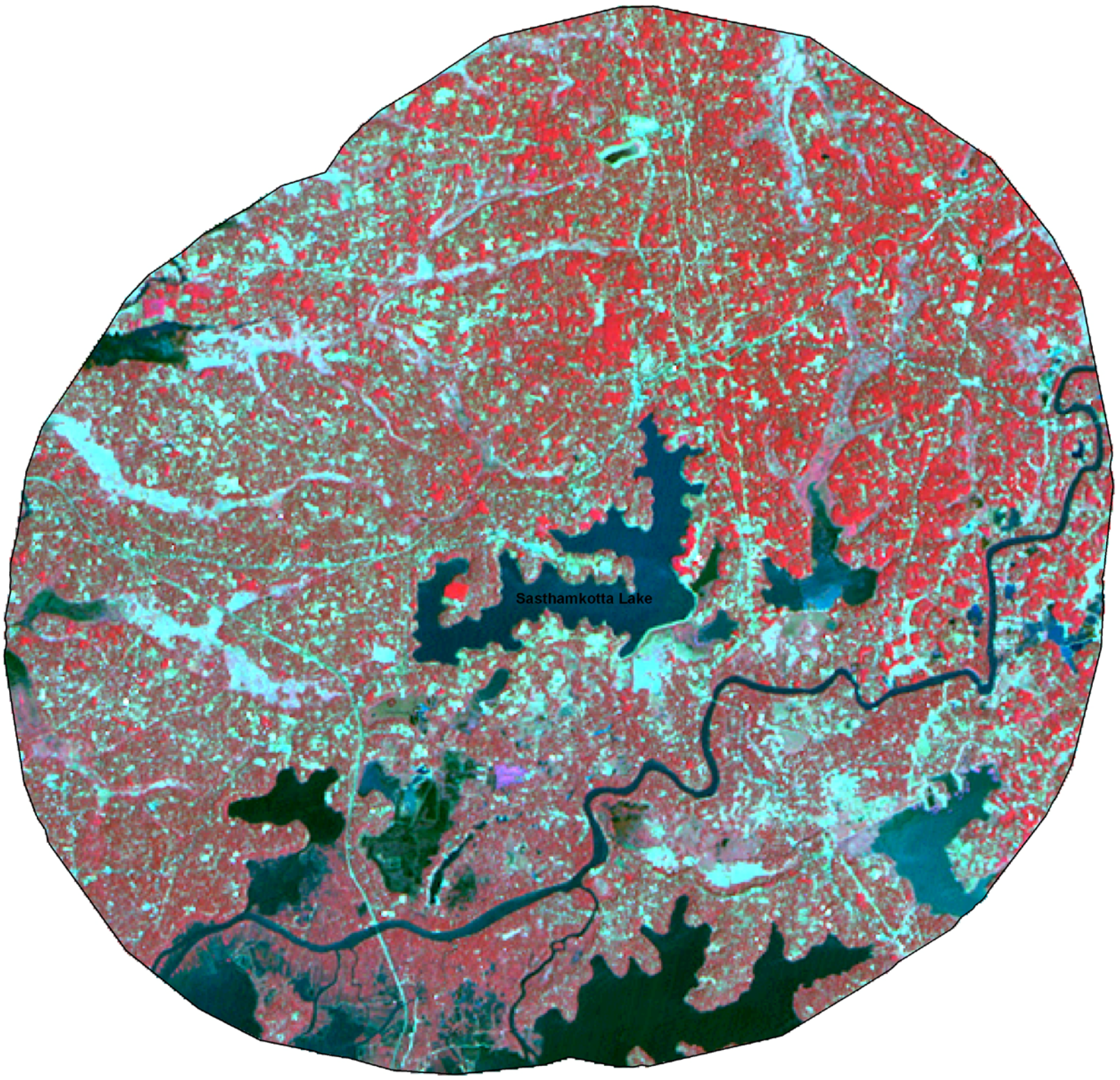
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 8: Wetland map - 5 km buffer area of Sasthamkotta Lake

State : Kerala

Sasthamkotta Lake



IRS P6 LISS-III post-monsoon data (2006)

Plate 9: IRS LISS-III FCC - 5 km buffer area of Sasthamkotta Lake

9.3 Vembanad-kol Wetland

Name: Vembanad-kol Wetland
Location:
Latitude : 9º 30′ 40" N to 9º 50′ 27" N
Longitude: 76º 21′ 4" E to 76º 25′ 55" E
Located at the border of Alappuzha, Ernakulam and Kottayam districts.
Area: 23540 ha
Wetland type: Lagoon
Average Annual Rainfall:
2400 mm, mostly occurring during June to September
Description:
Declared as Ramsar sites on *19/08/02*. The largest brackish, humid tropical wetland ecosystem on the southwest coast of India, fed by 10 rivers and typical of large estuarine systems on the western coast, renowned for its clams and supporting the third largest waterfowl population in India during the winter months. Over 90 species of resident birds and 50 species of migratory birds are found in the Kol area. Flood protection for thickly-populated coastal areas of three districts of Kerala is considered a major benefit.
Kumarakom Bird Santuary is located around Vembanad Lake. Thaneermukkom salt barrier divides the lake into two parts-one with brackish water perennially and other with fresh water from rivers draining into the lake. The wetland support diverse fauna, including a large variety of fish, prawns and clams, reptiles and birds and provide a habitat for both anadromous and catadromous fish species.
Principal Vegetation: The major aquatic plants of the area are: *Eichhornia crassipes,Salvania molestsa, Nymphaea stellata, N. Nouchali, Hydrilla verticellata, Najas minor, Limnophila heterophyll*
Fauna: More than 20,000 waterfowls found and ideal habitat for shrimps
Turbidity of the lake water is low. Aquatic vegetation is present in post-monsoon and pre-monsoon season.

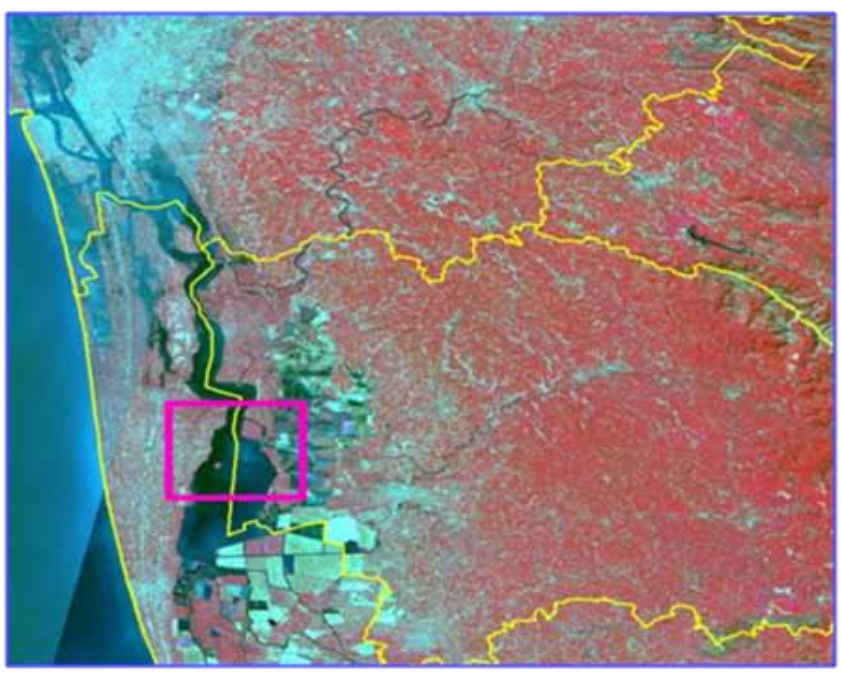
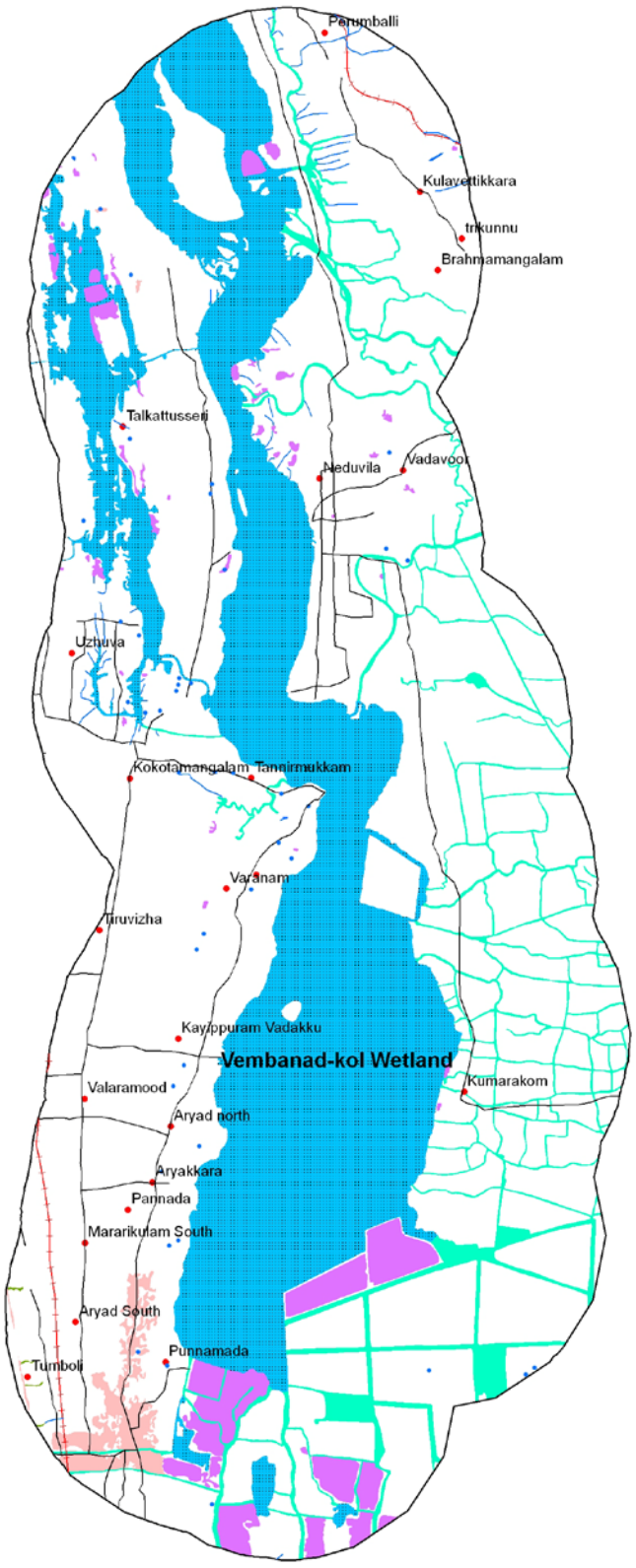


Plate 10: Vembanad-kol Wetland

State : Kerala

WETLAND MAP

Vembanad-kol Wetland

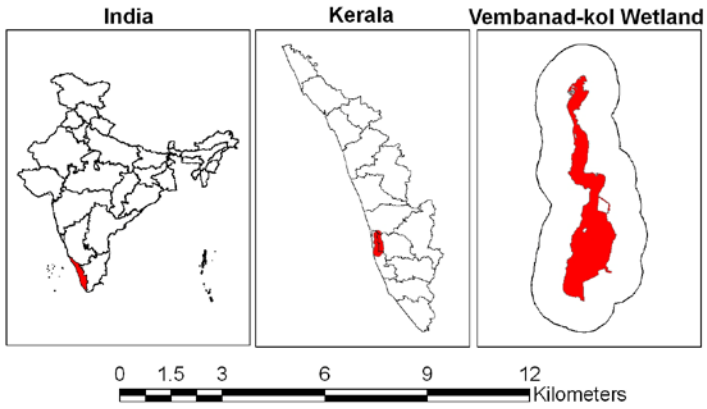


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary
- 5 km buffer area

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 11: Wetland map - 5 km buffer area of Vembanad-kol Wetland

State : Kerala

Vembanad-kol Wetland

IRS P6 LISS-III post-monsoon data (2006)

Plate 12: IRS LISS-III FCC - 5 km buffer area of Vembanad-kol Wetland

9.4 Parambikulam Dam

Name: Parambikilam Dam

Location:
Latitude : 10º 21´ 36“ N to 10º 24´ 31“ N
Longitude: 76º 45´ 51“ E to 76º 50´ 54“ E
Located in Palakkad district, Kerala

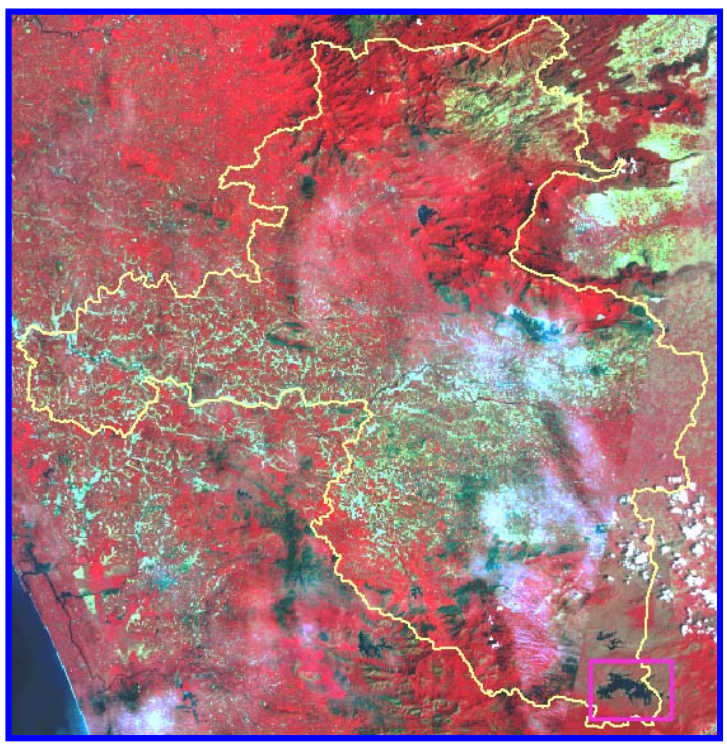
Area: 1762 ha

Wetland type: Reservoir

Average Annual Rainfall:
2590 mm, mostly occurring during June to September

Description:
The reservoir is located within the Parambikulam Wildlife Sanctuary. The terrain around the reservoir is hilly and the elevation varies from 459 m to 1439 m. The area was declared a Wildlife Sanctuary in 1962. The reservoir meets a part of the water needs of Tamil Nadu state.

The turbidity of lake water is low.



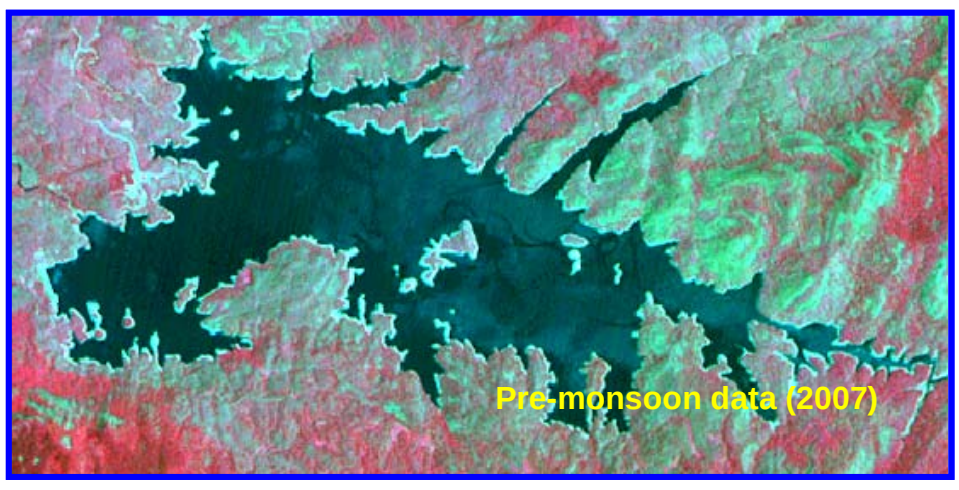
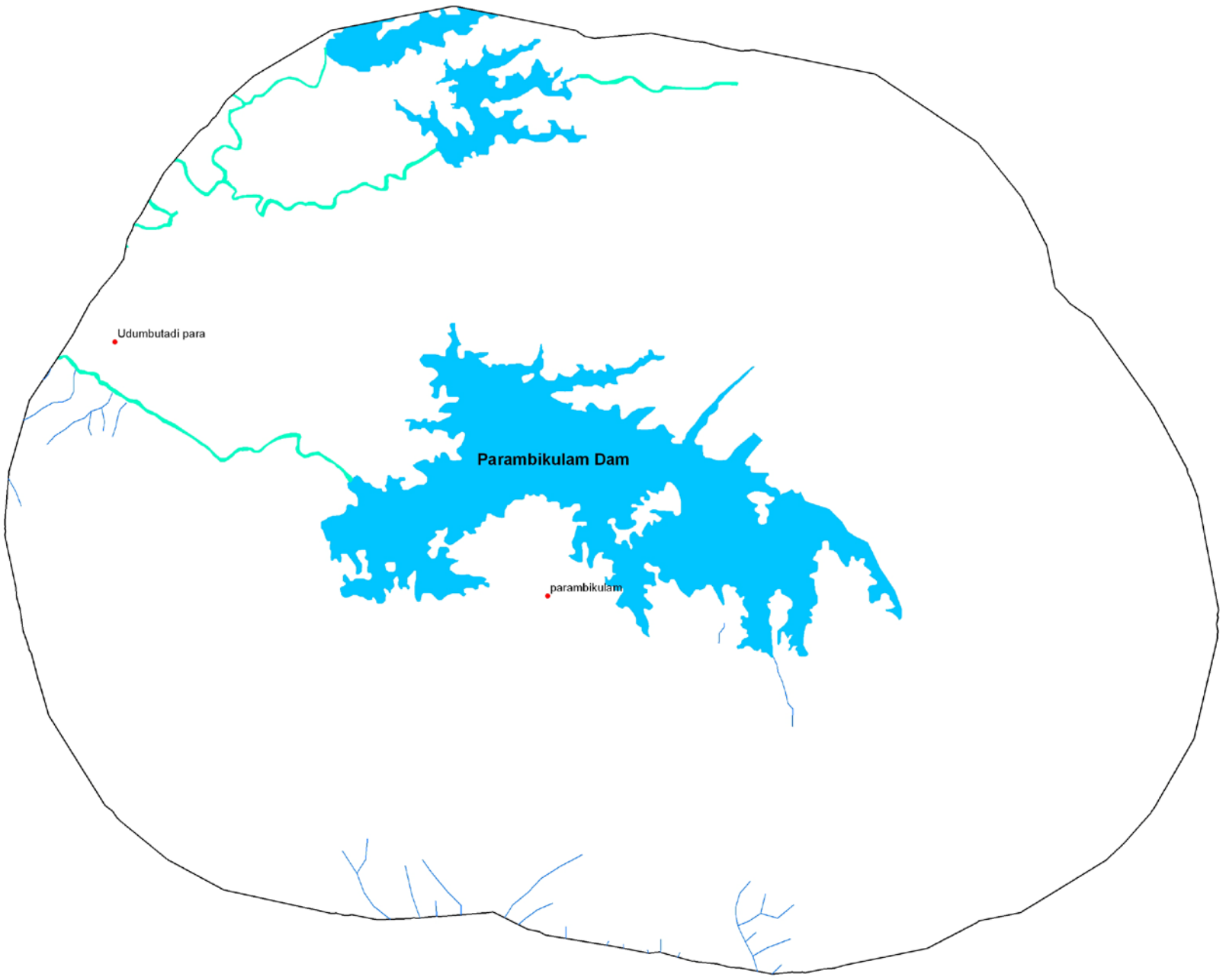


Plate 13: Parambikulam Dam

State : Kerala

WETLAND MAP

Parambikulam Dam

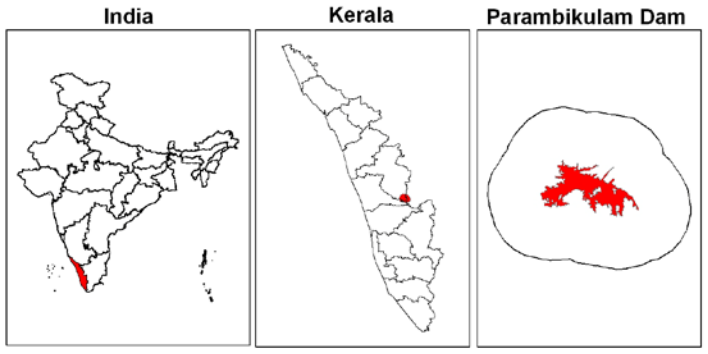


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary
- 5 km buffer area

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

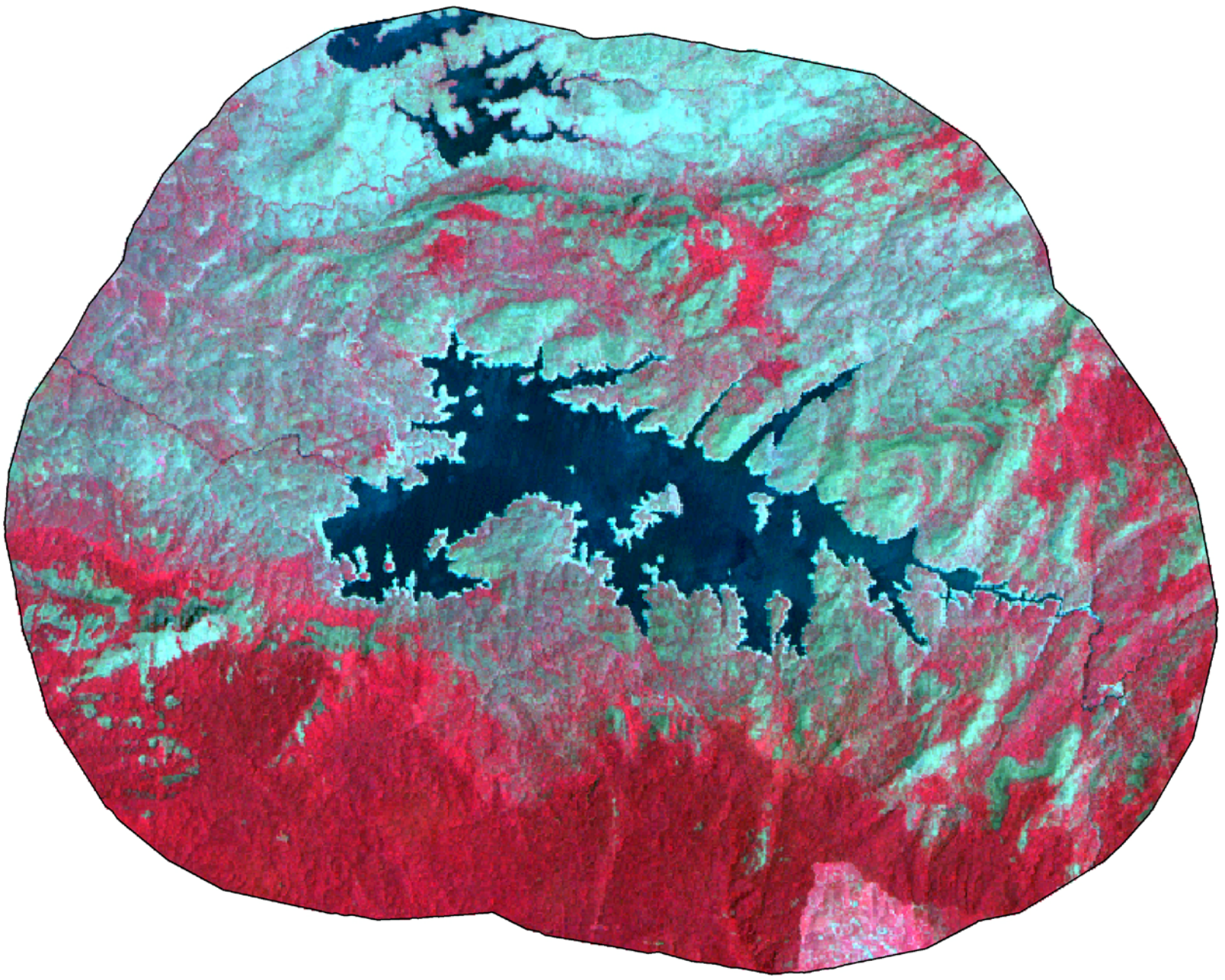
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 14: Wetland map - 5 km buffer area of Parambikulam

State : Kerala

Parambikulam Dam



IRS P6 LISS-III post-monsoon data (2006)

Plate 15: IRS LISS-III FCC - 5 km buffer area of Parambikulam Dam

9.5 Periyar Lake

Name: Periyar Lake

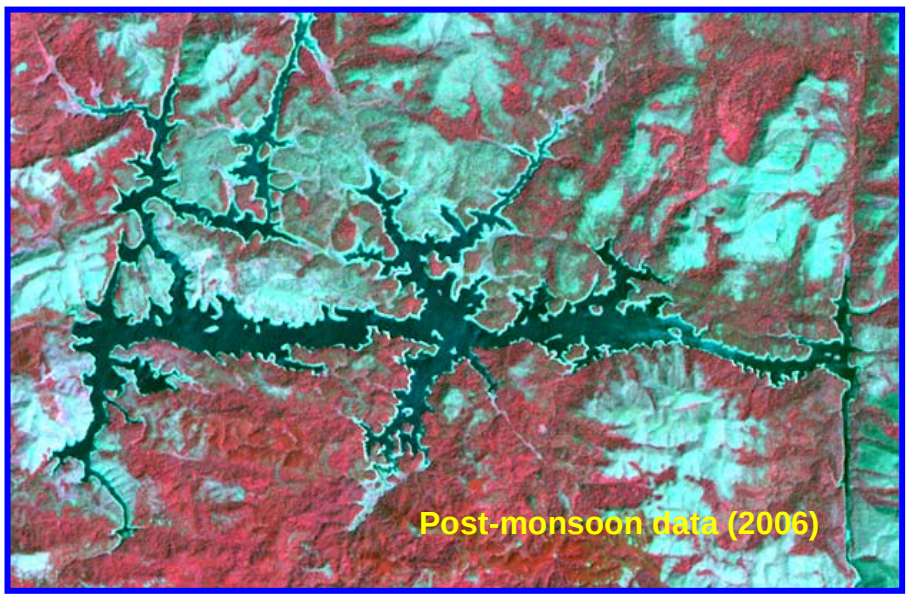
Location:
Latitude : 9º 28´ 35“ N to 9º 35´ 38“ N
Longitude: 77º 8´ 16“ E to 77º 17´ 20“ E
Located in Iddukki district in the Southern Ghats, Kerala

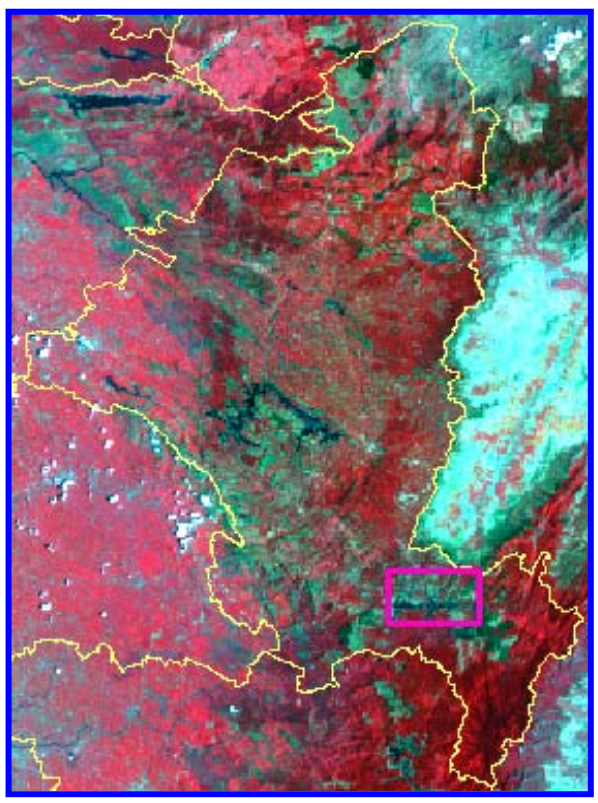
Area: 2041 ha

Wetland type: Reservoir

Average Annual Rainfall:
3000 mm, mostly occurring during June to September

Description:
A large water storage reservoir formed by a dam on the Periyar river. The reservoir receives inflow from numerous perennial creeks from the surrounding forests, and has a highly indented shoreline. The surrounding hills are covered in tropical evergreen and deciduous forest interspersed with areas of grassland and *Eucalyptus* plantations.
The Reservoir is protected in the Periyar Wildlife Sanctuary. There are excellent facilities for tourists, including a large hotel by the lake and another on an island; boats are available for wildlife viewing.
The turbidity of lake water is moderate.





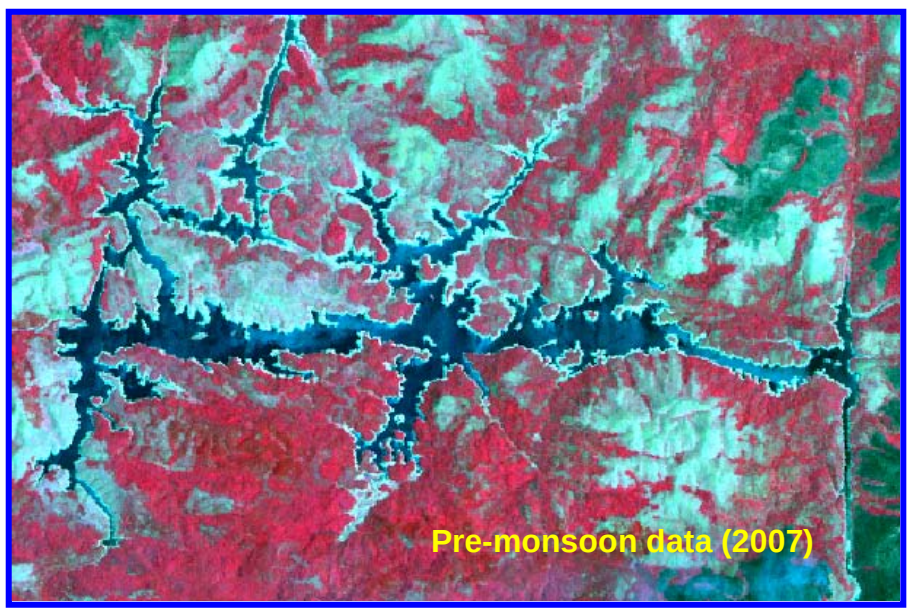
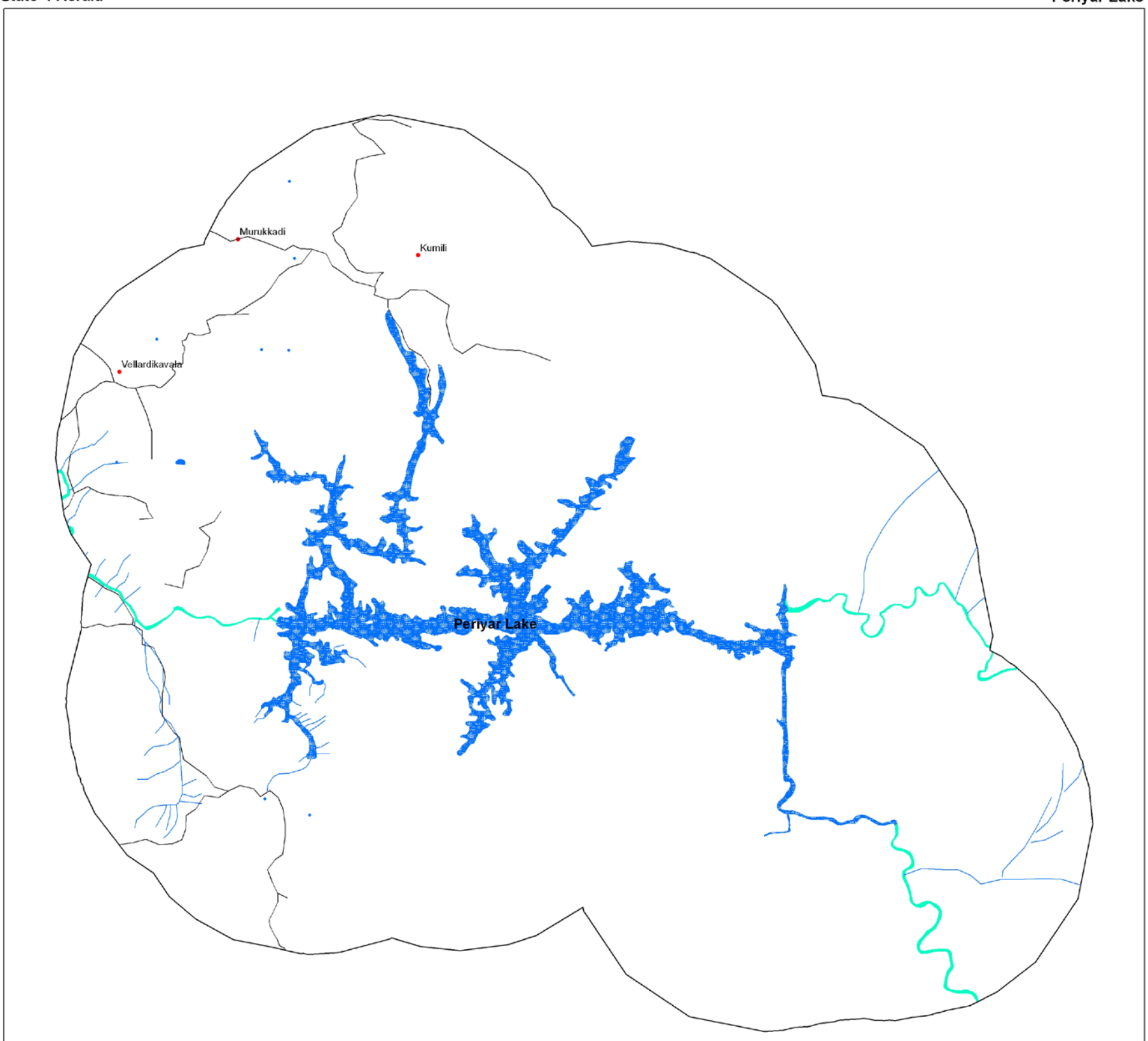


Plate 16: Periyar Lake

State : Kerala

WETLAND MAP

Periyar Lake

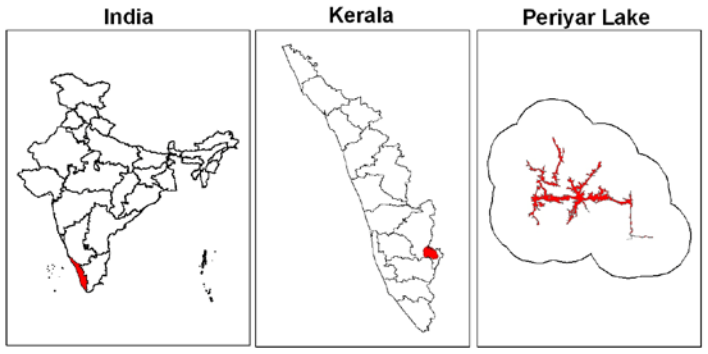


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25ha)
- Roads
- Railway
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary
- State boundary
- 5 km buffer area

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

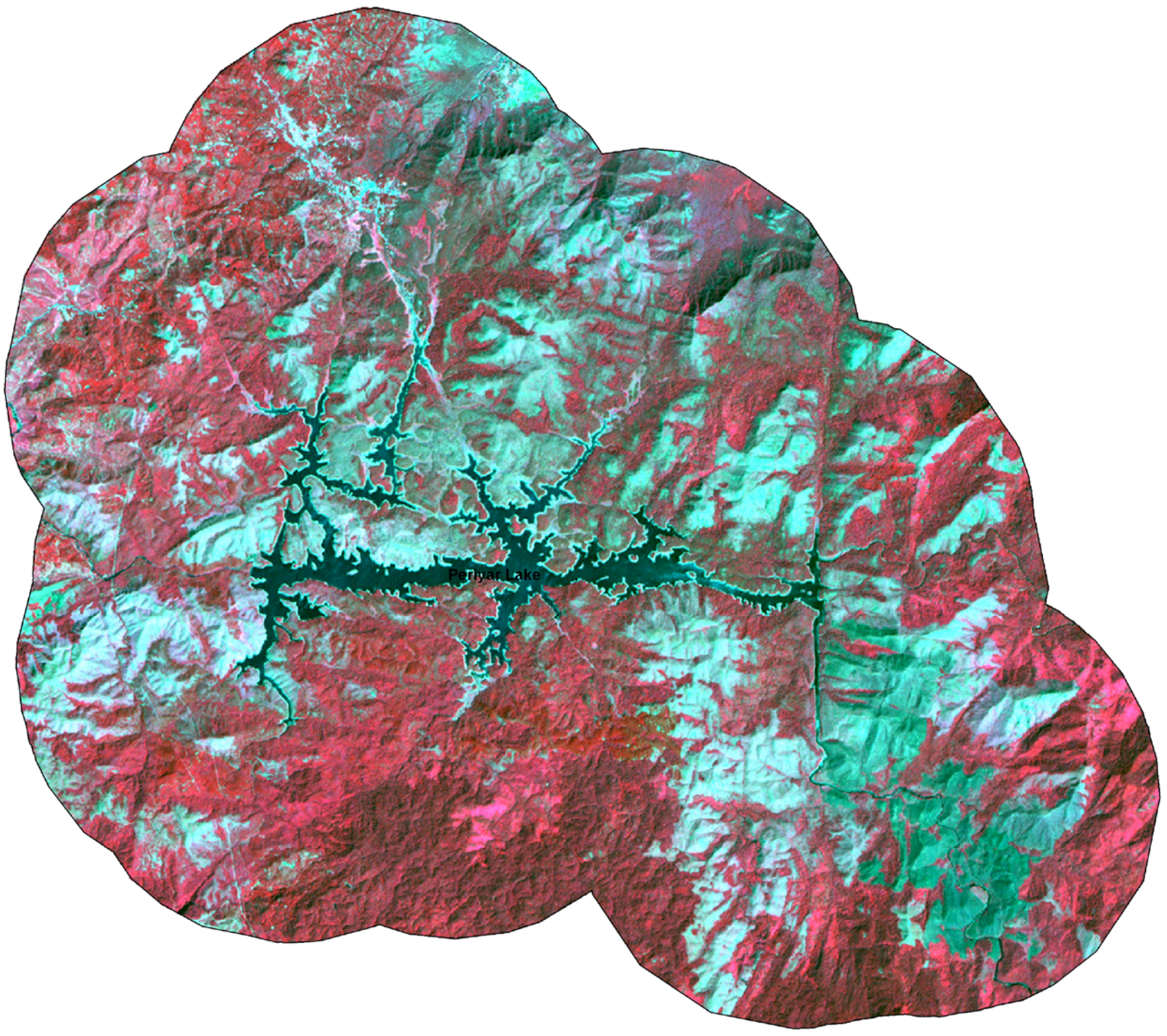
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 17: Wetland map - 5 km buffer area of periyar Lake

State : Kerala

Periyar Lake



IRS P6 LISS-III post-monsoon data (2006)

Plate 18: IRS LISS-III FCC - 5 km buffer area of periyar Lake

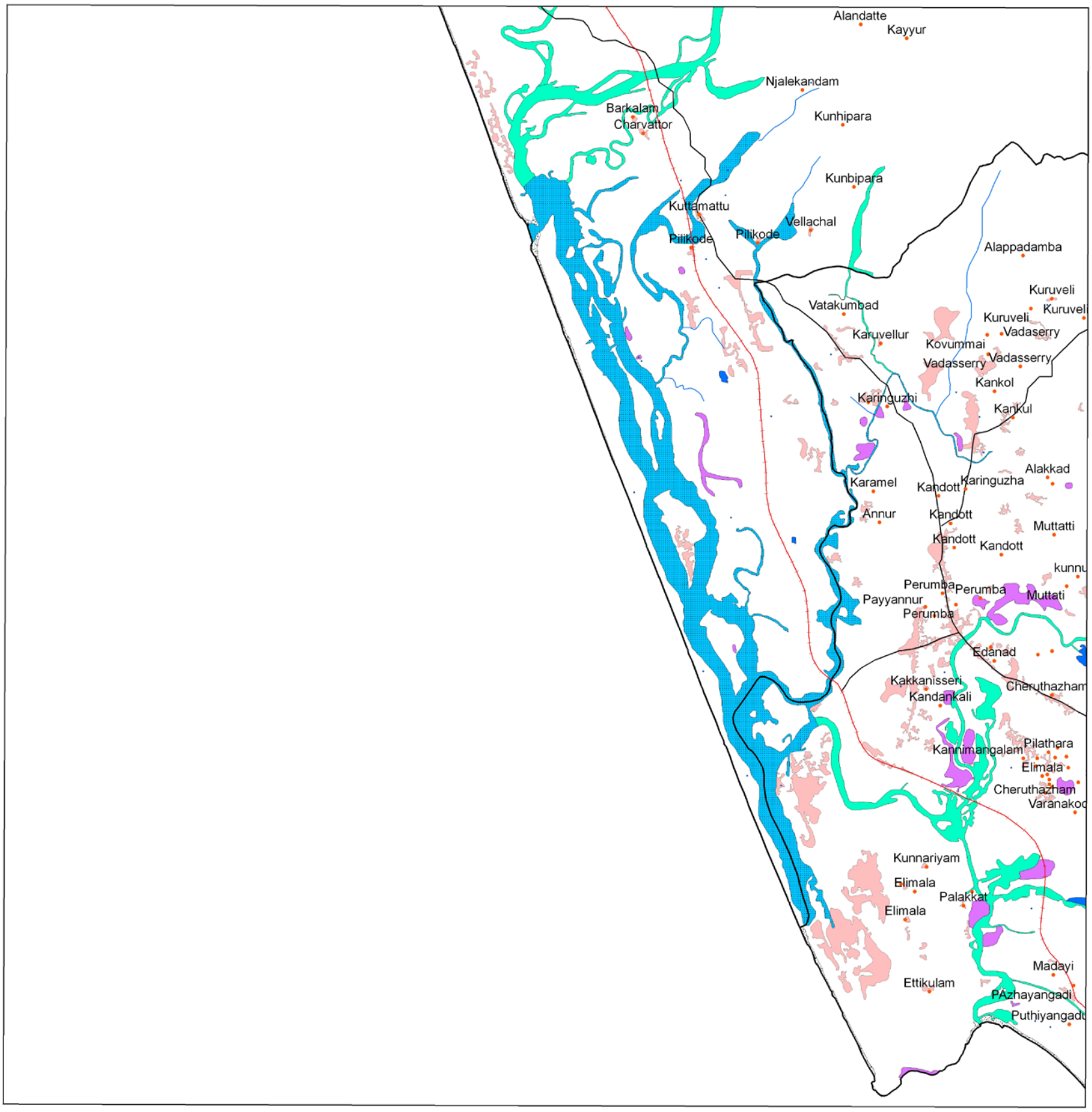
SOI MAP SHEET-WISE WETLAND MAPS

(Selected)

State : Kerala

WETLAND MAP

Map No. : 48P/4

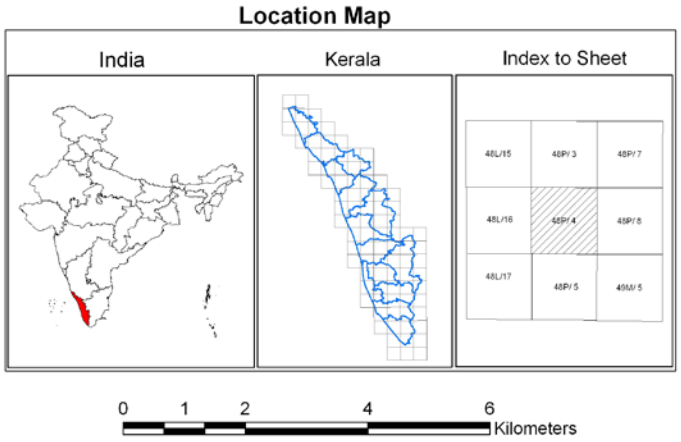


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

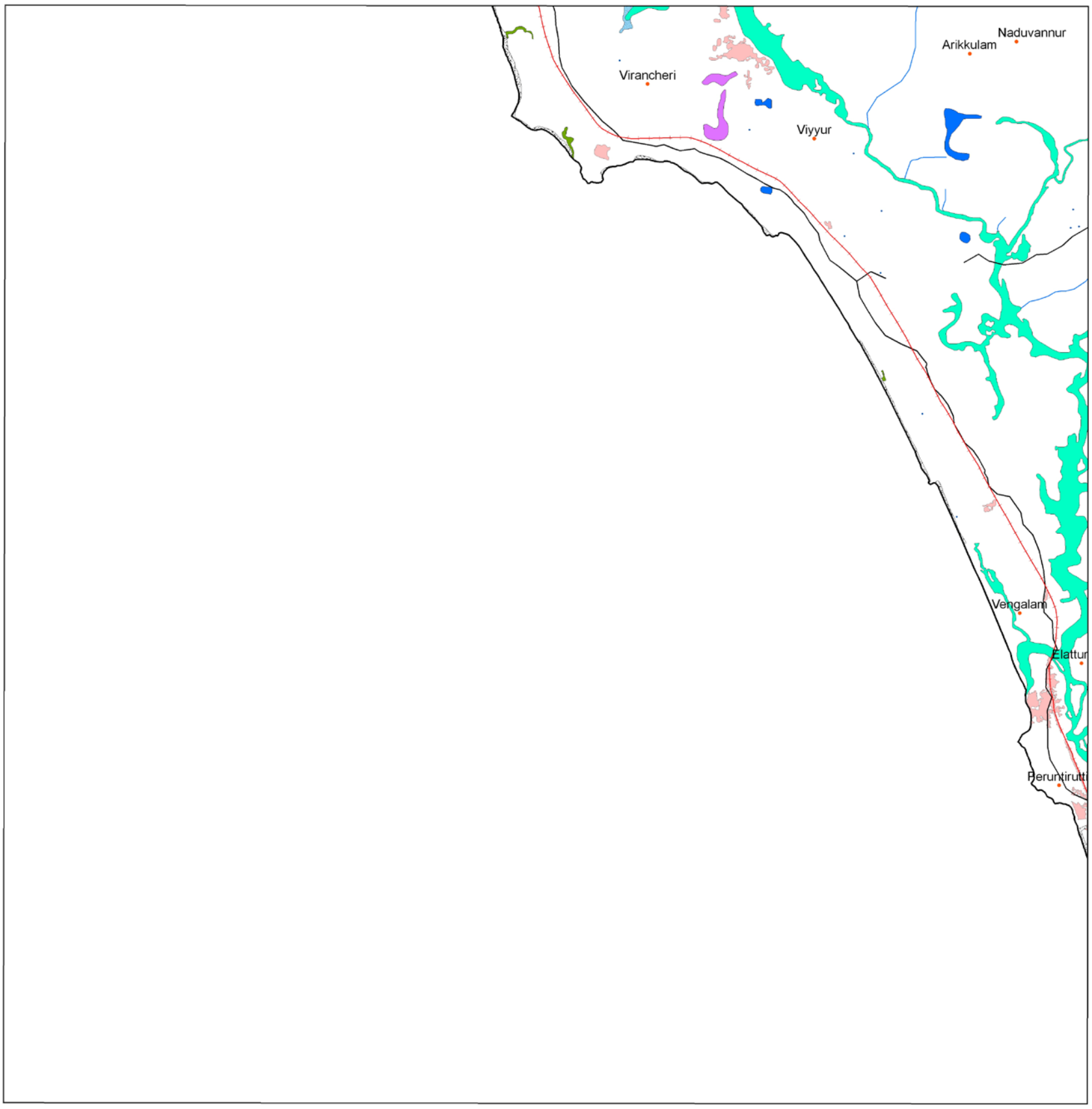
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

WETLAND MAP

Map No. : 49M/11

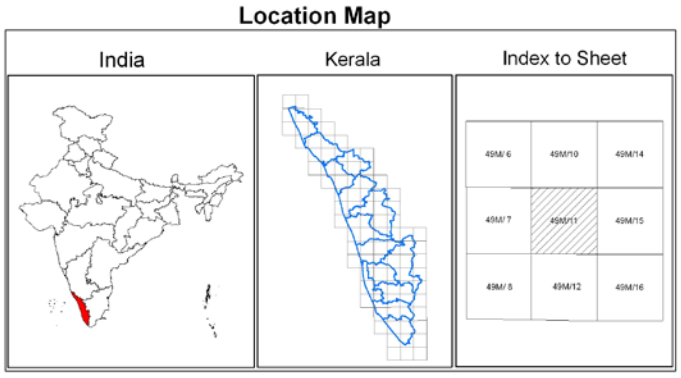


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

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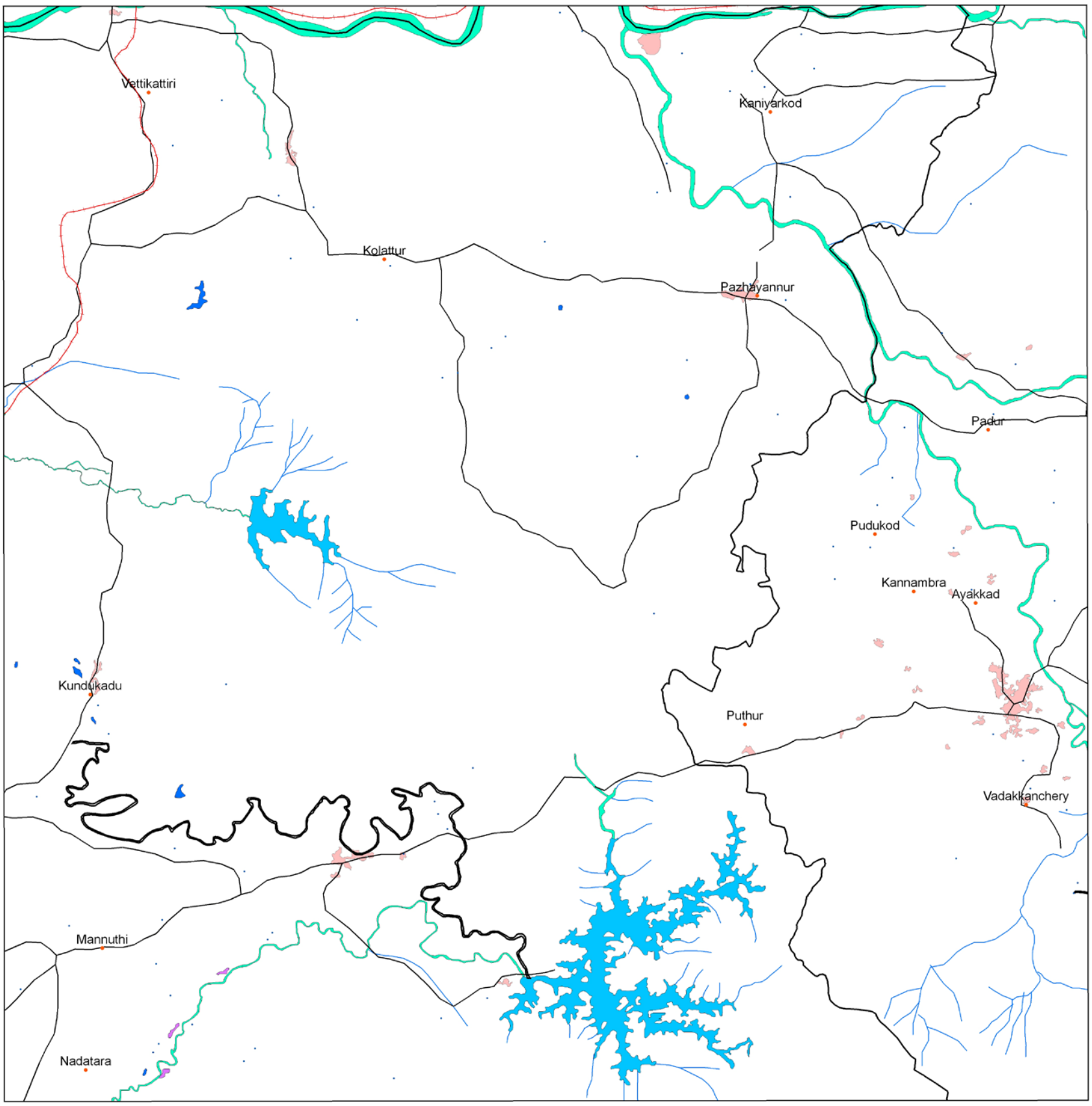
Government of India

State : Kerala

WETLAND MAP

Map No. : 58B/6

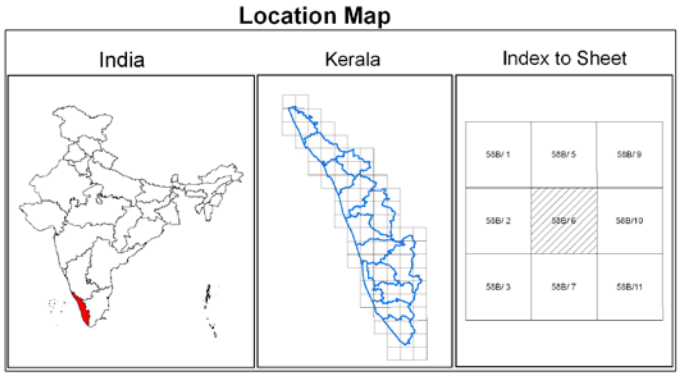


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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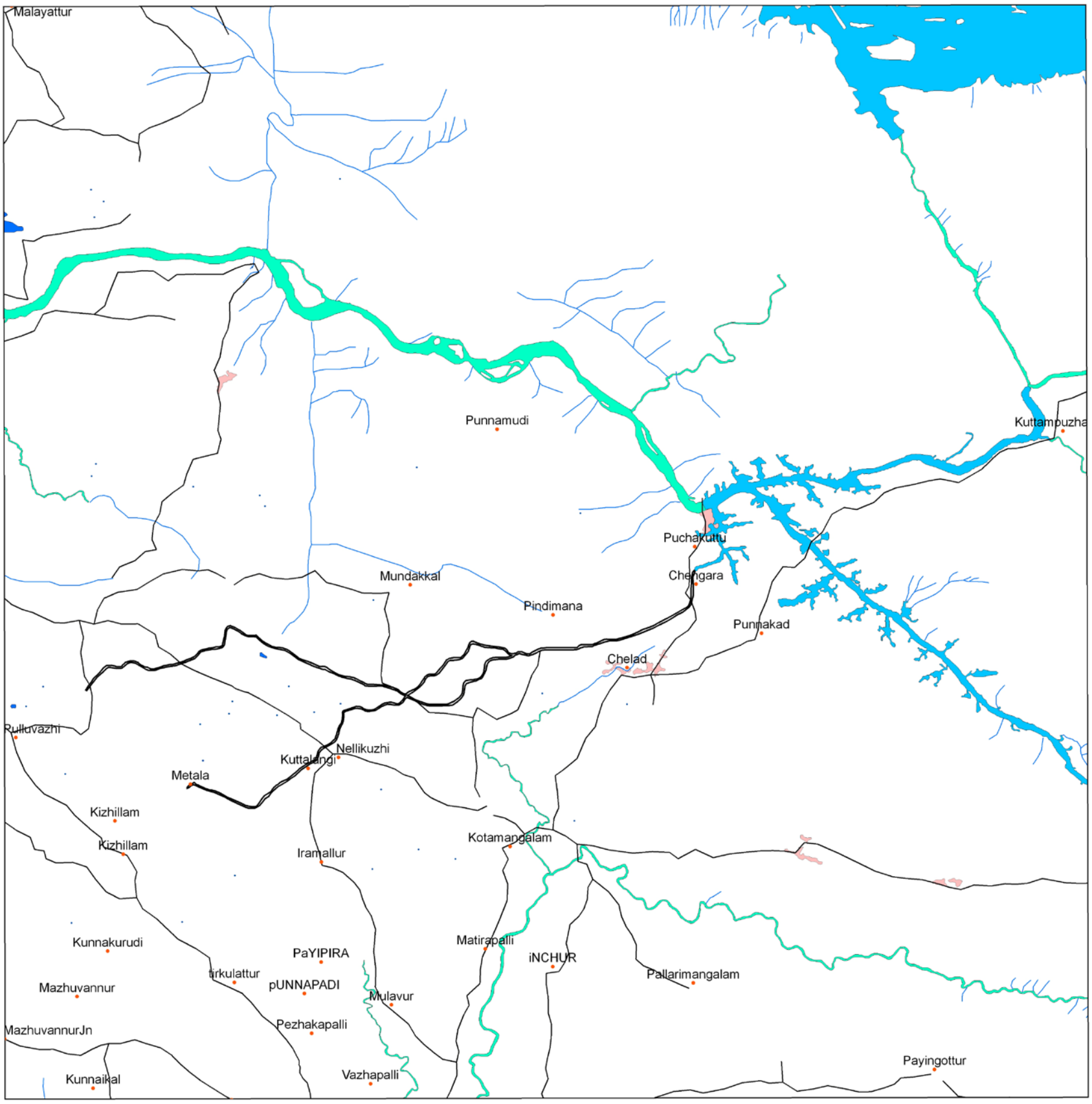
State : Kerala

WETLAND MAP

Map No. : 58B/12

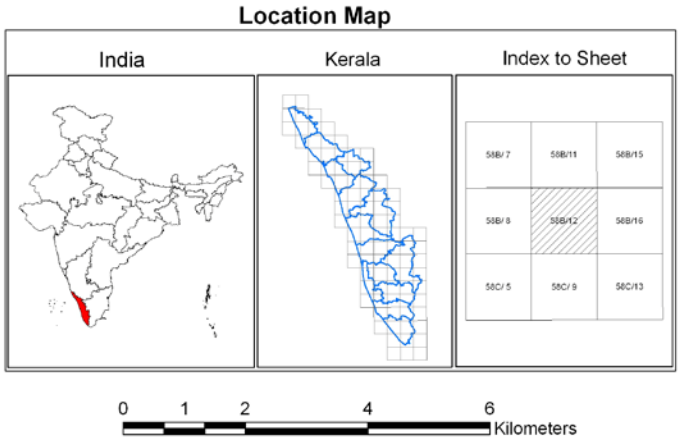


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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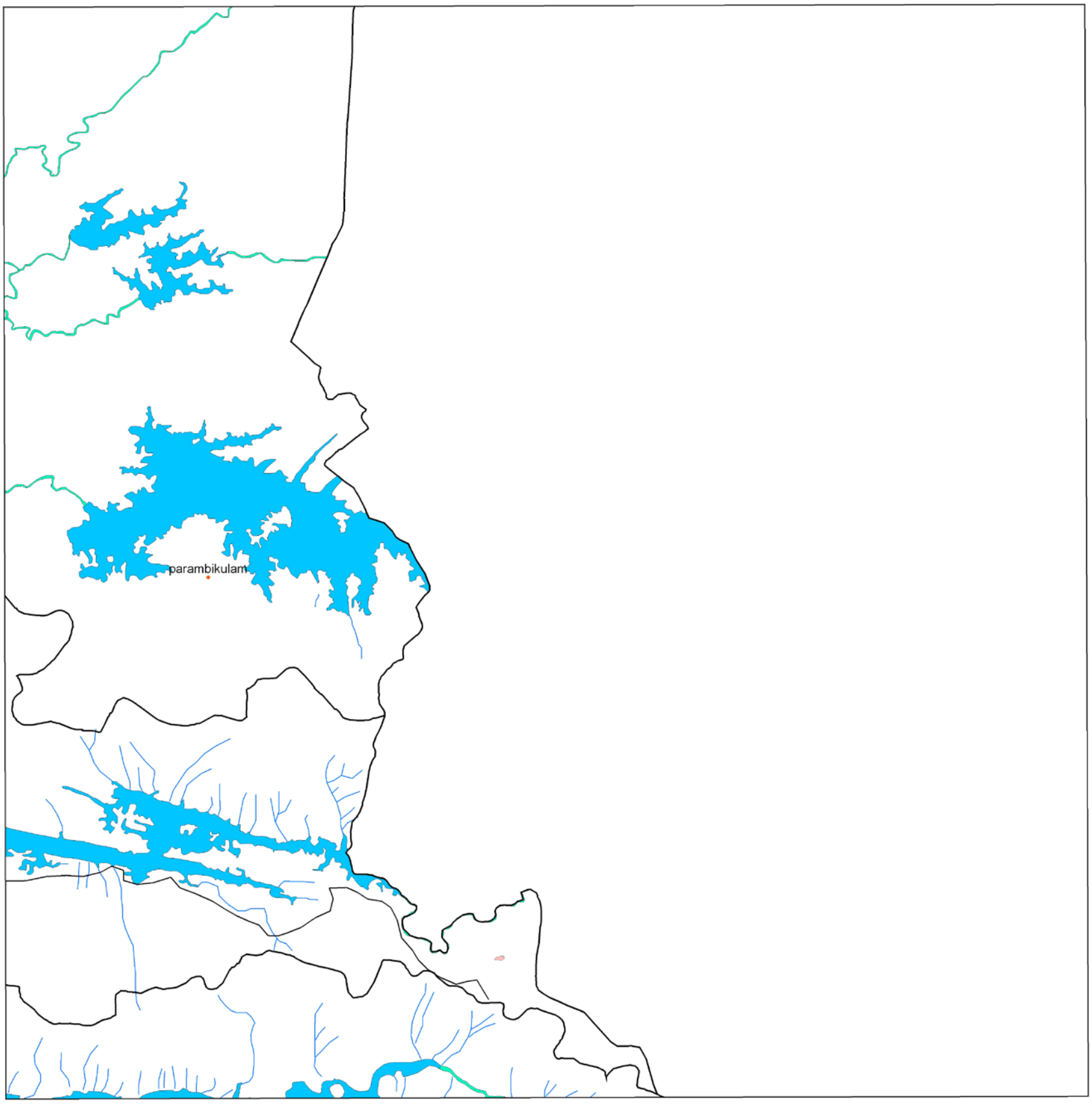
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

WETLAND MAP

Map No. : 58B/15

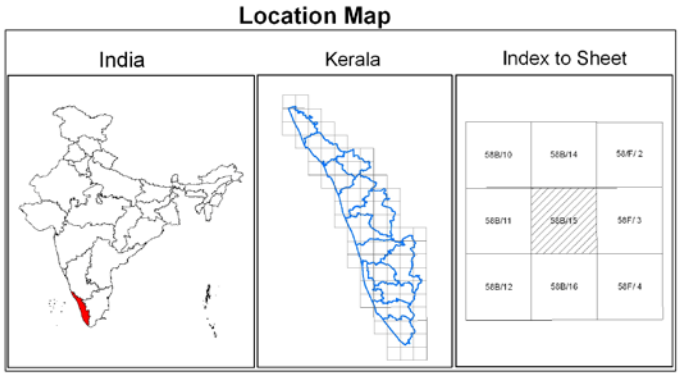


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



0 1 2 4 6 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

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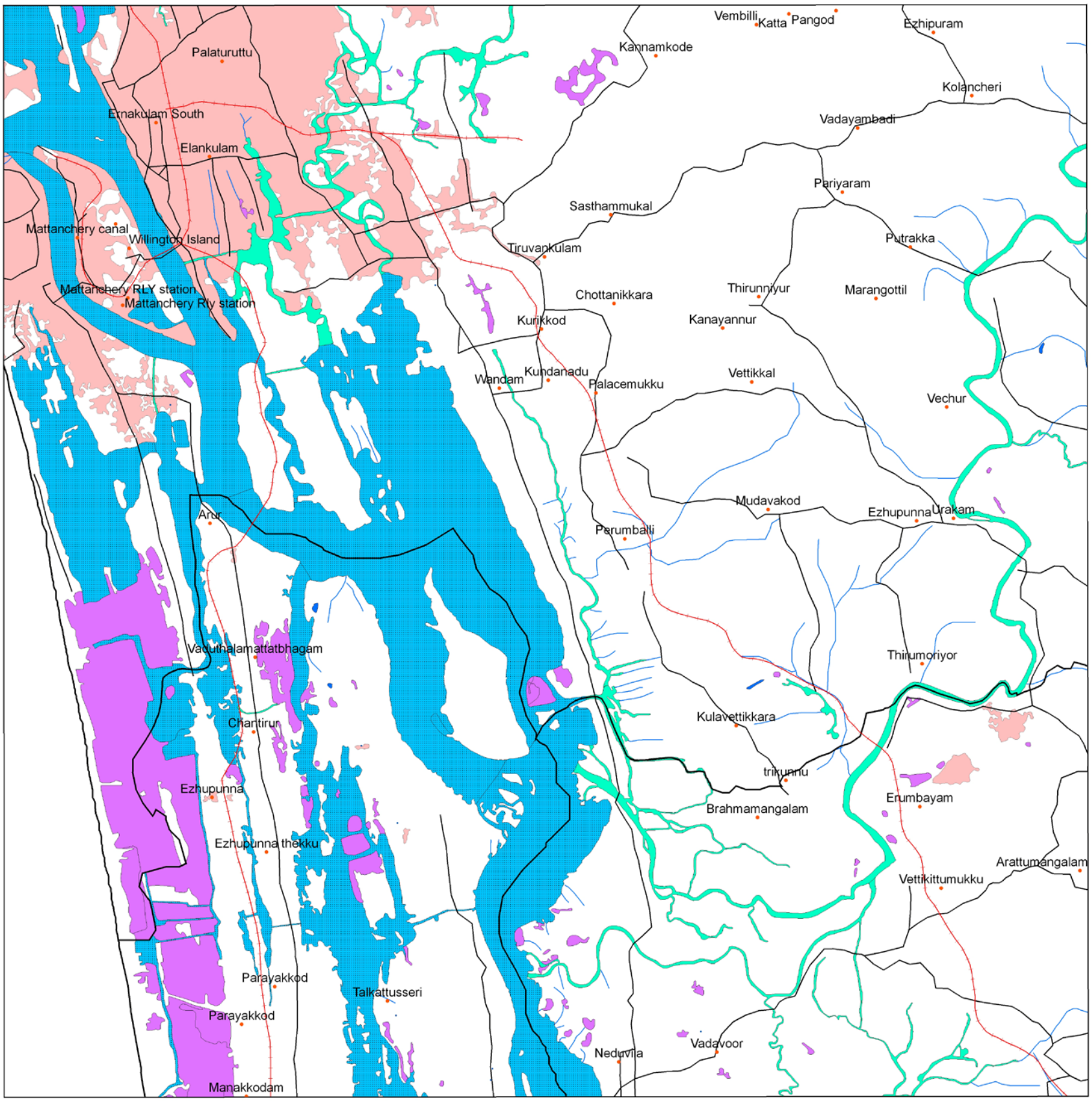
Ministry of Environment and Forests
Government of India

State : Kerala

WETLAND MAP

Map No. : 58C/5

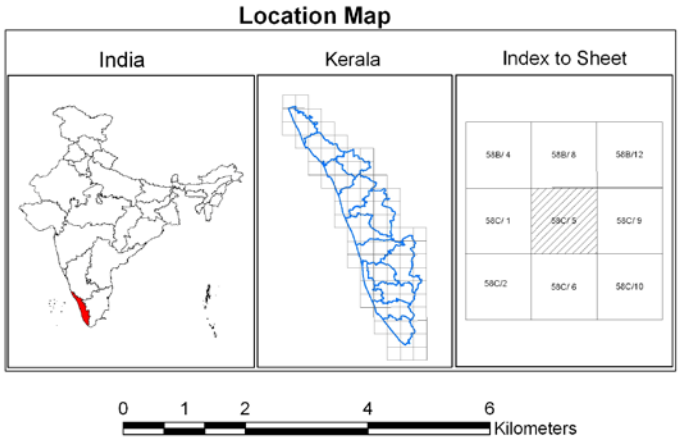


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

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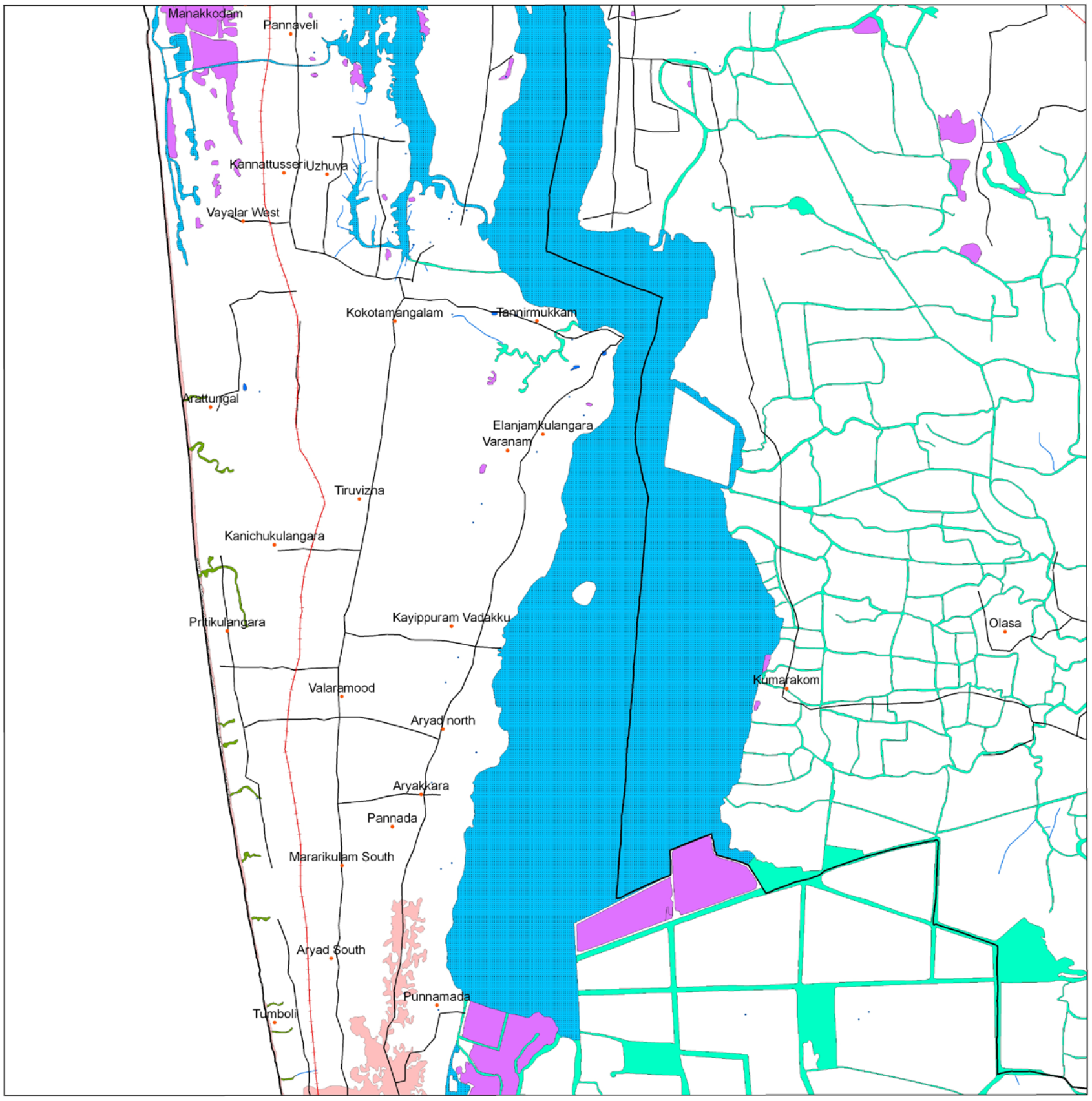
Government of India

State : Kerala

WETLAND MAP

Map No. : 58C/6

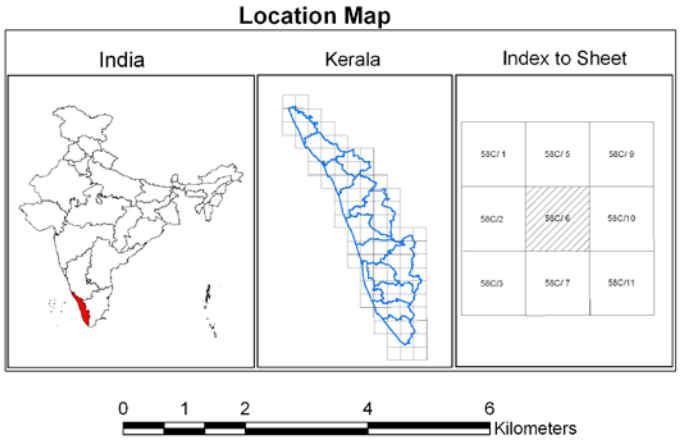


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

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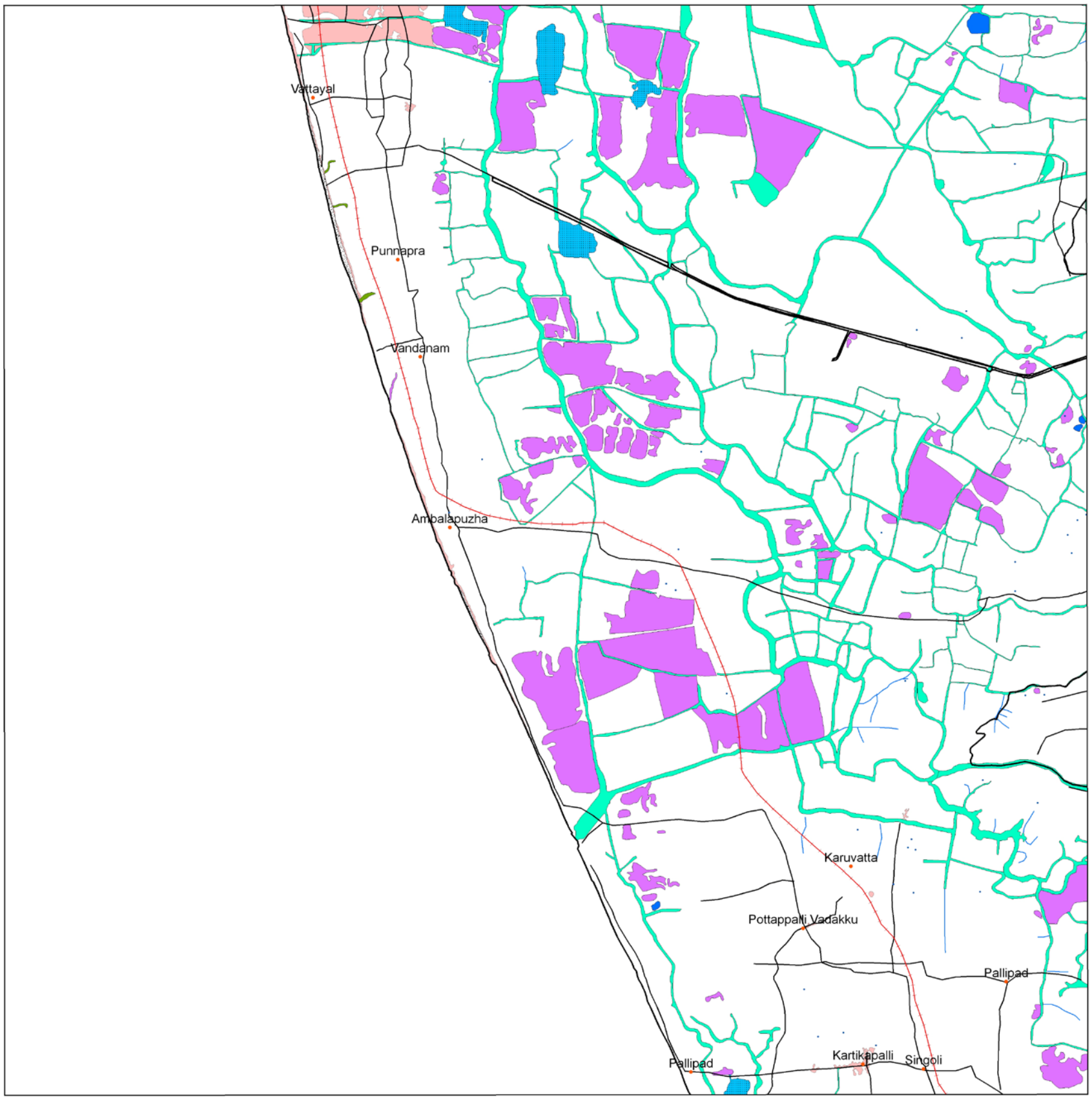
Government of India

State : Kerala

WETLAND MAP

Map No. : 58C/7

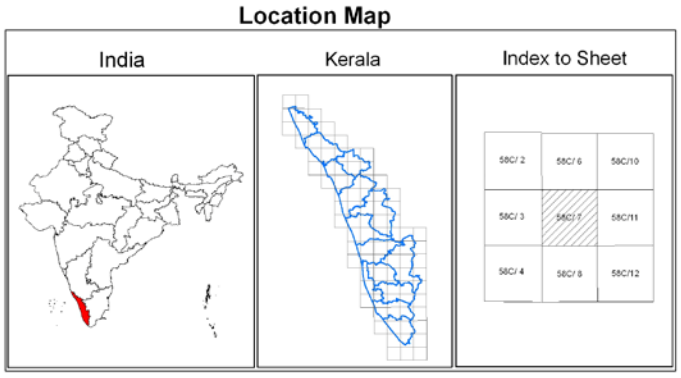


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



0 1 2 4 6 Kilometers

Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

Sponsored By:

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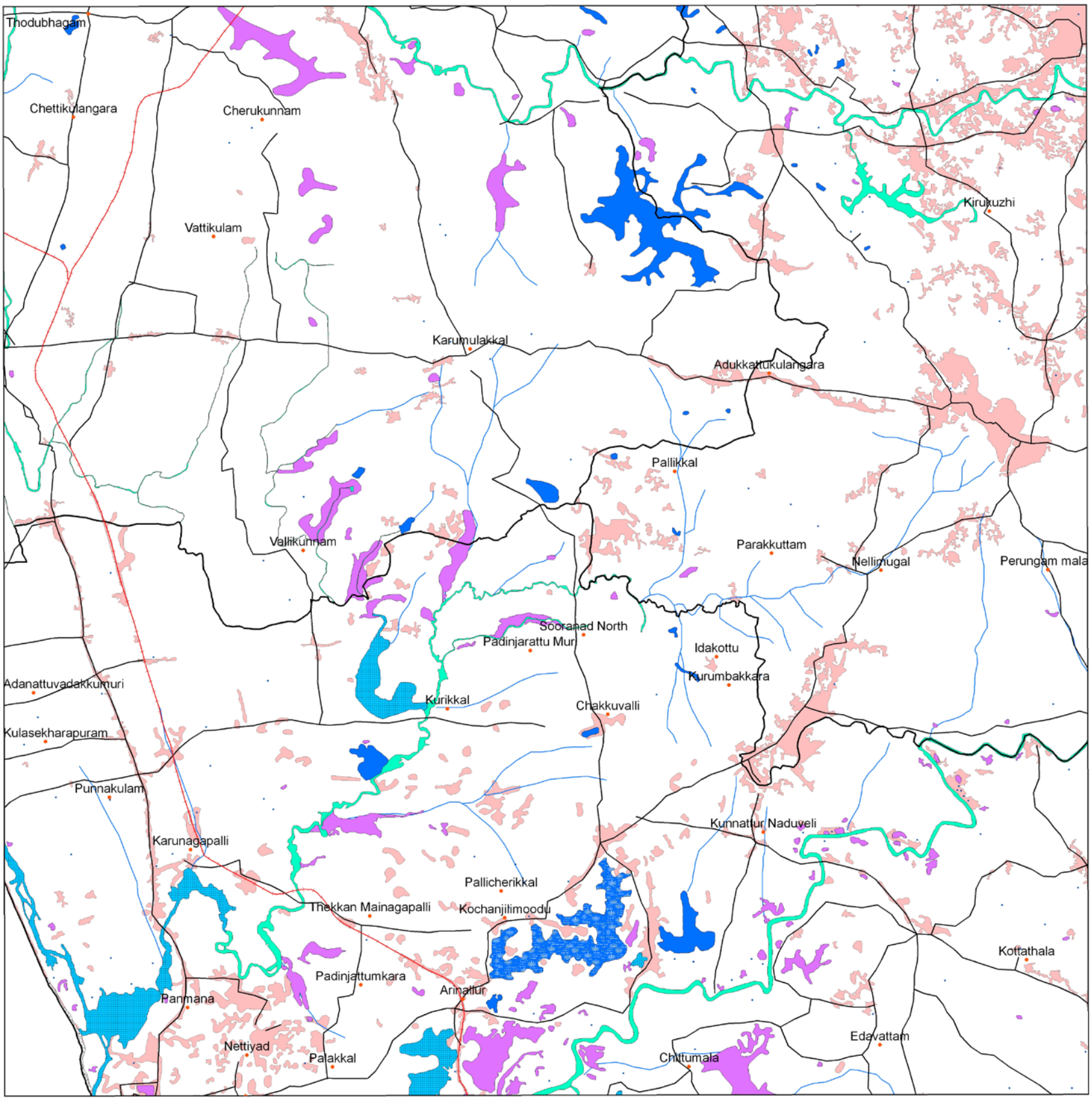
Government of India

State : Kerala

WETLAND MAP

Map No. : 58C/12

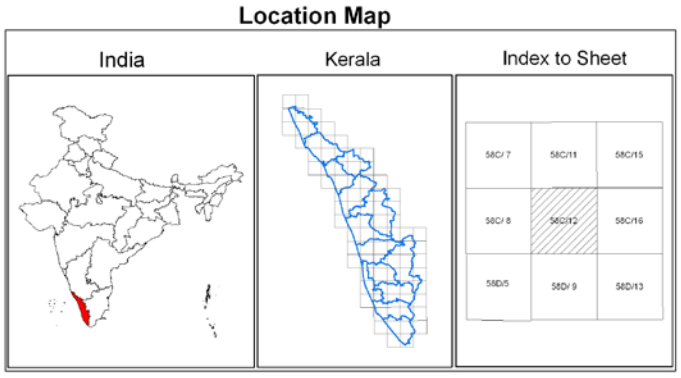


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

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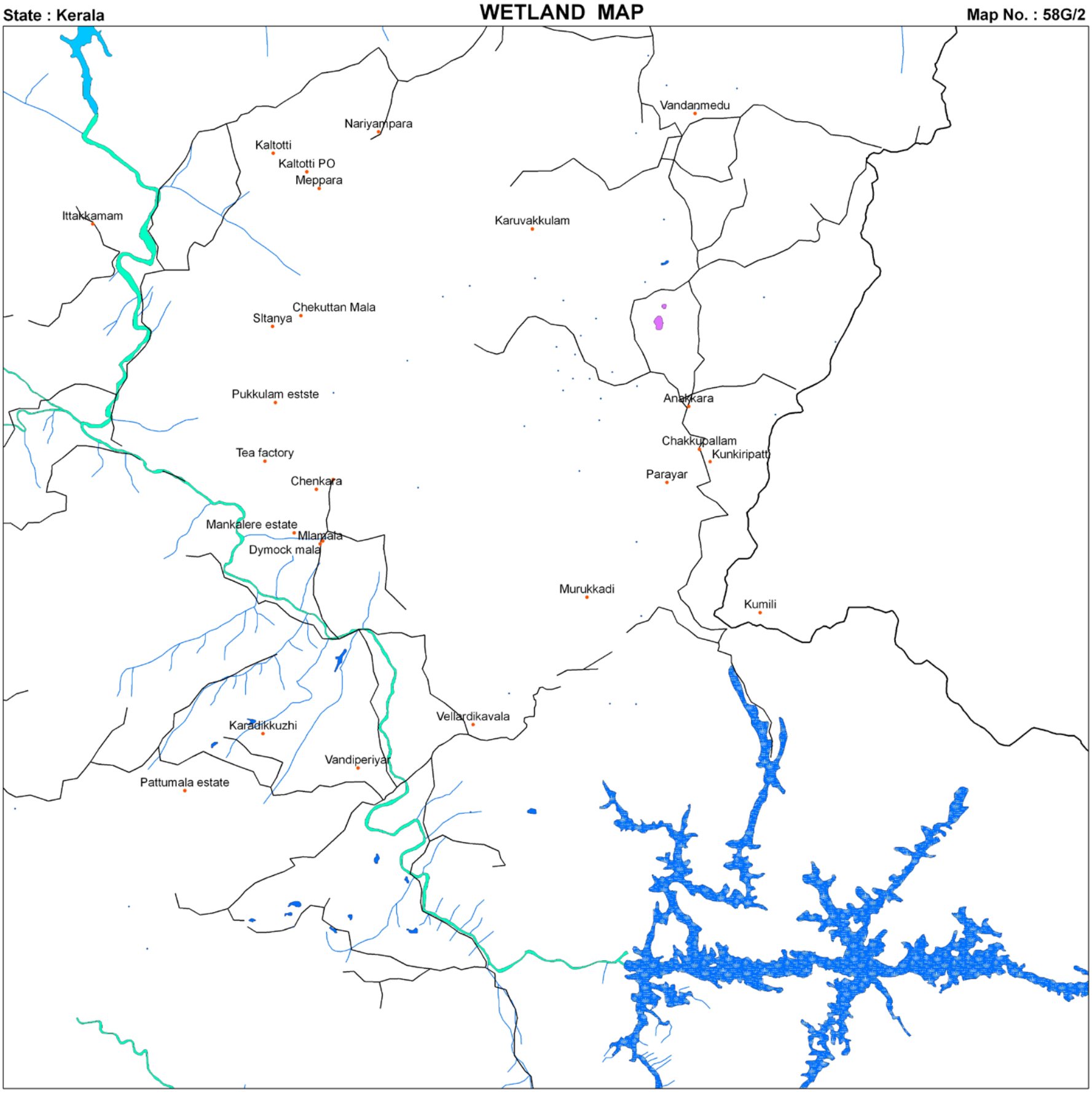
Government of India

State : Kerala

WETLAND MAP

Map No. : 58G/2

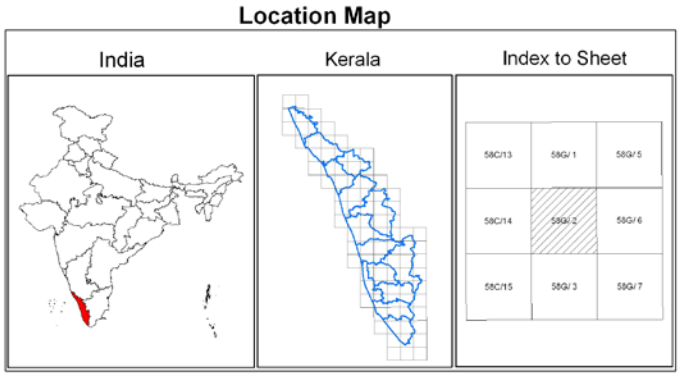


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

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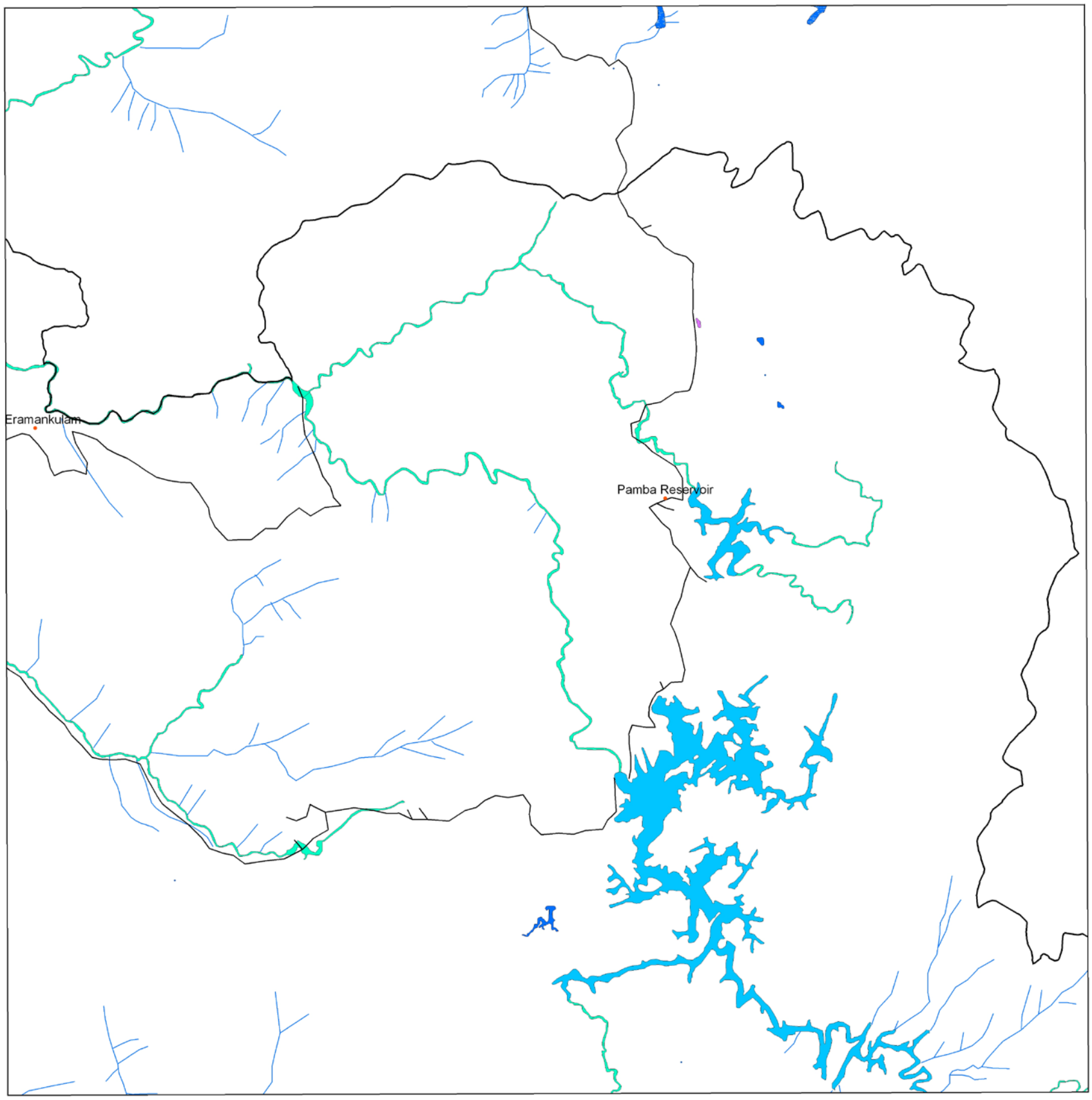
Ministry of Environment and Forests
Government of India

State : Kerala

WETLAND MAP

Map No. : 58G/3

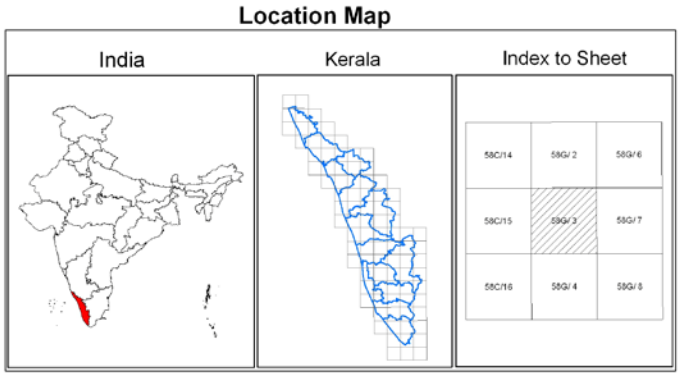


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram

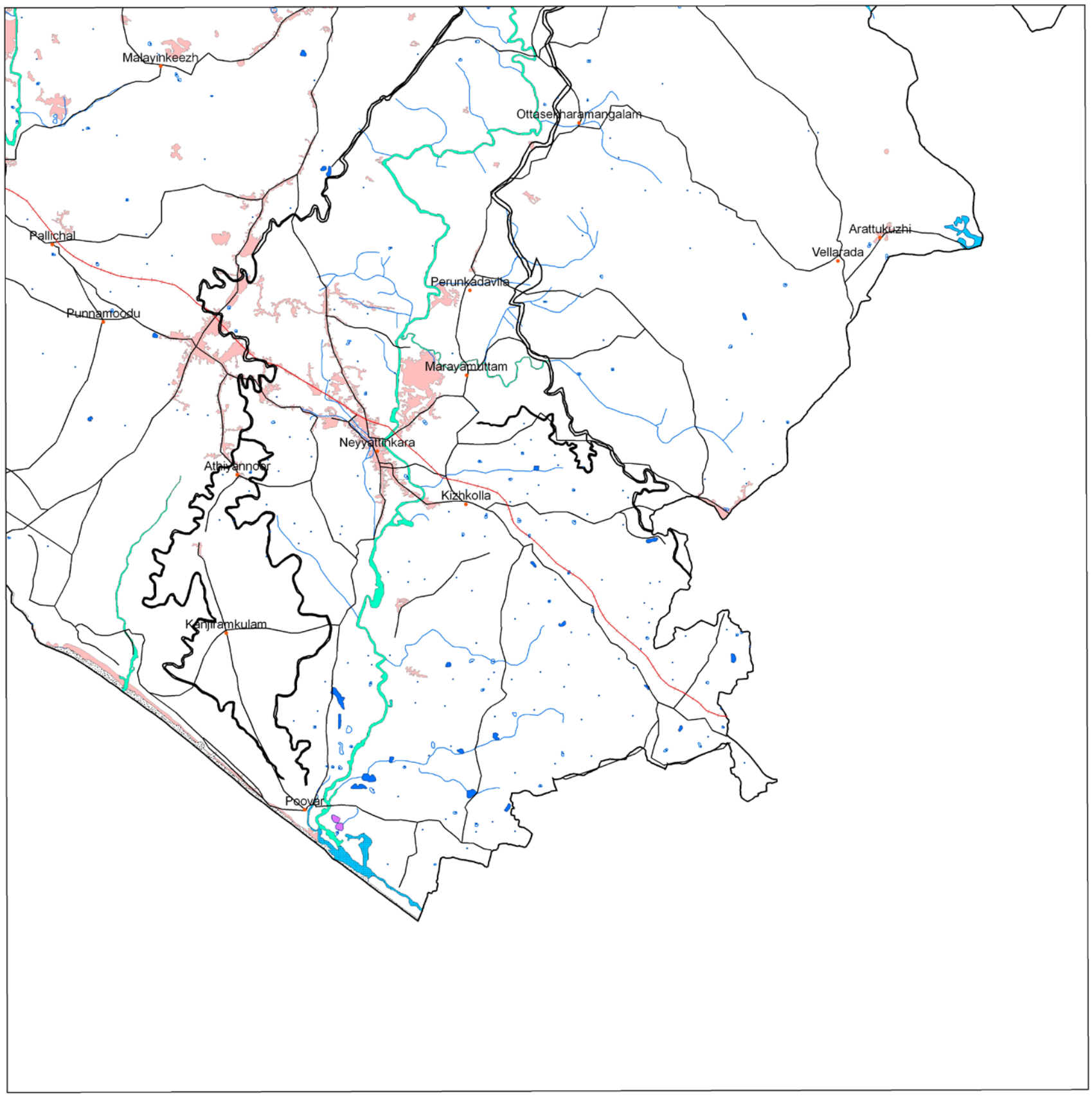
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Kerala

WETLAND MAP

Map No. : 58H/3

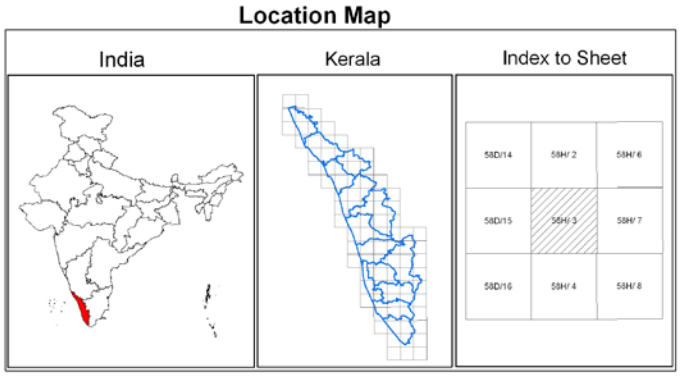


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

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Annexure I
Definitions of wetland categories used in the project

For ease of understanding, definitions of wetland categories and their typical appearance on satellite imagery is given below:

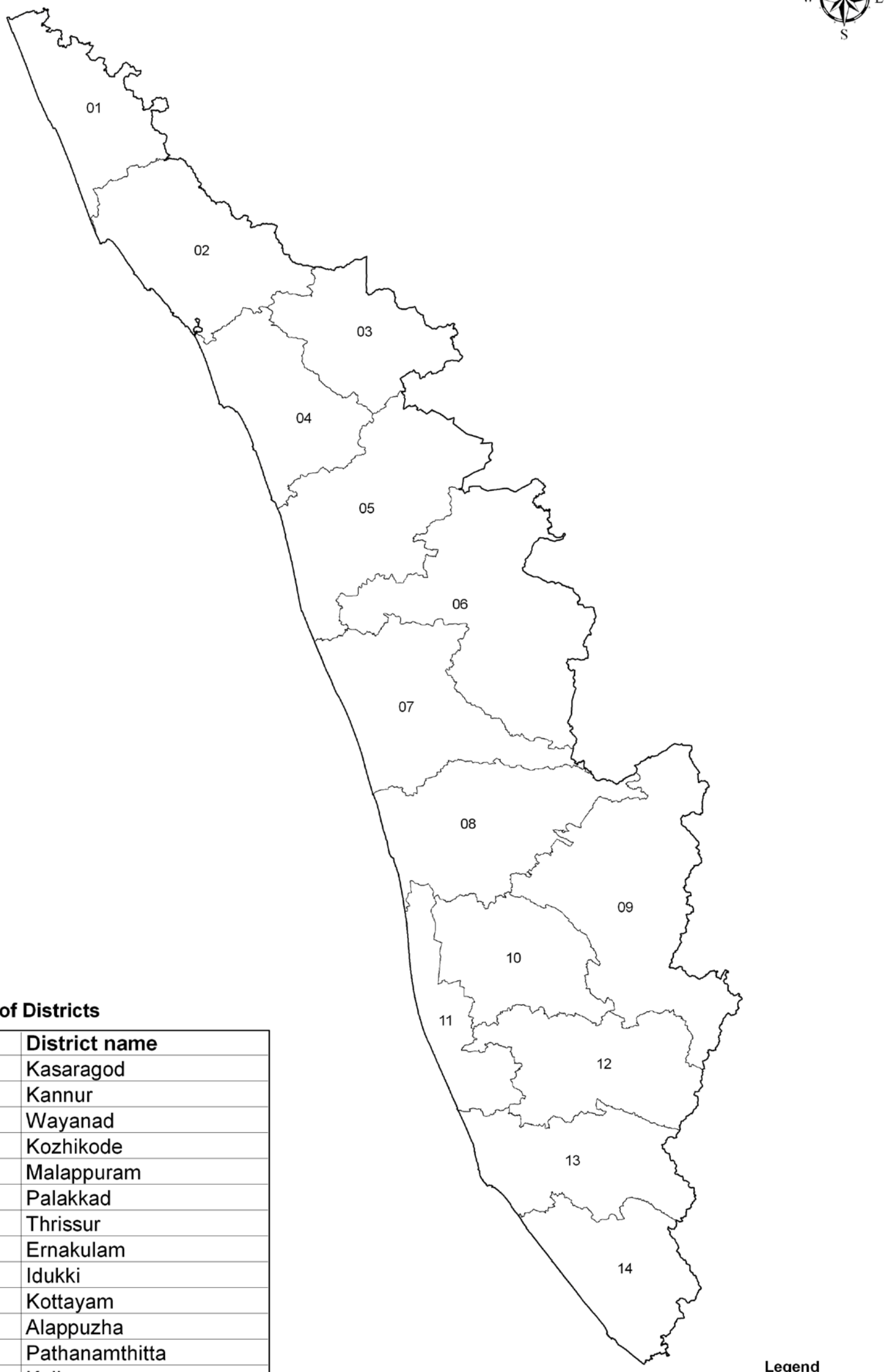
Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different hues of blue interspersed with pink (aquatic vegetation), islands (white if unvegetated, red in case of terrestrial vegetation). Vegetation if scattered make texture rough.
1102	**Ox-bow lakes/ Cut off meanders**: A meandering stream may erode the outside shores of its broad bends, and in time the loops may become cut-off, leaving basins. The resulting shallow crescent-shaped lakes are called oxbow lakes (Reid *et al*, 1976). On the satellite image Ox-bow lakes occur near the rivers in plain areas. Some part of the lake normally has aquatic vegetation (red/pink in colour) during pre-monsoon season.
1103	**High Altitude lakes:** These lakes occur in the Himalayan region. Landscapes around high lakes are characterized by hilly topography. Otherwise they resemble lakes in the plain areas. For keeping uniformity in the delineation of these lakes contour line of 3000 m above msl will be taken as reference and all lakes above this contour line will be classified as high altitude lakes.
1104	**Riverine Wetlands**: Along the major rivers, especially in plains water accumulates leading to formation of marshes and swamp. **Swamps** are 'Wetland dominated by trees or shrubs' (U.S. Definition). In Europe, a forested fen (a peat accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly *Sphagnum*) could be called a swamp. In some areas reed grass - dominated wetlands are also called swamps). (Mitsch and Gosselink, 1986). **Marsh**: A frequently or continually inundated wetland characterised by emergent herbaceous vegetation adapted to saturated soil conditions. In European terminology a marsh has a mineral soil substrate and does not accumulate peat (Mitsch and Gosselink, 1986). Tone is grey blue and texture is smooth. **Comment**: Using satellite data it is difficult to differentiate between swamp and marsh. Hence, both have been clubbed together.
1105	**Waterlogged:** Said of an area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die (Margarate *et al*, 1974). Floods or unlined canal seepage and other irrigation network may cause waterlogging. Spectrally, during the period when surface water exists, waterlogged areas appear more or less similar to lakes/ponds. However, during dry season large or all parts of such areas dry up and give the appearance of mud/salt flats (grey bluish).
1106	**River/stream:** Rivers are linear water features of the landscape. Rivers that are wider than the mapping unit will be mapped as polygons. Its importance arises from the fact that many stretches of the rivers in Indo-Gangetic Plains and peninsular India are declared important national and international wetlands (Ex. The river Ganga between Brajghat and Garh Mukteshwar, is a Ramsar site, Ranganthattu on the Cavery river is a bird sanctuary etc.). Wherever, rivers are wide and features like sand bars etc. are visible, they will be mapped.
1200	**Man-made**
1201	***Reservoir****: A pond or lake built for the storage of water, usually by the construction of a dam across a river (Margarate et al, 1974). On RS images, reservoirs have irregular boundary behind a prominent dyke. Wetland boundary in case of reservoir incorporates water, aquatic vegetation and footprint of water as well. In the accompanying images aquatic vegetation in the reservoir is seen in bright pink tone. Tone is dark blue in deep reservoirs while it is ink blue in case of shallow reservoirs or reservoirs with high silt load. These will be annotated as Reservoirs/Dam.* **Barrage:** Dykes are constructed in the plain areas over rivers for creating Irrigation/water facilities. Such water storage areas develop into wetlands (Harike Barrage on Satluj – a Ramsar site, Okhla barrage on the Yamuna etc. – a bird sanctuary). Water appears in dark blue tone with a smooth texture. Aquatic vegetation appears in pink colour, which is scattered, or contiguous depending on the density. Reservoirs formed by barrages will be annotated as reservoir/barrage.

1202	**Tanks/Ponds:** A term used in Ceylon and the drier parts of Peninsular India for an artificial pond, pool or lake formed by building a mud wall across the valley of a small stream to retain the monsoon (Margarate *et al*, 1974). **Ponds** Generally, suggest a small, quiet body of standing water, usually shallow enough to permit the growth of rooted plants from one shore to another (Reid *et al*, 1976). Tanks appear in light blue colour showing bottom reflectance. In this category **Industrial ponds/mining pools mainly comprising Abandoned Quarries are also included (**Quarry is defined as "An open or surface working or excavation for the extraction of stone, ore, coal, gravel or minerals." In such pits water accumulate (McGraw Hill Encyclopaedia of Environmental Sciences, 1974), **Ash pond/Cooling pond** (The water body created for discharging effluents in industry, especially in thermal power plants (Encyclopaedic Directory of Environment, 1988) and **Cooling pond**: An artificial lake used for the natural cooling of condenser-cooling water serving a conventional power station (Encyclopaedic Directory of Environment, 1988). These ponds can be of any shape and size. Texture is rough and tonal appearance light (quarry) to blue shade (cooling pond).
1203	**Waterlogged :** Man-made activities like canals cause waterlogging in adjacent areas due to seepage especially when canals are unlined. Such areas can be identified on the images along canal network. Tonal appearance is in various hues of blue. Sometimes, such waterlogged areas dry up and leave white scars on the land. Texture is smooth.
1204	**Salt pans:** Inland salt pans in India occur in Rajasthan (Sambhar lake). These are shallow rectangular man-made depressions in which saline water is accumulated for drying in the sun for making salt.
2000	**Coastal Wetlands**
2100	**Natural**
2101	**Lagoons/Backwaters:** Such coastal bodies of water, partly separated from the sea by barrier beaches or bass of marine origin, are more properly termed lagoons. As a rule, lagoons are elongate and lie parallel to the shoreline. They are usually characteristic of, but not restricted to, shores of emergence. Lagoons are generally shallower and more saline than typical estuaries (Reid *et al*, 1976). **Backwater**: A creek, arm of the sea or series of connected lagoons, usually parallel to the coast, separated from the sea by a narrow strip of land but communicating with it through barred outlets (Margarate *et al*, 1974).
2102	**Creek:** A notable physiographic feature of salt marshes, especially low marshes. These creeks develop as do rivers "with minor irregularities sooner or later causing the water to be deflected into definite channels" (Mitsch and Gosselink, 1986). Creeks will be delineated, however, their area will not be estimated.
2103	**Sand/Beach:** Beach is an unvegetated part of the shoreline formed of loose material, usually sand that extends from the upper berm (a ridge or ridges on the backshore of the beach, formed by the deposit of material by wave action, that marks the upper limit of ordinary high tides and wave wash to low water mark(Clark,1977).Beach comprising rocky material is called rocky beach.
2104	**Intertidal mudflats**: Most unvegetated areas that are alternately exposed and inundated by the falling and rising of the tide. They may be mudflats or sand flats depending on the coarseness of the material of which they are made (Clark, 1977).
2105	**Salt Marsh**: Natural or semi-natural halophytic grassland and dwarf brushwood on the alluvial sediments bordering saline water bodies whose water level fluctuates either tidally or non- tidally (Mitsch and Gosselink, 1986). Salt marshes look in grey blue shade when wet.
2106	**Mangroves**: The mangrove swamp is an association of halophytic trees, shrubs, and other plants growing in brackish to saline tidal waters of tropical and sub-tropical coastlines (Mitsch and Gosselink, 1986). On the satellite images mangroves occur in red colour if in contiguous patch. When mangrove associations are scattered or are degraded then instead of red colour, brick red colour may be seen.
2107	**Coral reefs:** Consolidated living colonies of microscopic organisms found in warm tropical waters. The term coral reef, or organic reef is applied to the rock- like reefs built-up of living things, principally corals. They consist of accumulations of calcareous deposits of corals and corraline algae with the intervening space connected with sand, which consists largely of shells of foraminefera. Present reefs are living associations growing on this accumulation of past (Clark, 1977). Reefs appear in light blue shade.
2200	**Man-made**
2201	**Salt pans**: An undrained usually small and shallow rectangular, man-made depression or hollow in which saline water accumulates and evaporates leaving a salt deposit (Margarate *et al*, 1974). Salt pans are square or rectangular in shape. When water is there appearance is blue while salt is formed tone is white.
2202	**Aquaculture ponds**: Aquaculture is defined as "The breeding and rearing of fresh-water or marine fish in captivity. Fish farming or ranching". The water bodies used for the above are called aquaculture ponds (Encyclopaedic Directory of Environment, 1988). Aquaculture ponds are geometrical in shape usually square or rectangular. Tone is blue.

Annexure – II
Details of District information followed in the atlas

State : Kerala

District Boundary Map



List of Districts

District code	District name
01	Kasaragod
02	Kannur
03	Wayanad
04	Kozhikode
05	Malappuram
06	Palakkad
07	Thrissur
08	Ernakulam
09	Idukki
10	Kottayam
11	Alappuzha
12	Pathanamthitta
13	Kollam
14	Thiruvananthapuram

Source : Survey of India (Surveyed in 2004 and published in 2005)

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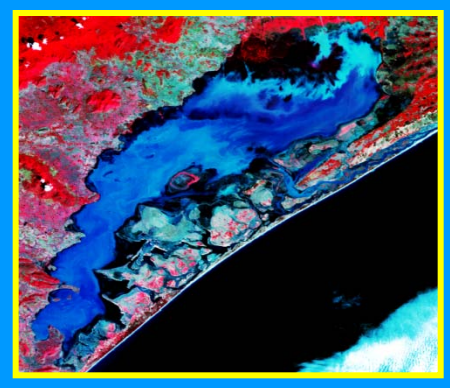

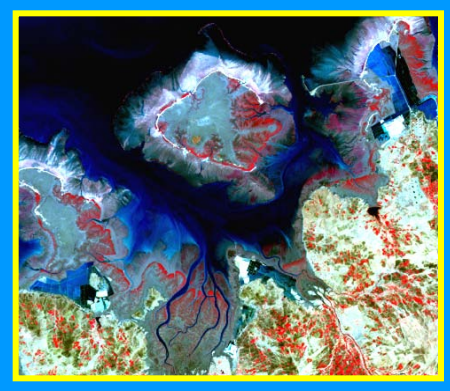

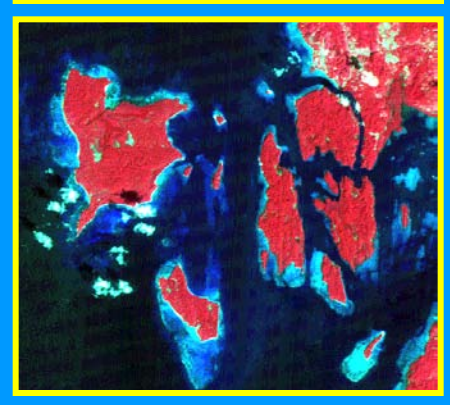

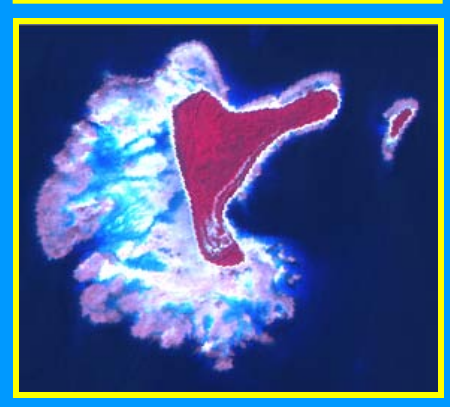

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