NATIONAL WETLAND ATLAS:

MANIPUR

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.

For further details contact:

Director,
Space Applications Centre, ISRO,
Ambawadi Vistar (P.O.)
Ahmedabad – 380 015

director@sac.isro.gov.in

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

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जयराम रमेश
JAIRAM RAMESH

राज्य मंत्री (स्वतंत्र प्रभार)
पर्यावरण एवं वन
भारत सरकार
नई दिल्ली-110003
MINISTER OF STATE (INDEPENDENT CHARGE)
ENVIRONMENT & FORESTS
GOVERNMENT OF INDIA
NEW DELHI - 110 003

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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)

जय हिन्द
डॉ. रंगनाथ आर. नवलगुंद
निदेशक
Dr. Ranganath R. Navalgund
Director

सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA
अंतरिक्ष विभाग DEPARTMENT OF SPACE
अंतरिक्ष उपयोग केन्द्र
SPACE APPLICATIONS CENTRE
अहमदाबाद AHMEDABAD - 380 015
(भारत) (INDIA)
दूरभाष PHONE : +91-79-26913344, 26764956
फैक्स/FAX : +91-79-26915843
ई-मेल E-mail : director@sac.isro.gov.in

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)

भारत सरकार
अन्तरिक्ष विभाग
अन्तरिक्ष उपयोग केन्द्र
आंबावाडी विस्तार डाक घर,
अहमदाबाद - 380 015. (भारत)
दूरभाष : +91-79-26912000, 26915000
फैक्स :

Government of India
Department of Space
SPACE APPLICATIONS CENTRE
Ambawadi Vistar P.O.
Ahmedabad - 380 015. (INDIA)
Telephone : +91-79-26912000, 26915000
Fax :

Dr. Sushma Panigrahy
Group Director, AFEG & Project Director, NWIA

Tel. 079-26914020 (O)
Fax : 079-26915823

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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, Coimbatore and Dr. R.K. Suri, Additional Director, Ministry of Environment and Forests, Govt. of India, New Delhi, to finalise the “Wetland Classification System” followed in this project by their active participation in the Peer Review meeting. We are thankful to the database experts from ISRO who participated in the peer Review meeting to finalise the hierarchical classification system.

We acknowledge the support received from Dr P S Roy, Dy Director, NRSC and Dr S Sudhakar, Head, LRD, NRSC in terms of valuable suggestions and providing the geo-referenced image of NRC-LU&LC project for use as master image 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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(Sushma Panigrahy)

PROJECT TEAM

Project Director : Dr. (Mrs.) Sushma Panigrahy

Space Applications Centre, ISRO, Ahmedabad

Shri J. G. Patel

Dr T. S. Singh

Shri T. V. R. Murthy

M. G. Science Institute, Ahmedabad

Dr. R. D. Shah

Shri Pragnesh Vaishnav

Mrs. Yatisha Vaishnav

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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 Manipur, 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, 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 (IRS) satellites. 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.

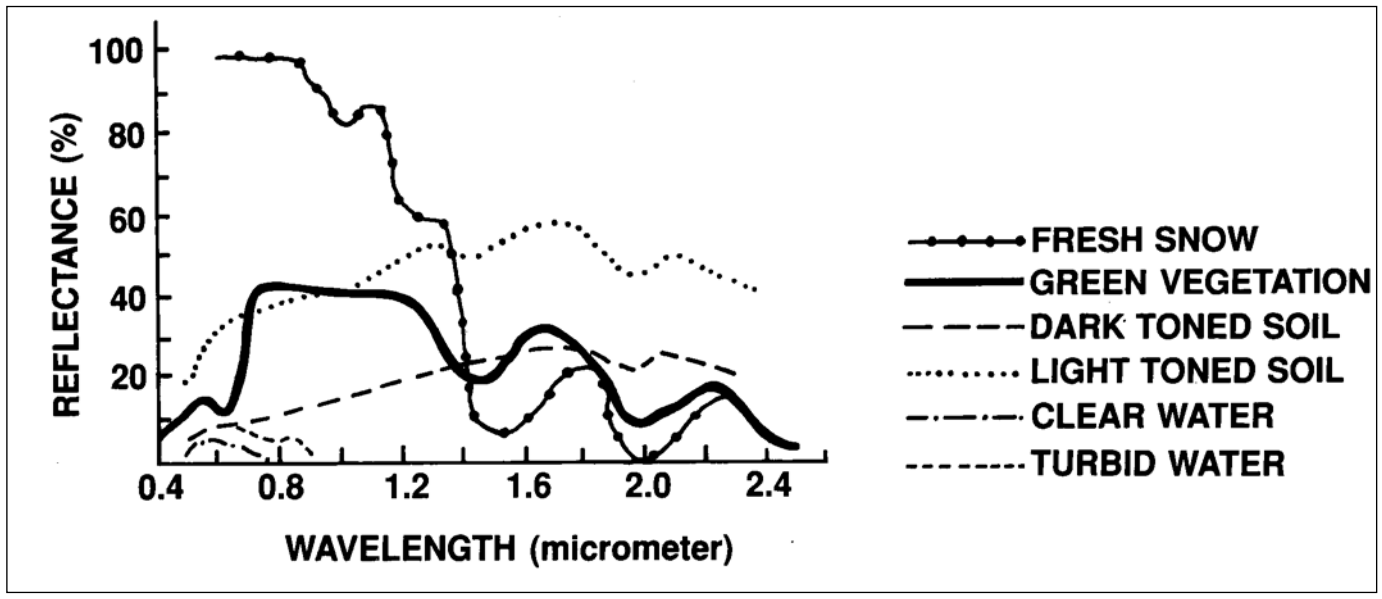


Figure 1: Spectral Signature of various targets

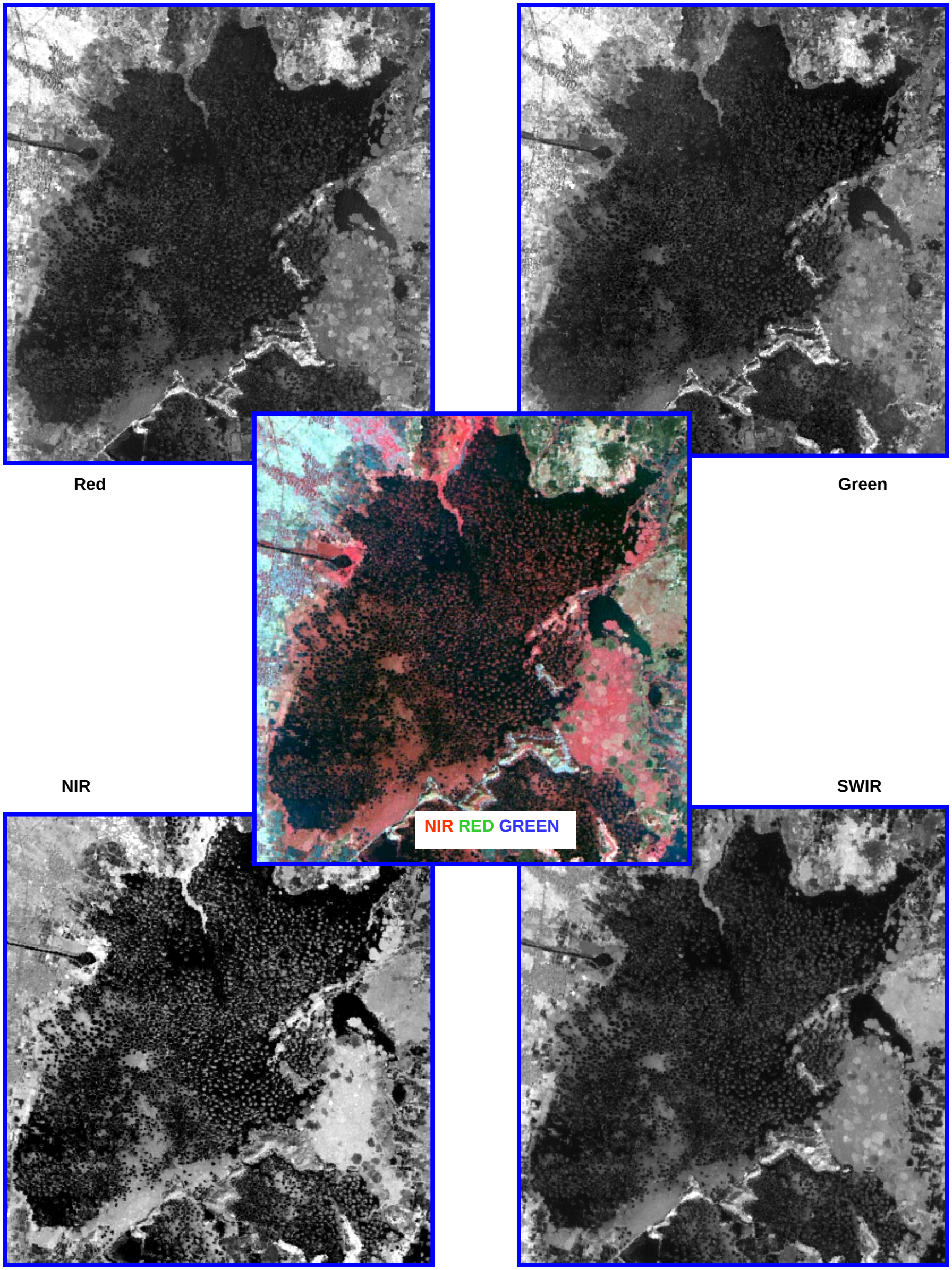


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC.

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 (IRS) satellite. 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). 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 Manipur.

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 trophic 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

The Manipur State came into existence on 21st January 1972. Manipur is situated in the extreme North-Eastern boarder of India. It is bounded on the north by the state of Nagaland, on the east by the Upper Myanmar, on the south by the Chin hills of Myanmar and the state of Mizoram and on the west by Cachar district of Assam. It lies between 92^0 59' E to 92^0 45' E longitude and 23^0 50' to 25^0 41' N latitude (Figure 3). The total geographic area of the state is 22,327 km^2 occupying an area of 0.67% of the total geographical area of the country and ranks 20th in terms of the areal extent in the country.

On the basis of geographical features, the state is divided into two physiographical units:

i) hills
ii) valley plains

Geology and Climate

Geologically, Manipur state belongs to the young folded mountains of the Himalayan system. The rocks in the state vary from upper cretaceous to the present Alluvium. The oldest rocks found in Manipur are mainly confined in the eastern part of the State close to Indo-Myanmar border and the rocks are grouped as cretaceous rocks consisting chromite, serpentine etc. The limestone deposits found in the Ukhrul district belong to the upper creataceous period. The sandstone, shale of the Disang group found over the eastern half of the Manipur belong to the Eocene period. The rocks consisting of sandstone, shale, clay, etc. of the Barail Group are confined over the rocks of Disang group and extending along the mid-western portion of the state and they belong to the upper Eocene and Oligocene periods.

The shales and sandstone of the Tipam and Surma groups cover the western banks of Manipur and they belong to the Miocene period. Rocks of alluvial deposits found in the Manipur valley portion are of recent origin and further they can be grouped as older and younger alluvium. The state is mainly composed of tertiary rocks. The soil in the state is mostly clay to clayey loam. Near Myanmar border the soil is sandy loam.

The plains consisting of the Manipur valley covers and area of about 2,238 km^2. The Manipur state is drained by several small rivers and the drainage is mainly from north to south. The major rivers viz., Barak, Imphal, Iril and Thoubal are perennial and of great importance.

Temperature and Rainfall

The mean maximum daily temperature is 31.1^o C and the mean minimum daily temperature during the winter season is 11.8^o C. The state has sub-tropical monsoon to temperature climate depending on the elevation. It receives rainfall from monsoon and the rainfall varies from 1016 to 1778 mm a year. The rainy season lasts from April to September and the amount of rainfall is more in hills than in the valley. The driest period is recorded from November to March. The maximum rainfall of the state is recorded in the month of July and August.

Demography

The total population of the Manipur was 23, 88, 634 during 2001 out of which 12,07,338 are male and 11,81,296 are female. The urban population was 23.88%. Population density of the state is 107 per km^2. The literacy rate of the state is 68.87%.

There are nine districts in the state. The Imphal east, Imphal west, Thoubal and Bishnupur districts are valley districts and the remaining i.e. Tamenglong, Senapati, Chandel, Ukhrul and Churachandpur are hill districts. The four valley districts cover 1/10th of the total geographical area of the state whereas 9/10th of the total population settled there only. The state is covered by forty-nine 1:50,000 scale SOI topographical maps that form the spatial frame work for mapping (Figure 4). The spatial framework was prepared using 15' x 15' grid.

Manipur is known for Loktak lake. The Loktak lake covering and area of 24,672 ha is one of the 25 Ramsar sites in the country. The Keibul Lamjo National Park is a part of the lake where the world famous deer species "Sangai" the brow-antlered deer, *Cervus eldi eldi*, has its natural habitat. State government and many other organizations are attempting to preserve this largest fresh water lake which is the only home of endangered "Sangai or dancing deer".

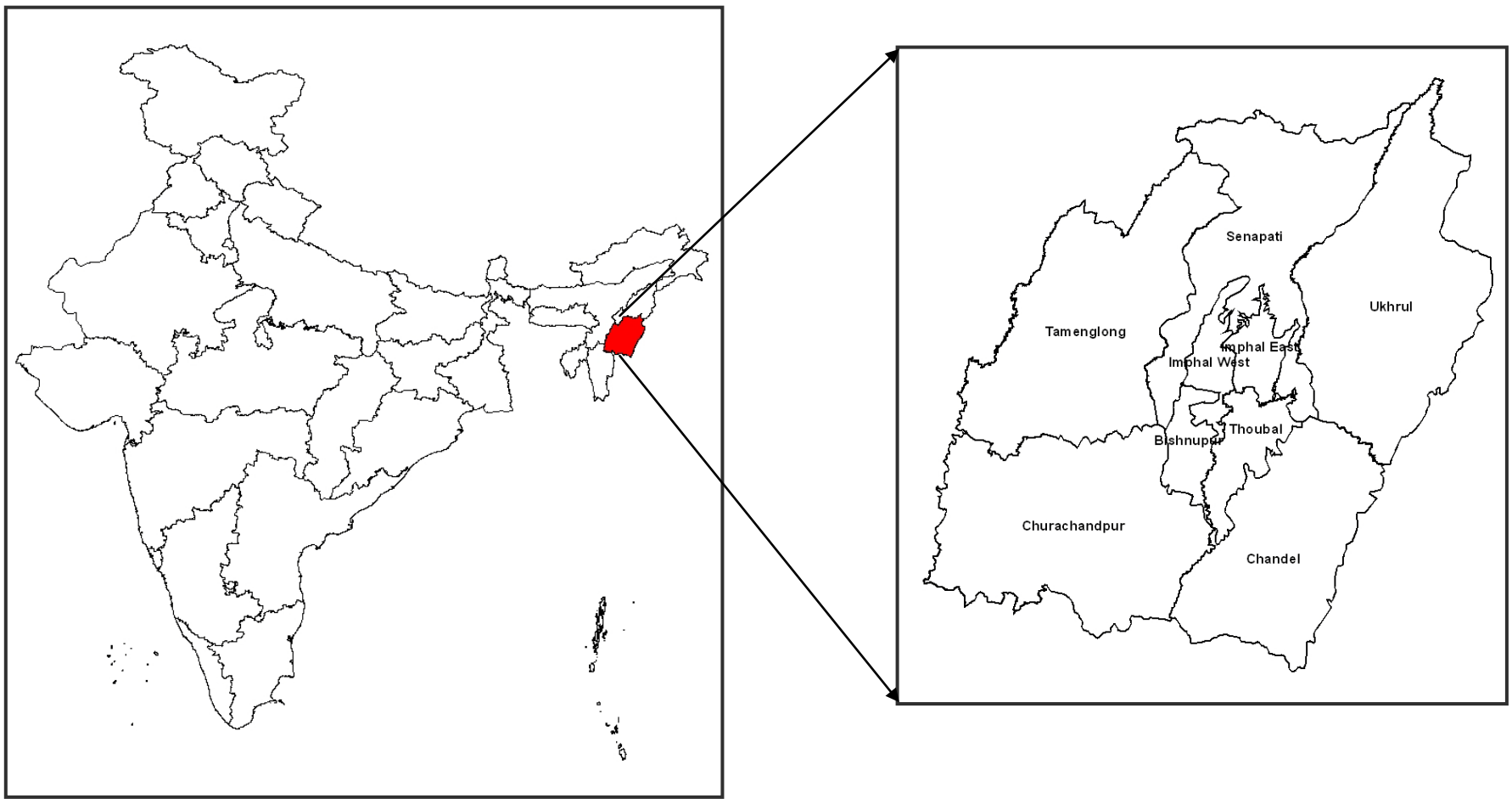


Figure 3: Location Map

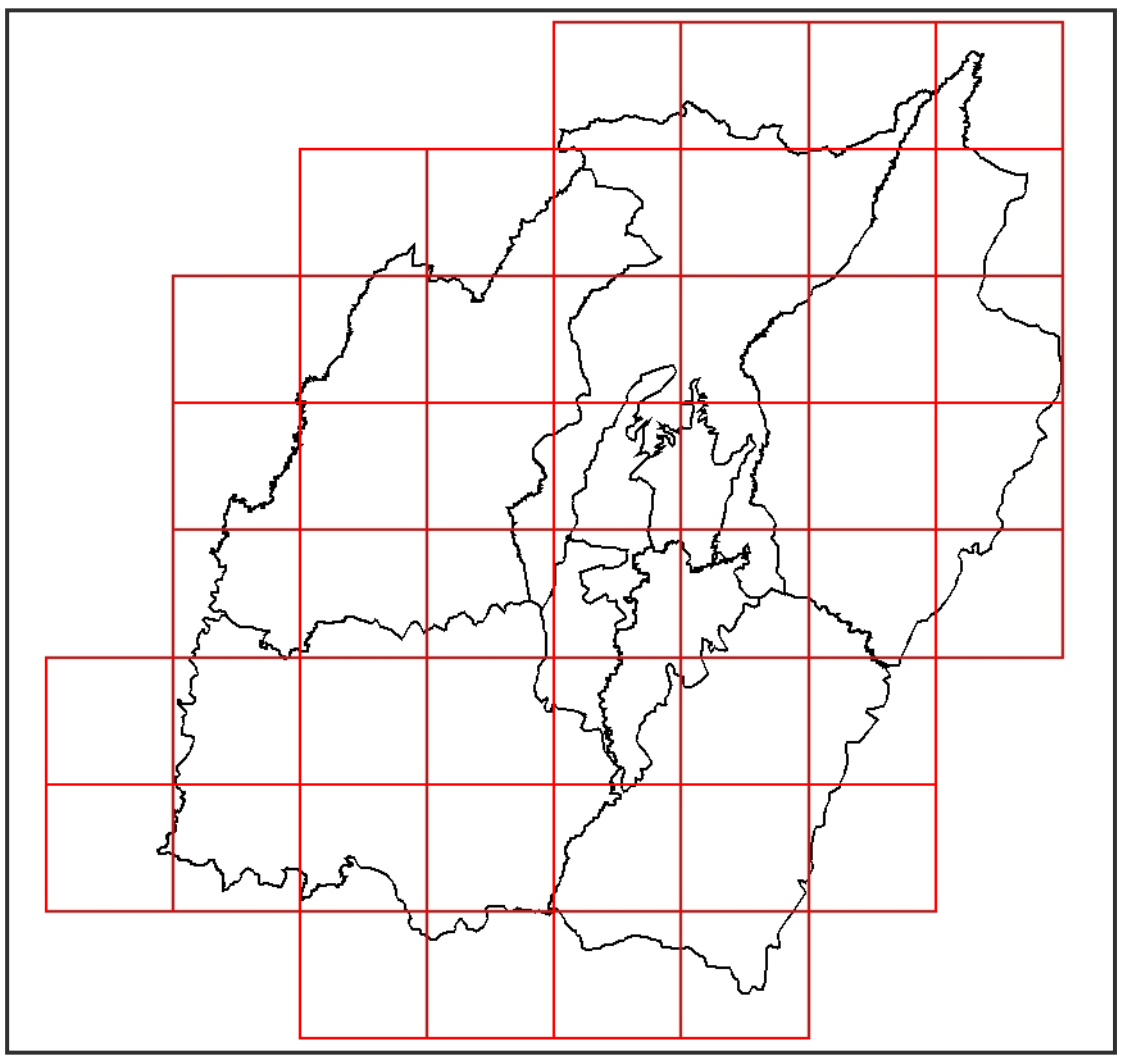


Figure 4: Spatial Framework of Manipur

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 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The state of Manipur is covered in 4 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 6 shows the overview of the part of Manipur as seen in the LISS III FCC of post- monsoon pre-monsoon data respectively.

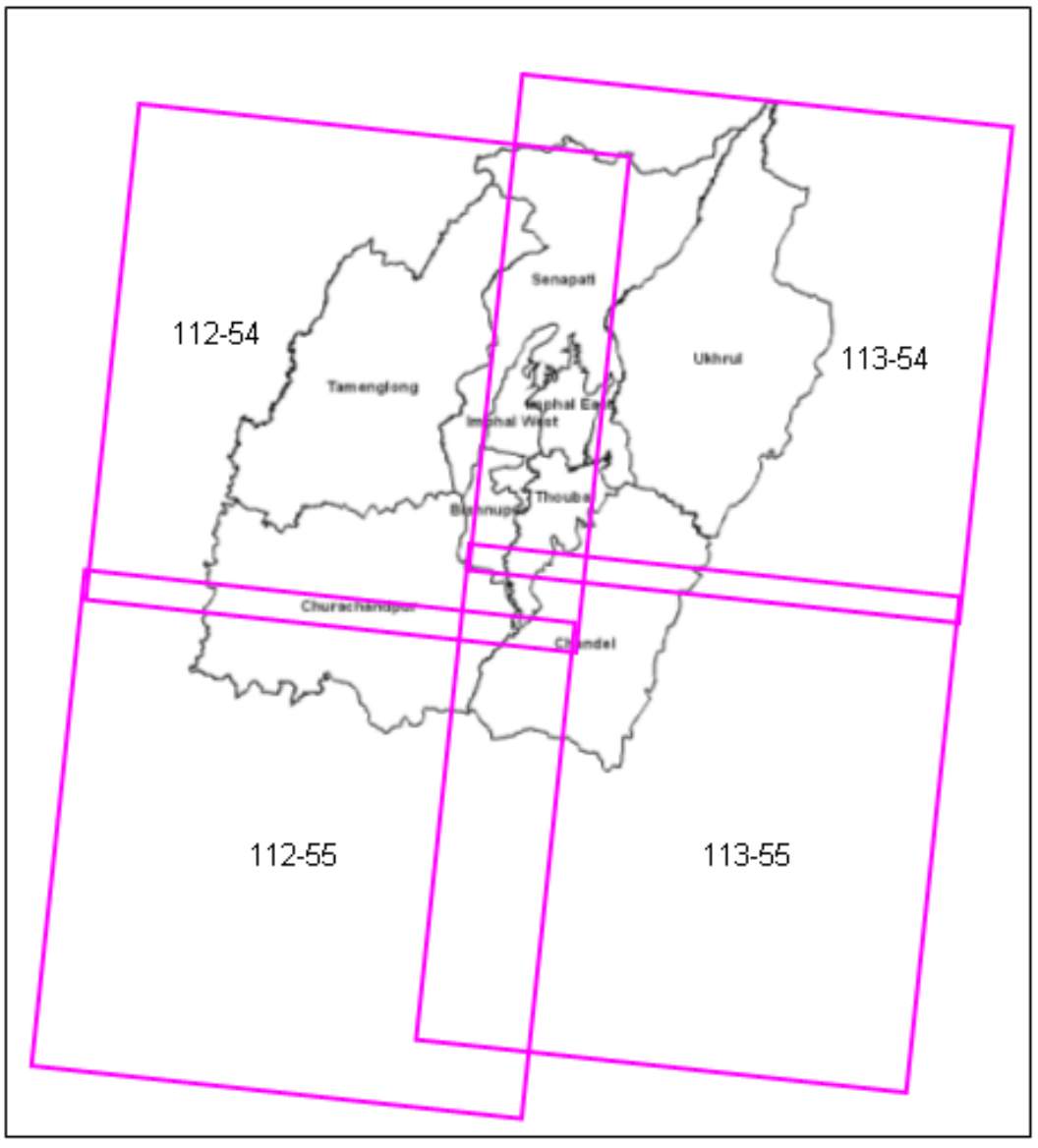


Figure 5: IRS P6 LISS-III coverage (path-row) of Manipur

Table-2: Satellite data used

Sr. No.	Sensor	Path-Row	Date of acquisition	
			Post-monsoon	Pre-monsoon
1.	LISS-III	112-54	Dec5, 2006	Jan 22, 2007
2.	LISS-III	112-55	Dec5, 2006	Mar 11, 2007
3.	LISS-III	113-54	Jan 27, 2006	May 3, 2007
4.	LISS-III	113-55	Jan 27, 2006	May 3, 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 Manipur 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)

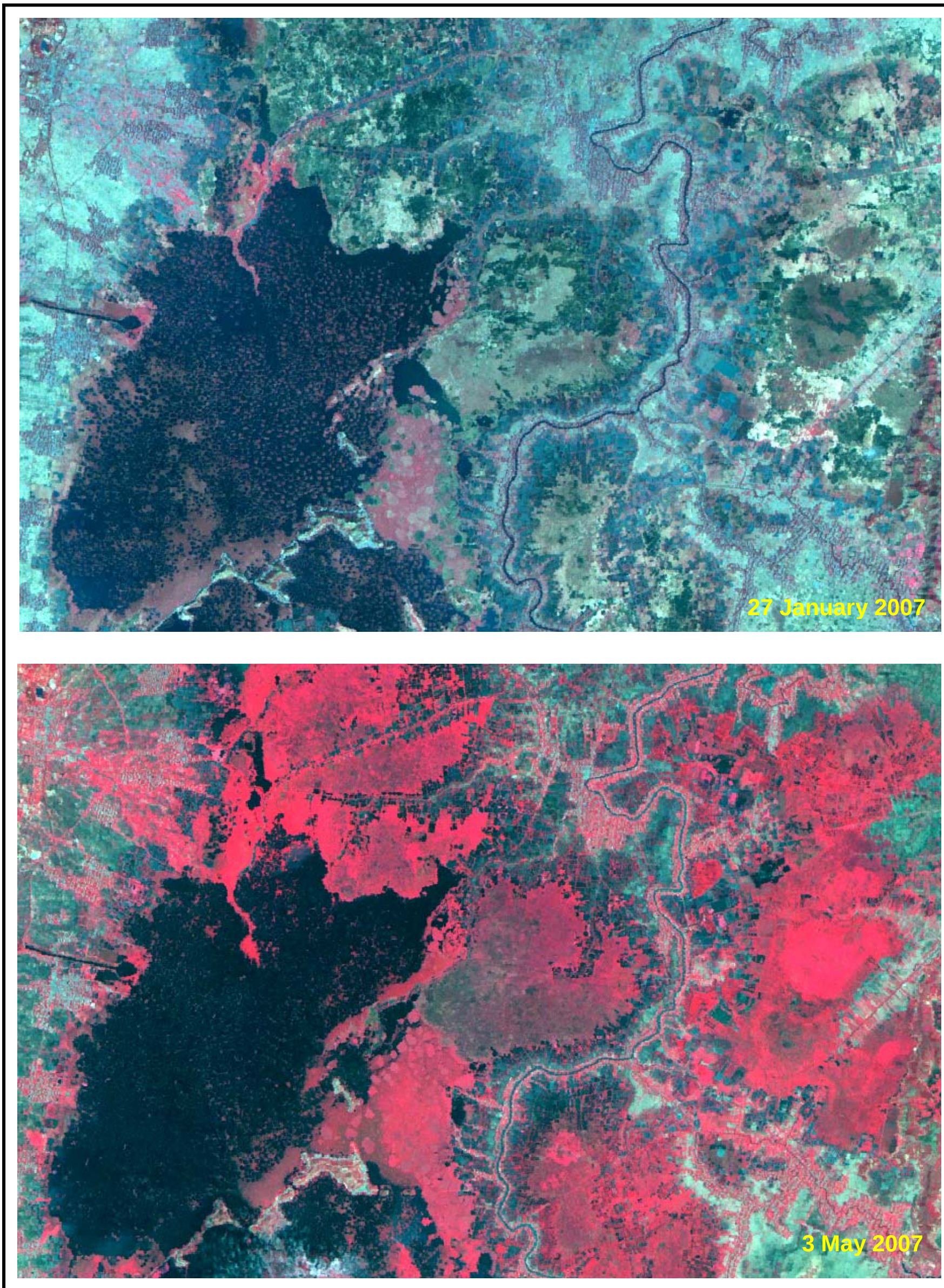


Figure 6: IRS LISS-III FCC(Post-monsoon and Pre-monsoon) : Part of Manipur state

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 as given in 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.

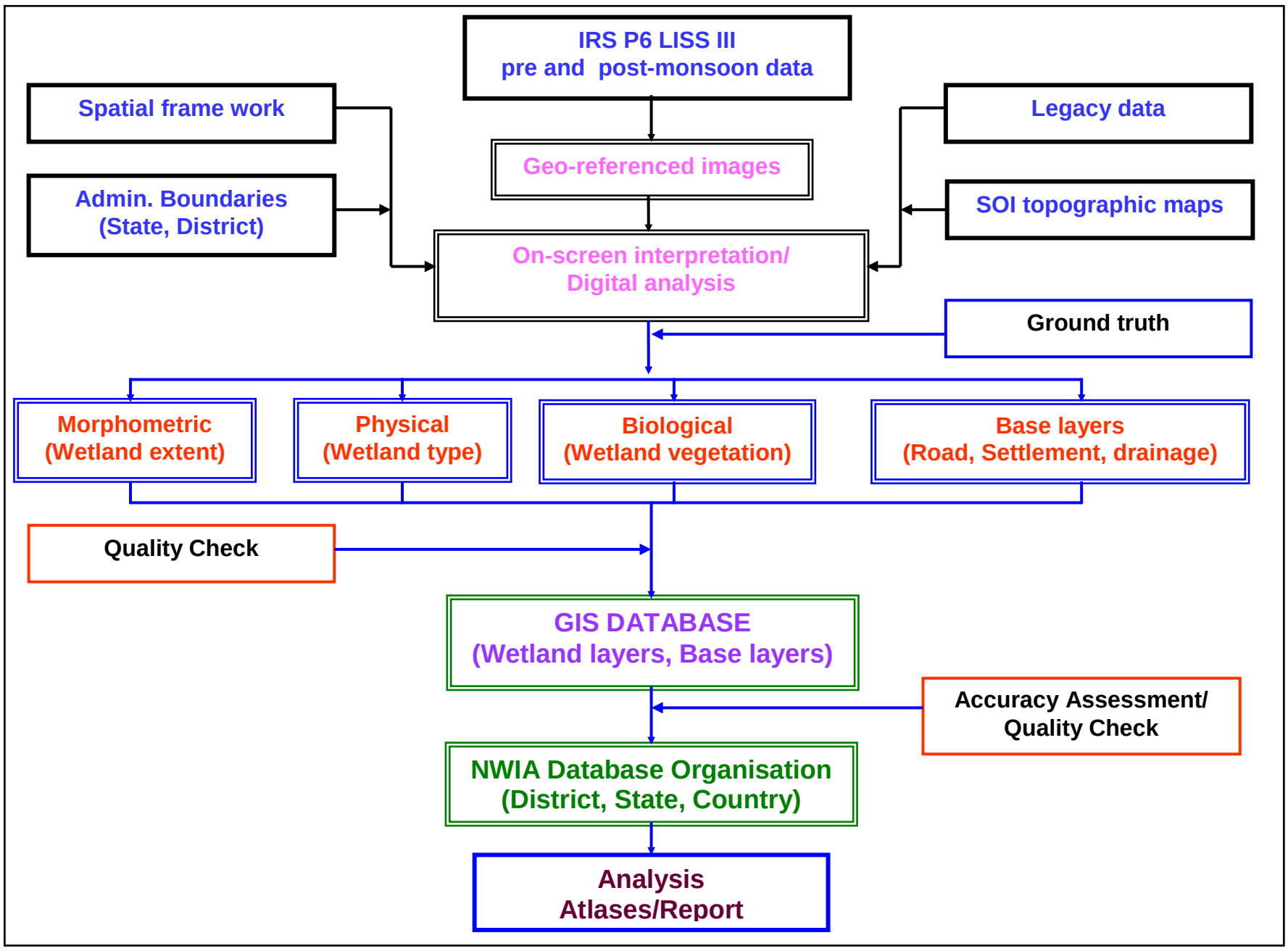


Figure 7: Flow chart of the methodology used

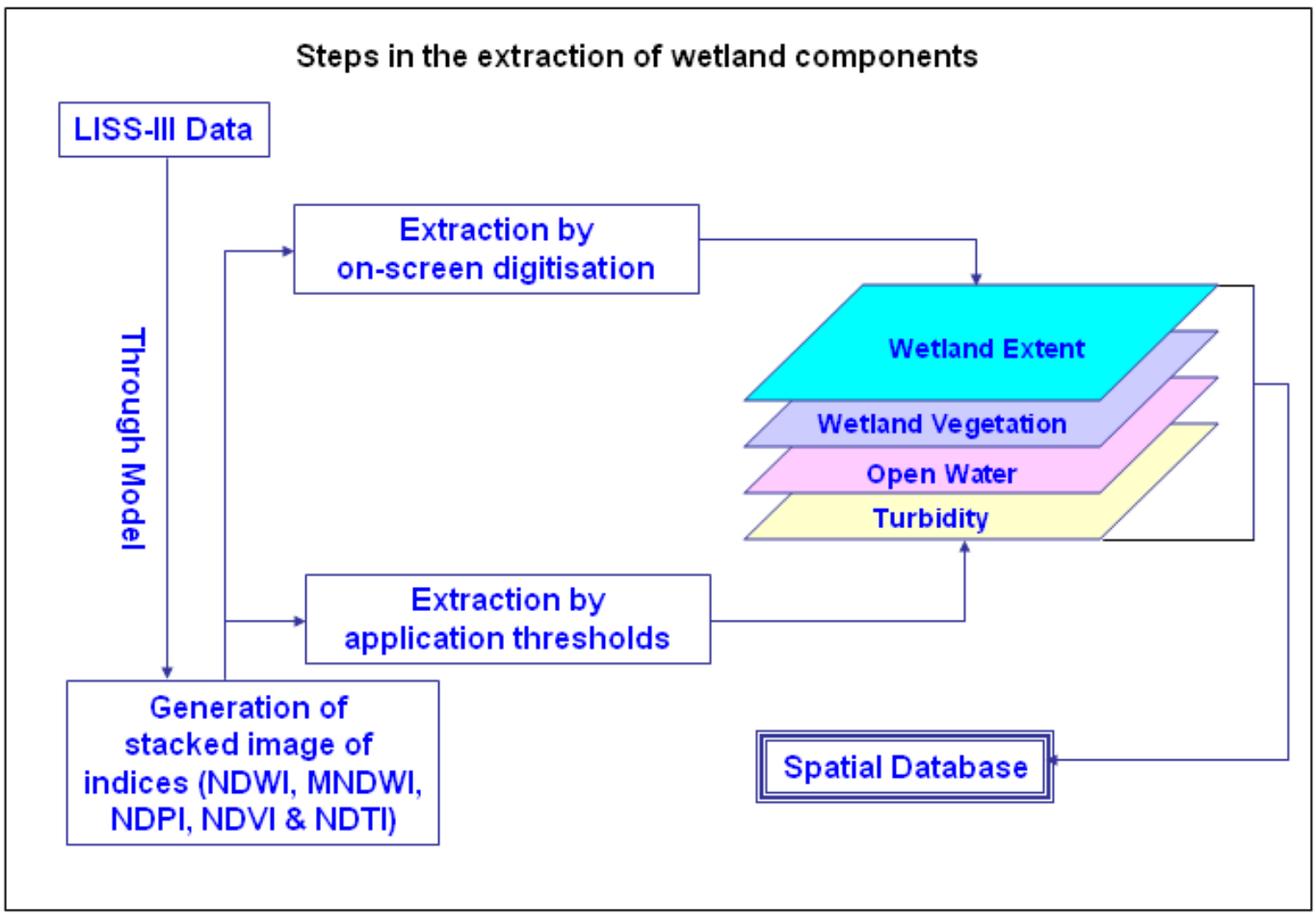


Figure 8: Steps in the extraction of wetland components

6.0 ACCURACY ASSESSMENT

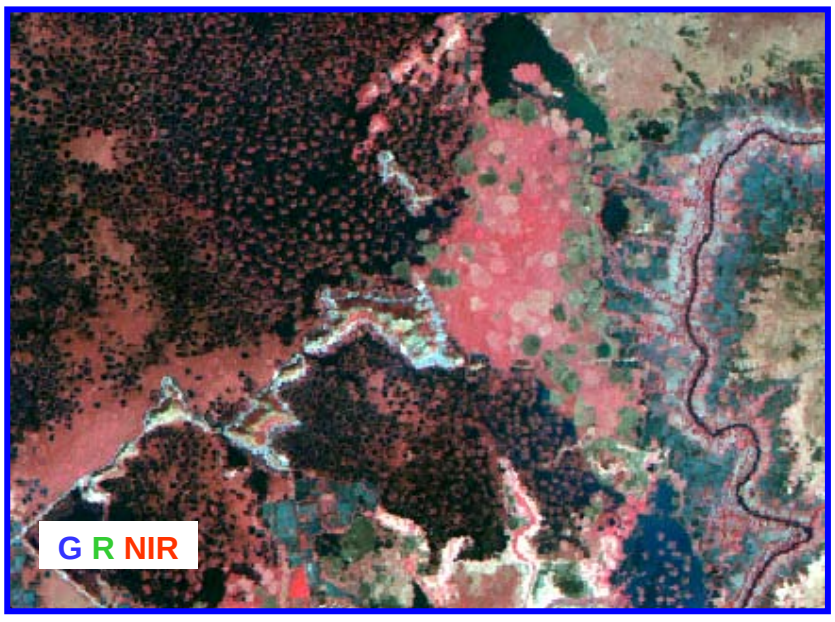
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as locational accuracy. In addition, GIS database(s) contents have been also evaluated 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.

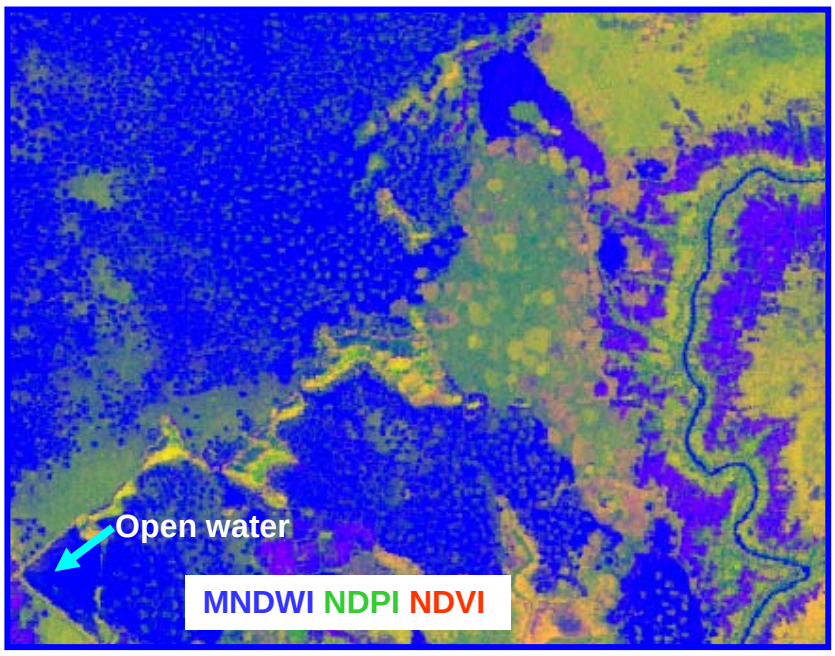
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imageries were reviewed by technical expert team for accuracy and code. The reviewing 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.

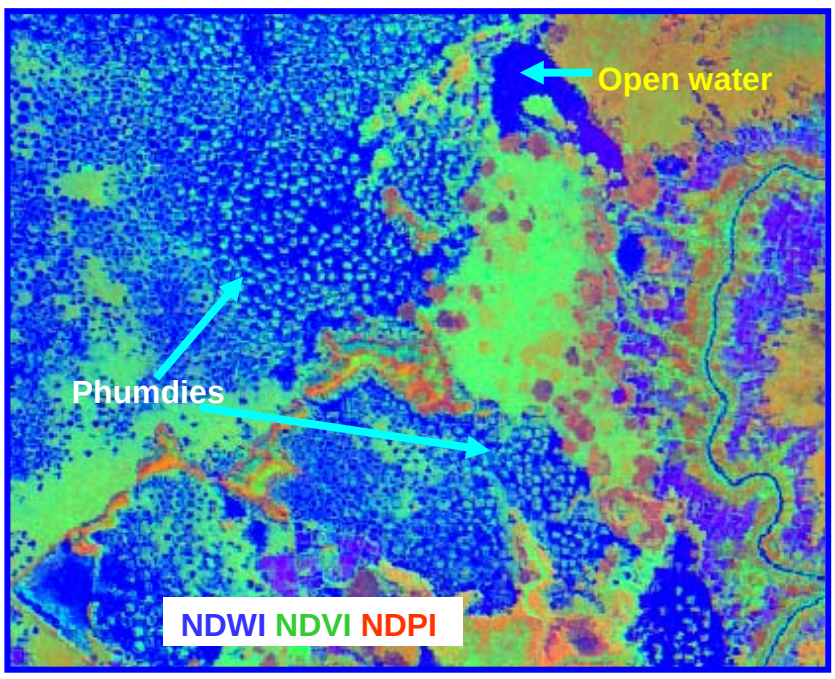
6.1 Data verification and quality assurance of output digital data files

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.

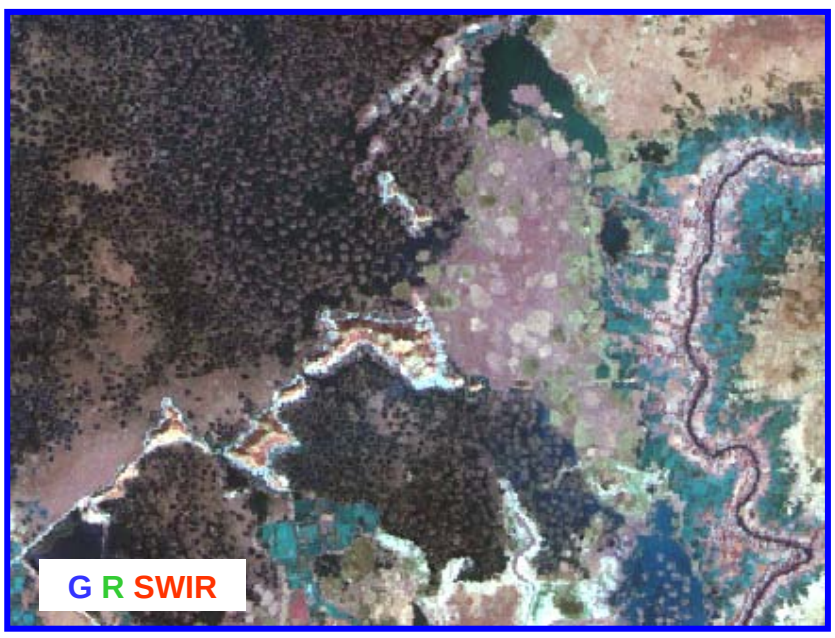


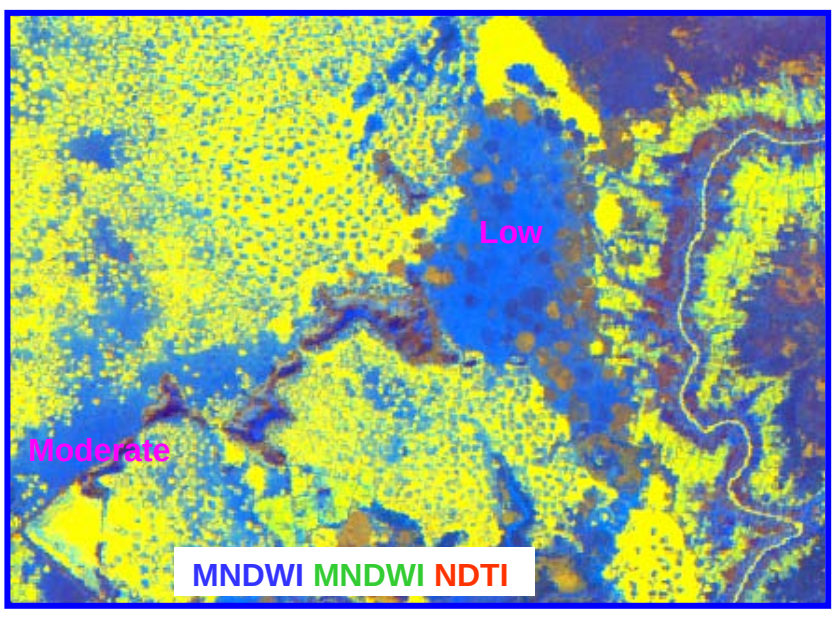


Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features





Useful for qualitative turbidity delineation

Part of Loktak lake,
IRS LISS III data, 27 January 2007

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

MAPS AND STATISTICS

7.0 WETLANDS OF MANIPUR: MAPS AND STATISTICS

Area estimates of various wetland categories for Manipur have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total 167 wetlands have been mapped at 1:50,000 scale in the state. In addition, 541 wetlands (smaller than 2.25 ha) have also been identified. Total wetland area estimated is 63616 ha that is around 2.85 per cent of the geographic area (Table 4). The major wetland types are lakes/ponds accounting for 62 percent of the wetlands (39124 ha), river/stream (16677 ha), waterlogged (3525 ha) and Aquaculture ponds (2643 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 71 and 62 percent of wetland area is under open water category during post monsoon and Pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 26 and 37 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 (around 39 and 59 percent respectively during post-monsoon).

Table 4: Area estimates of wetlands in Manipur

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	15	39123	61.50	22300	17276
2	1102	Ox-bow lakes/ Cut-off meanders	9	64	0.10	59	64
3	1105	Waterlogged	61	3525	5.54	2845	2191
4	1106	River/Stream	15	16677	26.22	16677	16677
	1200	**Inland Wetlands -Man-made**					
5	1201	Reservoirs/Barrages	3	856	1.35	856	657
6	1202	Tanks/Ponds	53	187	0.29	184	187
		Total - Inland	**156**	**60432**	**94.99**	**42921**	**37052**
	2200	**Coastal Wetlands - Man-made**					
7	2202	Aquaculture ponds	11	2643	4.15	2383	2339
		Total - Coastal	**11**	**2643**	**4.15**	**2383**	**2339**
		Sub-Total	**167**	**63075**	**99.15**	**45304**	**39391**
		Wetlands (<2.25 ha), mainly Tanks	541	541	0.85	-	-
		Total	**708**	**63616**	**100.00**	**45304**	**39391**

Area under Aquatic Vegetation	16756	23500

Area under turbidity levels		
Low	17866	17261
Moderate	26911	21841
High	527	289

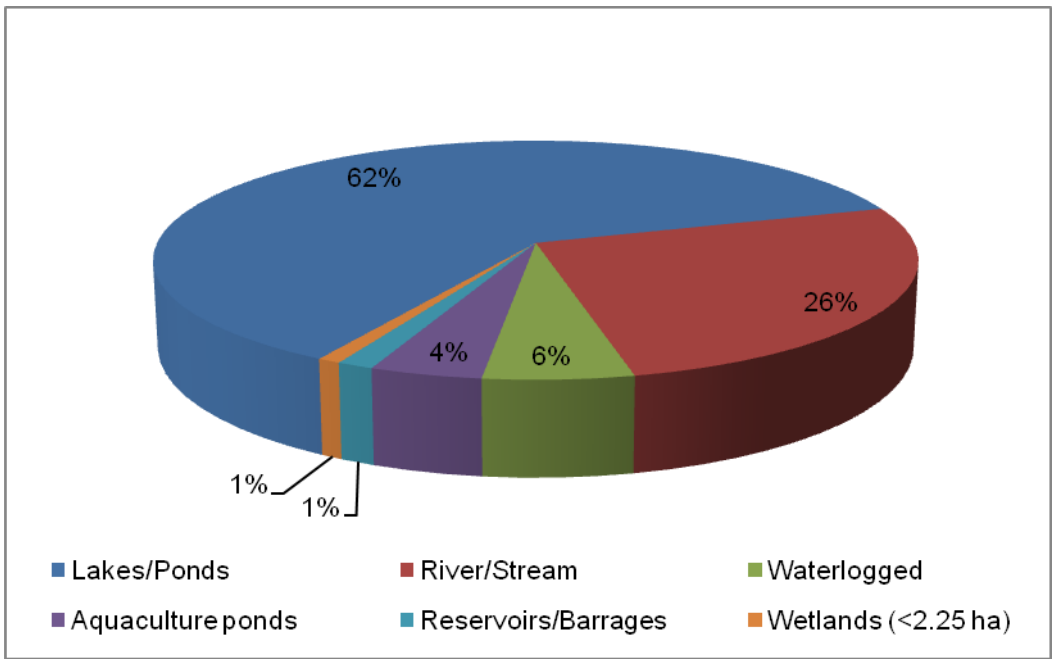


Figure 10: Type-wise wetland distribution in Manipur

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has nine districts. District-wise distribution of wetlands showed that three districts can be called as wetland rich. Bishnupur has highest concentration with around 30.7 percent of geographic area under wetland. This is mainly due to the location of the famous Loktok lake. The other two districts are: Thoubal and Imphal West with around 30.3 and 2.6 per cent area under wetland. Chandel district has the lowest area under wetland (around 0.44 per cent). Wetland category of Aquaculture pond was observed only in Bishnupur and Imphal West district, mainly due to the presence of the Loktak lake. Only three reservoirs/barrages are observed. District-wise wetland area estimates is given in Table-5. Figure 11 shows district-wise graphical distribution of wetlands.

The districts with very high concentration of small wetlands (< 2.25 ha) are Senapati and Thoubal with 120 and 91 numbers respectively, while Chandel district has lowest with 25 such wetlands.

Table-5: District-wise wetland highlights

Sr. No.	District	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of district geographic area
1	Senapathi	496	1911	3.01	3.85
2	Tamelong	3313	5086	8.02	1.54
3	Churachandrapur	4570	4102	6.47	0.90
4	Bishnupur	709	21753	34.29	30.68
5	Thoubal	519	15718	24.78	30.29
6	Imphal West	3271	8418	13.27	2.57
7	Imphal East	4391	2098	3.31	0.48
8	Ukhrul	514	2355	3.71	4.58
9	Chandel	4544	1991	3.14	0.44
	Total	**22327**	**63432**	**100.00**	

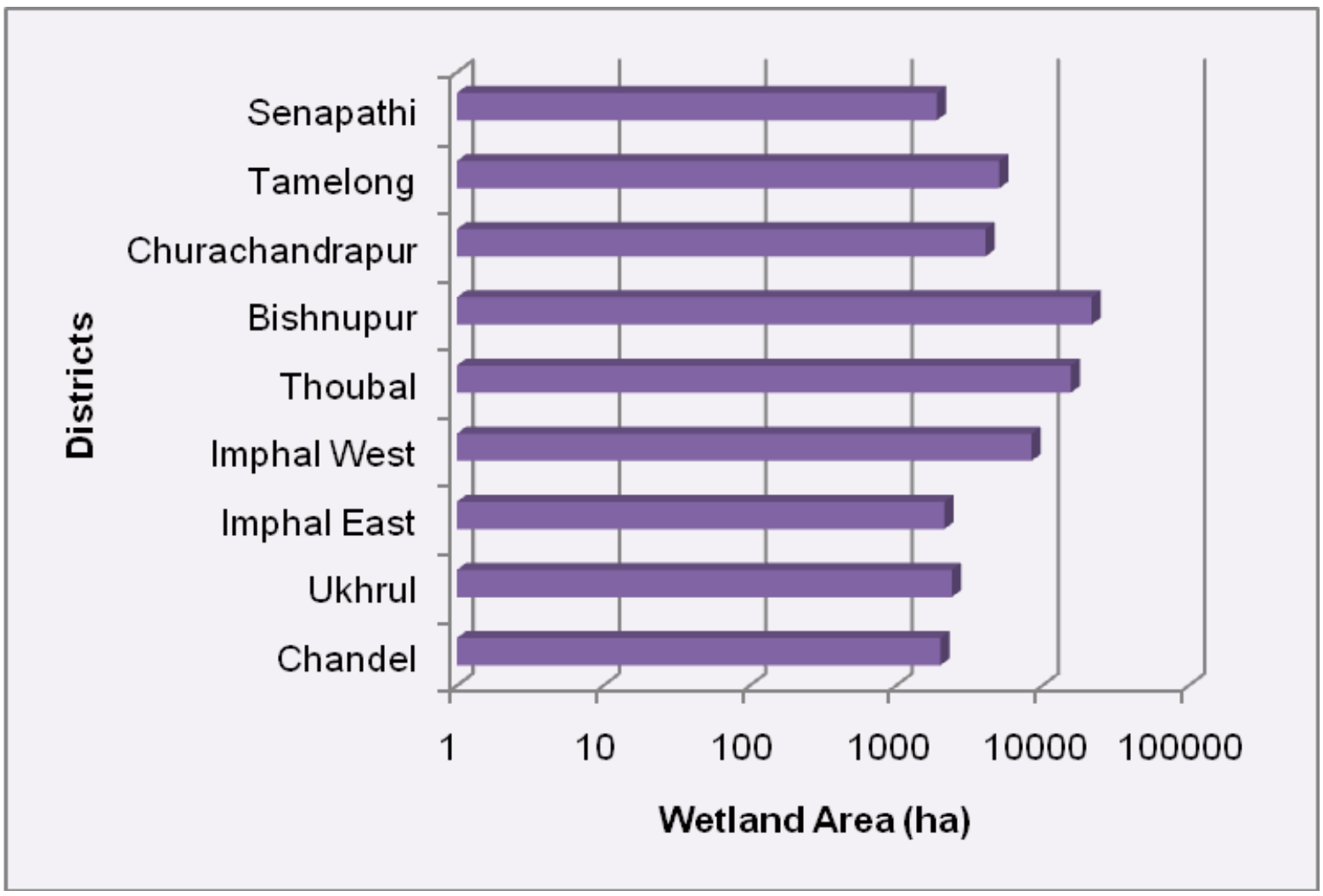
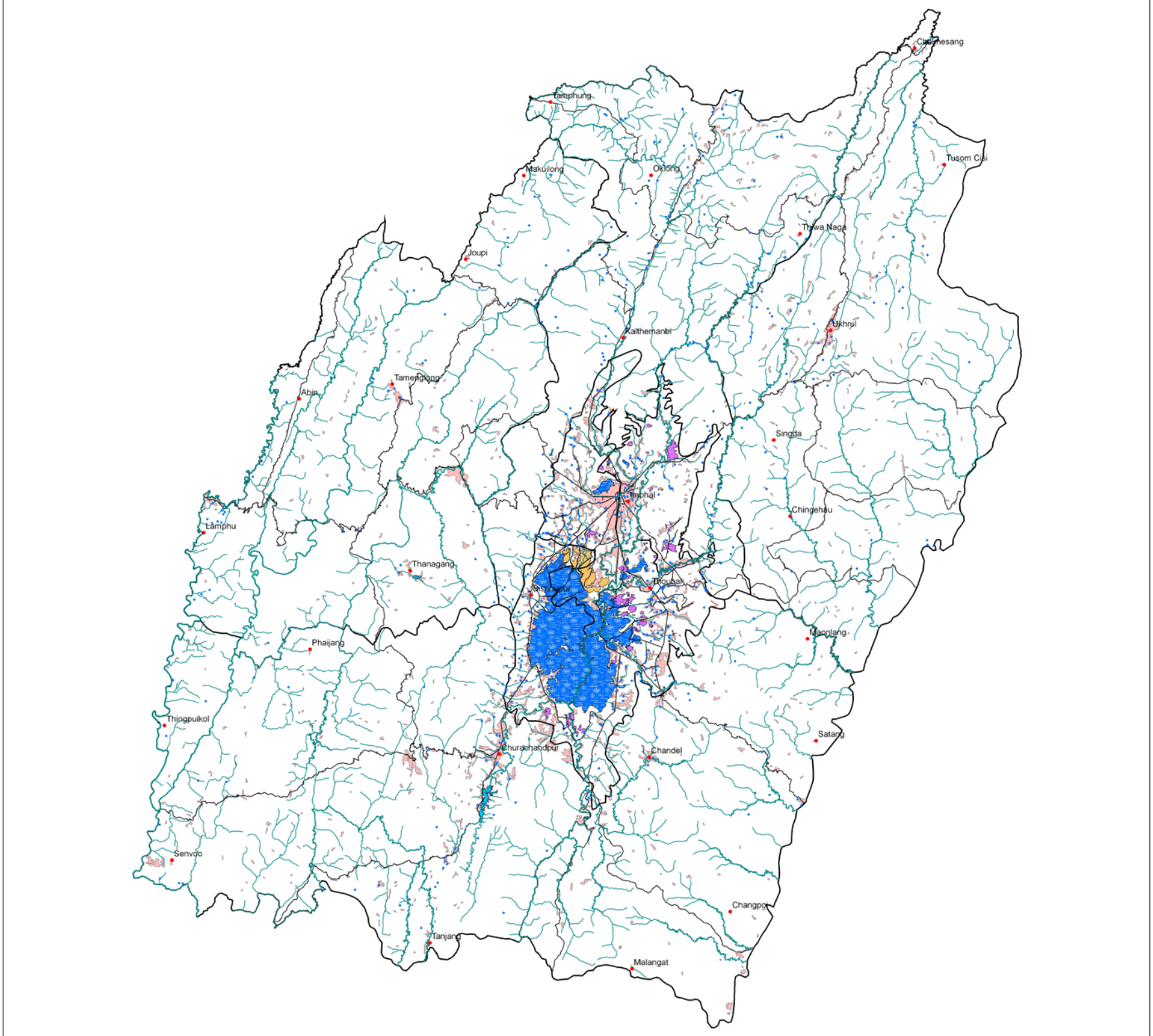


Figure 11: District-wise graphical distribution of wetlands

State : Manipur

WETLAND MAP

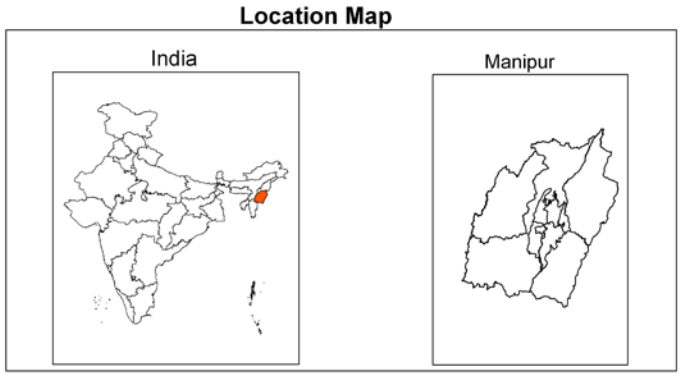


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements

Location Map



0 5 10 20 30 40 Kilometers

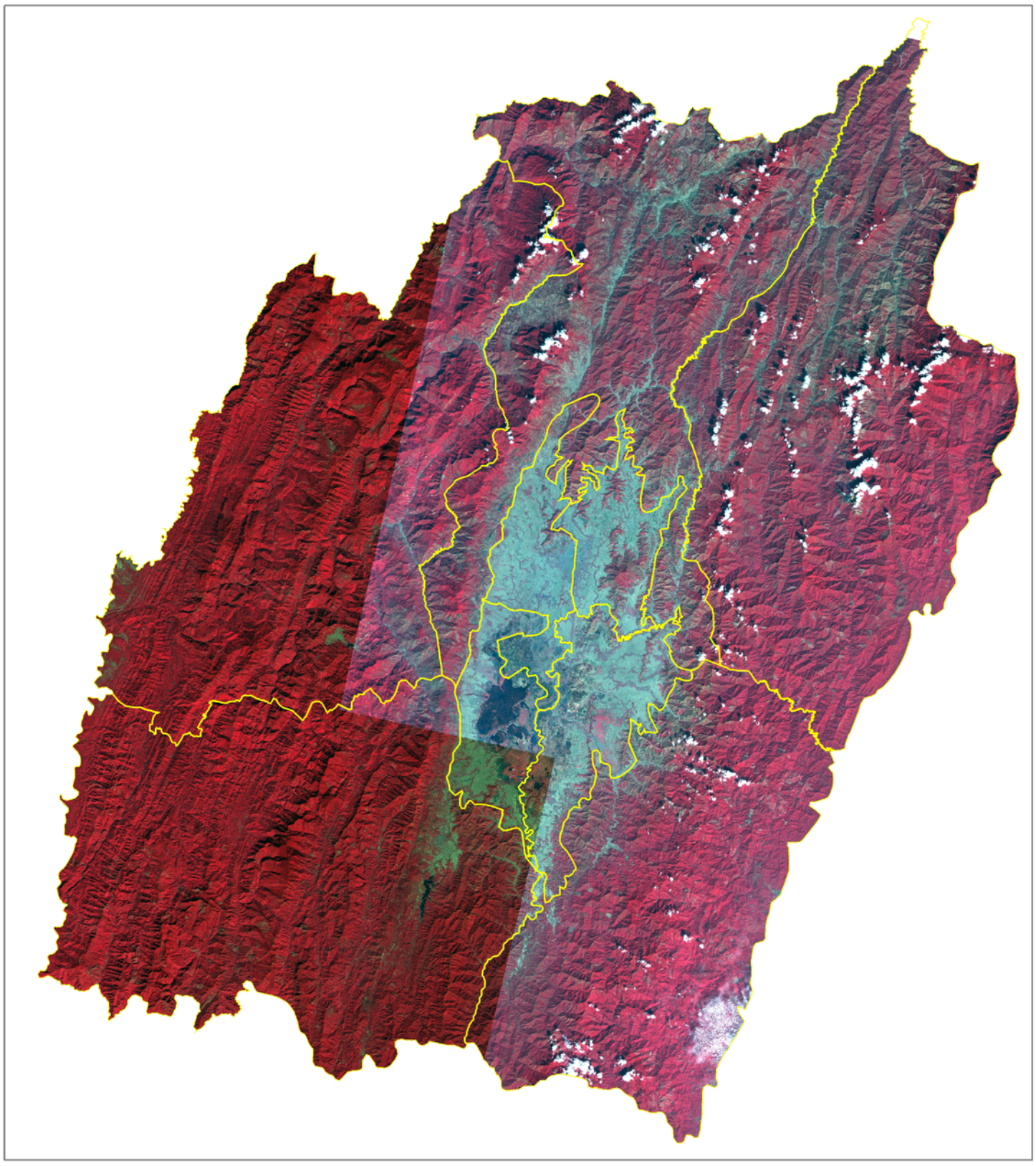
Data Source :
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP



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

7.1.1 Senapati

The Senapati District is located in the northern part of Manipur. The head quarter is Senapati town. It is bounded on the east by Ukhrul District, on the west by Tamenglong District, on the north by Phek District of Nagaland and on the south by Imphal East District and Imphal West District. The District is at an altitude varying from 1061 m to 1788 m above mean sea level. The hills run along the north south direction and gradually slope down towards south and meet the Imphal valley. The District is endowed with kaleidoscopic landscape of blue hills, green valleys, serpentine streams and rivers flowing through mountains and deep gorges. The total geographic area of the district is 3,271 sq km. The total population of the district is 3,79,214 (census 2001).

The wetland area estimated is 1911 ha. Small wetlands, which are less than minimum mapable units (MMU), are 120 in the district. The major wetland types are River/Streams and Reservoir. Details are given in Table 6.

Table 6: Area estimates of wetlands in Senapati

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	2	13	0.68	13	13
2	1106	River/Stream	19	1723	90.16	1723	1723
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	1	43	2.25	43	36
4	1202	Tanks/Ponds	4	12	0.63	12	12
		Sub-Total	**26**	**1791**	**93.72**	**1791**	**1784**
		Wetlands (<2.25 ha), mainly Tanks	120	120	6.28	-	-
		Total	**146**	**1911**	**100.00**	**1791**	**1784**

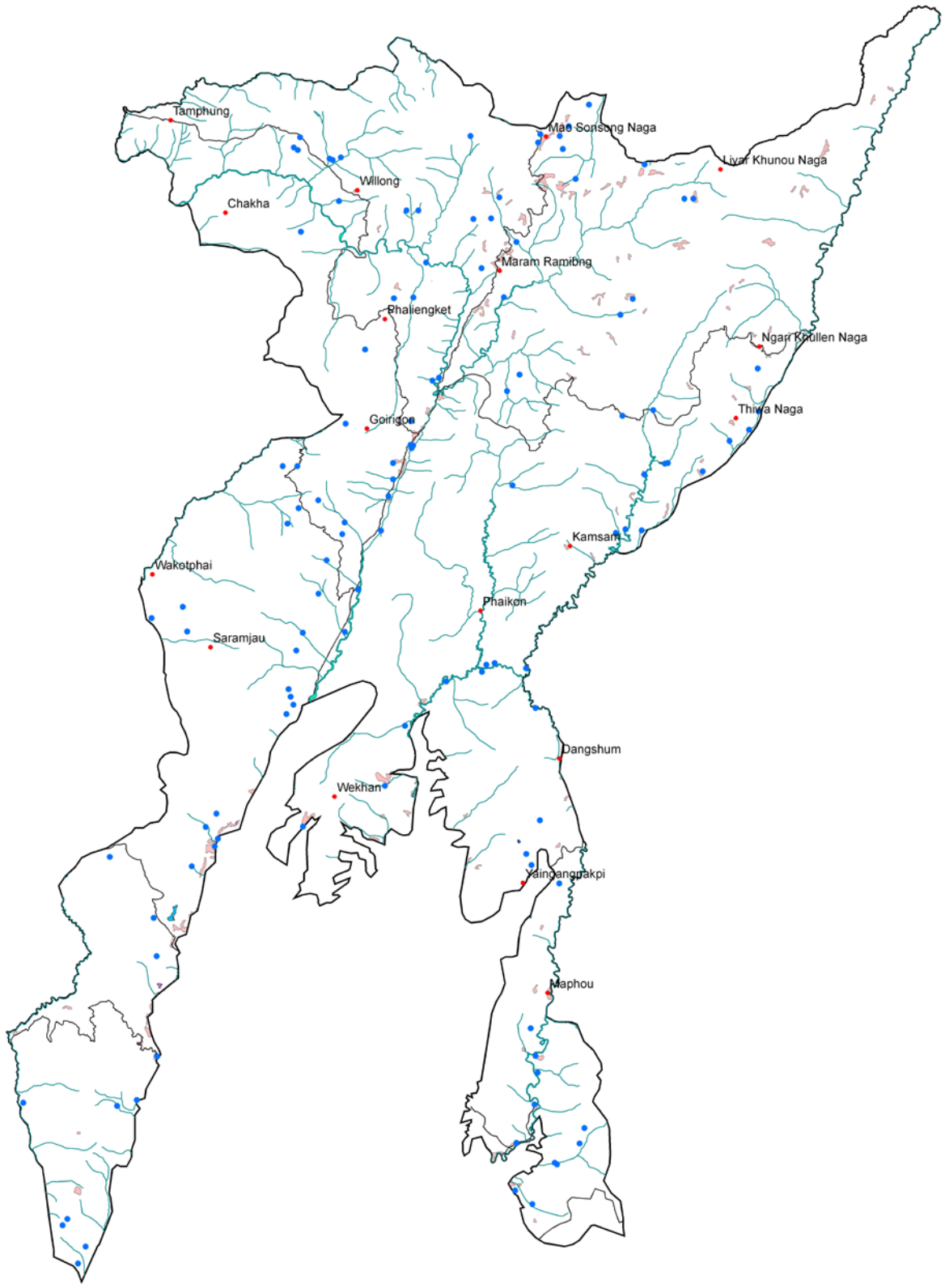
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	1767	1760
Moderate	24	24
High	-	-

State : Manipur

WETLAND MAP

District : Senapati

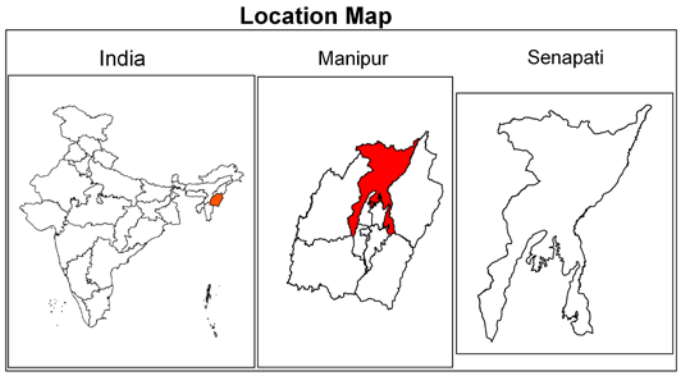


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/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

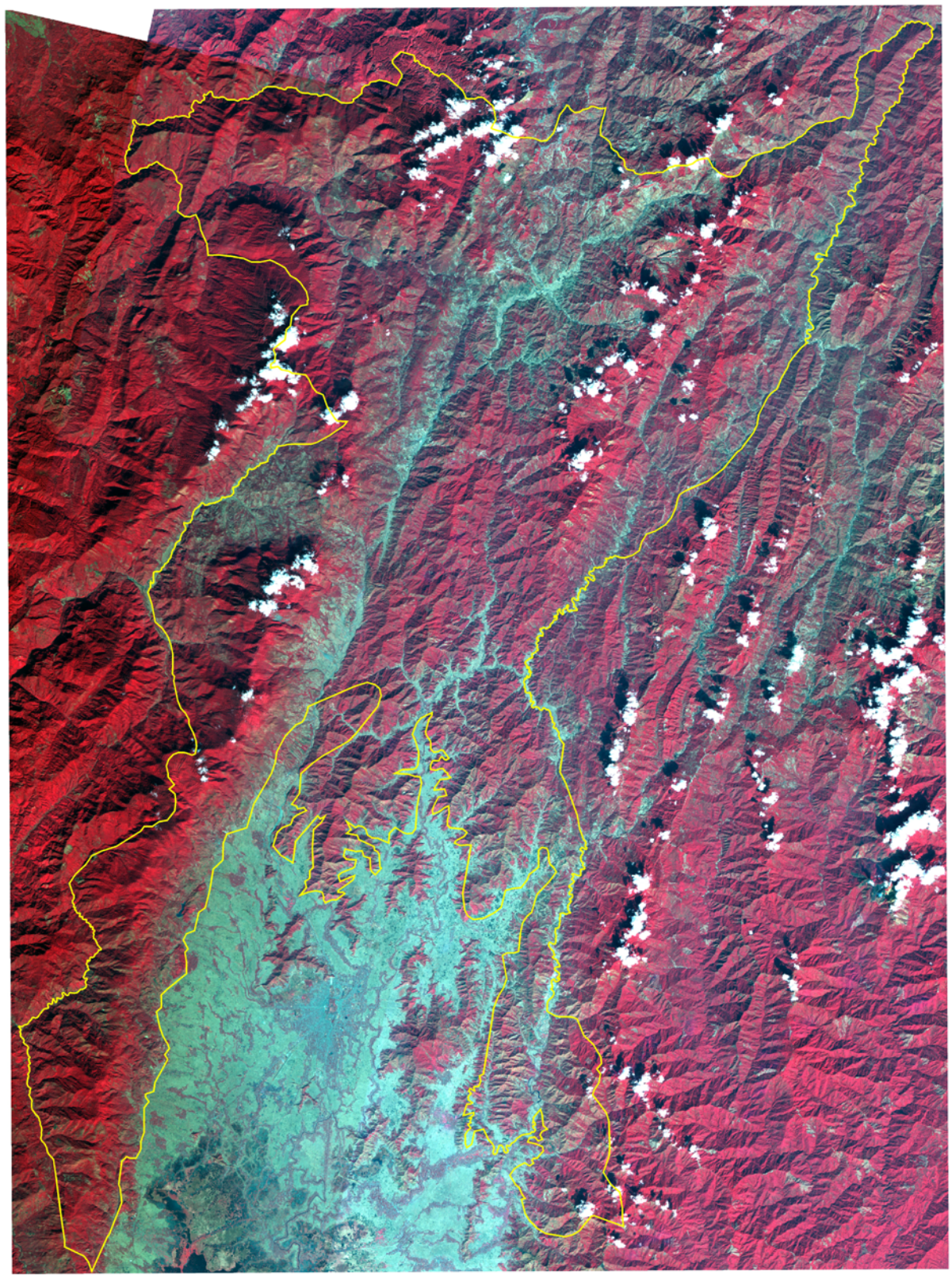
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Senapati



IRS P6 LISS-III post-monsoon data : 2006

7.1.2 Tamenglong

Tamenglong is located along the western boundary of the state. Tamenglong is entirely composed of hills, ranges and narrow valleys. The hilltops and valley sides are dotted with small hamlets, located at strategic points. The total geographic area of Tamenglong district is 4,391 sq km. The total population of the district is 1,11,493 (census 2001). The head-quarter of the district is Tamenglong town.

The wetland area estimated is 5086 ha. Small wetlands, which are less than minimum mapable units (MMU), are 47 in the district. The major wetland types are River/Streams. Details are given in Table 7.

Table 7: Area estimates of wetlands in Tamenglong

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	1106	River/Stream	7	4959	97.50	4959	4959
	1200	**Inland Wetlands -Man-made**					
2	1201	Reservoirs/Barrages	1	73	1.44	73	73
3	1202	Tanks/Ponds	3	7	0.14	7	7
		Sub-Total	**11**	**5039**	**99.08**	**5039**	**5039**
		Wetlands (<2.25 ha), mainly Tanks	47	47	0.92	-	-
		Total	**58**	**5086**	**100.00**	**5039**	**5039**

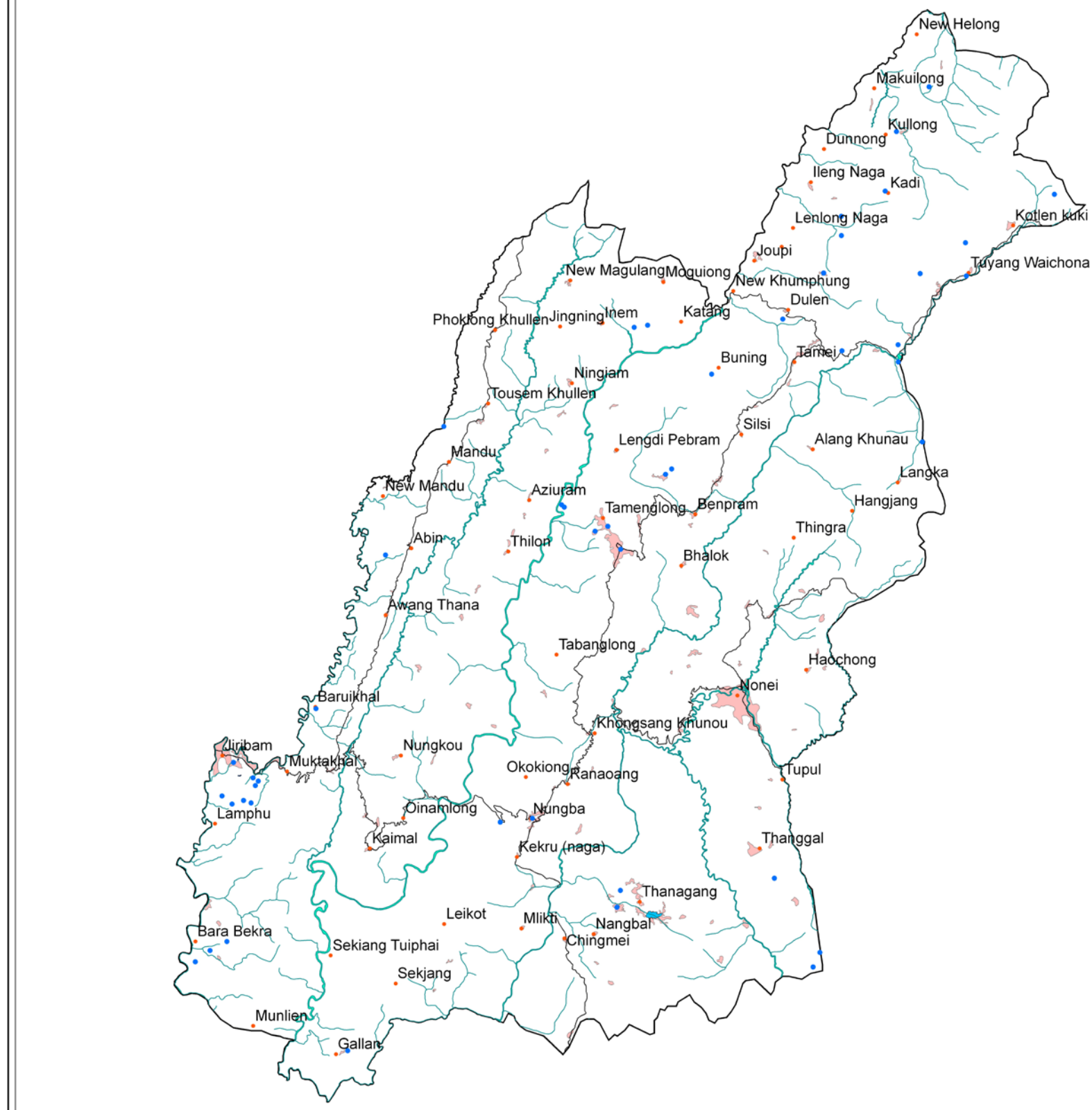
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	4959	4959
Moderate	80	80
High	-	-

State : Manipur

WETLAND MAP

District : Tamenglong

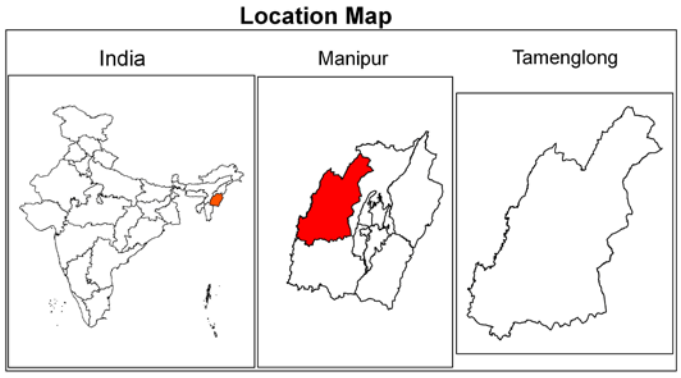


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/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

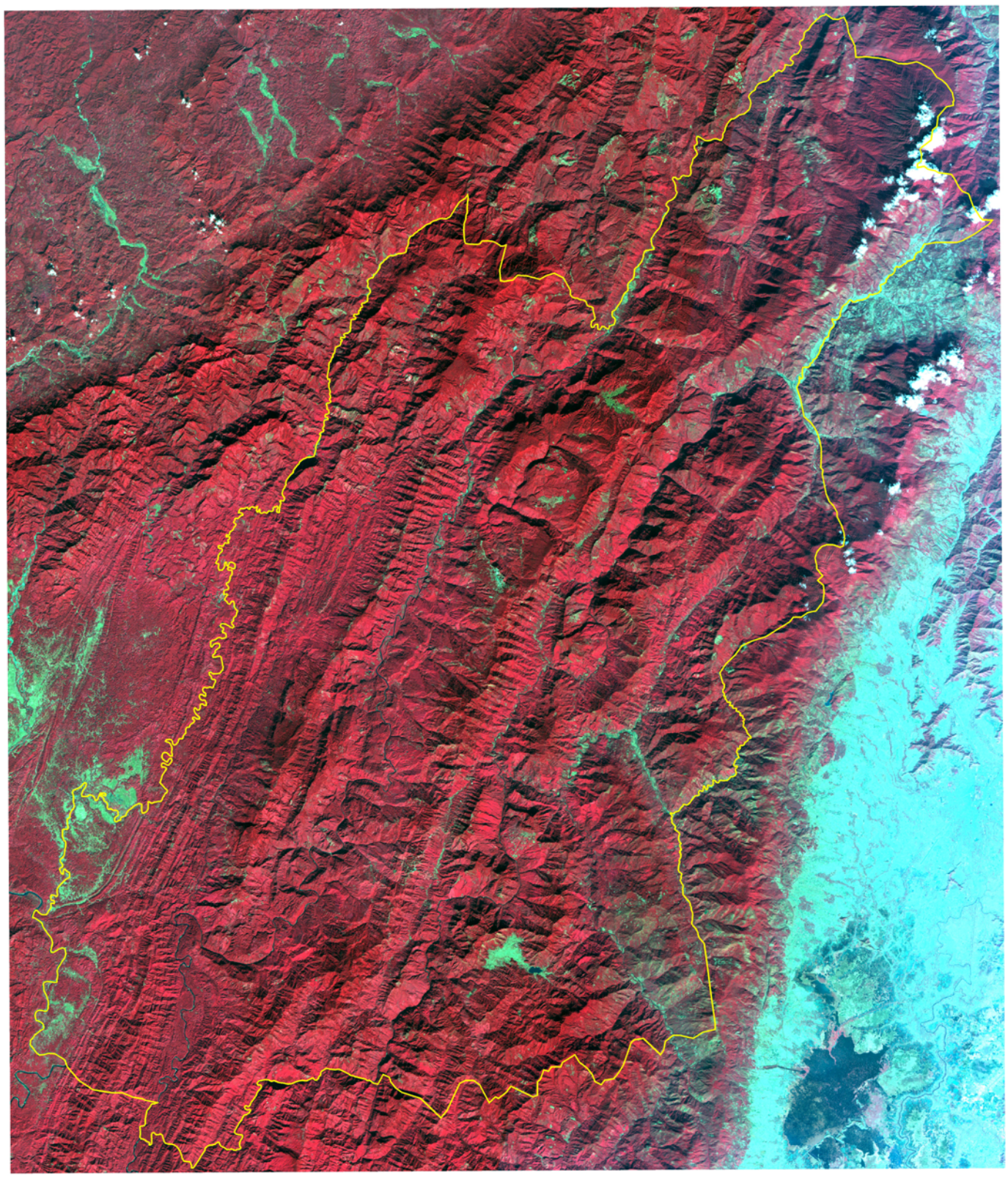
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Tamenglong



IRS P6 LISS-III post-monsoon data : 2006

7.1.3 Churachandrapur

Churachandpur District, in the southwestern corner of Manipur, has an area of 4570 sq.km. Its location is $23^{0}55^{'}$ to $24^{0}30^{'}$ North and $92^{0}59^{'}$ to $93^{0}50^{'}$ east. It is a hilly district with a very small percentage of the area being plain. According to 2001 census, the total population of the district is 2,28,707 and inhabited by several tribes, mainly belonging to the Kuki-Chin-Mizo group. The district is divided into 5 Revenue Sub-divisions, namely Churachandpur, Singngat, Thanlon, Parbung (Tipaimukh) and Henglep. The head-quarter of the district is Churachandrapur town.

The wetland area estimated is 4102 ha. Small wetlands, which are less than minimum mapable units (MMU), are 56 in the district. This is mainly due to presence of river/streams. One reservoir is located near Lamzang. Details of the wetlands are shown in Table-8.

Table 8: Area estimates of wetlands in Churachandrapur

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	1102	Ox-bow lakes/ Cut-off meanders	1	8	0.20	8	8
2	1106	River/Stream	19	3294	80.30	3294	3294
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	1	740	18.04	740	548
4	1202	Tanks/Ponds	1	4	0.10	4	4
		Sub-Total	**22**	**4046**	**98.63**	**4046**	**3854**
		Wetlands (<2.25 ha), mainly Tanks	56	56	1.37	-	-
		Total	**78**	**4102**	**100.00**	**4046**	**3854**

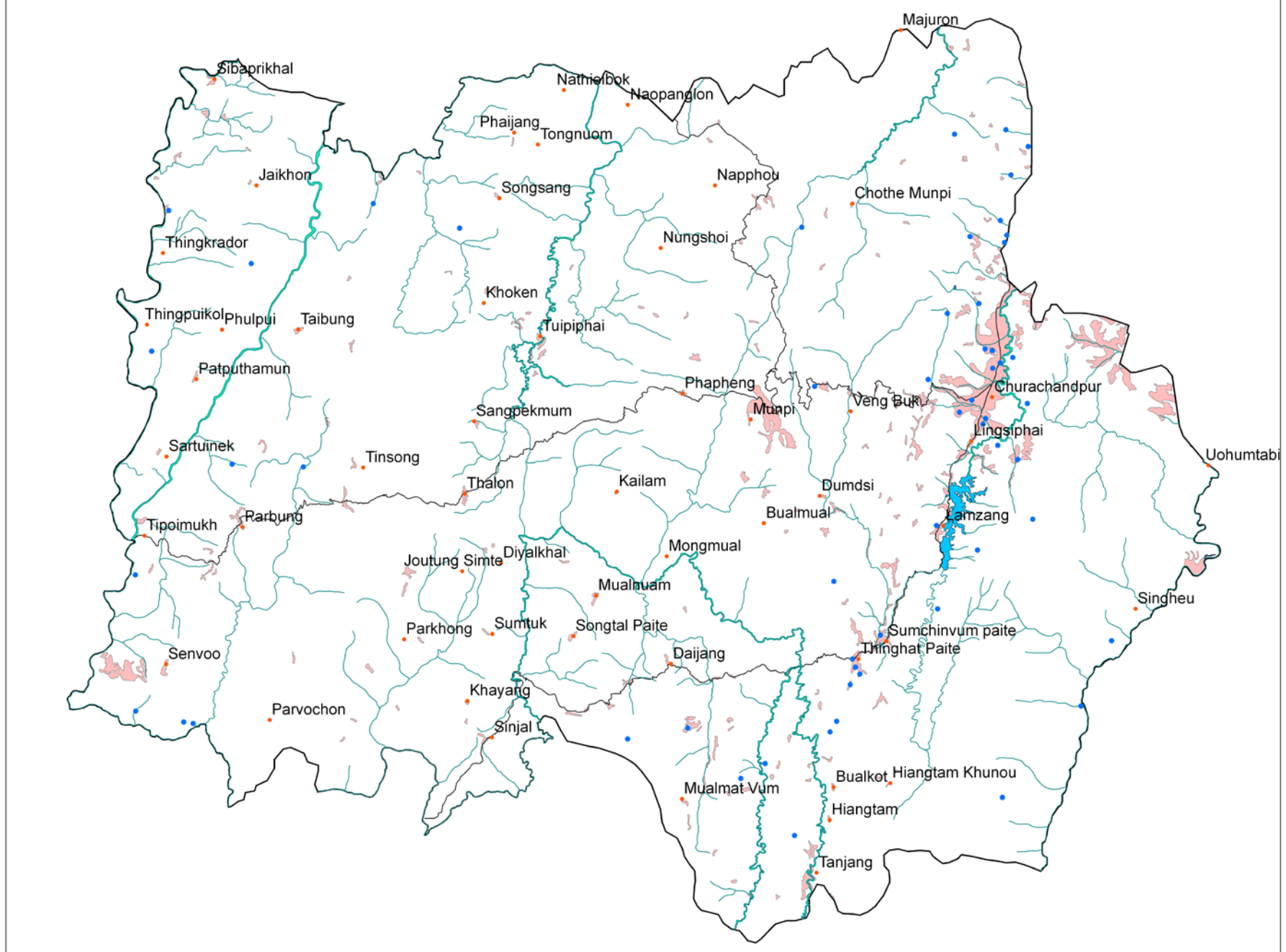
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	4034	3842
Moderate	4	4
High	8	8

State : Manipur

WETLAND MAP

District : Churachandpur

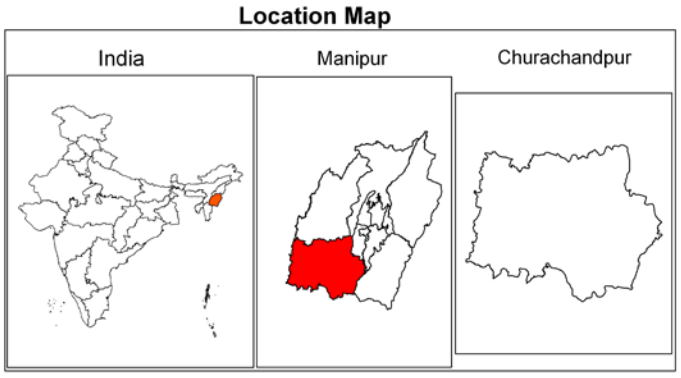


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/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

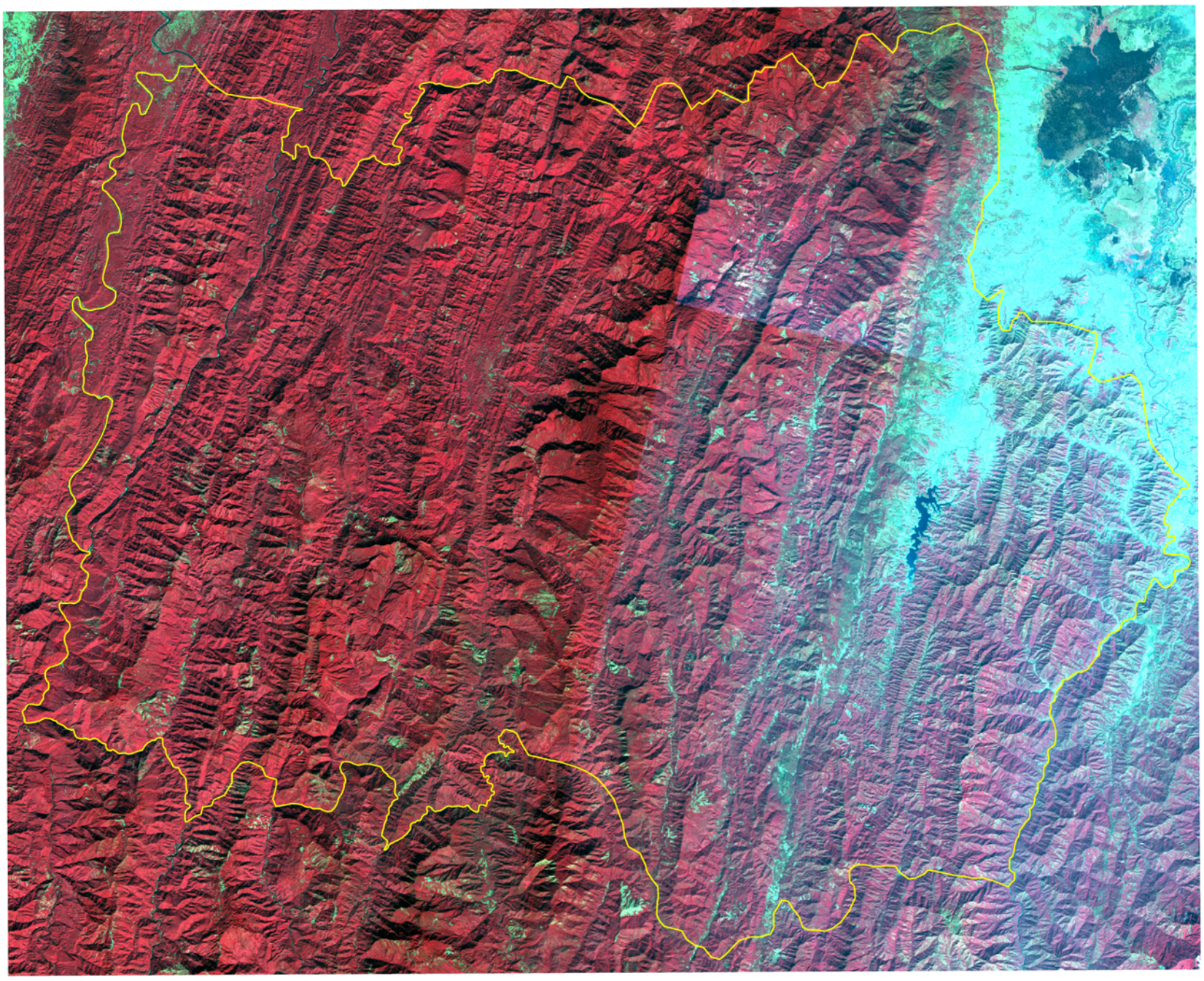
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Churachandpur



IRS P6 LISS-III post-monsoon data : 2006

7.1.4 Bishnupur

The Bishnupur with its headquarter at Bishnupur (27 Km. from Imphal) lies between 93.43º E and 93.53º E Longitudes and 24.18º N and 24.44º N Latitudes and the total geographical area of the District is 496 Sq. Km. It is bounded on the North by Imphal West District, on the South by Churachandpur District, on the East by Imphal and Thoubal Districts. The total population of the district is 2,05,907 (census 2001). The District is divided into three Sub-Divisions, viz (1) Bishnupur Sub-Division with its HQ at Bishnupur, (2) Moirang Sub-Division with its HQ at Moirang and (3) Nambol Sub-Division with its HQ at Nambol. The head-quarter of the district is Bishnupur town.

This district can be termed as the wetland district of the state as the wetland area estimated is 21,753 ha, accounting for 43.9 per cent of geographic area. Small wetlands, which are less than minimum mapable units (MMU), are 43 in the district. The wetland types found are Lakes/Ponds, Waterlogged area, Aquaculture ponds and River/Stream.

The dominant type of wetland found in the state is Lake/ponds which account for around 91 percent of the total wetland area of the district. Major part of the famous Loktak Lake lies in this district. Around 64 percent area of wetlands is under open water and 35 per cent having aquatic vegetation (floating and emergent type) during post-monsoon. The turbidity rating of the open water is observed to be mainly moderate.

Details of the wetland statistics of the district is given in Table 9.

Table 9: Area estimates of wetlands in Bishnupur

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	2	19900	91.48	12437	12178
2	1105	Waterlogged	4	283	1.30	173	167
3	1106	River/Stream	2	369	1.70	369	369
	1200	**Inland Wetlands -Man-made**					
4	1202	Tanks/Ponds	10	37	0.17	37	37
		Total - Inland	**18**	**20589**	**94.65**	**13016**	**12751**
	2200	**Coastal Wetlands - Man-made**					
5	2202	Aquaculture ponds	8	1121	5.15	1092	1121
		Total - Coastal	**8**	**1121**	**5.15**	**1092**	**1121**
		Sub-Total	**26**	**21710**	**99.80**	**14108**	**13872**
		Wetlands (<2.25 ha), mainly Tanks	43	43	0.20	-	-
		Total	**69**	**21753**	**100.00**	**14108**	**13872**

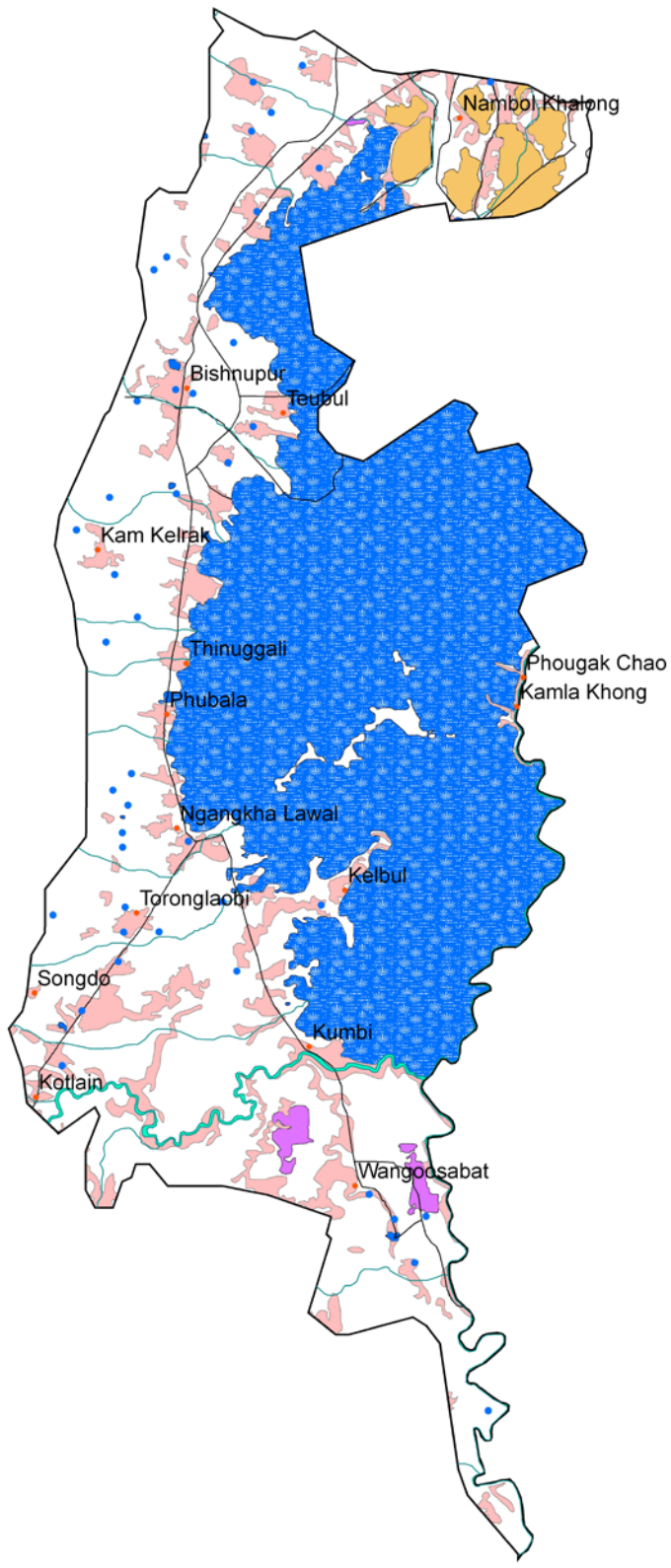
Area under Aquatic Vegetation	7541	7943

Area under turbidity levels		
Low	369	369
Moderate	13739	13503
High	0	0

State : Manipur

WETLAND MAP

District : Bishnupur

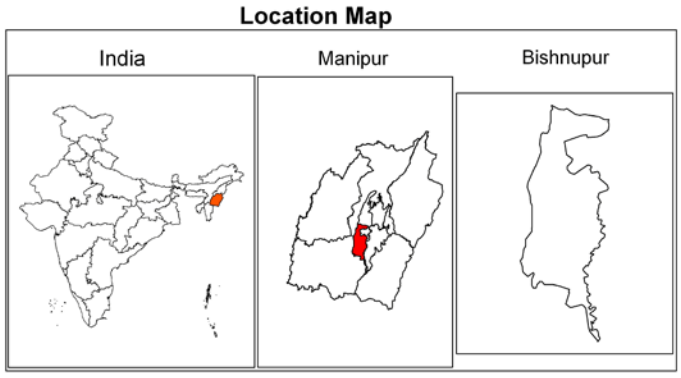


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements

Location Map



0 2 4 8 Kilometers

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

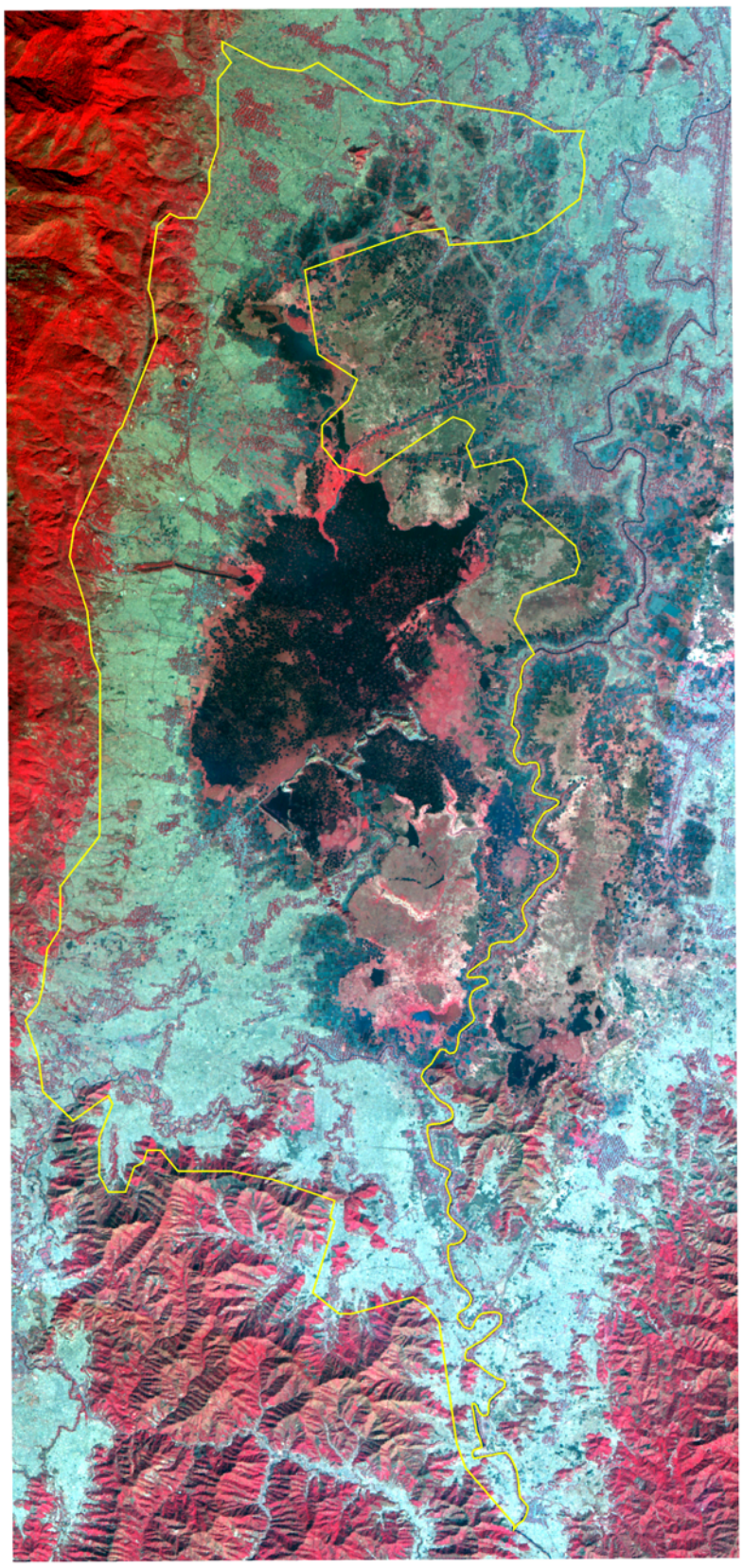
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Bishnupur



IRS P6 LISS-III post-monsoon data : 2006

7.1.5 Thoubal

The district of Thoubal, lies between 23° 45' N and 24°45' N latitude and 93°45' E and 94°15' E longitude. The total geographic area of Thoubal district is 514 sq km. The head-quarter of the district is Thoubal town. It is bounded on the north by Imphal district, on the east by Ukhrul and Chandel districts, on the south by Chandel and Churachandpur districts and on the west by the districts of Imphal and Bishnupur. The total population of the district is 3,66,341 (census 2001). Many rivers flow through the district and many lakes dot its surface. Important rivers that flow through the district are the Imphal and the Thoubal. The Thoubal river originates in the hill ranges of Ukhrul and is an important tributary of the Imphal river. On its course, it passes through Yairipok and Thoubal before joining the Imphal at Irong near Mayang Imphal. The Imphal river rises in the hills of Senapati district and flows south. It forms the boundary demarcating line of Thoubal district on its north and the west. Many important lakes of Manipur are in this district. The south-western portion of the district is a low-land forming a part of the Loktak Lake region and this area has a number of shallow and rain fed lakes, the important ones being Kharung, Ikop, Pumlen, and Khoidum. On the northern portion there are Wathou, Usholpam and Aongokham lakes. These lakes drain into the Imphal river.

The wetland area estimated is 15,718 ha. Small wetlands, which are less than minimum mapable units (MMU), are 91 in the district. The major wetland types are Lakes/Ponds, Waterlogged and River/Streams. The wetlands are highly eutrophic. The turbidity of the open water is mainly moderate. Details are given in Table 10.

Table 10: Area estimates of wetlands in Thoubal

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	7	12875	81.91	6895	1678
2	1105	Waterlogged	30	1829	11.64	1792	908
3	1106	River/Stream	11	854	5.43	854	854
	1200	**Inland Wetlands -Man-made**					
4	1202	Tanks/Ponds	14	69	0.44	69	69
		Sub-Total	**62**	**15627**	**99.42**	**9610**	**3509**
		Wetlands (<2.25 ha), mainly Tanks	91	91	0.58	-	-
		Total	**153**	**15718**	**100.00**	**9610**	**3509**

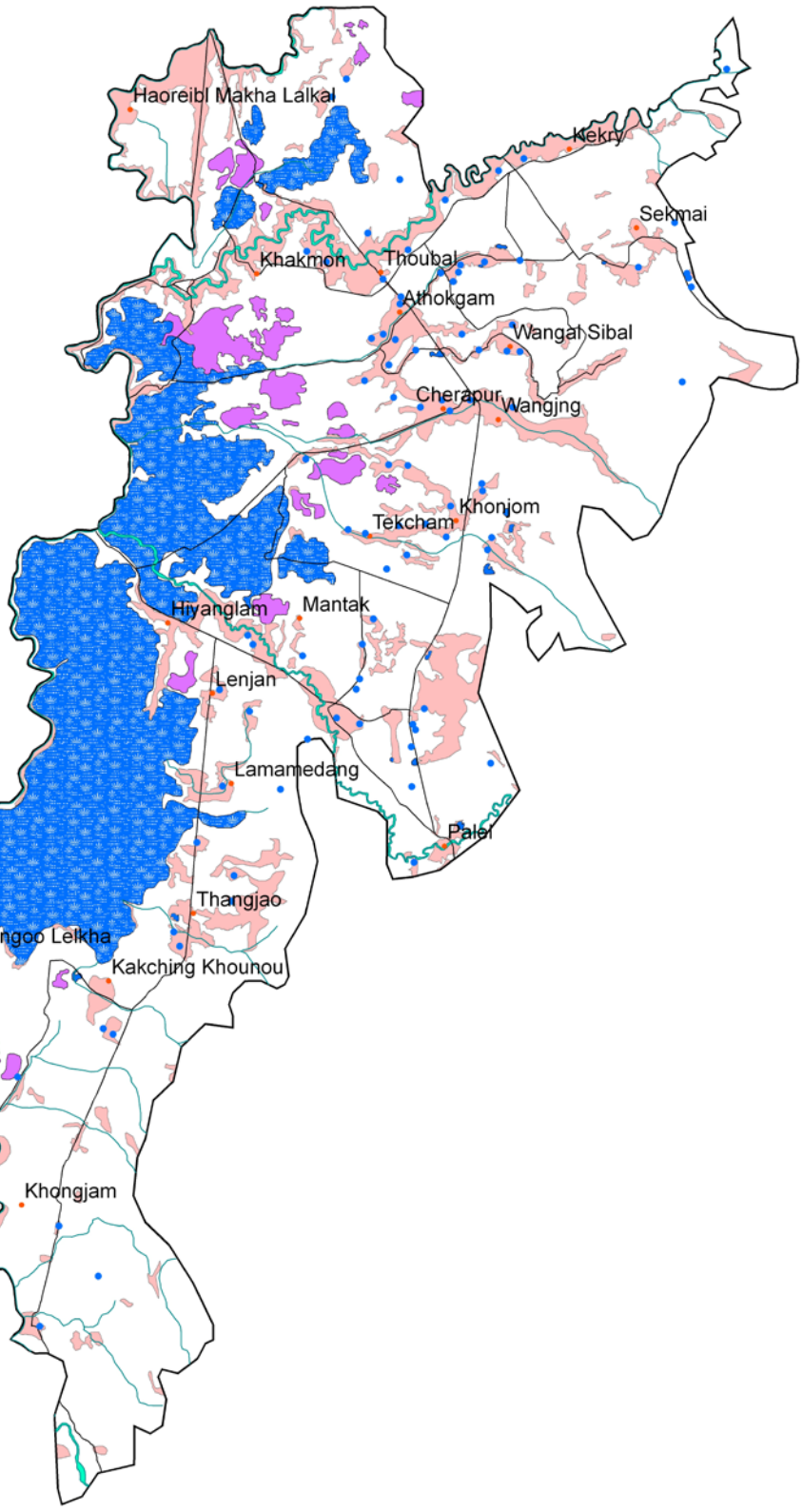
Area under Aquatic Vegetation	5907	12136

Area under turbidity levels		
Low	1259	854
Moderate	8110	2655
High	241	-

State : Manipur

WETLAND MAP

District : Thoubal

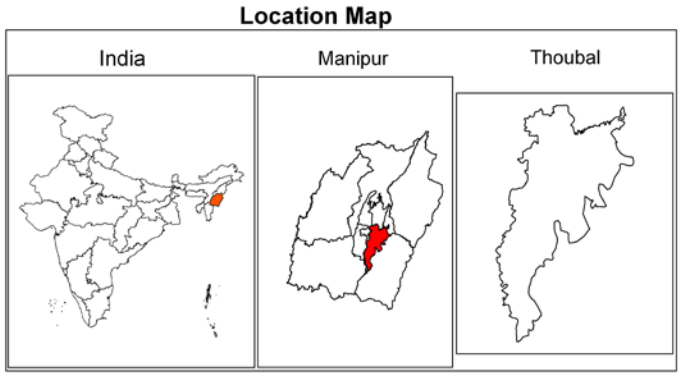


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements

Location Map



0 2.5 5 10 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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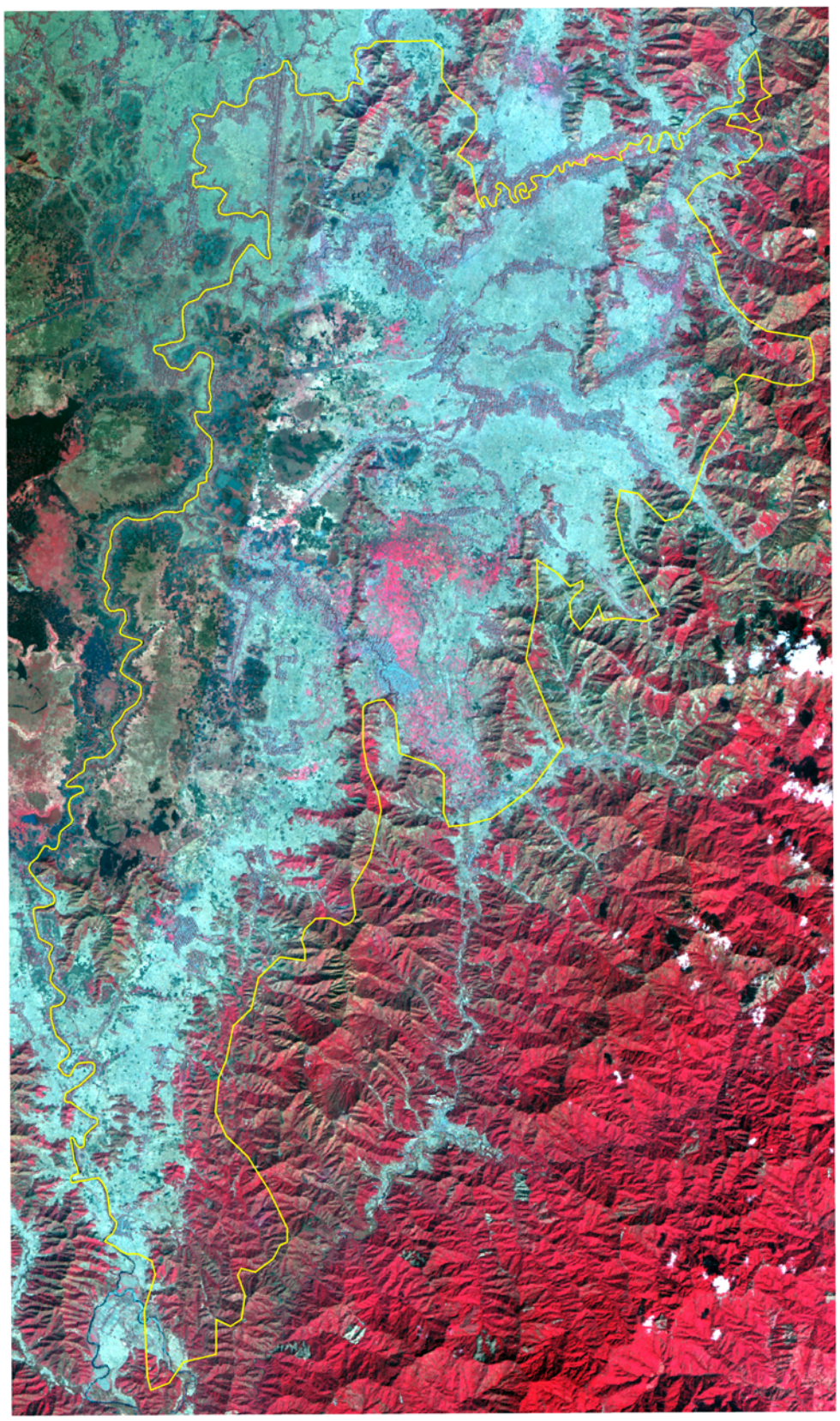
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Thoubal



IRS P6 LISS-III post-monsoon data : 2006

7.1.6 Imphal West

The Imphal West District falls in the Category of Manipur valley region. It is a tiny plain at the centre of Manipur surrounded by Plains of other districts. Imphal City, the State Capital is the nodal functional centre of this District. The whole district is under the influence of the monsoons characterised by hot and humid rainy seasons during the summer, and cool and dry seasons during the winter. Temperature ranges from minimum of 0^{o} C to maximum of 36^{o}C. The total geographic area of Imphal West district is 519 sq km. The total population of the district is 4,39,532 (census 2001).

The wetland area estimated is 8470 ha. Small wetlands, which are less than minimum mapable units (MMU), are 52 in the district. The major wetland types are Lakes/pond, aquaculture ponds and waterlogged. A large part of Loktak lake lies in this district. Around 38 per cent area are under aquatic vegetation (floating and emergent). The turbidity of the open water is mainly moderate. Details are given in Table 11.

Table 11: Area estimates of wetlands in Imphal West

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	6	6242	73.70	2862	3314
2	1105	Waterlogged	9	223	2.63	211	223
3	1106	River/Stream	3	418	4.94	418	418
	1200	**Inland Wetlands -Man-made**					
4	1202	Tanks/Ponds	6	13	0.15	13	13
		Total - Inland	**24**	**6896**	**81.42**	**3504**	**3968**
	2200	**Coastal Wetlands - Man-made**					
5	2202	Aquaculture ponds	6	1522	17.97	1291	1218
		Total - Coastal	**6**	**1522**	**17.97**	**1291**	**1218**
		Sub-Total	**30**	**8418**	**99.39**	**4795**	**5186**
		Wetlands (<2.25 ha), mainly Tanks	52	52	0.61	-	-
		Total	**82**	**8470**	**100.00**	**4795**	**5186**

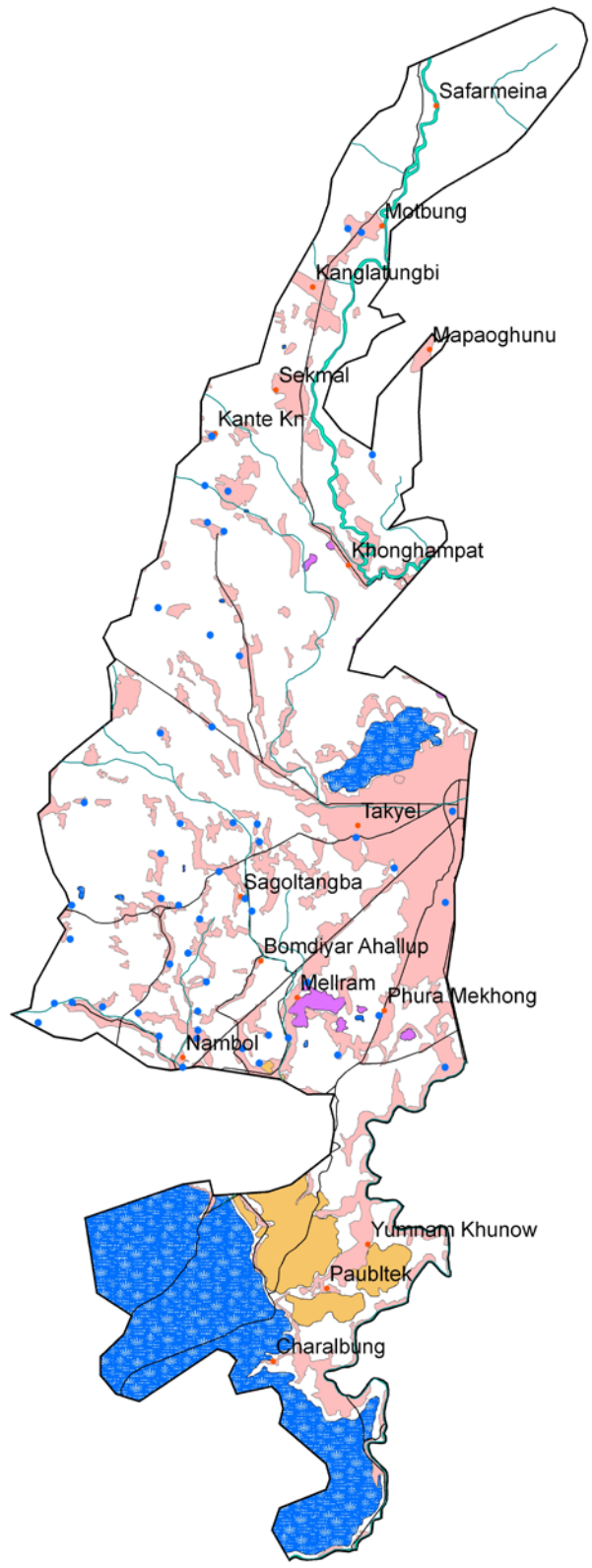
Area under Aquatic Vegetation	3011	3231

Area under turbidity levels		
Low	418	417
Moderate	4150	4544
High	227	225

State : Manipur

WETLAND MAP

District : Imphal_west

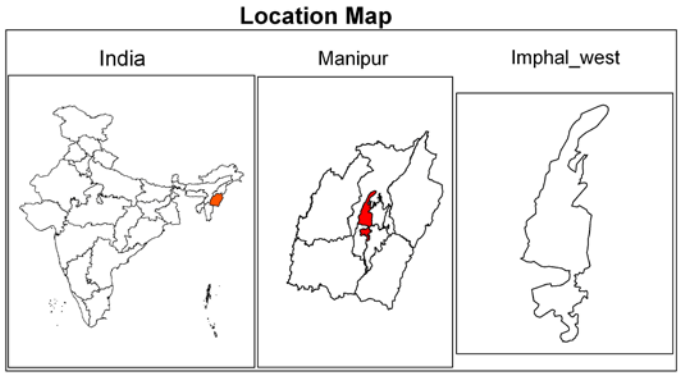


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements

Location Map



0 2.5 5 10 Kilometers

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

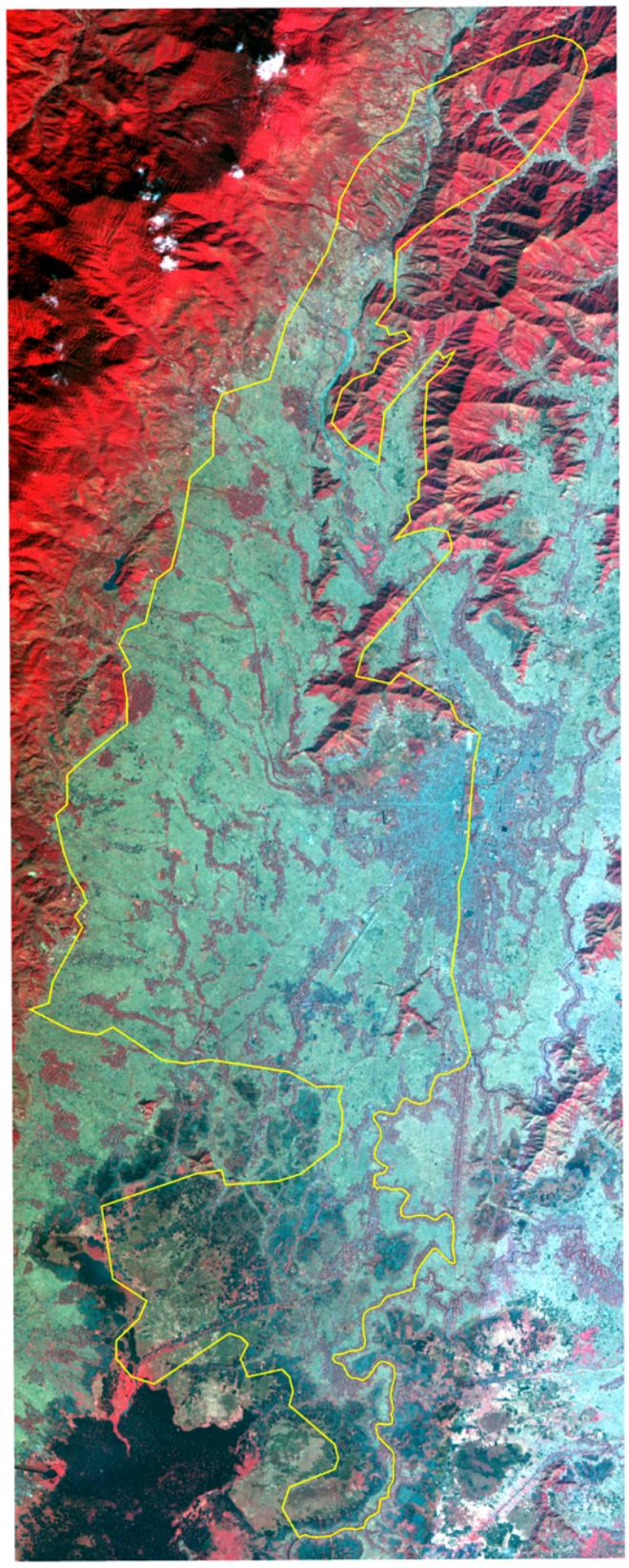
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Imphal_west



IRS P6 LISS-III post-monsoon data : 2006

7.1.7 Imphal East

Imphal East District is situated in two separate valleys of the state namely Central Valley and Jiribam Valley. The total geographic area of Imphal East district is 709 sq km. The head quarters is Porompat . The District is situated at an altitude 790 metres above the M.S. Level. The minimum temperature goes down to 0.6^0 C in winter and 41^0 C in summer. The District is connected with N.H. 39, N.H. 53 and N.H. 150. Agriculture is the main occupation of the people in the district. The total population of the district is 3, 93,780 (census 2001). In the district there are around 31000 ha area under rice cultivation.

The wetland area estimated is 2149 ha. Small wetlands, which are less than minimum mapable units (MMU), are 51 in the district. The major wetland type is Waterlogged (21 numbers) followed by River/Streams. Details are given in Table 12.

Table 12: Area estimates of wetlands in Imphal East

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	2	106	4.93	106	106
2	1102	Ox-bow lakes/ Cut-off meanders	6	42	1.95	37	42
3	1105	Waterlogged	21	1177	54.77	656	880
4	1106	River/Stream	7	737	34.30	737	737
	1200	**Inland Wetlands -Man-made**					
5	1202	Tanks/Ponds	13	36	1.68	33	36
		Sub-Total	**49**	**2098**	**97.63**	**1569**	**1801**
		Wetlands (<2.25 ha), mainly Tanks	51	51	2.37	-	-
		Total	**100**	**2149**	**100.00**	**1569**	**1801**

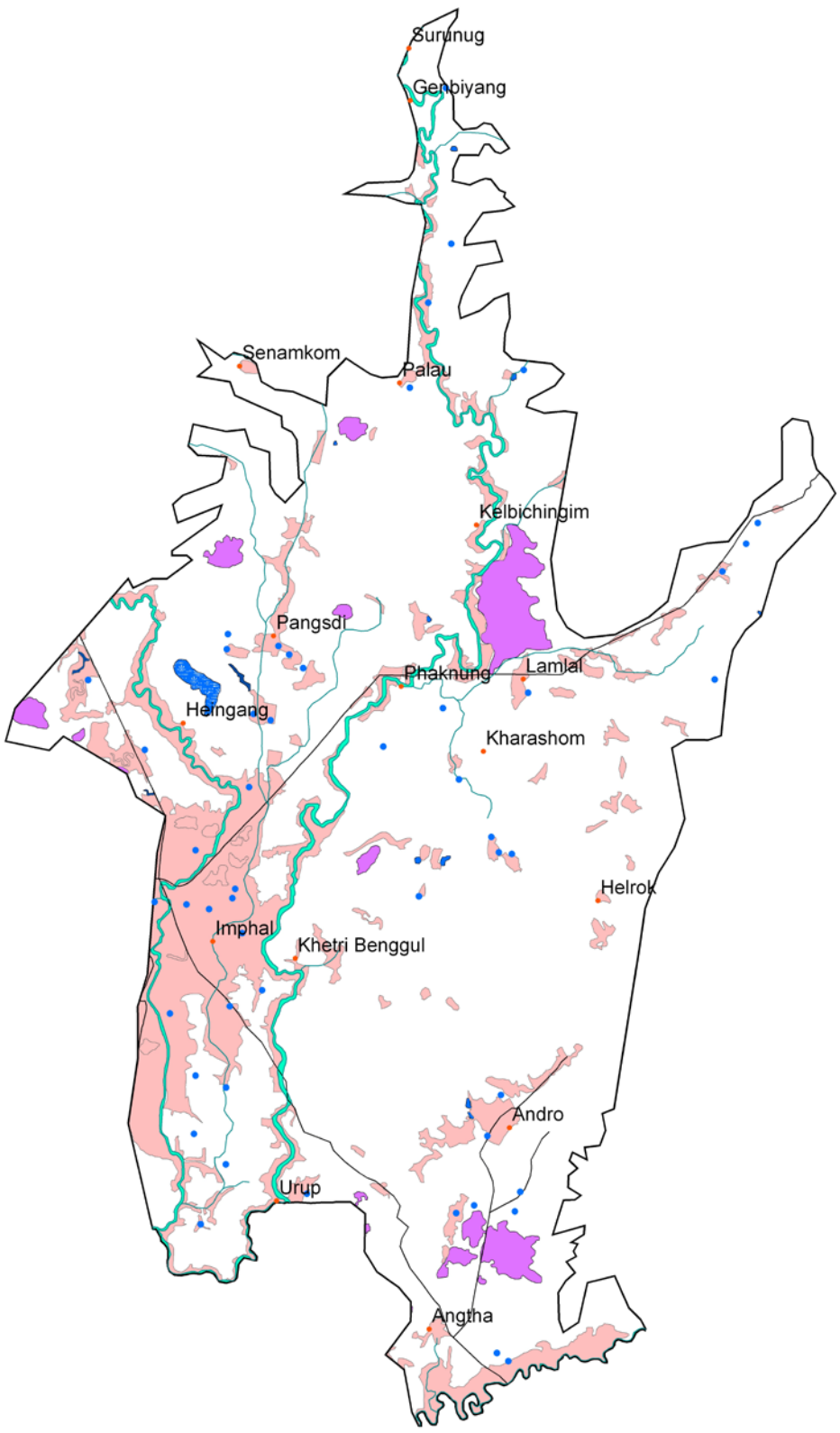
Area under Aquatic Vegetation	297	190

Area under turbidity levels		
Low	737	737
Moderate	795	1022
High	37	42

State : Manipur

WETLAND MAP

District : Imphal_east

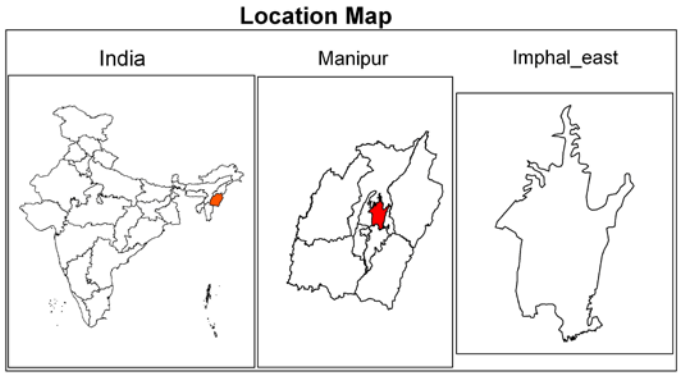


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements

Location Map



0 1.5 3 6 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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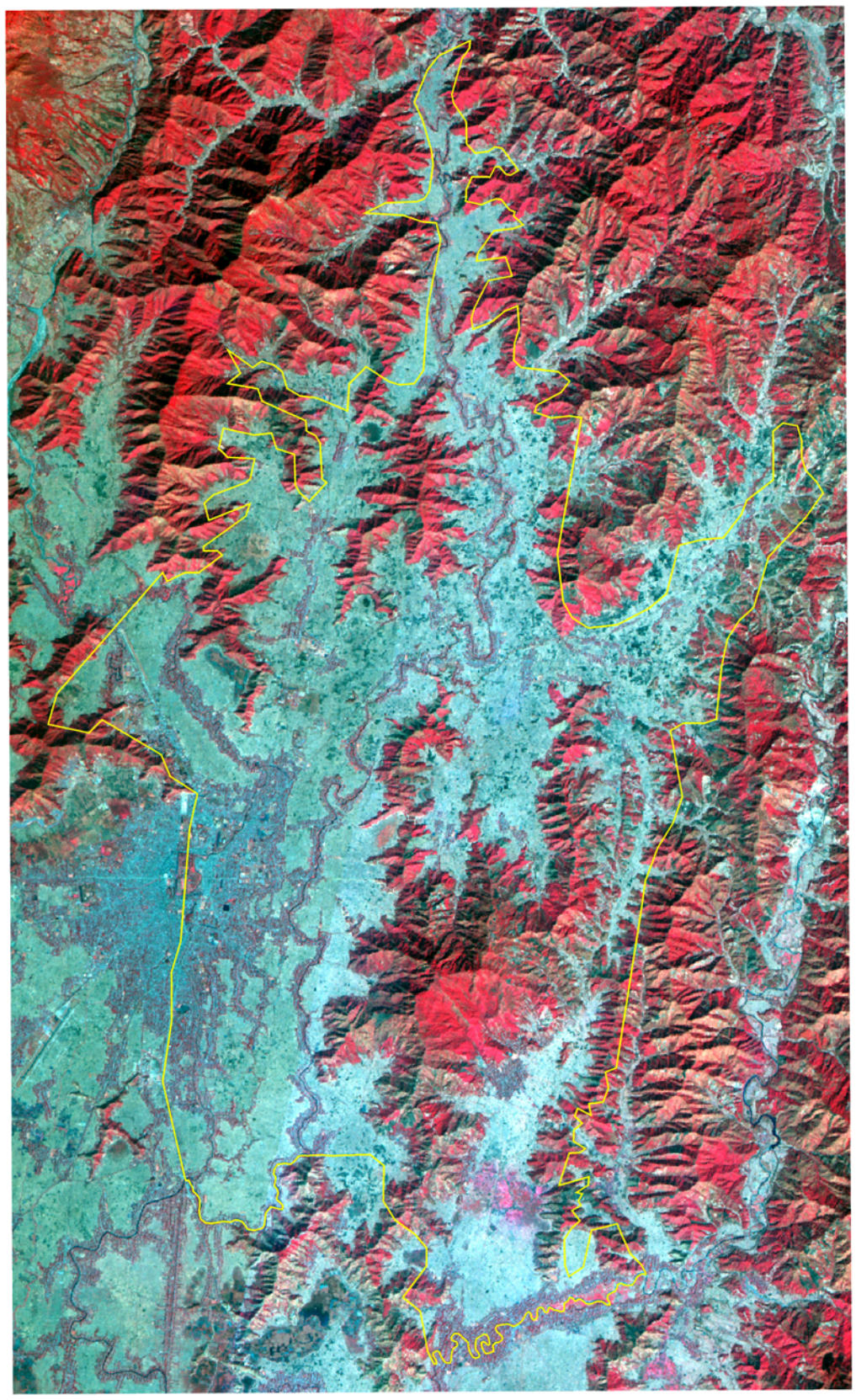
Government of India

State : Manipur

WETLAND MAP

District : Imphal_east



IRS P6 LISS-III post-monsoon data : 2006

7.1.8 Ukhrul

Ukhrul District is bounded by Myanmar in the East, Chandel District in the South, Imphal East and Senapati Districts in the West and Nagaland State in the North. The terrain of the district is hilly with a varying heights of 913 m to 3114 m (MSL). The head-quarter of the district is Ukhrul town. The climate of the district is of temperate nature with a minimum and maximum degrees of 3° C to 33° C. The total geographic area of Ukhrul district is 4,544 sq km. The total population of the district is 1,40,946 (census 2001).

The wetland area estimated is 2,411 ha. Small wetlands, which are less than minimum mapable units (MMU), are 56 in the district. The major wetland type is River/Stream. Details are given in Table 13.

Table 13: Area estimates of wetlands in Ukhrul

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	1106	River/Stream	14	2348	97.39	2348	2348
	1200	**Inland Wetlands -Man-made**					
2	1202	Tanks/Ponds	2	7	0.29	7	7
		Sub-Total	**16**	**2355**	**97.68**	**2355**	**2355**
		Wetlands (<2.25 ha), mainly Tanks	56	56	2.32	-	-
		Total	**72**	**2411**	**100.00**	**2355**	**2355**

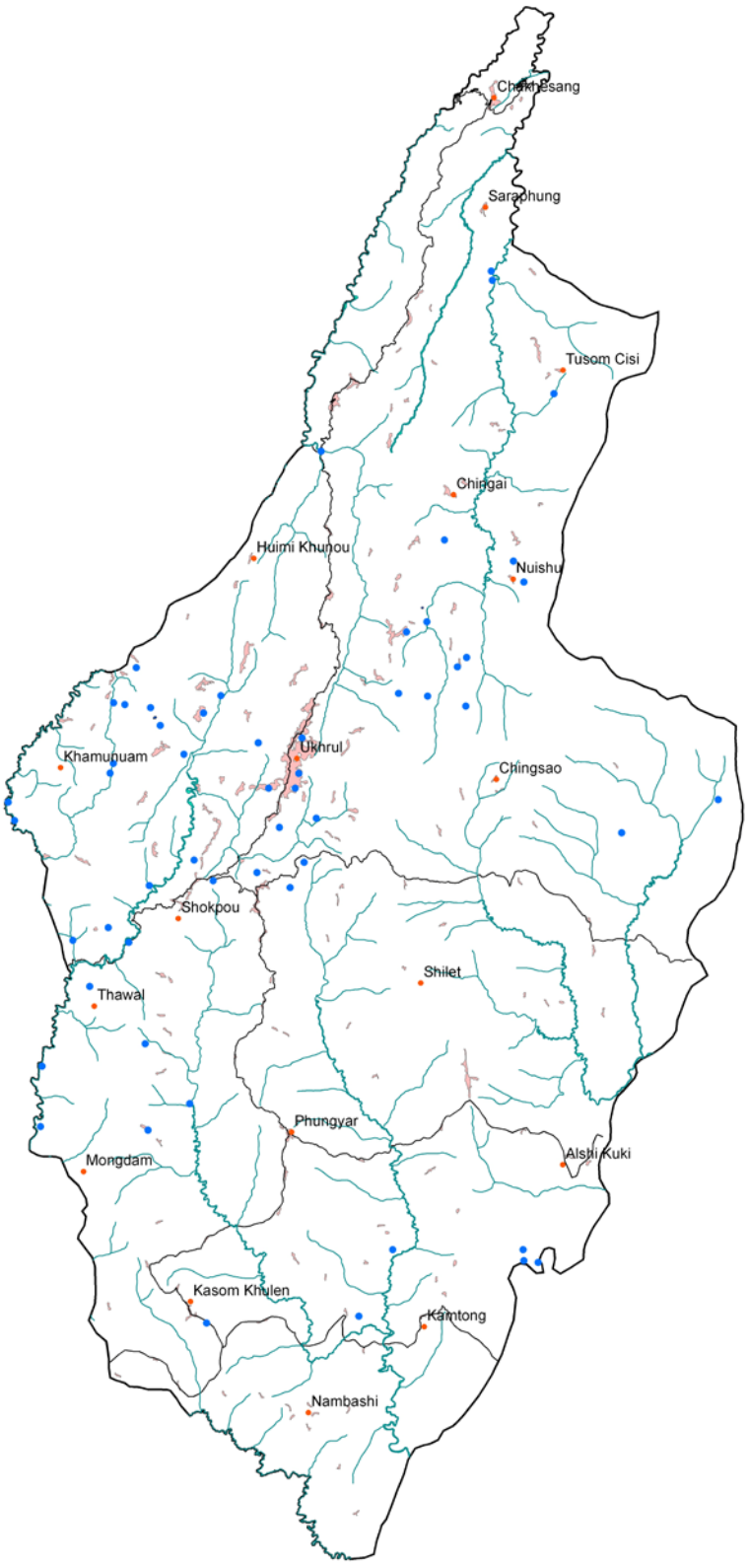
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2348	2348
Moderate	7	7
High	-	-

State : Manipur

WETLAND MAP

District : Ukhrul

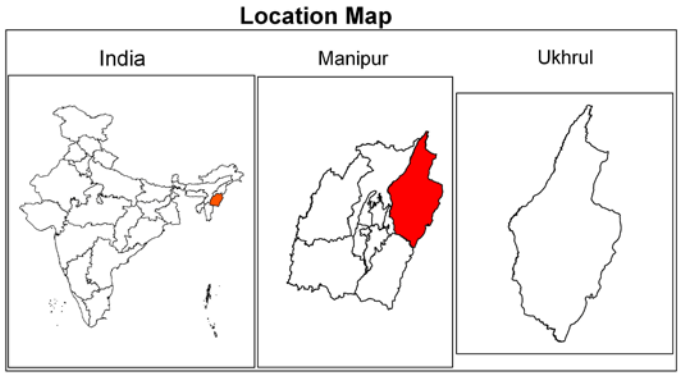


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/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

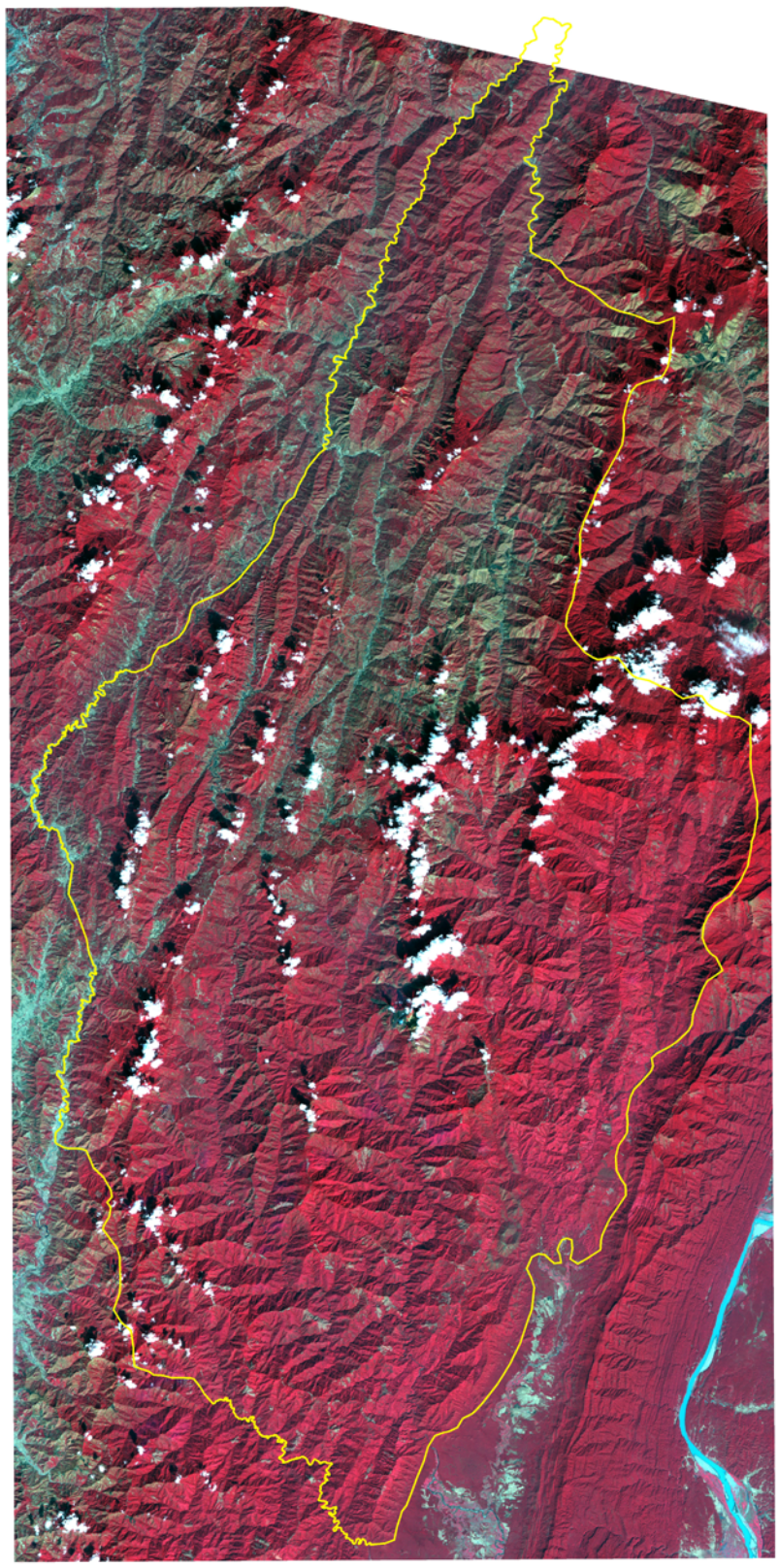
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Ukhrul



IRS P6 LISS-III post-monsoon data : 2006

7.1.9 Chandel

The Chandel District lies in the south-eastern part of Manipur at 24^{o}40' N Latitude and 93^{o}50' E Longitude. It is the border district of the state. Its neighbors are Myanmar (erstwhile Burma) on the south, Ukhrul district on the east, Churachandpur district on the south and west, and Thoubal district on the north. It is about 64 km. away from Imphal. The National Highway No. 39 passes through this district. The Moreh town, the international trade centre of the state, lies on the southernmost part of the district. The head-quarter of the district is Chandel town. It is a hill district with an area of 3,313 sq. km. It is sparsely inhabited by about 20 different tribes. As per Census 2001, the population of the district is 1,34,462 with the density of population per sq. km. being 41.

The district has very less wetlands. The wetland area estimated is 2,016 ha. Small wetlands, which are less than minimum mapable units (MMU), are 25 in the district. The major wetland type is River/Stream (Table14).

Table 14: Area estimates of wetlands in Chandel

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	1102	Ox-bow lakes/ Cut-off meanders	2	14	0.69	14	14
2	1106	River/Stream	10	1975	97.97	1975	1975
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	1	2	0.10	2	2
		Sub-Total	**13**	**1991**	**98.76**	**1991**	**1991**
		Wetlands (<2.25 ha), mainly Tanks	25	25	1.24	-	-
		Total	**38**	**2016**	**100.00**	**1991**	**1991**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	1975	1975
Moderate	2	2
High	14	14

State : Manipur

WETLAND MAP

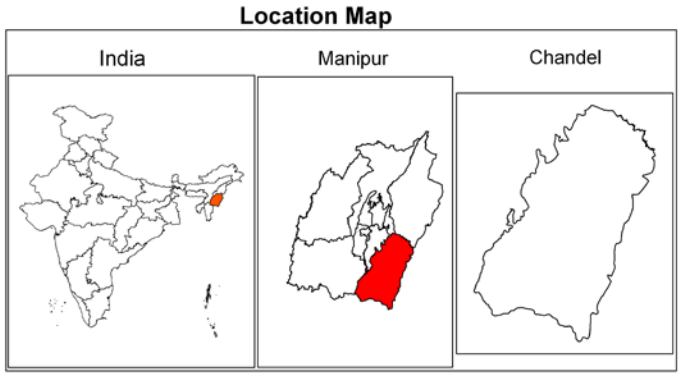
District : Chandel

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
- Drainage (line)
- Settlements
- Town/Settlements

Location Map



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

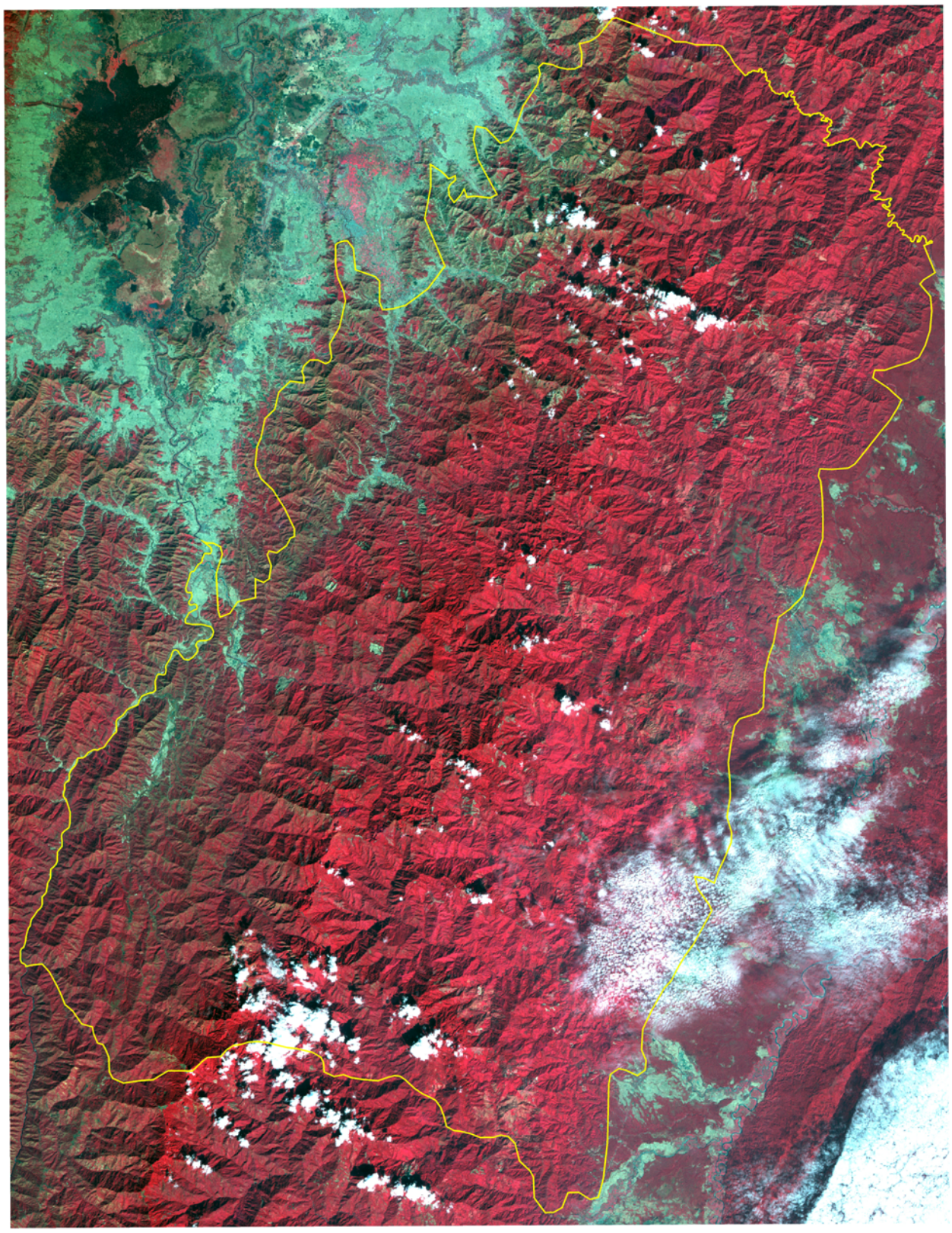
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

District : Chandel



IRS P6 LISS-III post-monsoon data : 2006

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF MANIPUR

Major wetland types observed in the state are Lakes, Rivers, Waterlogged areas and Aquaculture ponds. Details are given in Plate-1. Ground truth data was collected for selected wetland sites. The standard proforma 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.

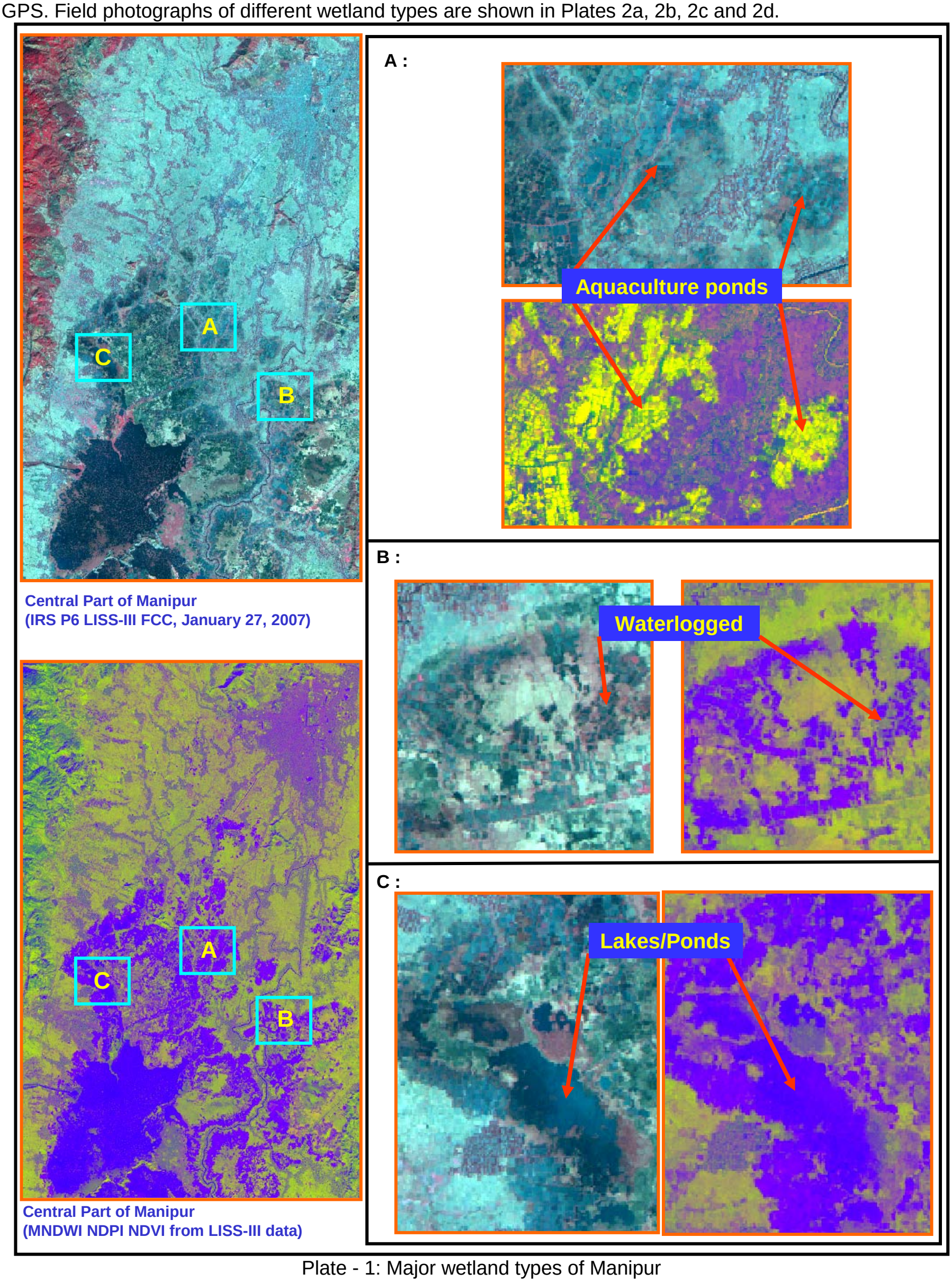


Plate - 1: Major wetland types of Manipur

Sr. No.	Description	Field photograph
1.	Wetland Type : Lake/Pond (Northern part of Loktak lake) Location : longitude: 93º 48' 58" E latitude : 24º 36' 10" N Turbidity : High Aquatic Vegetation : Yes	
2.	Wetland Type : Lake/Pond Location : longitude: 93º 48' 34" E latitude : 24º 35' 54" N Turbidity : Moderate Aquatic Vegetation : Common Name :*Nymphaeaceae* Local Name :*Thambal* Scientific Name:*Nelumbium speciocum*	
3.	Wetland Type : Lake/Pond (Western part of Loktak lake) Location : longitude: 93º 46' 21" E latitude : 24º 33' 38" N Turbidity : Moderate Aquatic Vegetation : Yes	
4.	Wetland Type : Lake/Pond (Central part of Loktak lake) Location : longitude: 93º 48' 18" E latitude : 24º 33' 10" N Turbidity : Moderate Aquatic Vegetation : Yes	

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

Sr. No.	Description	Field photograph
5.	Wetland Type : Lake/Pond (Southern part of Keibul Lamjao National Park) Location : longitude: 93º 49' 54" E latitude : 24º 29' 43" N	
6.	Wetland Type : Lake/Pond (Resting place of Sangai, Part of Keibul Lamjao National Park) Location : longitude: 93º 50' 17" E latitude : 24º 30' 16" N	
7.	Wetland Type : Waterlogged (permanent) Location : longitude: 93º 58' 28" E latitude : 24º 32' 48" N Turbidity : Moderate Aquatic Vegetation : Yes	
8.	Wetland Type : Lake/Pond (Eastern part of Loktak lake) Location : longitude: 93º 53' 38" E latitude : 24º 32' 52" N Turbidity : Moderate Aquatic Vegetation : *Eichhornia* species	

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

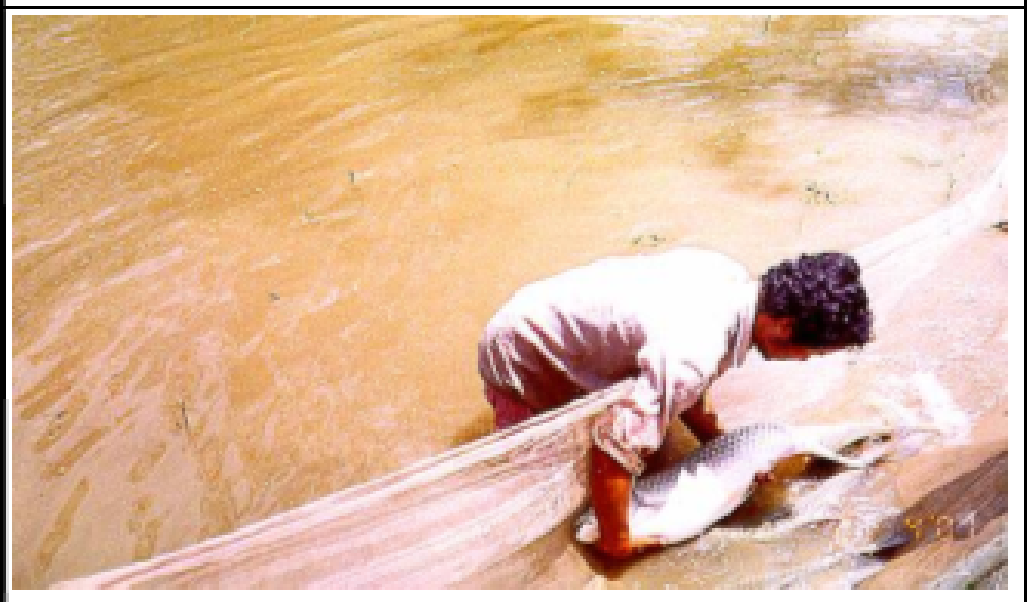
Sr. No.	Description	Field photograph
9.	Wetland Type : Lake/Pond (Keibul Lamjao National Park) Location : longitude: 93º 49' 55" E latitude : 24º 30' 56" N <u>Phumdi sinking area</u> Small patches of phumdi is sinking in many places of the lake. It is due to the decrease in buoyancy of the phumdi. It affects to fishing. It leads to the siltation of the lake	
10.	Wetland Type : Reservoir (Churachandrapur district) Location : longitude: 93º 40' 21" E latitude : 24º 16' 14" N Turbidity : Moderate Aquatic Vegetation : No	
11.	Wetland Type : Aquaculture Pond (Fish seed farm at Laphupat Tera) Location : longitude: 93º 52' 11" E latitude : 24º 39' 15" N Turbidity : High Aquatic Vegetation : Yes	
12.	Wetland Type : River Location : longitude: 93º 55' 47" E latitude : 24º 32' 52" N Turbidity : Moderate	

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

Sr. No.	Description	Field photograph
13.	Wetland Type : Lake/Pond Location : longitude: 93º 48' 32" E latitude : 24º 35' 5" N Turbidity : Low Aquatic Vegetation : Yes	
14.	Wetland Type : Lake/Pond Location : longitude: 93º 48' 9" E latitude : 24º 38' 31" N Turbidity : Low Aquatic Vegetation : Yes	
15.	Wetland Type : Waterlogged (permanent) Location : longitude: 93º 55' 32" E latitude : 24º 37' 55" N Turbidity : Moderate Aquatic Vegetation : Yes	
16.	Wetland Type : Waterlogged (permanent) Location : longitude: 93º 55' 33" E latitude : 24º 37' 55" N Turbidity : Moderate Aquatic Vegetation : Yes	

Plate 2d: Field photographs and ground truth data of different wetland types in Manipur

IMPORTANT WETLANDS OF MANIPUR

9.0 IMPORTANT WETLANDS OF MANIPUR

The wetlands of the state comprise of a large as well as small lakes in the southern portion of the Manipur valley. There are also a number of freshwater swamps and marshes which are found in the inter revering tracts. The lakes besides the rivers constitute the major part of the wetlands of the state. Loktak lake (including Keibul Lamjao, Sana pat, Laphu pat & Thaunamcha pat) is most important wetland areas of Manipur state. Southern part of Loktak lake is declared as Keibul Lamjao National Park(KLNP). Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of wetland site. Details of each wetland and wetland map of 5 km buffer area are shown in plates 3-5. There other important lakes like Ikop(Kharung) Pat, Waithou(Punnem) Pat, and Aongbikhong Pat are exist in surrounding area of Loktak lake.

9.1 Loktak lake

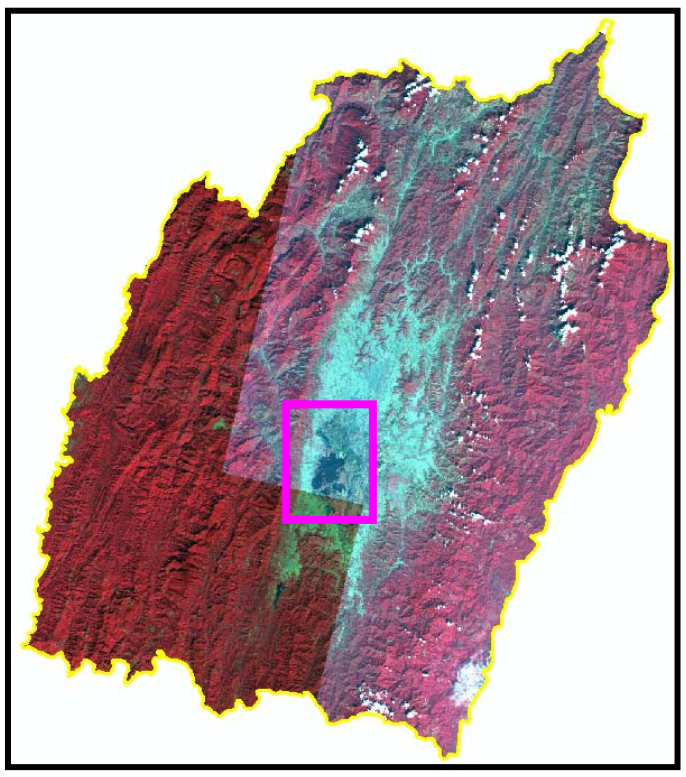
Loktak lake of Manipur is the largest fresh water lake in the North-Eastern India. Loktak Lake lies between 24^0 25 ' N and 24^0 41' N latitudes and 93^0 46 ' E and 93^0 55 ' E longitudes. Loktak Lake is located near Moirang in Manipur state. This is also known as the only floating lake in the world due to the floating mats (heterogeneous mass of vegetation, soil, and organic matters at various stages of decomposition) on it. The floating mats, formed by collection of decaying vegetable matter, locally called '*phumdi*' play a significant role in the socio-cultural life of the people and are characteristic of the lake. These *phumdis* are most widespread in Loktak lake, The area of the lake is 246.72 km^2, comprising large pockets of open water and marshy land formed at the southern part of the Imphal valley up to the confluence of Manipur River and Khuga River in the district of Imphal West. Within the lake and on its periphery, there are 14 hills of varying size and elevation; the islands in the southern part of the lake are called the Sendra, Ithing and Thanga islands.

Towards the east and the southeast of Loktak lake, three smaller lakes namely the Ipok Pat, the Kharung Pat and the Pumlen Pat complete the wetland ecosystem of the Manipur valley. Wetland habitats include the Miao river, its tributaries, and associated marshes.

Catchment Area of the Loktak lake

Loktak Lake is facing a serious problem of silting up, due to erosion in the catchment and deposition of silt in the lake. Topographically, its catchment comprises two units, viz. Hills, and Valley with low laying plains. Loktak Lake falls under the sub-basin of the Manipur River and its direct catchment occupies an area of 1040 sq. km. The topography of the direct catchment area is an undulating terrain having elevation of 780 metres at the foot hills and about 2068 metres at the highest peak. A number of streams originate from the hill ranges, which lie on the western side of the Loktak Lake, and drain directly into it. The hill areas of Manipur constitute the catchment areas of important rivers like, Imphal, Iril, Thoubal, Sekmai and Khuga Imphal, Iril, Thoubal, Sekmai and Khuga and are under pressure mainly due to deforestation, prolonged practice of *jhum* cultivation and overall exploitation of resources. This has mainly contributed to the rapid siltation of the Lake and consequently hampered its water holding capacity. The major land use pattern in the catchment is shifting cultivation in the forests on the hills and paddy cultivation in the valley.

Name	**Loktak Lake**
Location	Between 24^0 25 ’ N and 24^0 41’ N latitudes and 93^0 46 ‘ E and 93^0 55 ‘ E longitudes
Area	246.72 sq km
Altitude	770 m
	The lake has no definite shoreline; the expanse of water and its depth varies with the season. There are 54 villages along the periphery, including five towns.
Climate	Average annual rainfall : 1183 mm Temperature: 0^o to 35^o C.
Morphometric features	Maximum length: 26 km Maximum breadth: 13 km Maximum depth: 4.58 m Average depth: 2.07 m
Turbidity	Moderate
Vegetation	The Important vegetation of the phumdis recorded are Eichornia crassipes, Phragmites karka, Oryza sativa, Zizania latifolia, Cynodon spp., Limnophila spp., Sagitlaria spp., Saccharum latifolium, Erianthus pucerus, Erianthus ravennae, Lersi hexandra, Carex spp.; Phragmites karka is reported to be the dominant specie. In the habitat patch with rooted floating plants, vegetation comprises the a) Nelumbo nucifera, b) Trapa natans, c) Euryale ferox, d) Nymphaea alba, e) N. nouchali, N. stellata and f) Nymphoides indica
Fauna	A great diversity of invertebrate and vertebrate fauna are associated with Loktak.
	Southern part of Loktak lake is declared as Keibul Lamjao National Park(KLNP)
	Due to its rich biodiversity & socio-economic importance, the Loktak Lake has been designated as one of the Ramsar Site for the identifying wetlands of international importance under the Ramsar Convention in 1990.



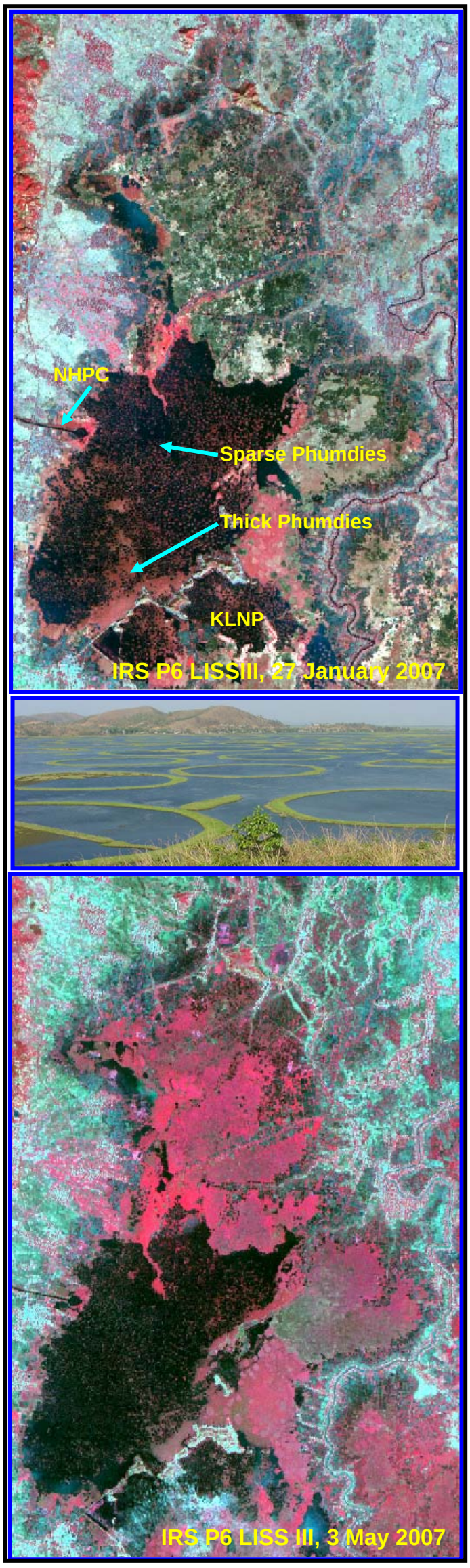
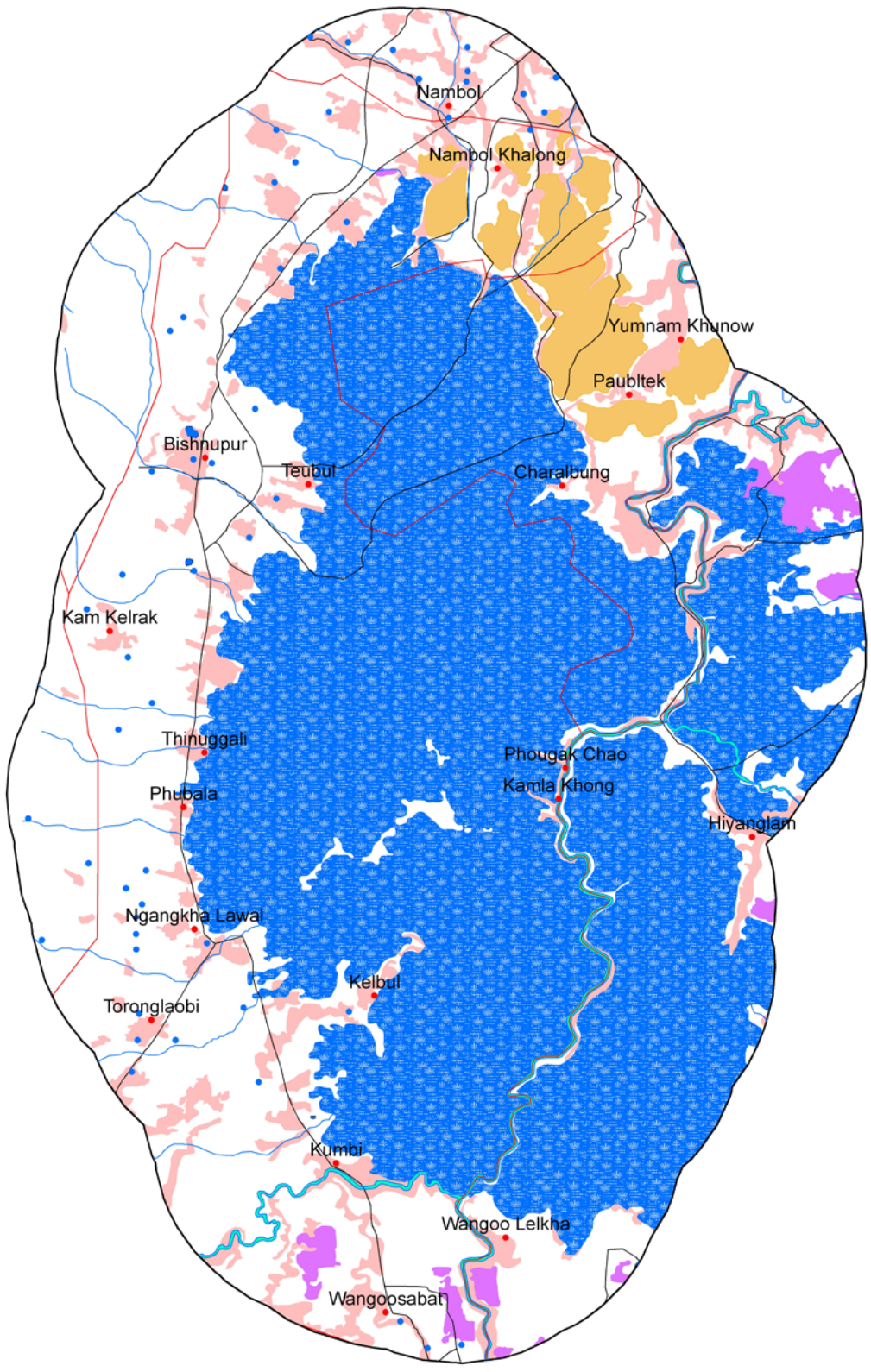


Plate 3: Loktak lake

State : Manipur

WETLAND MAP

Loktak Lake

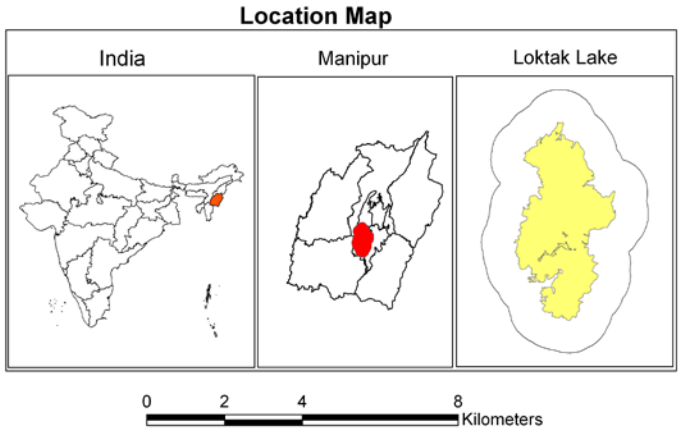


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements
- District Boundary

Location Map



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

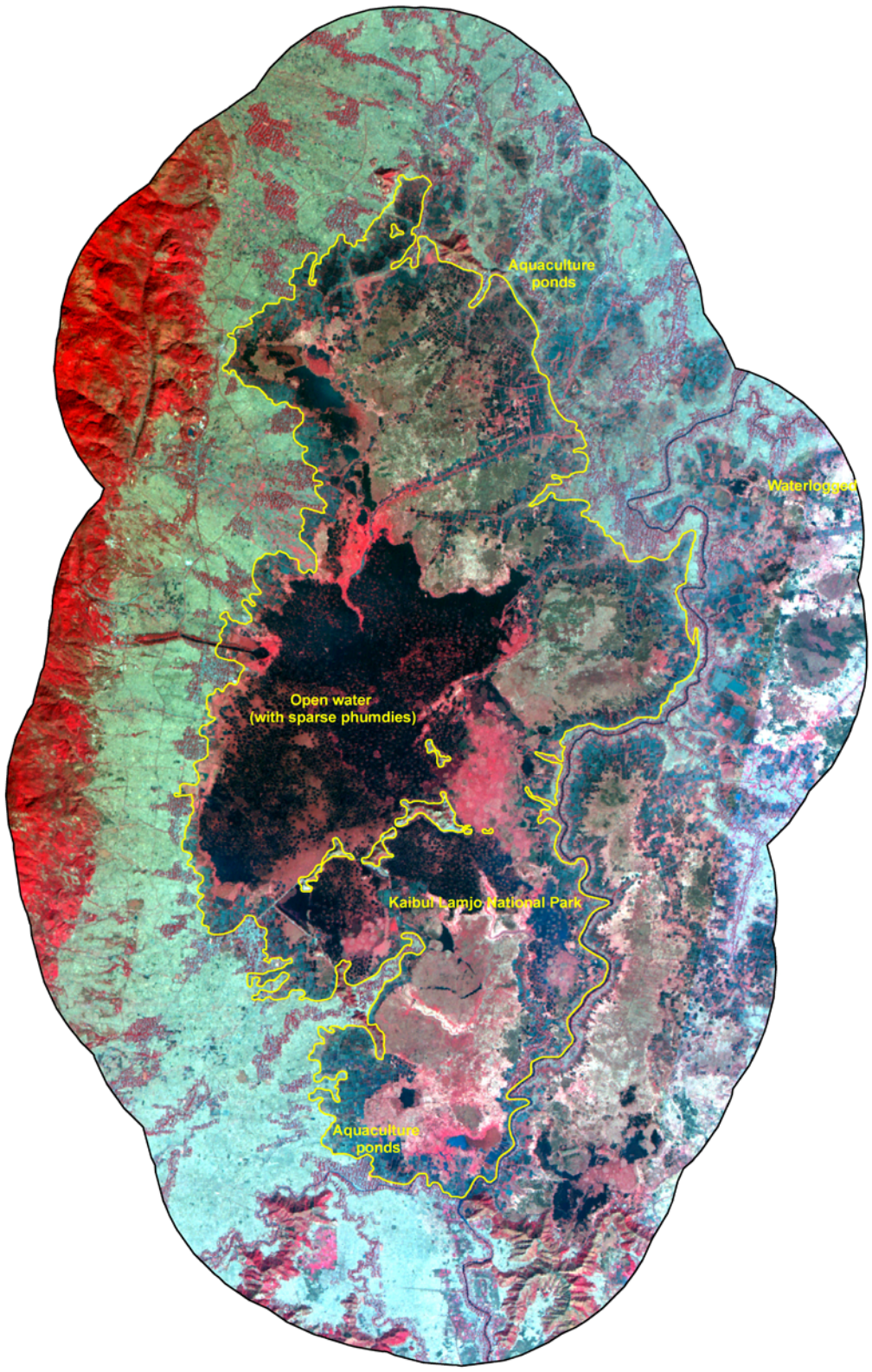
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 4: Wetland map - 5 km buffer area of Loktak lake

State : Manipur

Loktak Lake

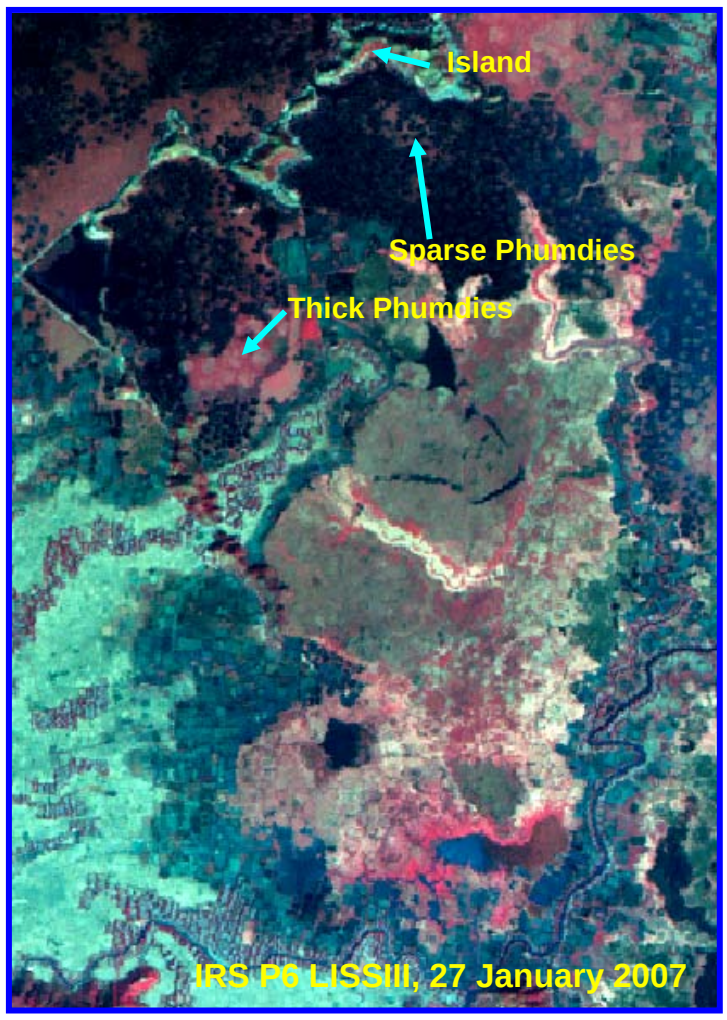


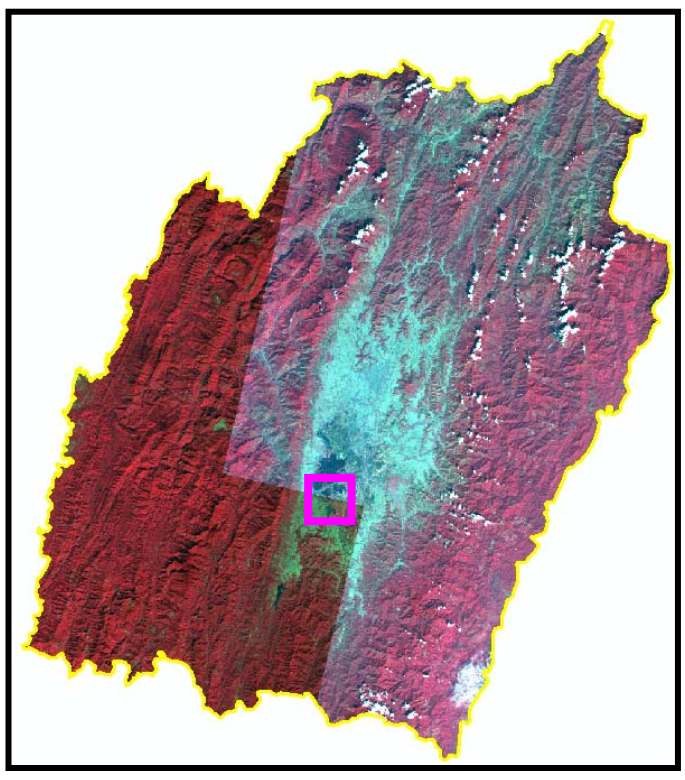
IRS P6 LISS-III post monsoon data (2006)

Plate 5: IRS LISS III FCC - 5 km buffer area of Loktak lake

9.2 Keibul Lamjao National Park

Name	**Keibul Lamjao National Park (KLNP)**
Location	24^0 25 ’ N latitude, 93^0 46 ‘ E longitude
Area	Formerly 4000 ha, recently reduced to 2160 ha
Altitude	785 m
	KLNP is a large expanse of swamp with floating mats of vegetation covering much of its surface. The swamp lies at the northest corner of the Loktak lake basin and is connected with Loktak lake by a channel. .
Climate	Average annual rainfall : 1183 mm Temperature : 0^o to 35^o C.
Turbidity	Moderate
Vegetation	There are two types of *phumdi, phumdi ataoba* (floating) and *phumdi aruppa* (sinking). The *ataoba* consists of reeds, grasses, and other plants growing on a mat of dead and decaying vegetation floating on the lake surface. *aruppa* consists of mats of vegetation which have sunk to the bottom of the lake and support rich emergent growth of reeds and grasses.
	Most interesting distinction of the *phumdi* in KLNP is that it is the only habitat and home / refuge of the highly endangered species of dancing deer locally called *sangai*, and also known as Manipur Brow – antlered deer *(Cervus eldi eldi*).





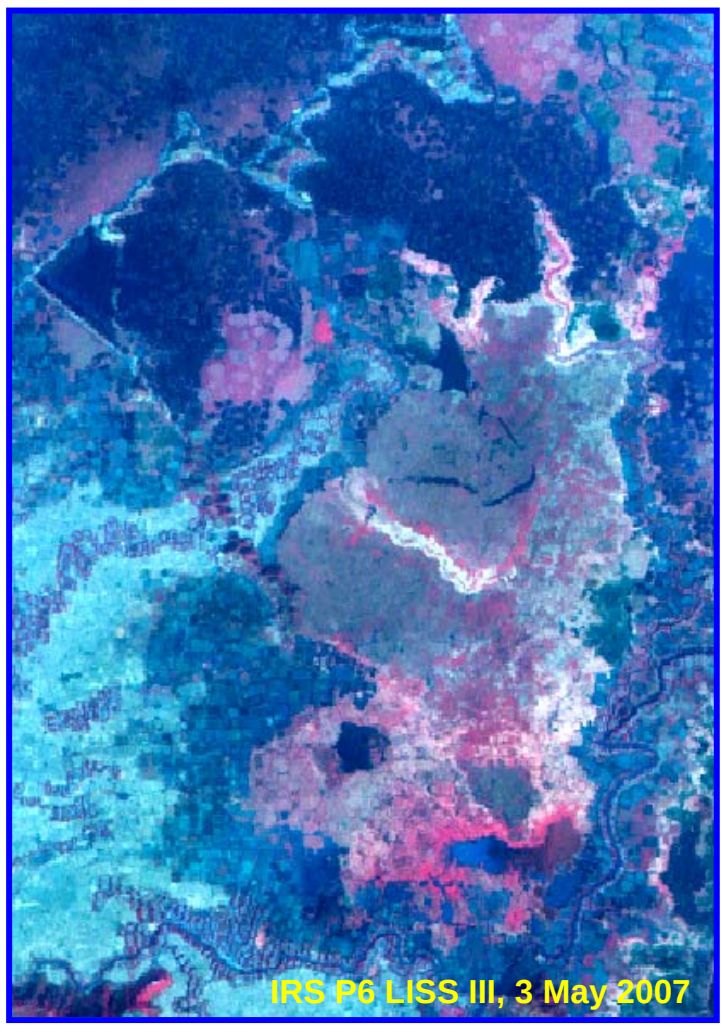
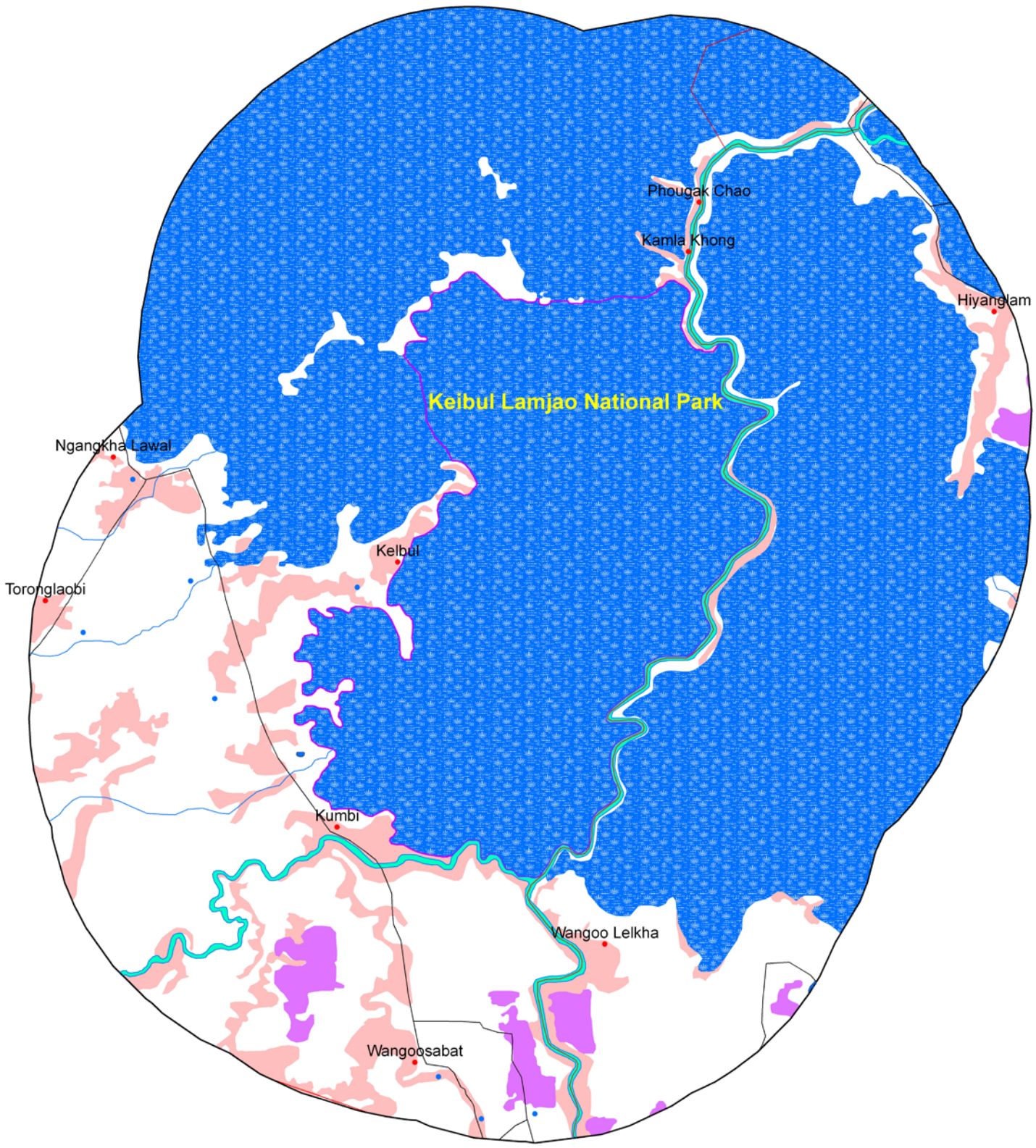


Plate 6: Keibul Lamjao National Park

State : Manipur

WETLAND MAP

Keibul Lamjao National Park

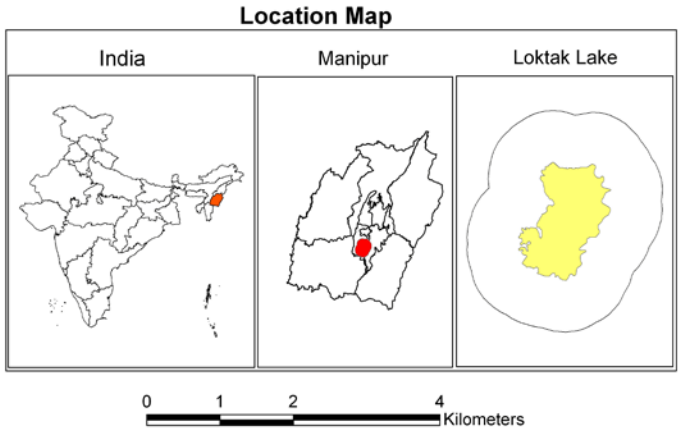


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements
- KLNP Area
- District Boundary

Location Map



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

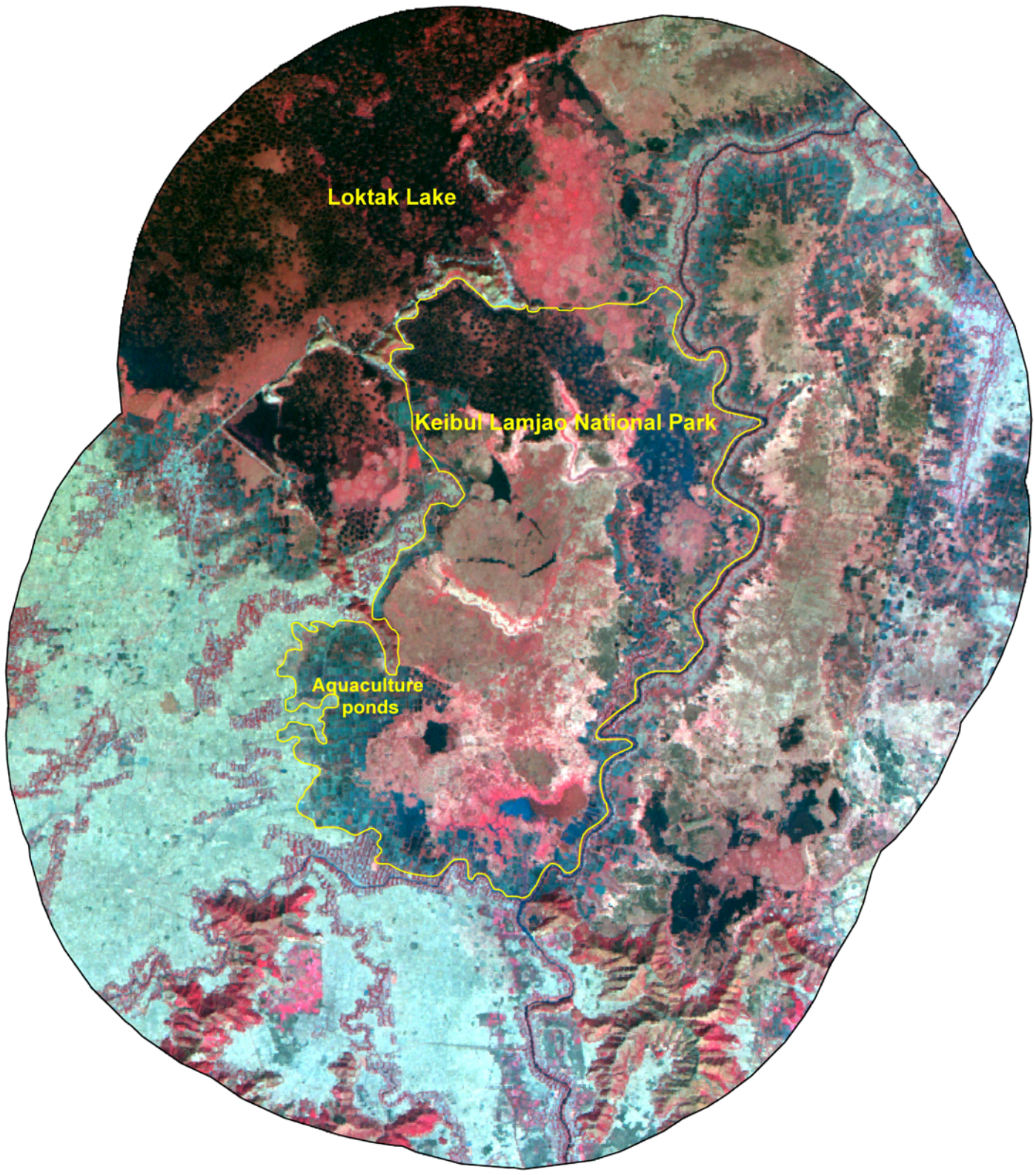
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 7: Wetland map - 5 km buffer area of Keibul Lamjao National Park

State : Manipur

Keibul Lamjao National Park



IRS P6 LISS-III post monsoon data (2006)

Plate 8: IRS LISS-III FCC - 5 km buffer area of Keibul Lamjao National Park

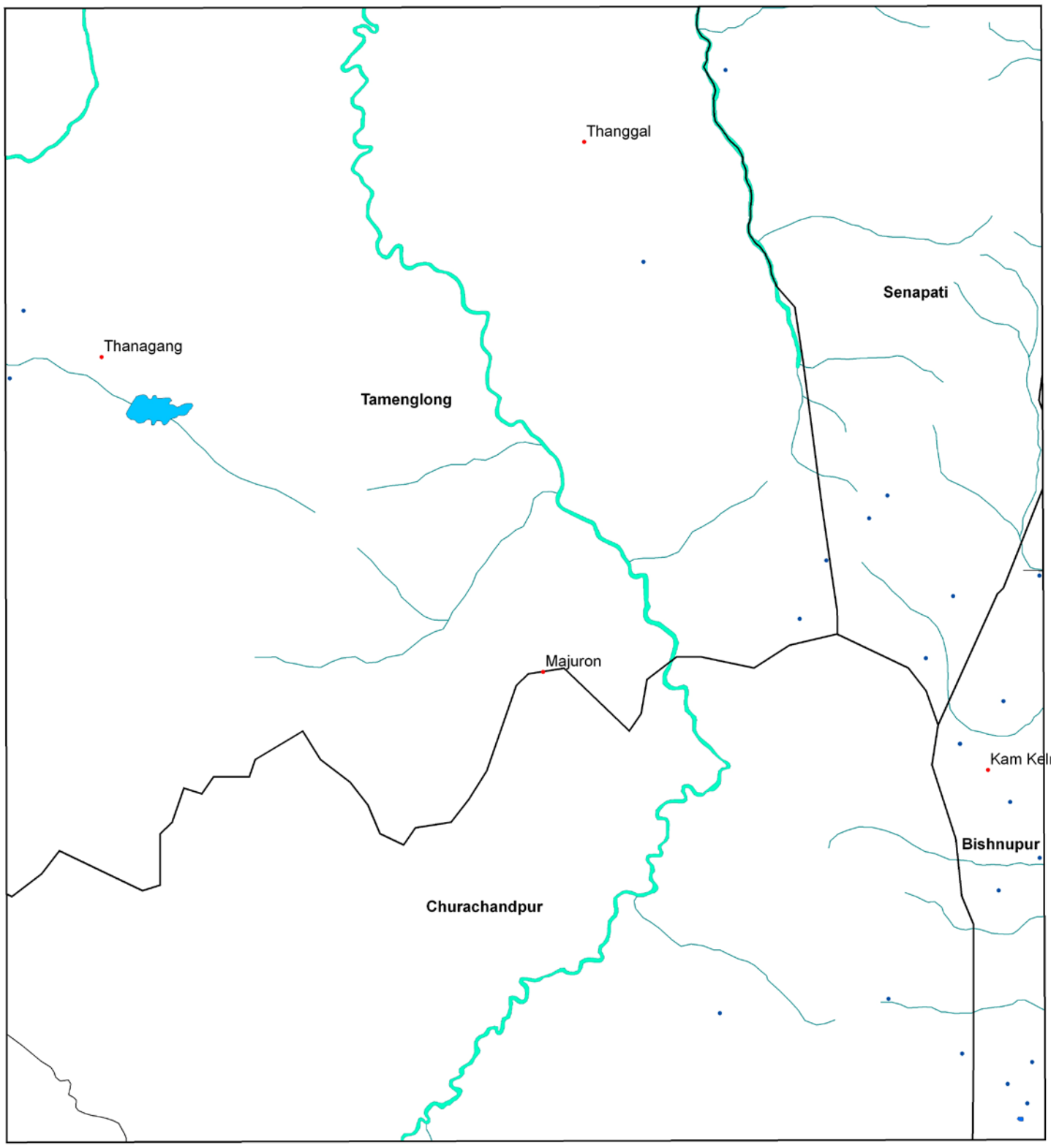
SOI MAP SHEET-WISE WETLAND MAPS

(Selected)

State : Manipur

WETLAND MAP

Map : 83H/10

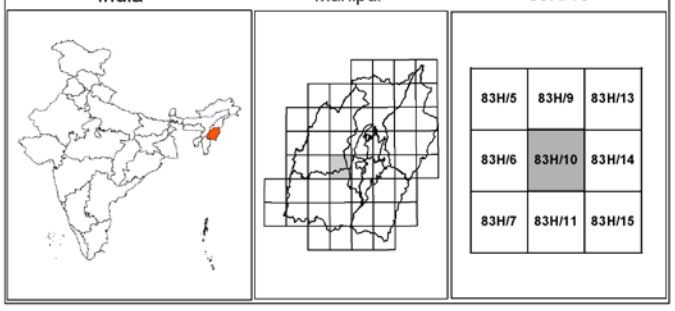


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

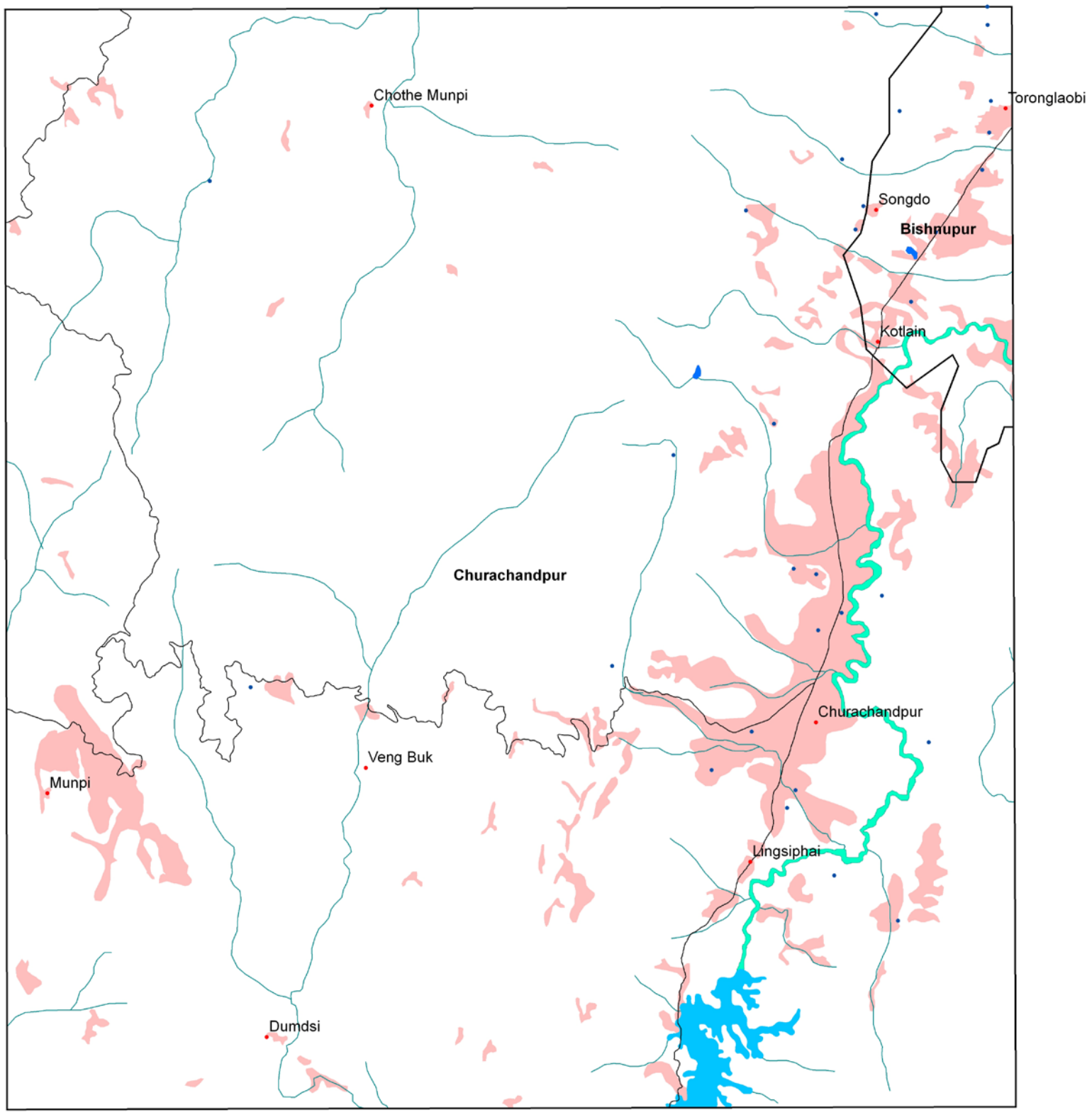
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

Map : 83H/11

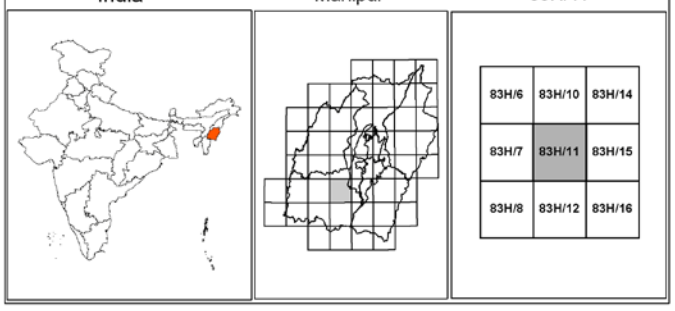


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 (<2.25ha)
- Roads
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

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

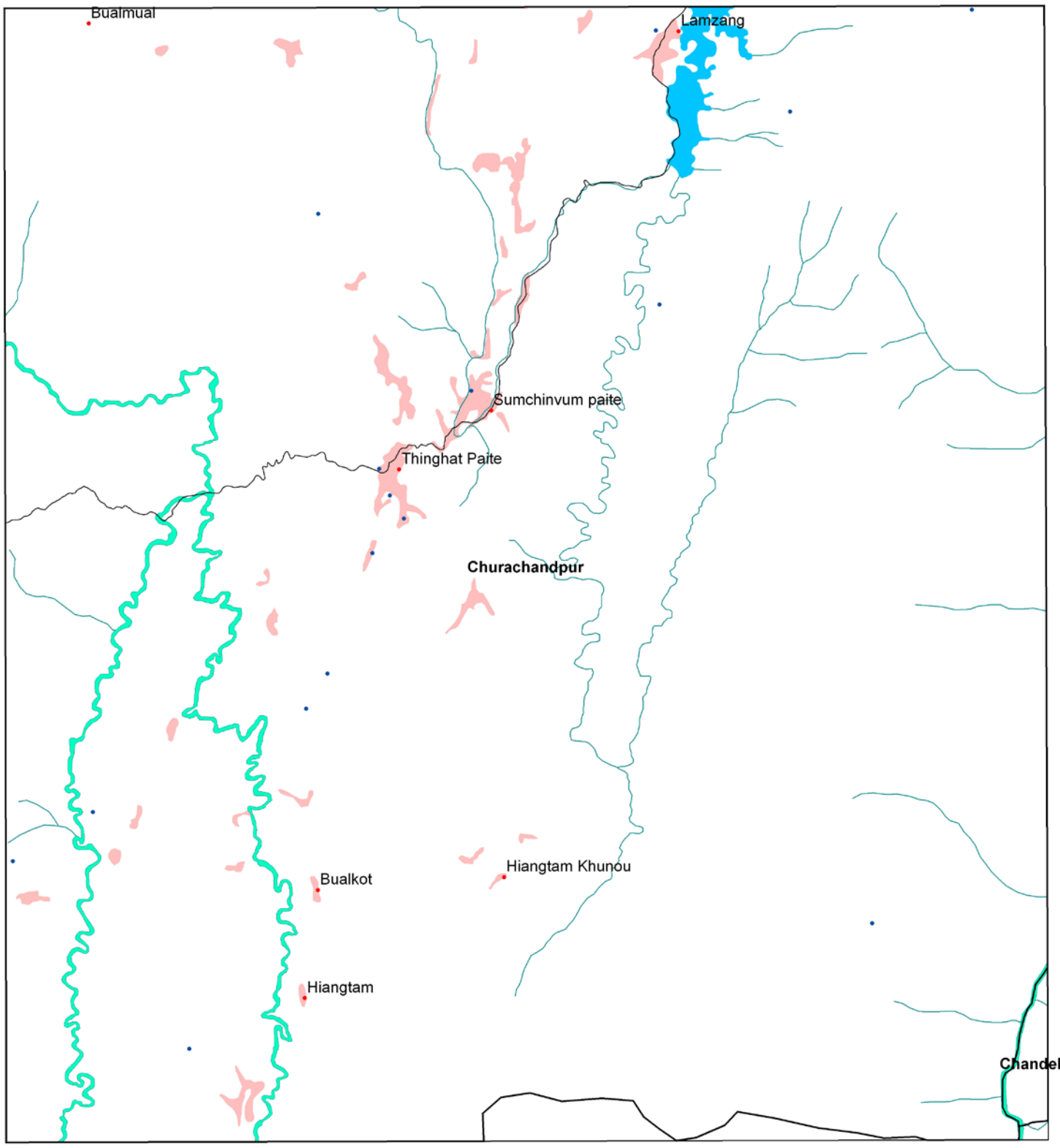
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

Map : 83H/12

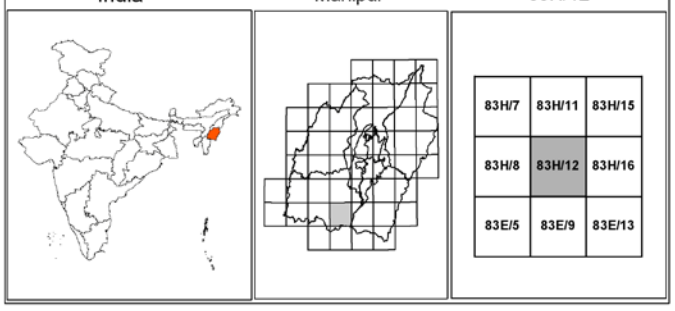


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 (<2.25ha)
- Roads
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

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

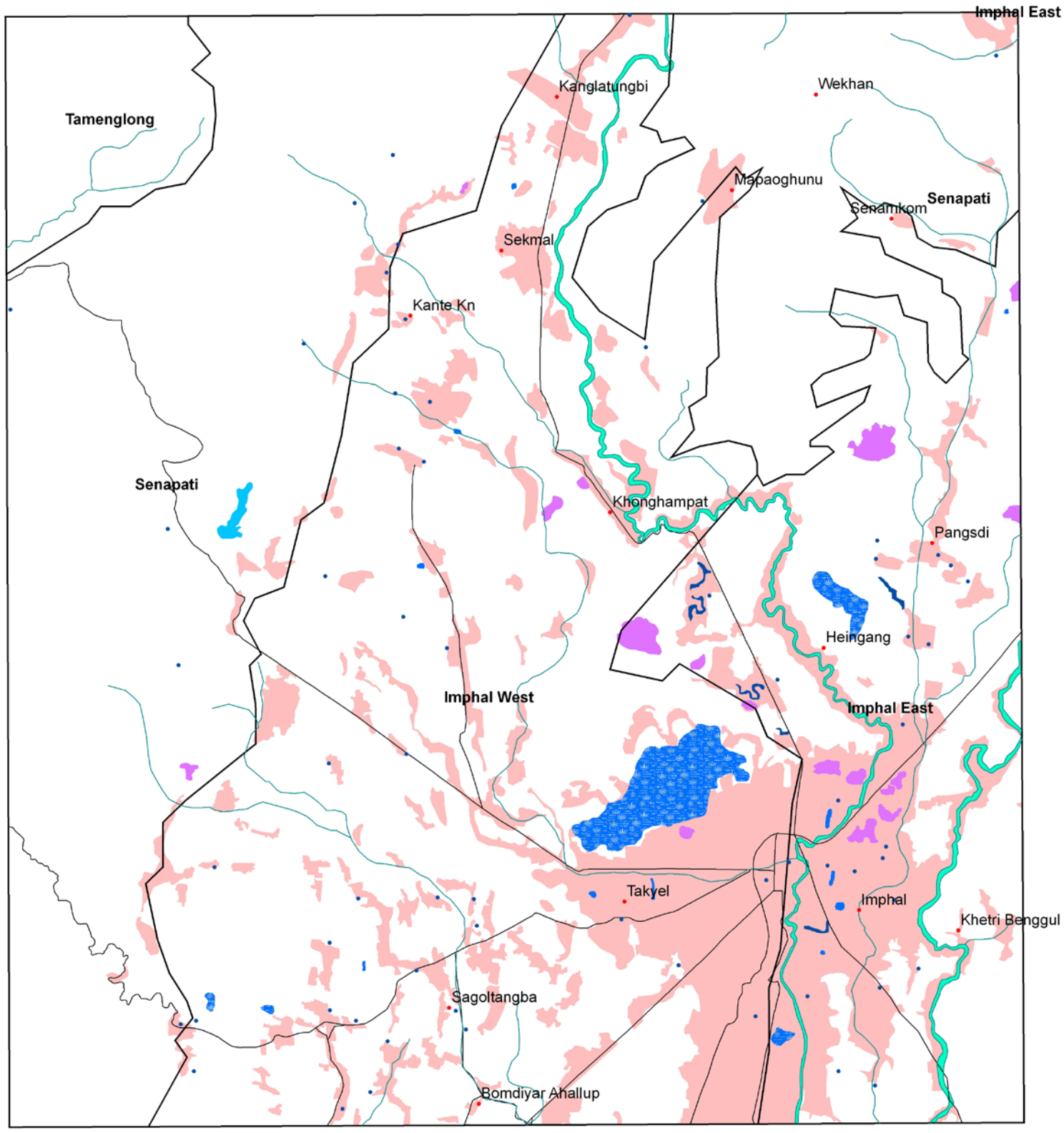
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

Map : 83H/13

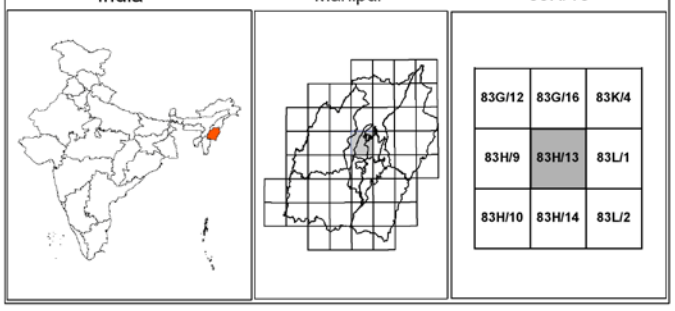


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

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

Prepared By :
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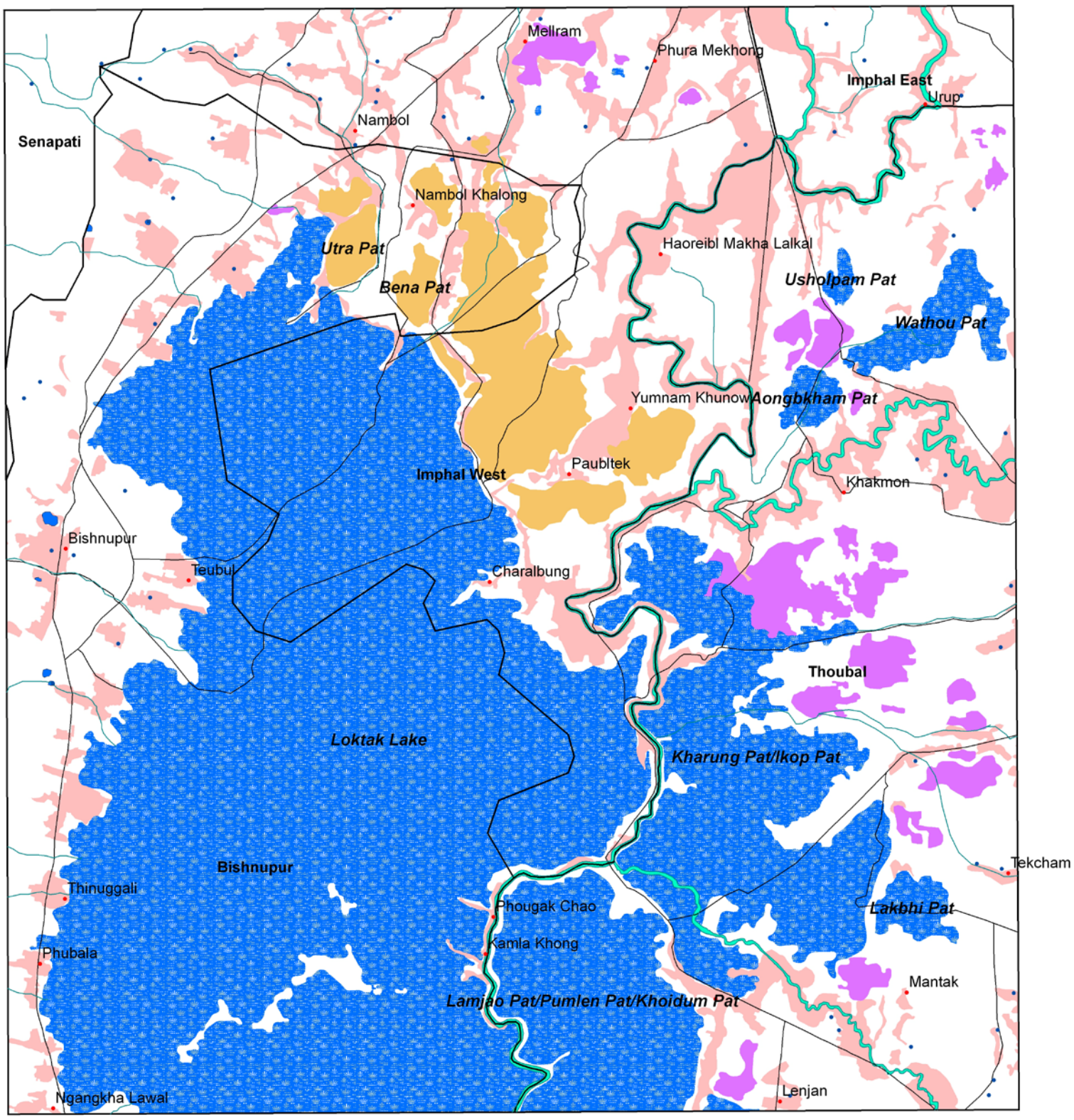
Government of India

State : Manipur

WETLAND MAP

Map : 83H/14

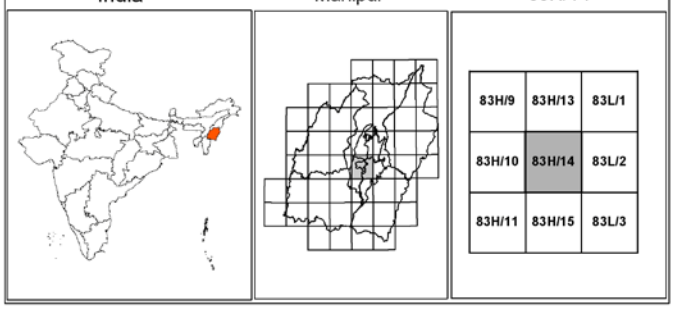


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

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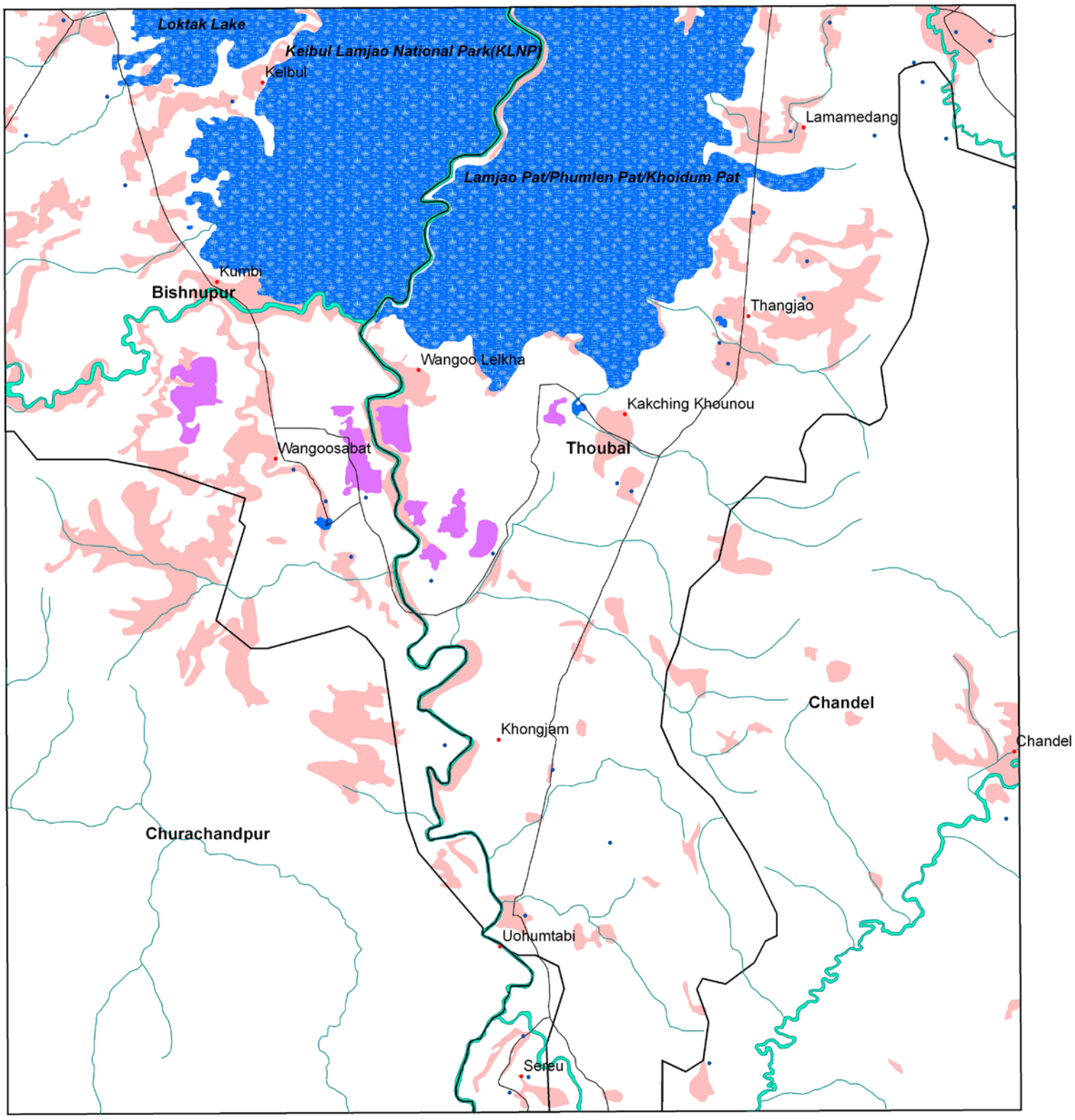
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

Map : 83H/15

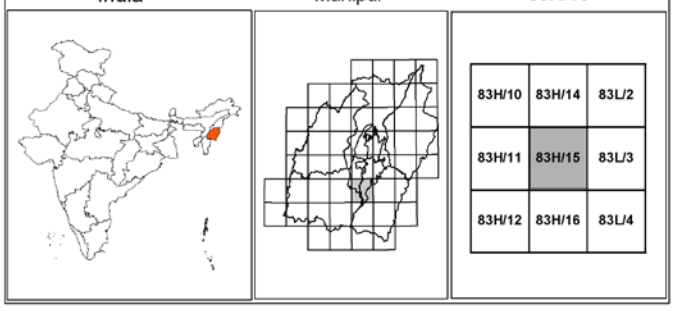


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 (<2.25ha)
- Roads
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 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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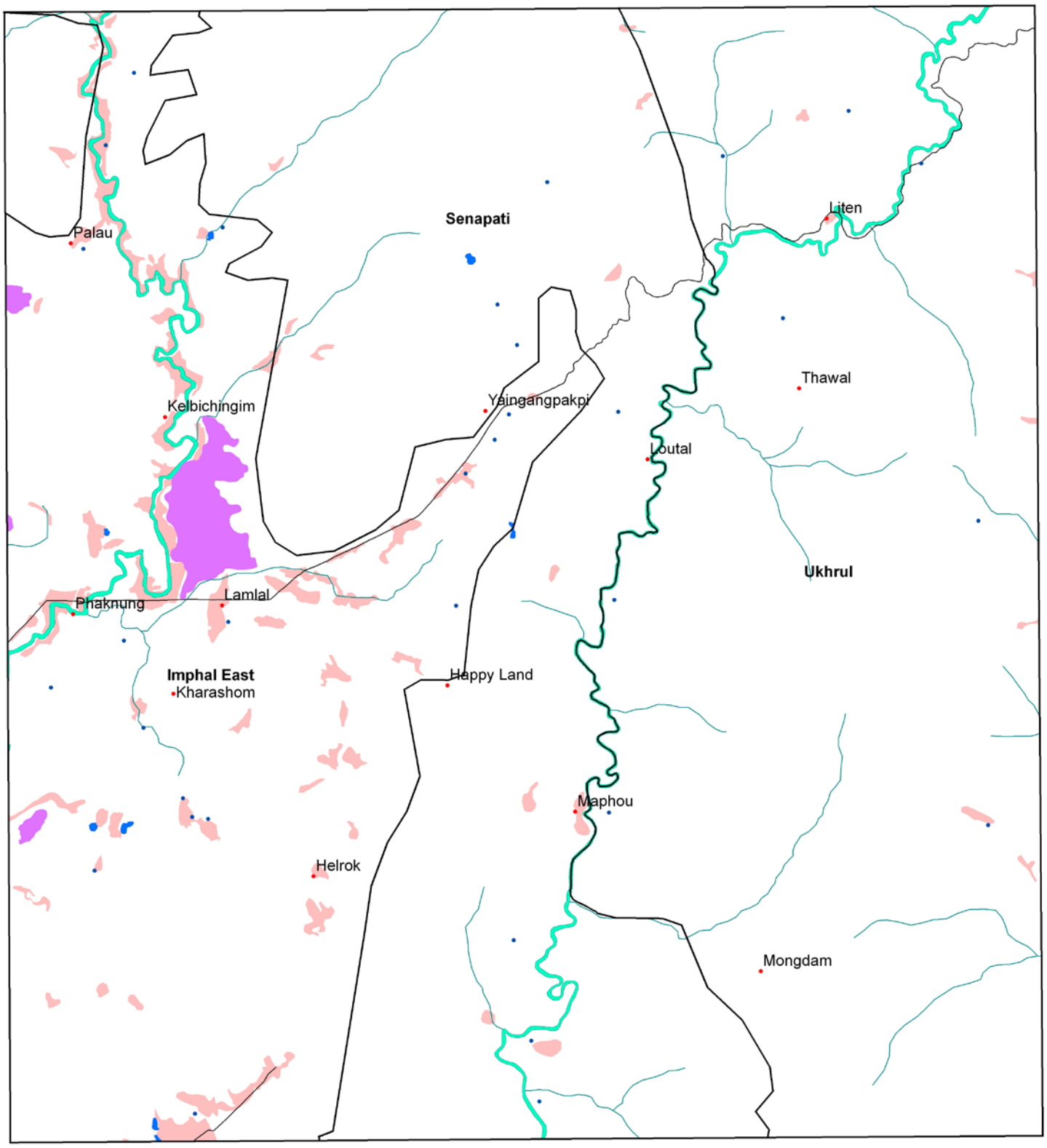
Government of India

State : Manipur

WETLAND MAP

Map : 83L/1

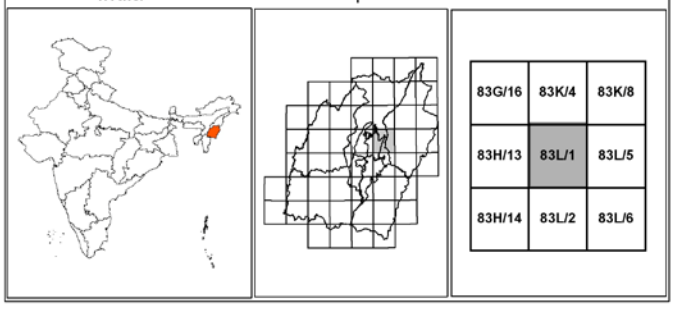


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

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

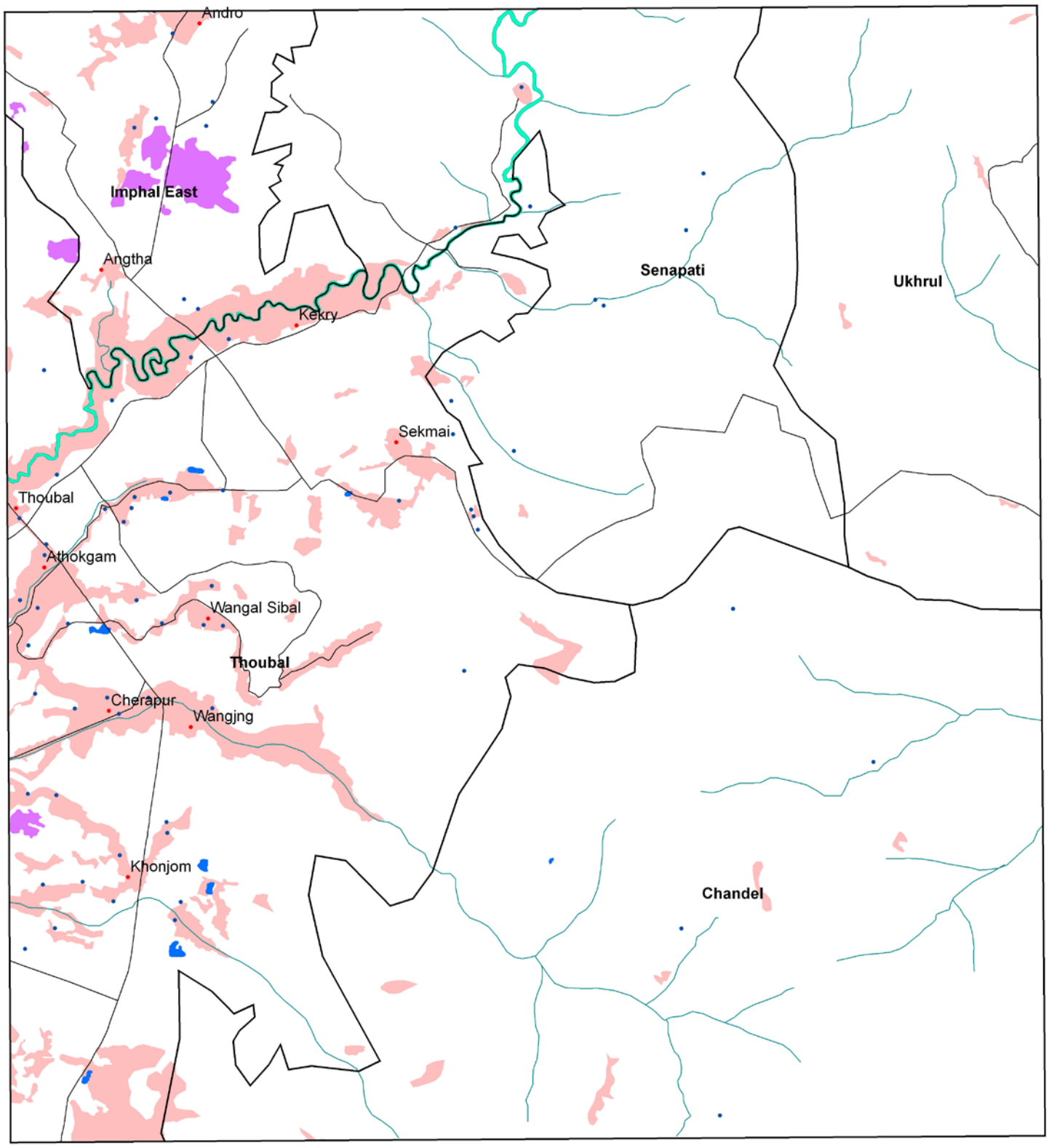
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

State : Manipur

WETLAND MAP

Map : 83L/2

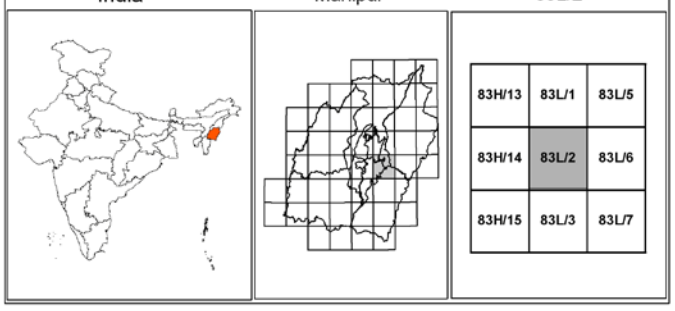


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 (<2.25ha)
- Roads
- Drainage (line)
- Settlements
- Town/Settlements
- District boundary

Location Map



0 1 2 4 Kilometers

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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

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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:

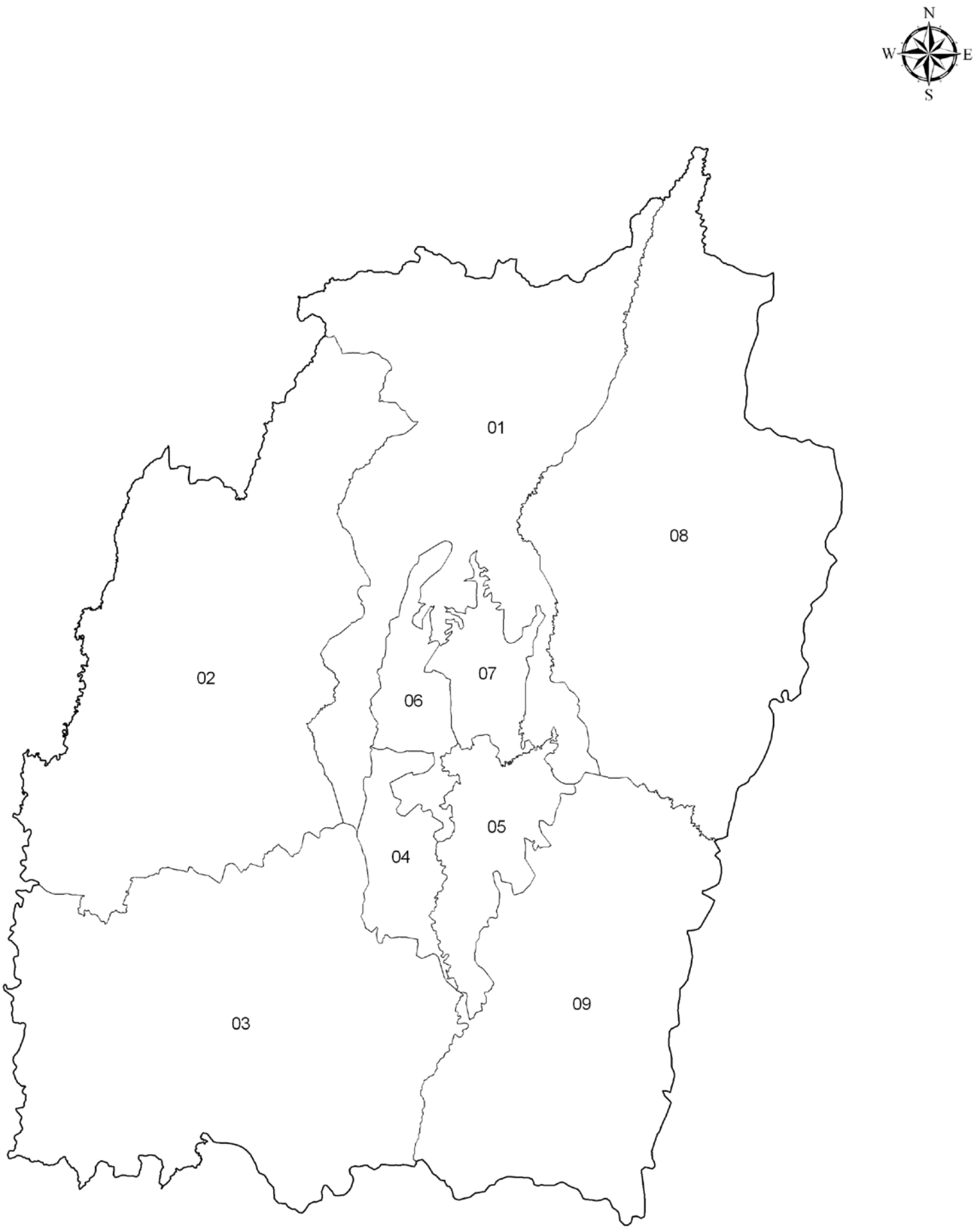
Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different 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 : Manipur

District Boundary Map



List of Districts

District Code	District Name
01	Senapathi
02	Tamelong
03	Churachandrapur
04	Bishnupur
05	Thoubal
06	Imphal West
07	Imphal East
08	Ukhrul
09	Chandel

Legend

State Boundary

District Boundary

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

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SAC is a host institution for the training programmes related to Satellite Communication, Satellite Meteorology and global change under the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations (UN).

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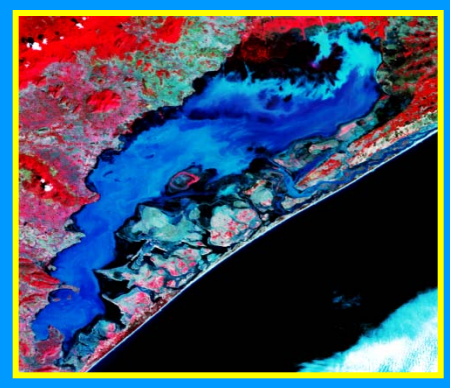

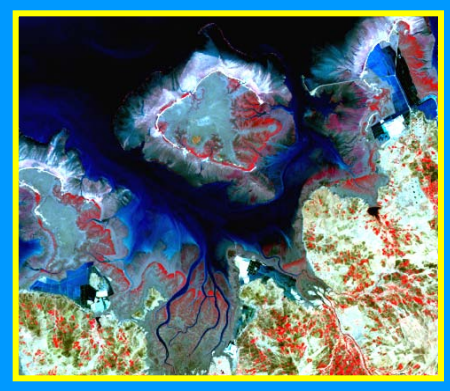

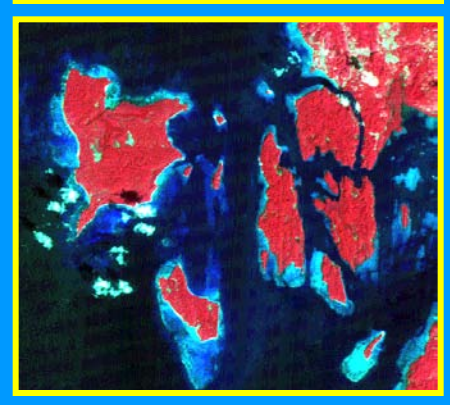

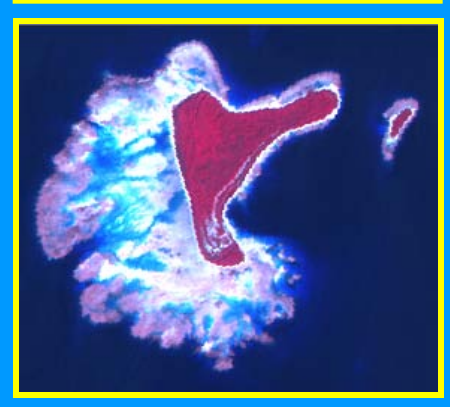

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015