NATIONAL WETLAND ATLAS:

NAGALAND

Sponsored by

Ministry of Environment and Forests

Government of India

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015

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

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

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

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NAGALAND

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Ministry of Environment and Forests, Government of India

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

Space Applications Centre (ISRO), Ahmedabad
and
Nagaland Science and Technology Council, Kohima.

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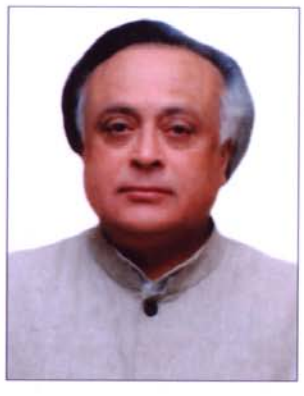
जयराम रमेश
JAIRAM RAMESH



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MESSAGE

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

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

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

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

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

(Jairam Ramesh)

जय हिन्द

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सत्यमेव जयते

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FOREWORD

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

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

January 25, 2010

(Ranganath R. Navalgund)

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

We are grateful to Dr G V Subramanyam, Adviser, MoEF for his very active and positive role for implementation of the project. We are also thankful to Dr Jag Ram, Director, MoEF , Dr Harendra Kharwal, MoEF for their support. We are thankful to the “Technical Review” team of SAC for critical comments and suggestion of the Atlas. 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.

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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 Nagaland, which is part of the National Wetland Atlas of India, is an attempt in this direction.

1.1 Wetlands

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

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

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

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

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

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

1.2 Mapping and Geospatial technique

To conserve and manage wetland resources, it is important to have inventory of wetlands and their catchments. The ability to store and analyse the data is essential. Digital maps are very powerful tools to achieve this. Maps relating the feature to any given geographical location has a strong visual impact. Maps are thus essential for monitoring and quantifying change over time scale, and 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 - A typical wetland located in Taoru block, Mewat district. In FCC, the vegetation thus appears invariably red (due to high reflection in NIR from green leaves).

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

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

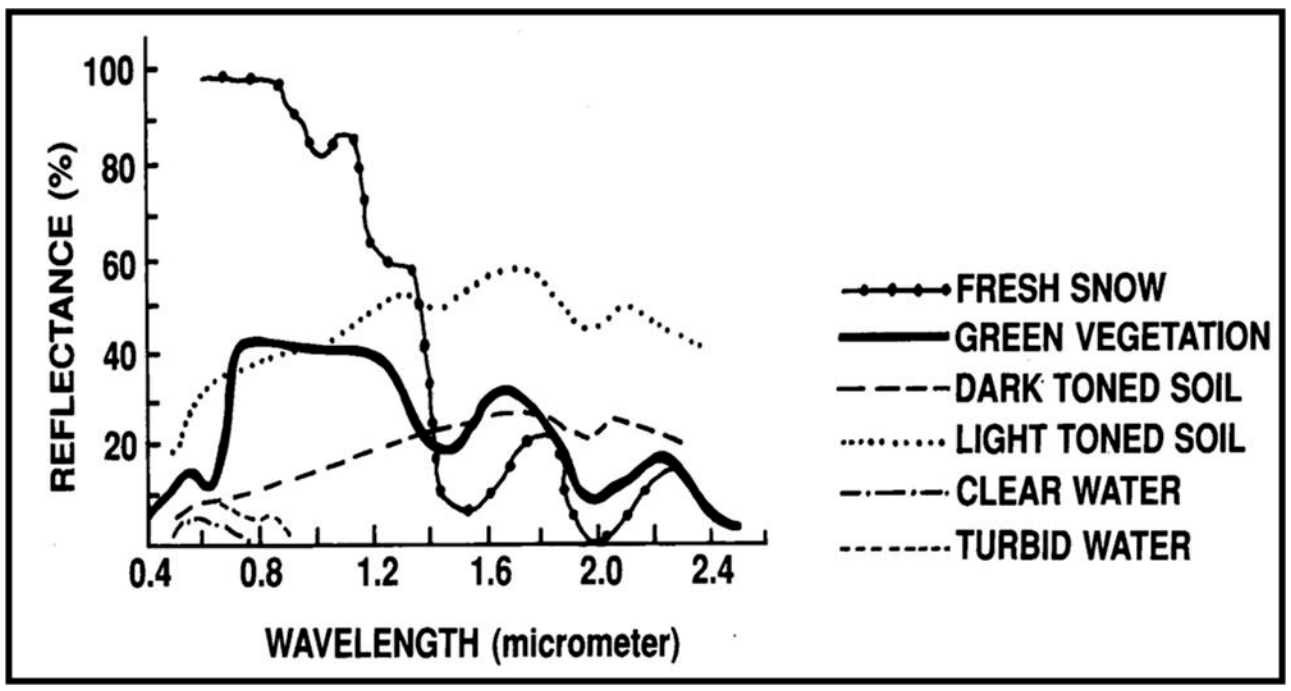
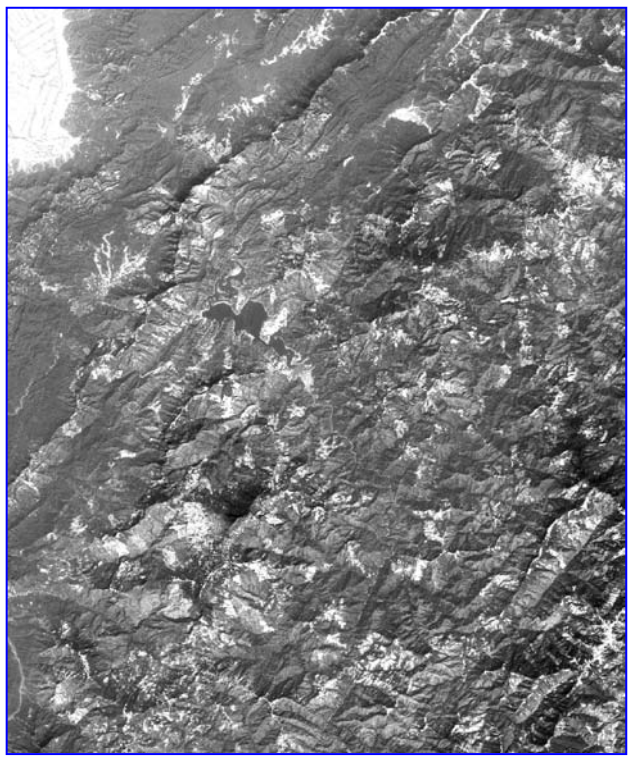
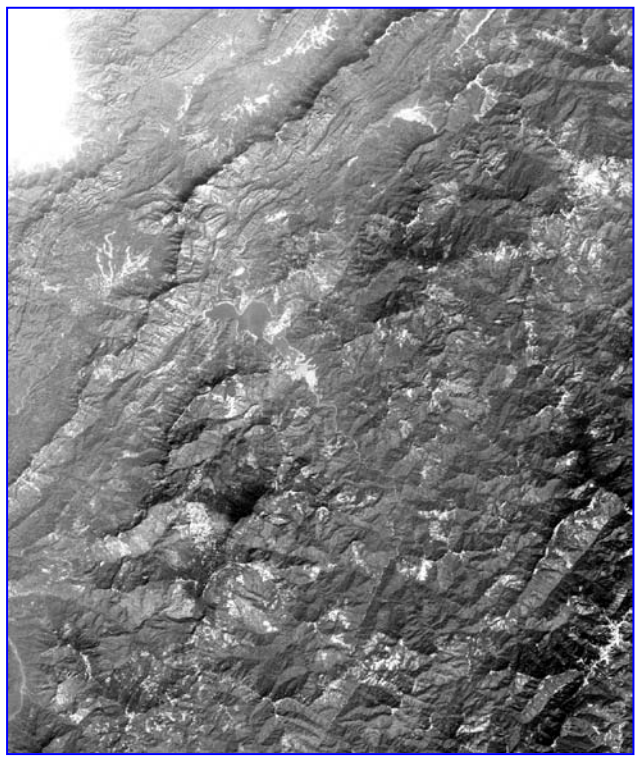


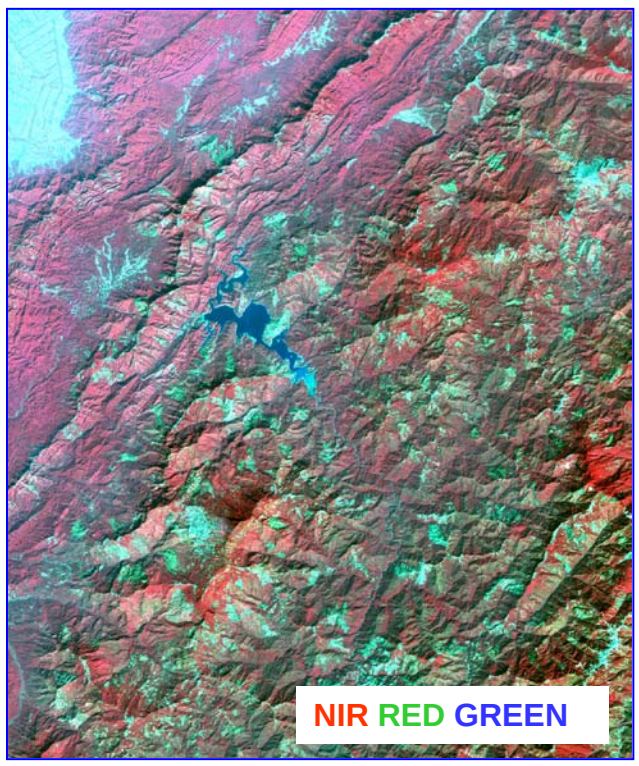
Figure 1: Spectral Signature of various targets



RED



GREEN



NIR

IRS LISS III FCC

SWIR

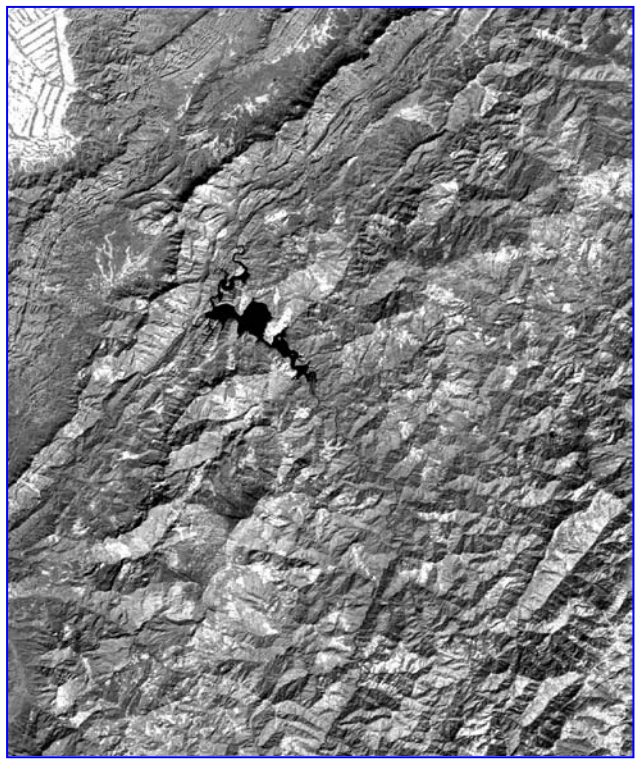


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC.

1.3 Wetland Inventory of India

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

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

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

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

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

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

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

2.0 NATIONAL WETLAND INVENTORY AND ASSESSMENT (NWIA) PROJECT

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

The main objectives of the project are:

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

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

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 extends 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

Nagaland as state of the India was born on 1st December 1963. It is one of the seven sister states of Northeastern states of India and is located in the extreme North Eastern end of India. It is bounded by Myanmar in the East; Assam in the West; Arunachal Pradesh and a part of Assam in the North with Manipur in the south. Nagaland has a total geographical area of 16,579 sq. km and extends from 25°6' N to 27°4' N latitude and 93°20' E to 95°15' E longitude. The location map of the state is shown in figure 3. The State of Nagaland is primarily a hilly terrain with rugged and rough hills with narrow alternating inter-mountain valleys. The altitude varies between 194 meters and 3048 meters above mean sea level. The hills have trends in NE to SW direction with moderate to steep slopes. The Naga Hills rise from the Brahmaputra Valley in Assam to about 2,000 feet (610 m) and rise further to the southeast, as high as 6,000 feet (1,800 m). Mount Saramati at an elevation of 12,552 feet (3,826 m) is the state's highest peak; this is where the Naga Hills merge with the Patkai Range in Burma. Physiographically, the State can be delineated into following altitudinal zones: Alluvial Plains, Low to moderate hills, Moderate hills and High hills. About one-sixth of Nagaland is under the cover of tropical and sub-tropical evergreen forests—including palms, bamboo, and rattan as well as timber and mahogany forests.

Nagaland has a largely monsoon climate with high humidity levels. Annual rainfall averages around 1,800–2,500 mm, concentrated in the months of May to September. There is not a single completely dry month in a year. Temperatures range from 21 °C to 40 °C. In winter, temperatures do not generally drop below 4 °C, but frost is common at high elevations.

The proximity to the Himalayan foothills and the torrential monsoon rains has resulted in the prosperity of the mighty rivers in Nagaland. The mountain region is the source of several streams and rivulets. There are four major river systems in the state, viz. Dhansiri, Doyang, Dikhu and Tizu. One of the chief tributaries of the Brahmaputra River is Dhansiri which originates in the mountainous Laisang peak in Nagaland. The districts of Nagaland receive water from the Dhansiri river prior to its confluence with the Brahmaputra River. Doyang river originates in the northern part of Manipur State ie. in the SE of Kohima and it flows northwards, up to east of Wokha town and changes its direction thereafter to northwest. The rivers are not navigable in any season, deep valley navigation is also not possible due o the rocky terrain. The drainage pattern in Nagaland is mainly dendritic in nature with varying densities. Fine dendritic type of drainage is developed in the central part of the state between Mokokchung and Tuensang. A very fine dendritic pattern is noticed between Kohima and Mon. In other parts, the drainage pattern is coarse dendritic in nature

The soils of the state have been derived from parent rock formations such as, shales, siltstones, mudstones, sandstone, alluvial and colluvial materials. The soils of the hill slopes have been genetically formed from shales and silts tones and that of valleys from alluvial and colluvial materials. The State, being generally a hilly area, composed of soils which are loamy to clayey in texture, highly acidic in reaction, possess high organic carbon content, low phosphorous and medium potash concentration

The state capital of Nagaland is Kohima. Nagaland comprises of eleven districts namely Dimapur, Kiphire, Kohima, Longleng, Mokokchung, Mon, Peren, Phek, Tuensang, Wokha and Zunheboto. There are 14 tribes in Nagaland, with Lothas, and Sumis being the largest Naga tribes. Almost all the tribes of Nagaland have their own language. English as the official language of Nagaland and is the medium for education in Nagaland. There are 52 administrative block and about 1317 villages in the state. The total population of the State according to 2001 census was 19, 88, 636

The state is covered by 43 Survey of India topographical maps on 1:50,000 scale that form the spatial frame work for mapping (Figure 4). The spatial framework was prepared using 15' x 15' grid.

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

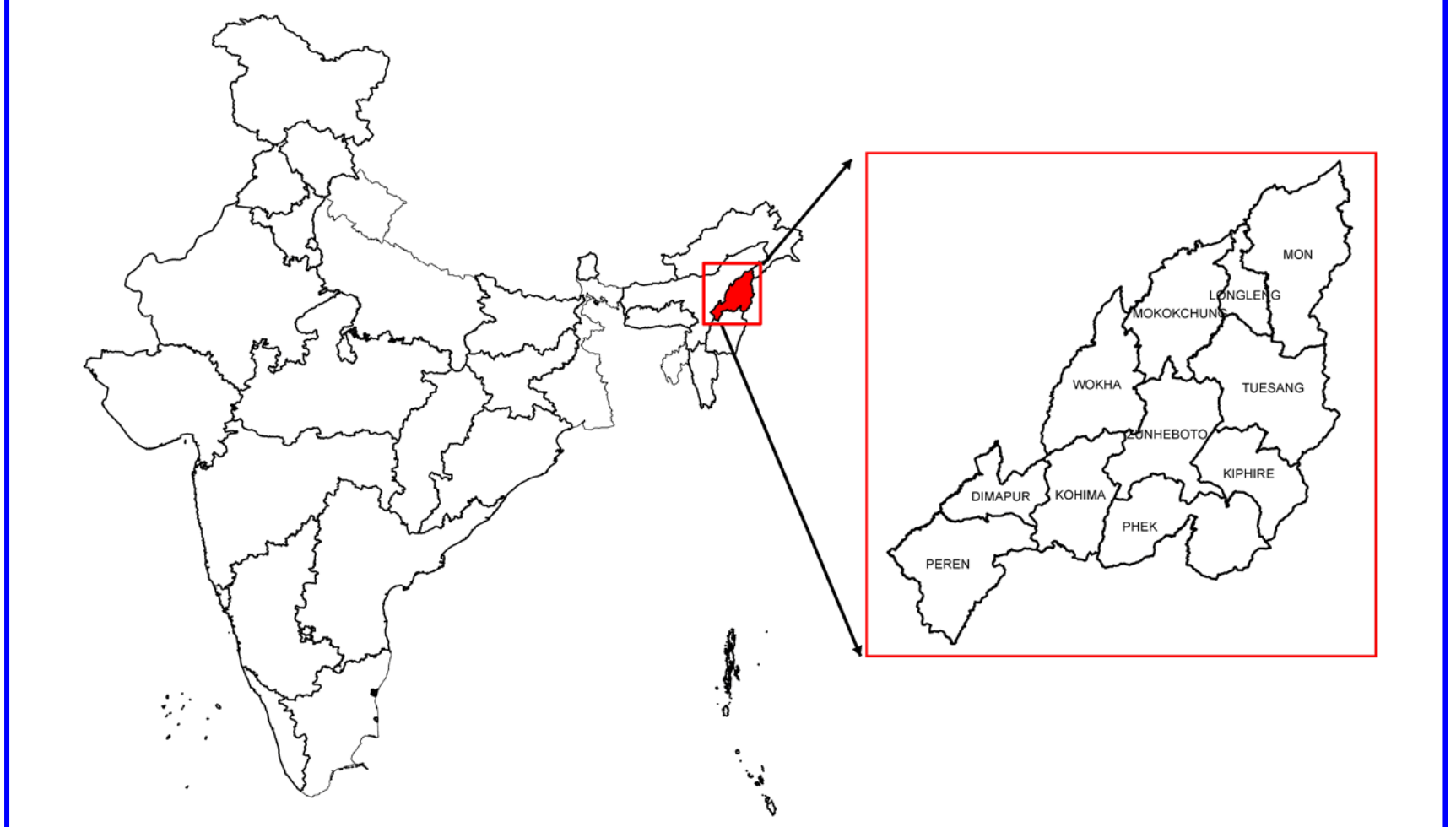


Figure 3: Location map

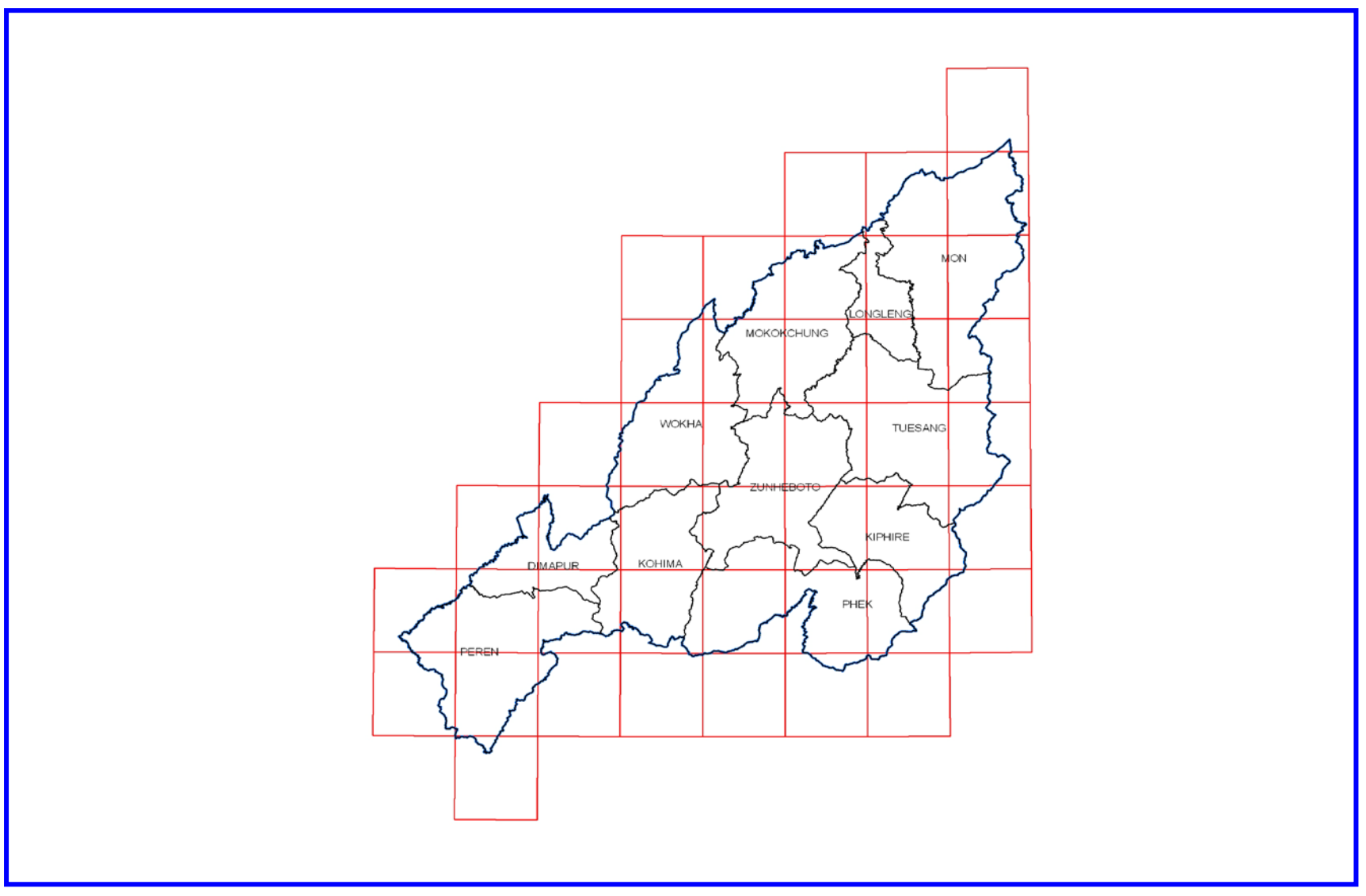


Figure 4: Spatial Framework of Nagaland

4.0 DATA USED

Remote sensing data

IRS P6 LISS III data was used to map the wetlands. IRS P6 LISS III provide 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 Nagaland is covered by five IRS LISS III scene (Figure 5). Two date data, one acquired during December and May 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 part of Nagaland as seen in the LISS III FCC of post- monsoon pre-monsoon data respectively.

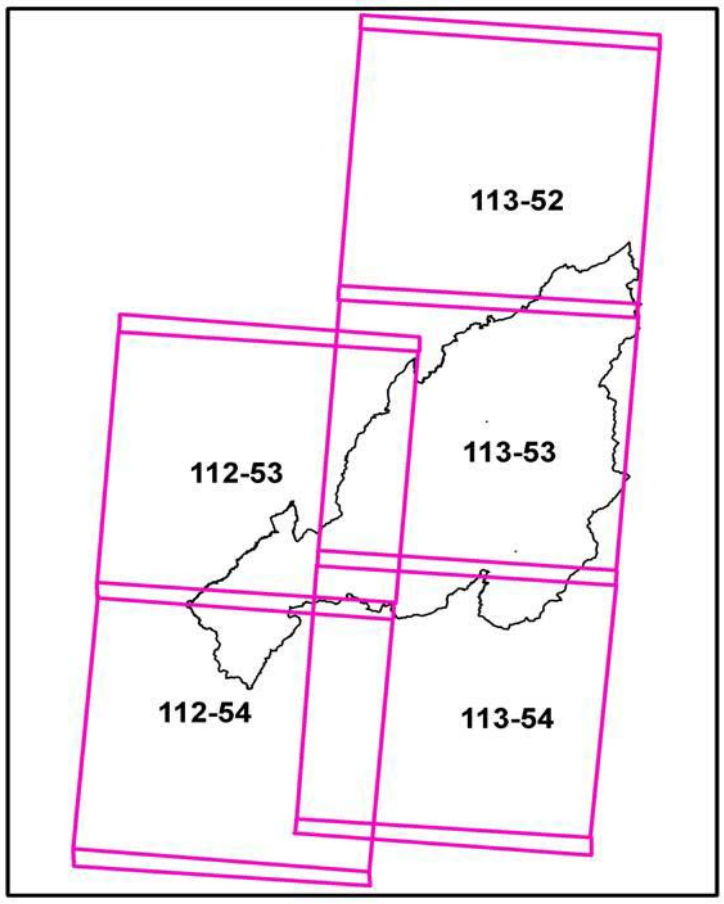


Figure 5: IRS P6 LISS-III coverage (path-row) of Nagaland

Table-2: Satellite data used

Sl. No	Path- Row	Post-Monsoon	Pre-Monsoon
1	112 - 53	December 05, 2006	March 11, 2007
2	112 - 54	December 05, 2006	January 22, 2007
3	113 - 52	January 27, 2007	May 03, 2007
4	113 - 53	January 27, 2007	May 03, 2007
5	113 - 54	January 27, 2007	May 03, 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 images. 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 November 2008 and March 2009.

Other data

Survey of India topographical maps (SOI) were used for reference purpose. Lineage data of National Wetland Maps at 1:2,50,000 scale was used for reference.

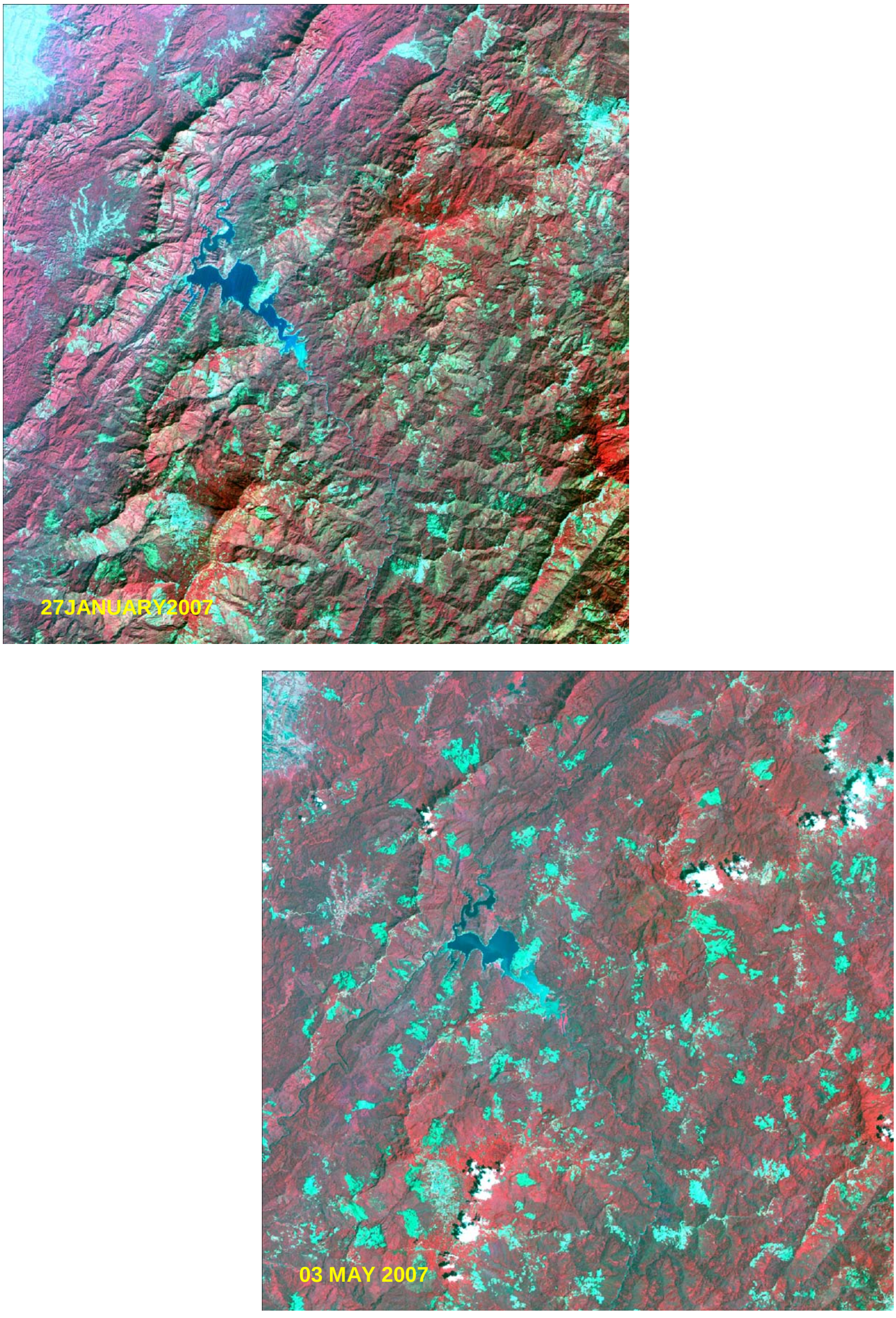


Figure 6: IRS LISS-III FCC showing part of Nagaland (pre-monsoon and post-monsoon satellite images)

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 sing 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.

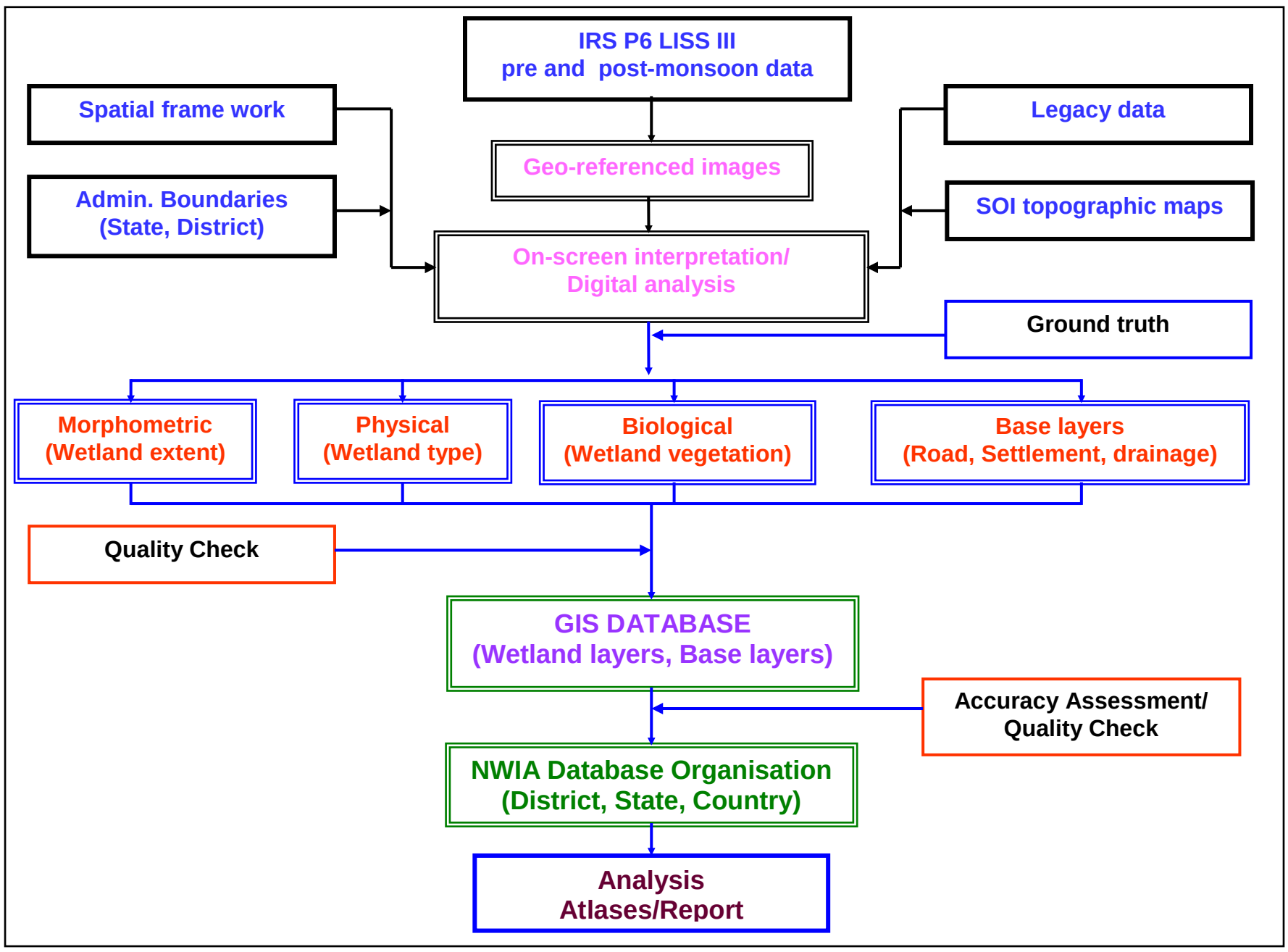


Figure 7: Flow chart of the methodology used

5.1 Creation of spatial framework

This is the most important task as the State forms a part of the national frame work and 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 (Ref. 5). The spatial framework for Nagaland 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 archive 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 archive 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. Steps in the extraction of wetland components are shown in Figure 8. In this project, five indices known in literature that enhances various wetland characteristics were used (*(Reference : 13, 17, 26, 27 and 28)* 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)

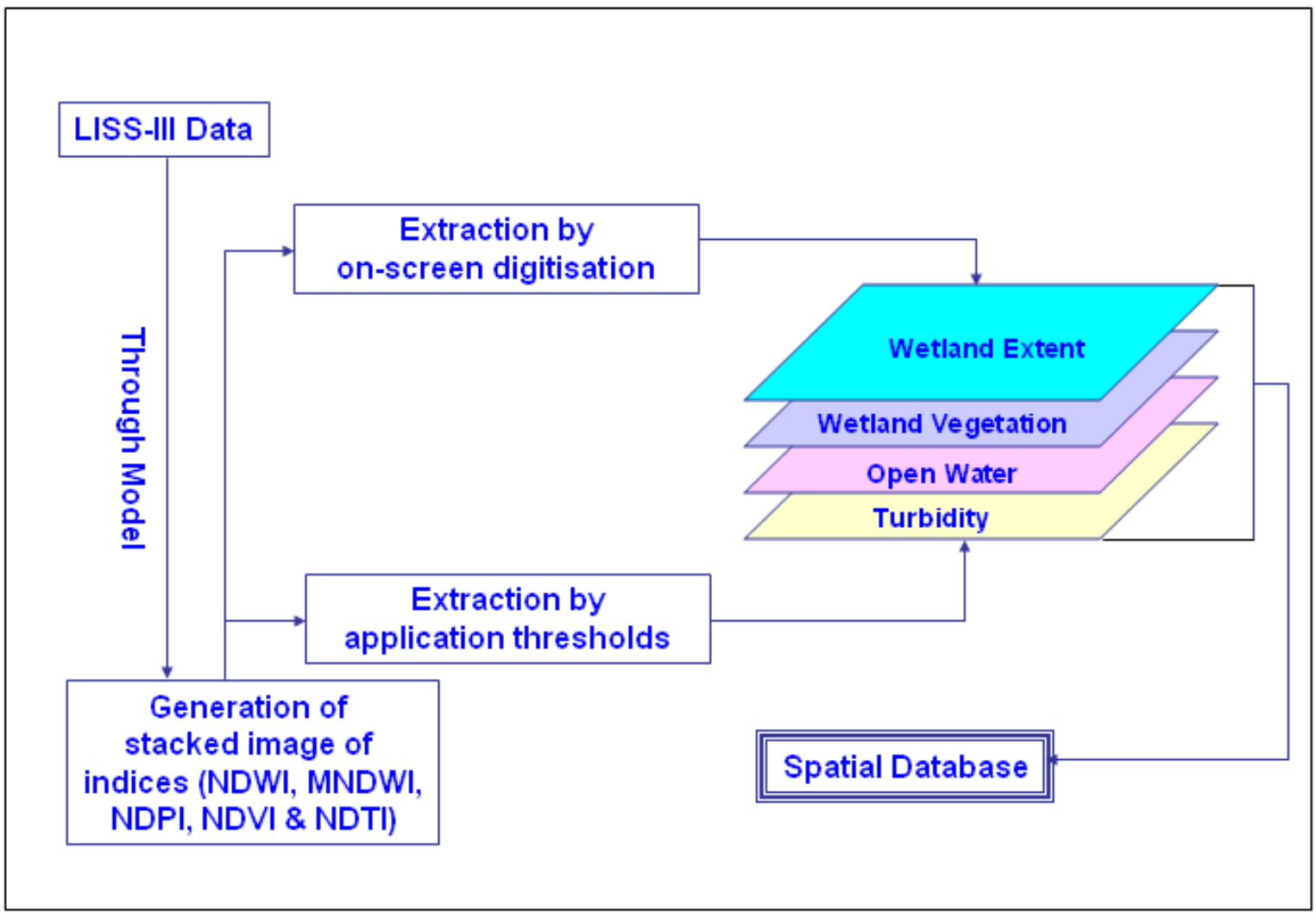


Figure 8: Steps in the extraction of wetland components

The indices were generated using standard image processing software, stacked as layers. 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 with in 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 conformation into a vector layer

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

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 data base. 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 in A3 size.

6.0 ACCURACY ASSESSMENT

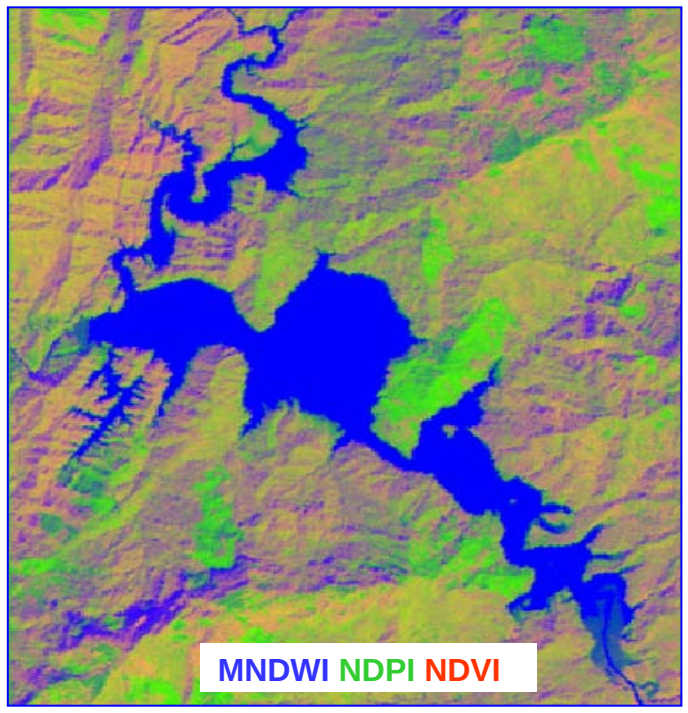
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as location accuracy. In addition GIS database(s) contents have been also evaluated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

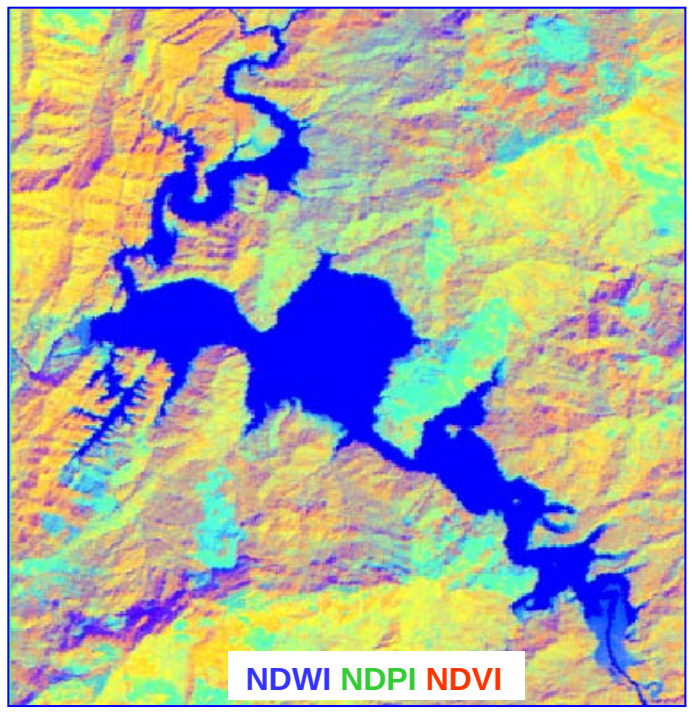
1. Image-Image Geo-referencing/Data generation
2. Reference layer preparation using NWIA post monsoon and pre-monsoon LISS-III data.
3. Wetland mapping using visual/digital interpretation techniques.
4. Geo-data base creation and organization
5. Output products.

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.

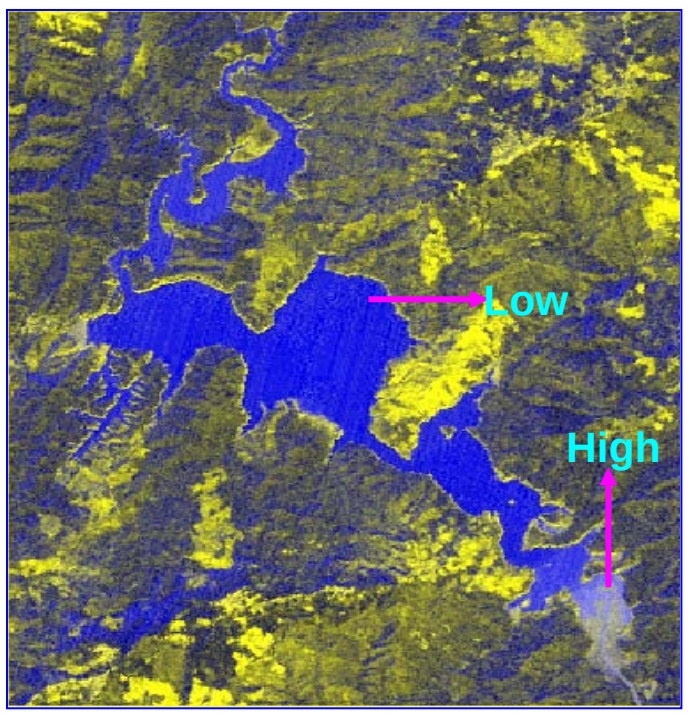


Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features

The Reservoir and River in Wokha District
IRS LISS III data, January 2007



Useful for qualitative turbidity delineation

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

MAPS AND STATISTICS

7.0 WETLANDS OF NAGALAND: MAPS AND STATISTICS

Area estimates of various wetland categories for Nagaland have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. The estimated wetland area of the state is 21544 ha area, that includes 267 small wetlands (< 2.25 ha). River/stream is the single most dominant wetland type of the state with 89.37% contribution. Among, other wetland types, reservoir/barrage is the major one. Two reservoirs are mapped with 1547 ha area (7.18%). Only one natural Lake/pond is mapped with 3 ha area. A detail of statistics of wetlands in the state is given in: Table 4. Graphical distribution of wetland type is shown in Figure 10.

Aquatic vegetation in the wetlands is negligible during post monsoon, while it occupied 604 ha area during pre monsoon. The open water spread of river/streams is almost same in both the seasons, indicating perennial condition. The open water in reservoir/barrage is slightly less during pre monsoon than during post monsoon. The turbidity of water is mainly high in both the seasons.

Table 4: Area estimates of wetlands in Nagaland

Area in ha

Sr. No	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	3	0.01	1	1
2	1102	Ox-bow lakes/ Cut-off meanders	3	9	0.04	9	3
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	90	423	1.96	351	283
6	1106	River/Stream	50	19254	89.37	19254	19254
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	1547	7.18	1287	1083
8	1202	Tanks/Ponds	8	41	0.19	36	26
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**154**	**21277**	**98.76**	**20938**	**20650**
		Wetlands (<2.25 ha), mainly Tanks	267	267	1.24	-	-
		Total	**421**	**21544**	**100.00**	**20938**	**20650**

Area under Aquatic Vegetation	7	604

Area under turbidity levels		
Low	2243	1065
Moderate	8071	7926
High	10624	11659

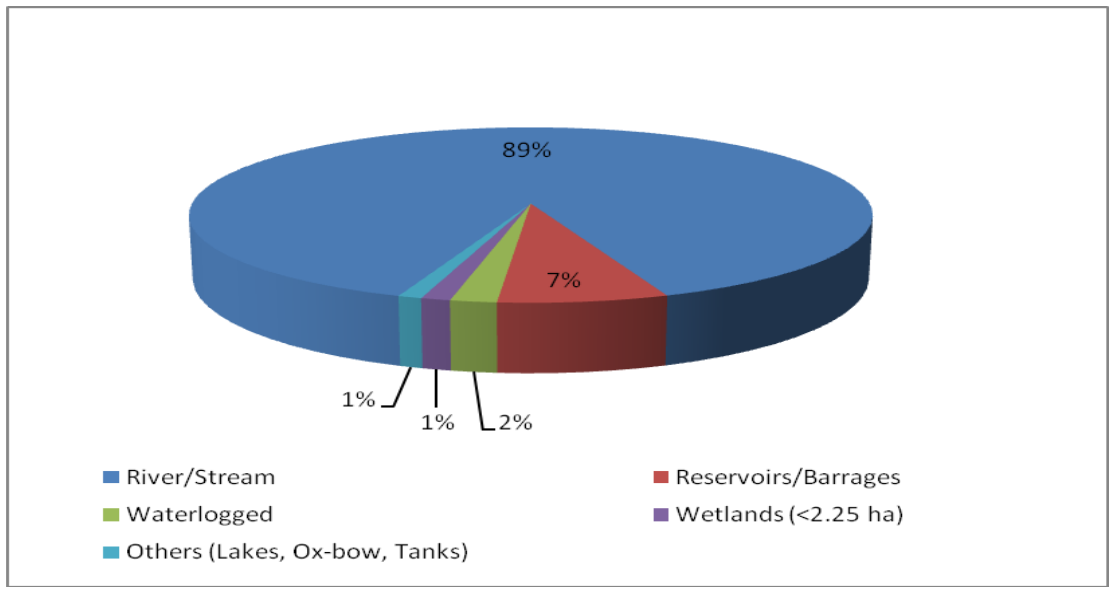


Figure 10: Type-wise wetland distribution in Nagaland

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has eleven districts. The geographic area of the districts varied from 563 sq.km. (Longleng) to 216 sq.km. (Mon). District Wokha has highest concentration of wetlands with 2946 ha area. District Kiphire has lowest concentration of wetland with 860 ha area. Dimapur district has highest concentration of small wetlands (<2.25 ha area). District-wise wetland area estimates is given in Table-5. The graphical distribution of district-wise wetland area is shown in Figure 11. Details of district level wetlands are described in this chapter.

Table – 5: District-wise wetland area

Area in ha

Sr. No.	District	Total Geographic Area	Wetland Area	Open water (Post- Monsoon)	Open water (Pre-Monsoon)
1	Dimapur	92700	2013	1835	1756
2	Kiphire	116185	860	857	857
3	Kohima	132176	1173	1162	1162
4	Longleng	56321	974	971	971
5	Mokokchung	160504	1747	1722	1720
6	Mon	216188	2820	2802	2797
7	Peren	173958	2324	2291	2296
8	Phek	202600	2414	2407	2407
9	Tuensang	214192	2015	2013	2013
10	Wokha	161782	2946	2636	2429
11	Zunheboto	125500	2258	2242	2242
	Total	**1657900**	**21544**	**20938**	**20650**

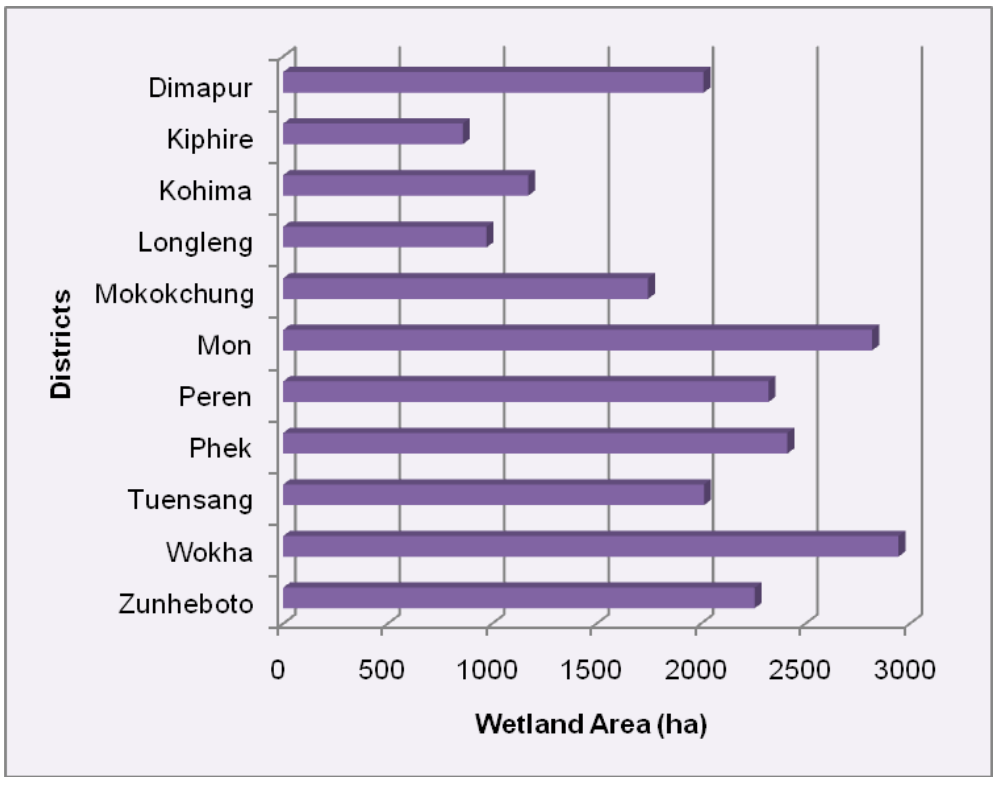
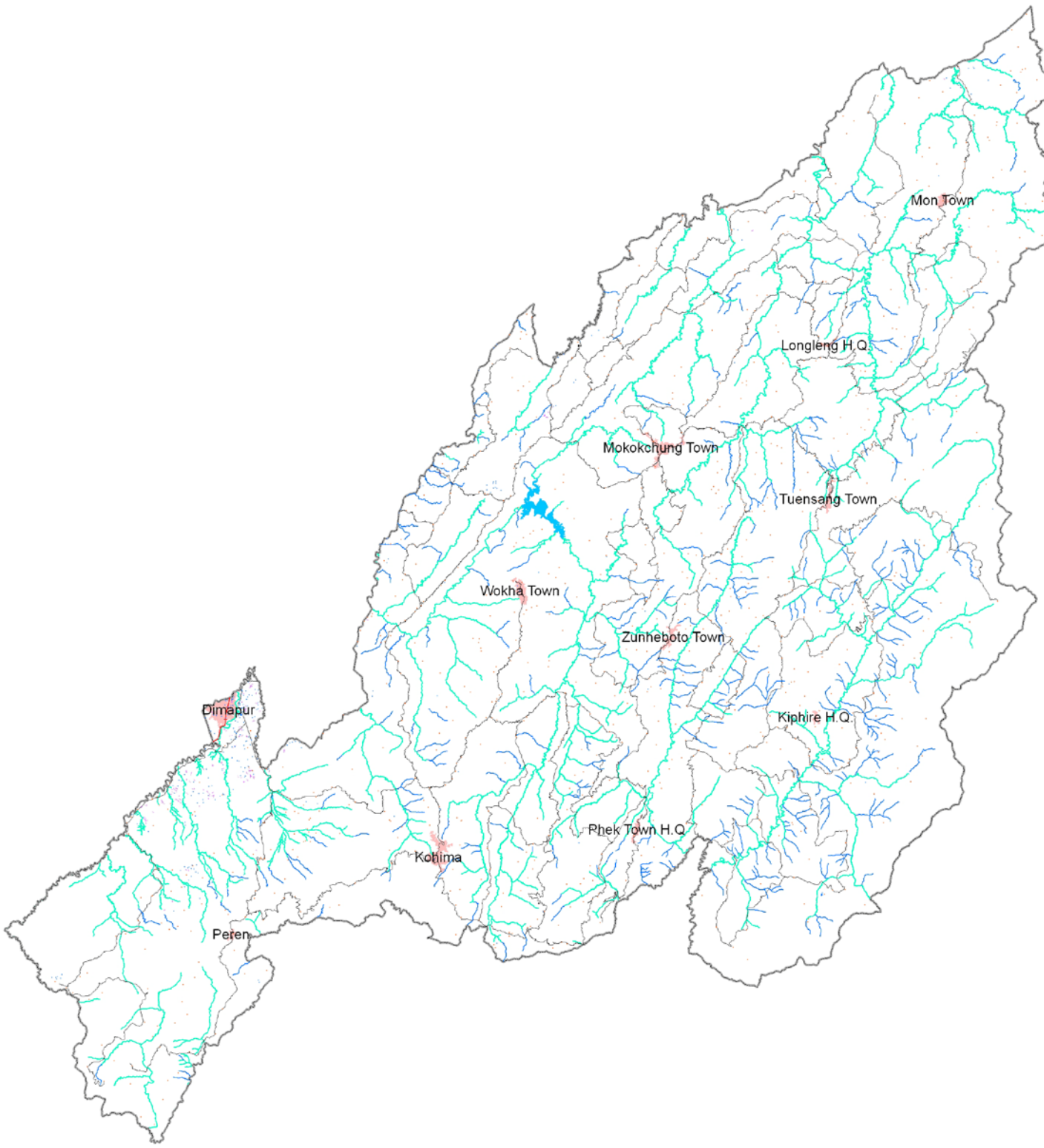


Figure 11: District-wise wetland distribution

State : Nagaland

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 (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | District

25 12.5 0 25 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.1 DIMAPUR

Dimapur, the gateway of Nagaland was officially inaugurated in April, 1988. The district name is derived from a Kachari word “Dimasa” after the river which flows through it. The district headquarter is located at Chumukedima. This fast developing district is also the commercial centre of the state. The total geographic area of Dimapur district is 92700 ha. The topography of the district is plains and valleys with average altitude of 145 metres above sea level. As per 2001 census, the district is home to 3,08,382 people.

Total 220 wetlands are mapped in the district including 130 small wetlands (<2.25 ha). The total wetland area estimated is 2013 ha. The major wetland type is River/Stream contributing 74.22%. Waterlogged (natural) is the second major wetland with 334 ha area (16.59%). Total 8 Tank/pond wetland type is mapped with 41 ha area (2.04%). Details of wetland statistics of the district is given in Table 6.

Table 6: Area estimates of wetlands in Dimapur

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	1102	Ox-bow lakes/ Cut-off meanders	1	3	0.15	3	2
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	71	334	16.59	295	228
6	1106	River/Stream	9	1494	74.22	1494	1494
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	11	0.55	7	6
8	1202	Tanks/Ponds	8	41	2.04	36	26
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**90**	**1883**	**93.54**	**1835**	**1756**
		Wetlands (<2.25 ha), mainly Tanks	130	130	6.46	-	-
		Total	**220**	**2013**	**100.00**	**1835**	**1756**

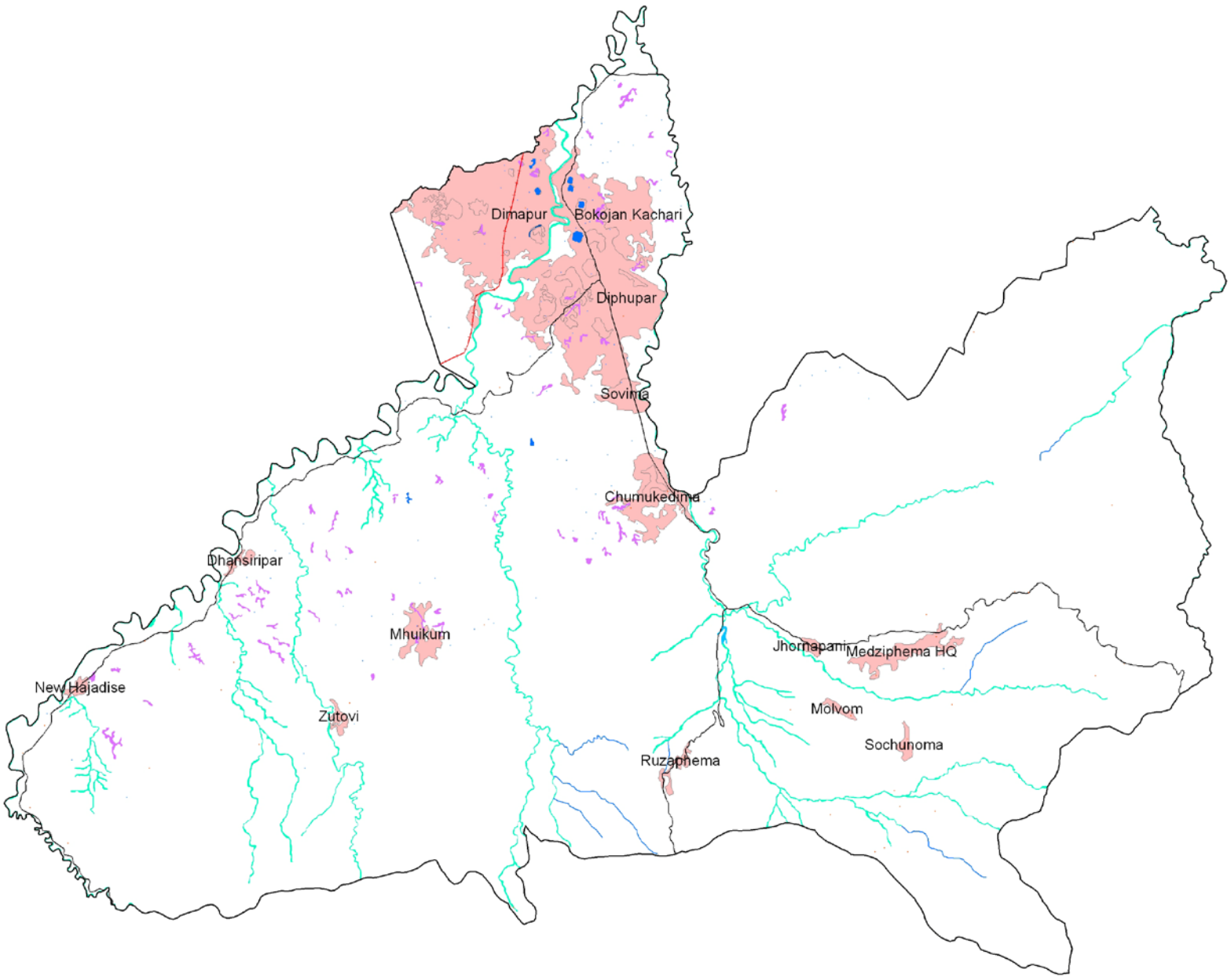
Area under Aquatic Vegetation	4	105

Area under turbidity levels		
Low	25	20
Moderate	1446	1403
High	364	333

State : Nagaland

WETLAND MAP

District : Dimapur

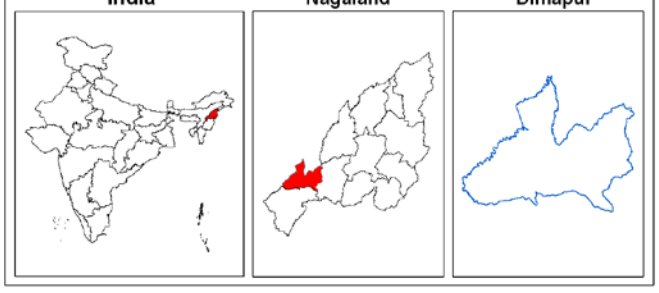


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



5 2.5 0 5 Kilometers

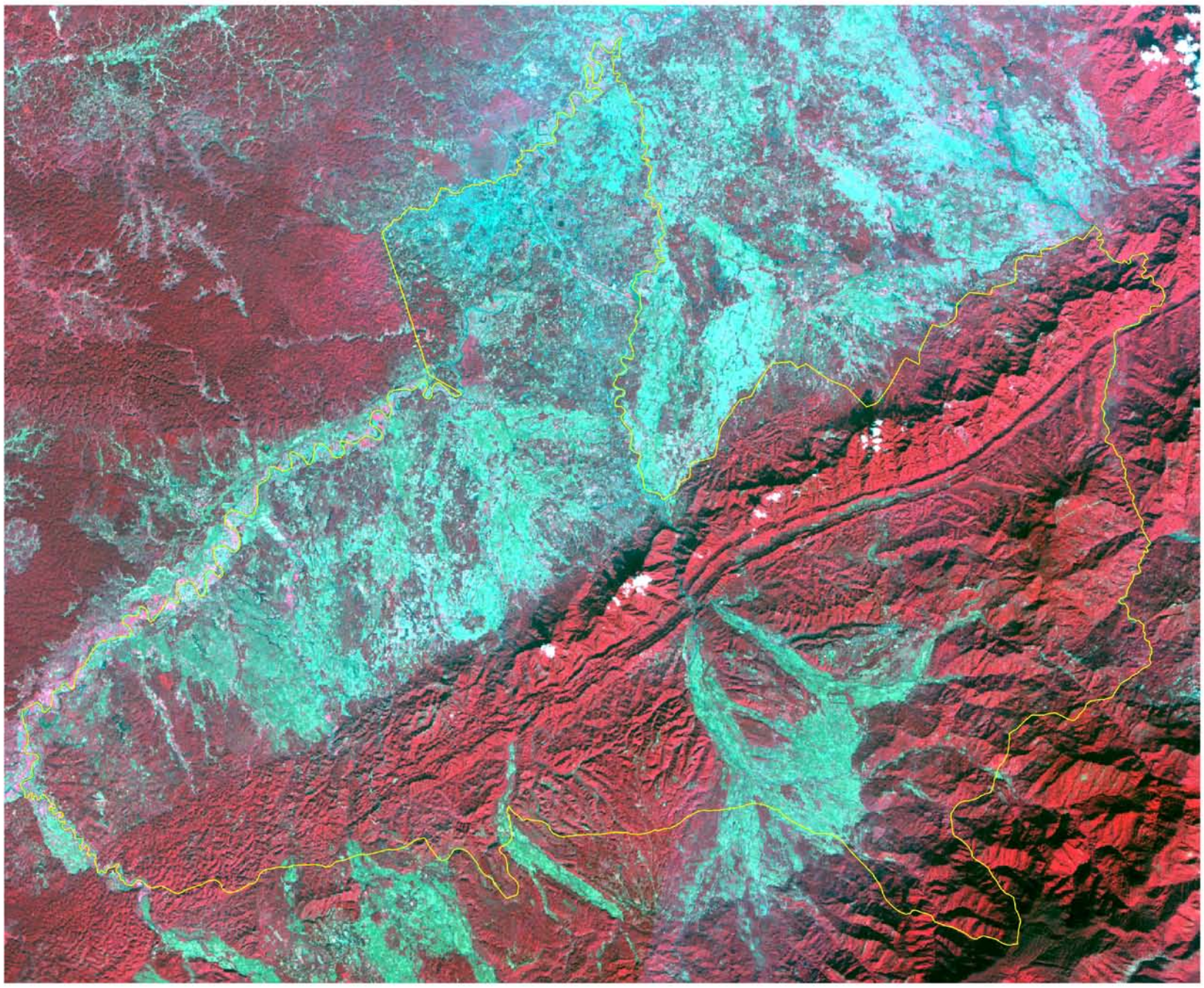
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District : Dimapur



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.2 Kiphire

Kiphire was carved out of Tuensang district on January 24th 2004 by upgrading the sub-division Kiphire. It is home to the Sema, Sangtam and Yimchunger tribes. The district headquarter is Kiphire. The district is bounded by Tuensang district in the north, Myanmar in the East, Zunheboto in the West and Phek district in the south. The physiography of the district is generally denudated hills with high hillslope. Saramati, with 3840 metre, which is the highest peak in Nagaland is located in this district. Fakim wildlife sanctuary, established in 1983 close to the Myanmar border is also located in this district which is 641 ha in area. The Likimro Hydel project is situated in the district towards Moya village under Pungro sub-division. The total geographic area of Kiphire district 116185 ha.

Total 8 wetlands are mapped in the district including 3 small wetlands (<2.25 ha). The total wetland area estimated is 860 ha. The major wetland type is River/Stream contributing 99.65%. No other wetland type is observed, except 3 small wetlands which are mainly tank/pond type. Details of wetland statistics of the district is given in Table 7. The open water spread of river/stream is same in both the seasons. The turbidity of water is high to moderate. No aquatic vegetation observed.

Table 7: Area estimates of wetlands in Kiphire

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	5	857	99.65	857	857
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**5**	**857**	**99.65**	**857**	**857**
		Wetlands (<2.25 ha), mainly Tanks	3	3	0.35	-	-
		Total	**8**	**860**	**100.00**	**857**	**857**

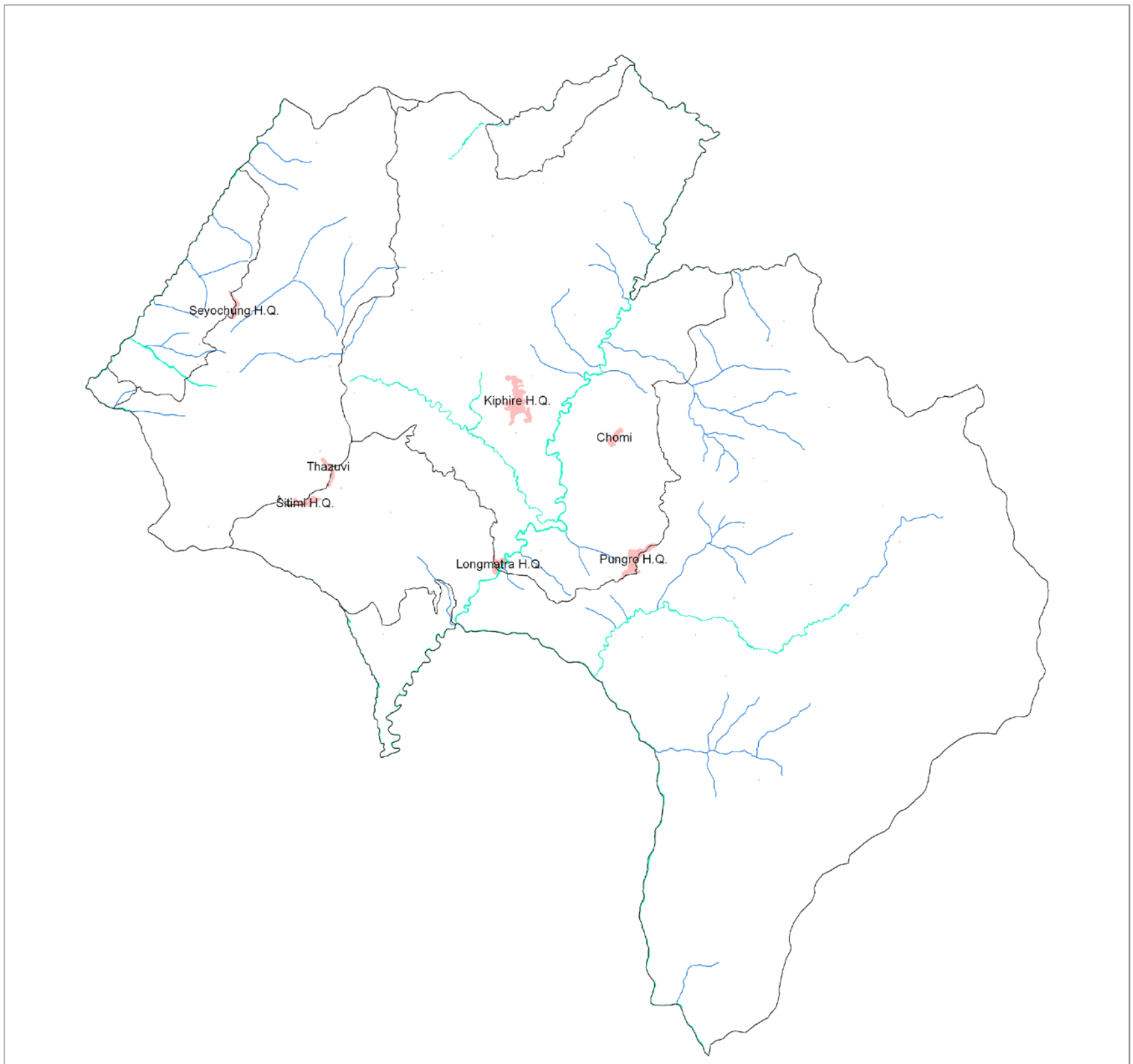
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	-	-
Moderate	267	267
High	590	590

State : Nagaland

WETLAND MAP

District: Kiphire

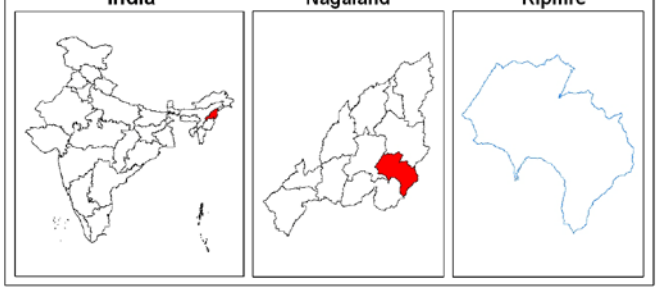


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



6 3 0 6 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
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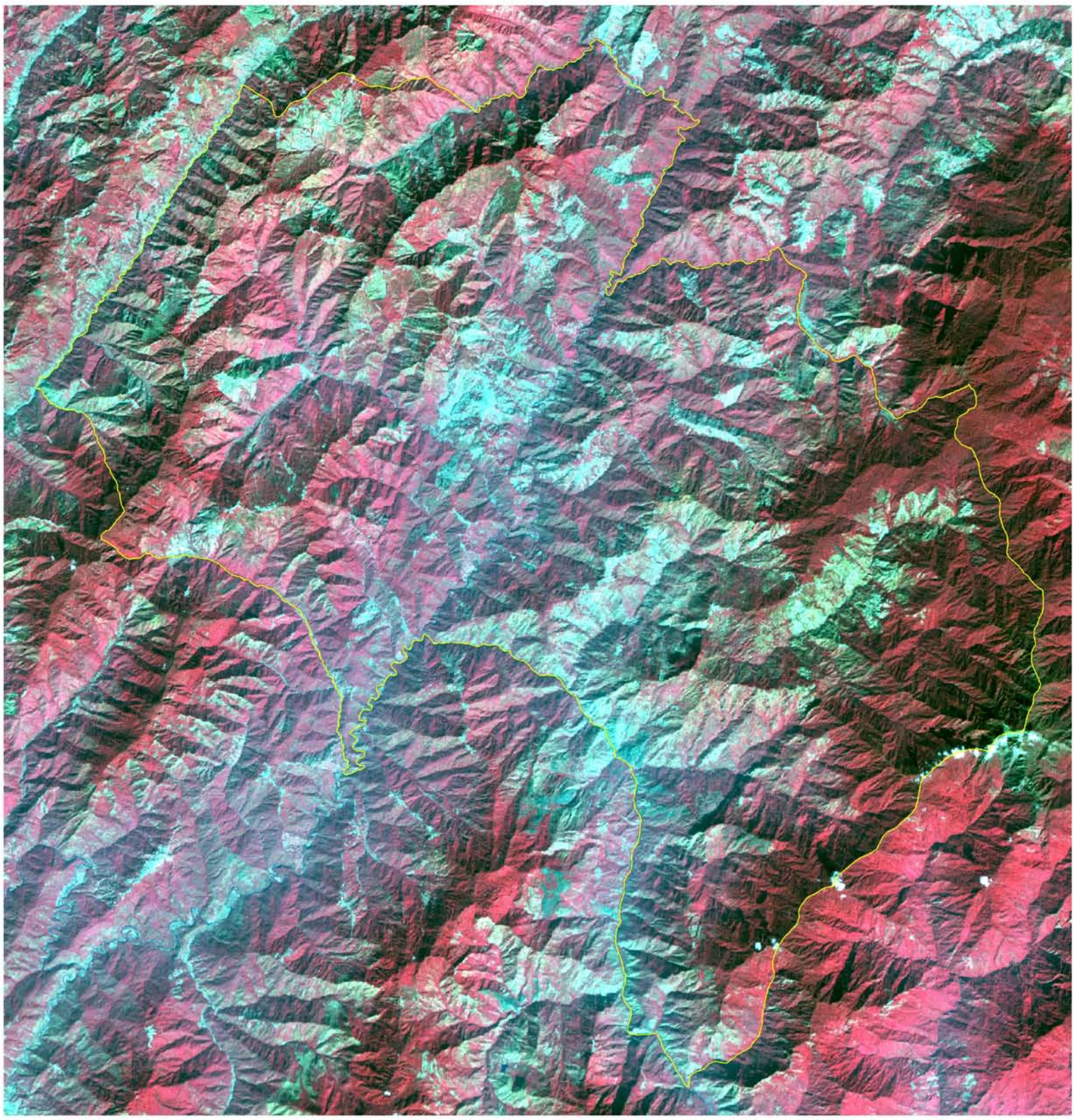
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District: Kiphire



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.3 Kohima

The very name of the state capital, Kohima was derived from a Tenyidie dialect Kewheimia meaning “people living in the hills.” of 132176.00 ha, with its district headquarter at Kohima town with an altitude of 1,444.12 meters above sea level. Kohima district is bounded in the east by Phek, west by Dimpaur, South by Manipur and North by Wokha. Japfii peak, which is the second highest peak in the state, stands at 3,015.60 meters above sea level in the south western part of the Capital town. The whole district is full of rugged and undulating terrains with the exception of the deep gorges and narrow valleys carved out by the rivers.

The major wetland type of the district is rivers /streams with 98.98%. Nine small wetlands (< 2.25 ha) are identified as point features. The open water spread of river/stream is same in both the seasons. The turbidity of water is Aquatic vegetation is nil in post monsoon, while 2 ha is observed, mainly in the one Lkae/pond mapped in the district. A detail of statistics of wetlands of the district is given in Table-8.

Table 8: Area estimates of wetlands in Kohima

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	3	0.26	1	1
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	10	1161	98.98	1161	1161
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**11**	**1164**	**99.23**	**1162**	**1162**
		Wetlands (<2.25 ha), mainly Tanks	9	9	0.77	-	-
		Total	**20**	**1173**	**100.00**	**1162**	**1162**

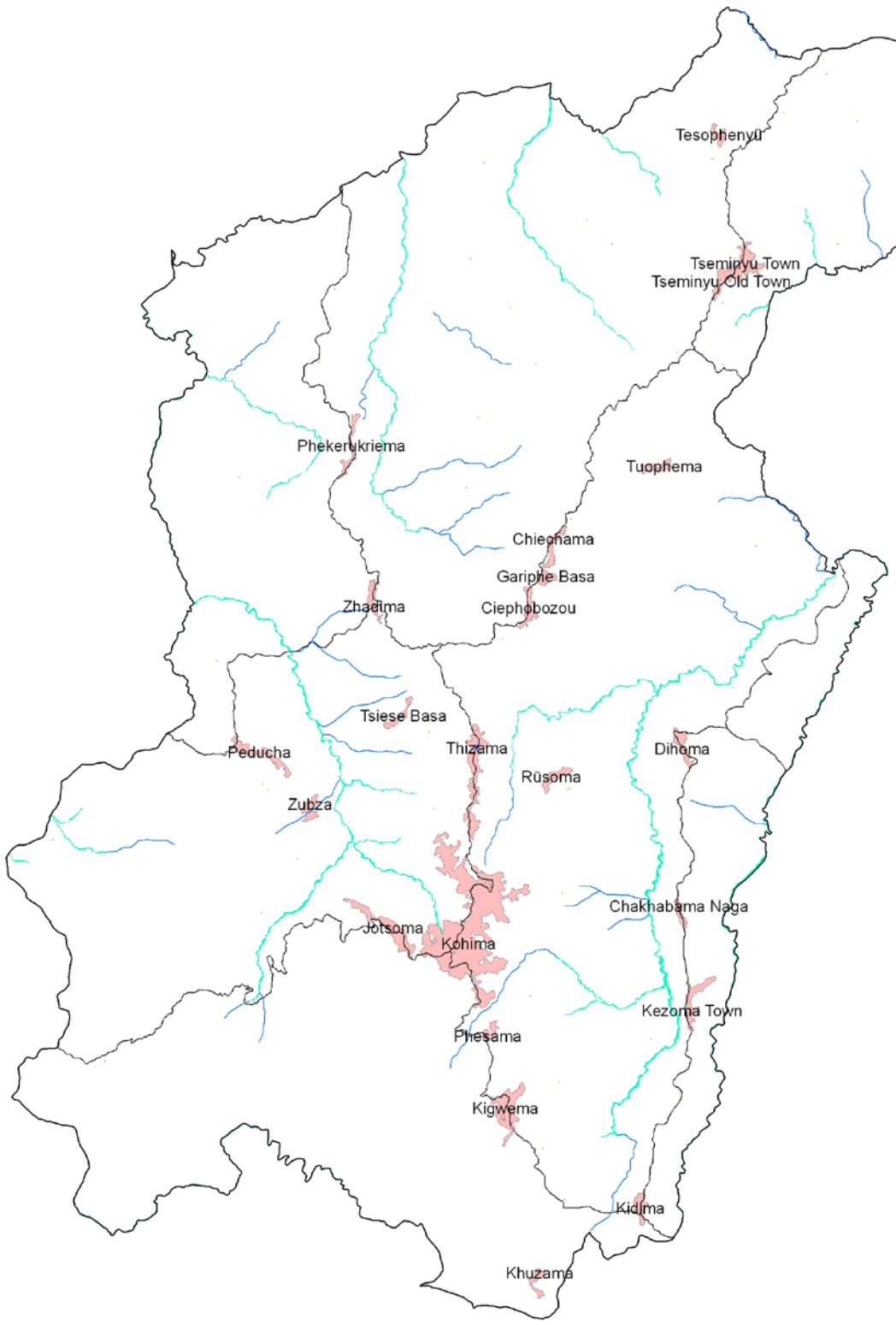
Area under Aquatic Vegetation	-	2

Area under turbidity levels		
Low	42	42
Moderate	613	408
High	507	712

State : Nagaland

WETLAND MAP

District:Kohima

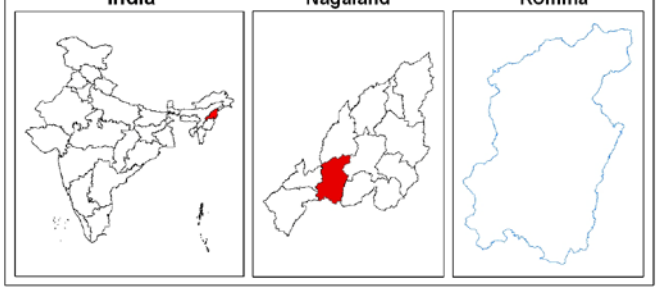


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



7 3.5 0 7 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
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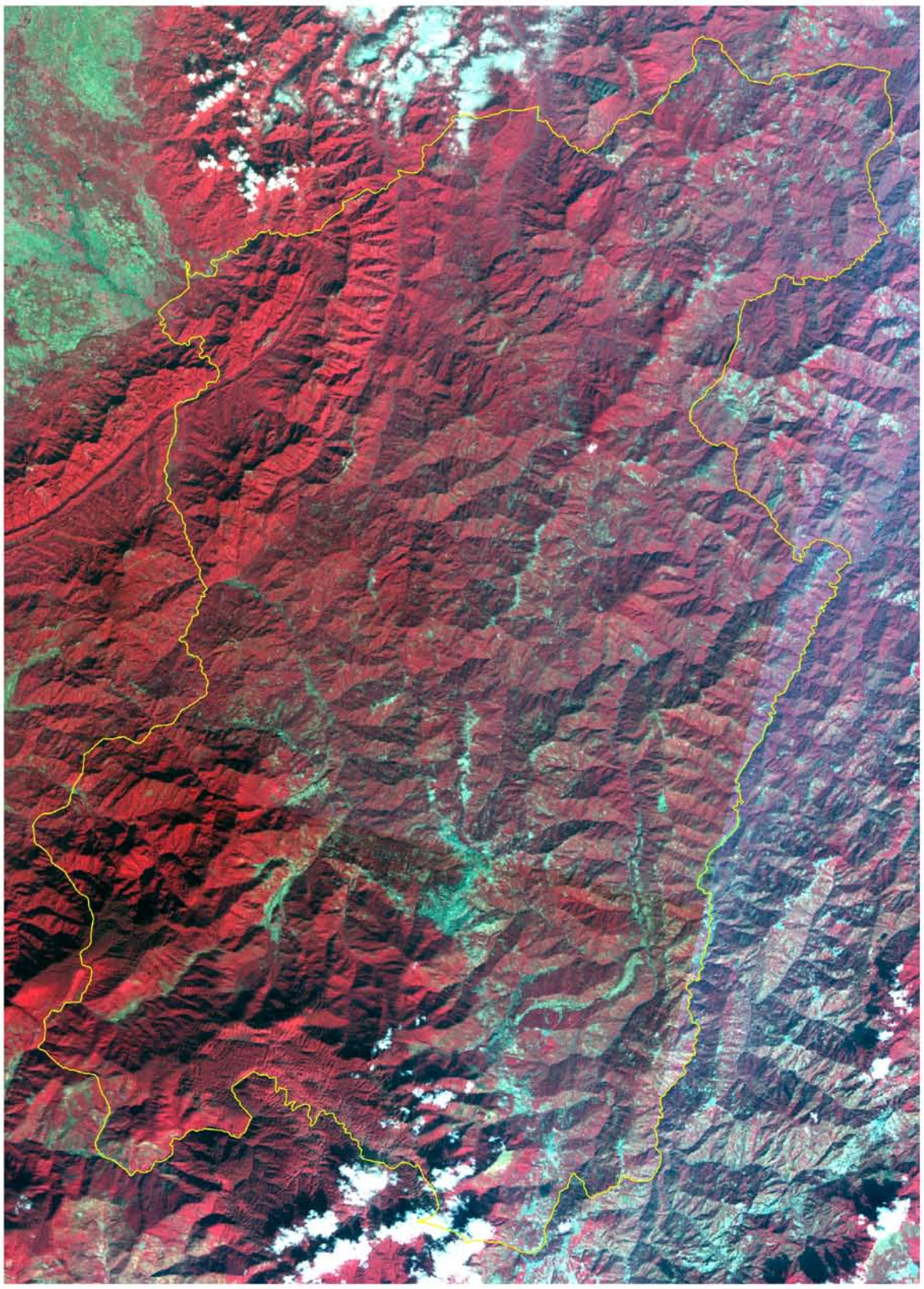
Government of India

State : Nagaland

District:Kohima



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.4 Longleng

Longleng district was carved out from Tuensang district on 26th January 2004. Longleng town is the district headquarters with an altitude of 1,063.39 meters above sea level. It has a total geographic area of 56321.50 ha. It is bounded in the east by Mon, North by Assam, West by Mokokchung and South by Tuensang. The indigenous inhabitants of the district are the Phom. The physiography of the district is mainly made up of denudated, low hill slopes. Its major rivers are Dikhu and Yangnyu. The river Dikhu enters Tuensang district through Longleng and then turns towards Brahmaputra river in the plains of Assam.

The total wetland area of Longleng is 974 ha with 3 wetlands less than 2.25 ha. The major wetland type is river/stream with 99.66% area. The open water spread of river/stream is same in both the seasons. The turbidity of open water of rivers is high to moderate in both the seasons. No aquatic vegetation is observed. A detail of statistics of wetland of the district is given in Table-9.

Table 9: Area estimates of wetlands in Longleng

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	3	971	99.69	971	971
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**3**	**971**	**99.69**	**971**	**971**
		Wetlands (<2.25 ha), mainly Tanks	3	3	0.31	-	-
		Total	**6**	**974**	**100.00**	**971**	**971**

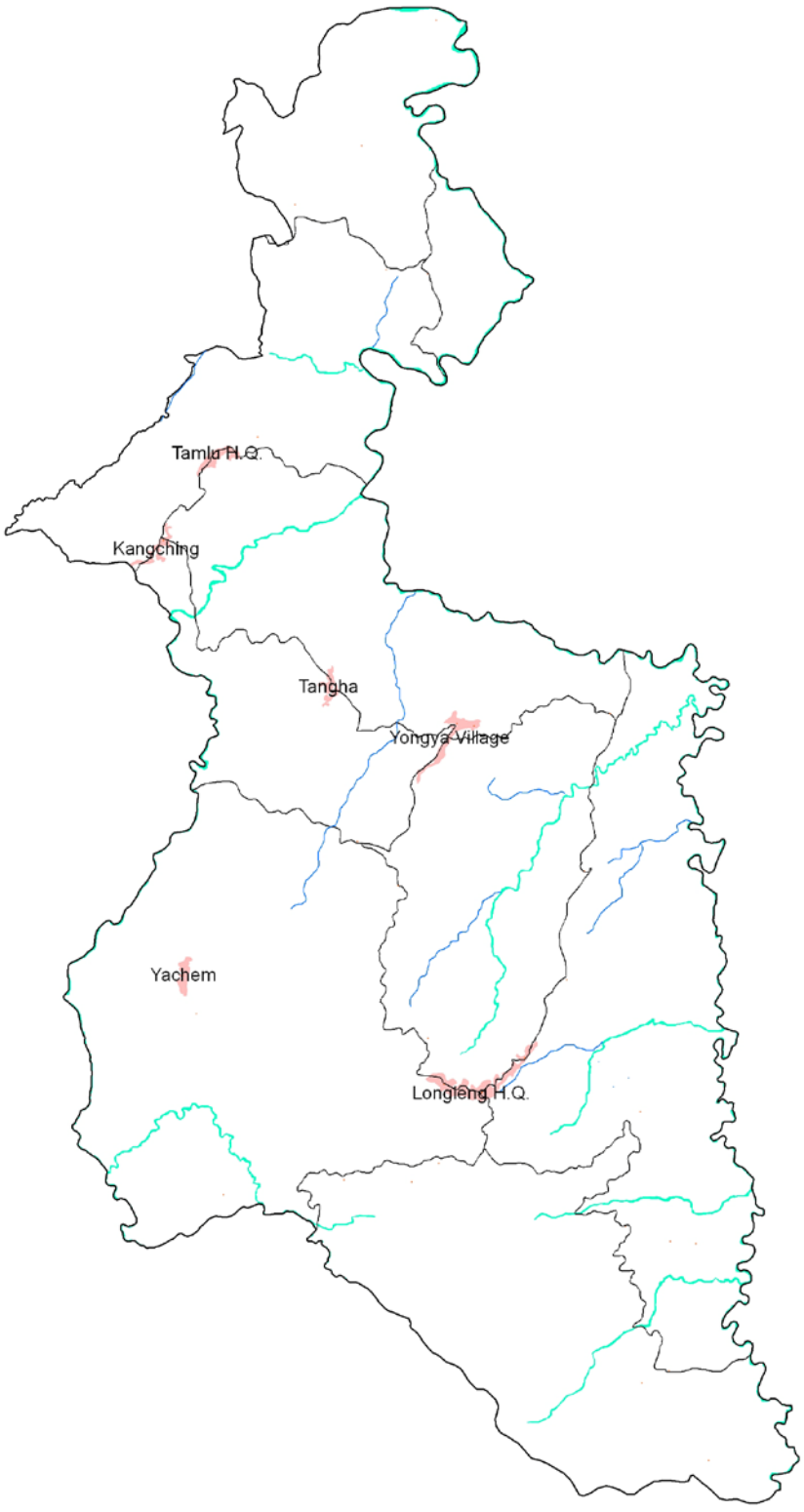
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	-	-
Moderate	465	465
High	506	506

State : Nagaland

WETLAND MAP

District:Longleng



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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | Longleng

7 3.5 0 7 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
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Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
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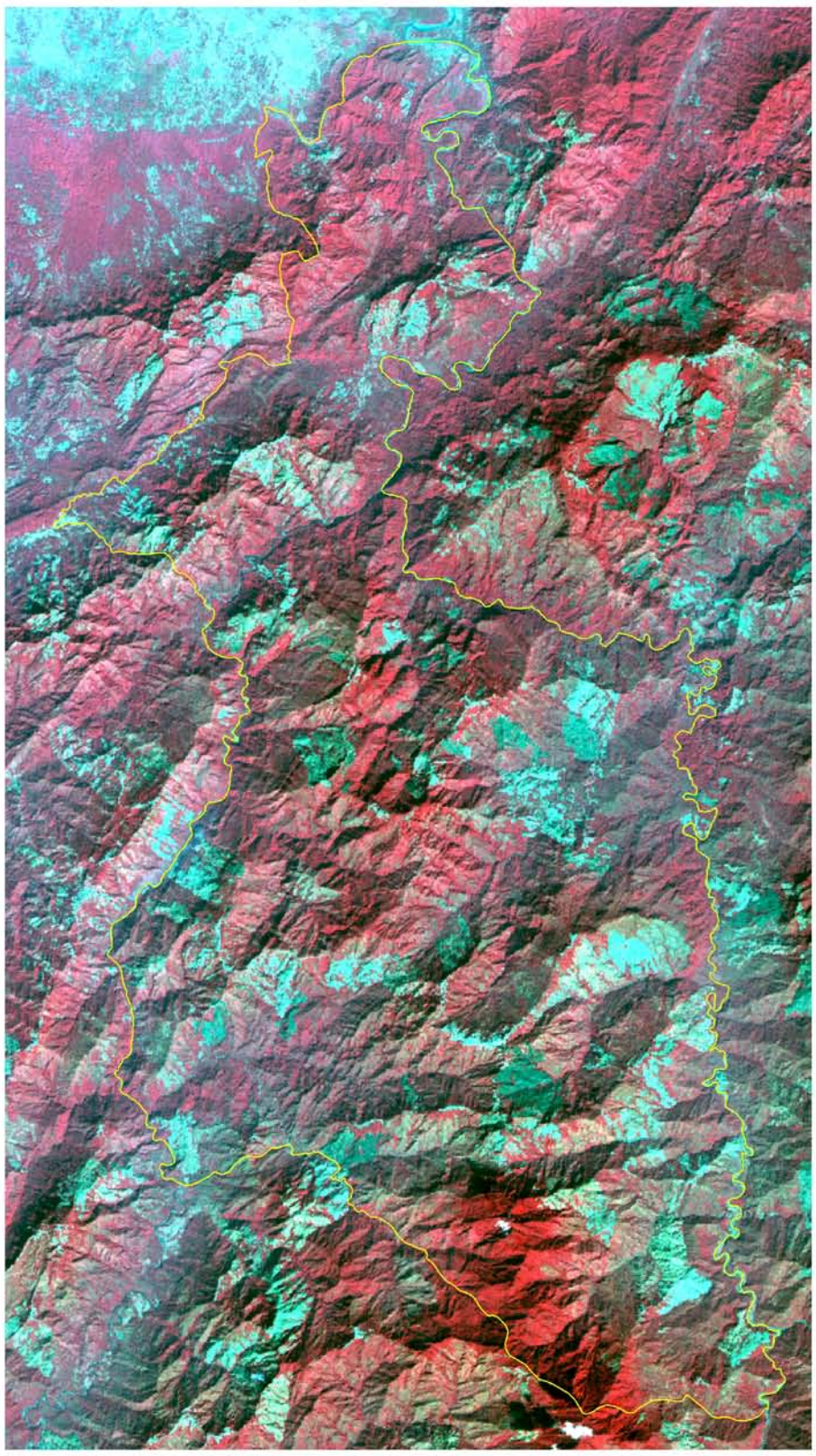
Government of India

State : Nagaland District:Longleng



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.5 Mokokchung

The Mokokchung District is surrounded by Zunheboto in the south, Tuensang and Longleng in the east and Assam in the North and Wokha in the west. The district is the cultural centre of the Ao Nagas. The total geographic area of the district is 160504.00 ha. The district headquarter is Mokokchung with an altitude of 1325.08 meters above sea level. The physiography of the district is made up of Highly dissected hillslope. The major rivers are Tsiira or Tiru river, Dikhu river, etc.

The total wetland area of the district is 1747 ha with 14 wetlands smaller than 2.25 ha. The major wetland types are River/Stream (98.05%). Details of wetland statistics of the district is given in Table-10.

Table 10: Area estimates of wetlands in Mokokchung

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	4	20	1.14	9	7
6	1106	River/Stream	6	1713	98.05	1713	1713
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**10**	**1733**	**99.20**	**1722**	**1720**
		Wetlands (<2.25 ha), mainly Tanks	14	14	0.80	-	-
		Total	**24**	**1747**	**100.00**	**1722**	**1720**

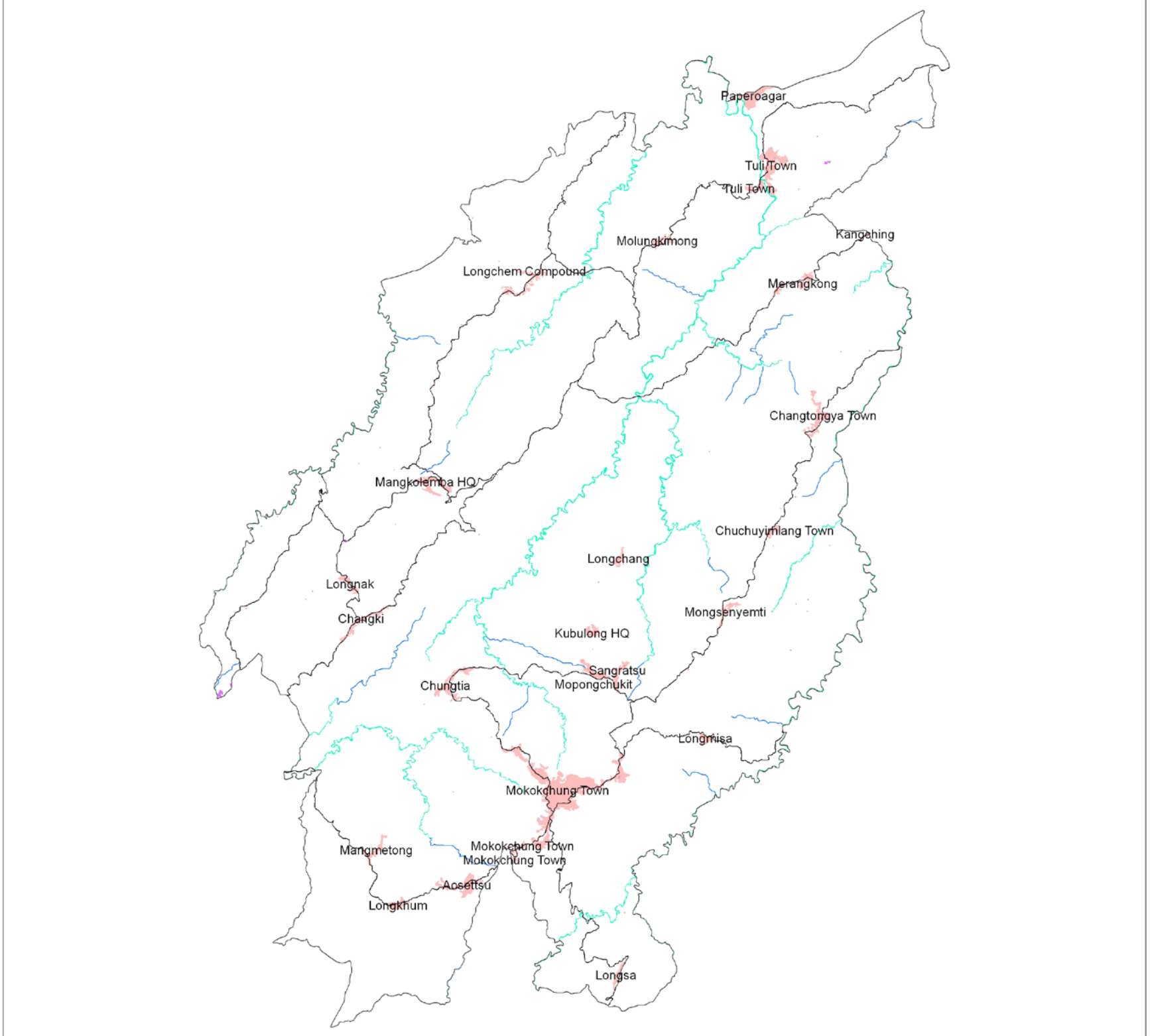
Area under Aquatic Vegetation	1	12

Area under turbidity levels		
Low	5	6
Moderate	524	521
High	1193	1193

State : Nagaland

WETLAND MAP

District:Mokokchung

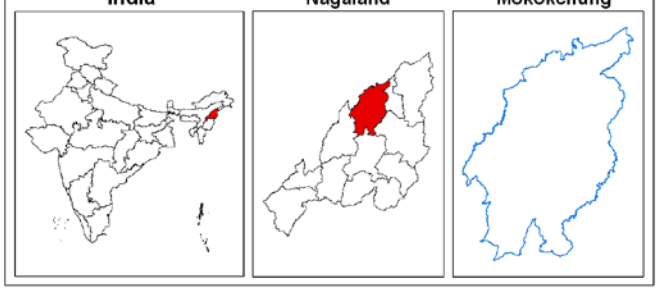


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



8 4 0 8 Kilometers

Data Source:
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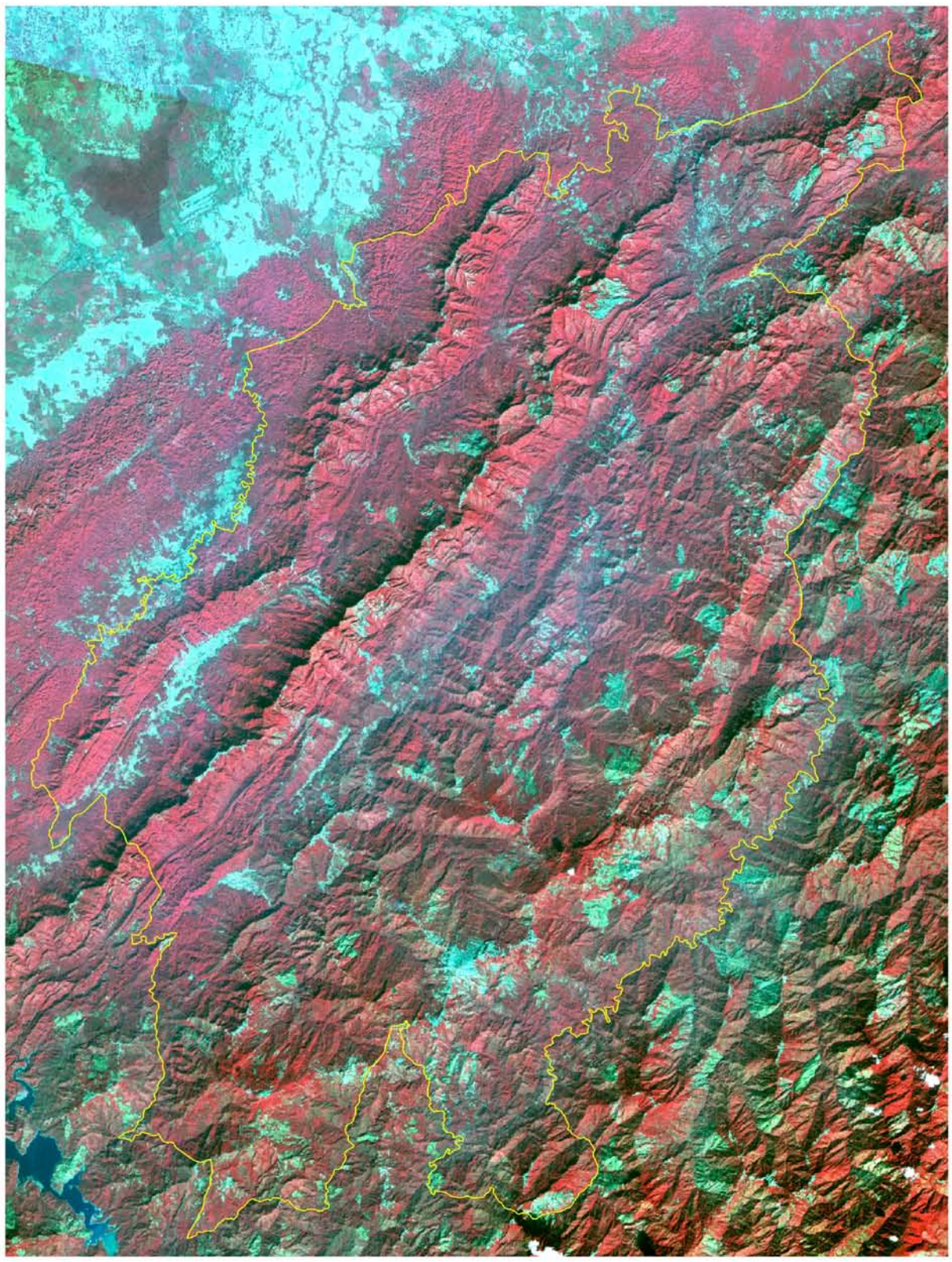
State : Nagaland

District:Mokokchung



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.6 Mon

The district Mon is bounded by Assam on the North, Tuensang on the South, Myanmar on the East and Longleng on the West. The district headquarter is Mon with an altitude of 897.64 meters above sea level. The total geographic area of the district is 216188.00 ha. The indigenous inhabitants of the district are the Konyak. The district is rich in coal and other mineral resources. The physiography is generally denudated hill slope.

Total 28205 ha wetland area is estimated. River/stream is the dominant wetland with 99.01% area. 16 small wetlands (< 2.25 ha), that are mainly tank/pond type are delineated as point features. The open water spread of rivers is same in both the seasons. The turbidity of water is mainly high in both the seasons. Details of wetland statistics of the district is given in Table-11.

Table 11: Area estimates of wetlands in Mon

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	1102	Ox-bow lakes/ Cut-off meanders	2	6	0.21	6	2
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	2	6	0.21	4	3
6	1106	River/Stream	13	2792	99.01	2792	2792
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**17**	**2804**	**99.43**	**2802**	**2797**
		Wetlands (<2.25 ha), mainly Tanks	16	16	0.57	-	-
		Total	**33**	**2820**	**100.00**	**2802**	**2797**

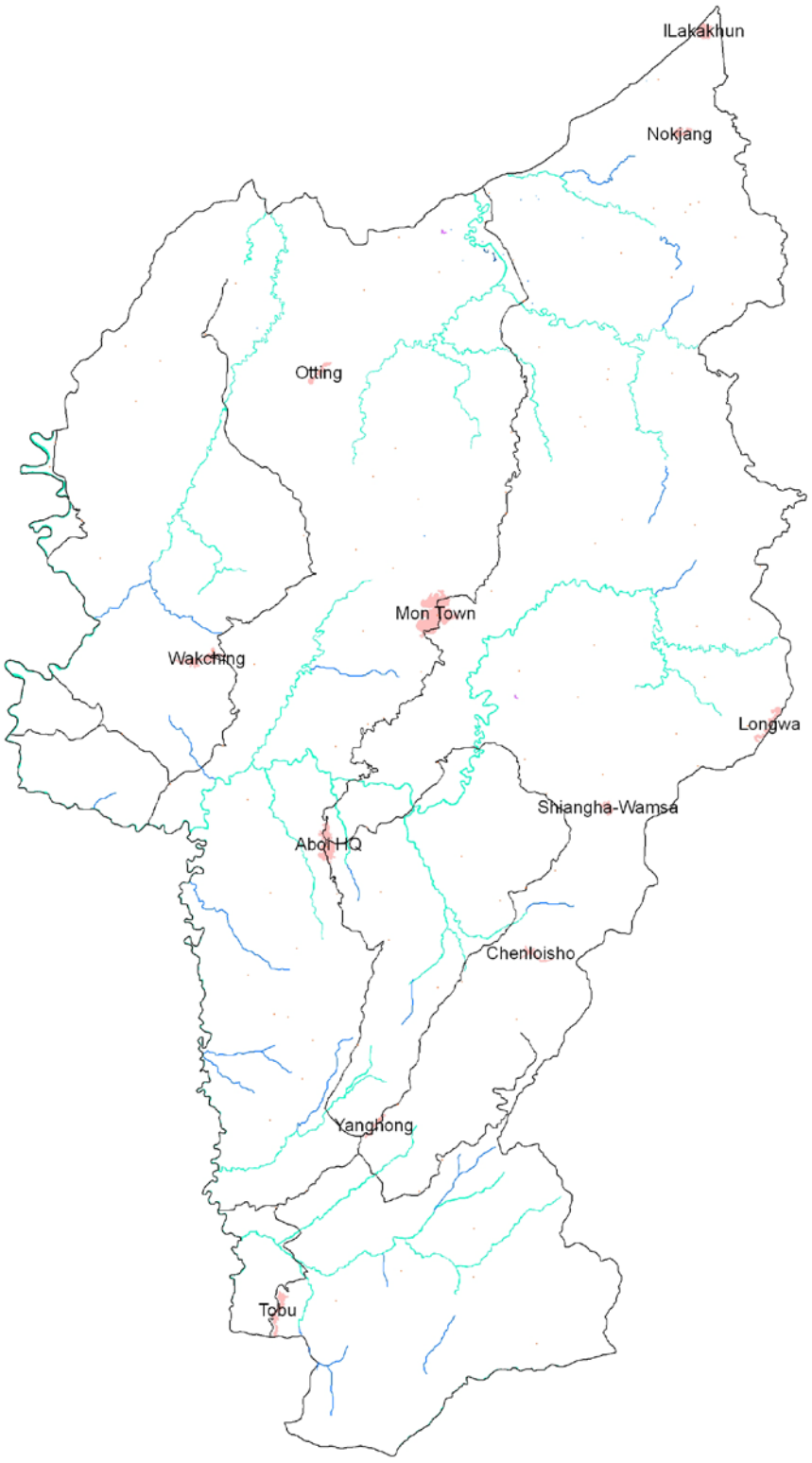
Area under Aquatic Vegetation	-	5

Area under turbidity levels		
Low	2	-
Moderate	288	285
High	2512	2512

State : Nagaland

WETLAND MAP

District: Mon

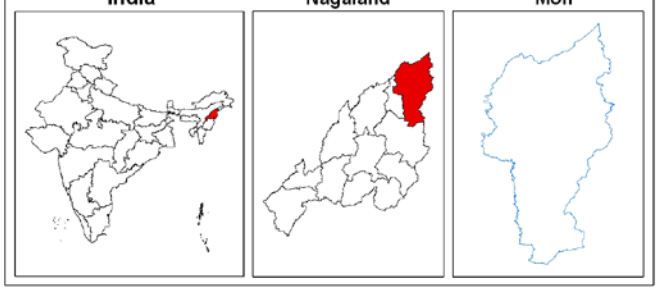


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



10 5 0 10 Kilometers

Data Source:
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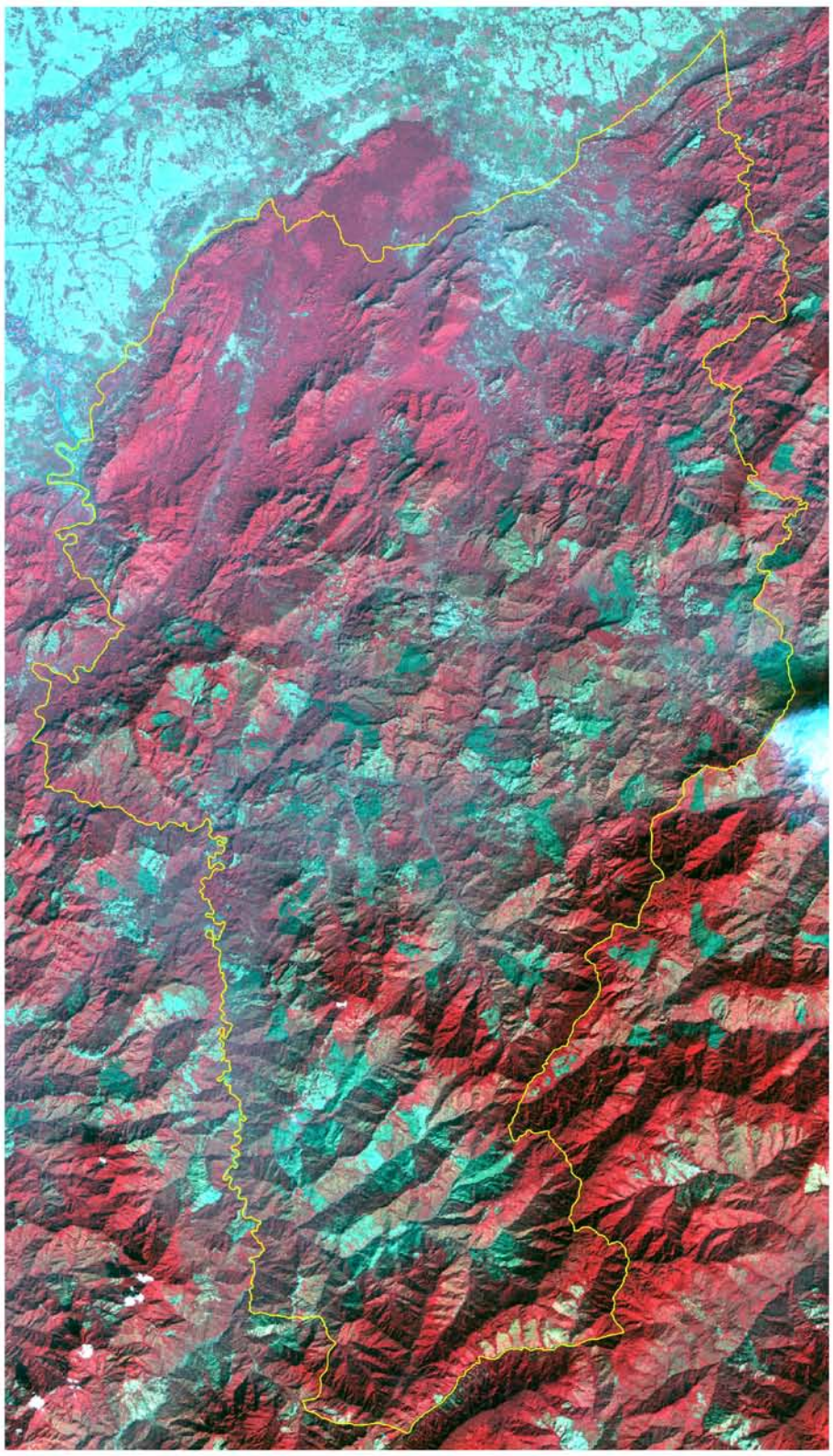
State : Nagaland

District: Mon



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.7 PEREN

The district was carved out from Kohima district in the year 2004 and is home to the Zeliang and Kuki tribe. The district headquarter is Peren with an altitude of 1445.36 metre. The topography of the district is highly dissected with undulating upland. It is bounded in north by Dimapur district, west by Assam and south by Manipur state and Kohima in the east. The total geographical area of the district is 173958.00 ha. It is an important link between Haflong in Assam and Nagaland.

Total 2324 ha wetland area is estimated. River/stream is the dominant wetland with 98.15% area. 5 sites of waterlogged (natural) is mapped with 16 ha area. Total 27 small wetlands (< 2.25 ha), that are mainly tank/pond type are delineated as point features. The open water spread of rivers is same in both the seasons. The turbidity of water is high to moderate in both the seasons. Details of wetland statistics of the district is given in Table-12.

Table 12: Area estimates of wetlands in Peren District

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	5	16	0.69	10	15
6	1106	River/Stream	12	2281	98.15	2281	2281
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**17**	**2297**	**98.84**	**2291**	**2296**
		Wetlands (<2.25 ha), mainly Tanks	27	27	1.16	-	-
		Total	**44**	**2324**	**100.00**	**2291**	**2296**

Area under Aquatic Vegetation	-	1

Area under turbidity levels		
Low	1	1
Moderate	1068	1073
High	1222	1222

State : Nagaland

WETLAND MAP

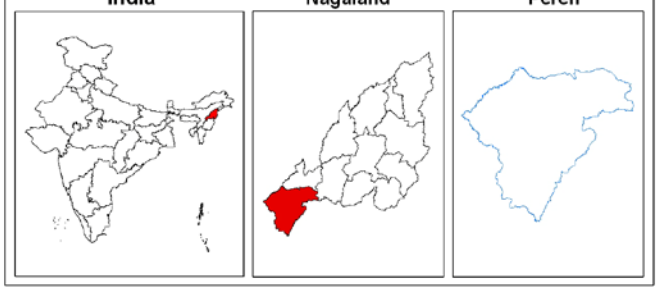
District:Peren

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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



8 4 0 8 Kilometers

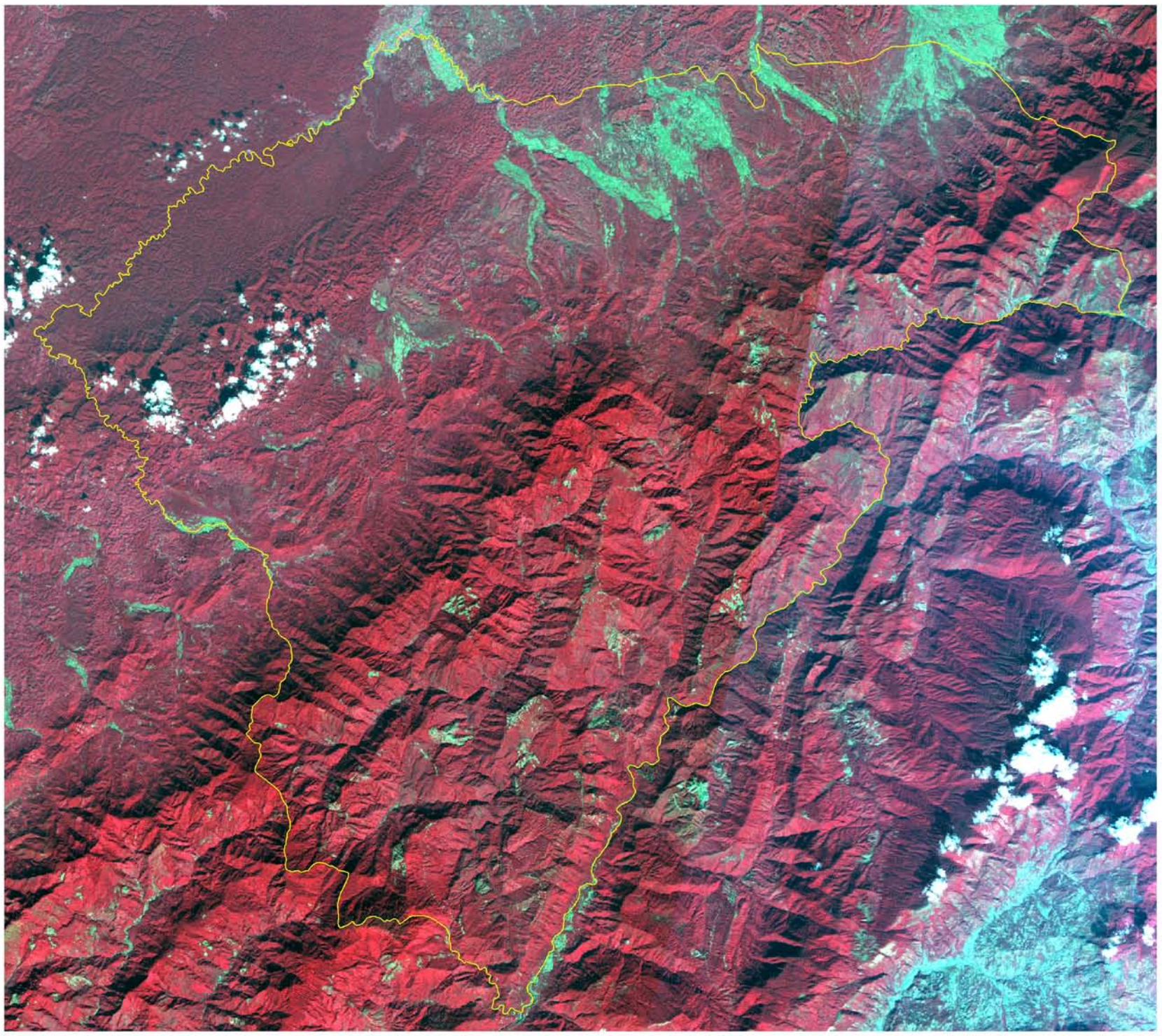
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District:Peren



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.8 . PHEK

Phek district was carved out of Kohima district on 21st Dec. 1973. It is bounded by Manipur in the South, Kohima in the West, Zunheboto and Kiphire on the North and Myanmar in the East. The principal inhabitants of the district are the Chakhesangs and Pochuries. Phek, with an altitude of 1,524 metre above sea level, is the district headquarter. The topography of the district is composed of high hillslope and denudational hillslope. The total geographical area of the district is 2,02,600.00 ha. Tizu is the major river flowing through the district.

Total wetland area estimated is 2,414 ha. The major wetland types are River/Stream with 99.17% area. In addition, 5 small wetlands (< 2.25 ha.) are mapped as point features. The open water spread of the rivers is same in both the seasons. The turbidity of water is high to moderate. Details of wetland statistics of the district is given in Table-13.

Table 13: Area estimates of wetlands in Phek

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	2	15	0.62	13	13
6	1106	River/Stream	14	2394	99.17	2394	2394
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**16**	**2409**	**99.79**	**2407**	**2407**
		Wetlands (<2.25 ha), mainly Tanks	5	5	0.21	-	-
		Total	**21**	**2414**	**100.00**	**2407**	**2407**

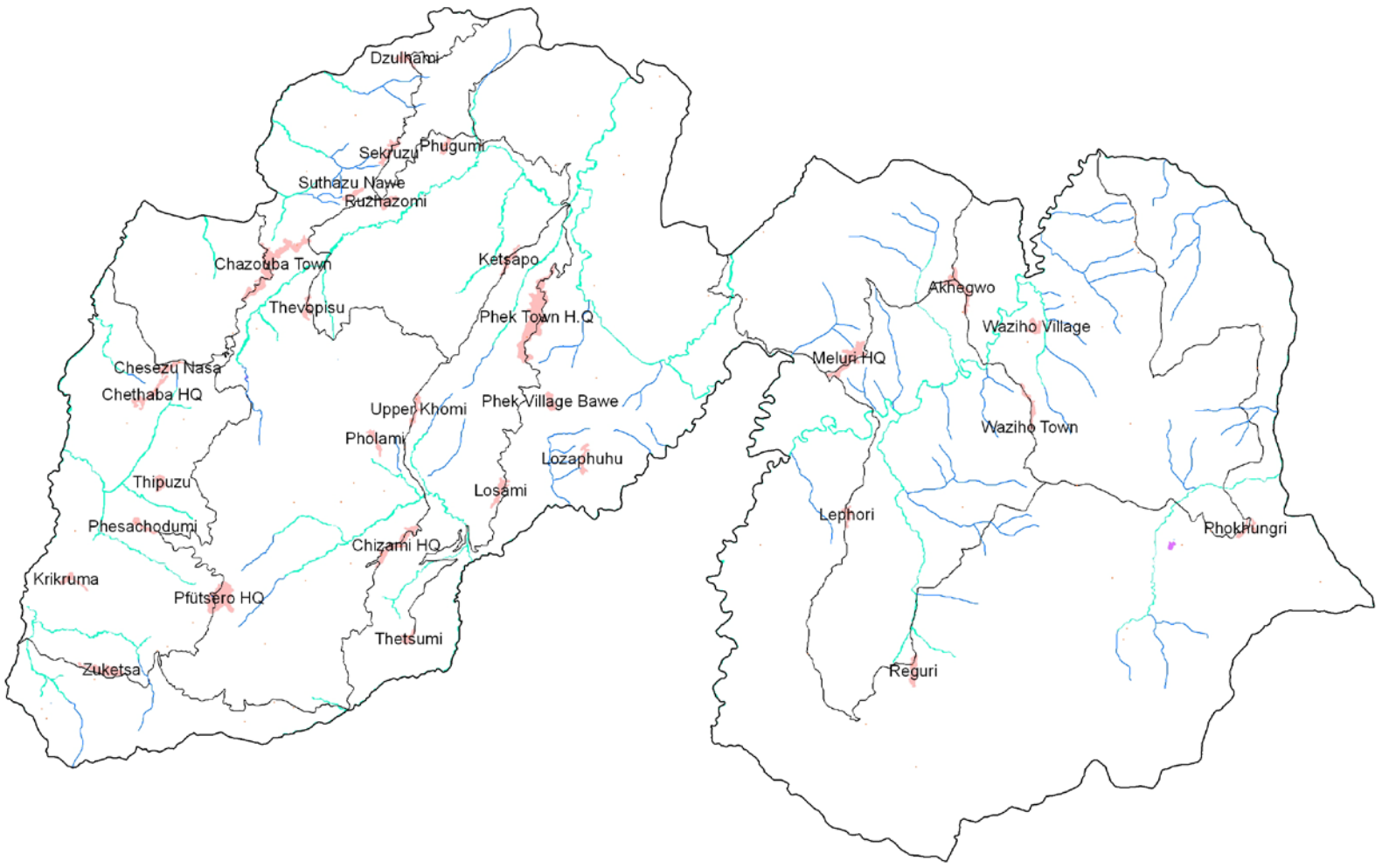
Area under Aquatic Vegetation	-	3

Area under turbidity levels		
Low	4	4
Moderate	1139	1139
High	1264	1264

State : Nagaland

WETLAND MAP

District:Phek

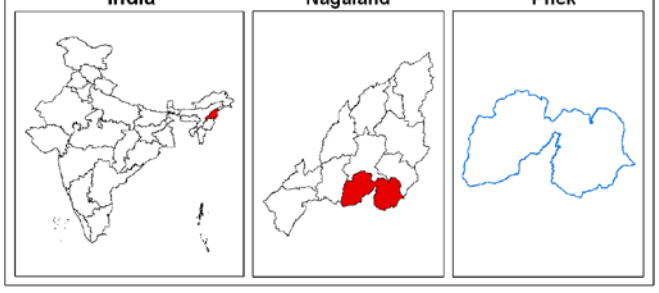


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



9 4.5 0 9 Kilometers

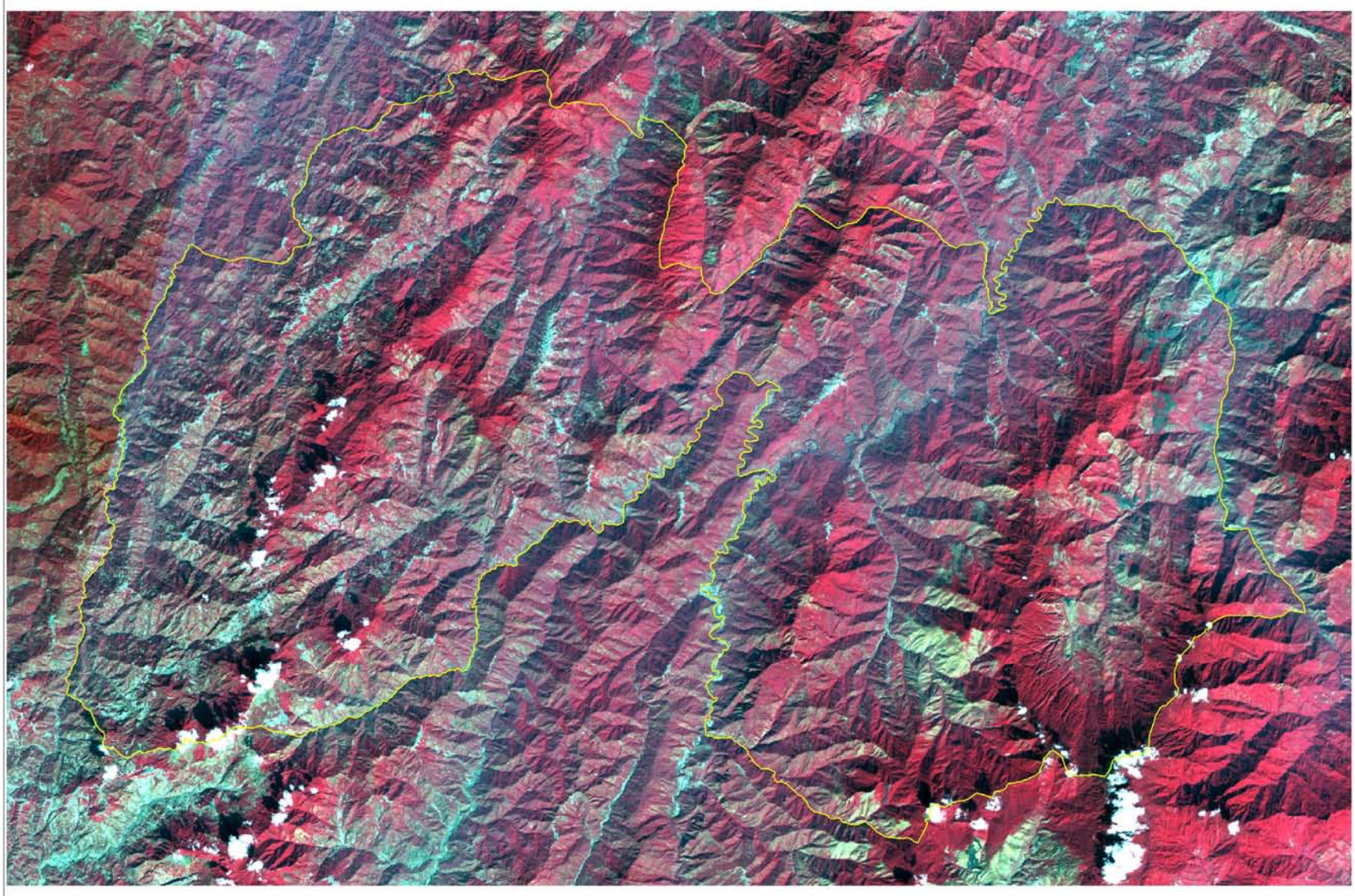
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District:Phek



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.9 TUENSANG

Tuensang district has a total geographical area of 2, 14,192.00 ha. It is bounded in the north by Longleng and Mon, West by Mokokchung, South by Kiphire and Myanmar in the East. Tuensang is the district headquarters with an altitude of 1,371.60 meter above sea level. The principal inhabitants of this district are Changs, Phoms, Sangtams, Yimchungers and Khiamuingans. Zungki is the major river flowing through the district.

Total wetland area estimated is 2,015 ha. The major wetland types are River/Stream with 99.9% area. In addition, 2 small wetlands (< 2.25 ha.) are mapped as point features. The open water spread of the rivers is same in both the seasons. The turbidity of water is high to moderate. Details of wetland statistics of the district is given in Table-14.

Table 14: Area estimates of wetlands in Tuensang

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	9	2013	99.90	2013	2013
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**9**	**2013**	**99.90**	**2013**	**2013**
		Wetlands (<2.25 ha), mainly Tanks	2	2	0.10	-	-
		Total	**11**	**2015**	**100.00**	**2013**	**2013**

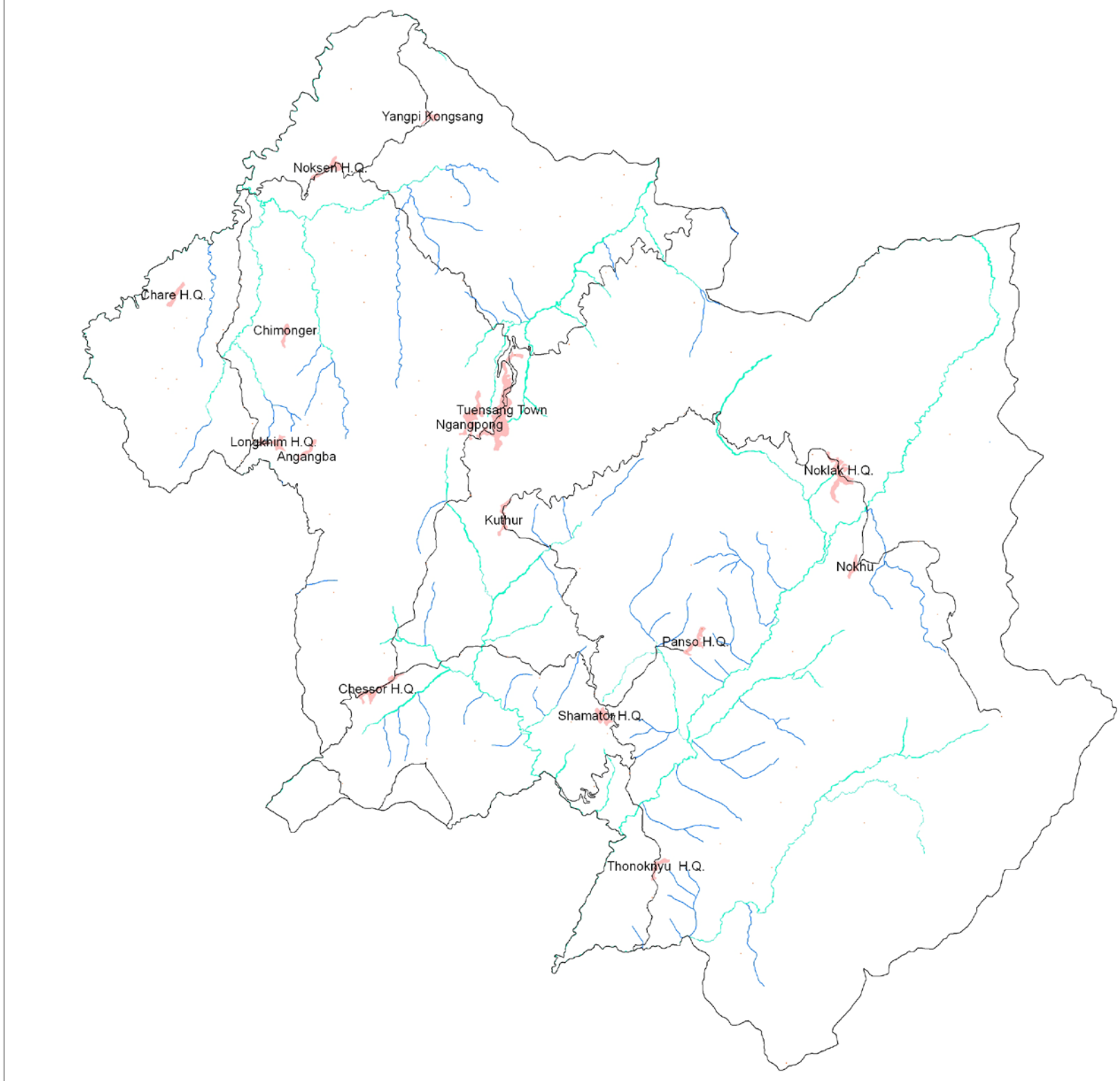
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	-	-
Moderate	409	409
High	1604	1604

State : Nagaland

WETLAND MAP

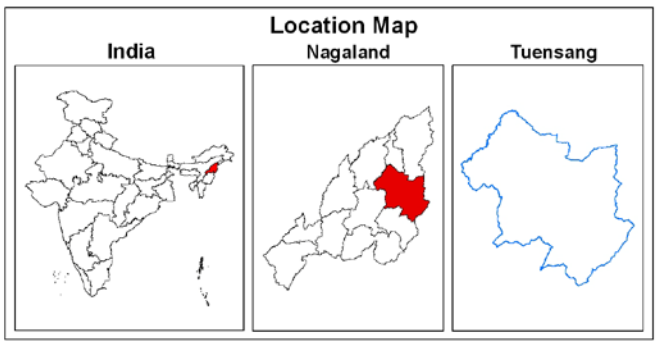
District:Tuensang



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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary



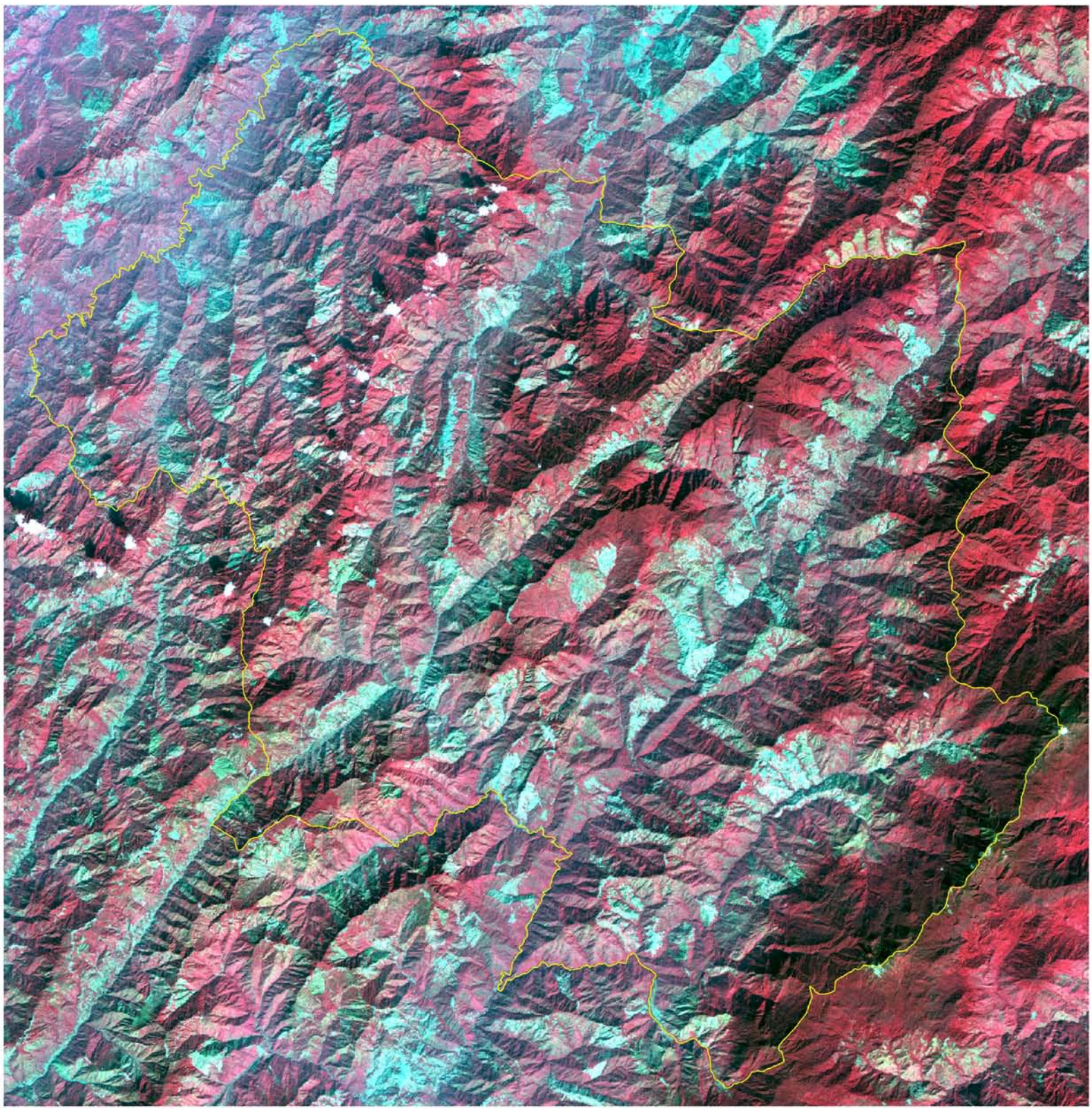
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District:Tuensang



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

7.1.10 WOKHA

Wokha literally means census and is the district headquarter with an altitude of 1313.69 meters above sea level. The Lothas are the principal inhabitants of the district. The total area of the district is 161782.00 ha. The biggest river of Nagaland, Doyang, flow through the middle of this district. The area is made up highly dissected hill slope.

Total wetland area estimated is 2946 ha area. Reservoir/barrage is the major wetland type of this district. One reservoir/barrage wetland type, the Doyang hydel power project reservoir is mapped with 1536 ha area occupying 52.54% area. The other wetland types are river/stream with 45.35% area, and waterlogged (natural) with 32 ha area . In addition, 42 small wetlands (< 2.25 ha.) are mapped as point features. The open water spread of the rivers is same in both the seasons. However, the open water spread of the reservoir is slightly more during post monsoon. The turbidity of water is moderate to low. Aquatic vegetation is observed in the reservoir wetland fringes during pre monsoon when water spread shrinks. Details of wetland statistics of the district is given in Table-15.

Table 15: Area estimates of wetlands in Wokha

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	7	32	1.09	20	17
6	1106	River/Stream	11	1336	45.35	1336	1336
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	1536	52.14	1280	1076
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**19**	**2904**	**98.57**	**2636**	**2429**
		Wetlands (<2.25 ha), mainly Tanks	42	42	1.43	-	-
		Total	**61**	**2946**	**100.00**	**2636**	**2429**

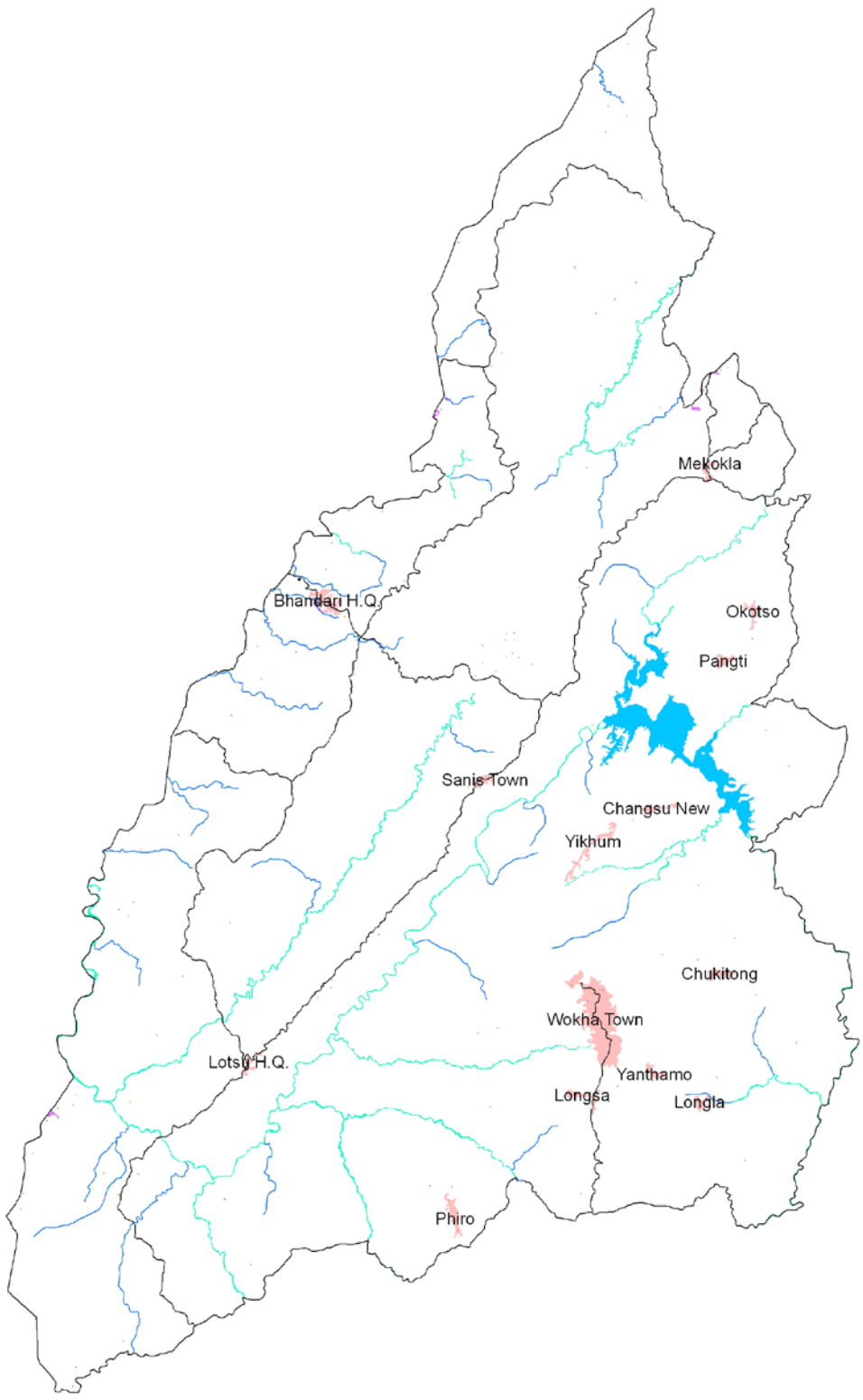
Area under Aquatic Vegetation	2	476

Area under turbidity levels		
Low	1310	138
Moderate	1207	1311
High	119	980

State : Nagaland

WETLAND MAP

District:Wokha

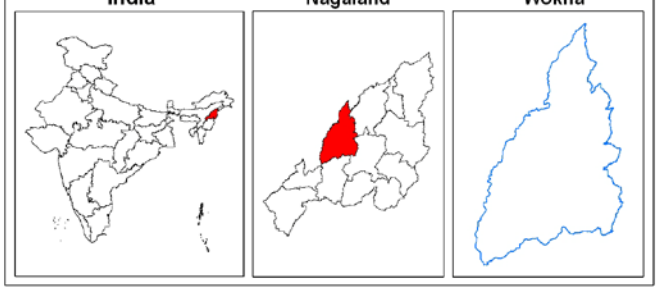


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



9 4.5 0 9 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
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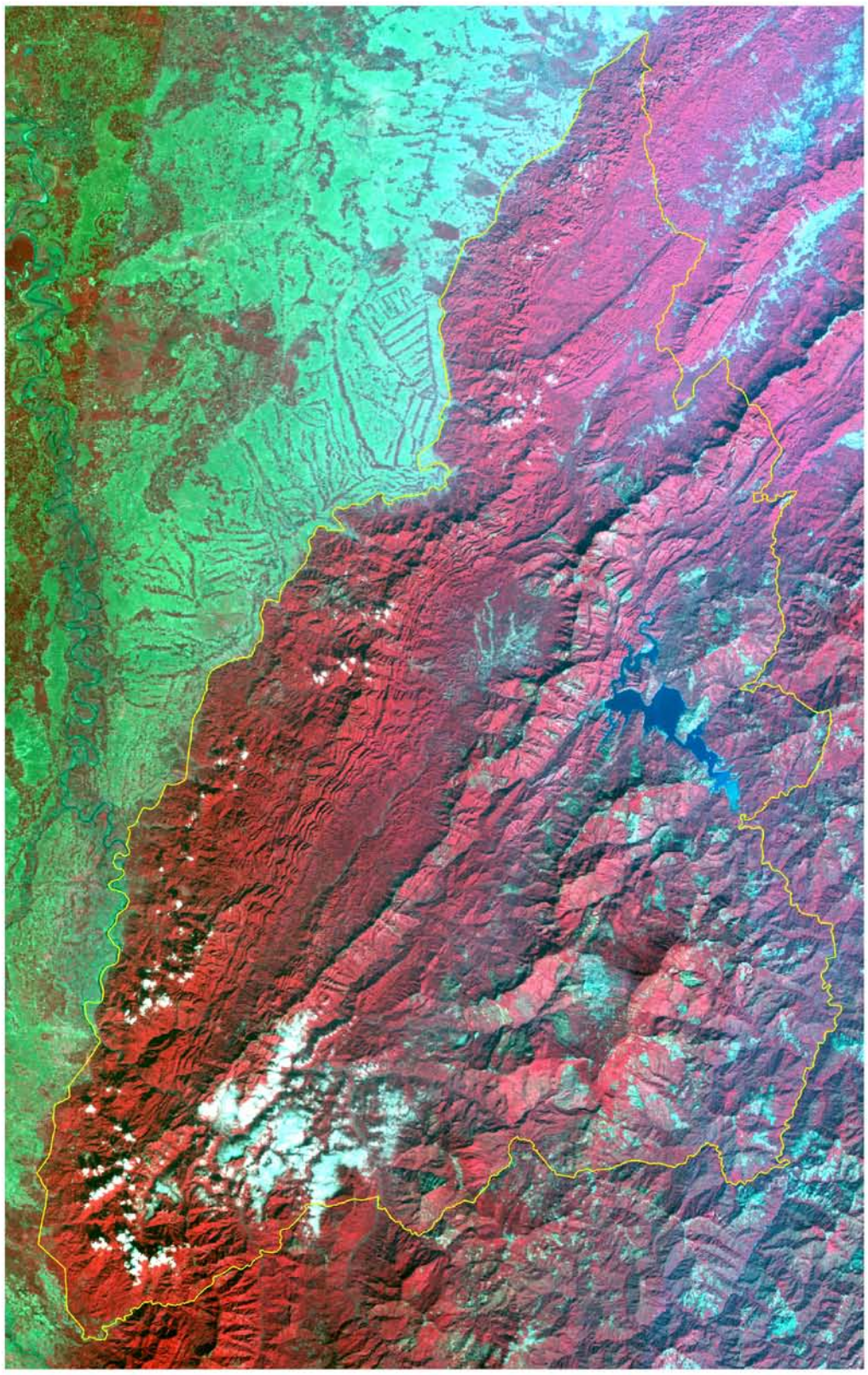
Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District:Wokha



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.11 ZUNHEBOTO

This district is bounded by Phek in the south, Kohima and Wokha in the west, Mokokchung in the north and Tuensang and Kiphire in the east. Zunheboto is the district headquarters with an altitude of 1874.22 metre above sea level. It has total geographical area of 1, 25,500.00 ha. The district is the home of the sema tribe. Physiographically, the district is made up of high to low hill slope.

Total wetland area estimated is 2,258 ha area. The major wetland types are River/Stream with 99.29% area. In addition, 16 small wetlands (< 2.25 ha.) are mapped as point features. The open water spread of the rivers is same in both the seasons. The turbidity of water ranged from low, moderate to high. Details of wetland statistics of the district is given in Table-16.

Table 16: Area estimates of wetlands in Zunheboto

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	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	10	2242	99.29	2242	2242
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**10**	**2242**	**99.29**	**2242**	**2242**
		Wetlands (<2.25 ha), mainly Tanks	16	16	0.71	-	-
		Total	**26**	**2258**	**100.00**	**2242**	**2242**

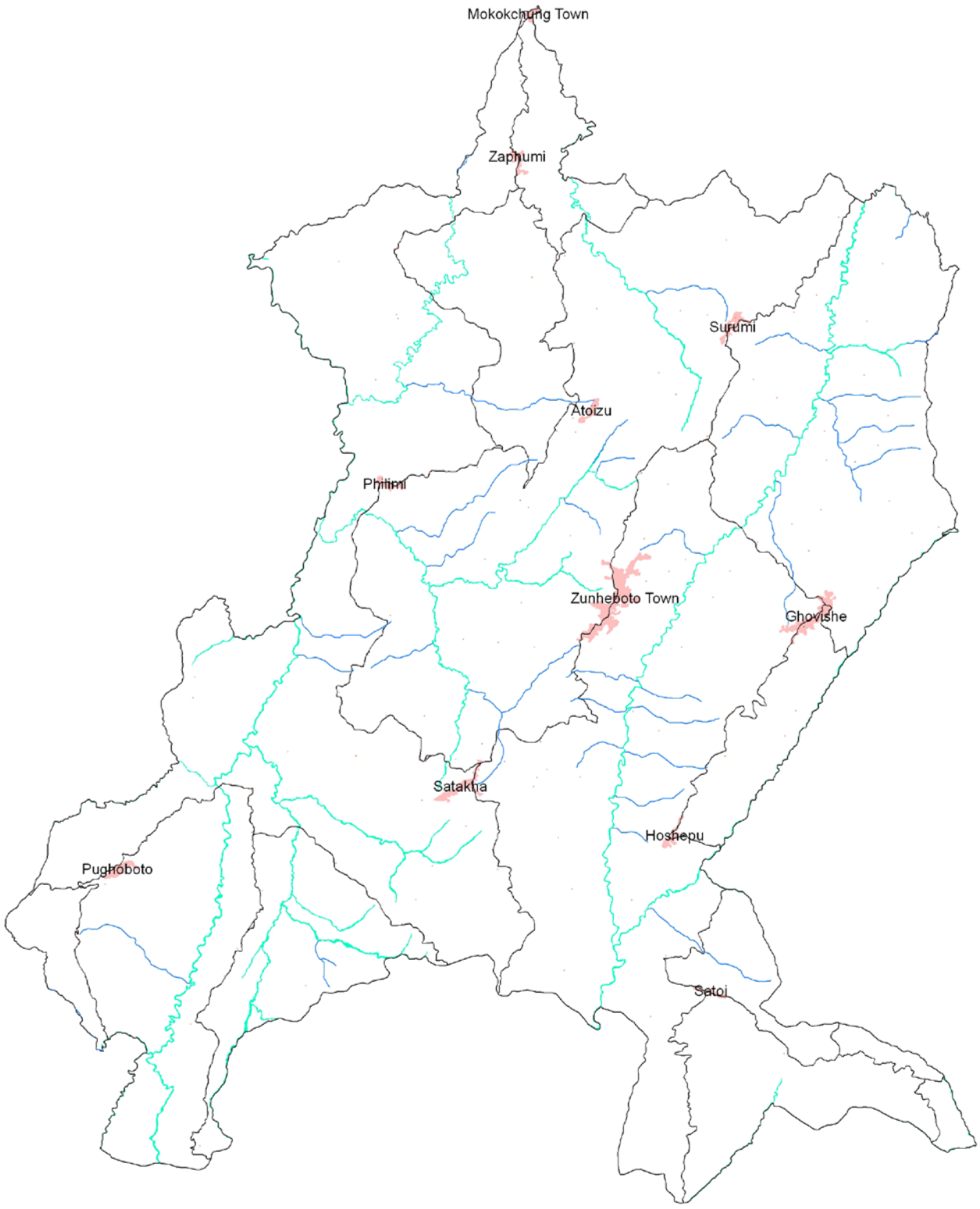
Area under Aquatic Vegetation	-	-

Area under turbidity levels	**-**	**-**
Low	854	854
Moderate	645	645
High	743	743

State : Nagaland

WETLAND MAP

District:Zunheboto



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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | Zunheboto

7.5 3.75 0 7.5 Kilometers

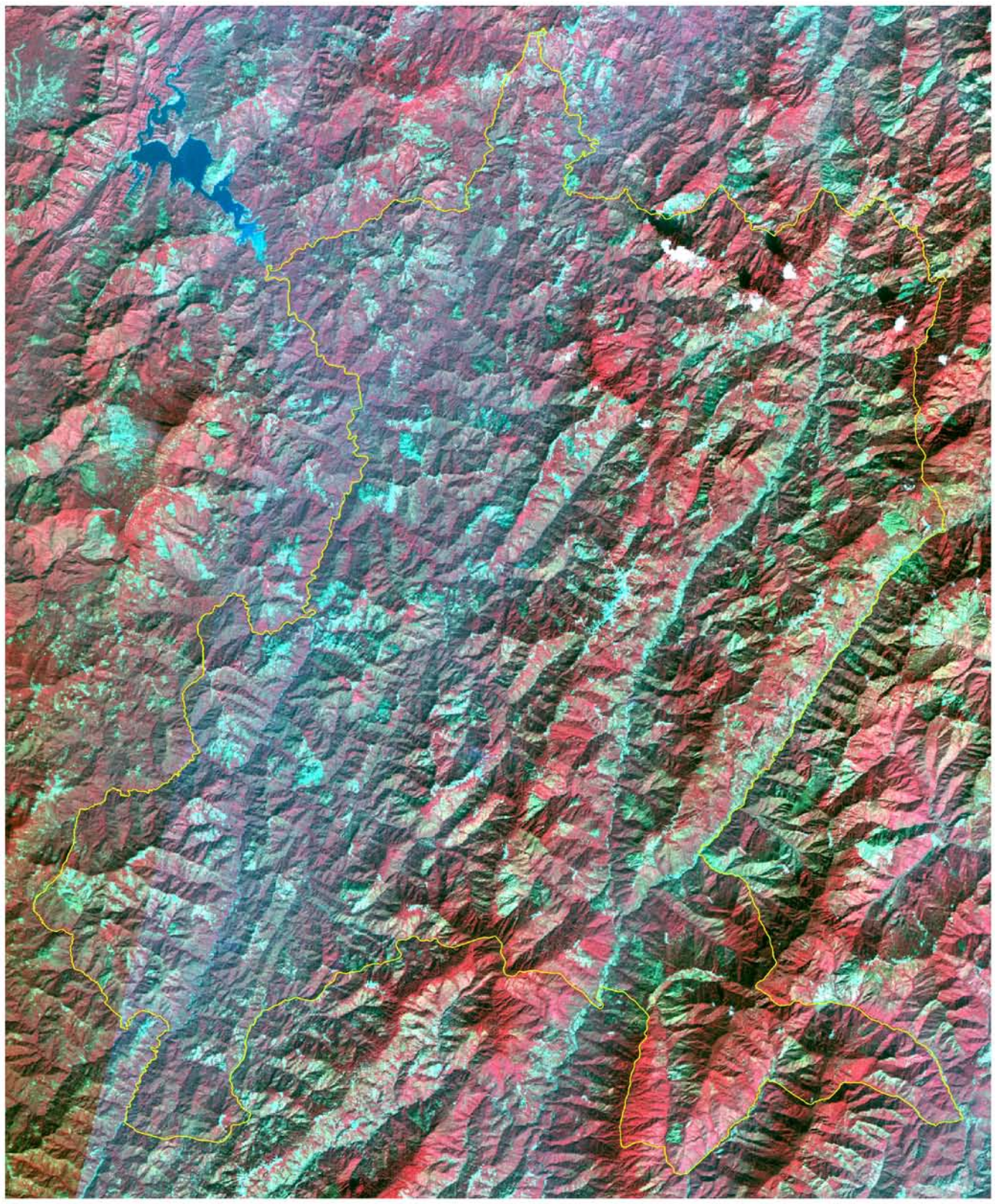
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

District:Zunheboto



IRS-P6 LISS-III Post-monsoon data(2006-2007)

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF NAGALAND

Major wetland types observed in the state are rivers, reservoirs and few lakes. The manifestation of these wetlands types in the LISS III image is shown in Plate-1. Field observation of the representative wetland types in terms of their geographic location using GPS, status of aquatic vegetation, turbidity of water were recorded. Some of these are shown in Plates 2a and 2b.

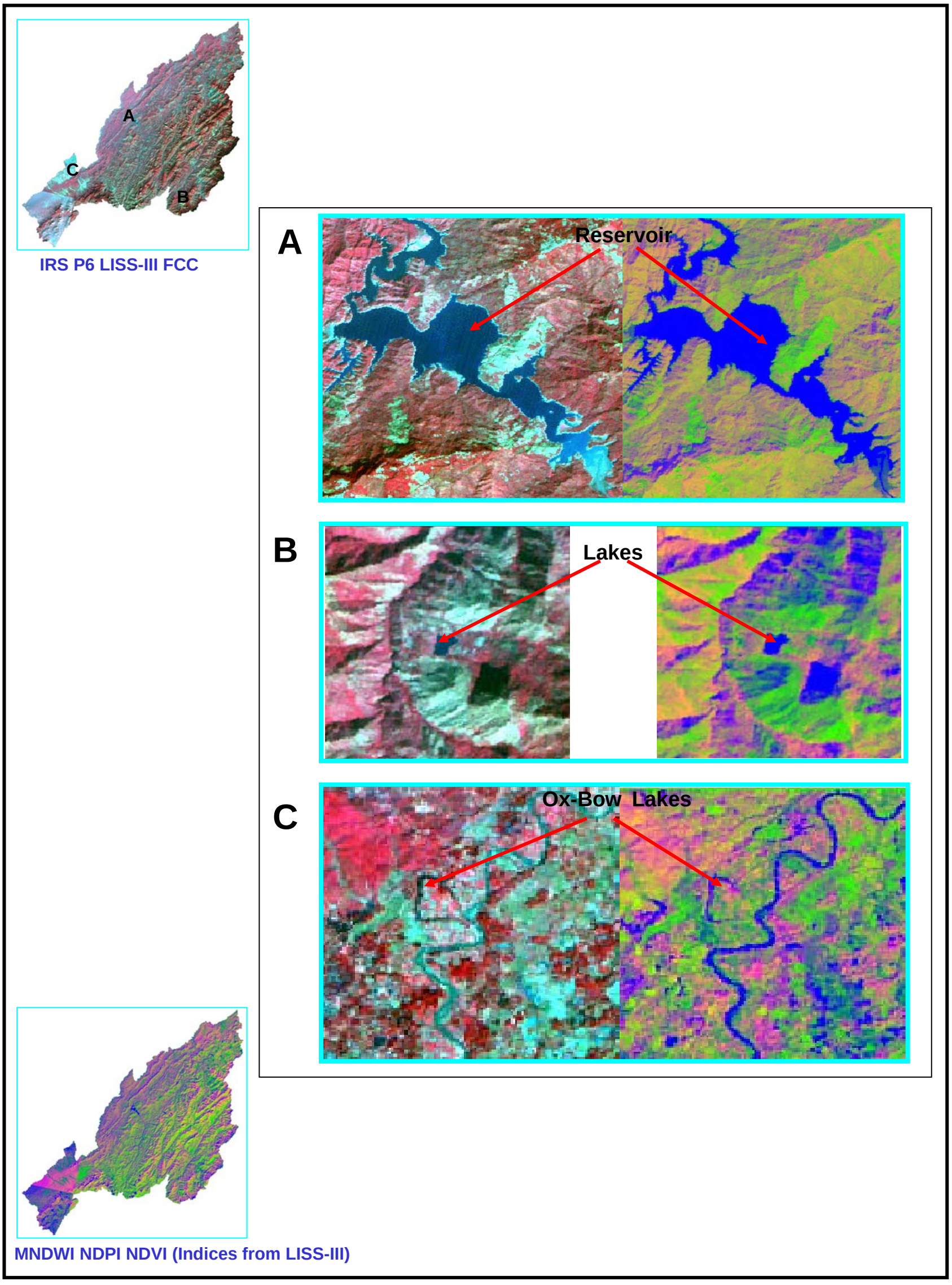


Plate - 1: Major wetland types of Nagaland

Sl. No.	Description	Field photograph
1.	Wetland Type : Natural Lake Name: Shilloi Lake Location : Longitude: 94 º 47’ 41.80”E Latitude : 25 º 35’ 42.55"N	
2.	Wetland Type : Reservoir Name: Likhimro Location : Longitude: 94 º 52’ 31.93”E Latitude : 25 º 46’ 39.84”N	
3.	Wetland Type : River Name: Tizü Location : Longitude: 94 º 35’ 06.94”E Latitude: 25 º 38’ 26.05”N Turbidity : Medium	
4.	Wetland Type : River Name: Züngki Location : Longitude: 94 º 50’ 47.68”E Latitude : 26 º 02’ 06.05”N Turbidity : High	

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

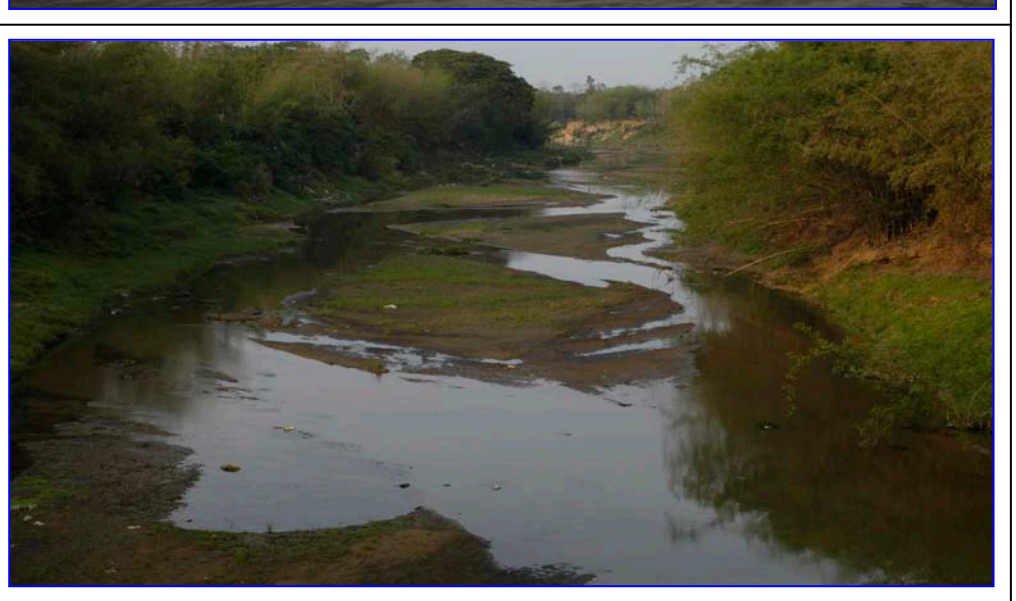
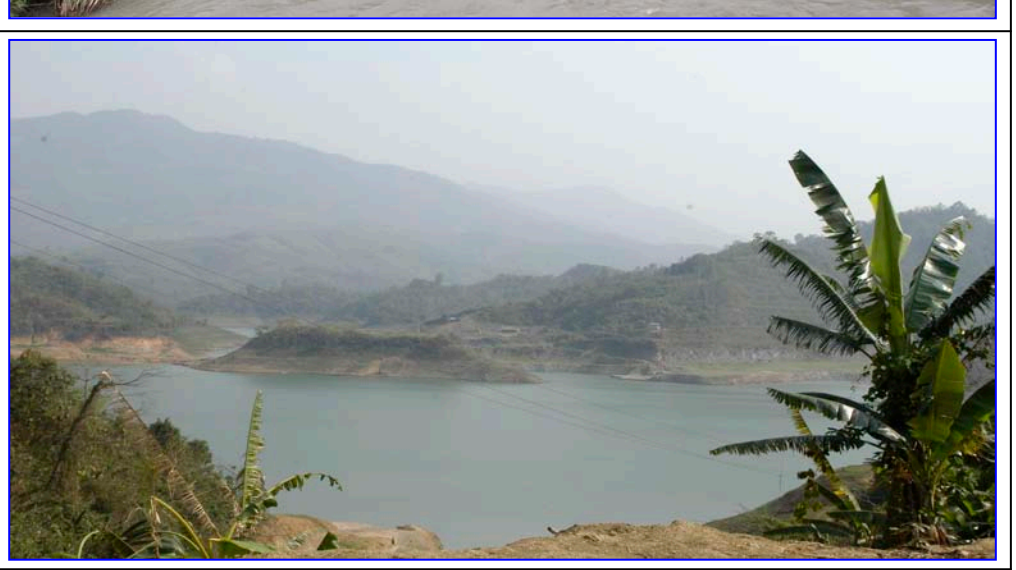
Sl. No.	Description	Field photograph
5.	Wetland Type : Reservoir Name: Chathe Location : Longitude: 93° 48’ 26.84”E Latitude : 25° 45’ 52.98”N	
6.	Wetland Type : River Name: Dhansiri Location : Longitude:93° 44’ 07.88”E Latitude : 25° 53’ 11.57”N	
7.	Wetland Type : River Name: Dikhu Location: Longitude: 94°35’ 26.93”E Latitude : 26°17’ 55.96”N Turbidity : Medium	
8.	Wetland Type: Reservoir Name: Doyang Location : Longitude: 94°17’ 13.97”E Latitude : 26°7’ 32.68”N	

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

IMPORTANT WETLANDS OF NAGALAND

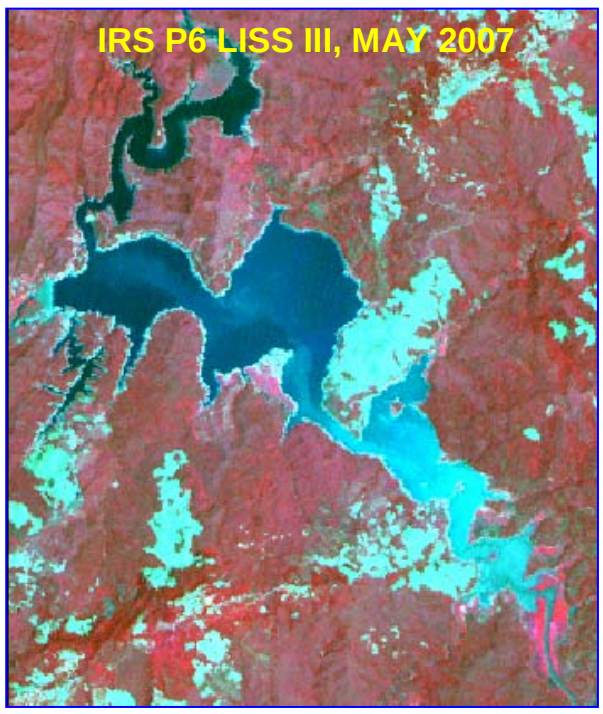
9.0 IMPORTANT WETLANDS OF NAGALAND

Doyang Lake, Chathe Reservoir, Shilloi Lake and part of Tizu River are some of the important wetlands of Nagaland. Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of each wetland sites. Details of each wetland and wetland map of 5 km buffer area are shown in plates 3 to 14.

9.1. Doyang Lake:

is located at a distance of 30 Kms from Wokha town and around 110 kms away from Kohima. The place is formed by damming the Doyang river under the NEEPCO-Hydro-Electric project.

	Name : Doyang Lake
1.	**Location**: 94°15' 43.79"E to 94° 20'11.65"E 26° 6' 05.53"N to 26°10' 53.30"N
2.	**Area**: 15.32 Sq Km
3.	**Wetland type**: Man- Made - Reservoir
4.	Observation: Doyang wetland shows significant change in the water spread in pre-monsoon and post monsoon season. Marked shrinkage of of water spread in May image and shallow ness of water is observed compared to the post monsoon image (December). Aqatic vegetation growth in the lower part of the wetland in pre monsoon is prominent. .
5.	Doyang Lake, is a spot where a massive hydro-electric dam has been constructed across the Doyang river. The Lake is popular for fishing. Some of the important introduced fish species in Doyang reservoir are *Cirrhinnus mrigala, Labeo rohita, Catla catla, Cyprinus carpio* and important fish fauna found in the river doyang are *Barilius bendelisis, Barilius tileo, Crrihinus reba, Crossocheilus latius, Crossocheilus burmanicus, Danio aequipinnatus Labeo dyocheilus, Neolissocheilus hexagonolepsis, Osteobrama coteo, Puntius shalynius, Rasbora rasbora, Salmostoma bacaila, Salmostoma acinaces, Tor putitora, Tor tor, Garra rupecula, Nemacheilus botia, Nemacheilus arunachalensis, Silurus afghan, Glyptothorex telchitta, Glyptothorex trilineatus, Channa orientalis, Mastacembelus armatus* etc). The climate of the area is sub-tropical montane characterized by mild summer and cold winters. The annual rainfall in the area is about 2878 mm. Currently, ferry serice is available. The lake can be made as a tourist destination by developing facilities like Water Sport and adventure, Kayaking.



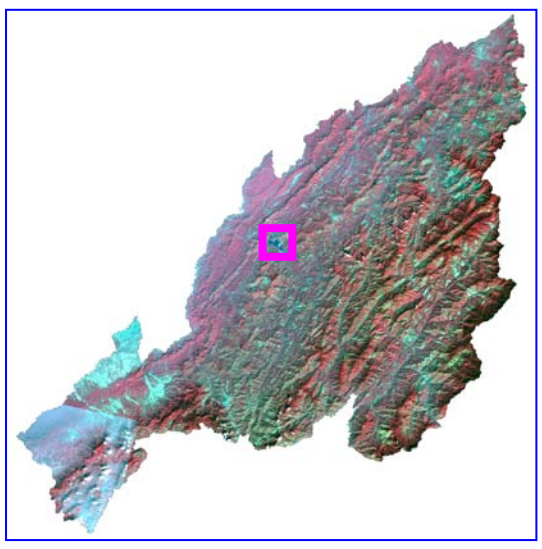
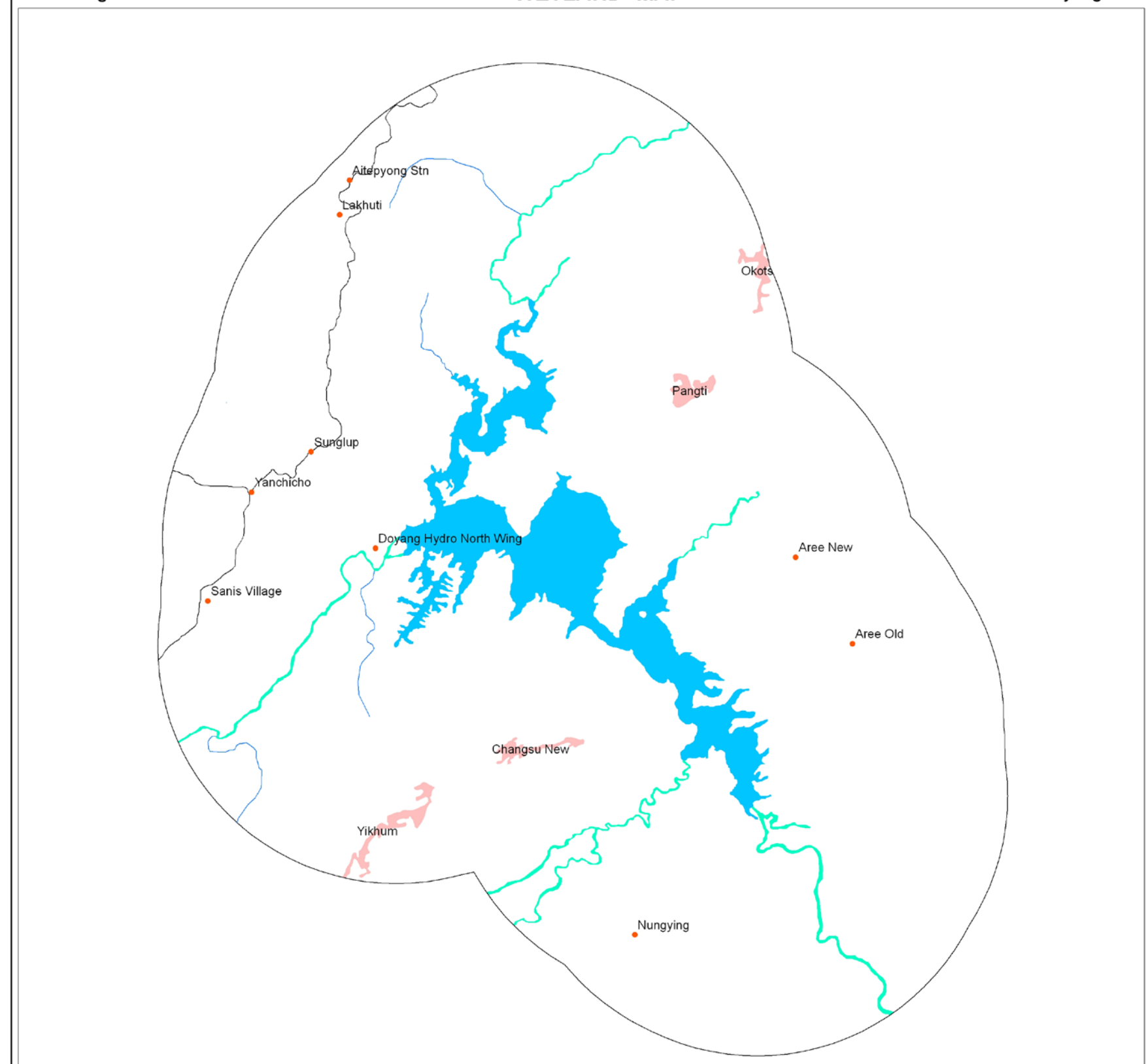


Plate 3: Doyang Lake

State : Nagaland

WETLAND MAP

Doyang 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 (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | Doyang Lake

2 1 0 2 Kilometers

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

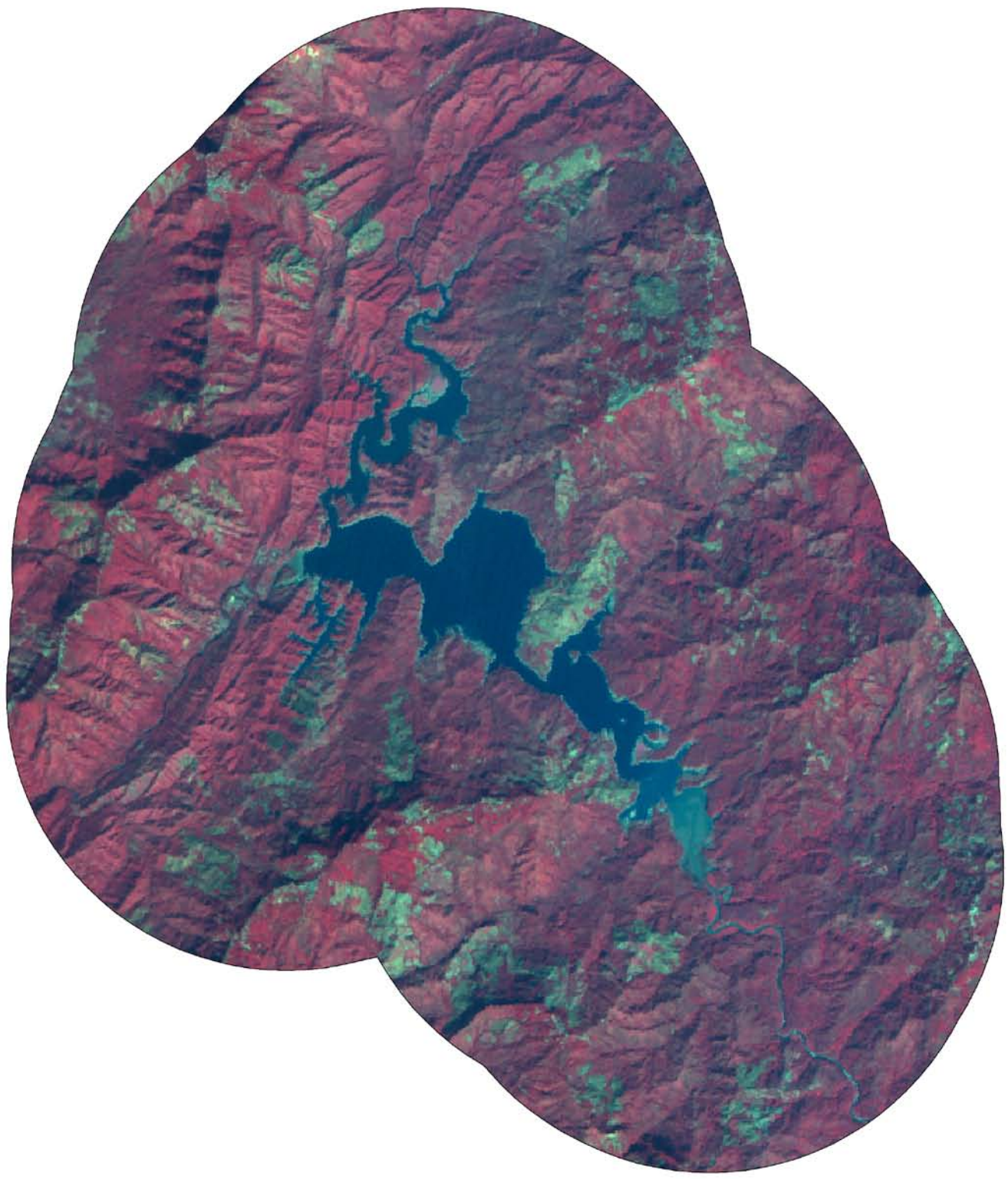
Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

Plate 4: Wetland map - 5 km buffer area of Doyang Lake

State : Nagaland

Doyang Lake



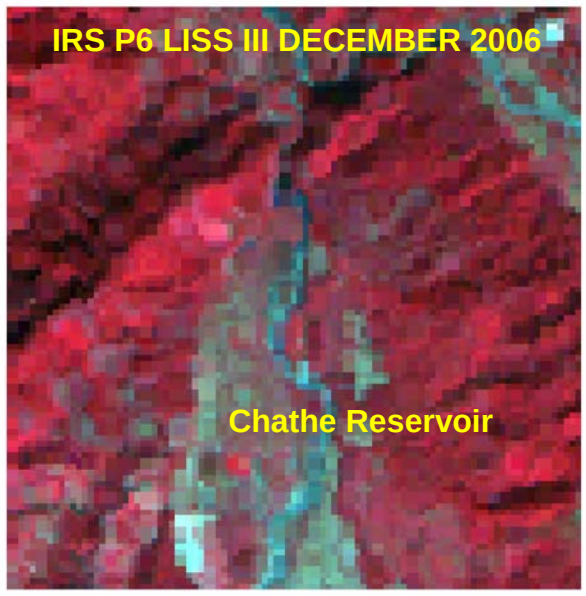
IRS-P6 LISS-III Post-monsoon data(2006)

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

9.2. Chathe Reservoir

It is located about 20 Kms away from Dimapur town. It is constructed as a water supply project to Dimapur town by the Dept of Public Health Engineering.

	Name : Chathe Reservoir
1.	Location : 93 ^{o} 48’ 26.84” E 25 ^{o} 45’ 52.98” N
2.	**Area** : 601 Hectares
3.	**Wetland type :** Man- Made - Reservoir
4.	Chathe Reservoir is formed by constructing a dam across the Chathe River for supplying water to whole of Chumukedima and Dimapur town. No significant change observed in the water spread and turbidity in the pre-monsoon and post-monsoon seasons.
5.	The climate of the area is humid to sub- tropical in summer and cold in winters. The annual rainfall in the area is about 1476mm. Some of the important fish species found in Chathe reservoir and rivers are *Danio aequipinnatis, Neolissocheilus hexagonolepsis Psilorhynchus homaloptera, Garra lissorhynchus, Nemacheilus multifasciatus, Exostoma stuarti, Glyptothorex saisii, Channa stewartii, Chagunius chagunio and Clupisoma garua.*



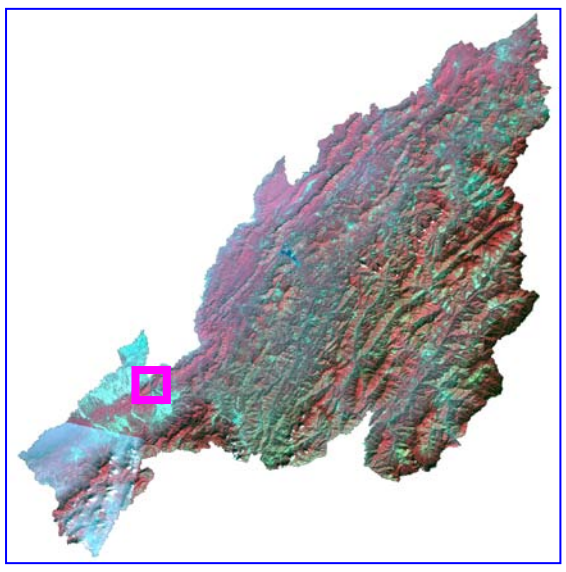
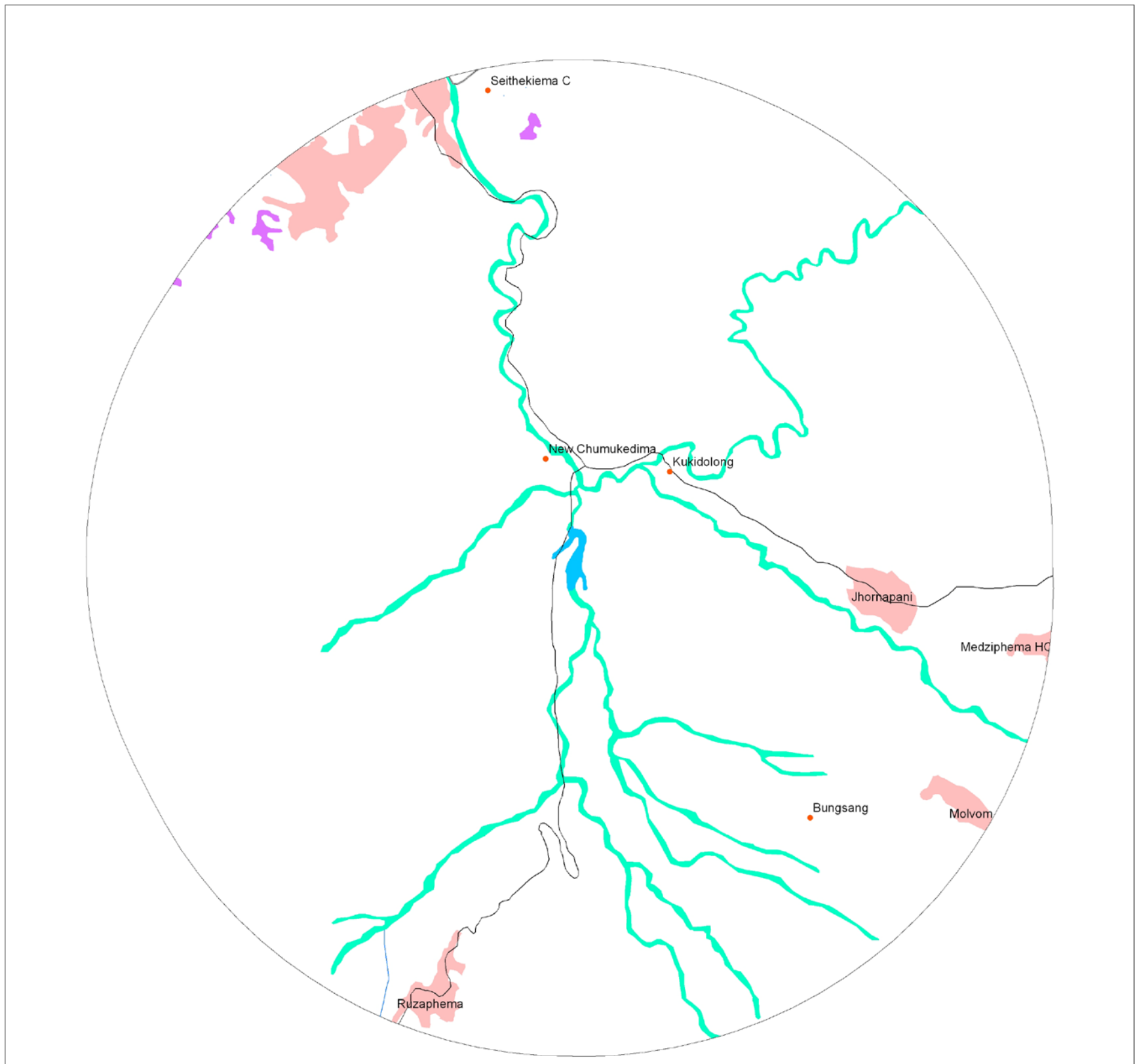


Plate 6: Chathe Reservoir

State : Nagaland

WETLAND MAP

Chathe Reservoir



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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | Chathe Reservoir

1 0.5 0 1 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

Plate 7: Wetland map - 5 km buffer area of Chathe Reservoir

State : Nagaland

Chathe Reservoir

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

Plate 8: IRS LISS-III FCC - 5 km buffer area of Chathe Reservoir

9.3. Shilloi Lake

This lake is located about 270 kms away from Kohima and about 190 kms from Phek towards the India-Myanmar border.

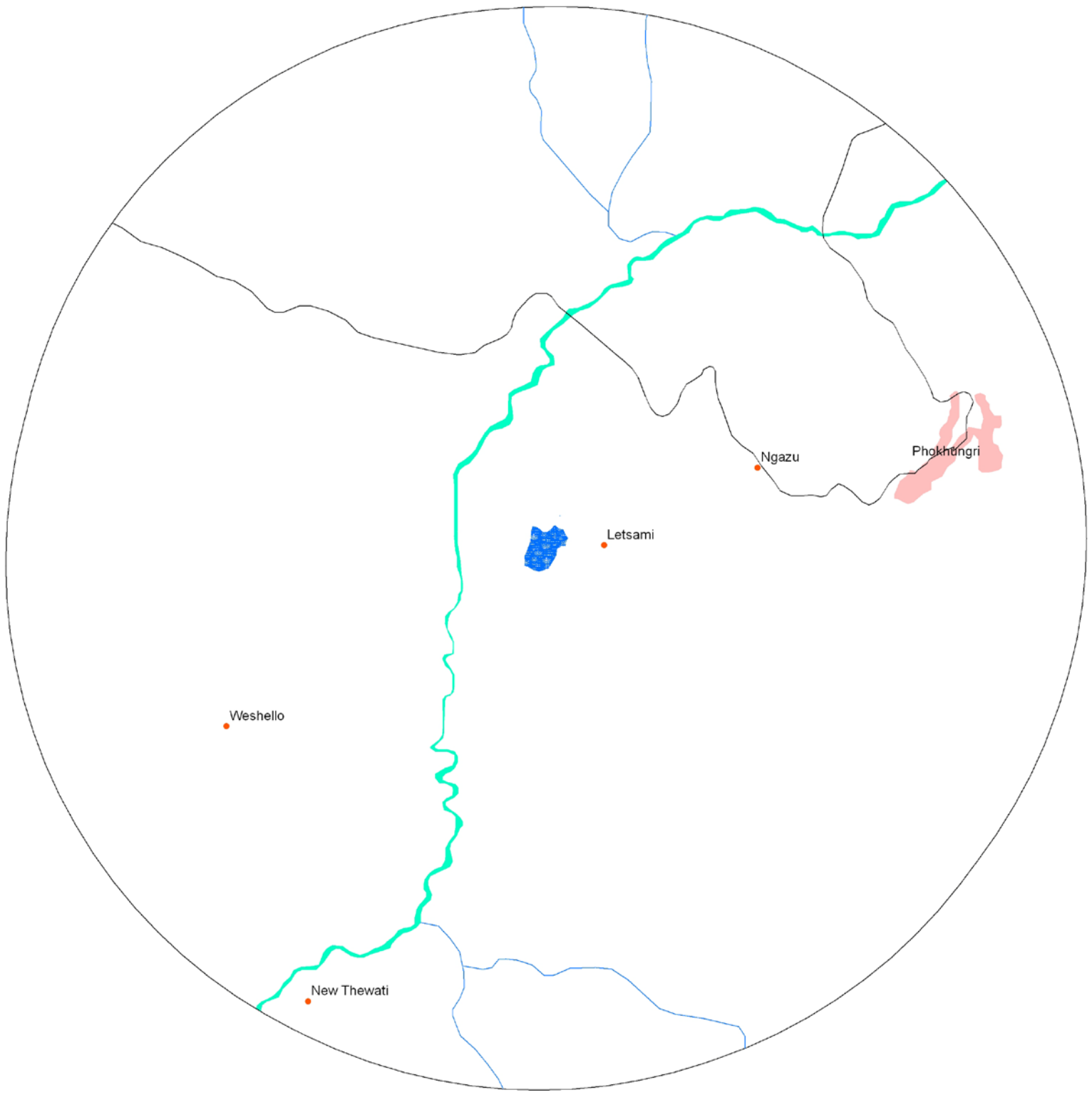
	Name : Shilloi Lake
1.	**Location** : 94 ^{o} 47’ 41.80” E 25 ^{o} 35’ 42.55” N
2.	**Area** : 0.11 Sq. km.
3.	**Wetland type** : Natural Lake
4.	As observed in the satellite image, the lake does not show much change in the water spread in pre-monsoon and post monsoon. However, one can observe the change in turbidity, which is mainly due to shallowness of the water. No significant growth of aquatic vegetation seen in the waterbody in post monsoon, but observed in pre monsoon along the western periphery of the lake.
5.	Shilloi lake, being situated in the Letsami village, it is also known as Letsam lake. It is the largest natural lake of Nagaland. It is shaped like a footprint. The climate of the area is sub-tropical characterized by hot summer and cold winters. The annual rainfall in the area is about 1728mm . It is also a place of great scenic beauty and important tourist spot. Major Fish species such as G*rass carp, Silver carp*, *Labeo rohita, Catla catla, Neolissocheilus hexagonolepsis* (Chocolate Mahseer) *etc,* have been introduced by the Department of Fishery, Government of Nagaland and *Neolissocheilus hexagonolepsis* has been declared as the State fish (Directorate of Fishery).

Plate 9: Shilloi Lake

State : Nagaland

WETLAND MAP

Shilloi 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 (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | Shilloi Lake

1 0.5 0 1 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

Plate 10: Wetland map - 5 km buffer area of Shilloi Lake

State : Nagaland

Shilloi Lake

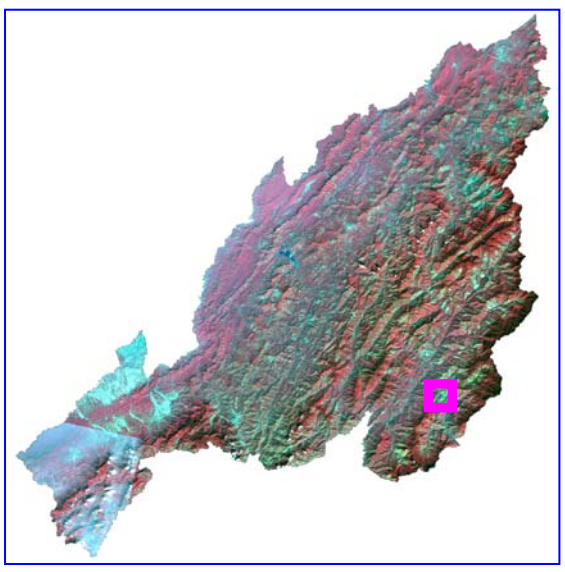
IRS-P6 LISS-III Post-monsoon data(2007)

Plate 11: IRS LISS-III FCC - 5 km buffer area of Shilloi Lake

9.4. Part of **Tizu River**

Located about 230 kms away from Kohima towards IN the India- Myanmar border. This river and its tributaries serve as one of the major source of irrigation and is one of the main fishing potential zone in the State.

	Name : Part of Tizu River
1.	**Location :** 94 ^{o} 35’ 06.94” E 25 ^{o} 38’ 26.05” N
2.	**Area:** 17.20 km
3.	**Wetland type** : River
4.	The river flows along the steep hills of Nagaland and joins the Chinwin river in Myanmar. The hills along the river stretch are covered by dense forests. As seen in the pre and post monsoon satellite image, the water spread is same in both the seasons; the water is clear with medium to low turbidity. The zig zag and meandering pattern of the river shows the undulating terrain.
5.	This river originates from Tuesang district near Sibongsang Village. It is one of the main fishing spots in the state of Nagaland. Fishing area on the river is approximately 10 to 12 kms. This important fish spieces are *Barilius vagra, Neolissocheilus hexagonolepsis, Puntius clavatus, Tor chelynoids, Tor putitora, Schizothorex richardsonii, Garra kempi, Garra lissorynchus, Garra naganensis, Psilorhynchus homaloptera and Bagarius yarrelii.* The climate of the area is sub-tropical to temperate characterized by warm summer and cold winters. The annual rainfall in the area is about 1730mm.



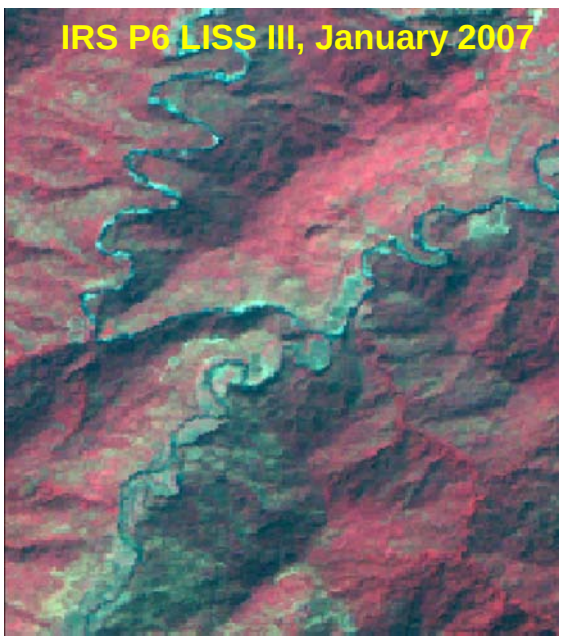
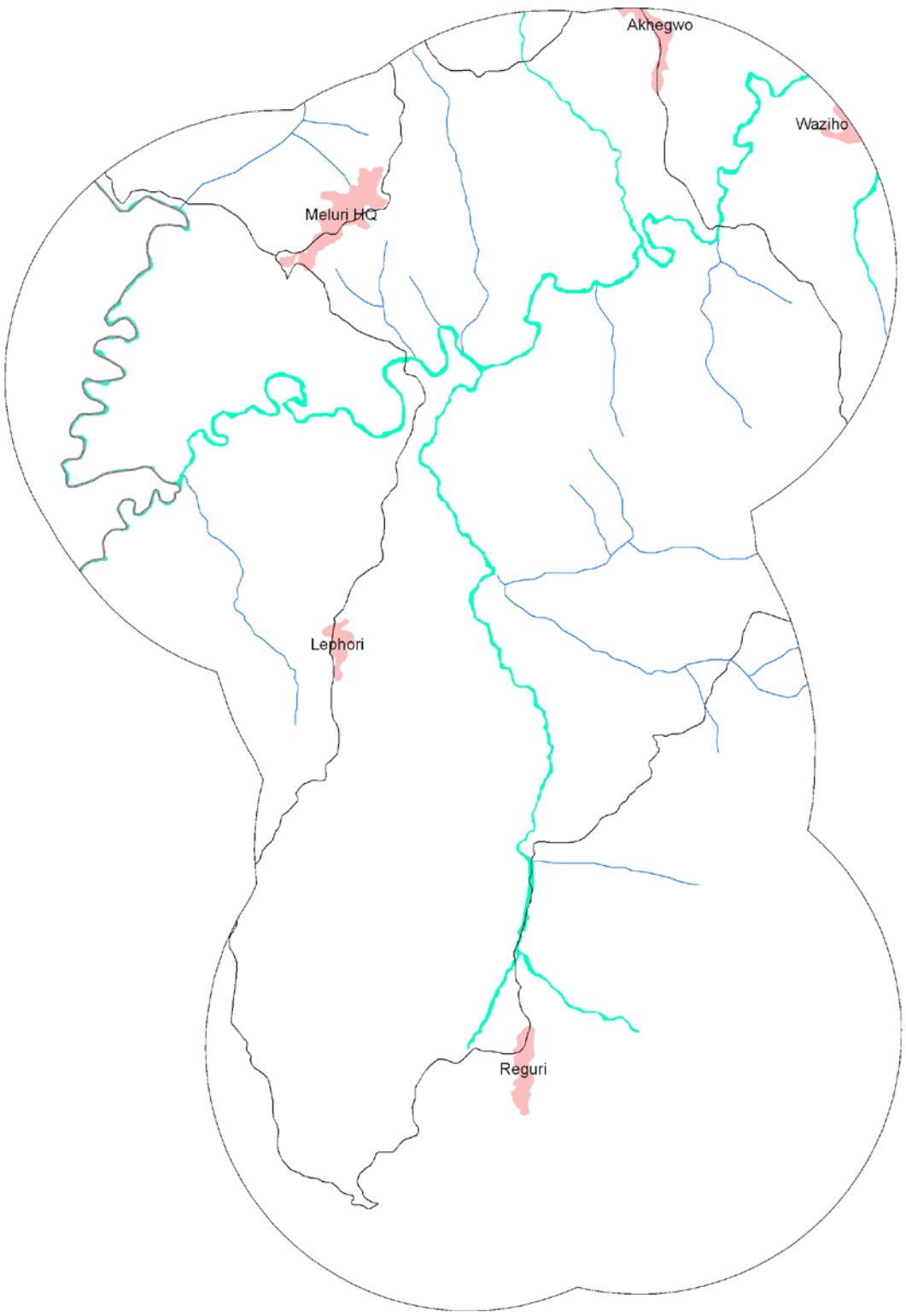


Plate 12: Part of Tizu River

State : Nagaland

WETLAND MAP

Part of Tizu River



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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India | Nagaland | Part of Tizu River

2.5 1.25 0 2.5 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

Plate 13: Wetland map - 5 km buffer area of part of Tizu River

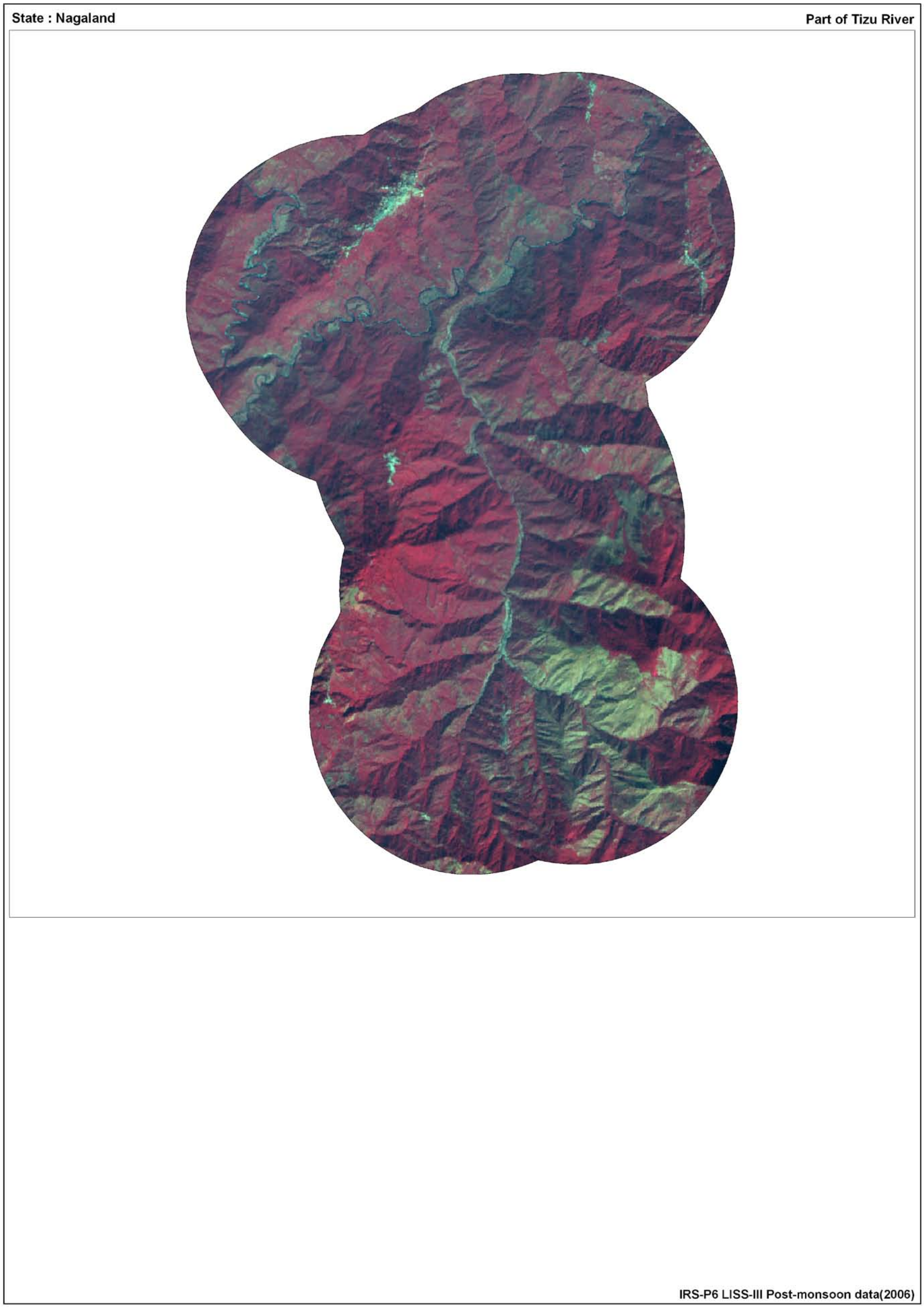


Plate 14: IRS LISS-III FCC - 5 km buffer area of part of Tizu River

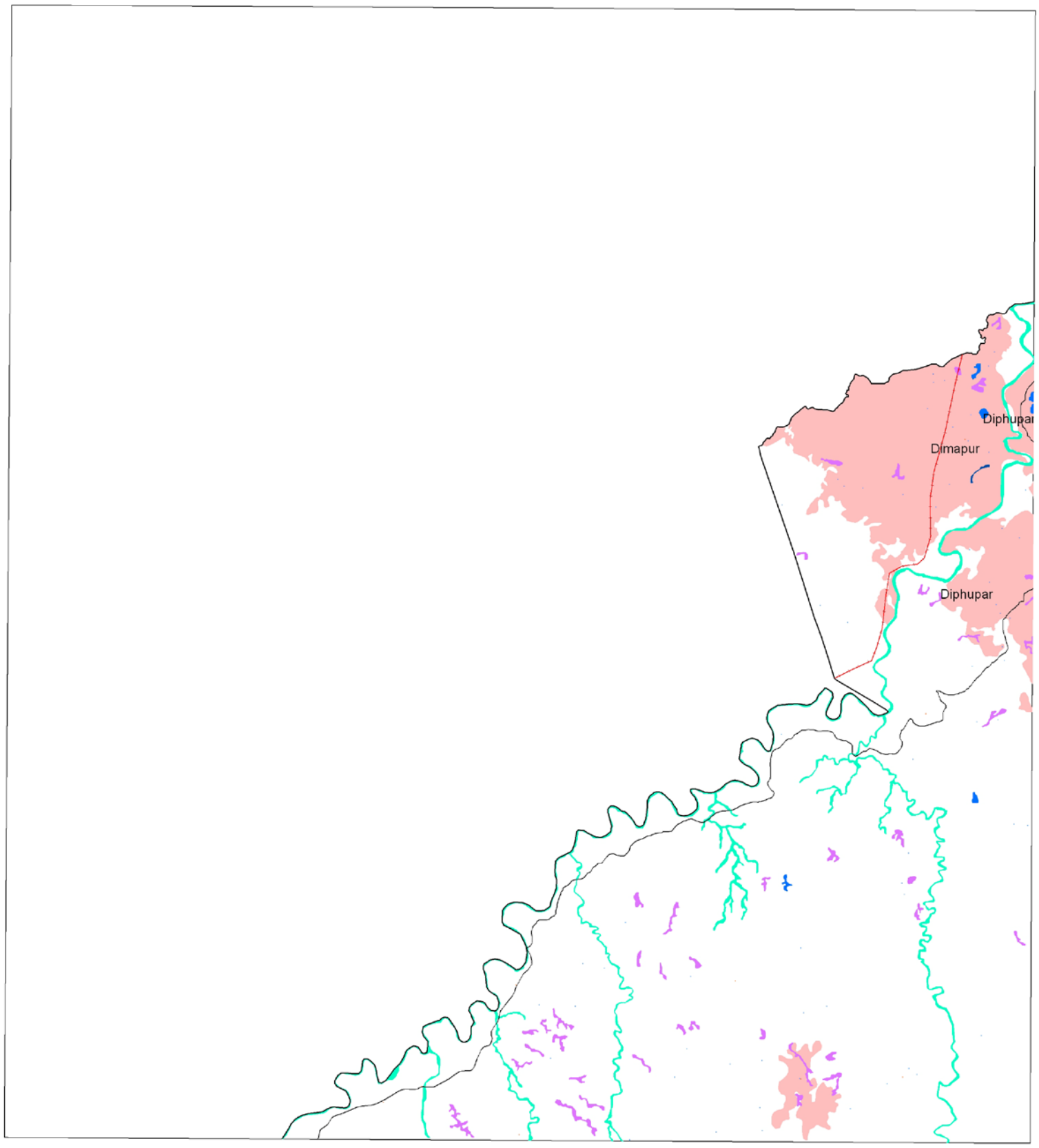
SOI MAP SHEET-WISE WETLAND MAPS

(Selected)

State : Nagaland

WETLAND MAP

Sheet: 83G/9



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
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	1204			Salt pans
		Coastal Wetlands		
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	2106			Mangroves
	2107			Coral reefs
			Man-made	
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	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
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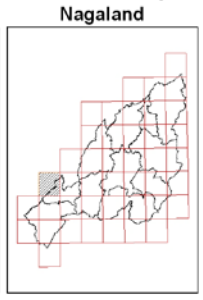
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Nagaland



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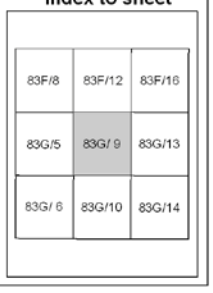


2 1 0 2 Kilometers

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

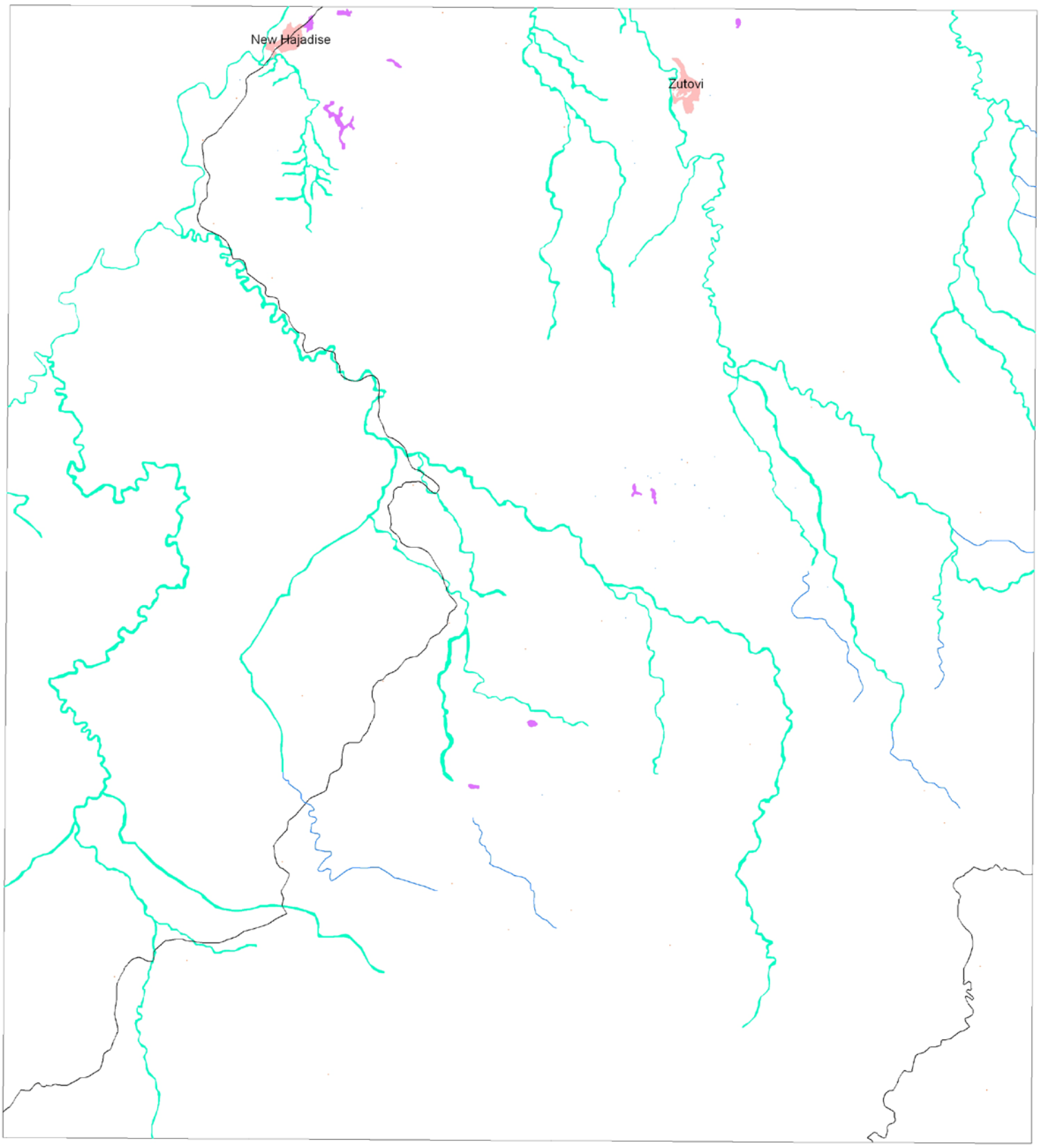
Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83G/10



Symbol	Typecode	Level I	Level II	Level III
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

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- Town/Settlements
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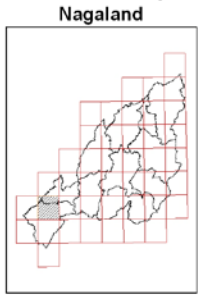
Location Map

India

Nagaland



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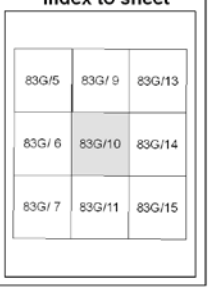


3 1.5 0 3 Kilometers

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

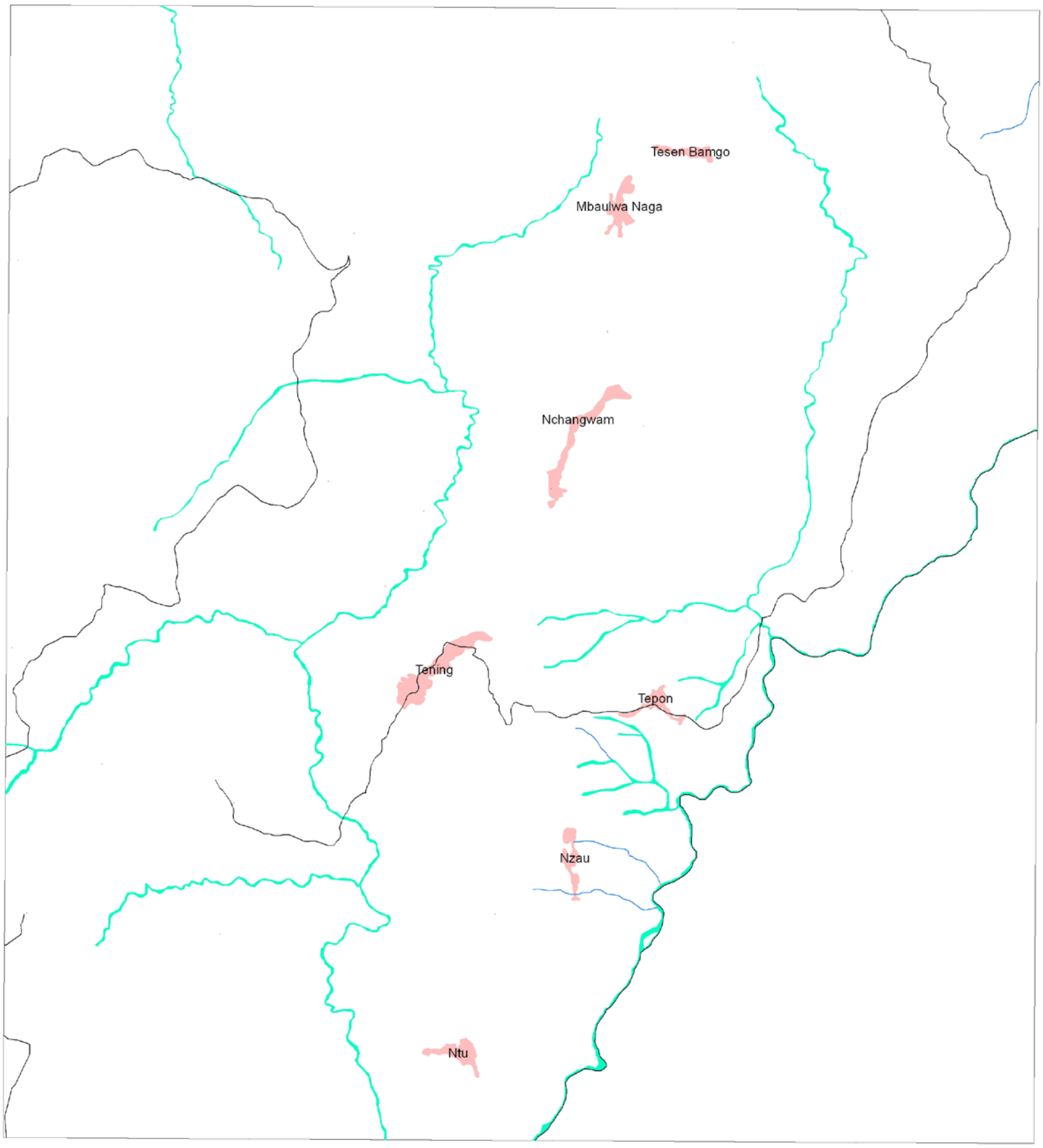
Prepared by:
Space Application Centre (ISRO), Ahmedabad
and
Nagaland Science & Technology Council (NASTEC), Kohima

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83G/11



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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			Man-made	
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Legend

- Wetlands (<2.25 ha)
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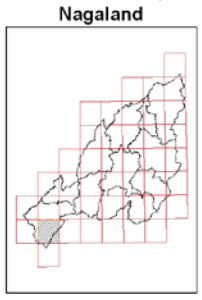
Location Map

India

Nagaland



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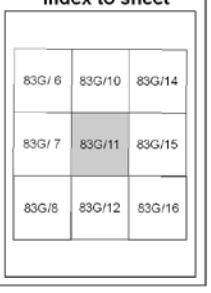

2 1 0 2 Kilometers

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

Prepared by:
Space Application Centre (ISRO), Ahmedabad
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Nagaland Science & Technology Council (NASTEC), Kohima

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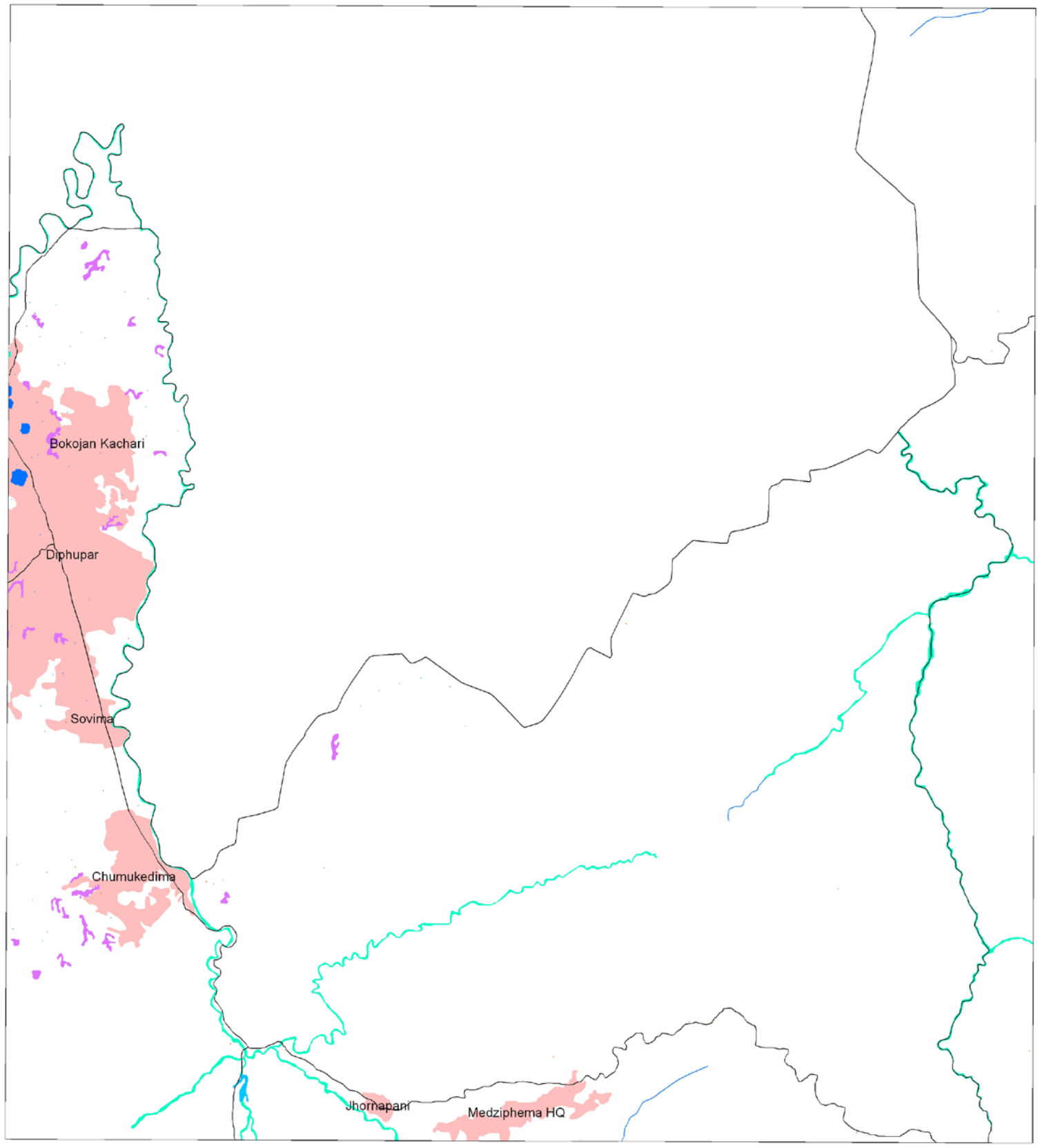
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83G/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

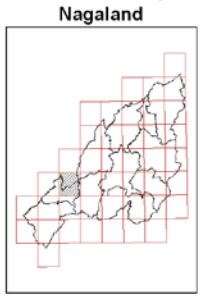
Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Nagaland



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83F/12	83F/16	83J/ 4
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83G/10	83G/14	83K/ 2

2 1 0 2 Kilometers

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

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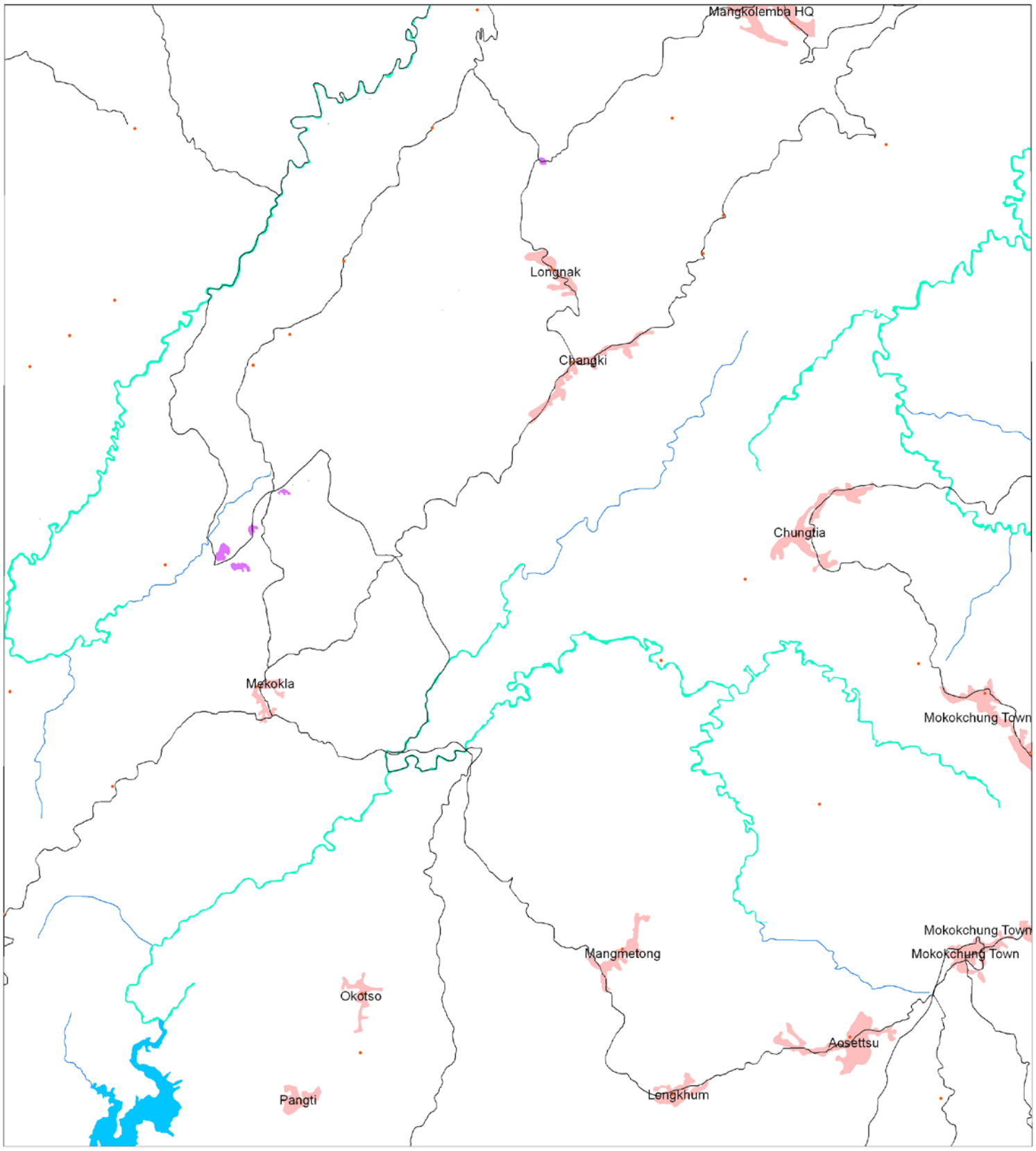
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83J/7



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

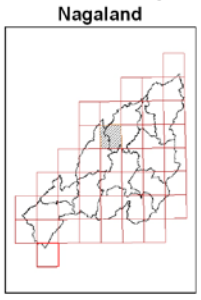
Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Nagaland



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83J/ 2	83J/ 6	83J/10
83J/ 3	83J/ 7	83J/11
83J/ 4	83J/ 8	83J/12

2 1 0 2 Kilometers

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

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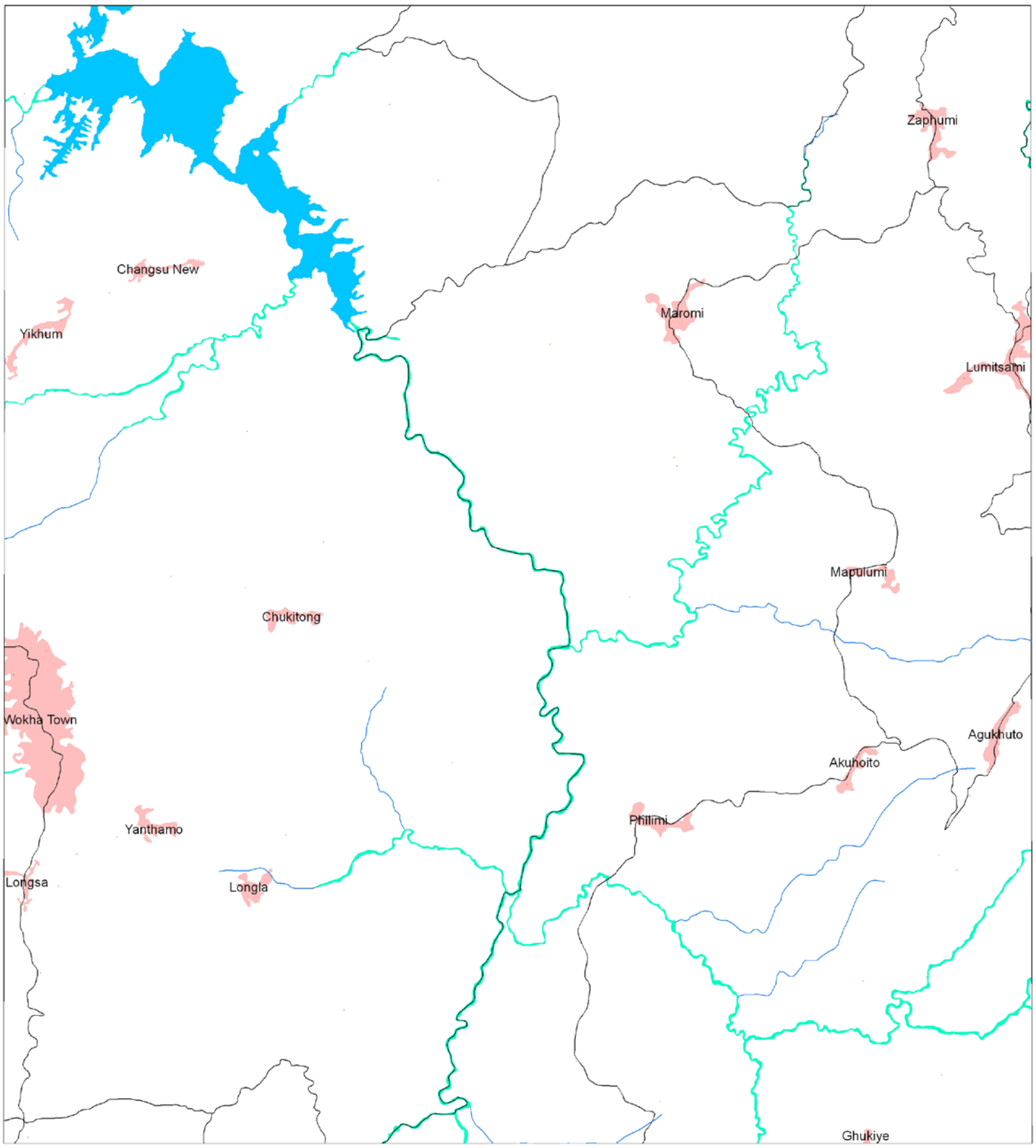
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83J/8



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

Legend

- Wetlands (<2.25 ha)
- Settlements
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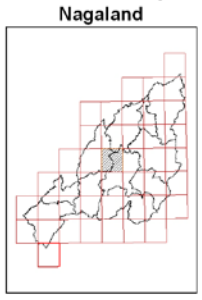
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Nagaland



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83J/ 4	83J/ 8	83J/12
83K/ 1	83K/ 5	83K/ 9

2 1 0 2 Kilometers

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

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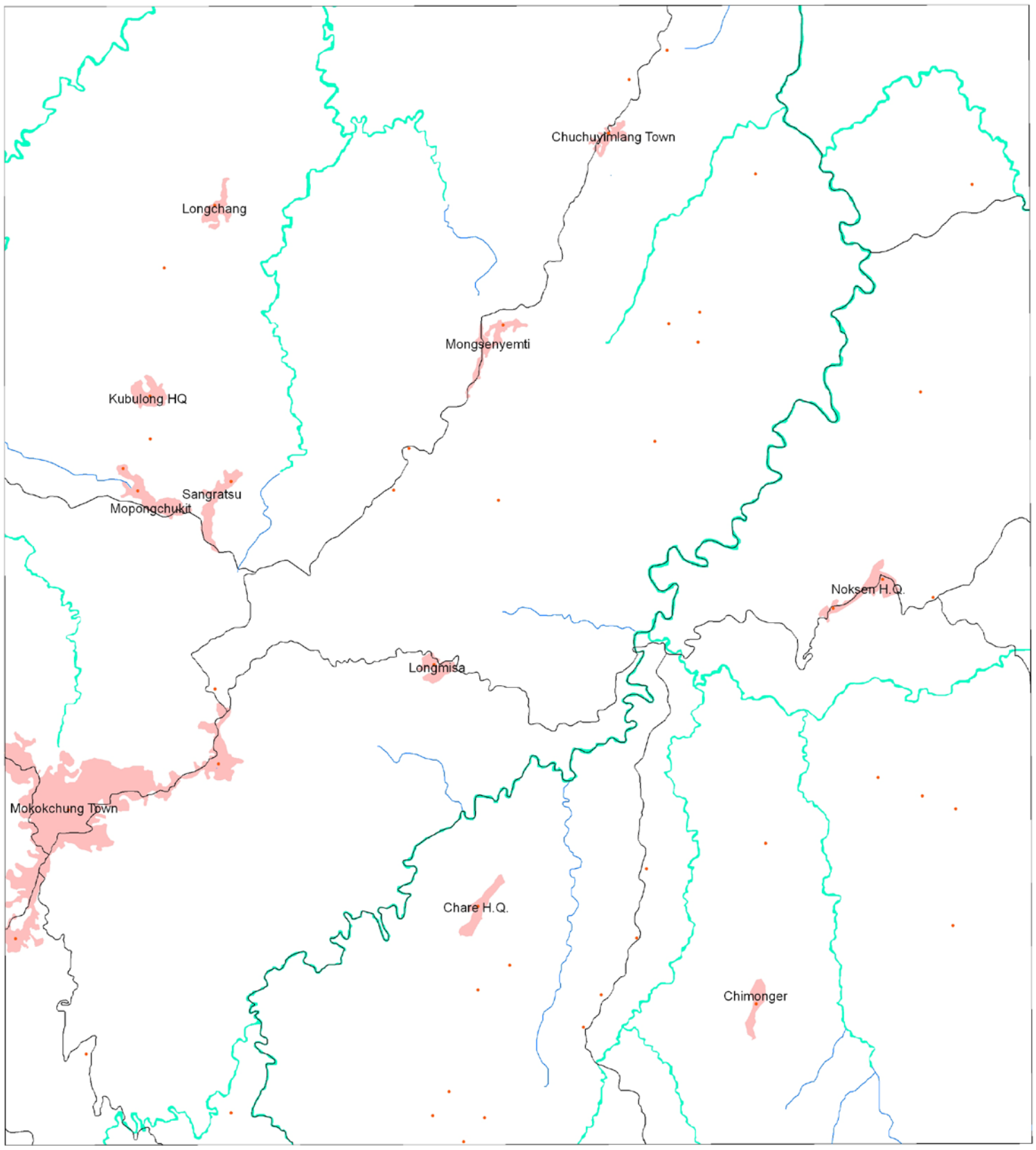
State : Nagaland

WETLAND MAP

Sheet: 83J/11



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

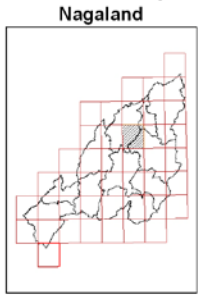
Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Nagaland



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83J/ 7	83J/11	83J/15
83J/ 8	83J/12	83J/16

2 1 0 2 Kilometers

Data Source:
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State : Nagaland

WETLAND MAP

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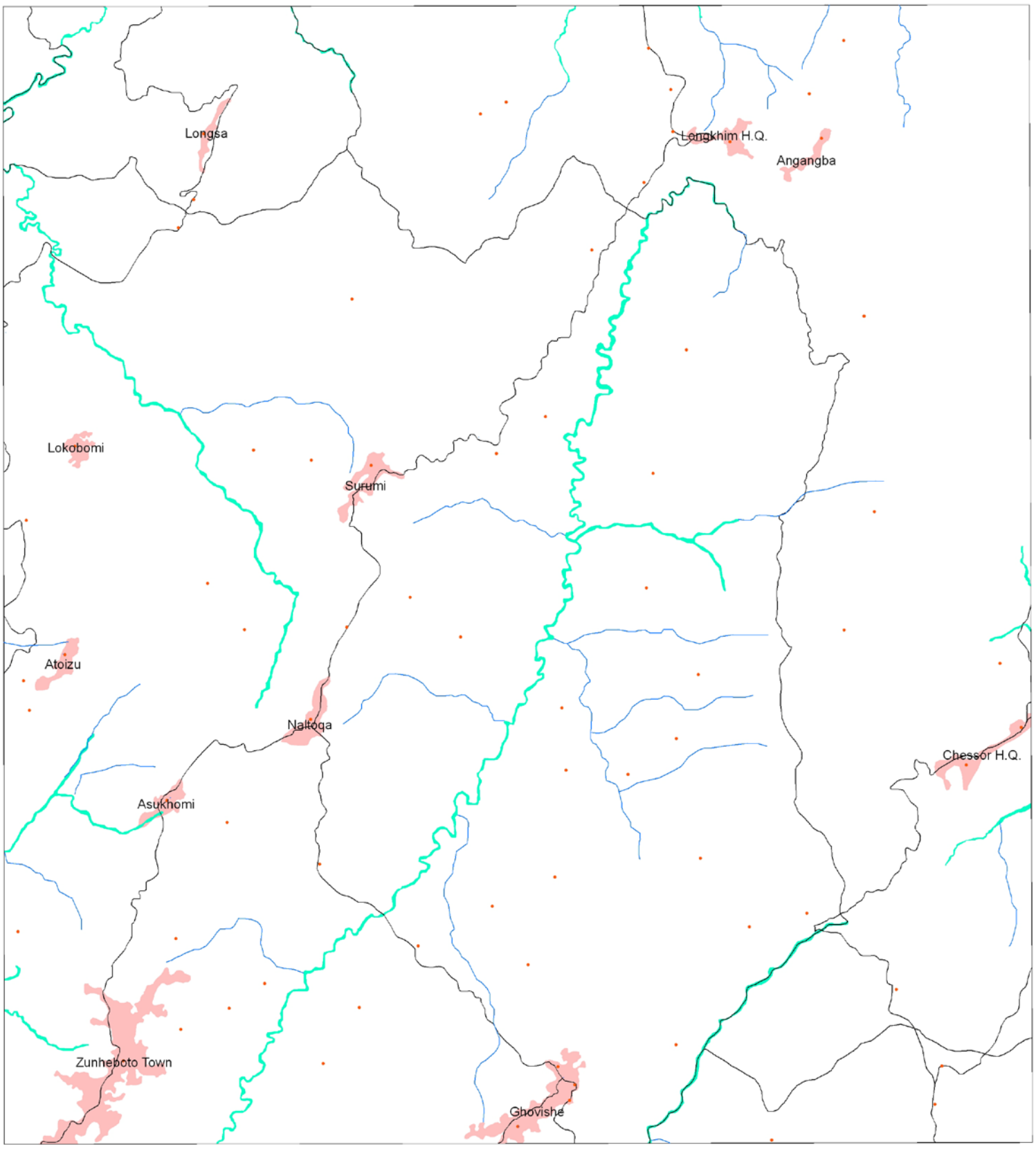

Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged
1204			Salt pans
	Coastal Wetlands		
		Natural	
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Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

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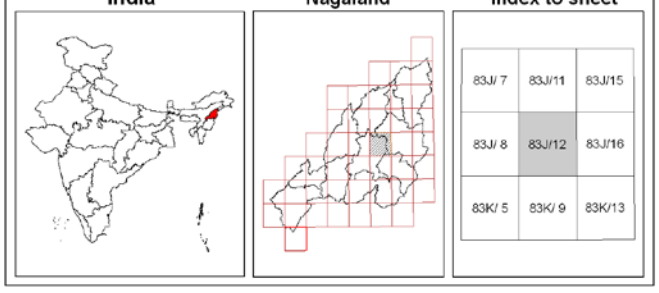

2 1 0 2 Kilometers

Data Source:
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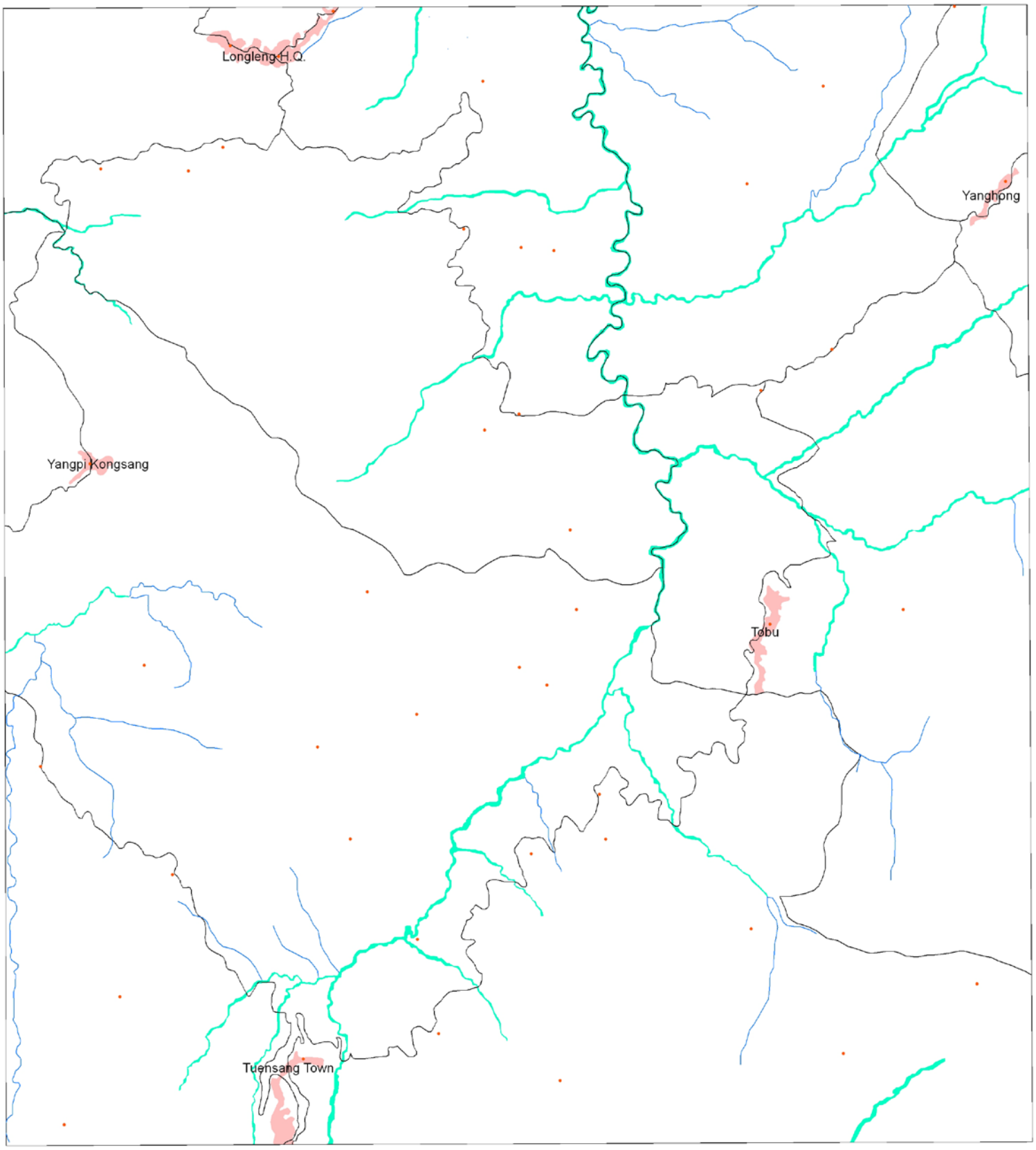
State : Nagaland

WETLAND MAP

Sheet: 83J/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	
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	2102			Creeks
	2103			Sand/Beach
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	2105			Salt marsh
	2106			Mangroves
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Legend

- Wetlands (<2.25 ha)
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- Canal
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- Railways
- Town/Settlements
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- State Boundary
- International Boundary

Location Map

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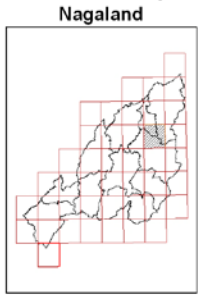
Nagaland



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83J/11	83J/15	83N/ 3
83J/12	83J/16	83N/ 4

2 1 0 2 Kilometers

Data Source:
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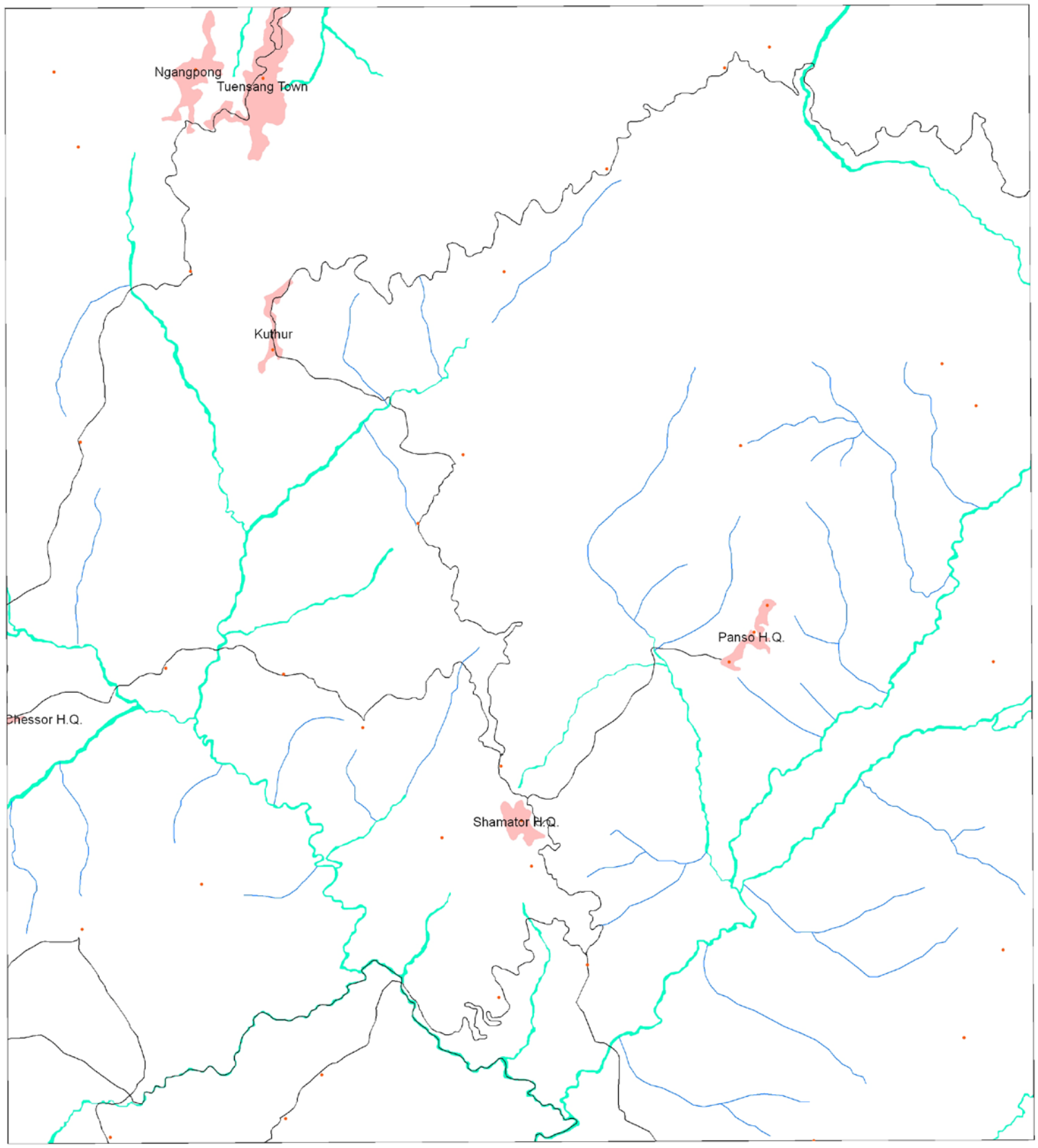
State : Nagaland

WETLAND MAP

Sheet: 83J/16



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	
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	2202			Aquaculture ponds

Legend

- Wetlands (<2.25 ha)
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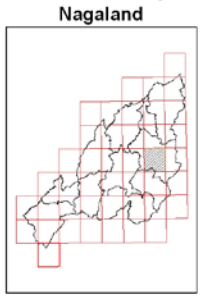
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Nagaland



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83J/11	83J/15	83N/ 3
83J/12	83J/16	83N/ 4
83K/ 9	83K/13	83O/ 1

2 1 0 2 Kilometers

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

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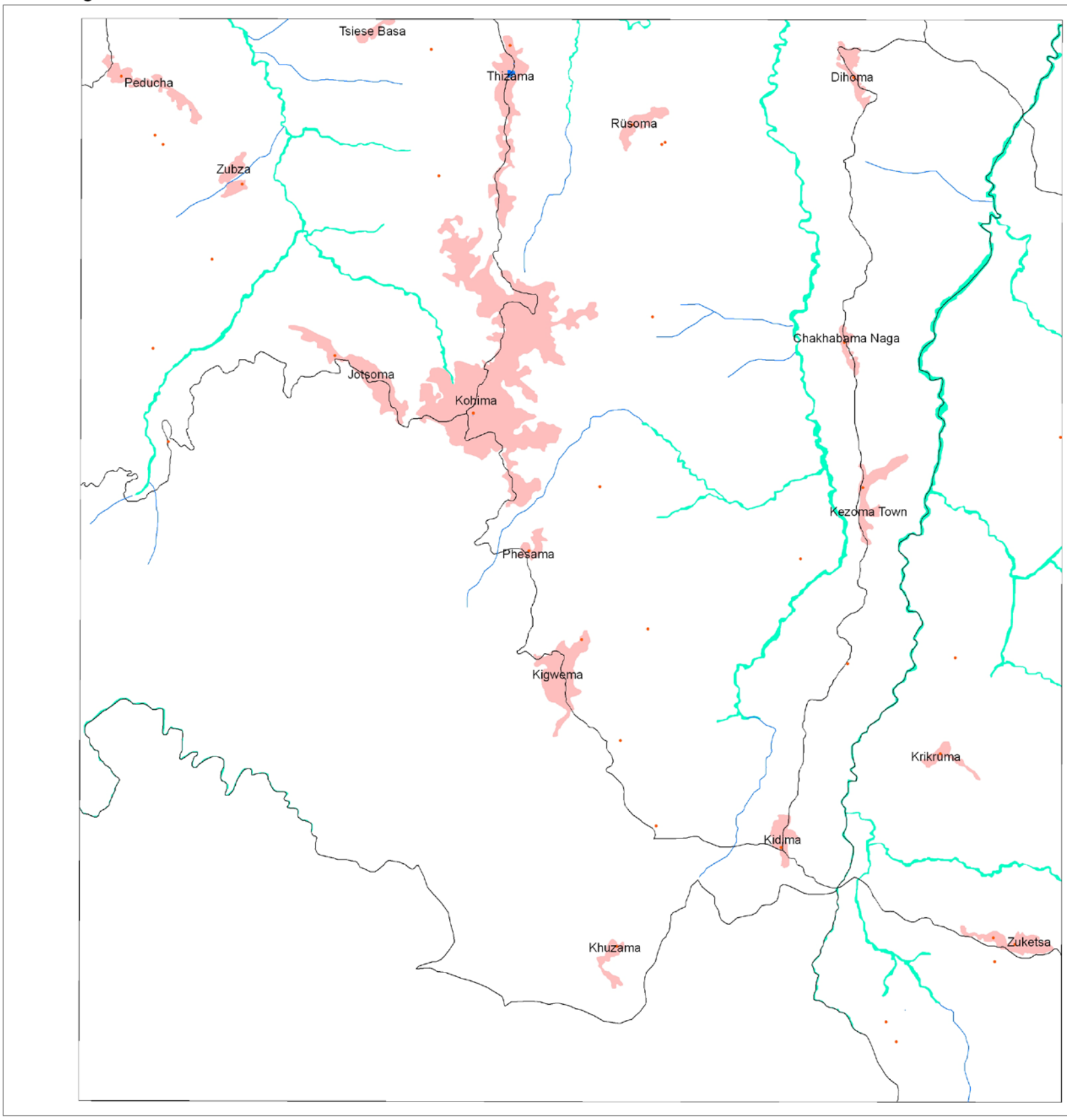
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83K/2



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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	1204			Salt pans
		Coastal Wetlands		
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Legend

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- State Boundary
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Location Map

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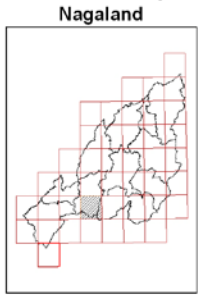
Nagaland



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83G/13	83K/ 1	83K/ 5
83G/14	83K/ 2	83K/ 6
83G/15	83K/ 3	83K/ 7

2 1 0 2 Kilometers

Data Source:
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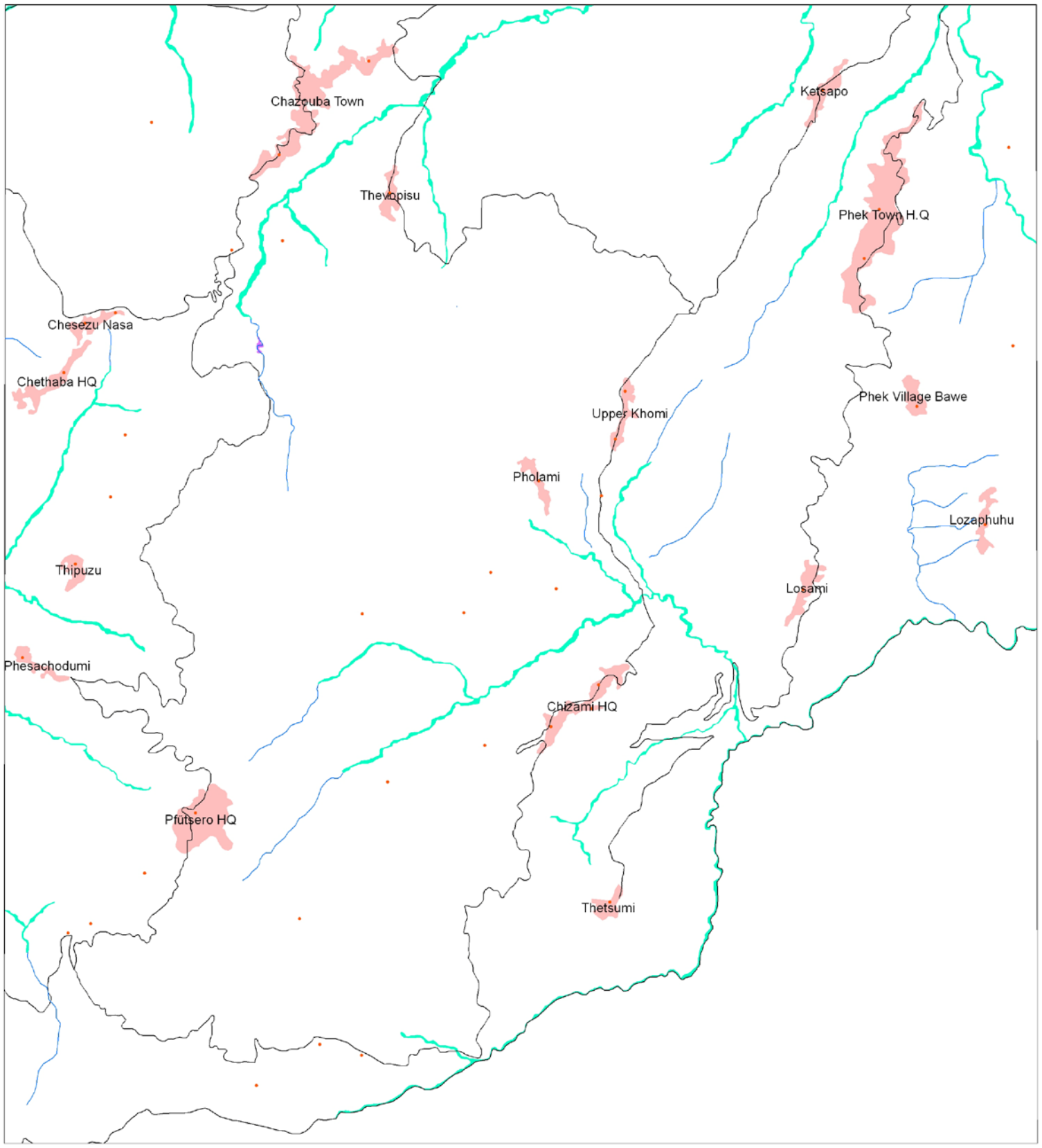
Government of India

State : Nagaland

WETLAND MAP

Sheet: 83K/6



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
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Legend

- Wetlands (<2.25 ha)
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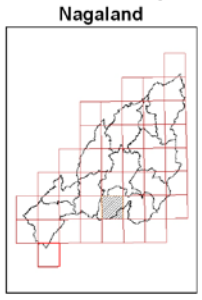
Location Map

India

Nagaland



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83K/ 1	83K/ 5	83K/ 9
83K/ 2	83K/ 6	83K/10
83K/ 3	83K/ 7	83K/11

2 1 0 2 Kilometers

Data Source:
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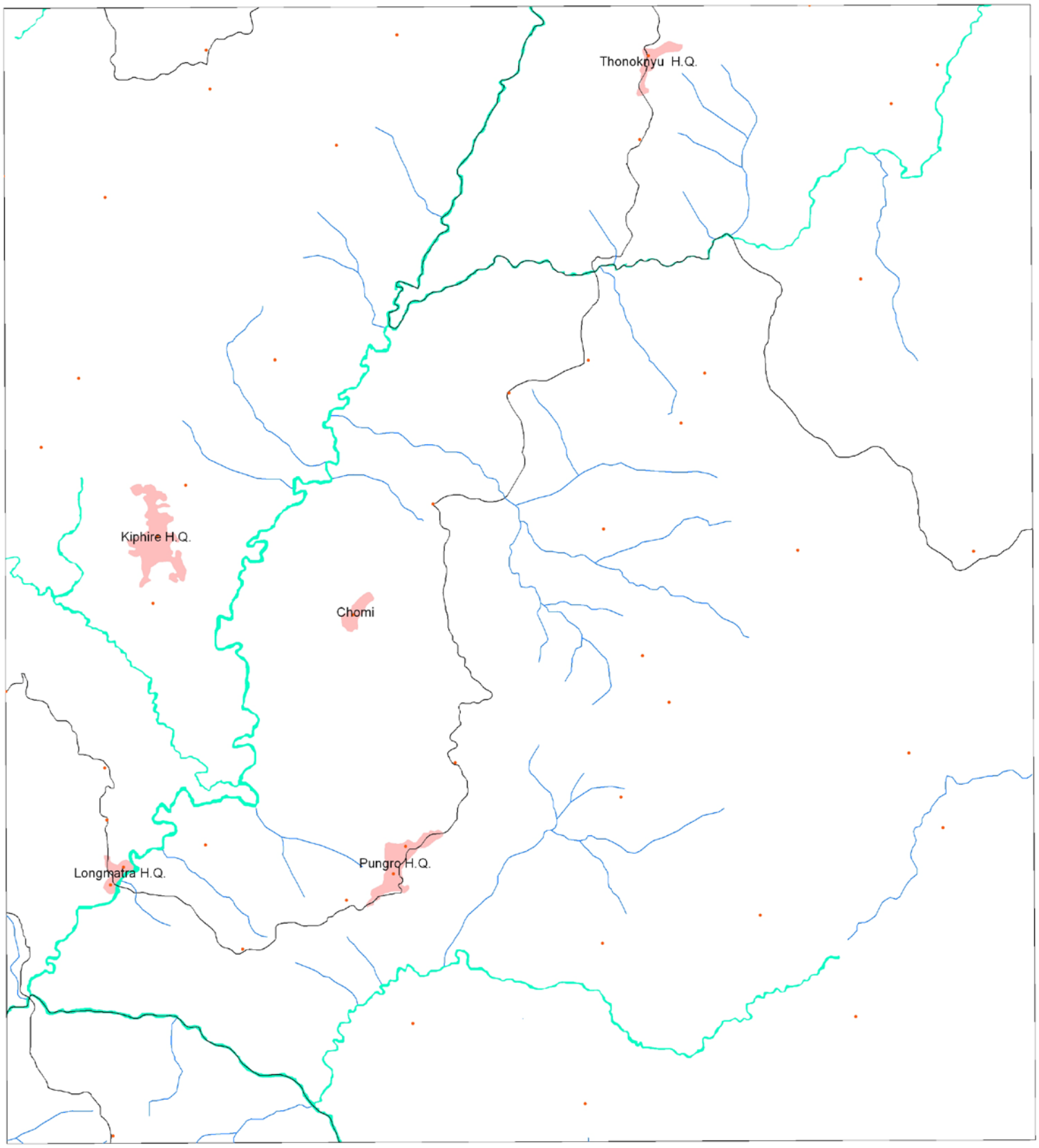
State : Nagaland

WETLAND MAP

Sheet: 83K/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
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	1204			Salt pans
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			Natural	
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
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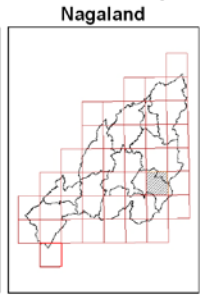

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83J/12	83J/16	83N/ 4
83K/ 9	83K/13	83O/ 1
83K/10	83K/14	83O/ 2

2 1 0 2 Kilometers

Data Source:
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Sponsored by:
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REFERENCES

1. Anon, 1990. *Directory of Wetlands in India*, Ministry of Environment and Forests, Govt. of India.

2. Basic fact of Nagaland, Directorate of Information and Public Relations, Government of Nagaland, 2008

3. Census of India, 2001.

4. Clark, John R. (1977). *Coastal Ecosystem Management,* A Wiley Interscience Publication, John Wiley & Sons, New York,.

5. Cowardin, L.M., Carter, V., Golet, E.C. and La Roe (1979). *Classification of wetlands and deep water habitats*. USFWS/085-79/31, Office of the Biological Services, U.S. Fish and Wildlife Service, Washington, D.C., .

6. De GROOT, R. S., 1992, *Functions of Nature*. *Evaluation of Nature in Environmental Planning, Management and Decision Making,* Wolters-Noordhoff, Amsterdan

7. Directory of Indian Wetlands, Compiled by World Wide Fund for Nature, India, 1993.

8. Directorate of Fishery, Government of Nagaland, 2009. List of fish species of Nagaland.

9. *Encyclopaedic Directory of Environment (1*988). (Ed. By G.R. Chatwal, D.K. Pandey, and K.K. Nanda). Vol. I-IV, Anmol Publications, New Delhi.

10. Fairbridge, Rhodes W. (1968). *The Encyclopaedia of Geomorphology,* Dowden Hutchinson & Ross, Inc., Stroudsburg, Pennsylvania.

11. Ao, S., Dey, S.C. and Sarmah, S.K. (2008), Fish and Fishes of Nagaland.

12. Garg, J.K., Singh, T.S. and Murthy, T.V.R. (1998). *Wetlands of India*. Project Report: RSAM/sac/resa/pr/01/98, June 1998, 240 p. Space Applications Centre, Ahmedabad,

13. Garg J.K. and Patel J. G., National Wetland Inventory and Assessment, Technical Guidelines and Procedure Manual, Technical Report, SAC/EOAM/AFEG/NWIA/TR/01/2007, June 2007, Space Applications Centre, Ahmedabad.

14. General Knowledge of Nagaland, 2006.

15. *Glossary of Geology* (1974). (Ed. By Margarate G., Robbert, M. Jr. and Wolf, C.L), American Geological Institute, Washington, D.C..

16. Hughes, J.M.R. and Heathwaite, A.L. (eds) (1995) *Hydrology and Hydrochemistry of British Wetlands,* Chichester: Wiley.

17. Jensen, J.R. (1986). *Introductory Digital Image Processing: A Remote Sensing Perspective,* Prentice Hall, Englewoods Cliff, NJ.

18. Lacaux, J.P., Tourre, Y.M., Vignolles, C., Ndione, J.A. and Lafaye, M. 2007. Classification of ponds from high-spatial resolution remote sensing: Application to Rift valley fever epidemics in Senegal. *Remote Sensing of Environment*.

19. Lillesand, T.M. and Keifer, R.W. 1987. Remote Sensing and Image Interpretation. John Wliey and Sons, New York.

20. *Manorama Yearbook 2007 and 2009*

21. *McGraw - Hill Dictionary of Scientific and Technical Terms* (1984). (Ed. Sybil P. Parkar), McGraw-Hill Book Company, New York.

22. *McGraw - Hill Encyclopaedia of Environmental Science* (1974). (Ed. Sybil P. Parkar), McGraw-Hill Book Company, New York.

23. McFeeters, S.K. 1996. The use of Normalised Difference Water Index (NDWI) in the delineation of open water features. *International Journal of remote Sensing* .

24. Millennium Ecosystem Assessment. 2005, Ecosystems and Human Well-being: A Framework for Assessment, http://www.MAweb.org

25. Mitsch, William J. and Gosselink, James G. (1986). *Wetlands*, Van Nostrand Reinhold Company, New York.

26. Navalgund, R.R., Nayak, S.R., Sudarshana, R., Nagaraja, R. and Ravindran, S. 2002. Proceedings of the ISPRS Commission VII. Symposium on Resource and Environmental Monitoring, IAPRS & SIS, Vol.35, Part-7, NRSA, Hyderabad.

27. NRDMs report of Kohima, 2007.

28. Patel J.G., Singh T.S., Garg J.K. et al, Wetland Information System, West Bengal, SAC/RSAM/RESA/FLPG/WIS/01/2003, April 2003, Technical report.

29. Ramsar Convention (2007). www.ramsar.org

30. Reid, George K and Wood, Richard D. (1976). *Ecology of Inland Waters and Estuaries*. D. Van Nostrand Company, New York.

31. SACON, 2004, Inland Wetlands of India : Conservation Atlas. Coimbatore, Salim Ali Centre for Ornithology and Natural History, 2004, ISBN 81-902136-1-X. ,Vedams eBooks (P) Ltd. Vardhaman Charve Plaza IV, Building # 9, K.P Block, Pitampura,

32. Singh T.S., Patel J.G., Garg J.K. et al. Loktak Lake Resources Information System (LRIS), SAC/RSAM/RESIPA/FLPG/WIS/ 02/ 2003, November 2003, Technical Report.

33. Soil and water conservation Department of Nagaland, 2007.

34. Statistical hand book of Nagaland, Directorate of economics and statistics, Govt. of Nagaland, 2007

35. Townshend, J.R., and Justice, C.O. 1986. Analysis of dynamics of African vegetation using the Normalised difference Vegetation Index. *International Journal of Remote Sensing.*

36. Tucker, C.J. and Sellers, P.J. 1986. Satellite remote sensing of primary productivity. *International Journal of Remote Sensing.*

37. Xu Hanqiu, 2006. Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. *International Journal of Remote Sensing.*

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:

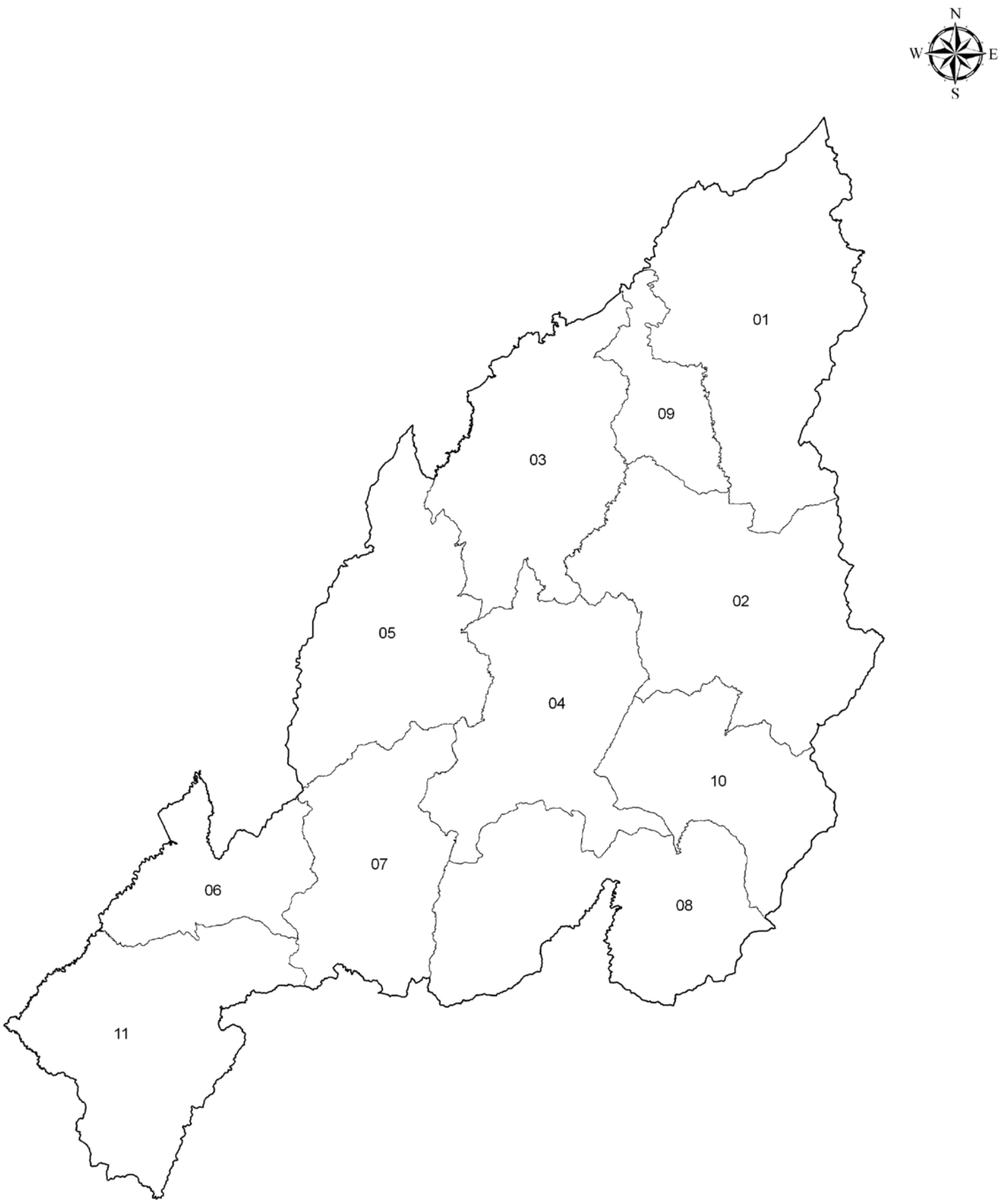
Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different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

District Boundary Map



List of Districts

District Code	District Name
01	MON
02	TUESANG
03	MOKOKCHUNG
04	ZUNHEBOTO
05	WOKHA
06	DIMAPUR
07	KOHIMA
08	PHEK
09	LONGLENG
10	KIPHIRE
11	PEREN

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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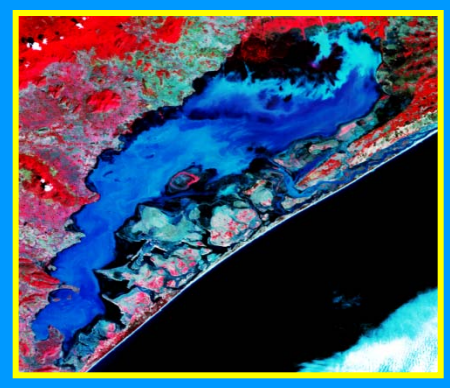

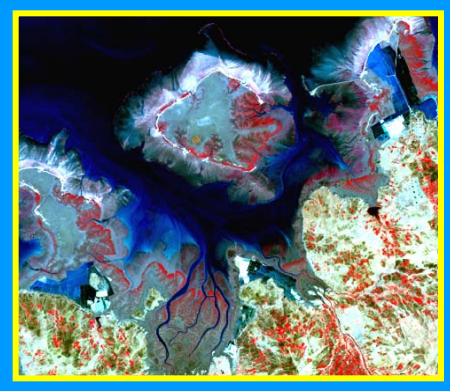

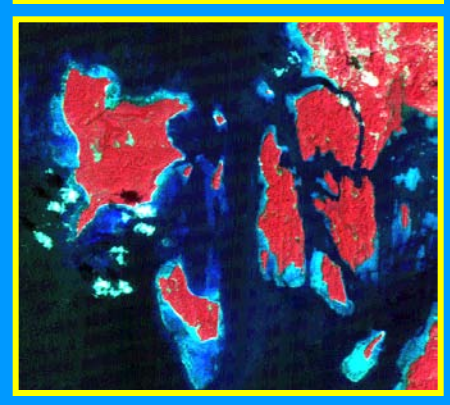

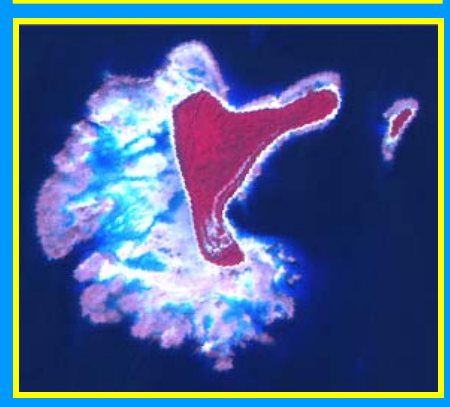

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