NATIONAL WETLAND ATLAS:

ARUNACHAL PRADESH

Sponsored by

Ministry of Environment and Forests

Government of India

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015

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

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

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

For further details contact:

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

director@sac.isro.gov.in

NATIONAL WETLAND ATLAS

Arunachal Pradesh

Sponsored by
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

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जयराम रमेश
JAIRAM RAMESH

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

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MESSAGE

MESSAGE

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

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

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

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

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

(Jairam Ramesh)

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

सत्यमेव जयते

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

FOREWORD

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

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

January 25, 2010

(Ranganath R. Navalgund)

भारतीय अनुसंधान संगठन INDIAN SPACE RESEARCH ORGANISATION

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

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

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

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

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

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

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(Sushma Panigrahy)

भारतीय अनुसंधान संगठन INDIAN SPACE RESEARCH ORGANISATION

PROJECT TEAM

Project Director : Dr. (Mrs.) Sushma Panigrahy

Space Applications Centre, ISRO, Ahmedabad

Shri J. G. Patel

Dr T. S. Singh

Shri T. V. R. Murthy

M. G. Science Institute, Ahmedabad

Shri Pragnesh Vaishnav

Mrs. Yatisha Vaishnav

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1.0 INTRODUCTION

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

1.1 Wetlands

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

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

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

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

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

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

1.2 Mapping and Geospatial technique

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

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

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

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

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

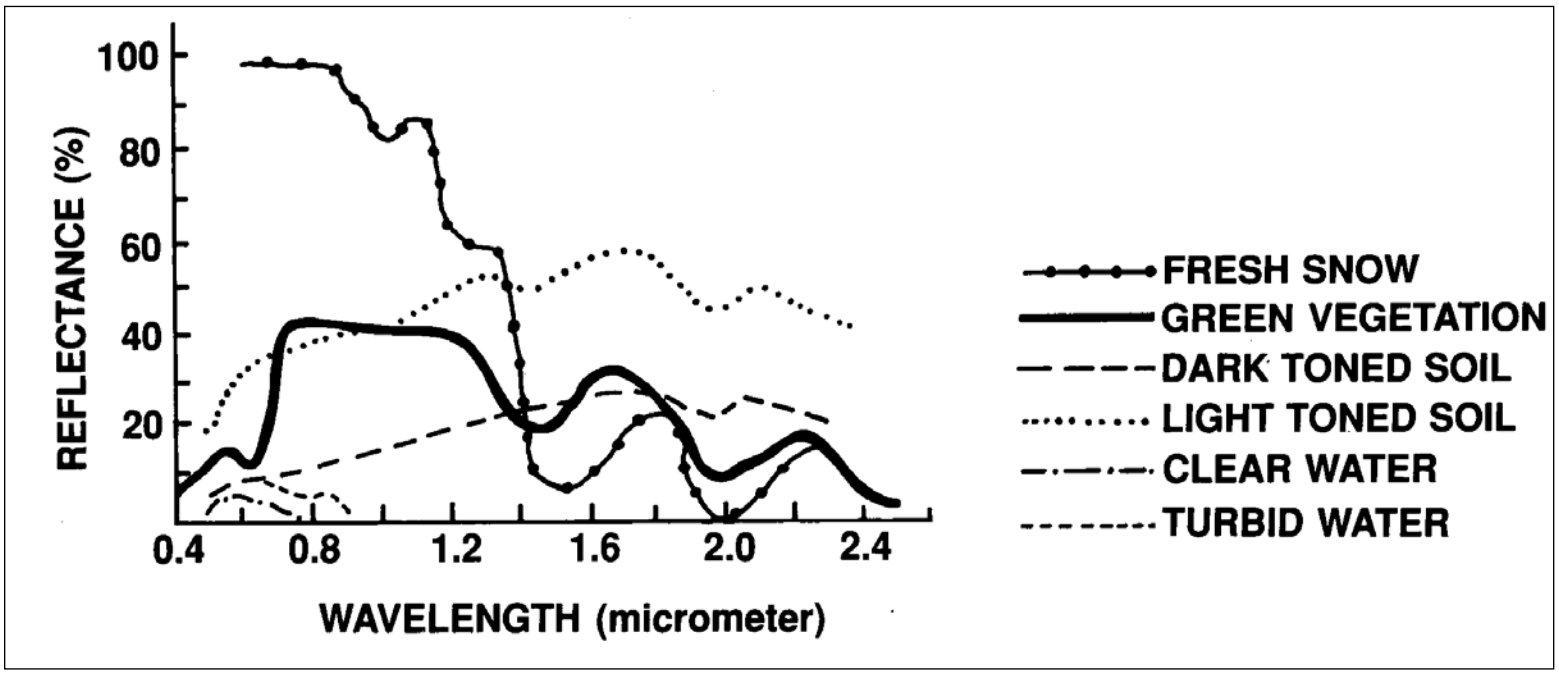


Figure 1: Spectral Signature of various targets

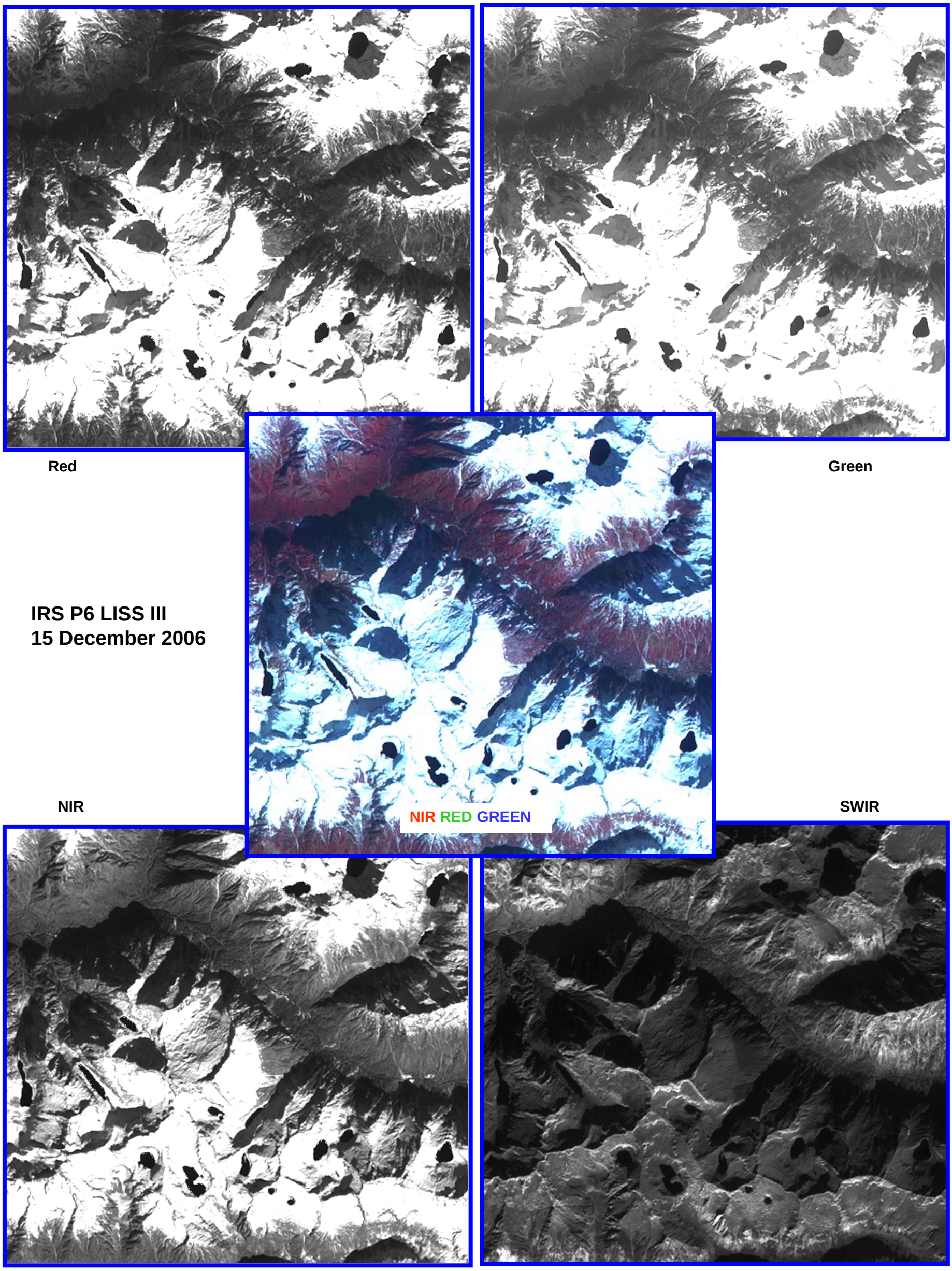


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC.

1.3 Wetland Inventory of India

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

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

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

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

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

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

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

2.0 NATIONAL WETLAND INVENTORY AND ASSESSMENT (NWIA) PROJECT

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

The main objectives of the project are:

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

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

2.1 Wetland Classification System

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

2.2.1 Spatial Framework and GIS Database

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

Following wetland layers are generated for each inland wetland:

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

- Aquatic vegetation spread: The presence of vegetation in wetlands provides information about its trophic condition. As is known, aquatic vegetation is of four types, viz. benthic, submerged, floating, and emergent. It is possible to delineate last two types of vegetation using optical remote sensing data. A qualitative layer pertaining to presence of vegetation is generated for each season (as manifested on post-monsoon and pre-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

Arunachal Pradesh is the easternmost state of India. Formerly the North-East Frontier Agency special territory, Arunachal Pradesh became a union territory in 1972 and a state in 1987. It lies between 91^0 32' E to 97^0 26' E longitude and 26^0 37' to 29^0 28' N latitude (Figure 3). Total population of the state is 1,091,120 (census 2001) and geographical area is 81,424 sq km. Arunachal Pradesh borders with the Indian state of Assam to the south and Nagaland to the southeast. Burma/Myanmar lies towards the east, Bhutan towards the west, and the state is bordered on the north by the Tibet region of China. Itanagar is the capital of the state. A remote region, it includes part of the Eastern Himalayas and extends through mountainous highlands to the plains of Assam. Arunachal Pradesh is inhabited by people of Mongolic stock, most of whom practice animism.

Arunachal Pradesh means "land of the dawn lit mountains" in Sanskrit. It is also known as "land of the rising sun" in reference to its position as the easternmost state of India. Arunachal Pradesh is entirely on the Eurasian Plate. Much of Arunachal Pradesh is covered by the Himalayas. However, parts of Lohit, Changlang and Tirap are covered by the Patkai hills. Kangto, Nyegi Kangsang, the main Gorichen peak and the Eastern Gorichen peak are some of the highest peaks in this region of the Himalayas. The Himalayan ranges that extend up to the eastern Arunachal separate it from China. The ranges extend toward Nagaland, and form a boundary between India and Burma in Changlang and Tirap district, acting as a natural barrier called Patkai Bum Hills. They are low mountains compared to the Greater Himalayas.

The climate of Arunachal Pradesh varies with elevation. Areas that are at a very high elevation in the Upper Himalayas close to the Tibetan border enjoy an alpine or Tundra climate. While below the Upper Himalayas are the Middle Himalayas, where people experience a climate which is temperate. Areas at the sub-Himalayan and sea-level elevation generally experience a humid sub-tropical climate, along with the hot summers and mild winters. Arunchal Pradesh receives heavy rainfall of 80 to 160 inches (2,000 to 4,100 mm) annually, most of it between May and September. The mountain slopes and hills are covered with alpine, temperate, and subtropical forests of dwarf rhododendron, oak, pine, maple, fir, and juniper; sal and teak are the main economic species.

Arunachal Pradesh attracts tourists from many parts of the world. Tourist attractions include the Namdapha tiger project in Changlang district, Sela lake near to Bomdila.

Agriculture is the primary driver of the economy. Jhum, the local word for shifting cultivation, which was widely practised among the tribal groups has come to be less practiced. Arunachal Pradesh has close to 61,000 square kilometers of forests, and forest products are the next most significant sector of the economy. Among the crops grown here are rice, maize, millet, wheat, pulses, sugarcane, ginger and oilseeds. Arunachal is also ideal for horticulture and fruit orchards. Its major industries are rice mills, fruit preservation units and handloom handicrafts. Arunachal Pradesh accounts for a large percent of India's untapped hydroelectric power production potential.

Arunachal Pradesh is divided into 13 districts, The state is covered by 172 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.

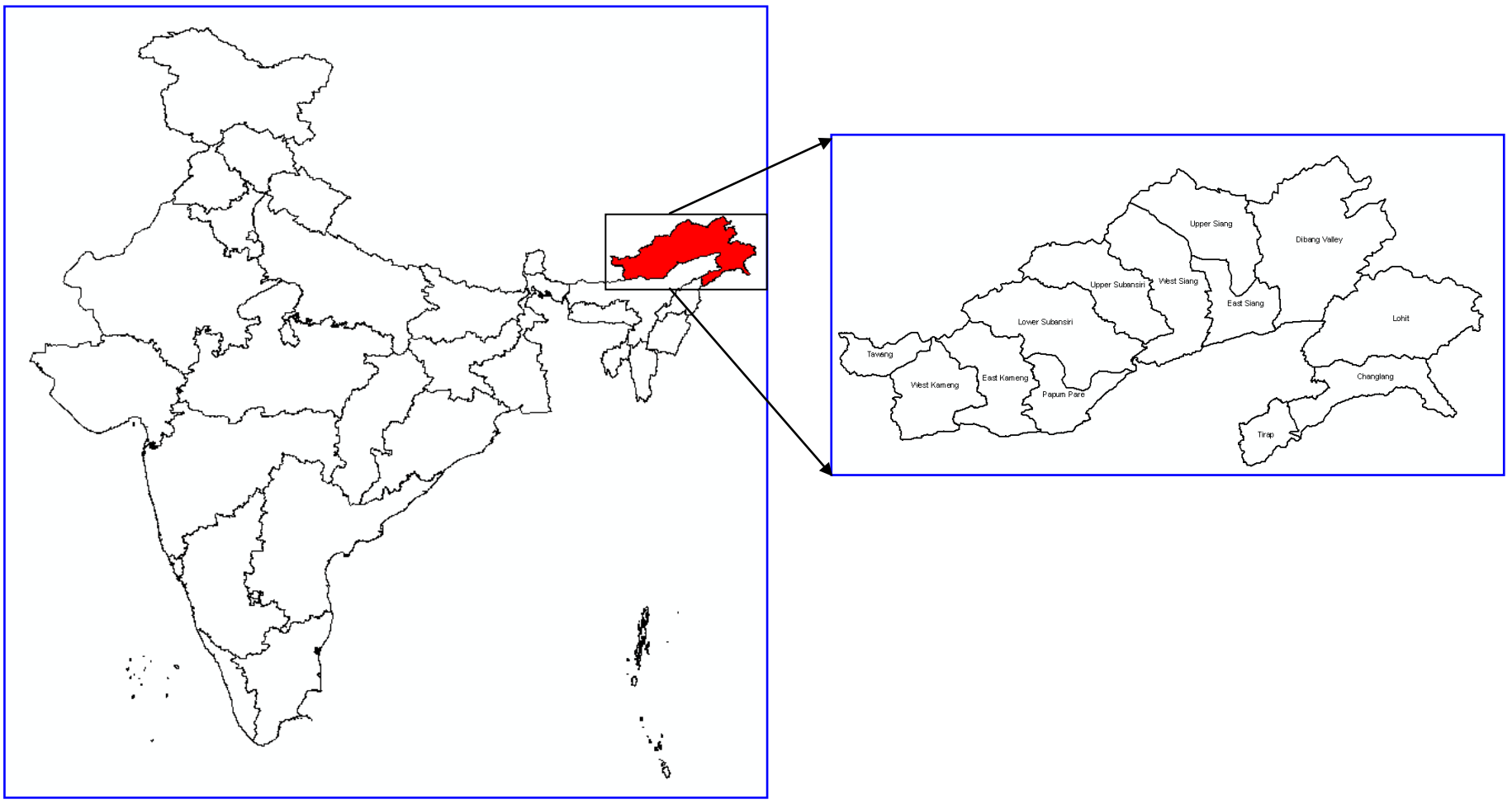


Figure 3: Location Map

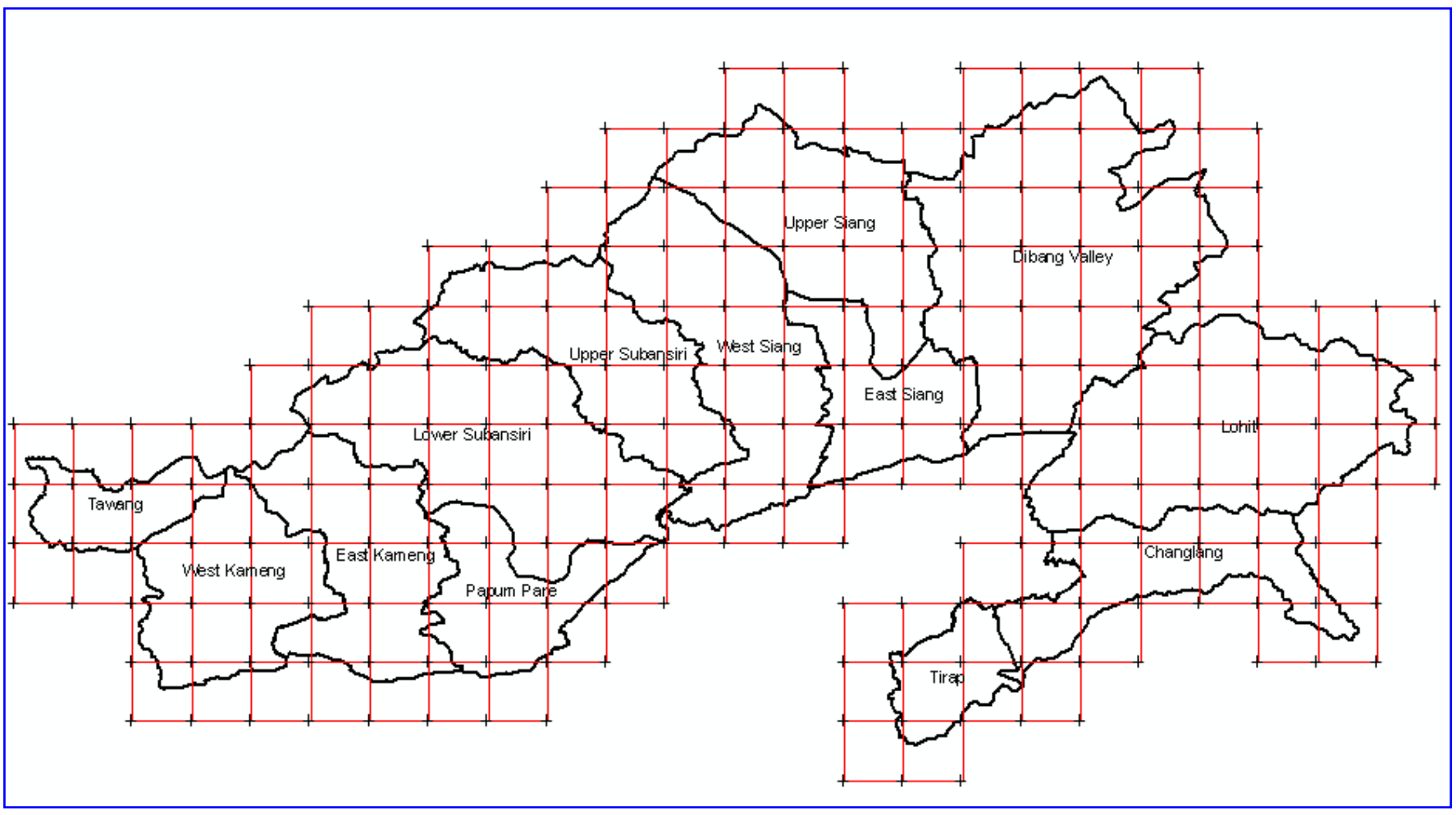


Figure 4: Spatial Framework of Arunachal Pradesh

4.0 DATA USED

Remote sensing data

IRS P6 LISS III data was used to map the wetlands. IRS P6 LISS III provides data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The state of Arunachal Pradesh is covered in 14 IRS LISS III scene (Figure 5). Two date data, one acquired during March and another during January were used to capture the pre-monsoon and post-monsoon hydrological variability of the wetlands respectively (Table-2). Figure 6 shows the overview of the part of Arunachal Pradesh as seen in the LISS III FCC of post- monsoon pre-monsoon data respectively.

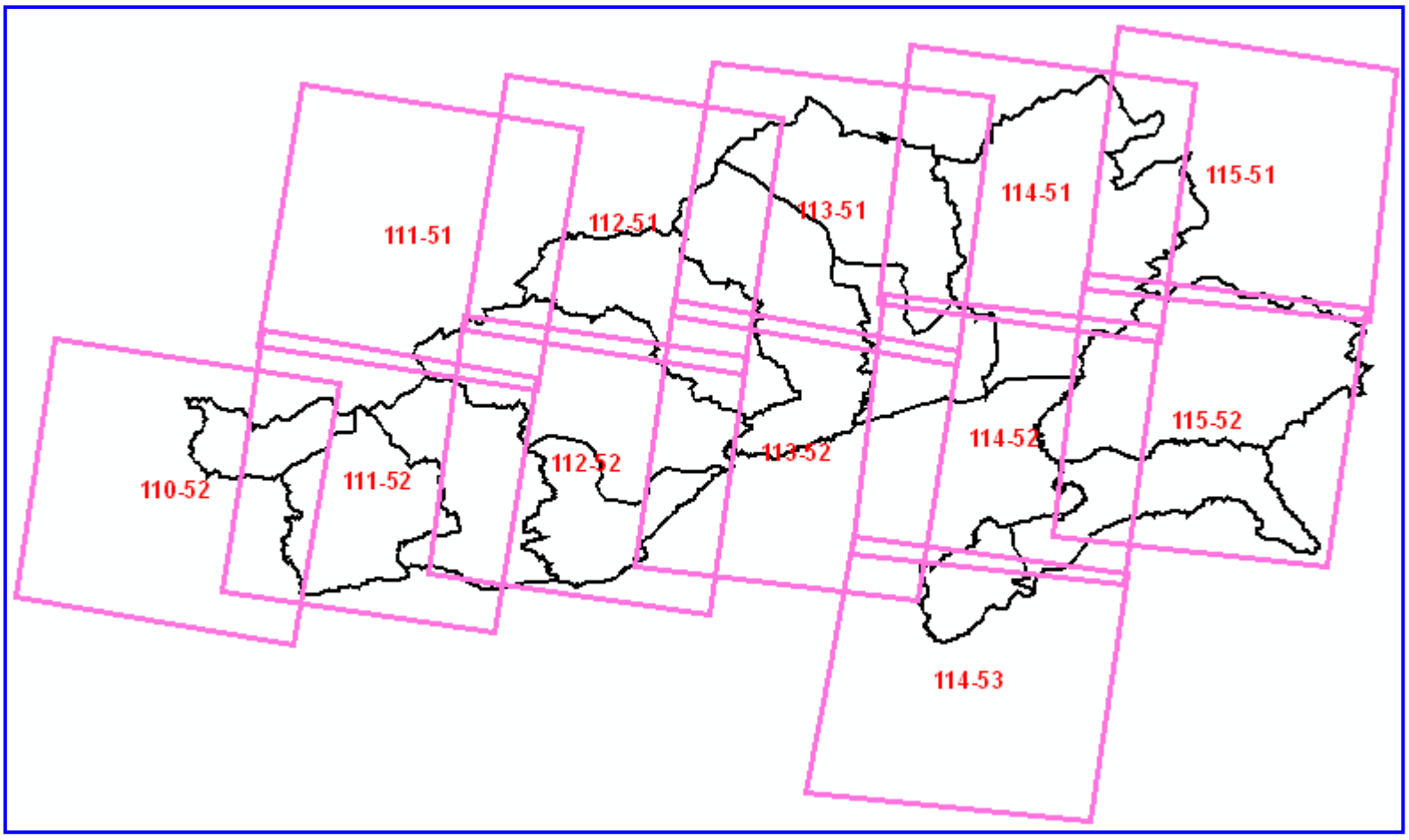


Figure 5: IRS P6 LISS-III coverage (path-row) of Arunachal Pradesh

Table-2: Satellite data used

Sl. No	Resourcesat LISS III Path Row	Post-Monsoon	Pre-Monsoon
1	101-52	November 06, 2005	-
2	111-51	November 11, 2005	January 27, 2005
3	111-52	November 11, 2005	January 3, 2005
4	112-50	December 5, 2006	January 27, 2006
5	112-51	December 5, 2006	January 27, 2006
6	112-52	December 5, 2006	January 27, 2006
7	113-50	December 5, 2005	January 13, 2005
8	113-51	October 28, 2005	February 1, 2006
9	113-52	January 27, 2007	May 3, 2007
10	114-50	February 6, 2006	February 6, 2006
11	114-51	December 15, 2006	April 14, 2007
12	114-52	September 15, 2005	April 14, 2007
13	115-51	December 20, 2006	April 19, 2007
14	115-52	December 20, 2006	April 19, 2007

Ground truth data

Remote sensing techniques require certain amount of field observation called “ground truth” in order to convert into meaningful information. Such work involves visiting a number of test sites, usually taking the satellite data. The location of the features is recorded using the GPS. The standard proforma as per the NWIA manual was used to record the field data. Field photographs are also taken to record the water quality

(subjective), status of aquatic vegetation and water spread. All field verification work has been done during October and November 2008.

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

5.0 METHODOLOGY

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

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

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

5.1 Creation of spatial framework

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

5.2 Geo-referencing of satellite data

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

5.3 Mapping of wetlands

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

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

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

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

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

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

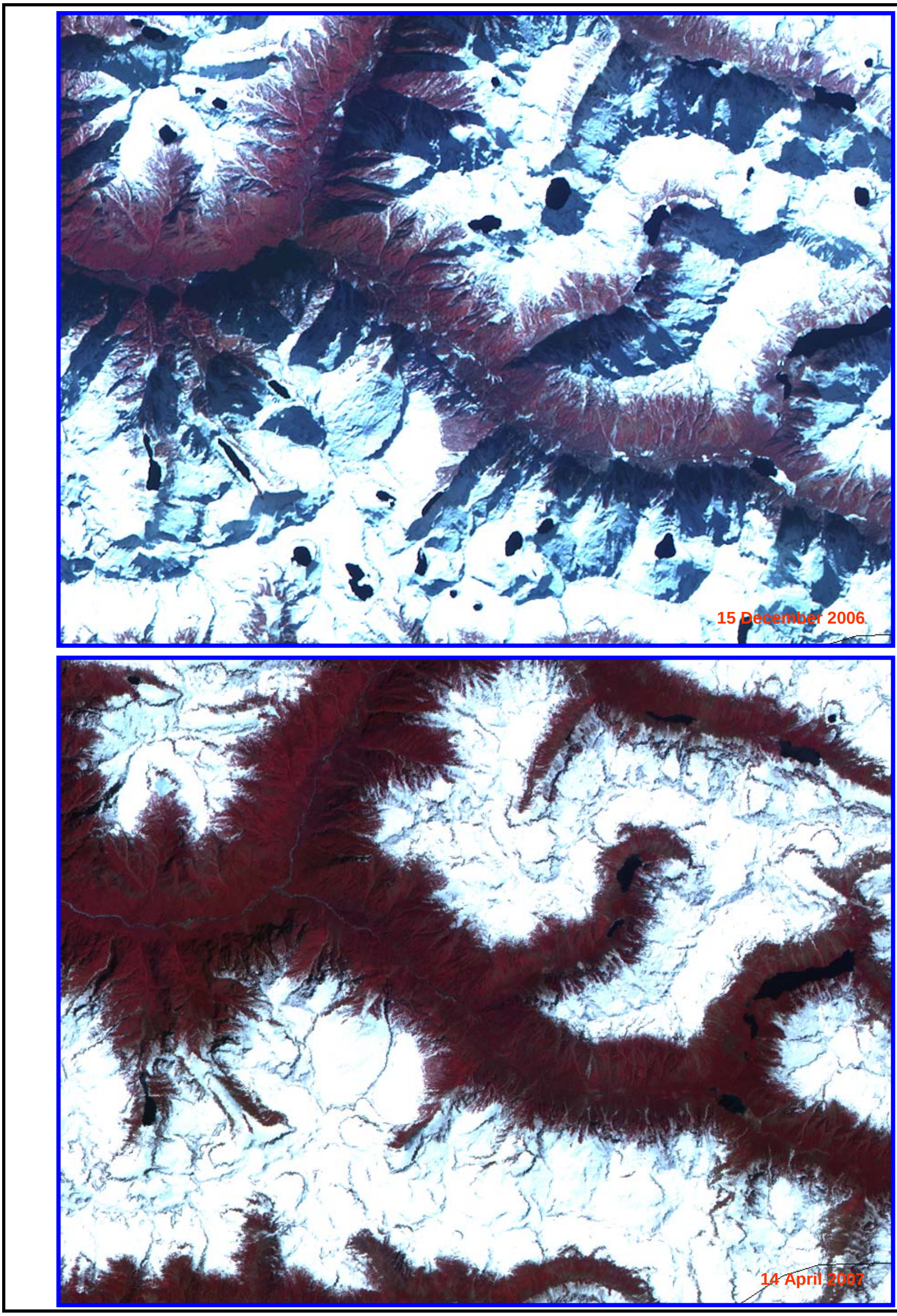


Figure 6: IRS LISS-III FCC(Post-monsoon and Pre-monsoon) : Part of Arunachal Pradesh state

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

- Extraction of wetland extent :

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

- Extraction of open water :

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

- Extraction of wetland vegetation :

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

- Turbidity information extraction :

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

Table 3: Qualitative turbidity ratings

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

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

The information on wetland extent, open water extent, vegetation extent and turbidity information was converted into vector layers using region growing properties or on-screen 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 database. The administrative boundaries (district, state) are taken from the known reference data.

5.6 Coding and attribute scheme

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

5.7 Map composition and output

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

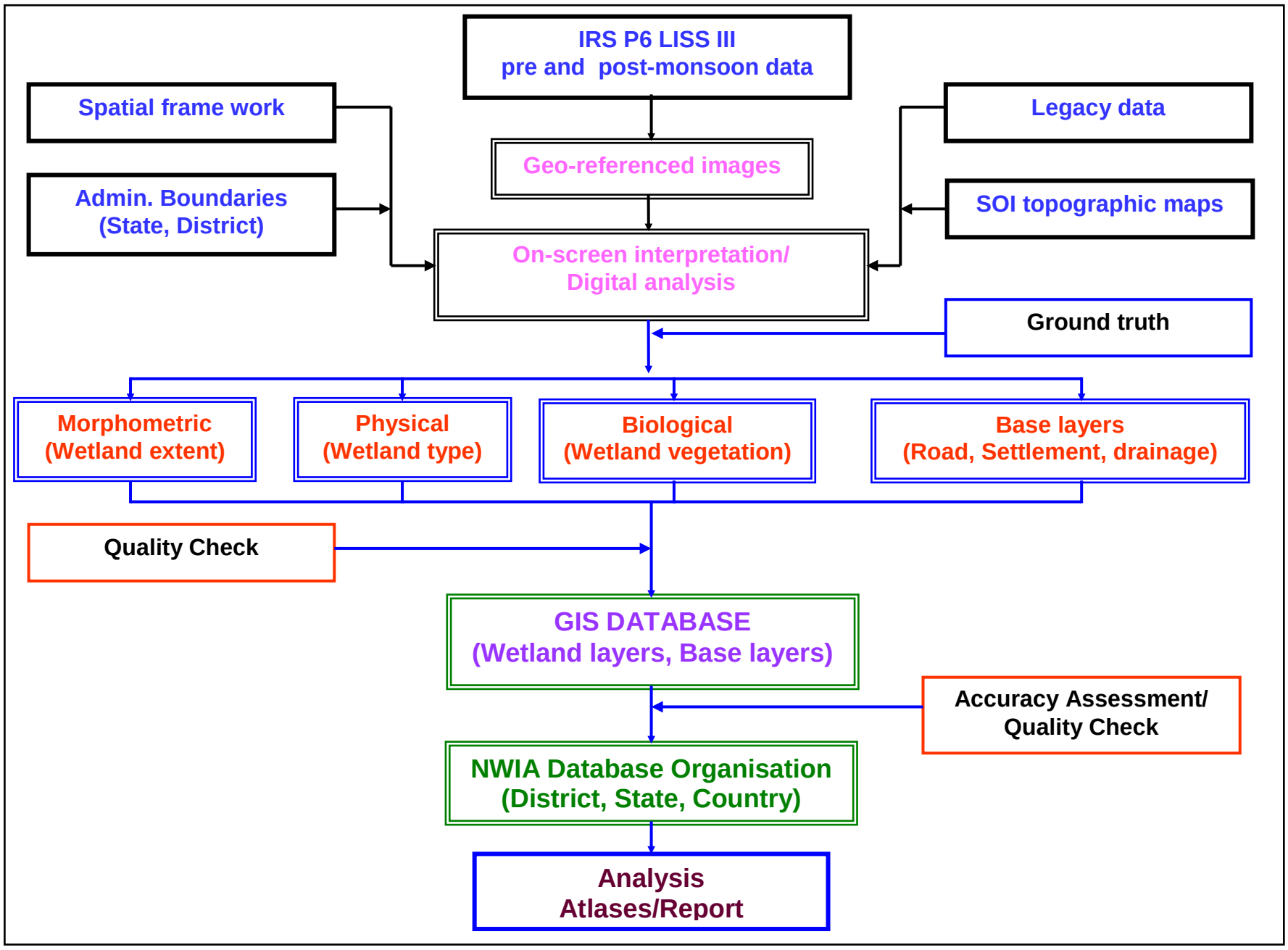


Figure 7: Flow chart of the methodology used

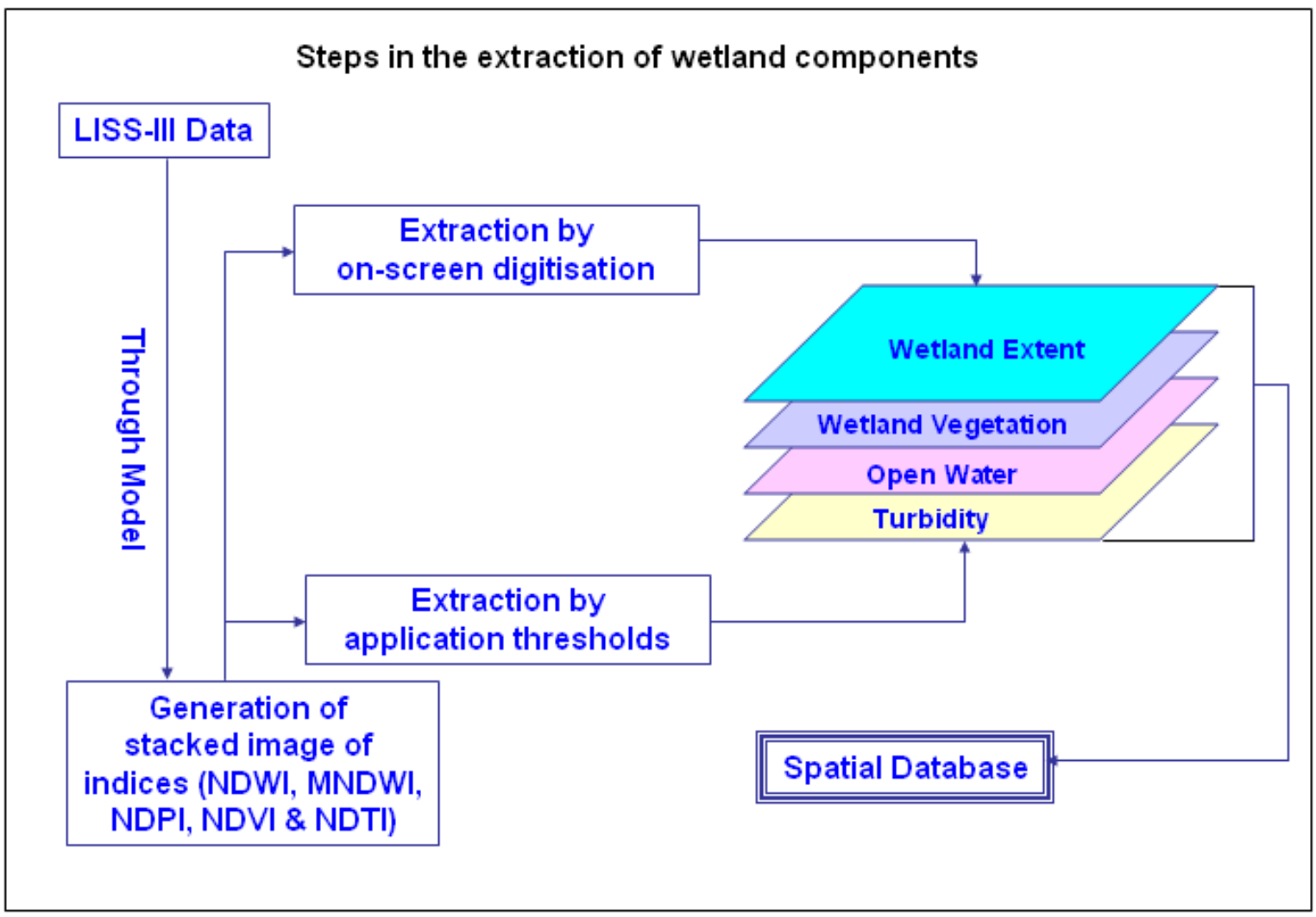


Figure 8: Steps in the extraction of wetland components

6.0 ACCURACY ASSESSMENT

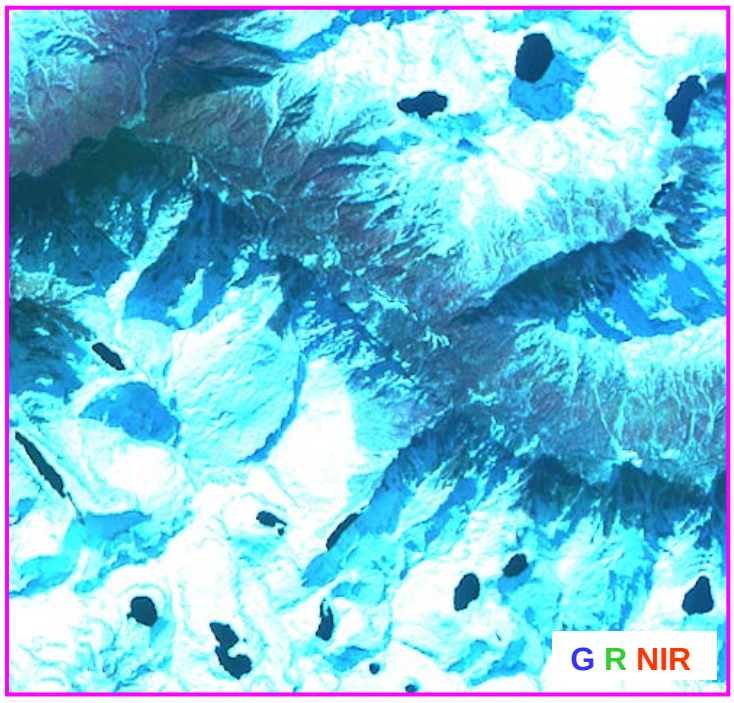
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as locational accuracy. In addition, GIS database(s) contents have been also evaluated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

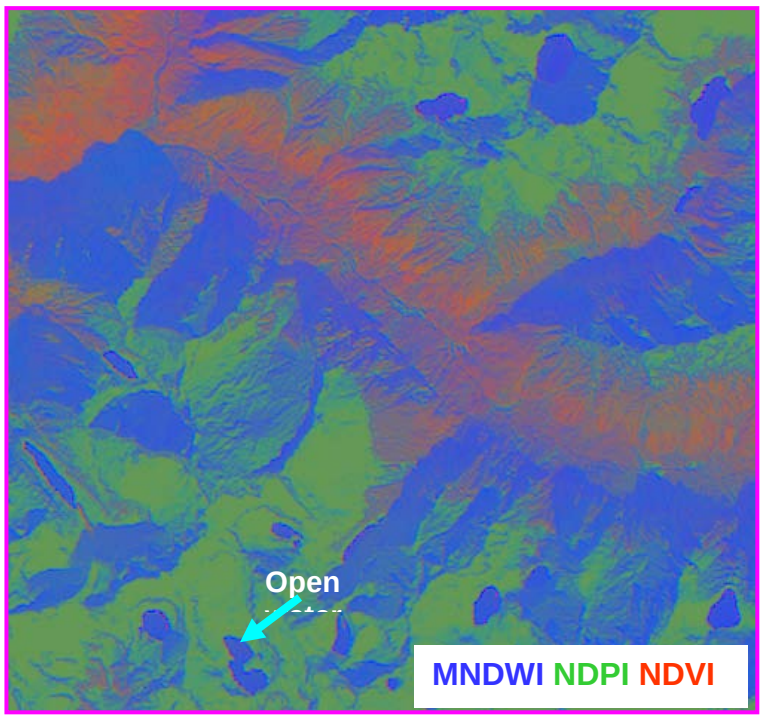
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imageries were reviewed by technical expert team for accuracy and code. The reviewing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

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

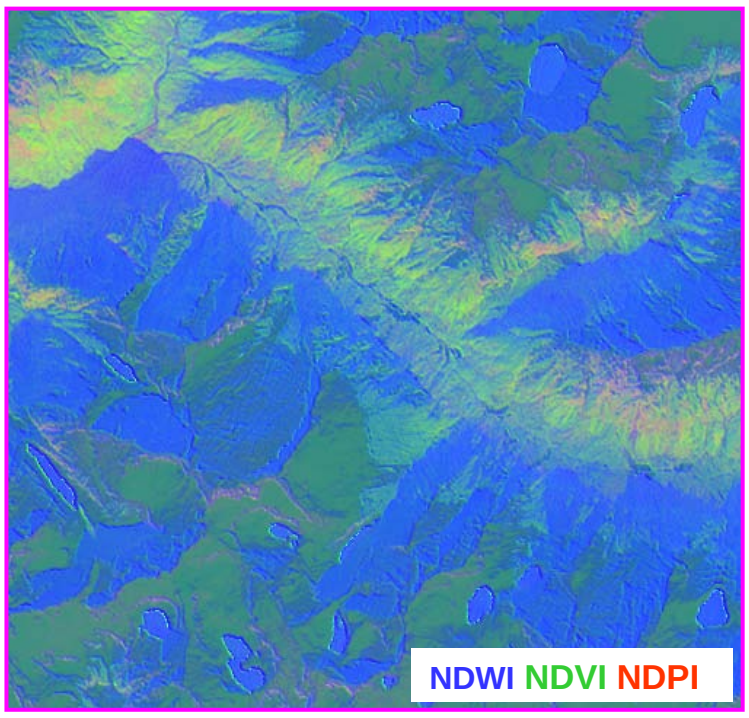
6.1 Data verification and quality assurance of output digital data files

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

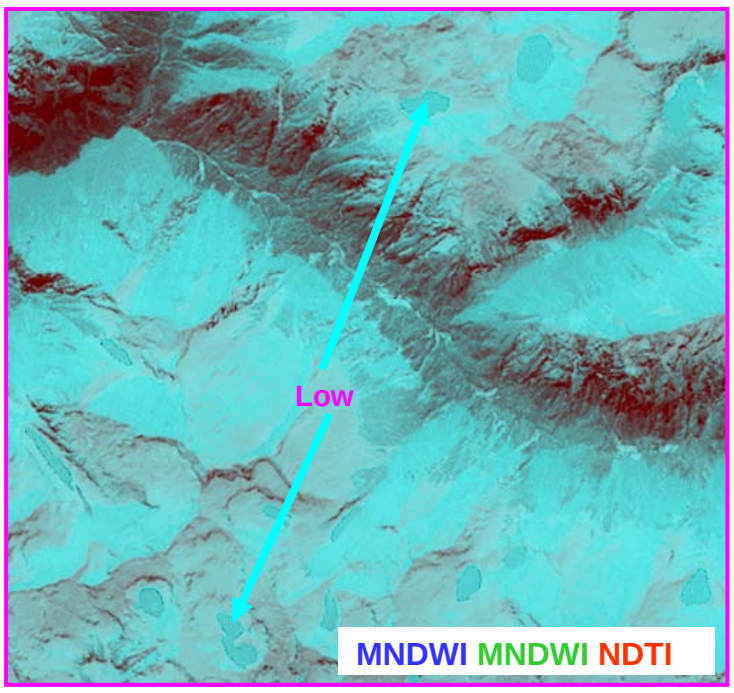




Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features



Useful for qualitative turbidity delineation

Part of Dibang Valley,
IRS LISS III data, 15 December 2006

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

MAPS AND STATISTICS

7.0 WETLANDS OF ARUNACHAL PRADESH: MAPS AND STATISTICS

Area estimates of various wetland categories for Arunachal Pradesh have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total 1534 wetlands have been mapped at 1:50,000 scale in the state. In addition, 1119 wetlands (smaller than 2.25 ha) have also been identified. Total wetland area estimated is 154609 ha that is around 1.91 per cent of the geographic area (Table 4). The major wetland types are river/stream accounting for 86 percent of the wetlands (134244 ha), High altitude wetlands (11422 ha), and waterlogged (8146 ha). Graphical distribution of wetland type is shown in Figure 10.

Analysis of wetland status in terms of open water and aquatic vegetation showed that around 43 and 37 percent of wetland area is under open water category during post monsoon and Pre-monsoon respectively. Aquatic vegetation (floating/emergent) occupies around 3.8 and 3.3 per cent of wetland area during post-and Pre-monsoon respectively. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail (around 85 and 12 percent respectively during post-monsoon).

Table 4: Area estimates of wetlands in Arunachal Pradesh

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	3	18	0.01	16	-
2	1102	Ox-bow lakes/ Cut-off meanders	29	520	0.33	180	39
3	1103	High altitude wetlands	1231	11422	7.33	7946	2984
4	1105	Waterlogged	107	8146	5.23	60	7
5	1106	River/Stream	128	134244	86.20	57811	54354
	1200	**Inland Wetlands -Man-made**					
6	1201	Reservoirs/Barrages	4	164	0.11	162	124
7	1202	Tanks/Ponds	32	95	0.06	47	8
		Sub-Total	**1534**	**154609**	**99.28**	**66222**	**57516**
		Wetlands (<2.25 ha), mainly Tanks	1119	1119	0.72	-	-
		Total	**2653**	**155728**	**100.00**	**66222**	**57516**

Area under Aquatic Vegetation	6002	5924

Area under turbidity levels		
Low	56471	45810
Moderate	7984	9541
High	1767	2165

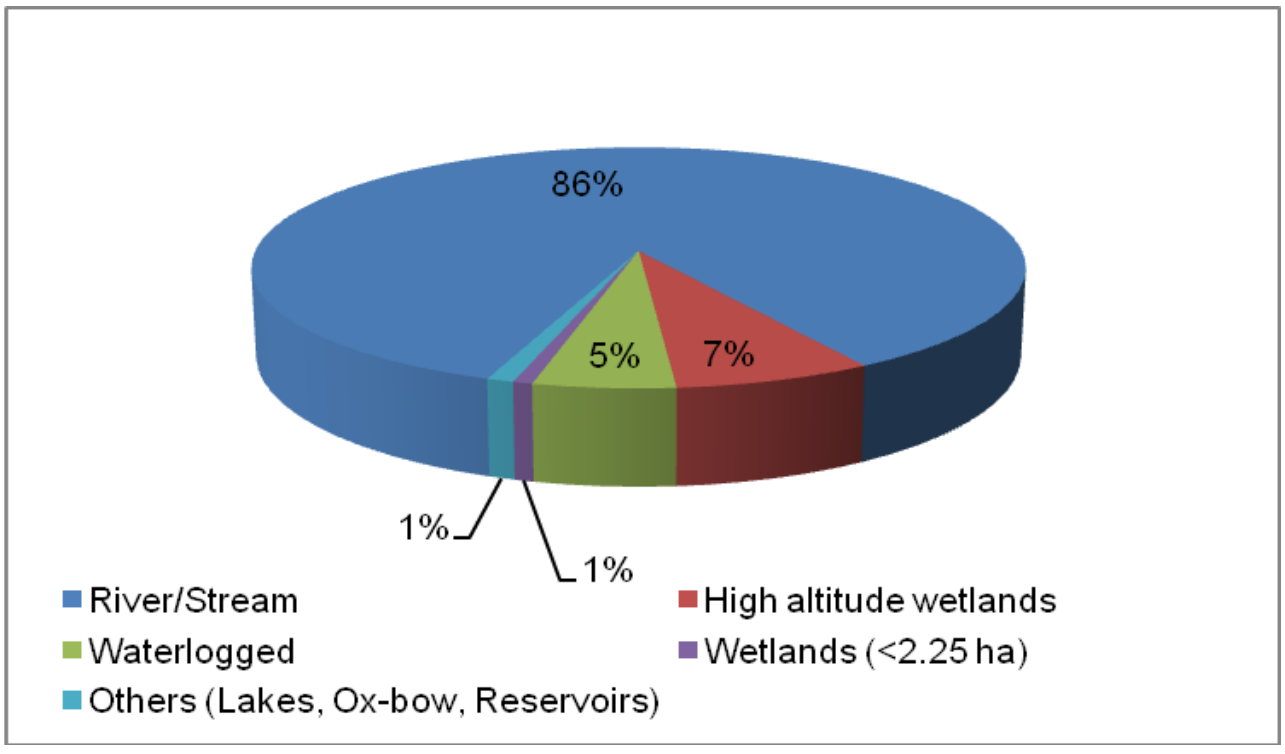


Figure 10: Type-wise wetland distribution in Arunachal Pradesh

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has Thirteen districts. District-wise distribution of wetlands showed that three districts can be called as wetland rich. Lohit has highest concentration with around 45719 ha area under wetland. This is mainly due to the large number of rivers/streams area. The other two districts are: Dibang valley and East Siang with around 37,602 ha and 25,512 ha area under wetland. Tirap district has the lowest area under wetland (around 1,262 ha). Wetland category of High Altitude lakes was observed in Dibang Valley(443), Lohit(204) and Tawang(204) districts. Few high altitude lakes are observed in West Kameng, East Kameng, West Siang Lower subansiri, Upper Subansiri and Upper Siang districts also. There are no major reservoirs exists in the state. District-wise wetland area estimates is given in Table-5. Figure 11 shows district-wise graphical distribution of wetlands.

The districts with very high concentration of small wetlands (< 2.25 ha) are Dibang Valley and Lohit with 266 and 240 numbers respectively, while East Kameng district has lowest with 12 such wetlands. Wetland statistics followed by wetland map and corresponding satellite data for each district is given to have a fairly good idea about the distribution pattern and density of wetlands in the district.

Table-5: District-wise wetland highlights

Sr. No.	District	Geographic Area	Wetland Area	% of total wetland area	% of district geographic area
1	Tawang	2172	1822	1.17	0.84
2	West Kameng	7422	3825	2.46	0.52
3	East Kameng	4134	5443	3.50	1.32
4	Papum Pare	2875	2718	1.75	0.95
5	Lower Subansiri	10125	3607	2.32	0.36
6	Upper Subansiri	7032	3365	2.16	0.48
7	West Siang	8325	6147	3.95	0.74
8	East Siang	4005	25512	16.38	-
9	Upper Siang	10113	6686	4.29	0.66
10	Dibang Valley	13029	37605	24.15	2.89
11	Lohit	11402	45719	29.36	4.01
12	Changlang	4662	12017	7.72	2.58
13	Tirap	2362	1262	0.81	0.53
	Total	**83653**	**155728**	**100.00**	

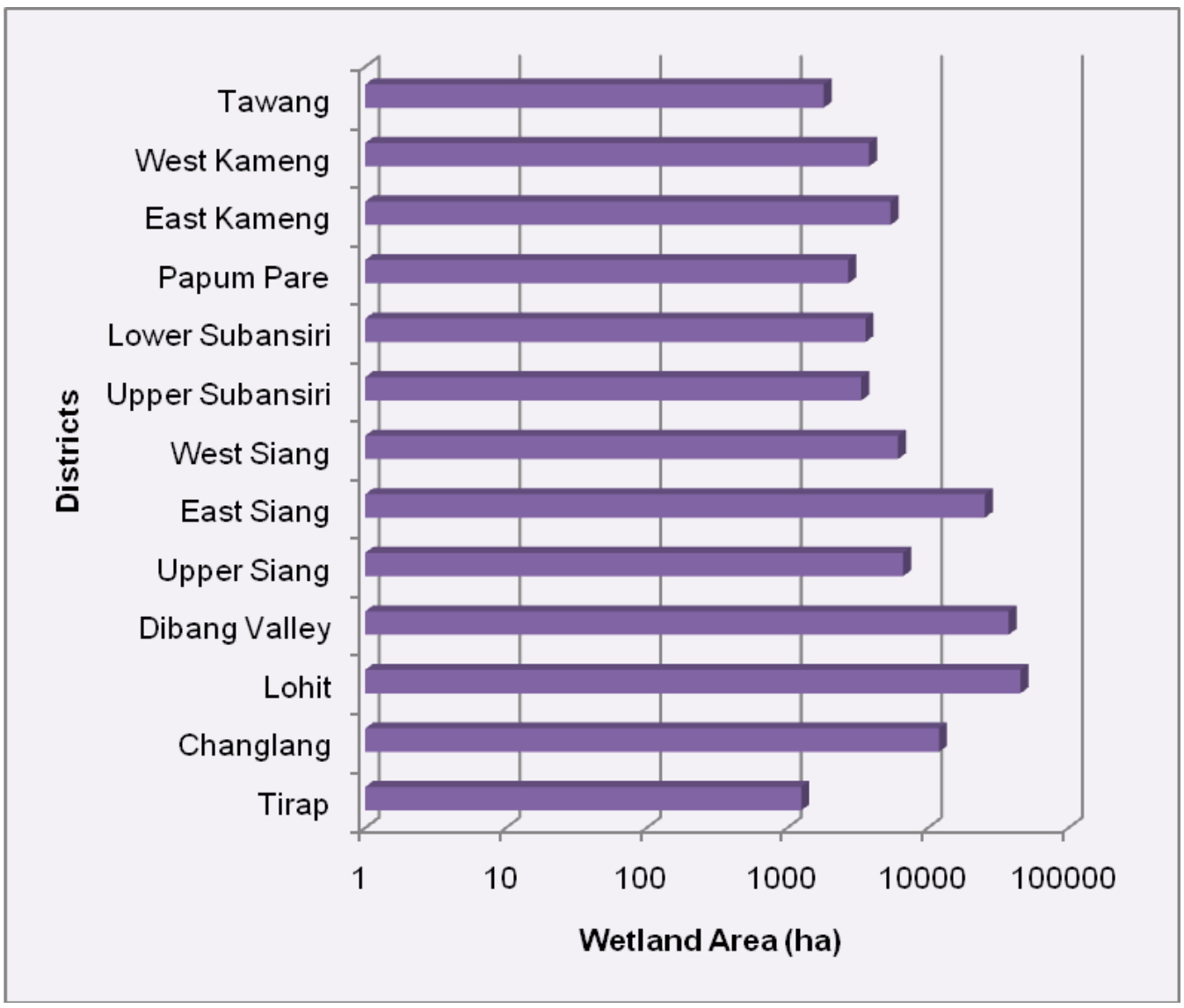
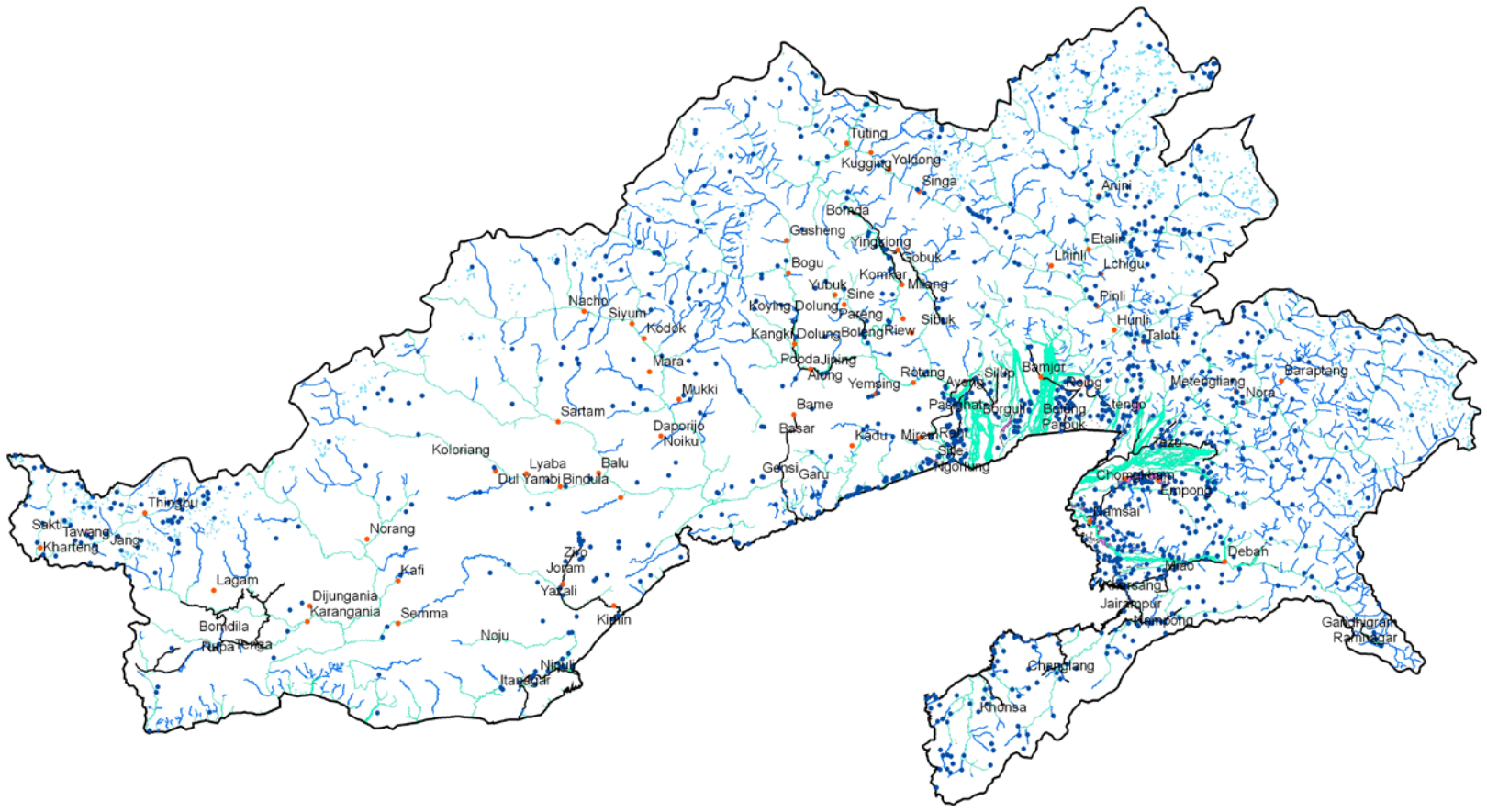


Figure 11: District-wise graphical distribution of wetlands

State : Arunachal Pradesh

WETLAND MAP

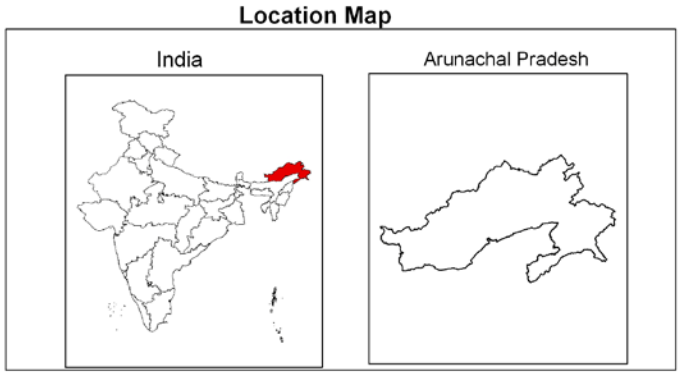


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



0 15 30 60 90 Kilometers

Data Source :

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

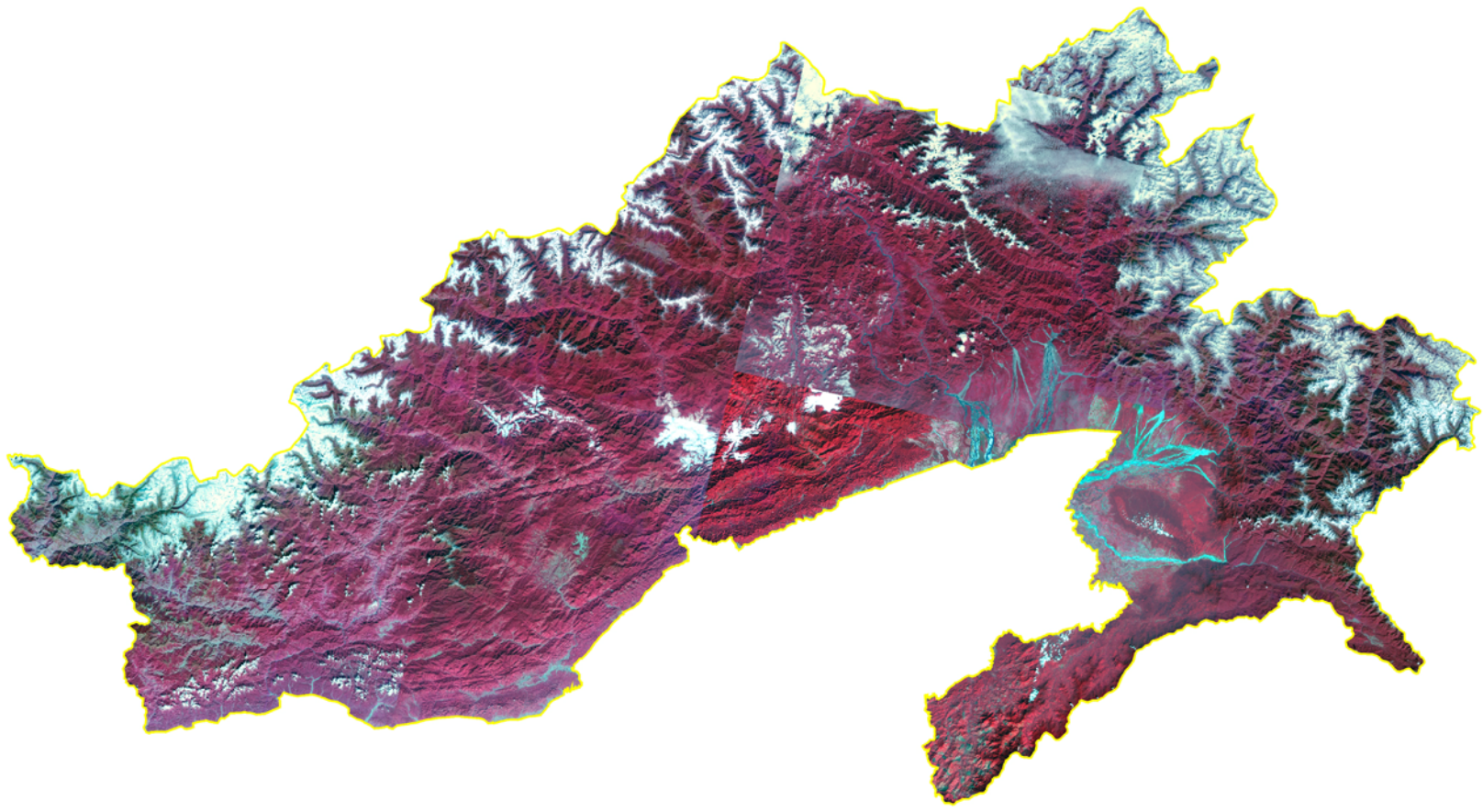
Prepared By :

Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh



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

7.1.1 Wetland Distribution in Tawang

Tawang Town is the district headquarters. The Tawang district is located around latitude 27º 45’ N and longitude 90º 15’ E at the northwest extremity of Arunachal Pradesh. Elevations range between 6,000 to 22,000 feet, and inhabitants are found in lower altitude, where they enjoy a cool temperate climate. The district was carved out of the West Kameng district, that adjoins it to the south and east. Bhutan borders The district occupies an area of 2085 square kilometers and has a population of 38,924 (as of 2001), almost 75% of which are considered "tribal", i.e. belonging to the native Monpa, Bhotia, Adi etc.

In winter, Tawang frequently experiences heavy snowfall.

Tawang district is further sub-divided into the Lumla, Jang and Tawang sub-divisions.

There are good number of high attitude wetlands exists in the district. Total wetland area estimated is 1822 ha. Small wetlands, which are less than minimum mapable units (MMU), are 58 in the district. The dominant type of wetland found in the district is high altitude wetlands. The turbidity rating of the open water is observed to be mainly low.

Details of the wetland statistics of the district is given in Table 6.

Table 6: Area estimates of wetlands in Tawang

Area in ha

	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	1103	High altitude wetlands	204	1084	59.50	1072	981
2	1106	River/Stream	1	680	37.32	646	680
		Sub-Total	**205**	**1764**	**96.82**	**1718**	**1661**
		Wetlands (<2.25 ha), mainly Tanks	58	58	3.18	-	-
		Total	**263**	**1822**	**100.00**	**1718**	**1661**

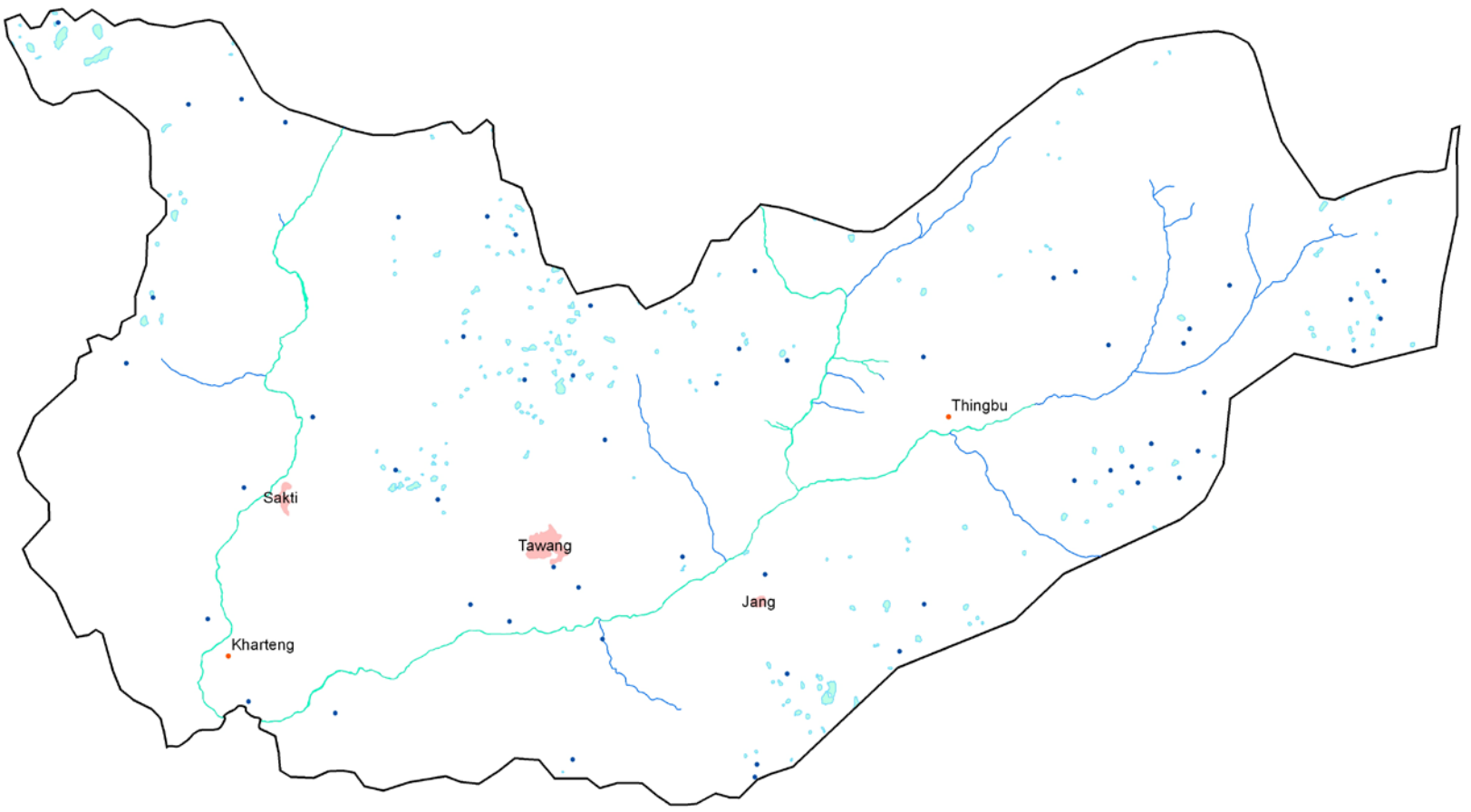
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	1698	1661
Moderate	2	-
High	18	-

State : Arunachal Pradesh

WETLAND MAP

District : Tawang

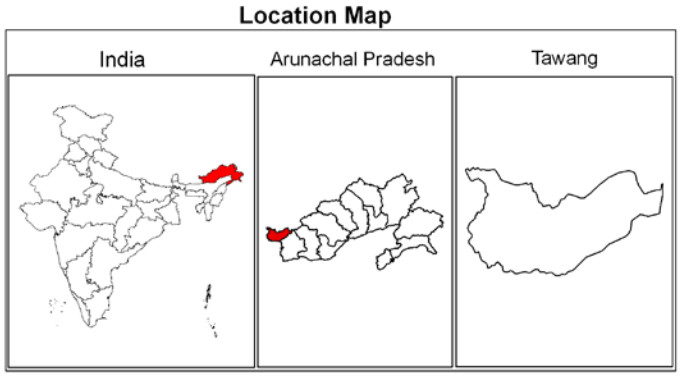


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 Kilometers

Data Source :

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

Prepared By :

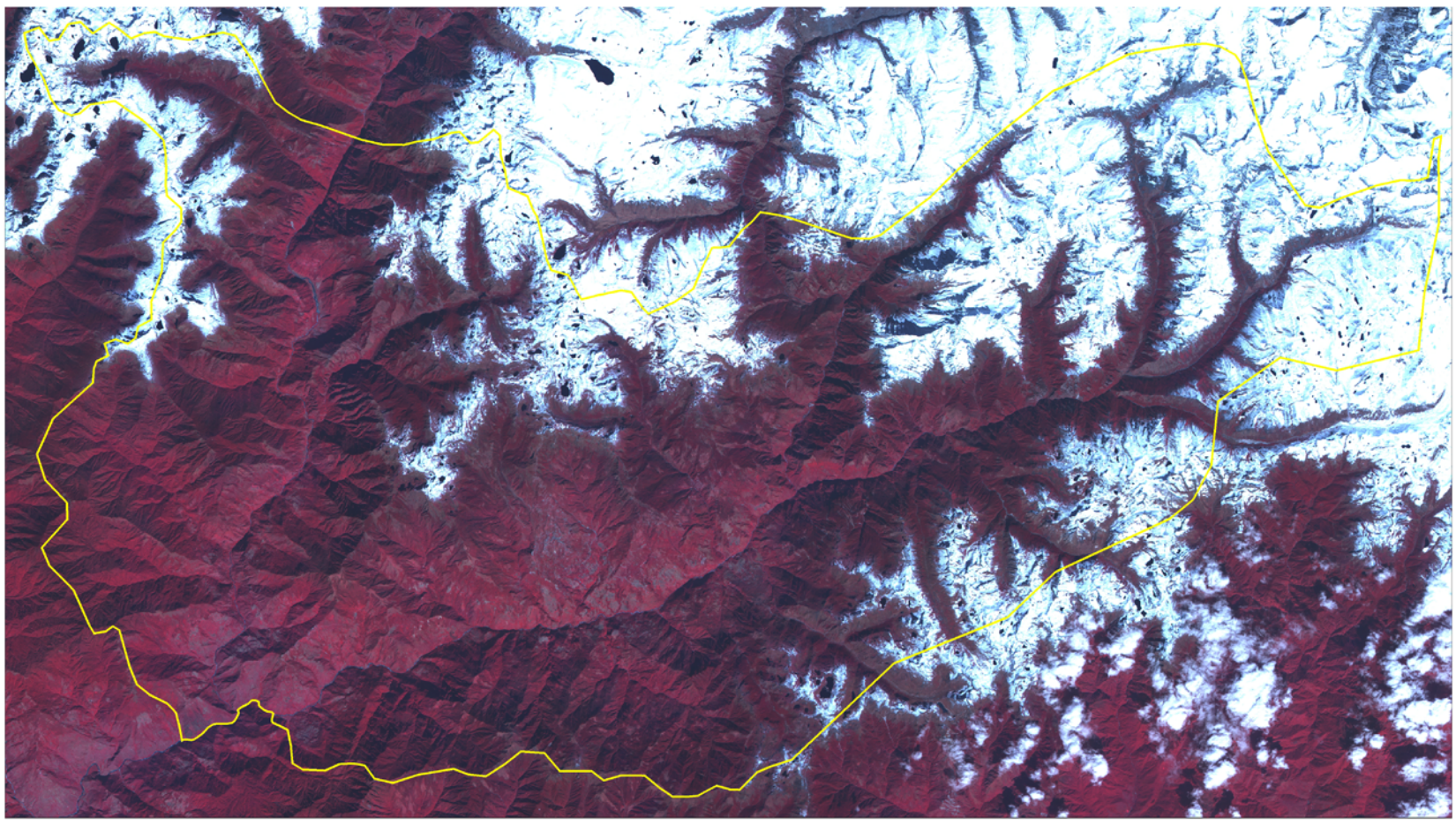
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Tawang



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

7.1.2 Wetland Distribution in West Kameng

West Kameng accounts for 8.86% of the total area of the state. The name is derived from the Kameng river, a tributary of the Brahmaputra, that flows through the district. The district headquarters are located at Bomdila. The district occupies an area of 7422 km² and has a population of 74,595 (as of 2001). The Kameng district was bifurcated between East Kameng and West Kameng on the June 1, 1980. The Tawang district, which initially belonged to part of the district, was separated on the October 6, 1984.

West Kameng comprises five major tribes: Monpa (which makes up 78% of the district's population and includes Dirang, Bhut, Lish, and Kalaktang Monpa), Miji (Sajolang), Sherdukpen, Aka (Hrusso), and Khowa (Bugun). Minority tribes include Takpa, Lishipa, Chugpa, and Butpa.

West Kameng lies approximately between 91° 30' to 92° 40' East longitudes and 26° 54' to 28° 01' North latitudes. The district shares an international border with Tibet in the north, Bhutan in the west, Tawang District in the northwest, and East Kameng district in the east. The southern border is shared with Sonitpur district and Darrang district of Assam. The Eaglenest Wildlife Sanctuary is located in West Kameng.

The topography is mostly mountainous. Much of West Kameng area is covered with the Himalayas. The highest peak in the district and state is Kangte. West Kameng district experiences an arid tundra or a cool temperate climate in the north. Snow fall occurs from mid-November to February.

The district is divided into three subdivisions, Thrizino, Rupa and Bomdila, and twelve administrative circles, including Dirang, Bomdila, Kalaktang, Balemu, Bhalukpong, Jameri, Sinchung, Nafra, Thrizino, Rupa, Thembang, Shergaon. The four development blocks are Dirang, Kalaktang, Nafra-Buragaon, and Thrizino.

Like most of Arunachal Pradesh, Jhum, or shifting cultivation, is practised among the tribes who live in lower elevations where there is a temperate or subtropical climate. Horiculture is practised as well.

The district has very less wetlands. Total wetland area estimated is 3825 ha. Small wetlands, which are less than minimum mapable units (MMU), are 23 in the district. The major wetland types are River/Stream and high altitude wetlands(Table7).
The turbidity rating of the open water is observed to be mainly low.

Table 7: Area estimates of wetlands in West Kameng

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	1103	High altitude wetlands	96	421	11.01	275	159
2	1106	River/Stream	23	3381	88.39	2689	2810
		Sub-Total	**119**	**3802**	**99.40**	**2964**	**2969**
		Wetlands (<2.25 ha), mainly Tanks	23	23	0.60	-	-
		Total	**142**	**3825**	**100.00**	**2964**	**2969**

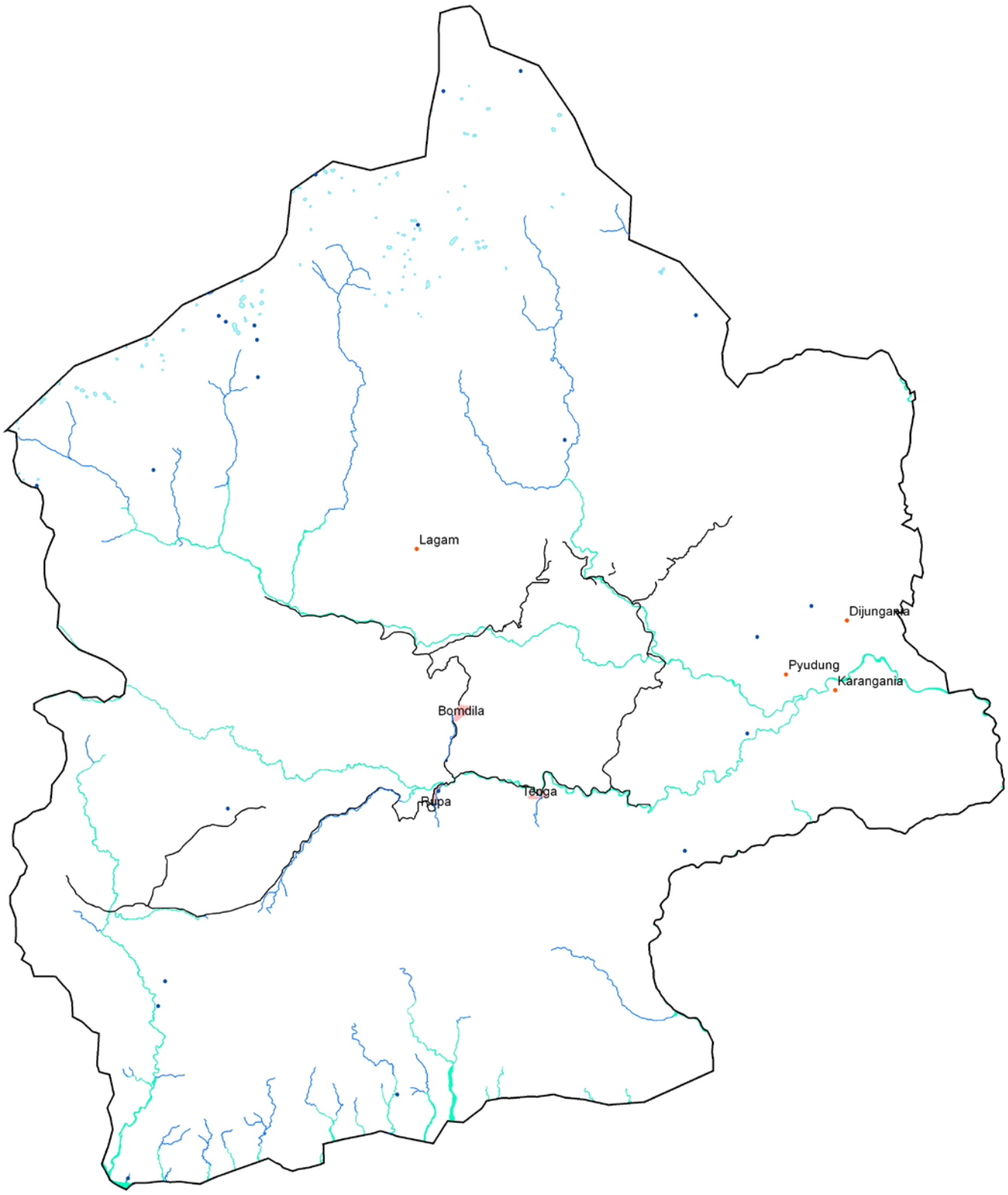
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2673	2969
Moderate	239	-
High	52	-

State : Arunachal Pradesh

WETLAND MAP

District : West Kameng

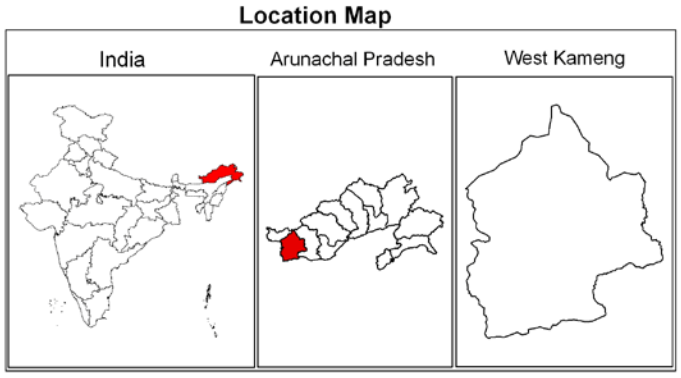


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



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Data Source :

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

Prepared By :

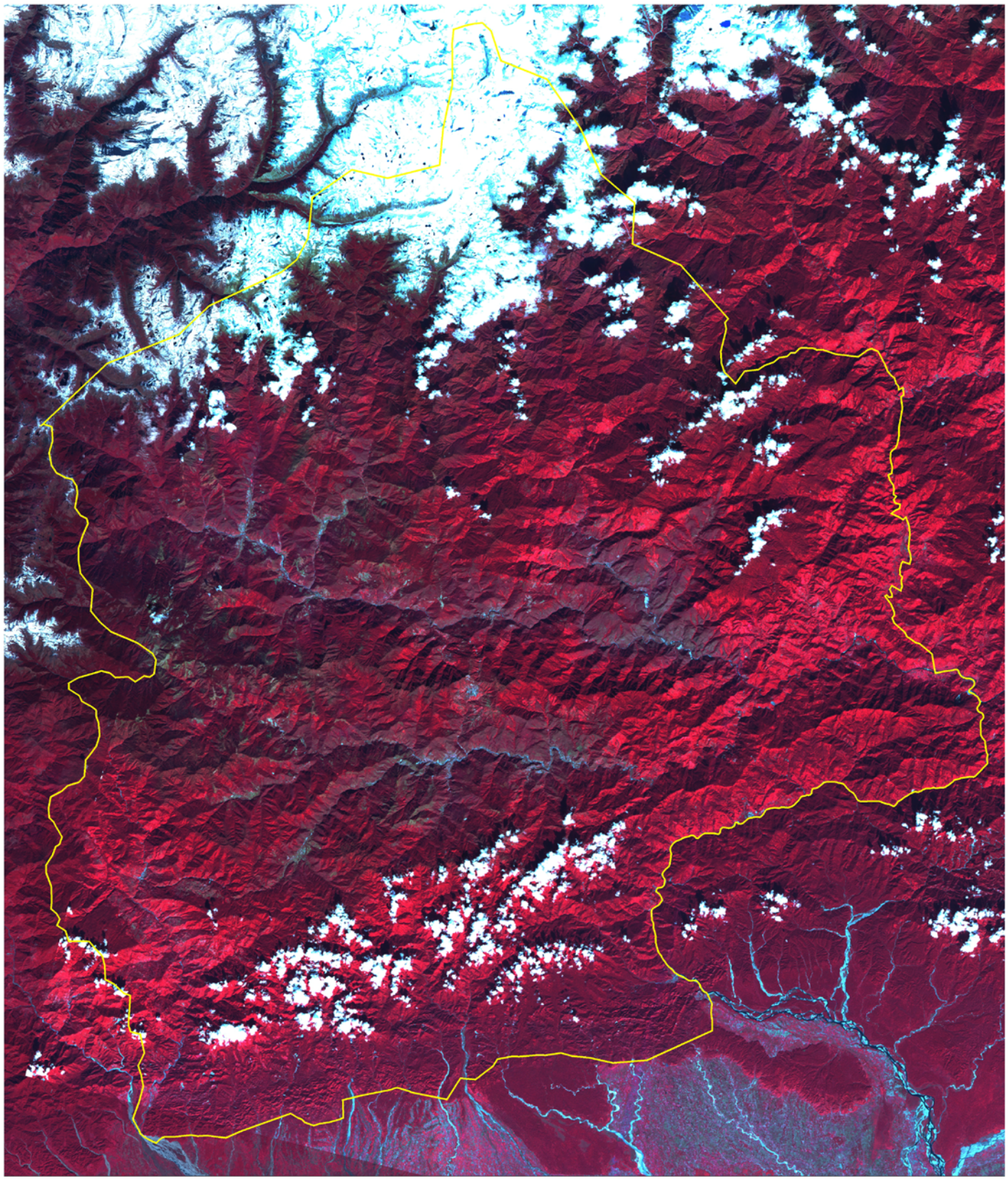
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : West Kameng



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

7.1.3 Wetland Distribution in East Kameng

The wetland area estimated is 5443 ha. Small wetlands, which are less than minimum mapable units (MMU), are 12 in the district. This is mainly due to presence of river/streams. There are about 27 high altitude lakes mapped covering 215 ha area. One reservoir is located near Lamzang. Details of the wetlands is shown in Table-8.

Table 8: Area estimates of wetlands in East Kameng

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	1103	High altitude wetlands	27	215	3.95	104	8
2	1106	River/Stream	20	5216	95.83	3468	3516
		Sub-Total	**47**	**5431**	**99.78**	**3572**	**3524**
		Wetlands (<2.25 ha), mainly Tanks	12	12	0.22	-	-
		Total	**59**	**5443**	**100.00**	**3572**	**3524**

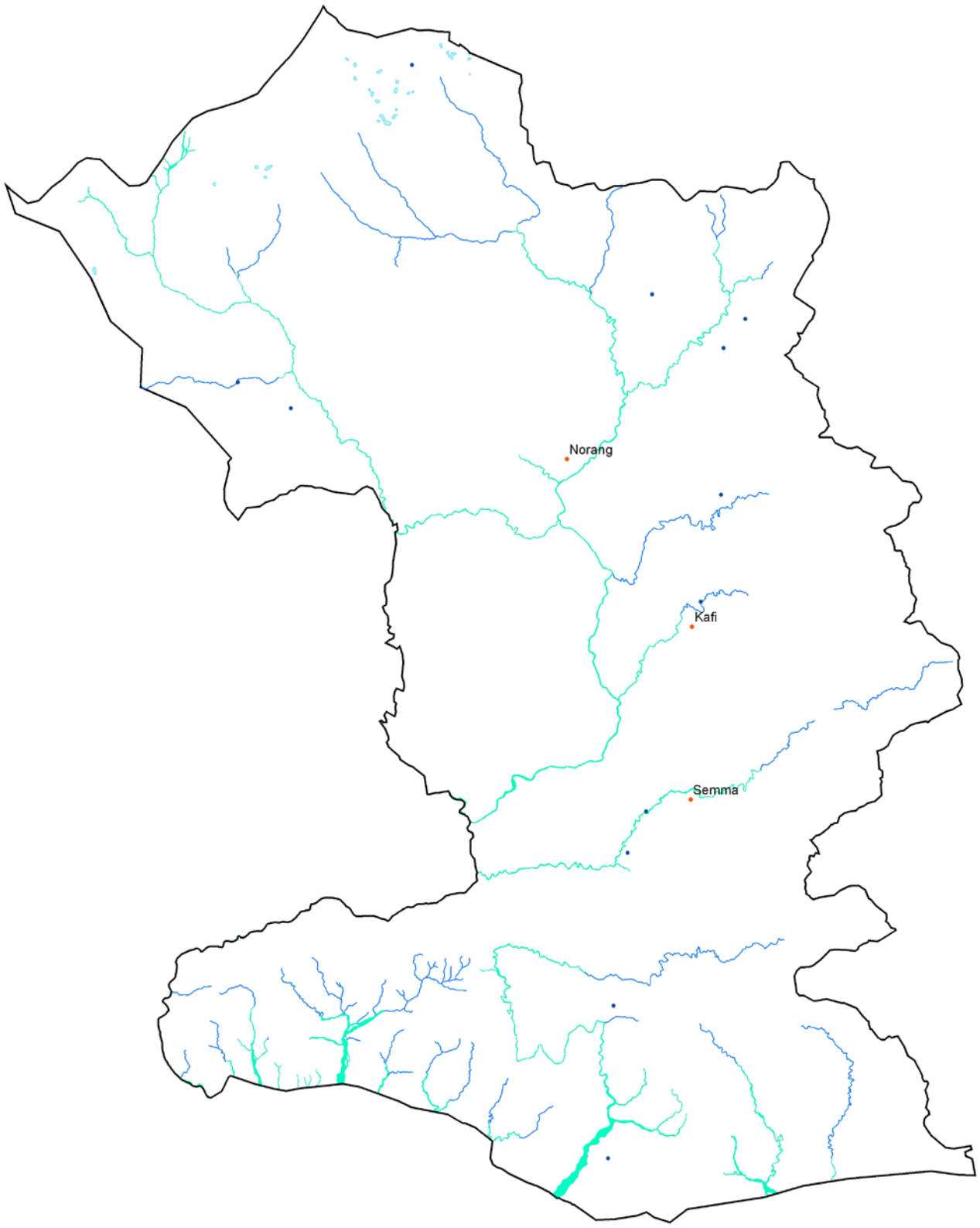
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2505	3524
Moderate	724	-
High	341	-

State : Arunachal Pradesh

WETLAND MAP

District : East Kameng

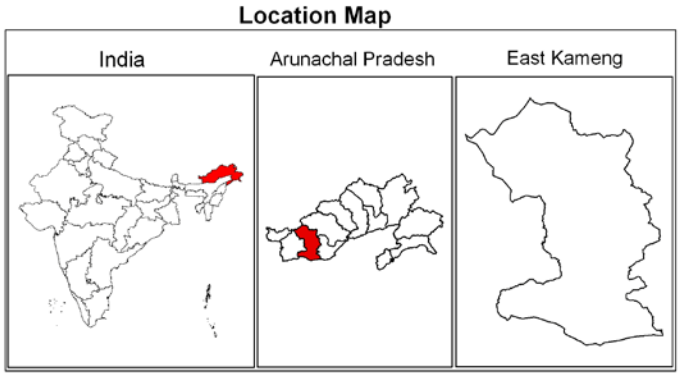


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



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Data Source :

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

Prepared By :

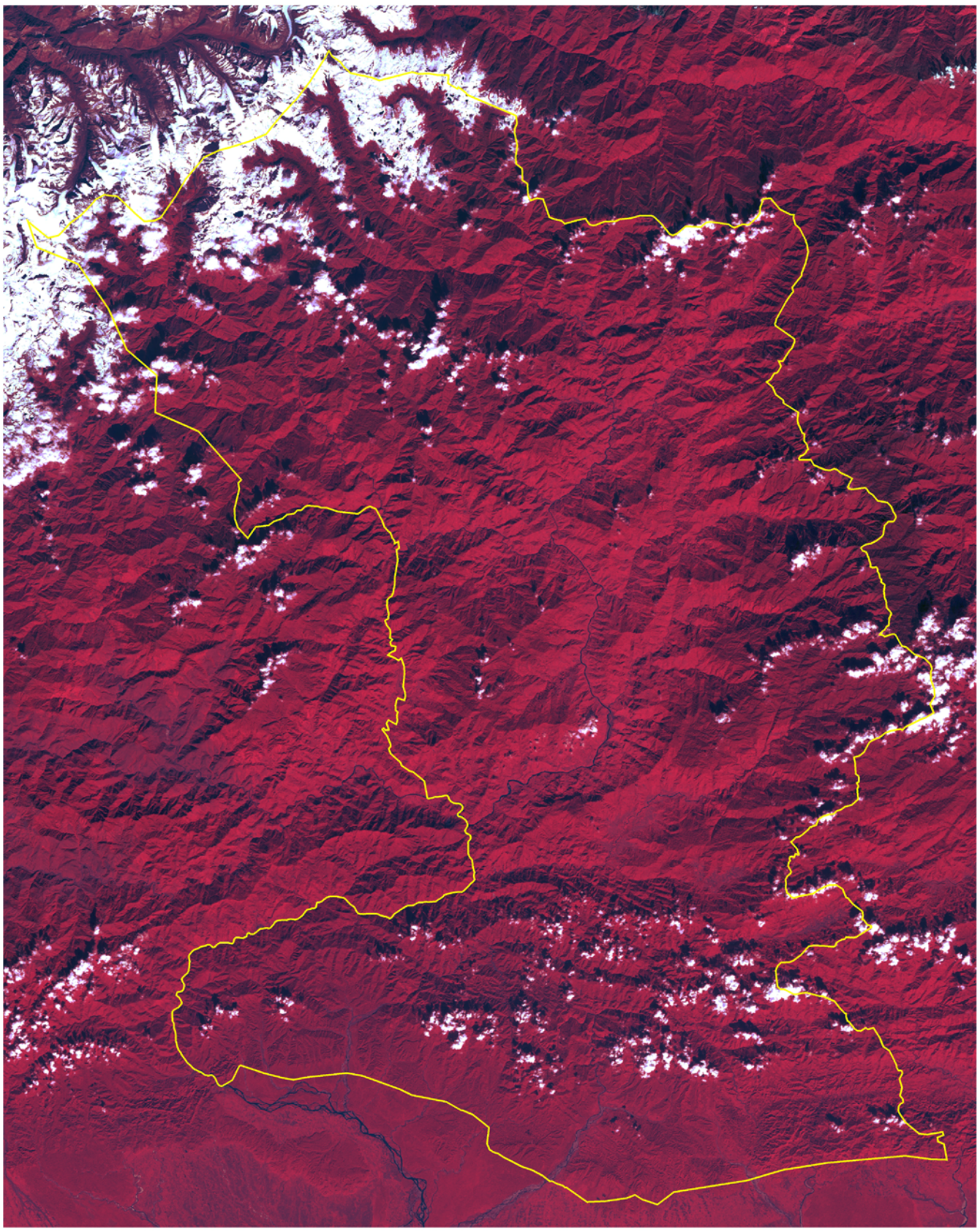
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : East Kameng



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

7.1.4 Wetland Distribution in Papum Pare

The district occupies an area of 2875 km² and has a population of 121,750 (as of 2001). The district headquarters are located at Yupia. Itanagar, which is state capital is also located at Papum Pare.

The wetland area estimated is 2718 ha. Small wetlands, which are less than minimum mapable units (MMU), are 28 in the district. The major wetland type is River/Streams. Details are given in Table 9.

Table 9: Area estimates of wetlands in Papum Pare

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1106	River/Stream	15	2681	98.64	1741	2005
	1200	**Inland Wetlands -Man-made**					
2	1201	Reservoirs/Barrages	1	9	0.33	7	8
		Sub-Total	**16**	**2690**	**98.97**	**1748**	**2013**
		Wetlands (<2.25 ha), mainly Tanks	28	28	1.03	-	-
		Total	**44**	**2718**	**100.00**	**1748**	**2013**

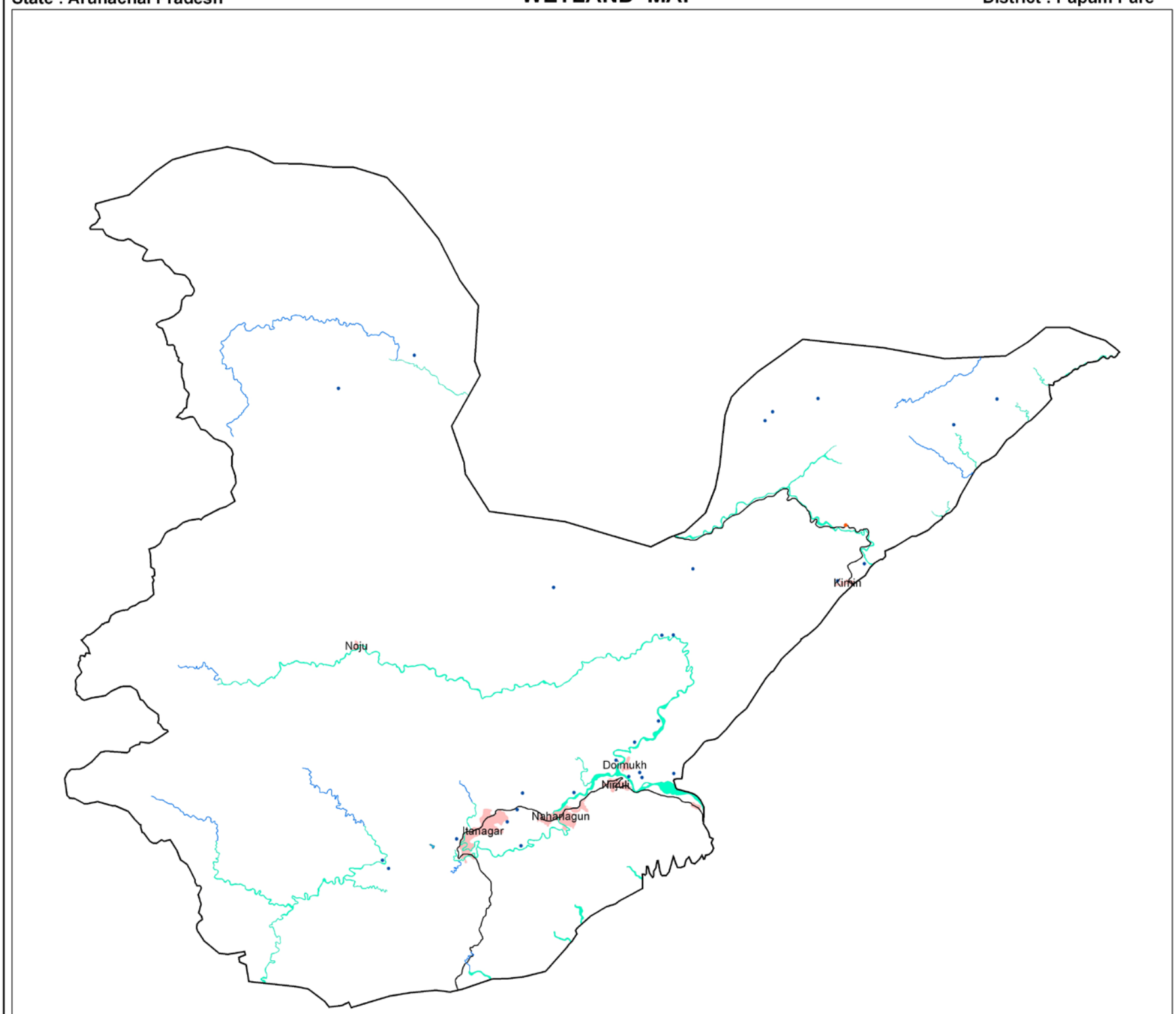
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	1390	1934
Moderate	202	79
High	156	-

State : Arunachal Pradesh

WETLAND MAP

District : Papum Pare

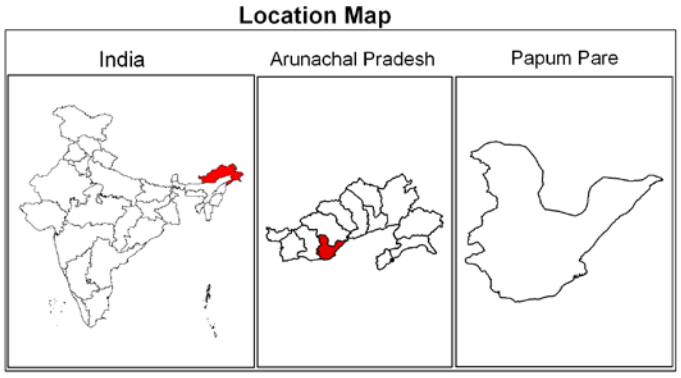


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 3 6 12 18 Kilometers

Data Source :

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

Prepared By :

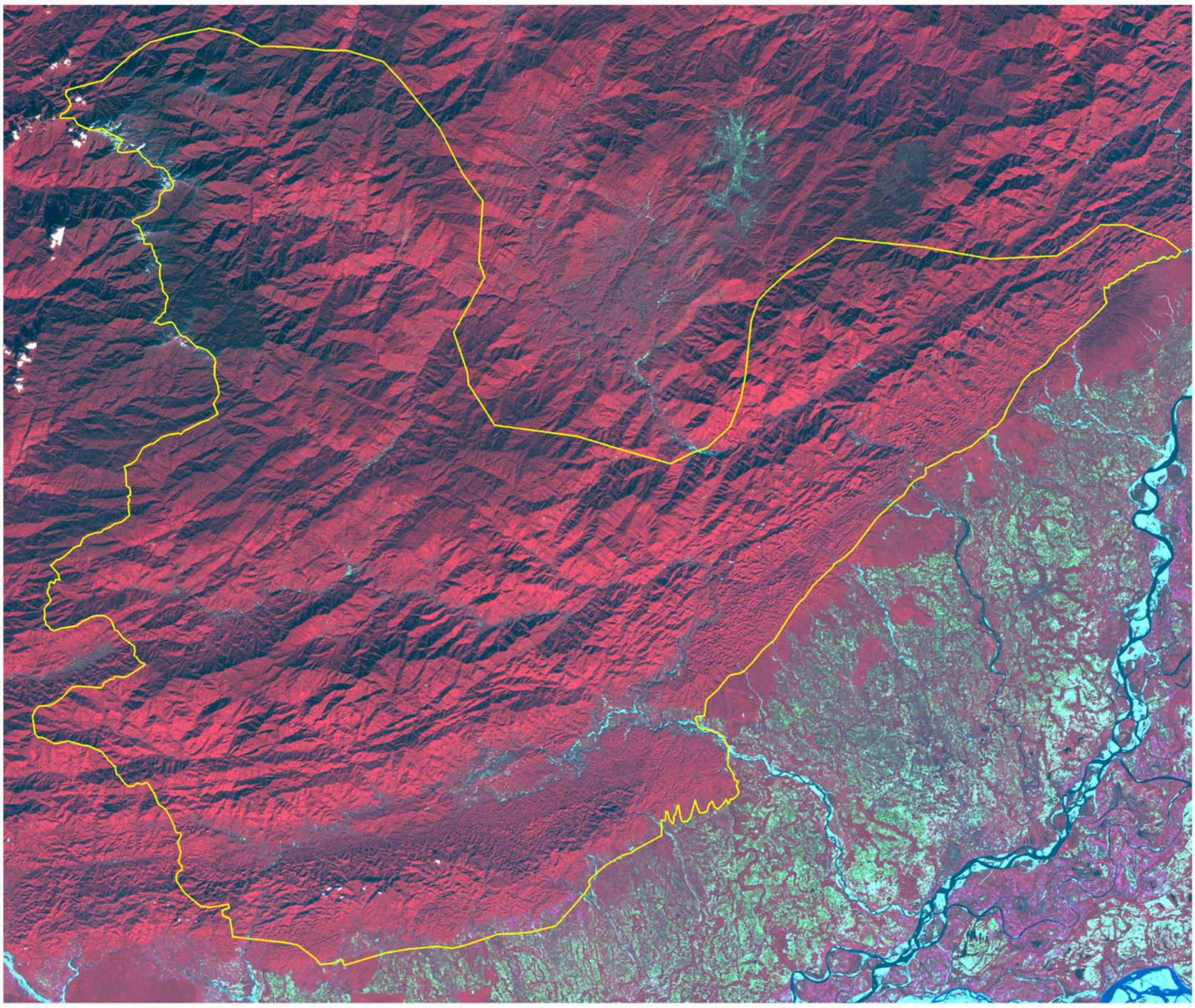
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Papum Pare



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

7.1.5 Wetland Distribution in Lower Subansiri

The district occupies an area of 10,135 km² and has a population of 97,614 (as of 2001). The district headquarters are located at Ziro. It is bounded on the North by China and Upper Subansiri District of Arunachal, on the South by Papum Pare District of Arunachal Pradesh and Assam, on the East by West Siang and some part of Upper Subansiri on the West by East Kameng Districts of Arunachal Pradesh.

The wetland area estimated is 3607 ha. Small wetlands, which are less than minimum mapable units (MMU), are 44 in the district. The major wetland types are River/stream and high altitude lakes. The turbidity of the open water is mainly low. Details are given in Table 10.

Table 10: Area estimates of wetlands in Lower Subansiri

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	1103	High altitude wetlands	31	241	6.68	237	-
2	1106	River/Stream	3	3322	92.10	2956	3023
		Sub-Total	**34**	**3563**	**98.78**	**3193**	**3023**
		Wetlands (<2.25 ha), mainly Tanks	44	44	1.22	-	-
		Total	**78**	**3607**	**100.00**	**3193**	**3023**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2665	3023
Moderate	271	-
High	257	-

State : Arunachal Pradesh

WETLAND MAP

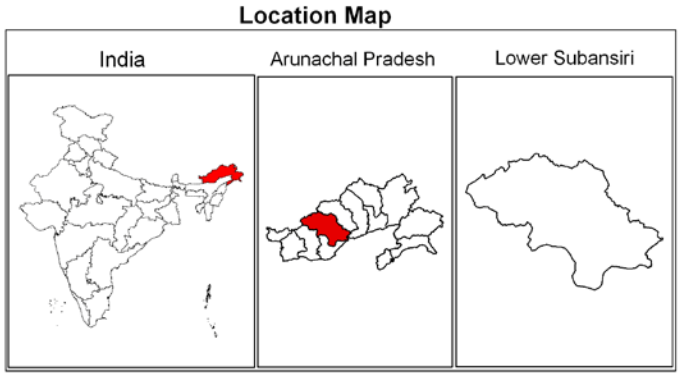
District : Lower Subansiri

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

Legend

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

Location Map



Data Source :

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

Prepared By :

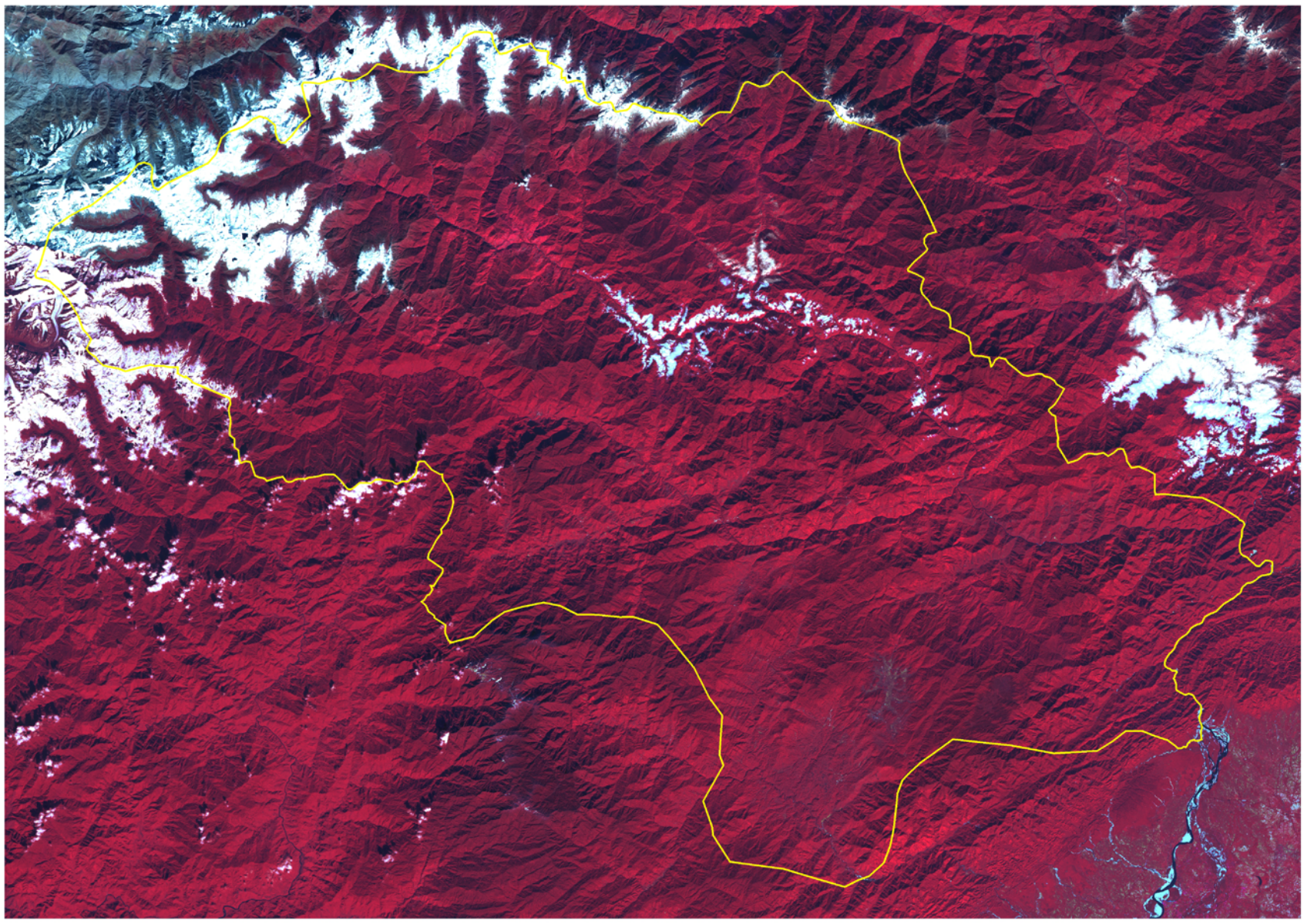
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Lower Subansiri



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

7.1.6 Wetland Distribution in Upper Subansiri

The district headquarters are located at Daporijo. The district occupies an area of 7032 km² and has a population of 54,995 (as of 2001). Members of the Tagin, Hill Miri and Adi tribal are found in the district

The wetland area estimated is 3365 ha. Small wetlands, which are less than minimum mapable units (MMU), are 28 in the district. The major wetland types are River/Streams and high altitude lakes. Details are given in Table 11.

Table11: Area estimates of wetlands in Upper Subansiri

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	11	0.33	-	-
2	1103	High altitude wetlands	53	577	17.15	564	66
3	1106	River/Stream	3	2749	81.69	2360	2381
		Sub-Total	**57**	**3337**	**99.17**	**2924**	**2447**
		Wetlands (<2.25 ha), mainly Tanks	28	28	0.83	-	-
		Total	**85**	**3365**	**100.00**	**2924**	**2447**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2800	2426
Moderate	109	21
High	15	-

State : Arunachal Pradesh

WETLAND MAP

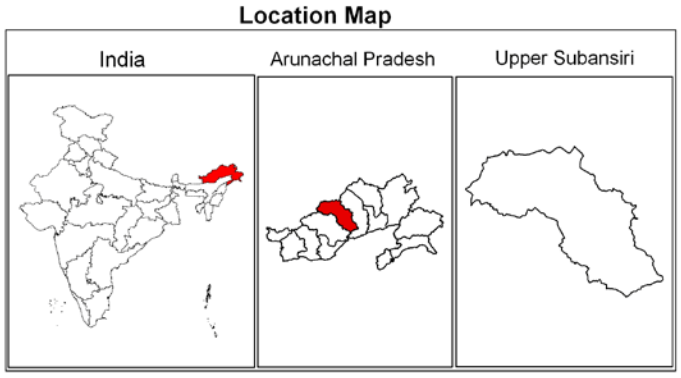
District : Upper Subansiri

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

Legend

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

Location Map



0 4 8 16 24 Kilometers

Data Source :

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

Prepared By :

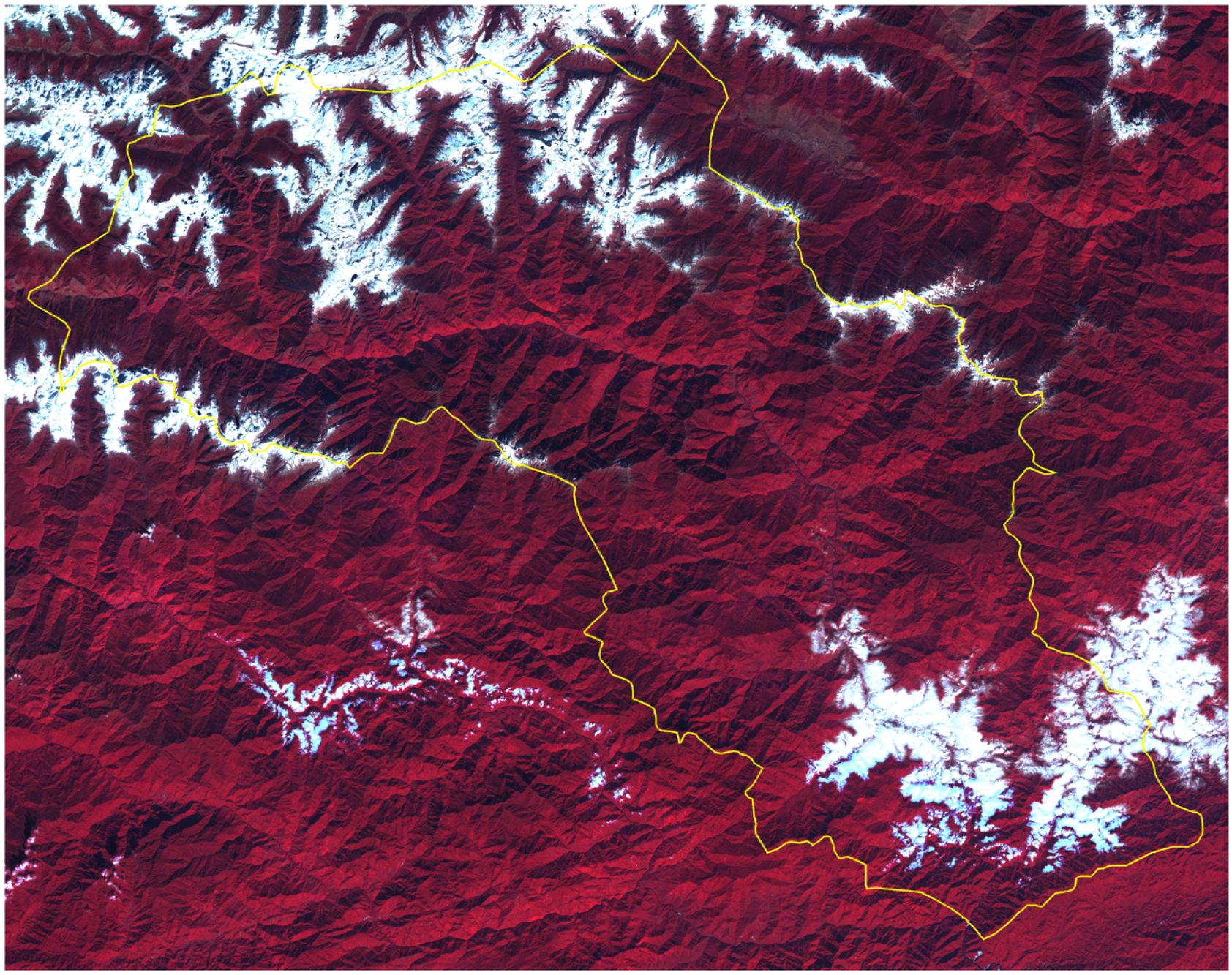
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Upper Subansiri



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

7.1.7 Wetland Distribution in West Siang

The district headquarters are located at Aalo. The district occupies an area of 8325 km² and has a population of 103,575 (as of 2001). Various tribal groups of the Adi people, Memba and Khamba tribes live in the district.

The wetland area estimated is 6147 ha. Small wetlands, which are less than minimum mapable units (MMU), are 72 in the district. The major wetland types are High altitude lakes and River/Streams. Details are given in Table 12.

Table 12: Area estimates of wetlands in West Siang

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	1103	High altitude wetlands	57	368	5.99	282	123
2	1106	River/Stream	33	5703	92.78	4358	4880
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	1	4	0.07	4	4
		Sub-Total	**91**	**6075**	**98.83**	**4644**	**5007**
		Wetlands (<2.25 ha), mainly Tanks	72	72	1.17	-	-
		Total	**163**	**6147**	**100.00**	**4644**	**5007**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2291	3665
Moderate	2089	448
High	264	894

State : Arunachal Pradesh

WETLAND MAP

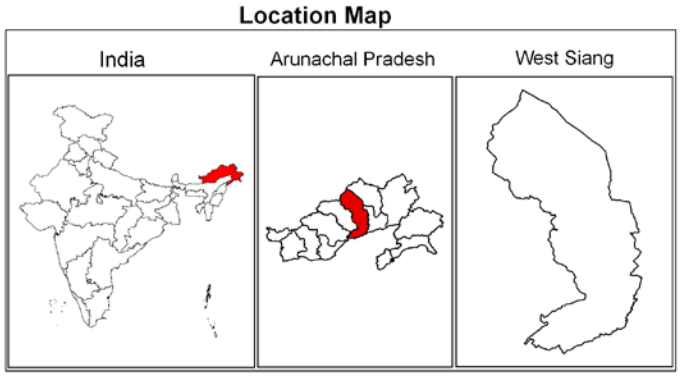
District : West Siang

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

Legend

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

Location Map



0 5 10 20 30 Kilometers

Data Source :

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

Prepared By :

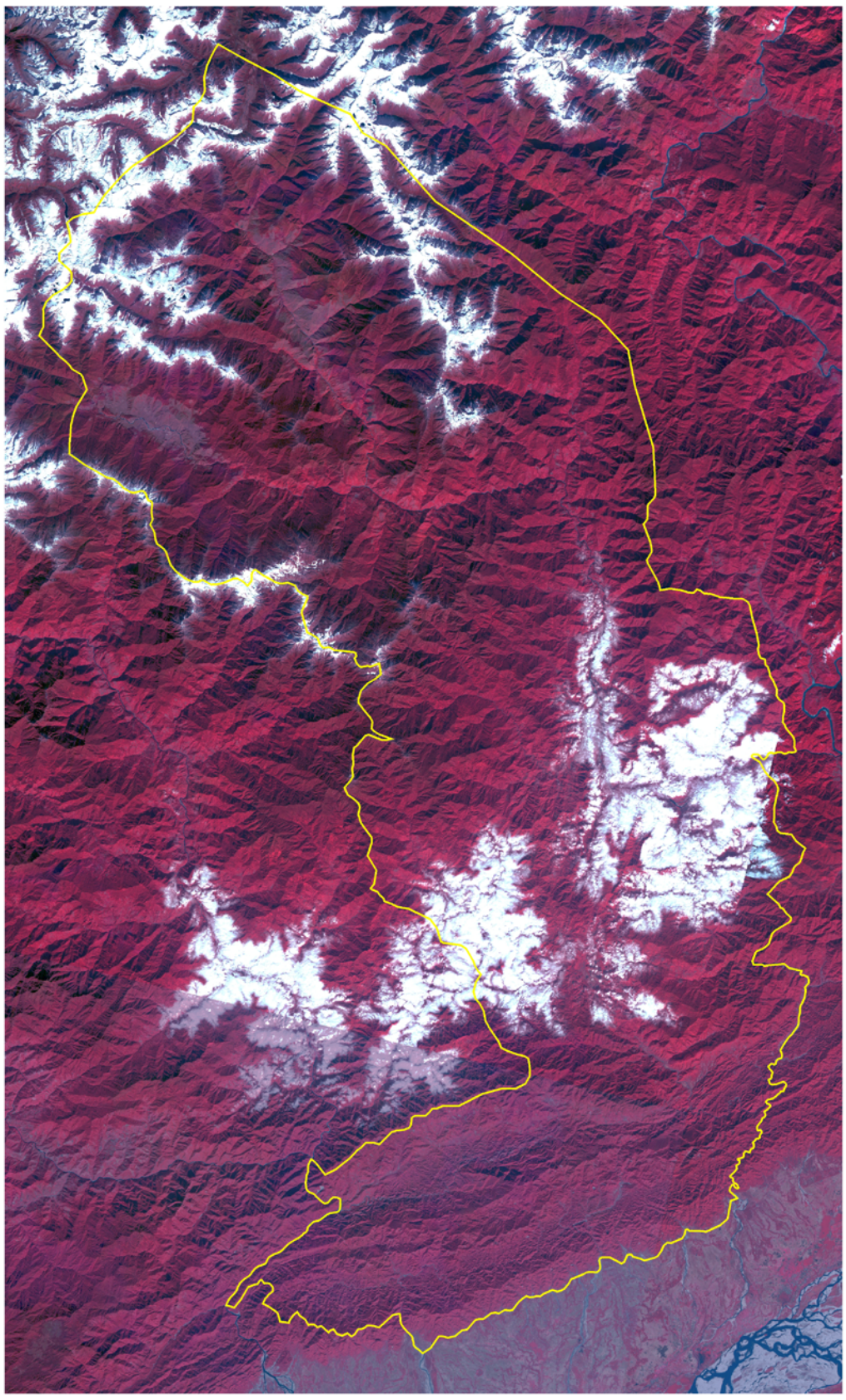
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : West Siang



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

7.1.8 Wetland Distribution in East Siang

The district headquarter is located at Pasighat. The district occupies an area of 4,005 square kilometres and has a population of 87,430 (as of 2001). Various tribal groups of the Adi people live in various parts of the district.

The wetland area estimated is 25,512 ha. Small wetlands, which are less than minimum mapable units (MMU), are 130 in the district. The major wetland types are Waterlogged, River/Streams and ox-bow lakes. The turbidity of the open water is mainly low. Details are given in Table 13.

Table 13: Area estimates of wetlands in East Siang

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1102	Ox-bow lakes/ Cut-off meanders	3	50	0.20	13	35
2	1105	Waterlogged	15	634	2.49	2	2
3	1106	River/Stream	26	24647	96.61	11010	7811
	1200	**Inland Wetlands -Man-made**					
4	1202	Tanks/Ponds	15	51	0.20	16	-
		Sub-Total	**59**	**25382**	**99.49**	**11041**	**7848**
		Wetlands (<2.25 ha), mainly Tanks	130	130	0.51	-	-
		Total	**189**	**25512**	**100.00**	**11041**	**7848**

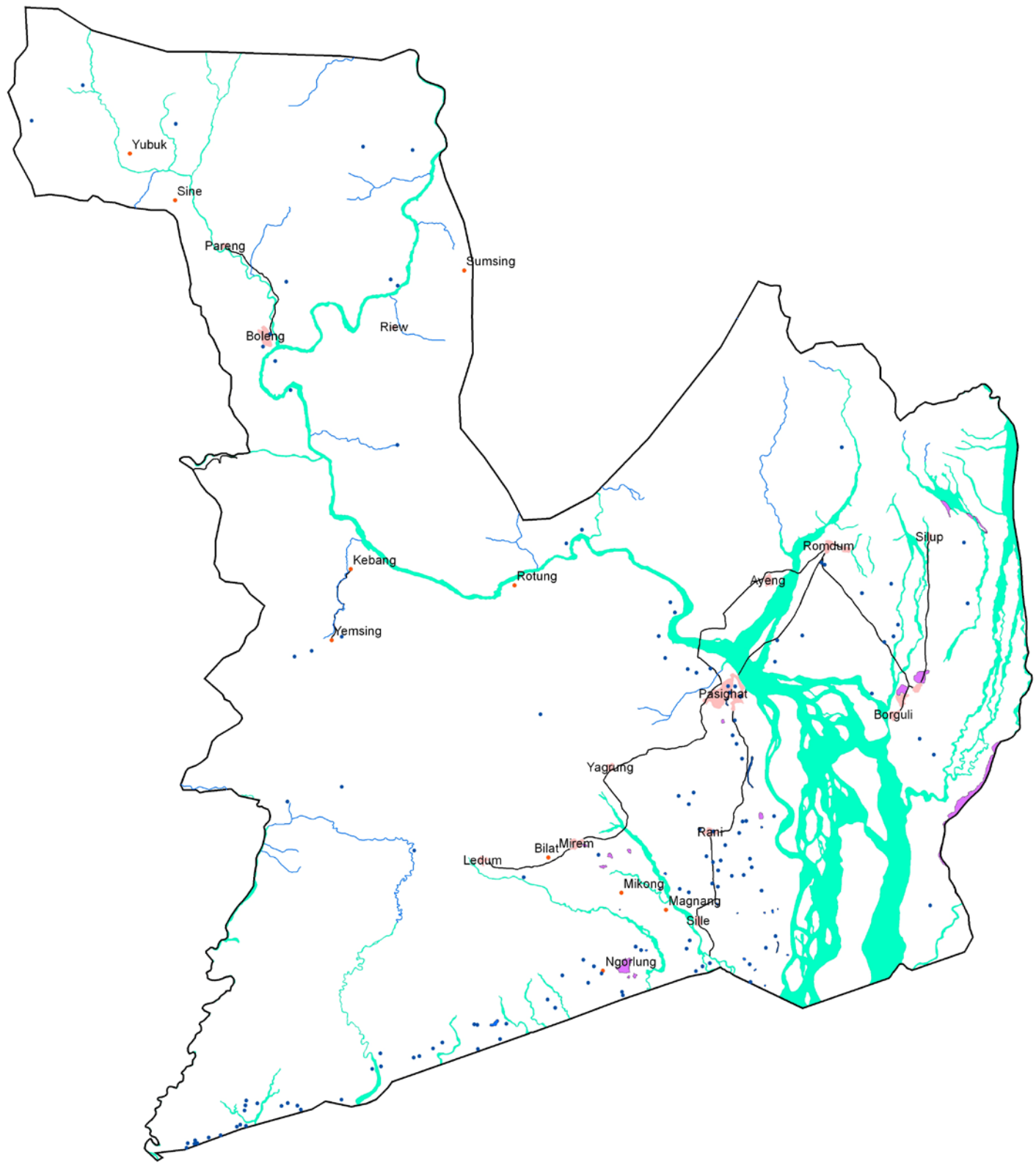
Area under Aquatic Vegetation	554	244

Area under turbidity levels		
Low	10720	7152
Moderate	321	321
High	-	375

State : Arunachal Pradesh

WETLAND MAP

District : East Siang

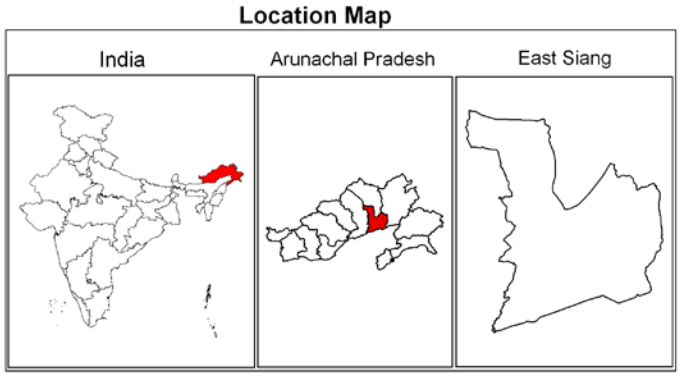


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 3 6 12 18 Kilometers

Data Source :

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

Prepared By :

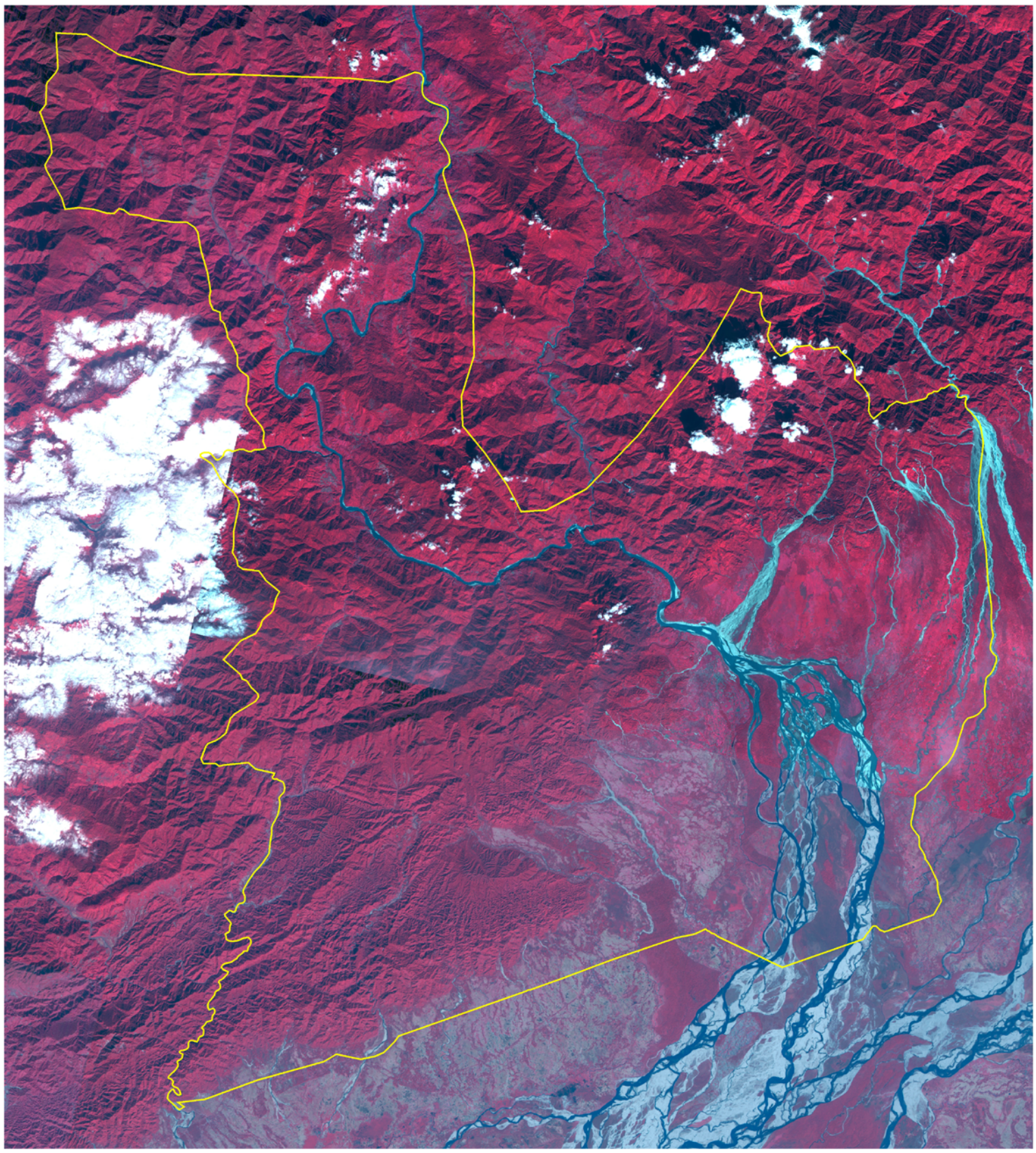
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : East Siang



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

7.1.9 Wetland Distribution in Upper Siang

Upper Siang is an administrative district in the state of Arunachal Pradesh in India. The district headquarters are located at Yingkiong. The district occupies an area of 6188 km² and has a population of 33,146 (as of 2001). Various tribal groups of the Adi people and the Memba tribe live in the district. The district is the location of the massive Upper Siang Hydroelectric Project.

The wetland area estimated is 6,686 ha. Small wetlands, which are less than minimum mapable units (MMU), are 49 in the district. The major wetland types are River/Stream and high altitude lakes. The turbidity of the open water is mainly low. Details are given in Table 14.

Table 14: Area estimates of wetlands in Upper Siang

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	1103	High altitude wetlands	67	567	8.48	388	72
2	1106	River/Stream	6	6070	90.79	4926	3812
		Sub-Total	**73**	**6637**	**99.27**	**5314**	**3884**
		Wetlands (<2.25 ha), mainly Tanks	49	49	0.73	-	-
		Total	**122**	**6686**	**100.00**	**5314**	**3884**

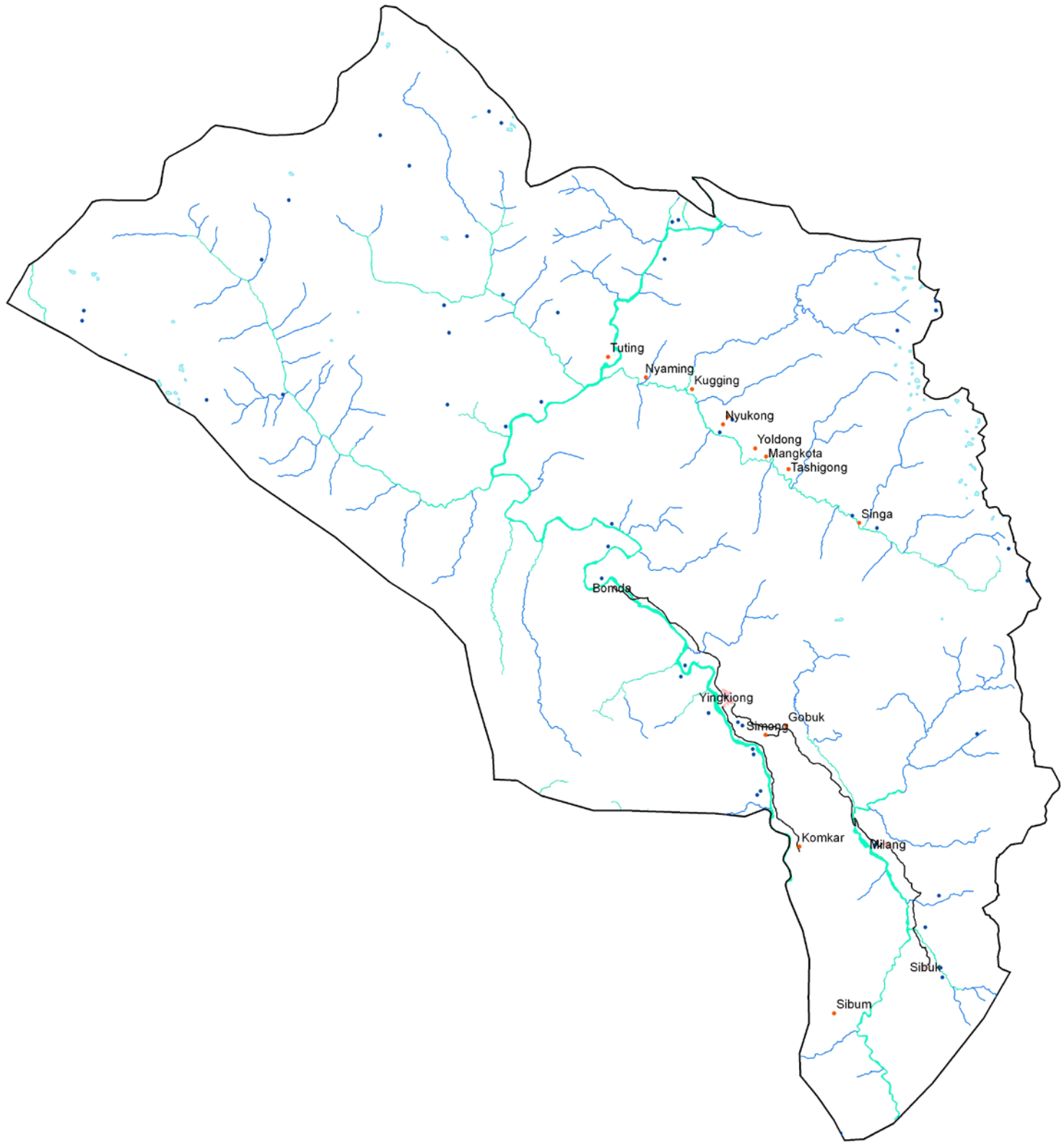
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	3670	3260
Moderate	1538	619
High	107	4

State : Arunachal Pradesh

WETLAND MAP

District : Upper Siang

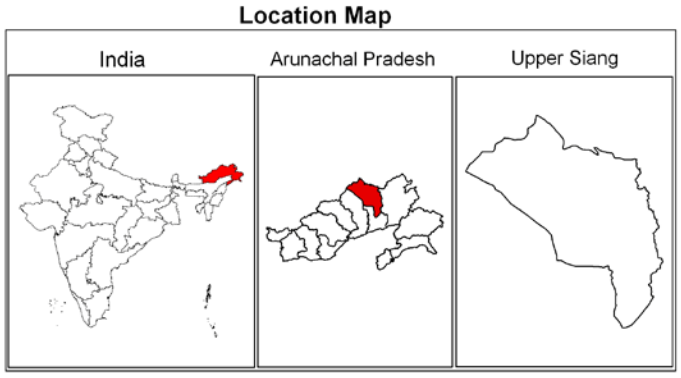


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 4.5 9 18 27 Kilometers

Data Source :

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

Prepared By :

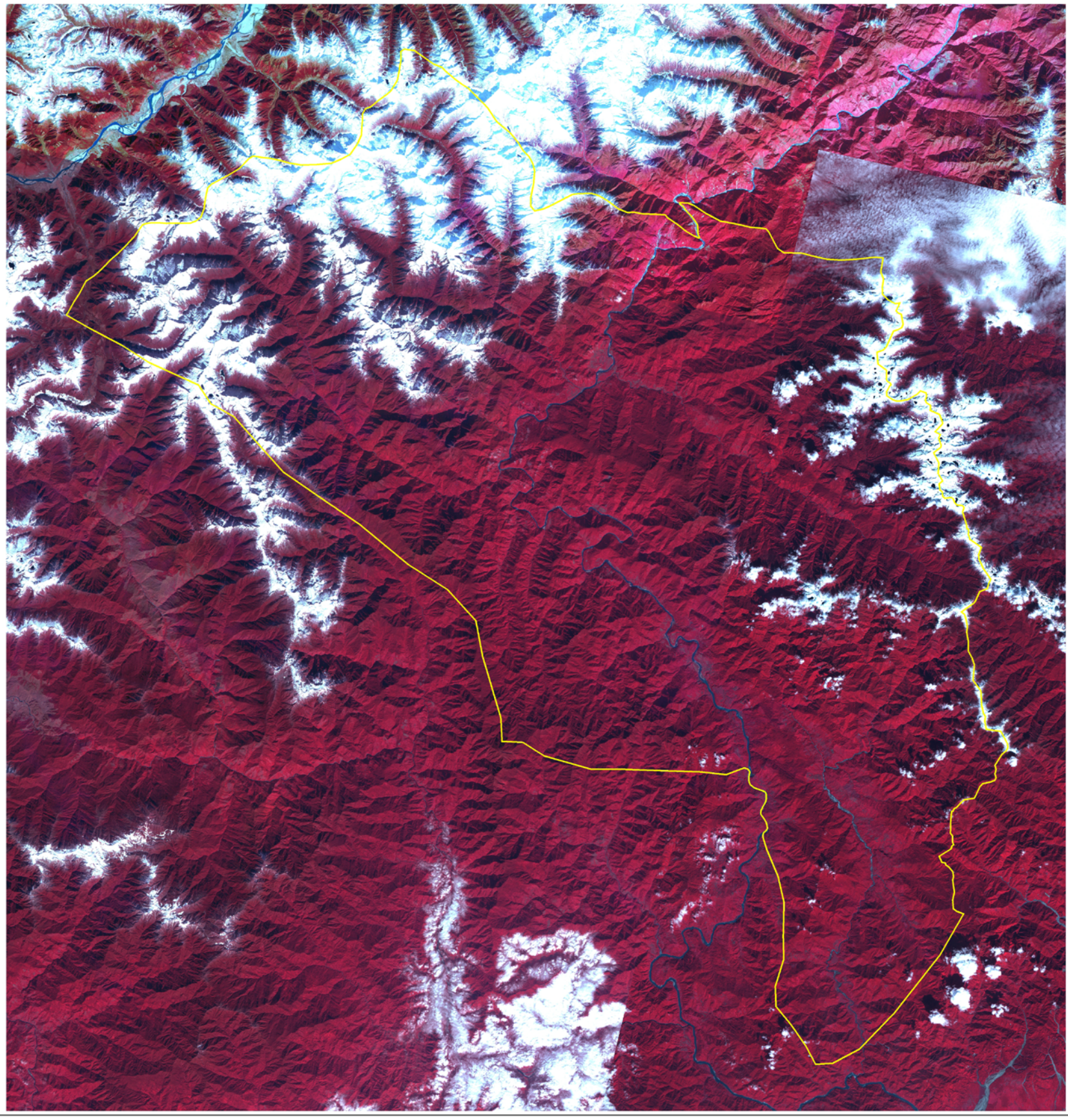
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Upper Siang



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

7.1.10 Wetland Distribution in Dibang Valley

The Dibang Valley is a district of Arunachal Pradesh named after the Dibang River or the Talon as the Idus call it. The river originates in the mountains of China and flows through the length of the valley, named after it. The major population of this district consist of the Adis (padams) and the idus.

The district has been divided further into lower and upper Dibang Valley for administrative convenience.The headquarters of the two districts are Roing and Anini respectively. Roing is a newborn town in the plains of the Mishmi hills. It is a beautiful place with picturesque nature and beautiful climate.

There are about 443 high altitude lakes exists in the districts. The wetland area of the district is 37,605 ha. Small wetlands, which are less than minimum mapable units (MMU), are 266 in the district. The major wetland types are River/Stream and high altitude lakes. The turbidity of the open water is mainly low. Details are given in Table 15.

Table 15: Area estimates of wetlands in Dibang Valley

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1102	Ox-bow lakes/ Cut-off meanders	3	7	0.02	5	1
2	1103	High altitude wetlands	443	5290	14.07	3631	1191
3	1106	River/Stream	23	31503	83.77	8912	8346
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/Barrages	2	121	0.32	121	81
5	1202	Tanks/Ponds	11	21	0.06	13	4
		Sub-Total	**484**	**37339**	**99.29**	**12682**	**9623**
		Wetlands (<2.25 ha), mainly Tanks	266	266	0.71	-	-
		Total	**750**	**37605**	**100.00**	**12682**	**9623**

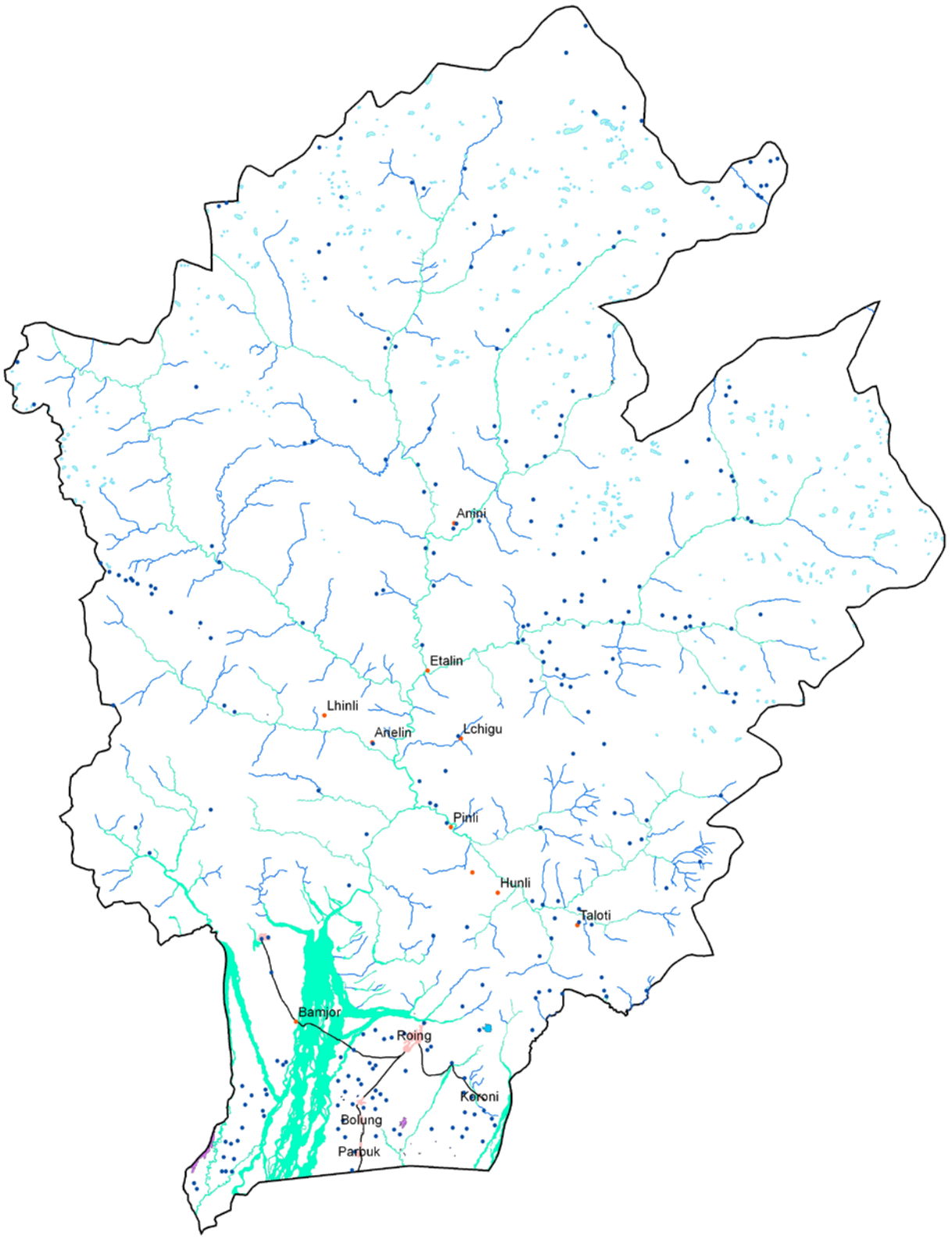
Area under Aquatic Vegetation	382	23

Area under turbidity levels		
Low	10708	1103
Moderate	1927	7628
High	47	892

State : Arunachal Pradesh

WETLAND MAP

District : Dibang Valley

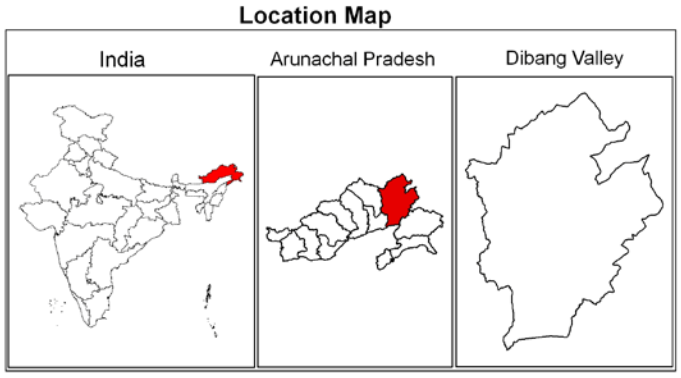


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 5 10 20 30 Kilometers

Data Source :

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

Prepared By :

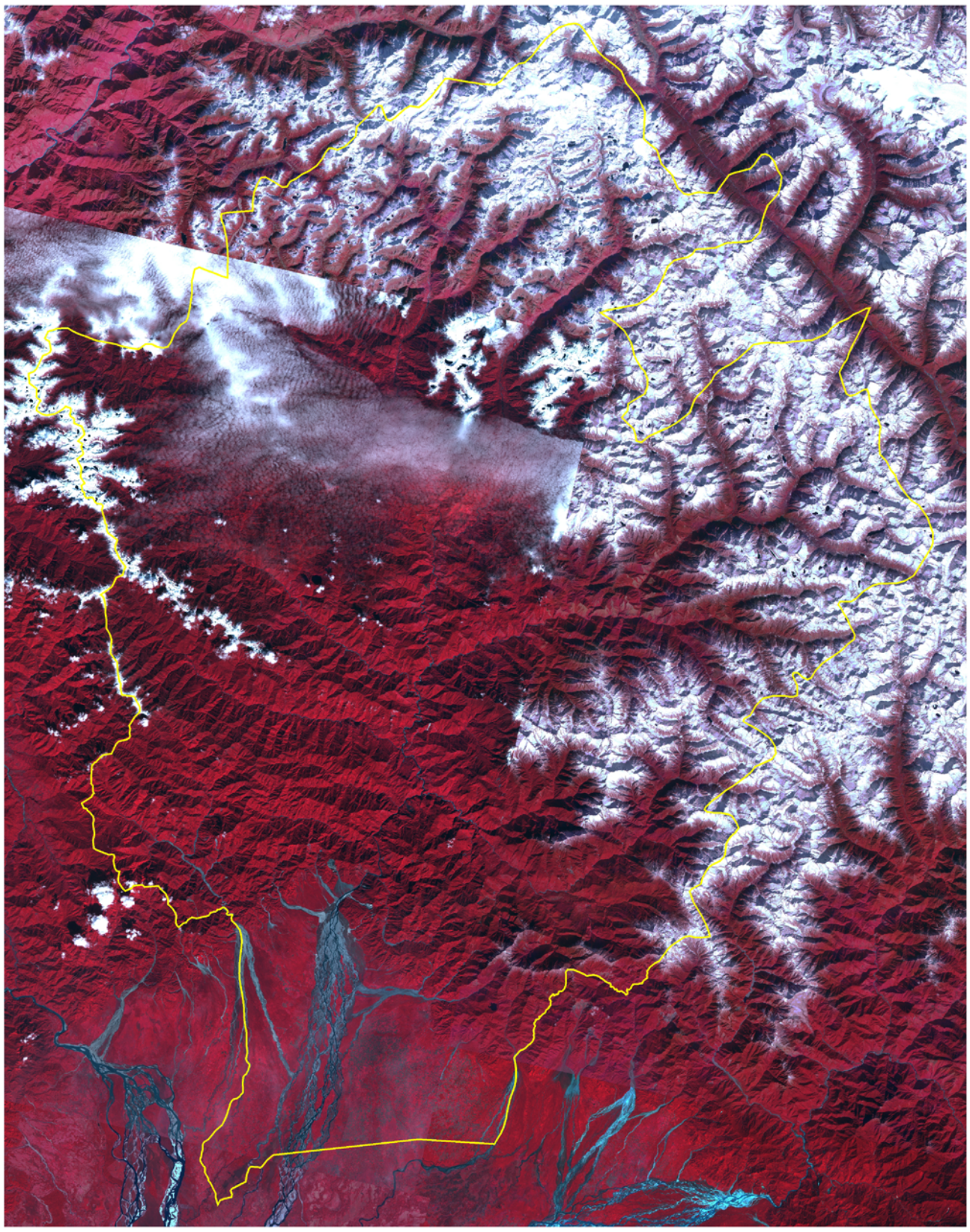
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Dibang Valley



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

7.1.11 Wetland Distribution in Lohit

Lohit is an administrative district in the state of Arunachal Pradesh in India. The district headquarters are located at Tezu. The district occupies an area of 11,402 km² and has a population of 143,478 (as of 2001). The district is named after the Lohit River, from the Sanskrit *Louhitya*, reddish- or rust-coloured, and consists of the river valley and hills/mountains to the North and South.

The area is highly inaccessible, and it is only in 2004 that a permanent bridge has been made operational across the Lohit at the holy site of Parashuram Kund, giving round-the-year connection to Tezu. East of Tezu (about 100 km.) lies the small town of Hayuliang, and this is slated to become the headquarters of a new district.

Lohit is the home of the Zekhring, Khampti, Deori, Singpho and Mishmi tribes. A small group of Tibetan refugees have settled in Lohit since the 1960s. The Zekhring are Tibetan Buddhists; the Khampti and Singpho are Theravada Buddhists, and the Mishmi are mainly Animists.

On 16 February, 2004, Anjaw district was carved out from the northern part of Lohit district bordering Tibet and Myanmar, with its Headquarters at Hawai. Anjaw was carved out under The Arunachal Pradesh Re-organization of Districts Amendment Bill.

The wetland area estimated is 45,719 ha. Small wetlands, which are less than minimum mapable units (MMU), are 240 in the district. The major wetland types are River/Stream, high altitude lakes, waterlogged and ox-bow lakes. Details are given in Table 16.

Table 16: Area estimates of wetlands in Lohit

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	7	0.02	16	-
2	1102	Ox-bow lakes/ Cut-off meanders	11	290	0.63	54	3
3	1103	High altitude wetlands	256	2640	5.77	1378	383
4	1105	Waterlogged	37	5525	12.08	45	2
5	1106	River/Stream	14	36967	80.86	10138	10272
	1200	**Inland Wetlands -Man-made**					
6	1201	Reservoirs/Barrages	1	35	0.08	35	35
7	1202	Tanks/Ponds	3	15	0.03	10	-
		Sub-Total	**324**	**45479**	**99.48**	**11676**	**10695**
		Wetlands (<2.25 ha), mainly Tanks	240	240	0.52	-	-
		Total	**564**	**45719**	**100.00**	**11676**	**10695**

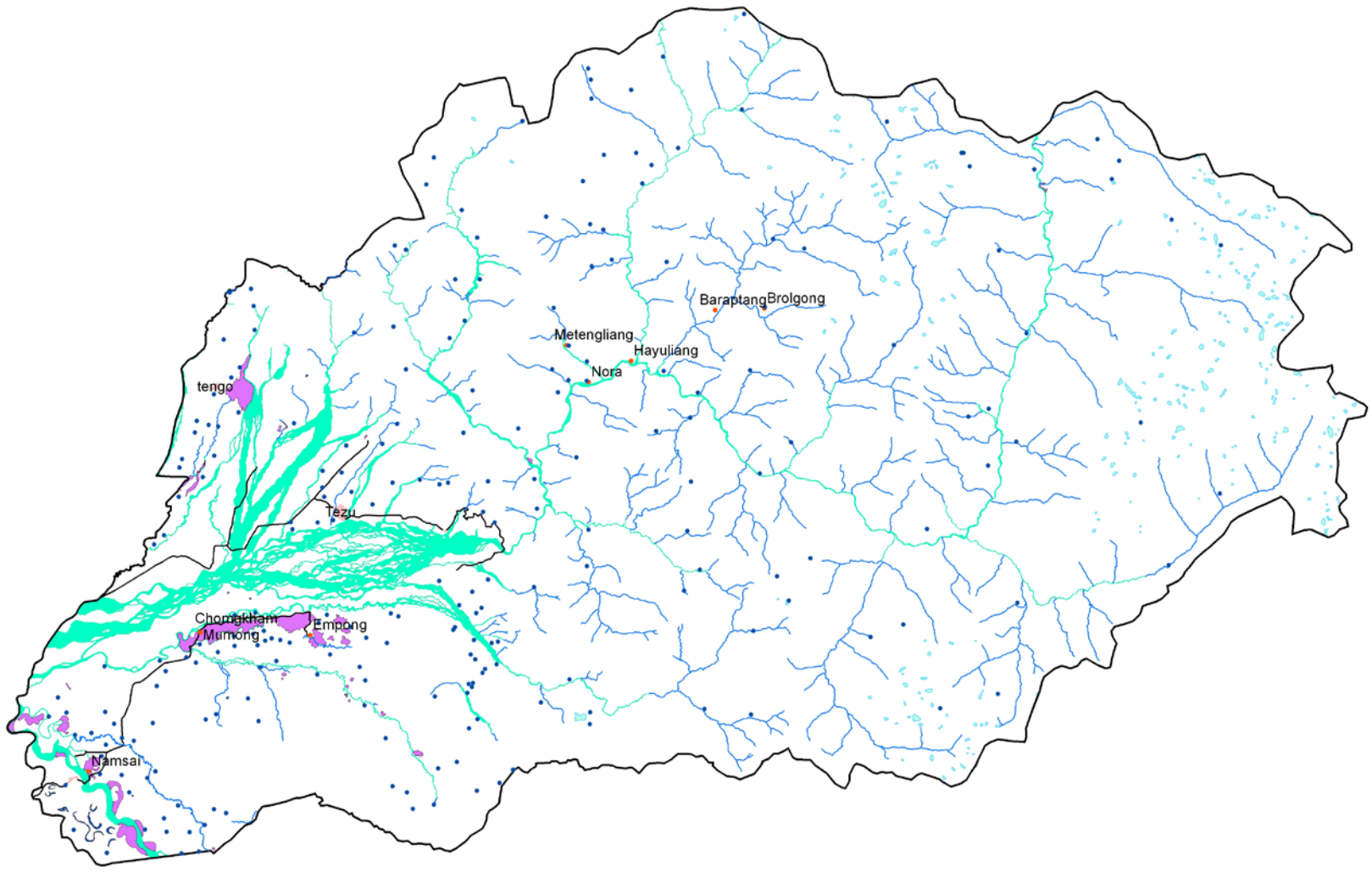
Area under Aquatic Vegetation	4208	4724

Area under turbidity levels		
Low	11496	10624
Moderate	180	71
High	-	-

State : Arunachal Pradesh

WETLAND MAP

District : Lohit

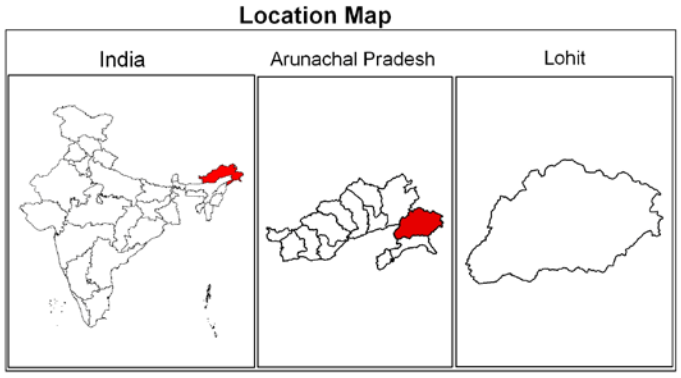


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 4.5 9 18 27 Kilometers

Data Source :

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

Prepared By :

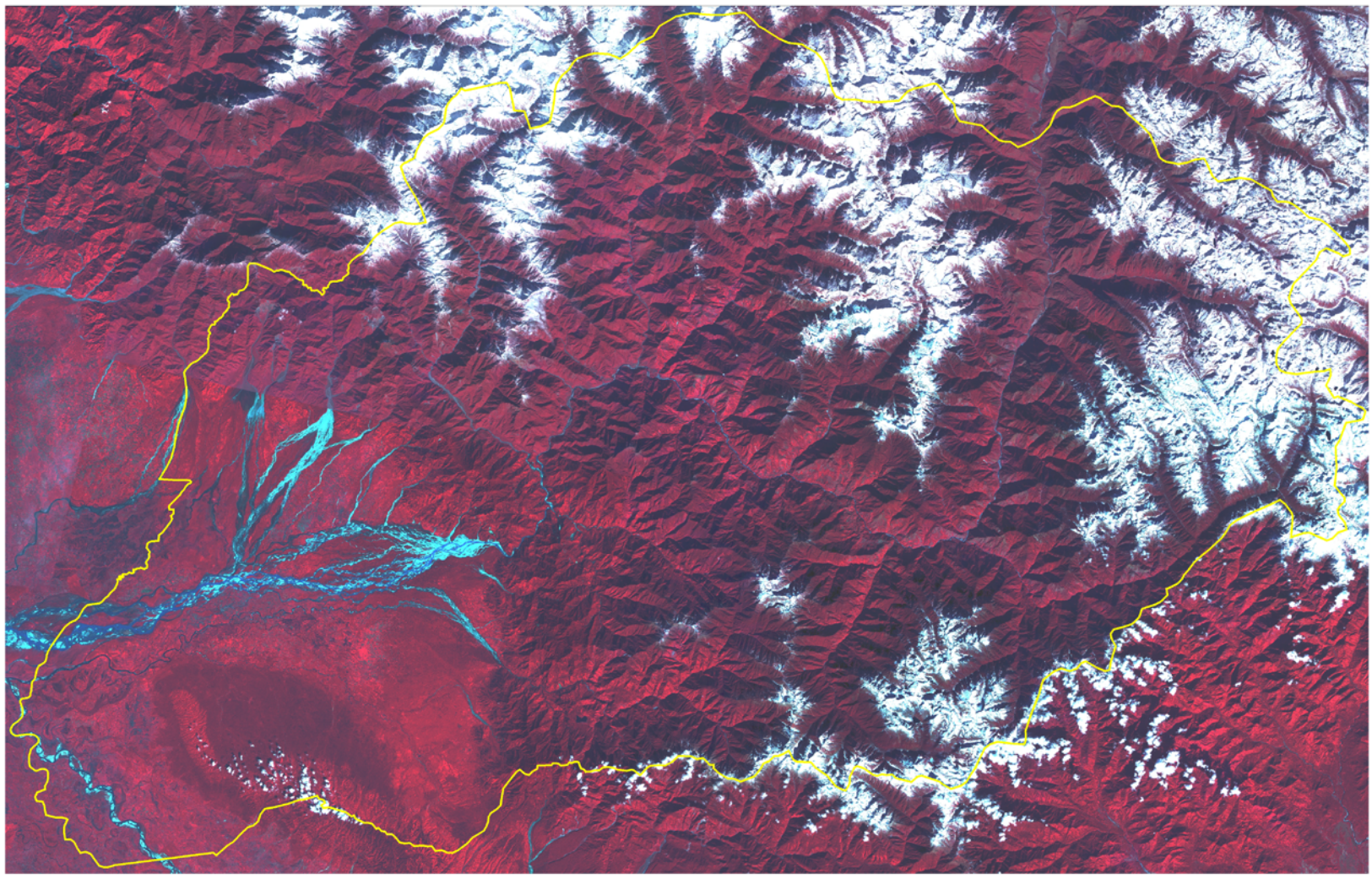
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Lohit



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

7.1.12 Wetland Distribution in Changlang

The Changlang district is located in Arunachal Pradesh, located south of the Lohit district and north of the Tirap district. Total geographic area of the district is 2362 sq km. The changlang town is a district head quarter. Total population of the district is 1,25,334(census 2001).

Changlang is populated by tribal groups, namely Tutsa, Tangsa, Nocte, Singpho and the Lisu. Sizeable communities of the Tibetans, Bodo Hajong and Chakma refugees do exist. The Tibetan refugees are clustered at Choephelling Tibetan Refugee settlement in Miao, which was set up in 1976 has hosts a population of 2200.

The Namdapha Tiger reserve is located in Miao town of this district. The other places to visit are World War II cemetery in Jairampur, Indo-Myanmar border town Nampong and Pangsau Pass.

The wetland area estimated is 12,017 ha. Small wetlands, which are less than minimum mapable units (MMU), are 117 in the district. The major wetland type is River/Stream and waterlogged area. Details are given in Table 17.

Table 17: Area estimates of wetlands in Changlang

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1102	Ox-bow lakes/ Cut-off meanders	10	155	1.29	89	-
2	1103	High altitude wetlands	3	18	0.15	14	2
3	1105	Waterlogged	53	1583	13.17	13	3
4	1106	River/Stream	25	10144	84.41	3427	3637
		Sub-Total	**91**	**11900**	**99.03**	**3543**	**3642**
		Wetlands (<2.25 ha), mainly Tanks	117	117	0.97	-	-
		Total	**208**	**12017**	**100.00**	**3543**	**3642**

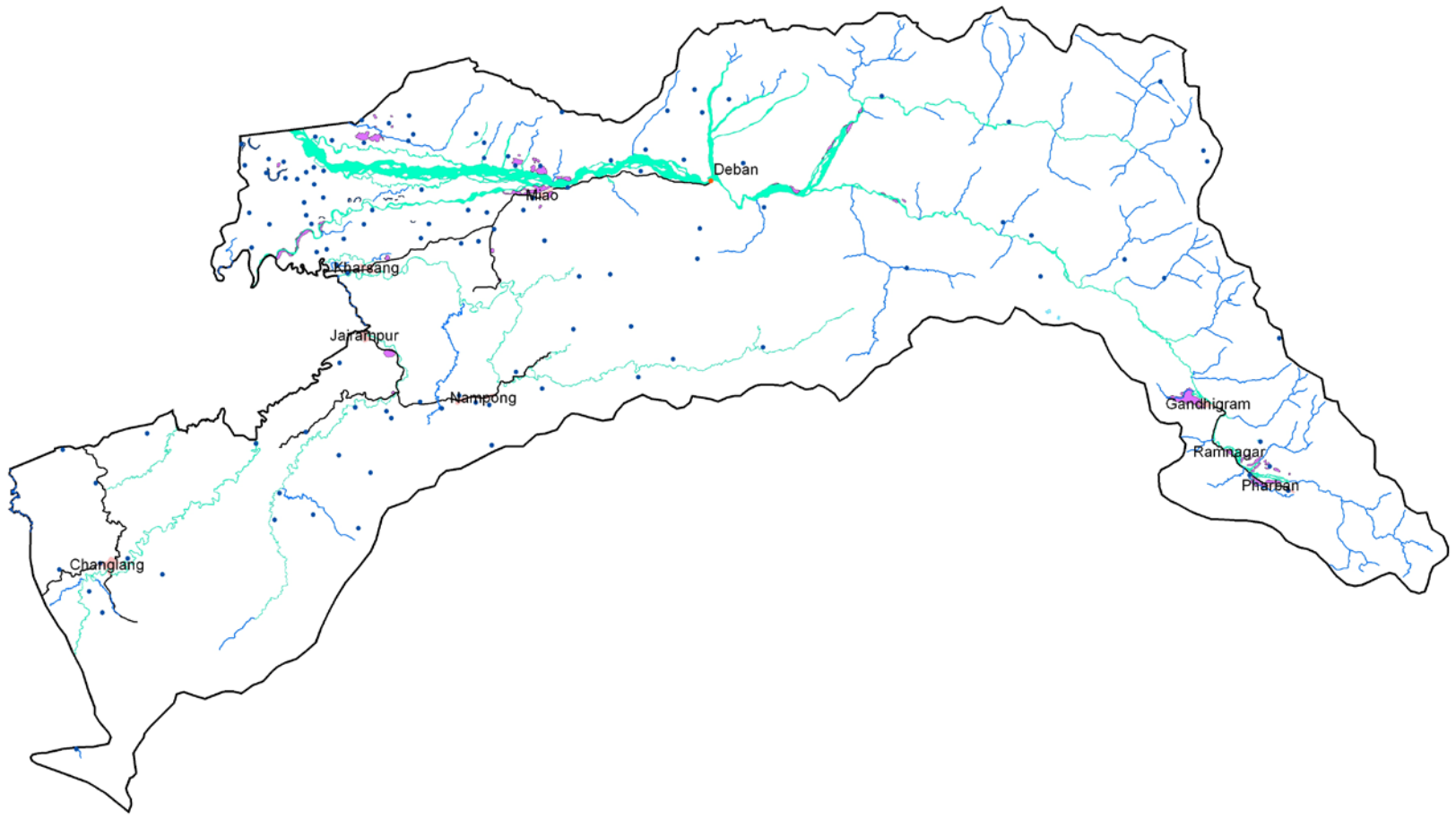
Area under Aquatic Vegetation	851	928

Area under turbidity levels		
Low	2668	3289
Moderate	364	353
High	512	-

State : Arunachal Pradesh

WETLAND MAP

District : Changlang

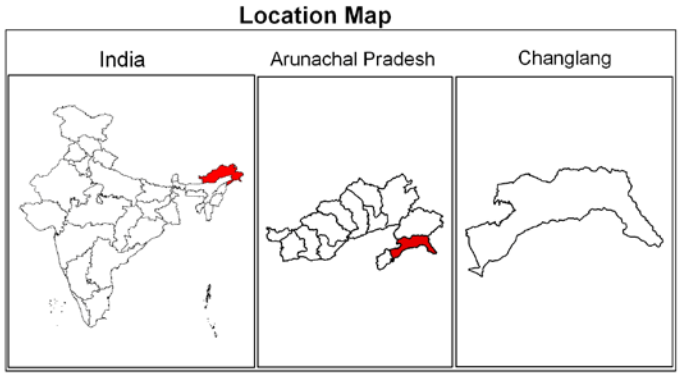


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 4.5 9 18 27 Kilometers

Data Source :

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

Prepared By :

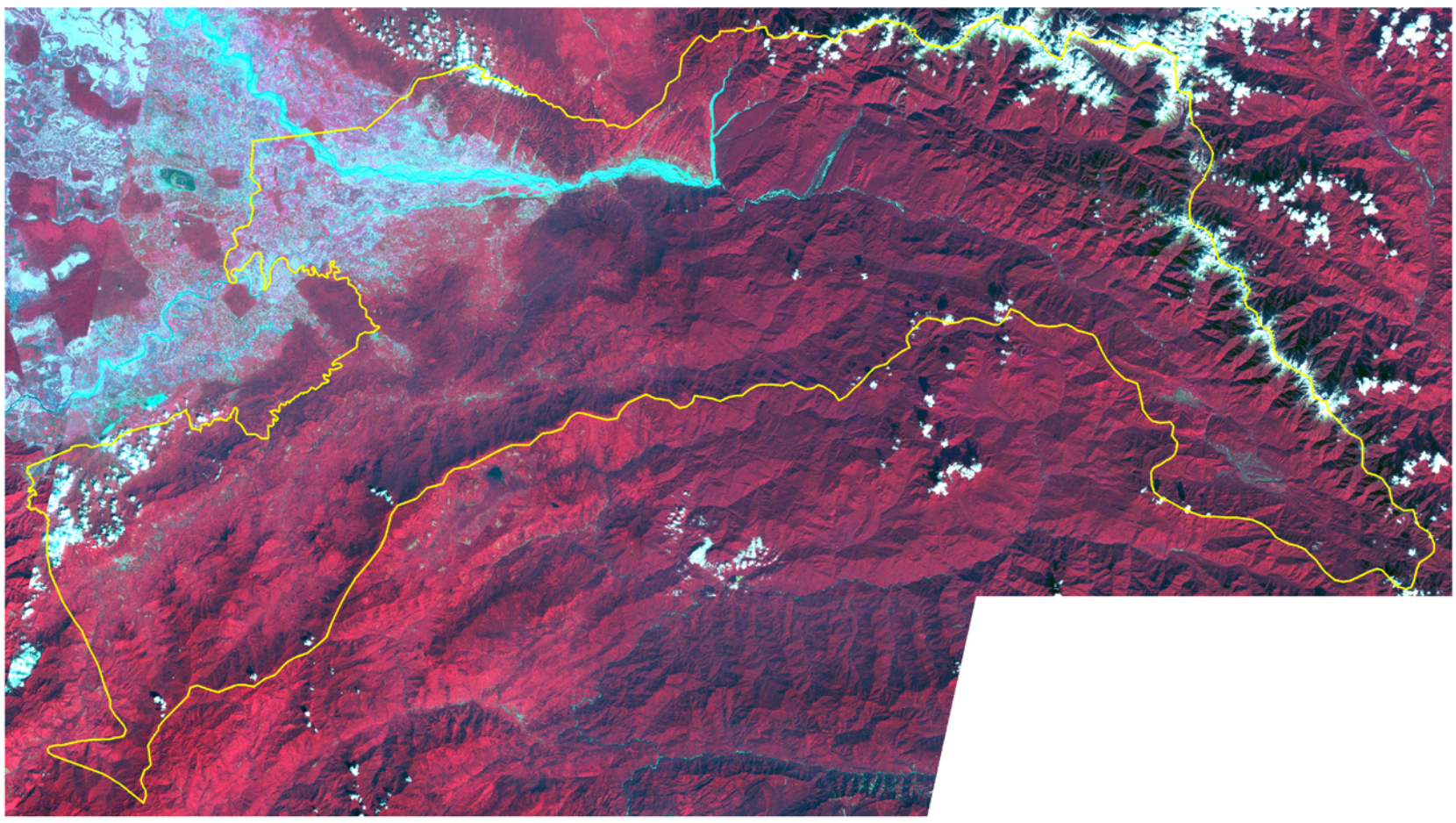
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Changlang



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

7.1.13 Wetland Distribution in Tirap

The Tirap district is located in the southeastern part of Arunachal Pradesh. The district occupies an area of 2362 km² and has a population of 100,227 (as of 2001). It shares a state border with Nagaland and Assam, an international border with Myanmar and a district border with Changlang. Khonsa Town is the district headquarters.

Much of the land lies not very far removed from those of the sea level, although a large portion of the district comprises the Patkoi Hills, which consists of the Namdhapa National Park. The park hosts a wide variety of wildlife species, from mithun to the Himalayan black bear, locally known as takin, to the wild goat.In Tirap District Nocte is the most populated tribe, they have the majority in the area.

The wetland area estimated is 1262 ha. Small wetlands, which are less than minimum mapable units (MMU), are 52 in the district. The major wetland types are River/Stream and waterlogged area. Details are given in Table 18.

Table 18: Area estimates of wetlands in Tirap

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1102	Ox-bow lakes/ Cut-off meanders	2	18	1.43	18	-
2	1106	River/Stream	13	1180	93.50	1180	1180
	1200	**Inland Wetlands -Man-made**					
3	1202	Tanks/Ponds	2	5	0.40	5	-
		Sub-Total	**18**	**1210**	**95.88**	**1203**	**1180**
		Wetlands (<2.25 ha), mainly Tanks	52	52	4.12	-	-
		Total	**70**	**1262**	**100.00**	**1203**	**1180**

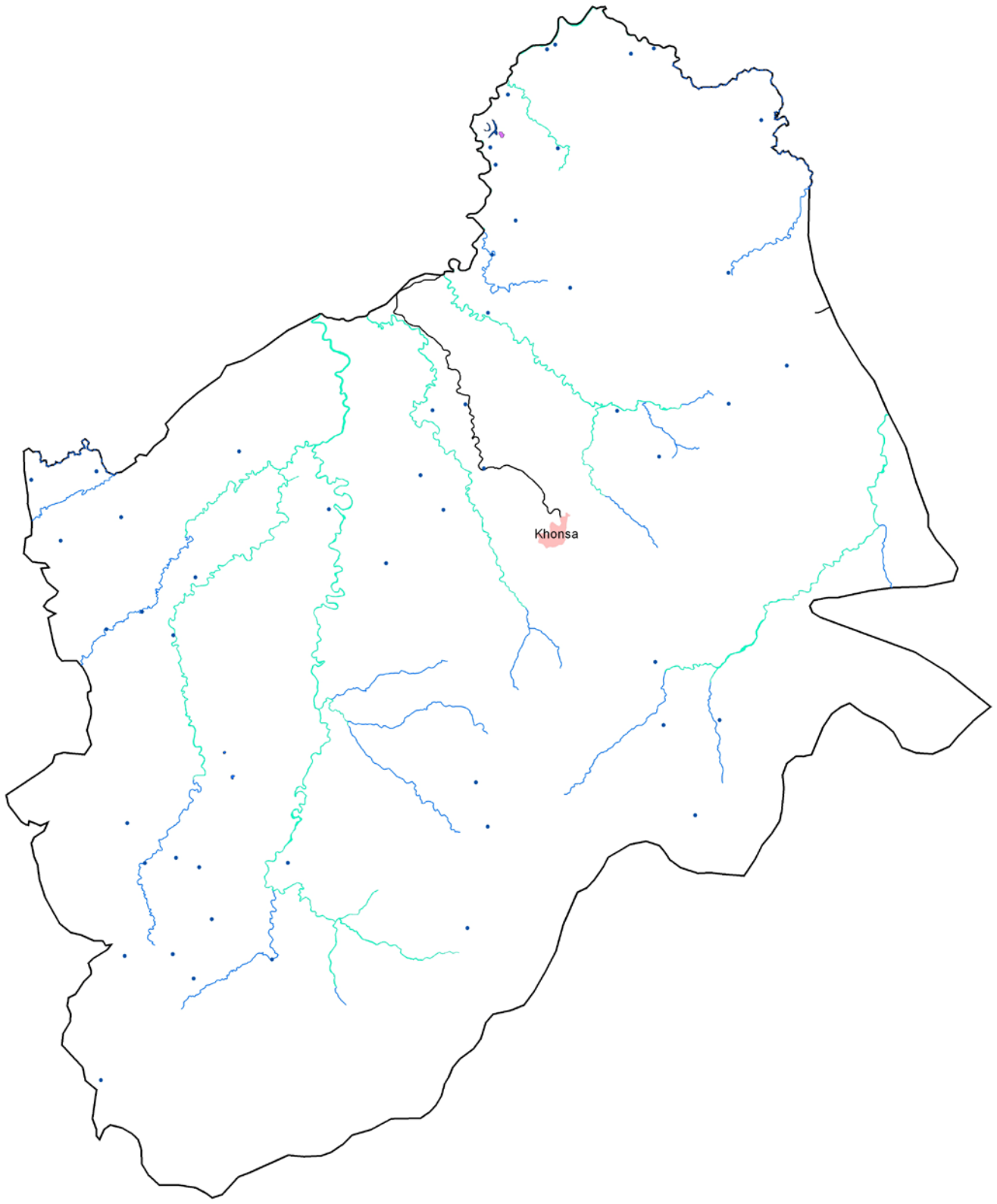
Area under Aquatic Vegetation	7	5

Area under turbidity levels		
Low	1185	1180
Moderate	18	-
High	-	-

State : Arunachal Pradesh

WETLAND MAP

District : Tirap

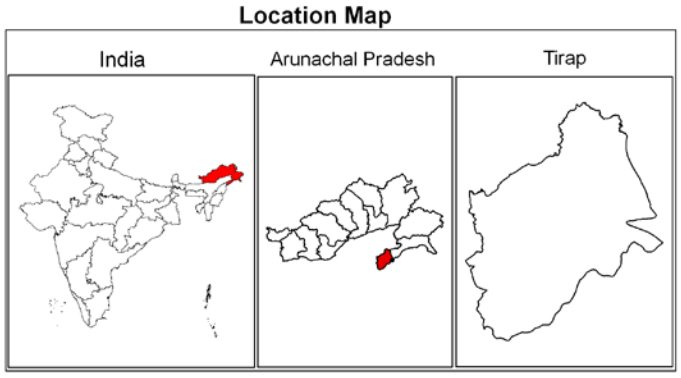


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2 4 8 12 Kilometers

Data Source :

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

Prepared By :

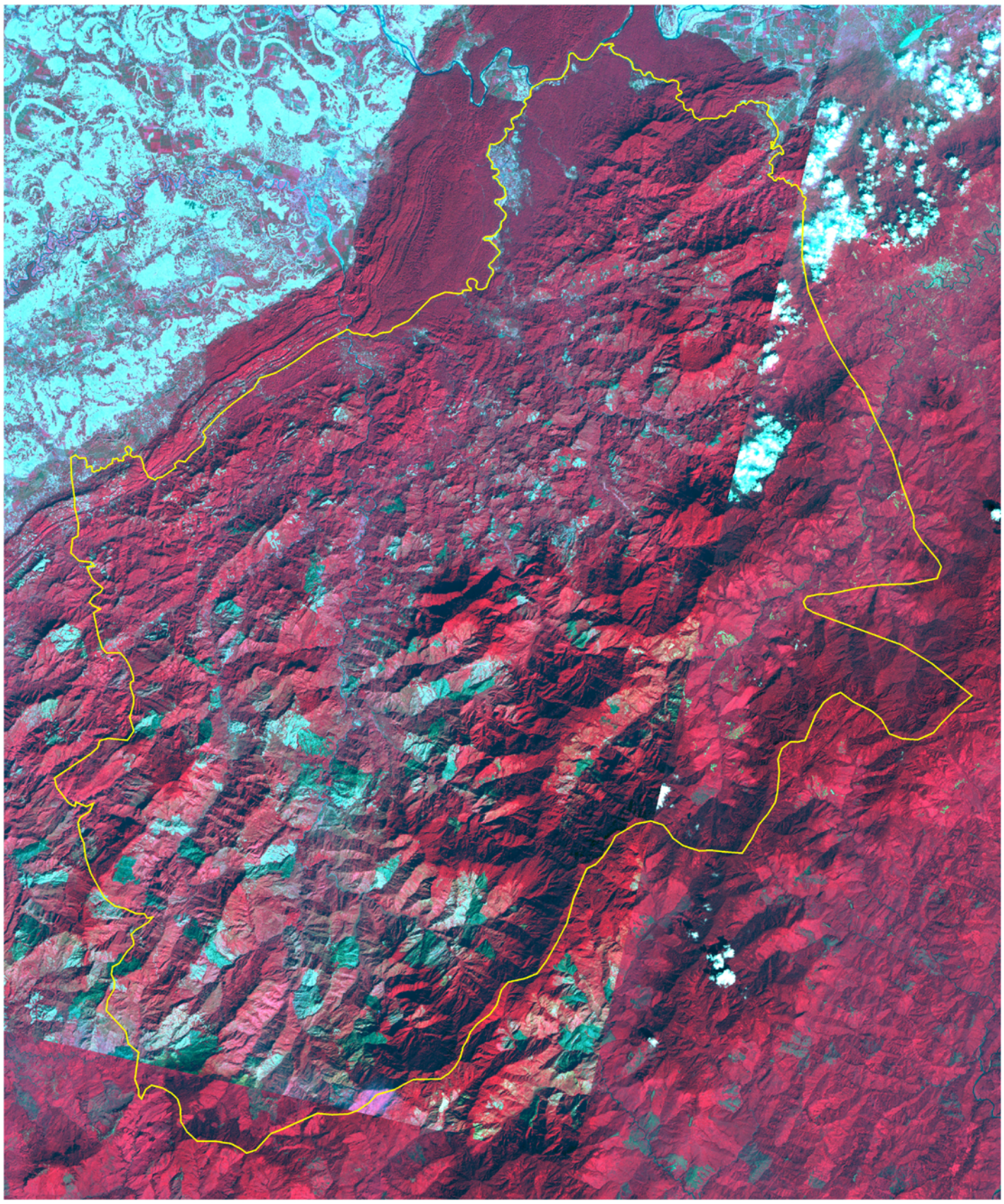
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

District : Tirap



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

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF ARUNACHAL PRADESH

Major wetland types observed in the state are Rivers, High Altitude lakes and Waterlogged areas. Details are given in Plate-1. Ground truth data was collected for selected wetland sites. The standard proforma was used to record the field data. Field photographs are also taken to record the water quality (subjective), status of aquatic vegetation and water spread. The location of the features was recorded using GPS. Field photographs of different wetland types are shown in Plate 1.

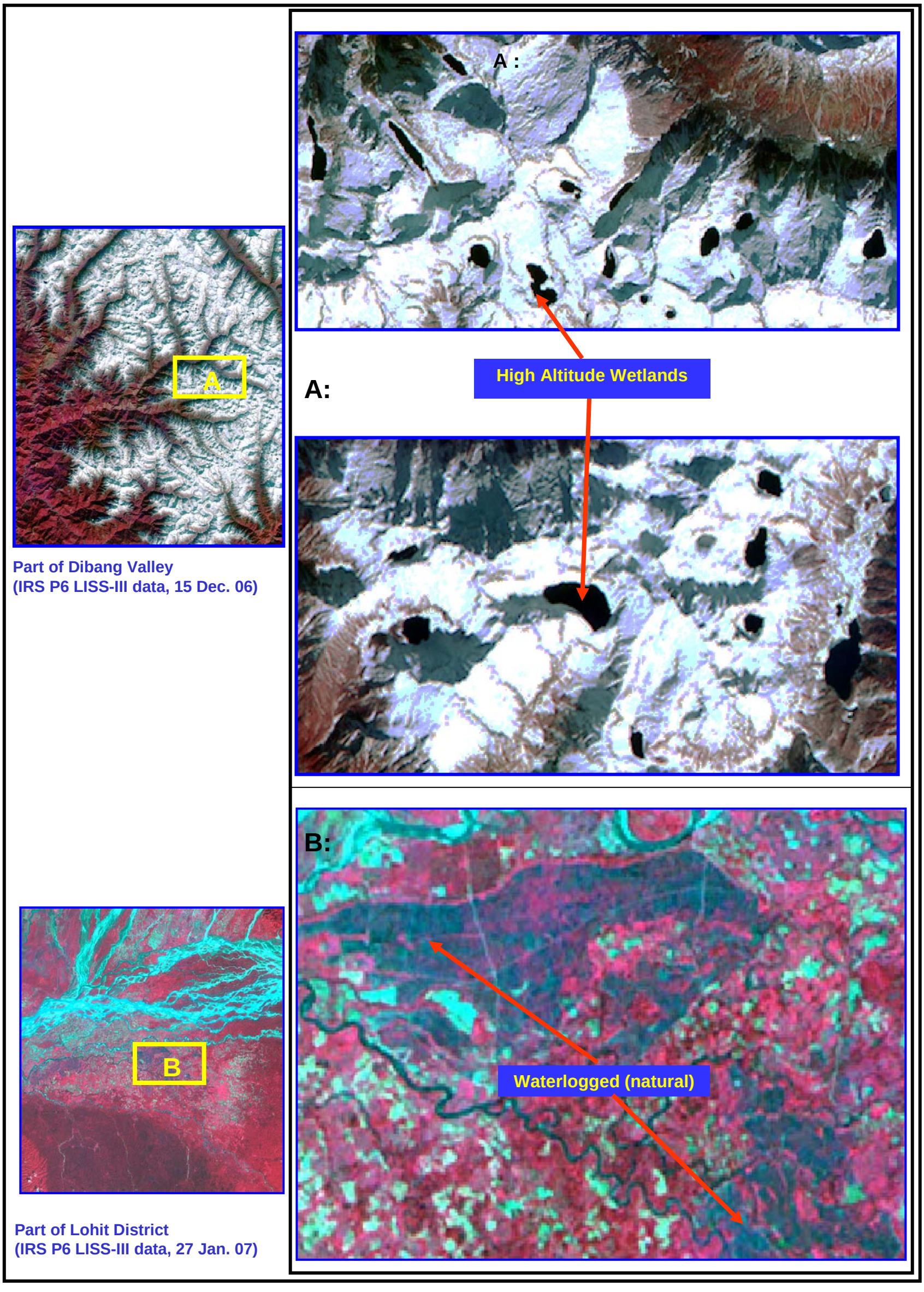


Plate - 1: Major wetland types of Arunachal Pradesh

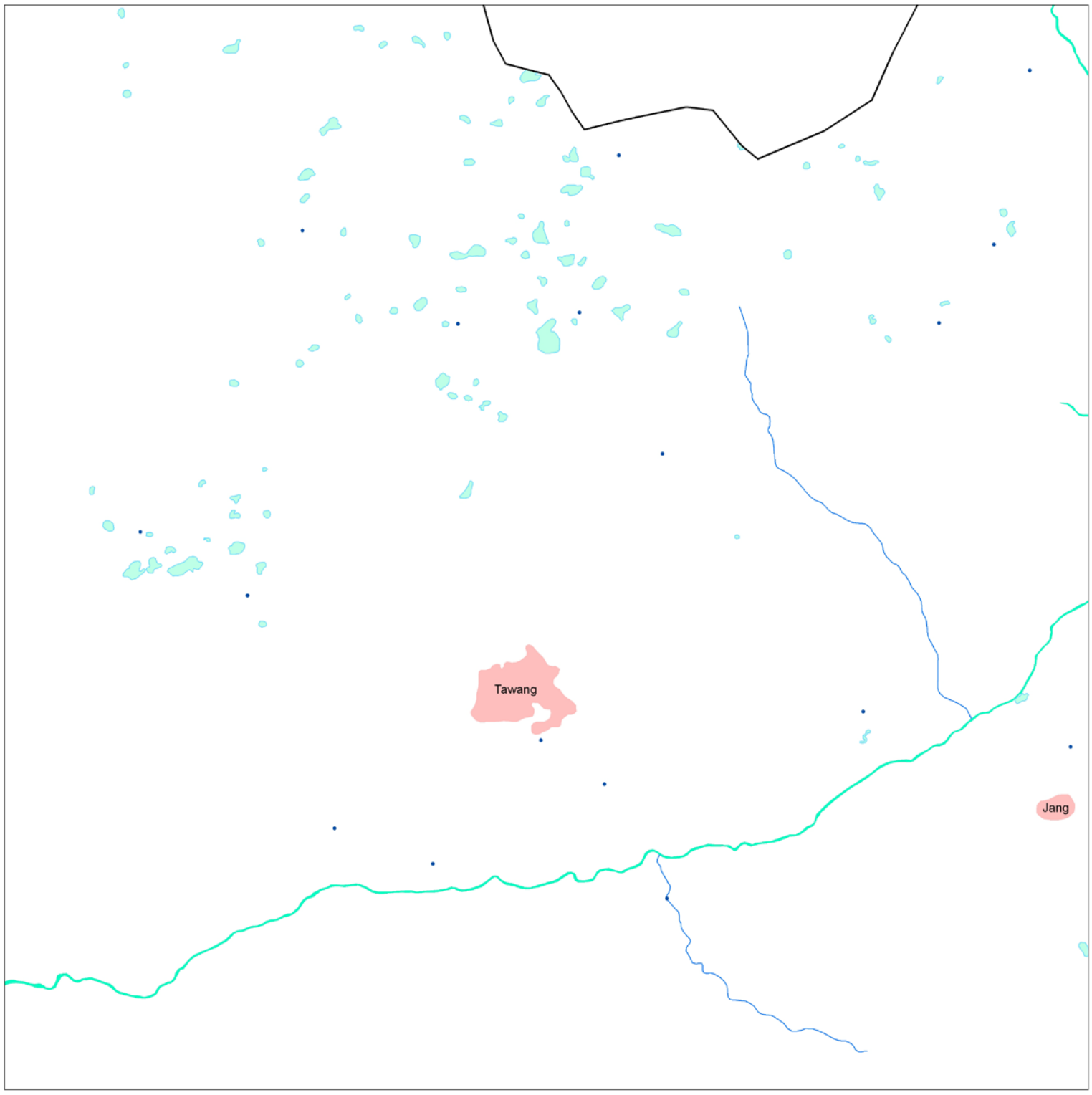
SOI MAP-SHEET WISE WETLAND MAPS

(Selected)

State : Arunachal Pradesh

WETLAND MAP

Map : 78M/14

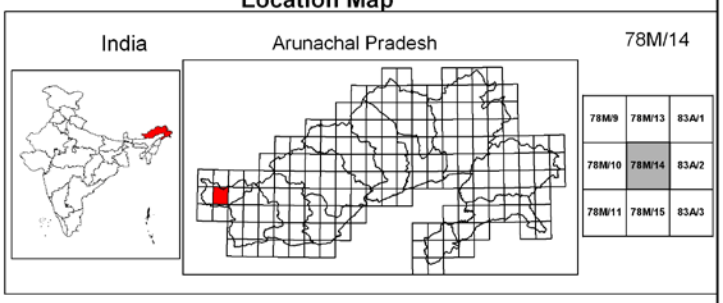


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

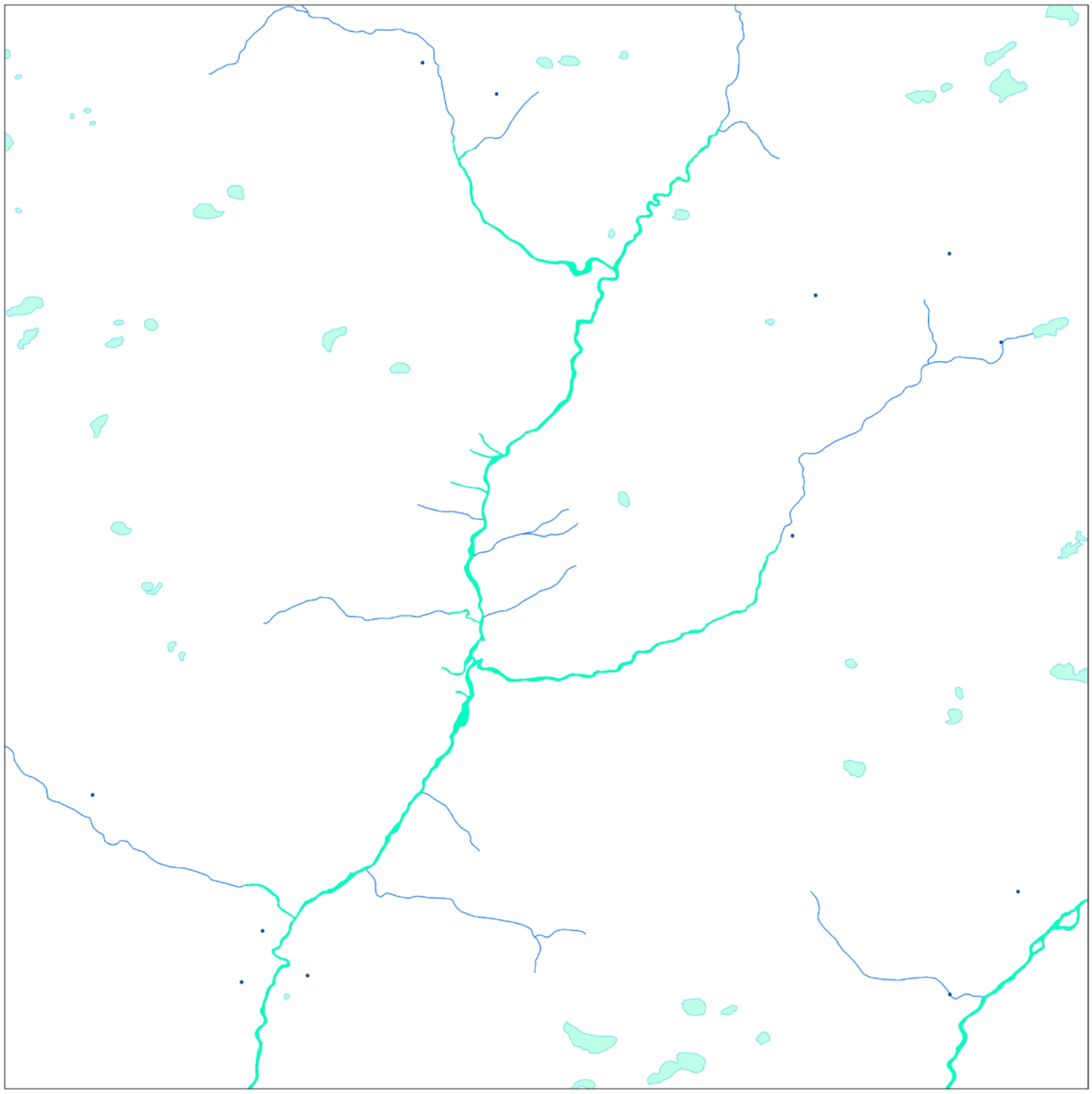
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 82O/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
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	1106			River/Stream
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	1201			Reservoirs/Barrages
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	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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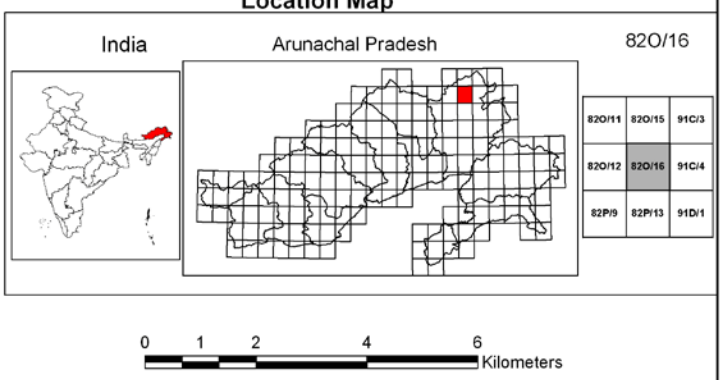
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

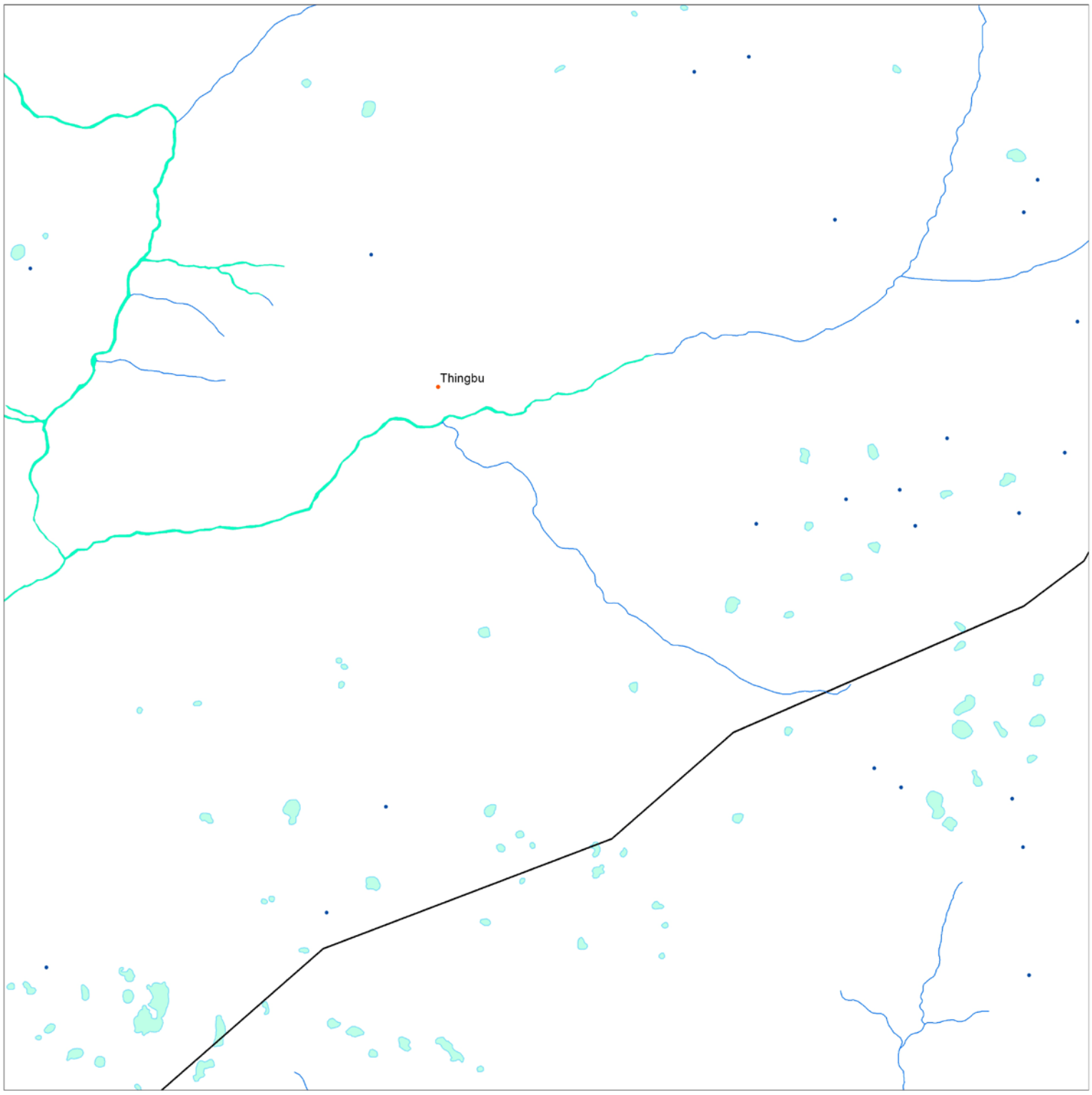
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 83A/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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			Man-made	
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			Natural	
	2101			Lagoons
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
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Legend

- Wetlands (<2.25 ha)
- Settlements
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- Drainage(line)
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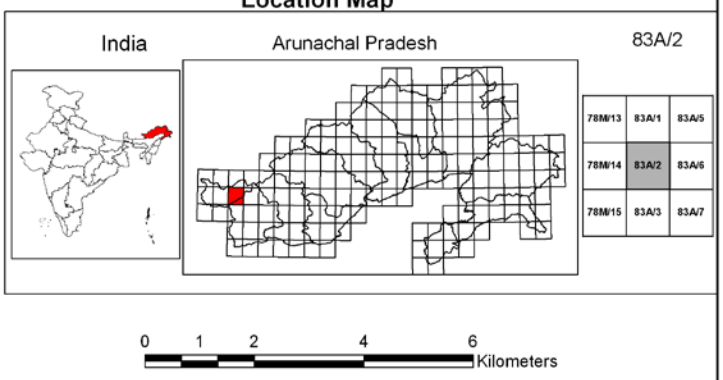
Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

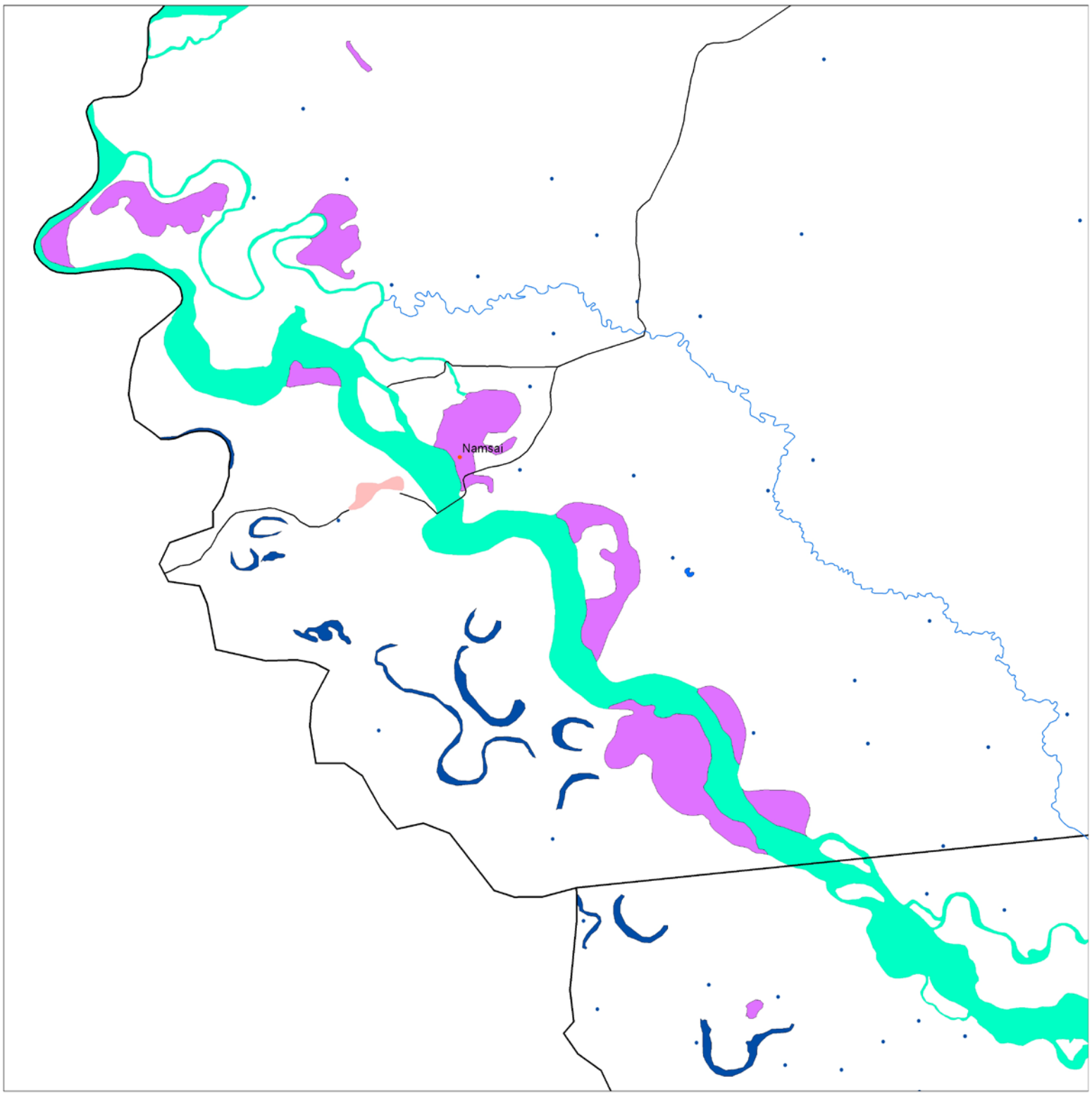
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 83M/14



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
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	2105			Salt marsh
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	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

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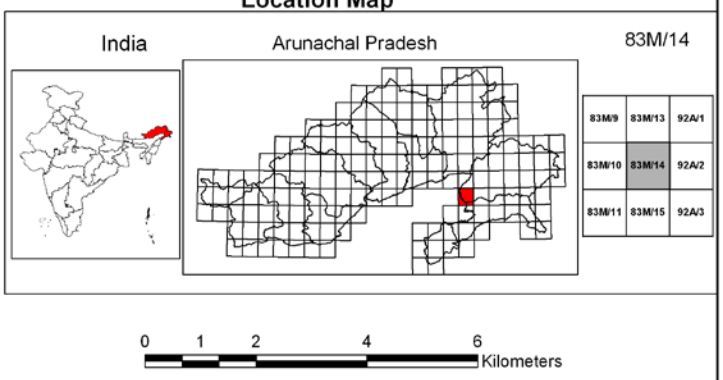
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

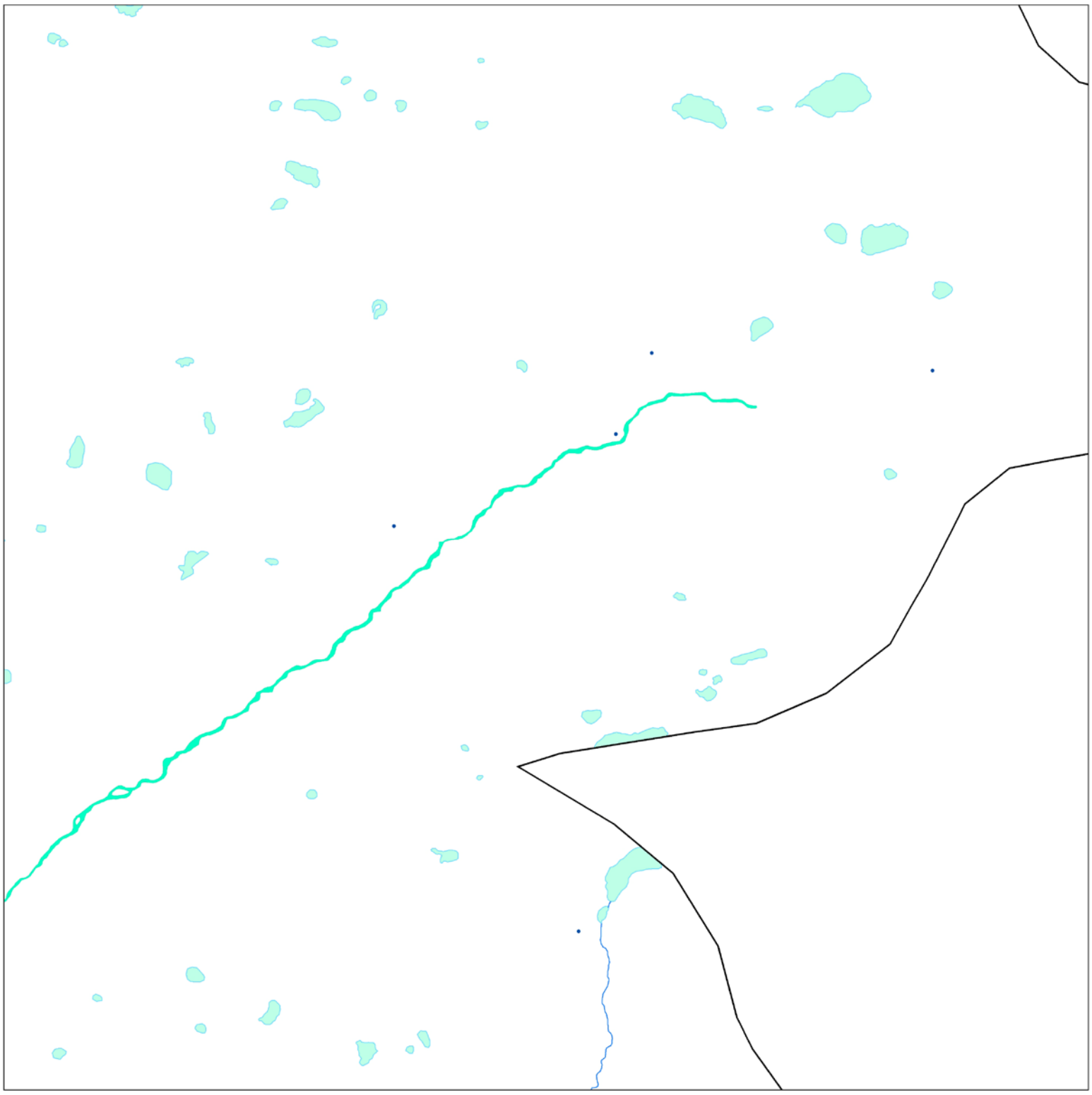
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 91C/4



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
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	1101			Lakes/Ponds
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	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

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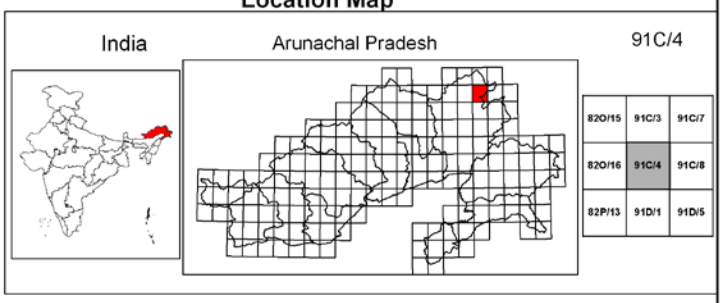
- Towns/Settlements

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

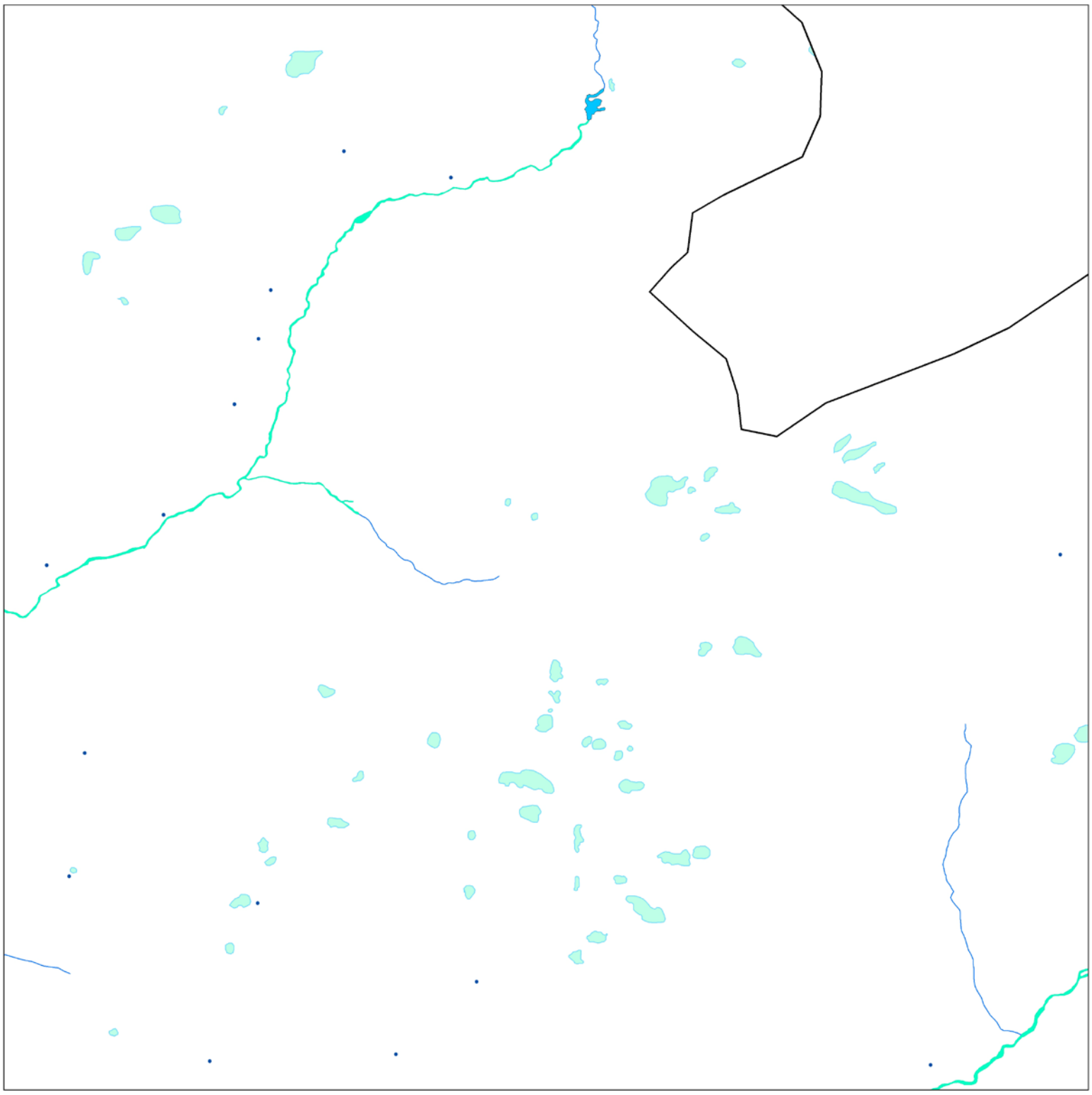
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 91D/1



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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Legend

- Wetlands (<2.25 ha)
- Settlements
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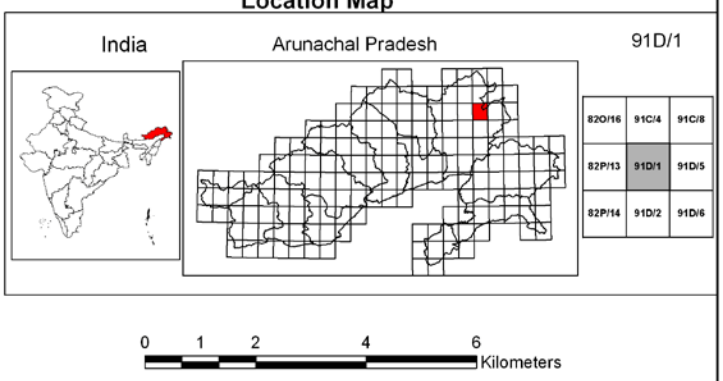
- District Boundary
- Towns/Settlements

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

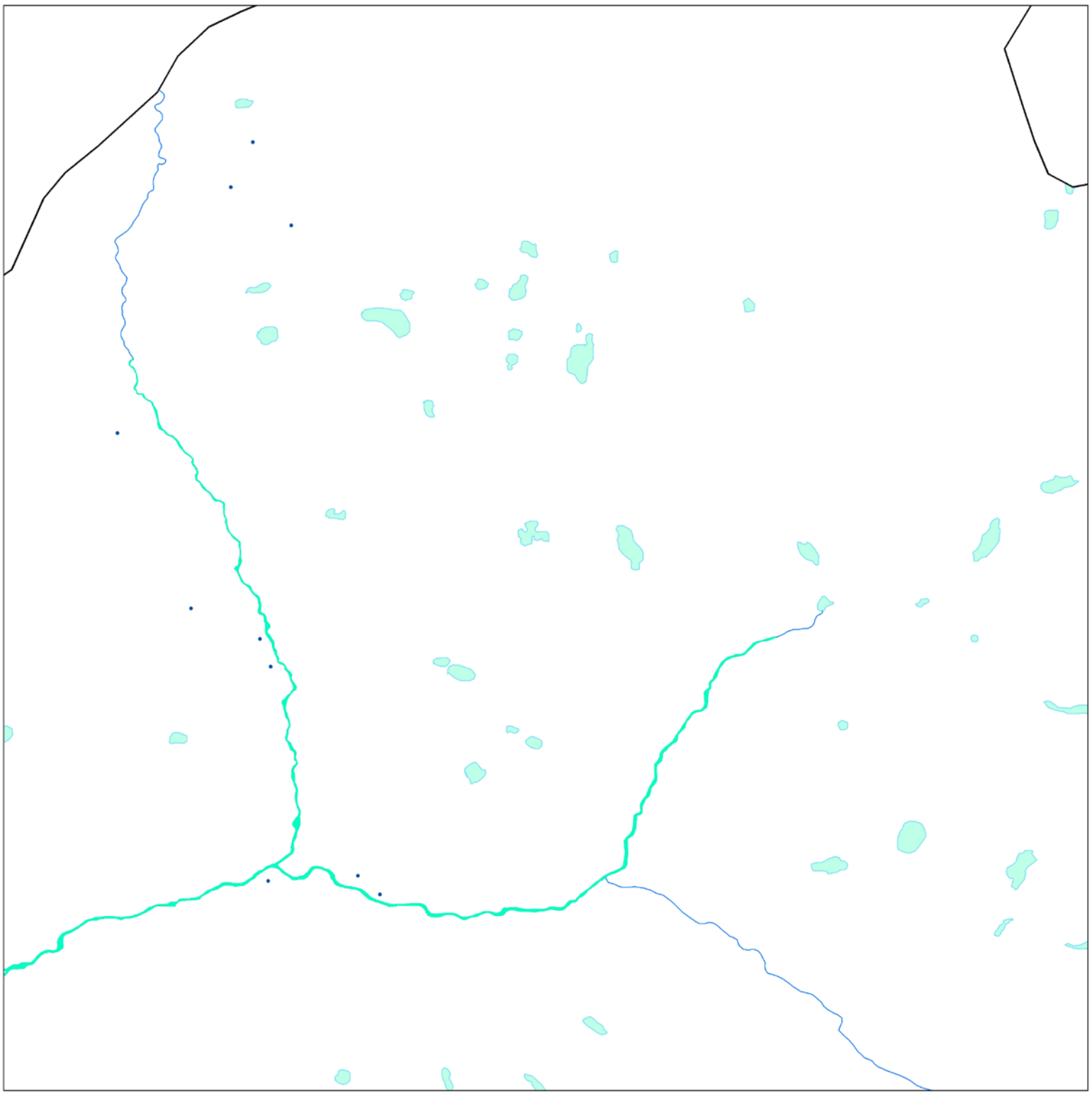
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 91D/5



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
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	1106			River/Stream
			Man-made	
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			Natural	
	2101			Lagoons
	2102			Creeks
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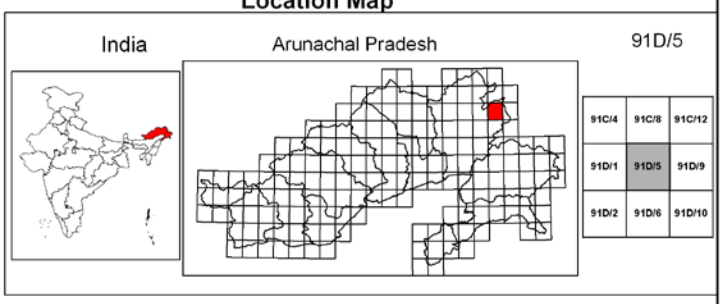
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

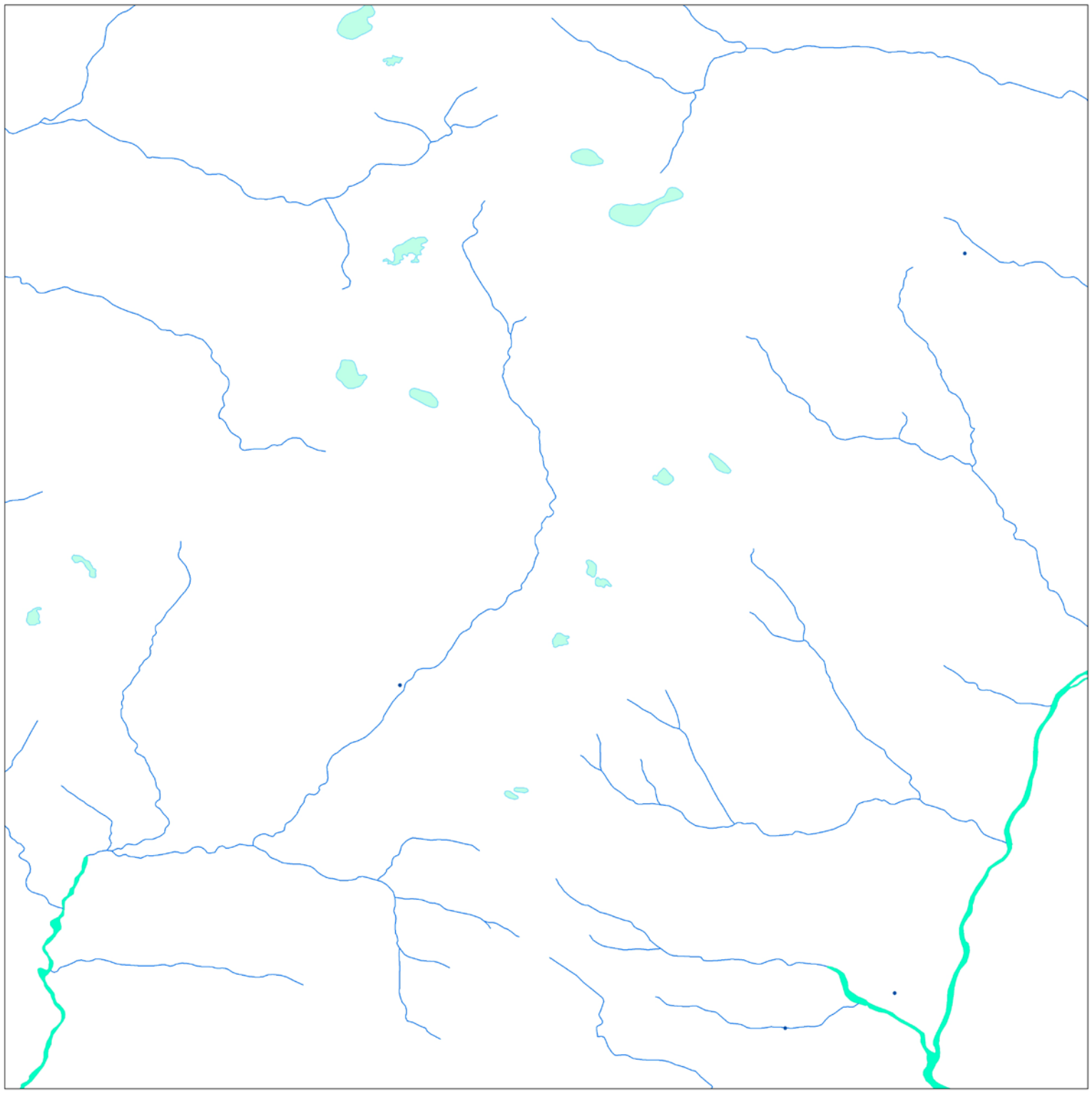
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 91D/16



Symbol	Typecode	Level I	Level II	Level III
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			Natural	
	1101			Lakes/Ponds
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- Wetlands (<2.25 ha)
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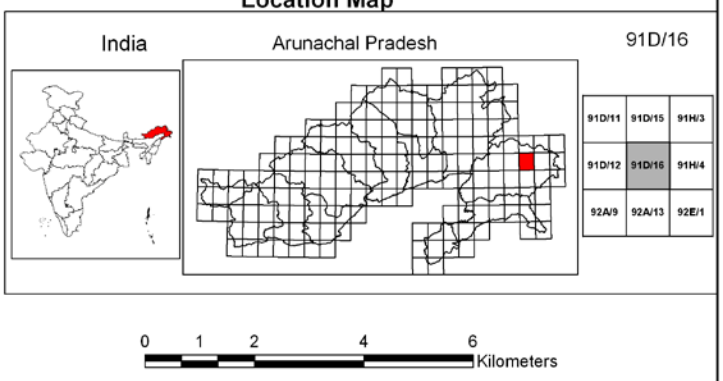
Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

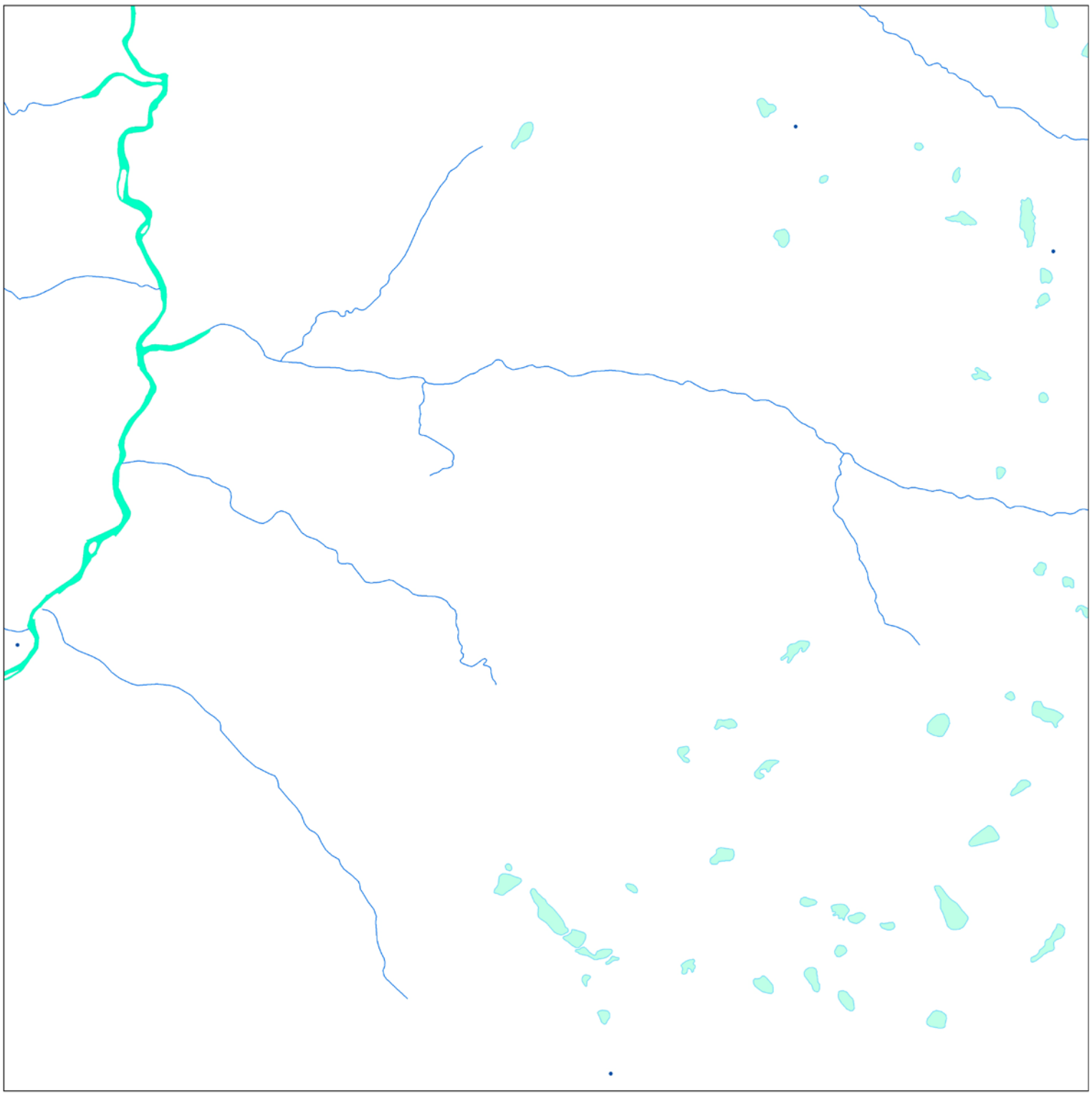
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 91H/4



Symbol	Typecode	Level I	Level II	Level III
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- Wetlands (<2.25 ha)
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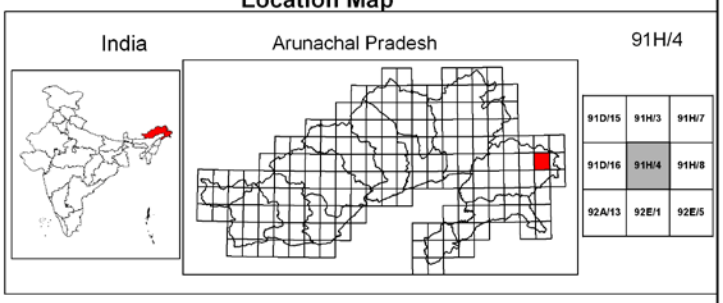
Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

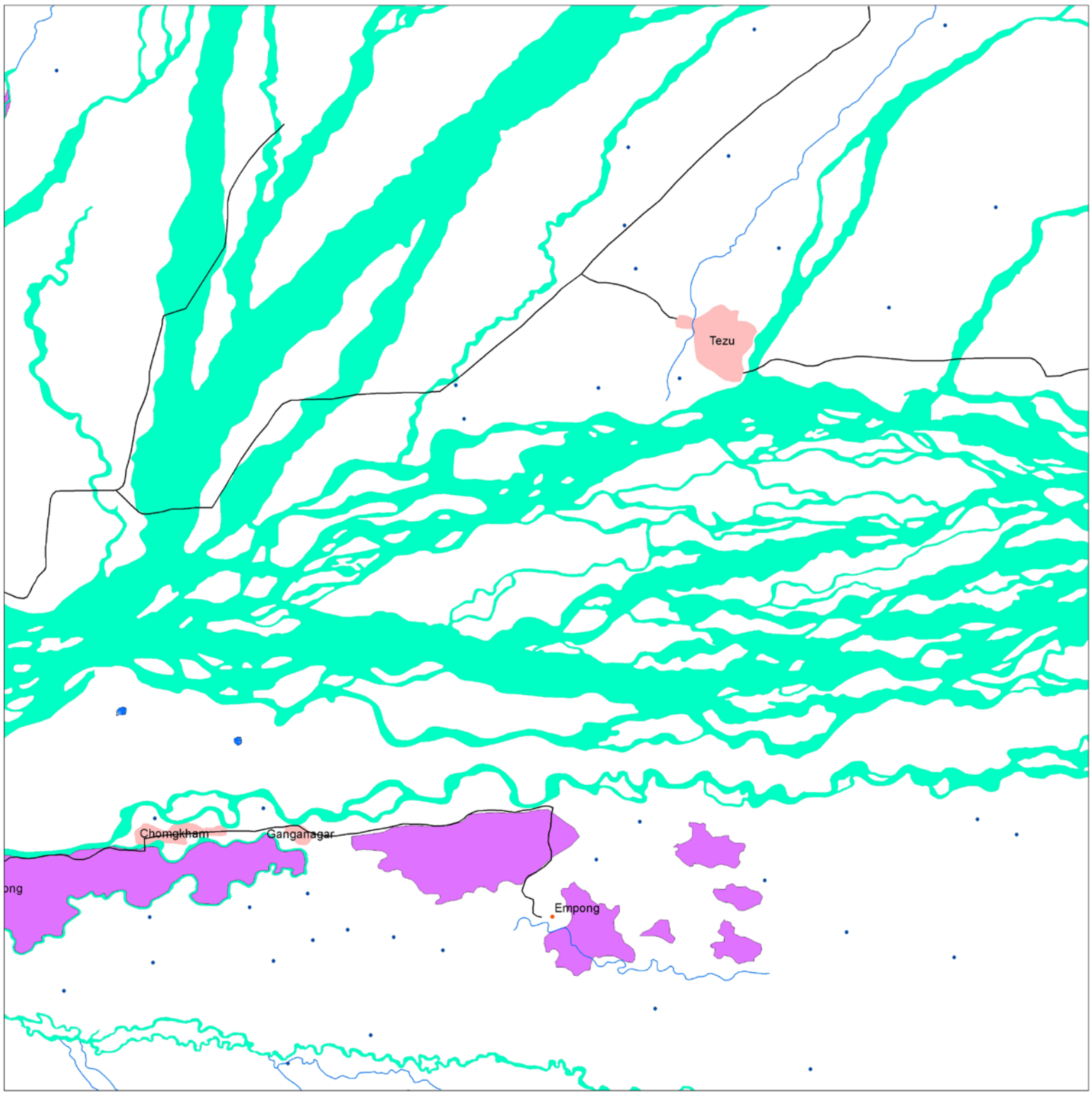
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Arunachal Pradesh

WETLAND MAP

Map : 92A/1



Symbol	Typecode	Level I	Level II	Level III
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	2201			Salt pans
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Legend

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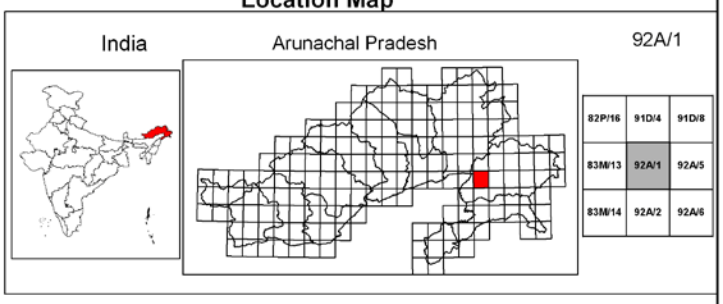
Location Map



Data Source :

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Prepared By :

Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

REFERENCES

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Annexure I
Definitions of wetland categories used in the project

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

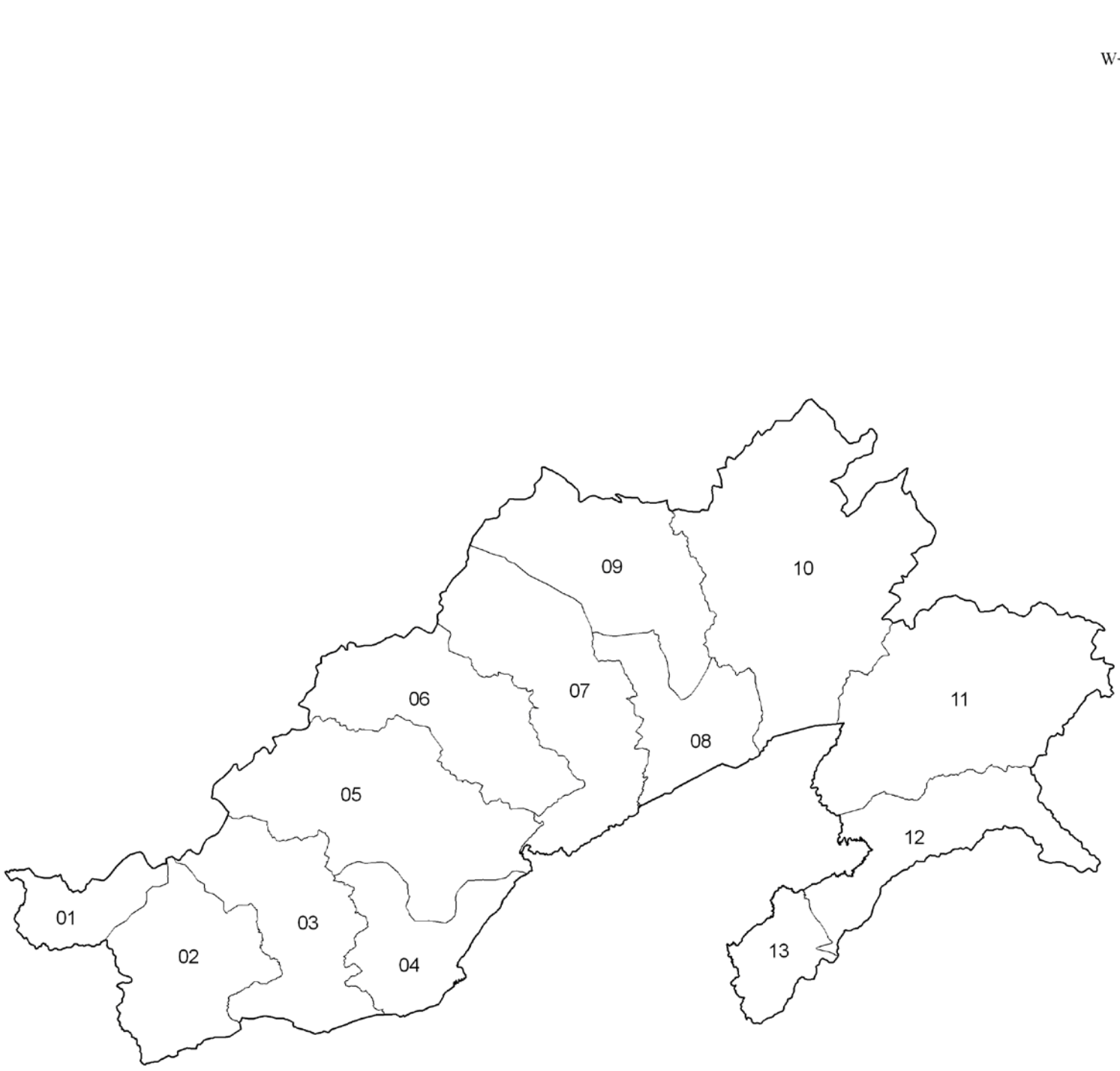
Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different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

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

Annexure – II
Details of District information followed in the atlas

State : Arunachal Pradesh

District Boundary Map



List of Districts

District Code	District Name
01	Tawang
02	West Kameng
03	East Kameng
04	Papum Pare
05	Lower Subansiri
06	Upper Subansiri
07	West Siang
08	East Siang
09	Upper Siang
10	Dibang Valley
11	Lohit
12	Changlang
13	Tirap

Legend

State Boundary

District Boundary

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

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

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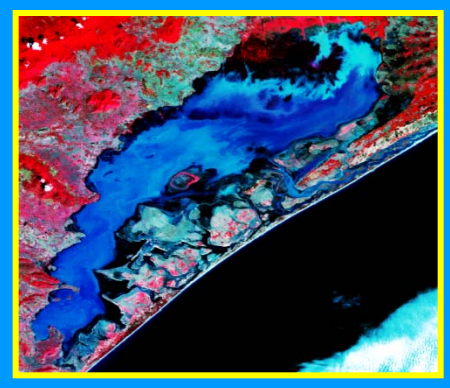

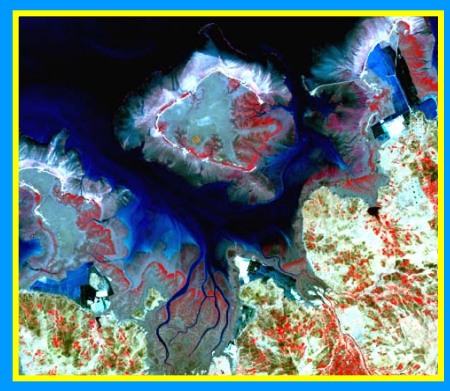

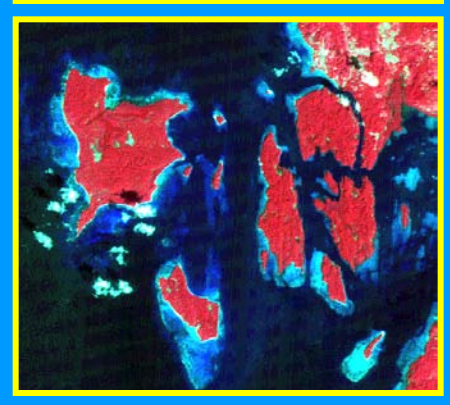

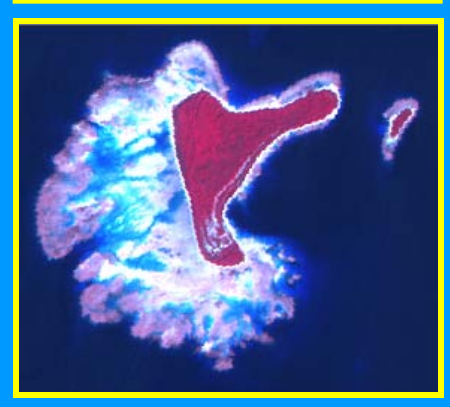

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015