NATIONAL WETLAND ATLAS:

UNION TERRITORIES

Sponsored by

Ministry of Environment and Forests

Government of India

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015

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

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

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

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

Space Applications Centre (ISRO)
Ahmedabad

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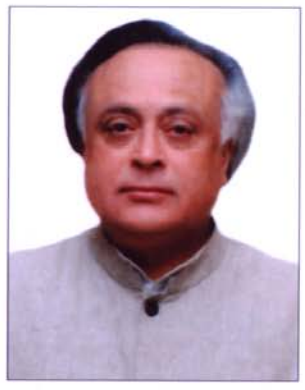
जयराम रमेश
JAIRAM RAMESH



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MESSAGE

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

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

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

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

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

(Jairam Ramesh)

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FOREWORD

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

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

January 25, 2010

(Ranganath R. Navalgund)

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

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

We acknowledge the positive role played by 16th SC-B (Standing Committee on Bio-resources 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)

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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 constraints most frequently faced for decision making is lack of scientific data of our natural resources. Often the data are sparse or unauthentic, rarely in the form of geospatial database (map), thus open to challenges. Hence, the current emphasis of every country is to have an appropriate geospatial database of natural resources based on unambiguous scientific methods. The wetland atlas of Union Territories, 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 wetland area is estimated to already have disappeared 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 relate the feature to any given geographical location has a strong visual impact. Thus maps are 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) topographical 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 recognised 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, satellite remote sensing can be defined 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, several satellites with suitable sensors have been launched into orbit to observe and monitor the earth and its environment. Most early satellite sensors acquired data for meteorological purposes. The advent of earth resources satellite sensors (those with a primary objective of mapping and monitoring land cover) occurred, when the first Landsat satellite was launched in July 1972. Currently, more than a dozen orbiting satellites of various types provide data crucial to improving our knowledge of the earth's atmosphere, oceans, ice and snow, and land. Of particular interest to India is the indigenous series of satellites called Indian Remote Sensing satellites (IRS-Series). Since the launch of the first satellite IRS 1A in 1987, India has now a number of satellites providing data in multi-spectral bands with different spatial resolution. IRS P6/RESOURCESAT 1 is the current generation satellite that provides multi-spectral images in spatial resolution of 5.8 m (LISS IV), 23.5 m (LISS III) and 56m (AWiFS). Over the past few decades, Indian remote sensing data has been successfully used in various fields of natural resources (Navalgund *et al*, 2002).

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

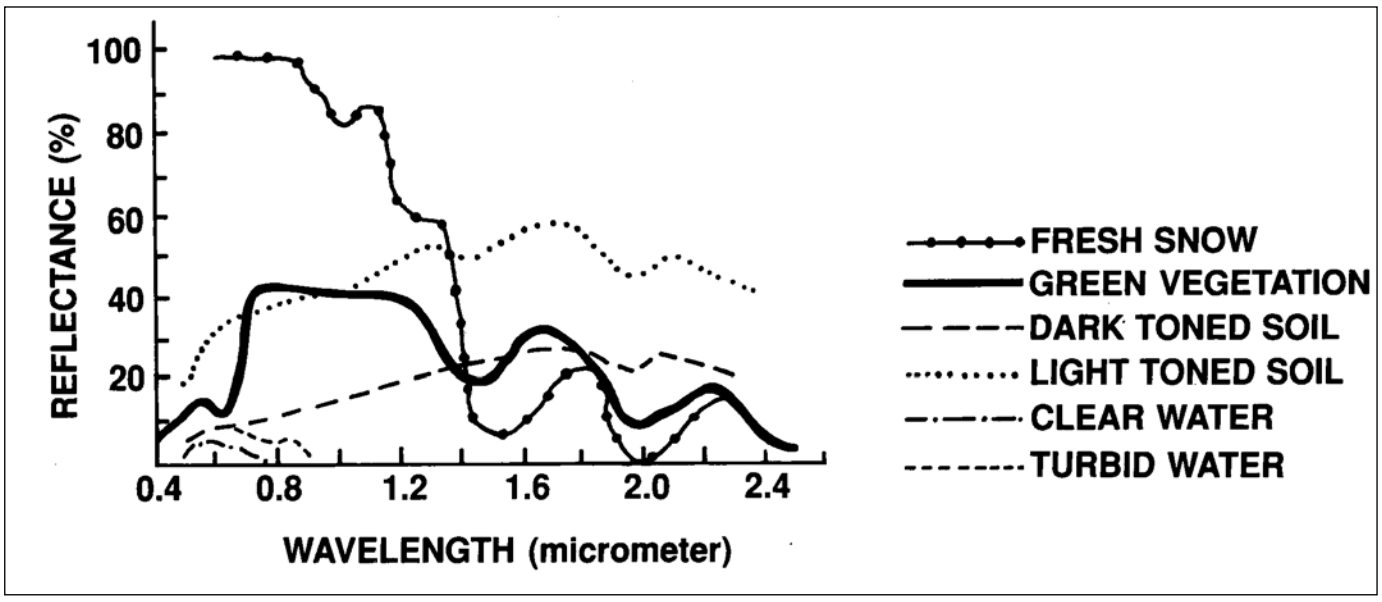


Figure 1: Spectral Signature of various targets

GREEN

RED

NIR

SWIR

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

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

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

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

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

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

2.0 NATIONAL WETLAND INVENTORY AND ASSESSMENT (NWIA) PROJECT

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

The main objectives of the project are:

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

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

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 considered as wetland class. Definitions of wetland categories used in the project is given in Annexure-I.

2.2 Spatial Framework and GIS Database

The National Spatial Framework) (NSF) has been used as the spatial framework to create the database (Anon. 2005a). The database design and creation standard suggested by NRDB/NNRMS guidelines is followed. Feature codification scheme for every input element has been worked out keeping in view the nationwide administrative as well as natural hierarchy (State-district- within the feature class for each of the theme. All data elements are given a unique name, which are self explanatory with short forms.

Following wetland layers are generated for each inland wetland:

- Wetland extent: As wetlands encompass open water, aquatic vegetation (submerged, floating and emergent), the wetland boundary should ideally include all these. Satellite image gives a clear signature of the wetland extent from the imprint of water spread over the years.

- Water spread: There are two layers representing post-monsoon and pre-monsoon water spread during the year of data acquisition.

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

- Turbidity 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: < 2.25 ha) 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).

Table 1: Wetland Classification System and coding

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

* Wetland type code

3.0 STUDY AREA

The are six Union Territories(UTs) in the country. Location map of UTs is shown in Figure 3. Details are given below.

Sr. No.	State Code	Name of Union Territory	Area (km^2)
1	04	Chandigarh	114
2	25	Daman and Diu	112
3	26	Dadra and Nagar Haveli	487
4	31	Lakshdweep	32
5	34	Puducherry	492
6	35	Andaman and Nicobar Islands	8249

3.1 Chandigarh

Chandigarh, is a union territory of India, that serves as the capital of two states, Punjab and Haryana. Chandigarh is located near the foothills of the Shivalik range of the Himalayas in Northwest India. It covers an area of 114 km². and shares its borders with the states of Haryana in the east and Punjab in the north, west and south. It has an average elevation of 321 metres. The surrounding districts are of Mohali, Patiala and Roopnagar in Punjab and Panchkula and Ambala in Haryana. The boundary of the state of Himachal Pradesh is also minutes away from its north border.

Chandigarh has a humid subtropical climate characterized by a seasonal rhythm: very hot summers, mild winters, unreliable rainfall and great variation in temperature (-1 °C to 41.2 °C). In winter, frost sometimes occurs during December and January. The average annual rainfall is 1110.7 mm. The city also receives occasional winter rains from the west.

As of 2001[update] India census, Chandigarh had a population of 900,635, making for a density of about 7900 persons per square kilometre. Chandigarh has an average literacy rate of 81.9%, higher than the national average of 64.8%.

Most of Chandigarh is covered by dense Banyan and Eucalyptus plantations. Asoka, Cassia, Mulberry and other trees flourish in the forested ecosystem.The city has forests surrounding it which sustain many animal and plant species. Deers, Sambars, Barking Deers, Parrots, Woodpeckers and Peacocks inhabit the protected forests. Sukhna Lake hosts a variety of ducks and geese, and attracts migratory birds from parts of Siberia and Japan in the winter season. A parrot sanctuary located in the city is home to a variety of bird species. The area is drained by two seasonal rivulets viz. Sukhna Choe in the east and Patiala-Ki-Rao Choe in the west.

3.2 Daman and Diu

Daman is situated on the Gujarat coast between 20o 22' 00" to 20o 27' 25" North latitude and 72o 49' 42" to 72o 54' 43" East longitude. Daman is bounded on the north and south by the Bhagwan and Kalem rivers respectively, on the east by Gujarat state and on the west by the Arabian Sea. Geographical area of Daman is 72 km². Locational advantages made Daman, excellent and exotic tourism destinations with tourist traffic rising year by year. Daman is having a pleasant climate all over the year. Maximum Temperature is 39 degree centigrade and minimum is 11 degree centigrade. The average annual rainfall is 1687 mm.

Diu is an island lying off the south coast of Gujarat's Kathiawar peninsula, separated from the mainland by a tidal creek. It has an area of 40 km² and coastline of 21 km. The climate is cool and dry, with an average annual rainfall of 700 mm. As of 2001 census, Diu had a population of 21,576. Diu has an average literacy rate of 75%, higher than the national average of 59.5%.

3.3 Dadra and Nagar Haveli

Dadra and Nagar Haveli lie near the west coast surrounded by the states of Gujarat and Maharashtra. It consists of two pockets namely Dadra and Nagar Haveli and these two pockets are intercepted by the territory of Gujarat. It has an area of 487 km² and consists of two talukas Dadra and Nagar Haveli. Silvassa is the headquarters of Dadra and Nagar Haveli. As of 2001[update] India census, Dadra and Nagar Haveli had a population of 220451.

Dadra and Nagar Haveli are in the watershed of the Daman Ganga River, which flows through the territory. The towns of Dadra and Silvassa both lie on the north bank of the river. The Western Ghats range rises to the east, and the foothills of the range occupy the eastern portion of the district. The territory is landlocked, although the Arabian Sea coast lies just to the west in Gujarat.

3.4 Lakshadweep

The Lakshadweep lies about 220 to 440 km from the coastal city of Cochin in Kerala between 8° and 13° Latitude and 71° and 74° Longitude. Even though the land area is extremely small, Lakshadweep is one of the largest territories when lagoon area (4200km^2), territorial water area (20000km^2) and economic zone (about 7 lakh km^2) put together. The tiniest Union Territory of India, Lakshadweep is an archipelago consisting of 12 atolls, 3 reefs and 5 submerged banks. Only ten islands are inhabited namely; Androth, Amini, Agatti, Bitra, Chetalat, Kadmat, Kalpeni, Kavaratti (Head quarters), Kiltan and Minicoy. Bitra is the smallest (0.1 km^2). The geographical area of the islands is 32 km^2 and as per the 2001 census the population is 60,650.

The flora of the islands includes Banana, Colacasia, Drumstic, Bread-fruit, Jack fruit and wild Almond. Coconut is the only crop of economic importance in Lakshadweep and found in different varieties such as laccadive micro, laccadive ordinary, green dwarf etc.. Two varieties of sea grasses namely; *Thalassia hemprichin* and *Cymodocea isoetifolia* are seen present adjacent to the beaches. They are known to play a preventive role of sea erosion and movement of the beach sediments.

The marine life is quite elaborate which include mollusks like; Honda cone, Tulip shells, Giant tun, Lace murex, capritus murex, pacific scallop, Measled cowry, dwarf olive, Bubble shells and Flame hepnet. Most of the fishes of economic importance fall under oceanic belonging to Tunas, Wahoo and sailfish. Of lesser importance are the Manta, barracuda, Marlins and Sword fish. The lagoon fishes are fabulous in their appearance and colours. Some of these are Saddle backed parrot fish (*Thallsoma hebracium*), Blue surgeon fish (*Acanthurus lenconsteron*), Pennant fish (*Aeanthuras gineatus*), Black bat fish (*Platax teria*), Blue rug butterfly fish (*Pomacantus annupares*) and Blue banded snapper (*Lutianus kasmira*). The commonly seen vertebrates are cattle and poultry. Oceanic avifauna generally seen is ‘tharathasi’ (*Sterna fuscata*) and ‘karifetu’ (*Anous stolidus*). Commonly seen birds are Grey Heron, Terns, Curlew, Golden Plover, White-eye and Phillipine Noddy. All these islands have been declared as bird sanctuaries and known as ‘Pitti’.

3.5 Puducherry

Puducherry; formerly known as Pondicherry, is a Union Territory of India. Puducherry consists of four noncontiguous regions: Puducherry, Karaikal, and Yanam on the Bay of Bengal and Mahe on the Arabian Sea. Puducherry and Karaikal are by far the larger ones, and are both enclaves of Tamil Nadu, Yanam in Andra Pradesh and Mahe on the West Coast in Kerala. Puducherry is the Capital of this Union Territory. The territory has a total area of 492 km^2: Puducherry 293 km^2 , Karaikal 160 km^2 , Mahe 9 km^2 and Yanam 30 km^2. As per census 2010, total population of Puducherry is 973829. Puducherry and Karaikal, experiences tropical maritime type of climate with small daily range of temperature and moderate rainfall.

Puducherry is one of the most popular tourist destinations in South India. The most popular tourist destinations are the four beaches in Puducherry, which are Promenade Beach, Paradise Beach, The Auroville Beach and Serinity Beach. Joyful boat rides at Chunnambar boat house (Puducherry-Cuddalore Road) and at Osutari lake, Botanical Garden for joyful train ride and for unseen natures beauty.

Karaikal region is embedded in the Nagappattinam and Tiruvarur District of Tamil Nadu State. Total geographic area of Karaikal is 161 sq. km. and has a population of 1,70,640 as per the 2001 census. Karaikal town about 16 km. north of Nagappattinam and 9 km. south of Tarangambadi is the district headquarters. Forming part of the fertile Cauveri delta the region is completely covered by the distributaries of Cauveri.

Mahe is a tiny point in the Geographical map of Kerela. Mahe covering 9 sq km area surrounded by Kerala state. Mahe lies parallel to Puducherry, 653 km away on the west coast. River mahe forms the northern boundary of Mahe town separating it from the enclaves of Kallayi and Naluthara on the north.

Yanam is one of the district in the Union Territory of Puducherry . which is 870 Kms away from it. It is situated on the East Coast of the Indian Peninsula bounded on all sides by the East Godavari District of Andhra Pradesh State. The town of Yanam lies on the spot where the River Coringa(Atreya) branches off from Gauthami into two parts. The entire region, consisting of Yanam town and six villages is treated as Municipality for purposes of local administration. The region, which covers an area of 30 sq km, has a population of 31,362 according to the 2001 census. The region is bounded on the east and south by river Gauthami Godavari river which discharges itself into Bay of bengal after flowing almost 14 Kms towards east from Yanam.

3.6 The Andaman and Nicobar Islands

The Andaman and Nicobar Islands are situated between 6° and 14° Latitude and 92° and 94° Longitude comprising a group of 572 islands/islets in the Bay of Bengal. Administrative purpose the islands are divided into two districts namely; Andaman and Nicobar. There are 38 inhabited islands in Andaman district and 13 in Nicobar district. The geographical area of the islands is 8,249 Sq. km and as per the 2001 census the population is 3,56,152.

The Andaman Group has, at the extreme north, Land Fall Island which is about 900 km from the mouth of Hooghly River. These islands mainly comprise three main islands namely, North Andaman, Middle Andaman and South

Andaman. All these islands are separated from each other by shallow seas and singularly called as Great Andaman. Further south, at a distance of about 100km from Port Blair, Lies Little Andaman Island. Besides these, there are large numbers of other islands in the group, many of them very small in size.

The Nicobar Group of Islands lying south of the Andaman extends from 6° to 10° north latitude. The northern-most island is car Nicobar which lies about 120km to the south of Little Andaman and the southernmost island is Great Nicobar barely 150 km from Sumatra. Pygmalion Point also known as Parsons Point which has since been renamed as “Indira Point” is the southernmost tip of India. The important islands in this group are Great Nicobar, Car Nicobar, Chowra, Teressa, Nancowrie, Katchal and Little Nicobar.

The climate of Andaman and Nicobar Islands is of tropical. The islands are exposed to both south-west as well as north-east monsoons and average rainfall (Port Blair) is 292 cm with an average 138 rainy days in a year. The temperature variation is slight between 30° to 22° and average relative humidity is 79%.

Sixteen National Parks and ninety four Sanctuaries were declared (Khan, 1983, Whitaker, 1985, Anon., 1993, Negi, 1995) in the Andaman and Nicobar Islands by 1995. The wetland-based ones are given in following Table.

Wetland based National Parks, Sanctuaries and Biosphere reserves of in the Andaman and Nicobar Islands

Sr. No.	Island Name	Area (Sq. km)	Important Wildlife	Declared in
1	North Button Island	0.92	Dolphin, dugong and blue whale	1979
2	Middle Button Island			
3	South Button Island			1977
4	Marine National Park, Wandur	234	Several marine species	1979
Sanctuaries				
1	North Reef Island	3.40	Andaman teal, Andaman pig, Saltwater crocodile	1977
2	Barren Island	8.10	Feral goats, flora	1977
3	Narcondam Island	6.81	Hornbill and island flora	1977
4	South Sentinel Island	1.61	Green sea turtle, olive ridley turtle, Robber crab and island flora	1977
Biosphere Reserves				
1	North Andaman Biosphere Reserve	1376	Mangrove ecosystem protection and extremely rich fauna	1979

However, keeping the conservation as priority, more were added in due course of time and by 2006 there are 96 wildlife sanctuaries, 9 National Parks and 2 Biosphere Reserve in these islands (Anon., 2006).

The spatial framework of all the Union Territories were prepared using 15’ x 15’ grid. The UTs are covered by 98 Survey of India topographic maps on 1:50,000 scale that form the spatial frame work for mapping (Figure 4a, 4b and 4c).

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

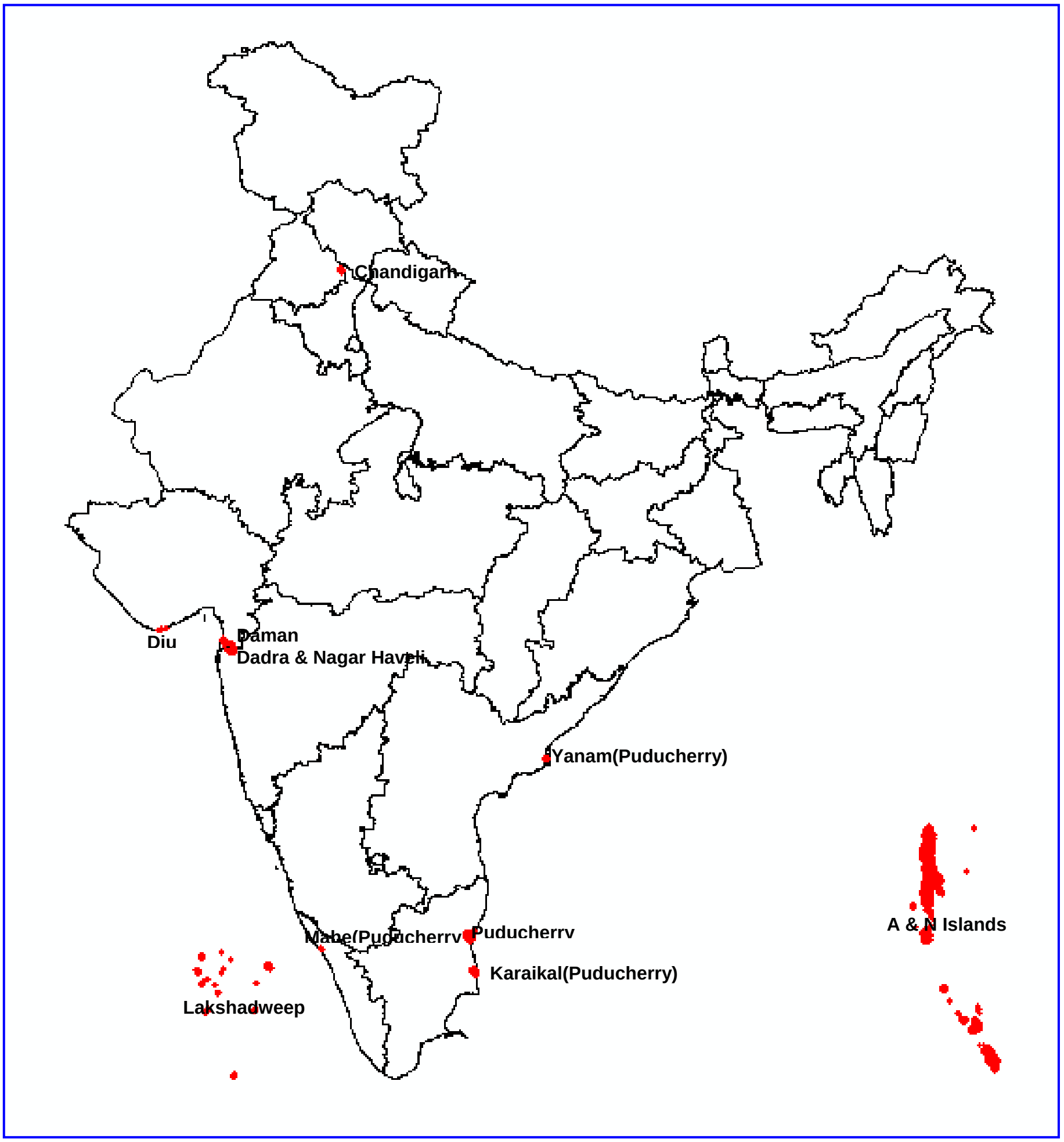
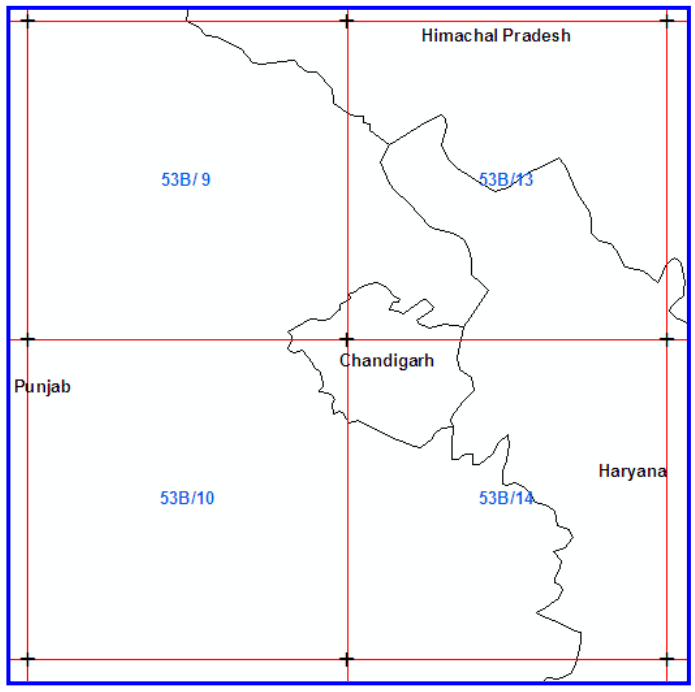
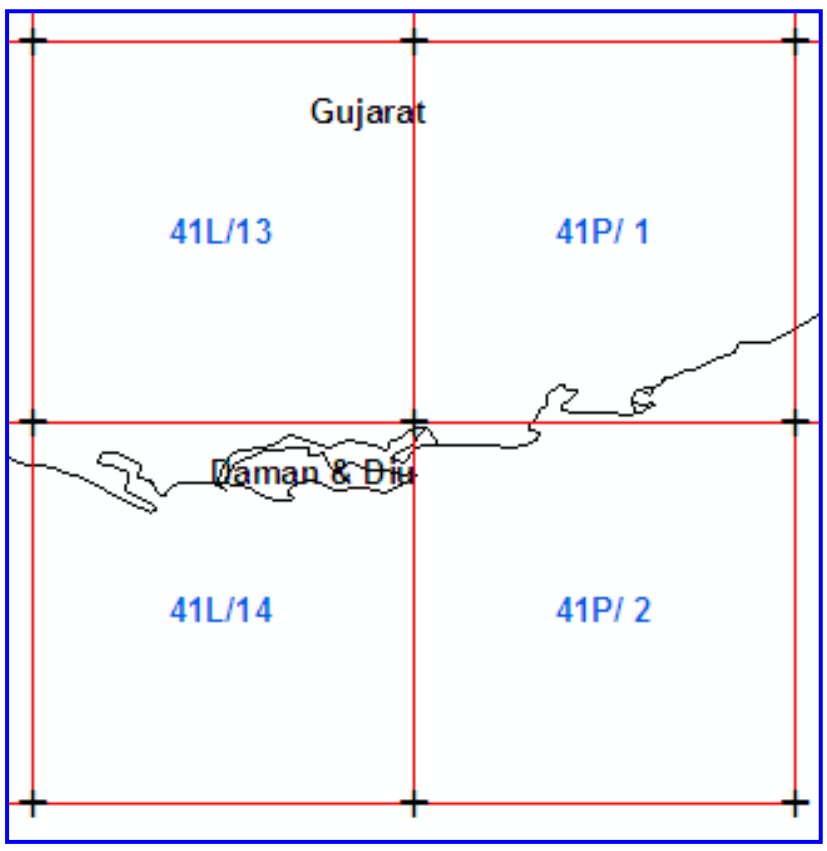


Figure 3: Location map

Chandigarh



Diu



Daman and Dadra & Nagar

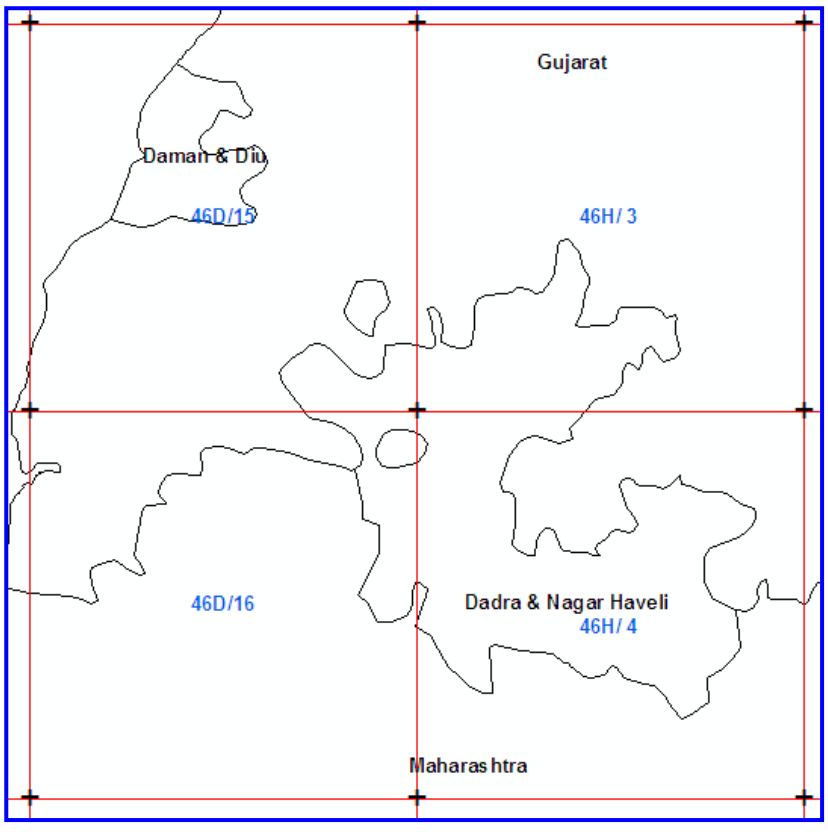


Figure 4a: Spatial framework of Daman & Diu and Dadra & Nagar Haveli

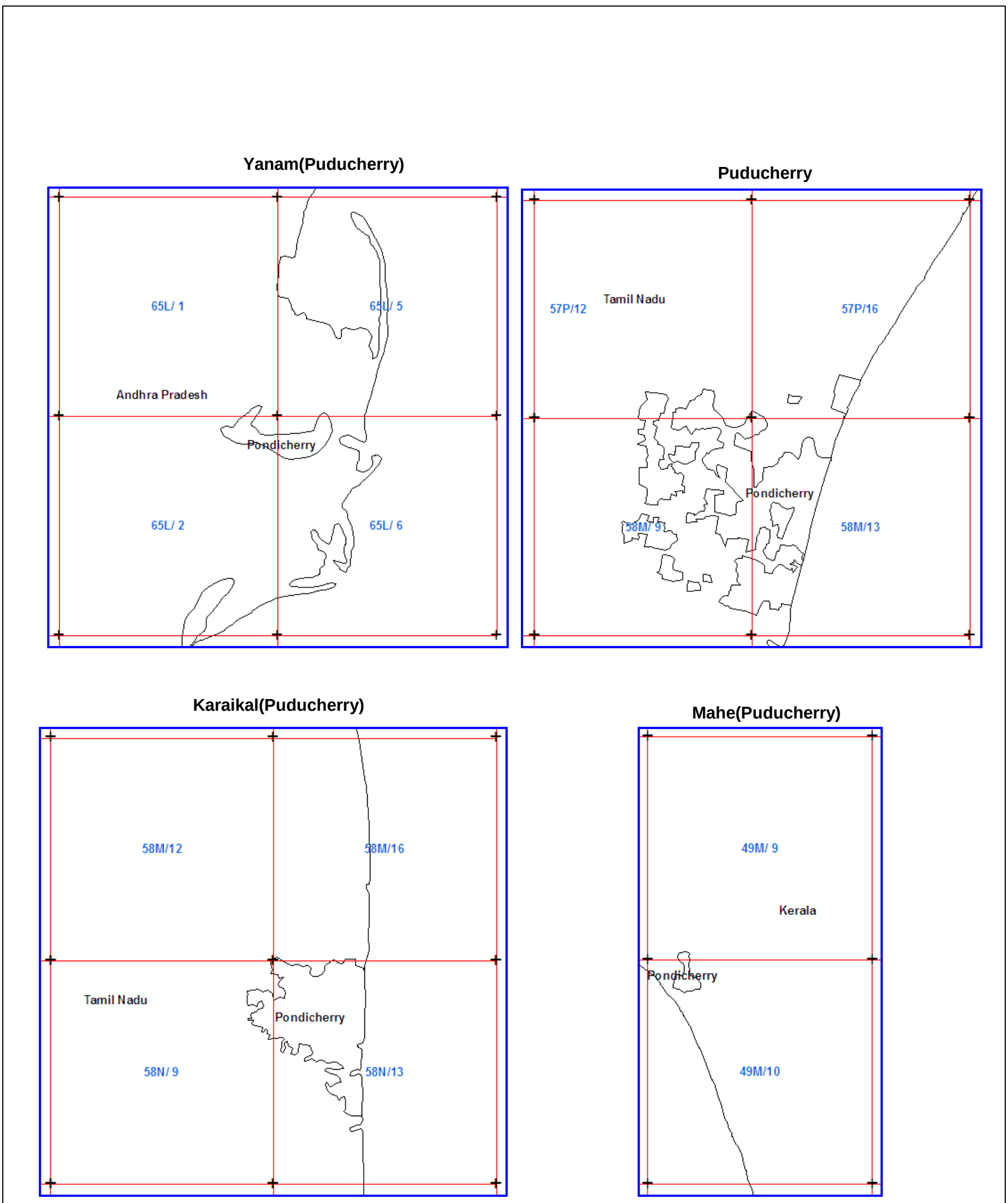


Figure 4b: Spatial framework of Puducherry

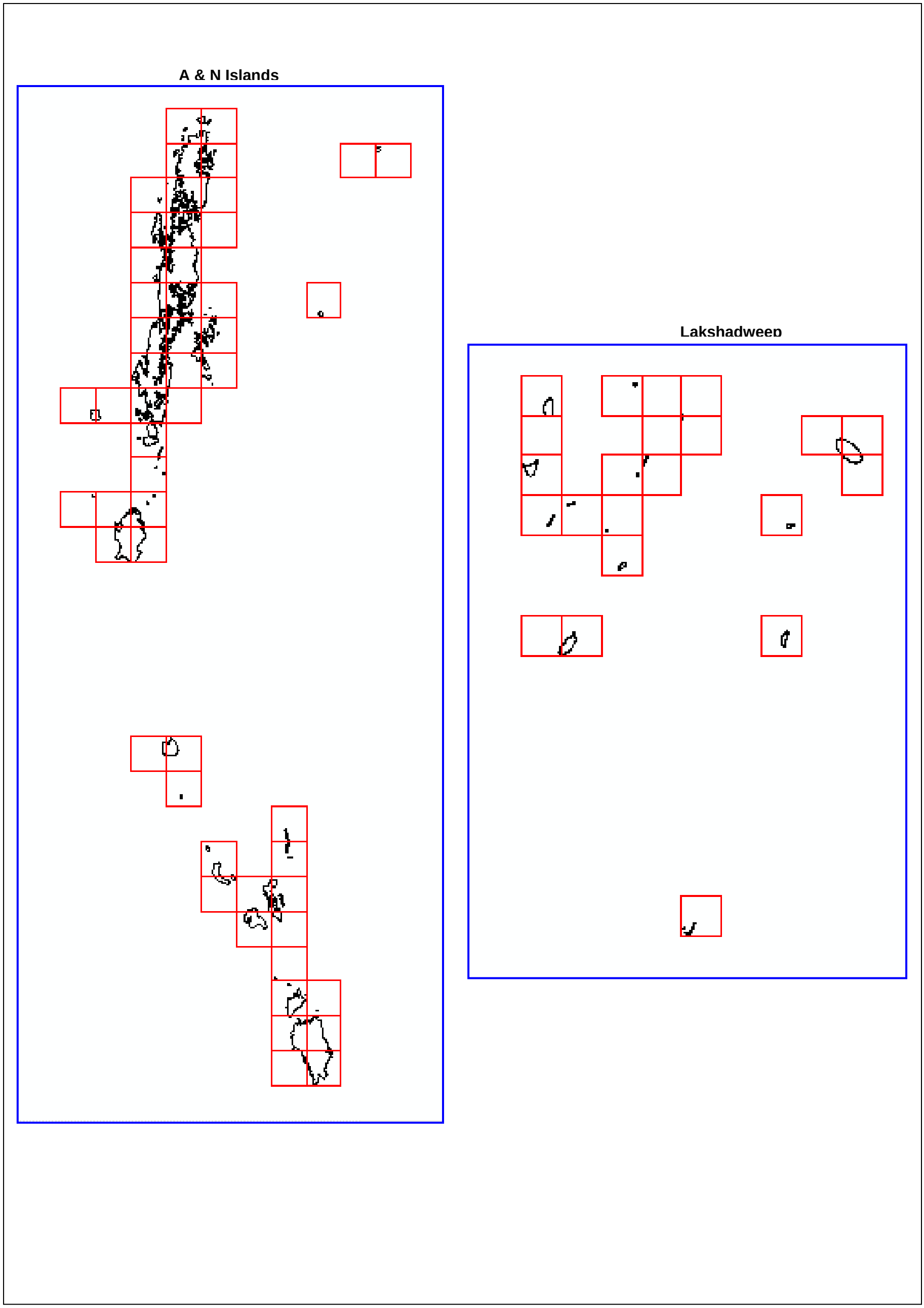


Figure 4c: Spatial framework of Lakshdweep and A & N Islands

4.0 DATA USED

4.1 Remote sensing data

IRS P6 LISS III and LISS-IV data were used to map the wetlands. IRS P6 LISS III provide data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23.5 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The Union Territories are covered in 21 IRS LISS III scene. IRS LISS-III Coverage of Andaman and Nicobar Islands and Lakshadweep are shown in Figures 5a and 5b respectively. 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 Union Territories as seen in the LISS III FCC of post- monsoon and pre-monsoon data respectively.

4.2 Ground truth data

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

4.3 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.

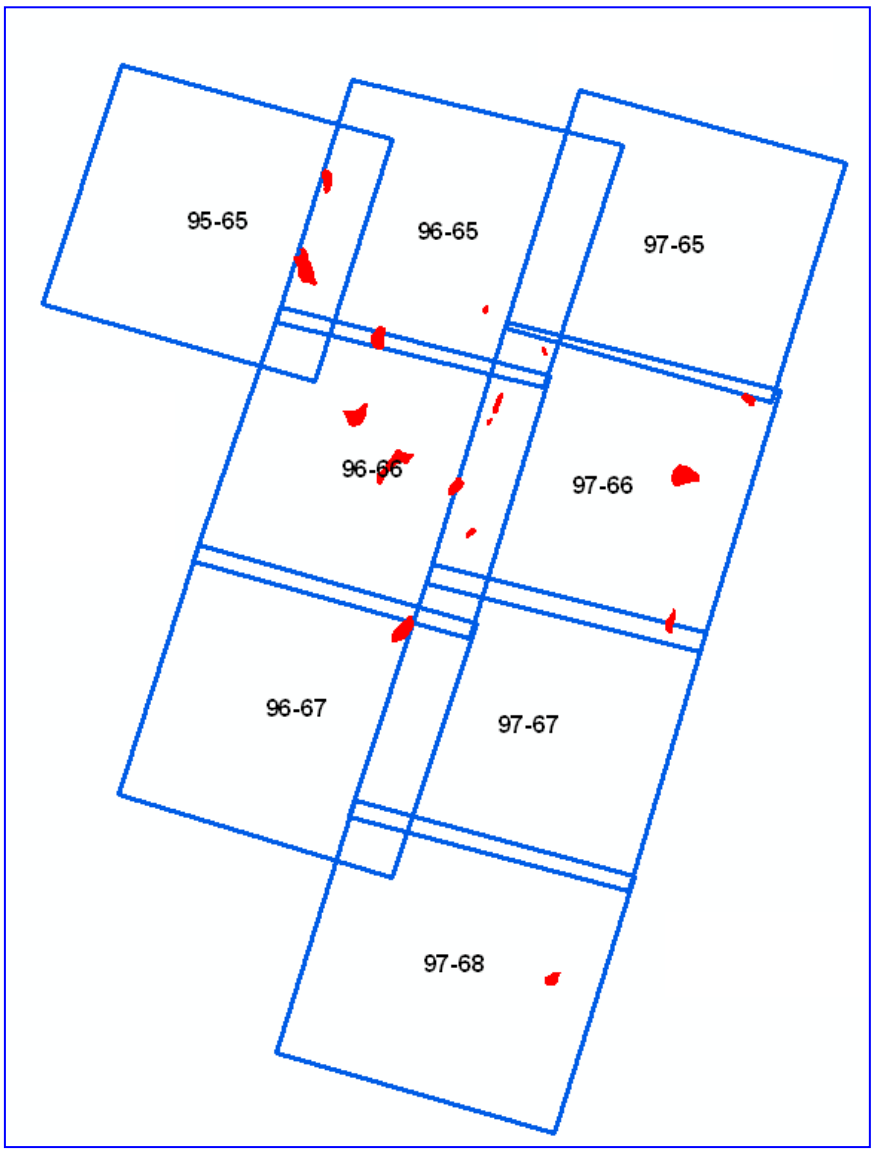


Figure 5a: IRS P6 LISS-III coverage of Lakshdweep

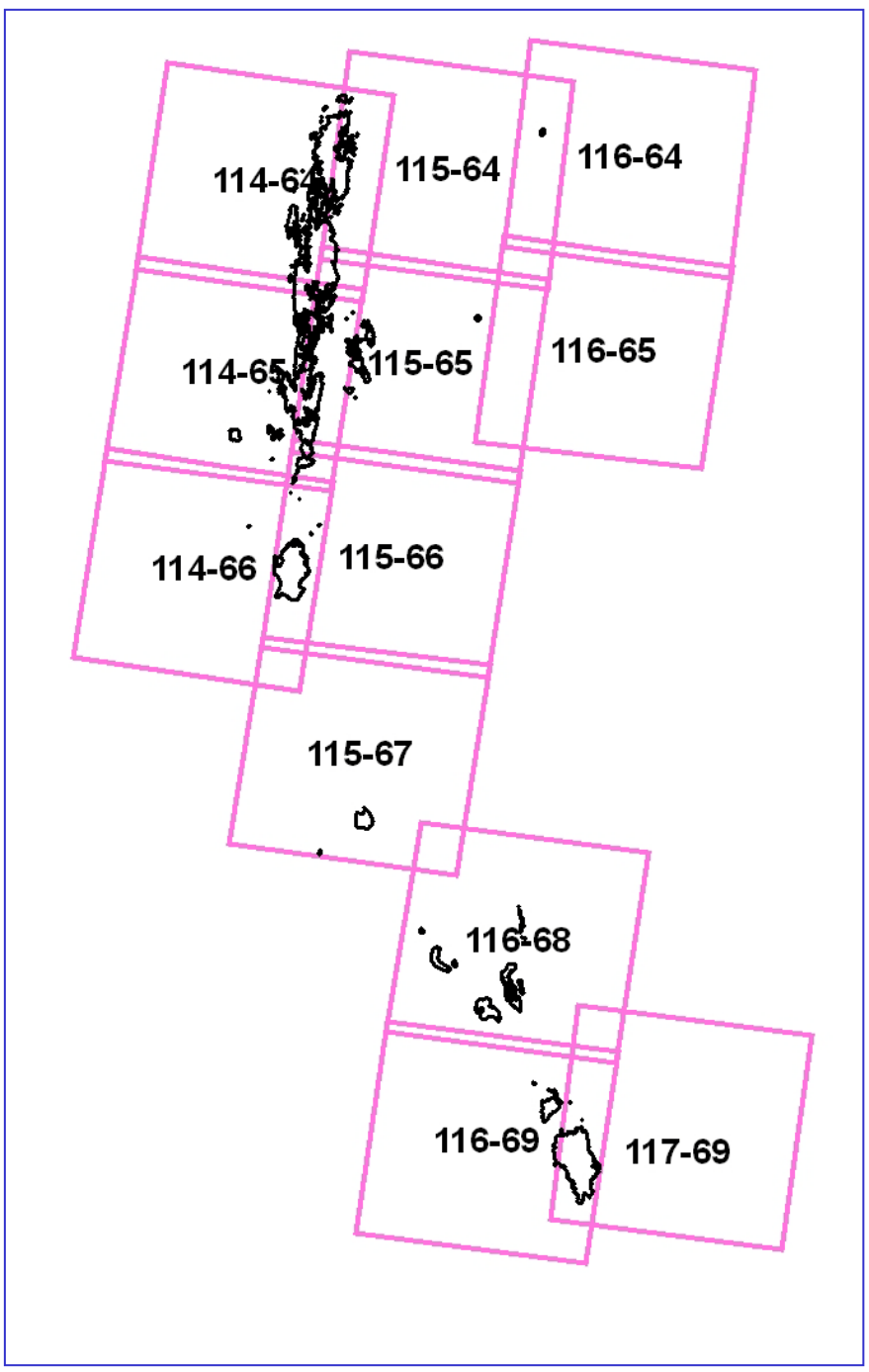


Figure 5b: IRS P6 LISS-III coverage of Andaman and Nicobar Islands

Table-2: Satellite data used

Sr. No.	Sensor	Path-Row	Date of acquisition	
			Post-monsoon	Pre-monsoon
	Diu and Daman			
1	LISS-III	92-58	Oct 14, 2006	Apr 24, 2007
2	LISS-III	94-58	Oct 24, 2006	May 4, 2007
	Dadra and Nagar Haveli			
1	LISS-III	94-58	Oct 24, 2006	May 4, 2007
	Andaman and Nicobar Islands			
1	LISS-III	114-64	06-02-2006	21-03-2007
2	LISS-III	114-65	06-02-2006	21-03-2207
3	LISS-III	114-66	06-02-2006	21-03-2007
4	LISS-III	115-64	20-12-2006	02-03-2007
5	LISS-III	115-65	02-03-2007	02-03-2007
6	LISS-III	115-67	02-11-2006	02-03-2007
7	LISS-III	115-68	02-11-2006	02-03-2007
8	LISS-III	116-68	07-04-2007	07-04-2007
9	LISS-III	116-69	05-04-2006	05-04-2006
10	LISS-III	117-69	26-02-2005	25-12-2007
	Lakshadweep			
1	LISS-IV	202-138	12-02-07	12-02-07
2	LISS-IV	203-87	16-12-06	16-12-06
3	LISS-IV	204-66	14-01-08	14-01-08
4	LISS-IV	203-63	11-12-07	11-12-07
5	LISS-IV	203-64	04-01-08	04-01-08
6	LISS-IV	202-132	01-07-07	01-07-07
7	LISS-IV	203-43	09-05-07	09-05-07
8	LISS-IV	101-166	16-07-06	16-07-06
9	LISS-IV	201-111	04-05-06	04-05-06
10	LISS-IV	202-130	03-03-07	03-03-07
	Pondicherry			
1	LISS-III	102-65	8-December-05	7-April-06 & 20-May-07
2	LISS-III	102-66	8-December-05	7-April-06 & 20-May-07
3	LISS-III	98-65	December 7, 2006	January 5, 2007 & January 29, 2006
4	LISS-III	103-61	Dec 8, 2006	May 25, 2007

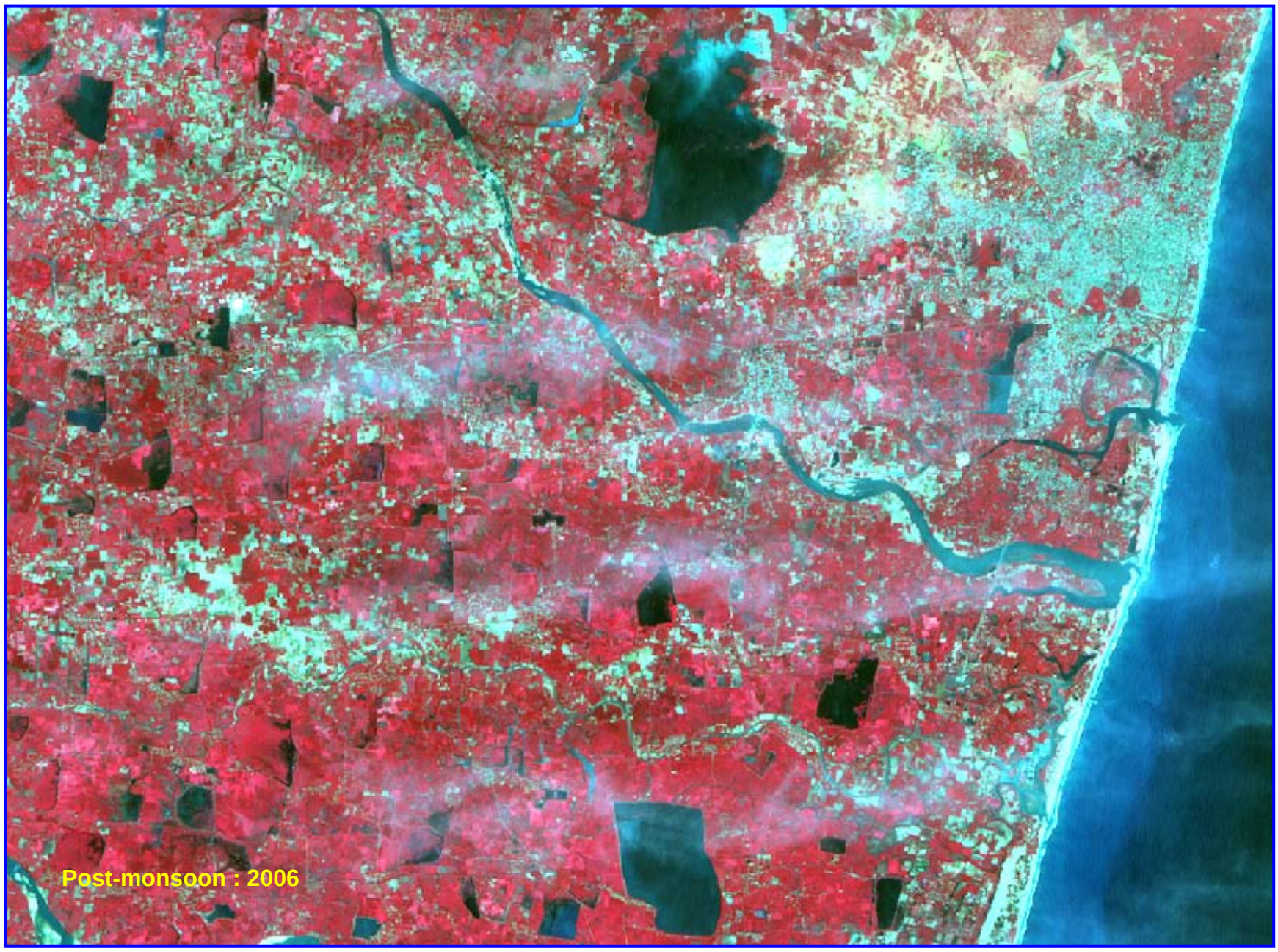


Figure 6: IRS LISS-III FCC (Post-monsoon and Pre-monsoon), Puducherry and surrounding area

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 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 (Patel and Garg, 2007). The spatial framework for Union Territories state is shown in Figure 4.

5.2 Geo-referencing of Satellite Data

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

5.3 Mapping of Wetlands

The delineation of wetlands through image analysis forms the foundation for deriving all wetland classes and results. Consequently, a great deal of emphasis has been placed on the quality of the image Interpretation. In the present study, the mapping of wetlands was done following digital classification and onscreen visual interpretation. Wetlands were identified based on vegetation, visible hydrology and geography. There are various methods for extraction of water information from remote sensing imagery, which according to the number of bands used, are generally divided into two categories, i.e. Single-band and multi-band methods. Single-band method usually involves choosing a band from multi-spectral image to distinguish water from land by subjective threshold values. It may lead to over- or under-estimation of open water area. Multi-band method takes advantage of reflective differences of each band.

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)

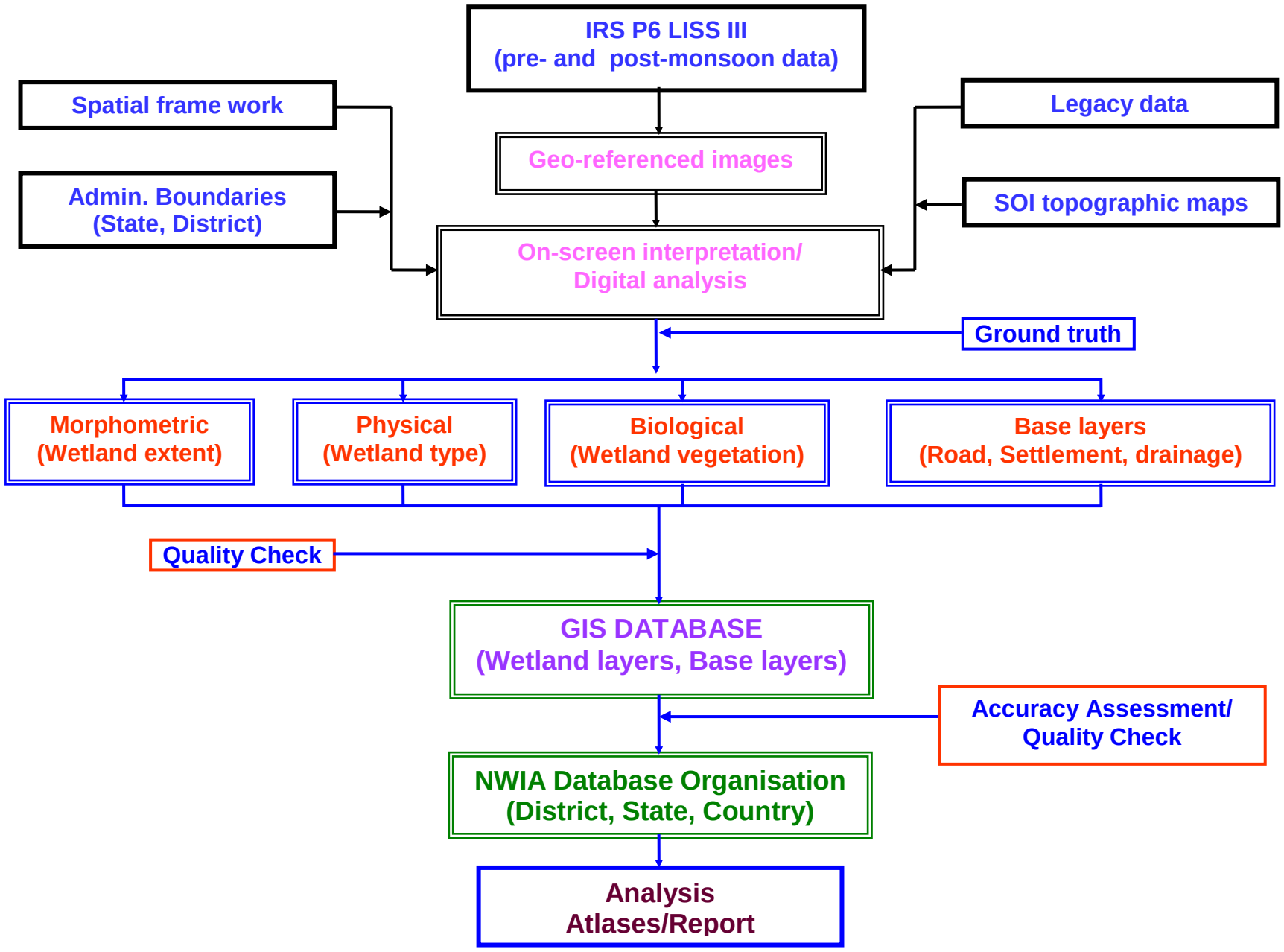


Figure 7: Flow chart of the methodology used

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 with in the wetland mask to delineate the water and no-water areas.

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

- Turbidity information extraction :
  MNDWI image was used to generate qualitative turbidity level (high, moderate and low) based on following steps:

  a) Conversion of post- and pre-monsoon water spread polygons into Area of Interest (AoI).

  b) Grouping of all AoIs excluding all non-wetland areas into a single entity.

  c) Generate a signature statistics like minimum, maximum, mean and standard deviations.

  d) Generate a raster turbidity image through a model for AoI only with *conditional* categorisation.

  e) Convert the raster into vector and update the attributes or edit the water spread layer (copied as turbidity layer) in polygon mode so as to retain all the attributes.

  f) Assign turbidity classes as per the table 3.

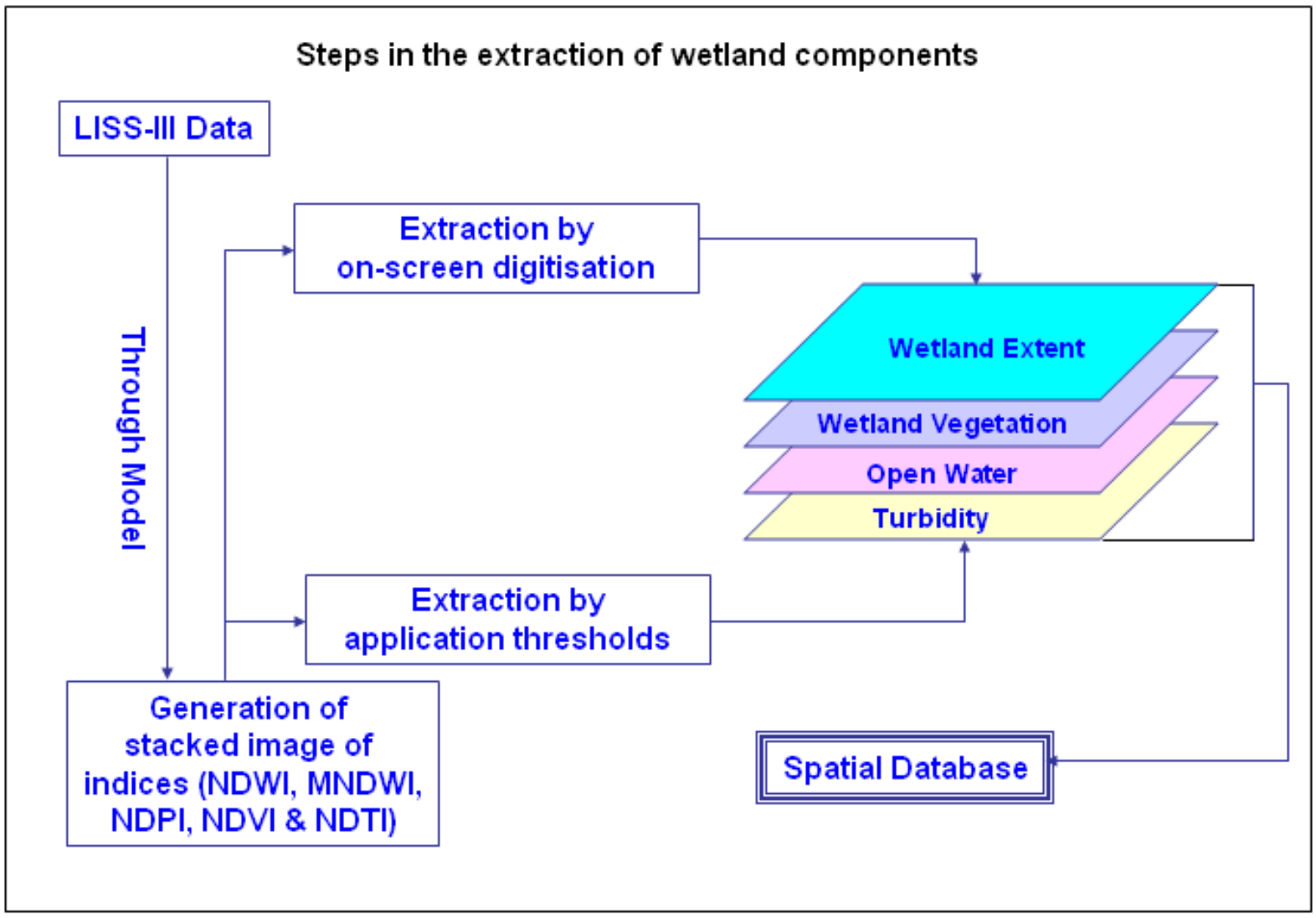


Figure 8: Steps in the extraction of wetland components

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 regional growing properties or on-screen digitization.

5.5 Generation of Reference Layers

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

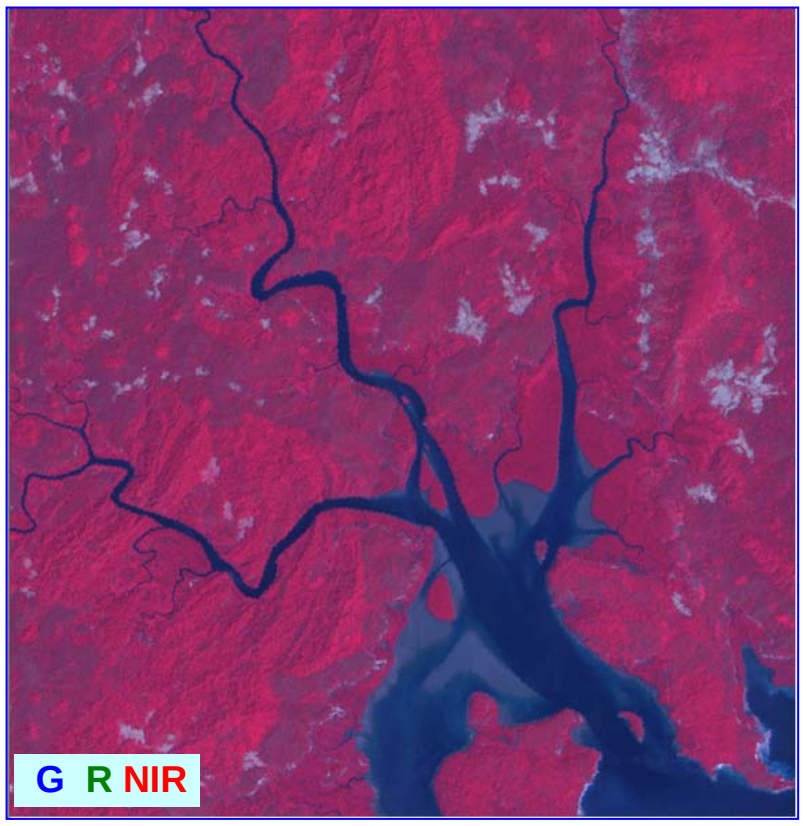
5.6 Coding and Attribute Scheme

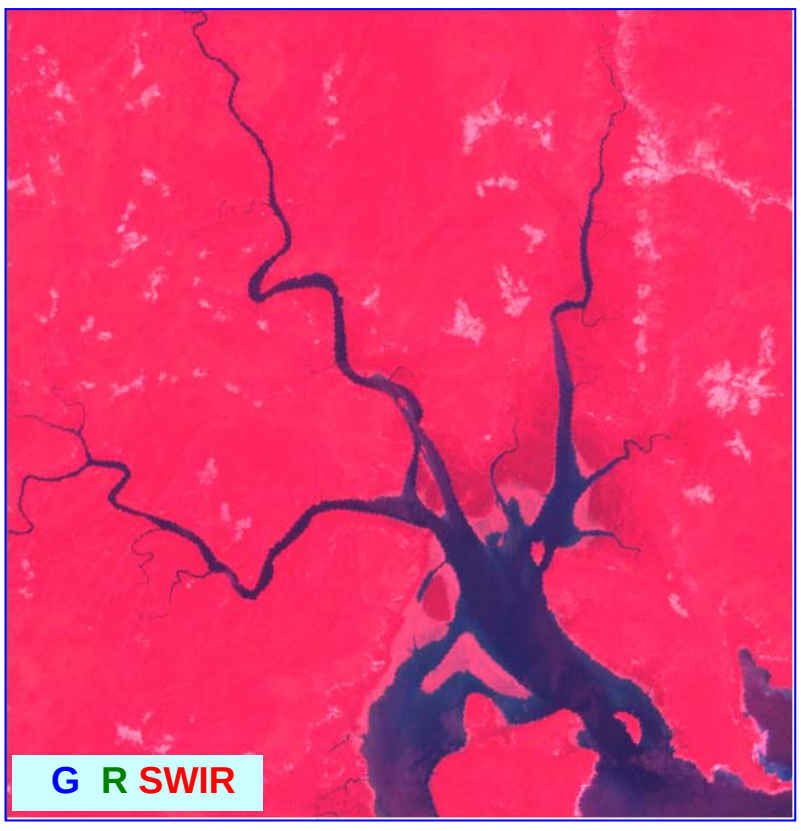
Feature codification scheme for every input element has been worked out keeping in view the nationwide administrative as well as natural hierarchy (State-district-taluka) within the feature class for each of the theme. All data elements are given a unique name/code, which are self explanatory with short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

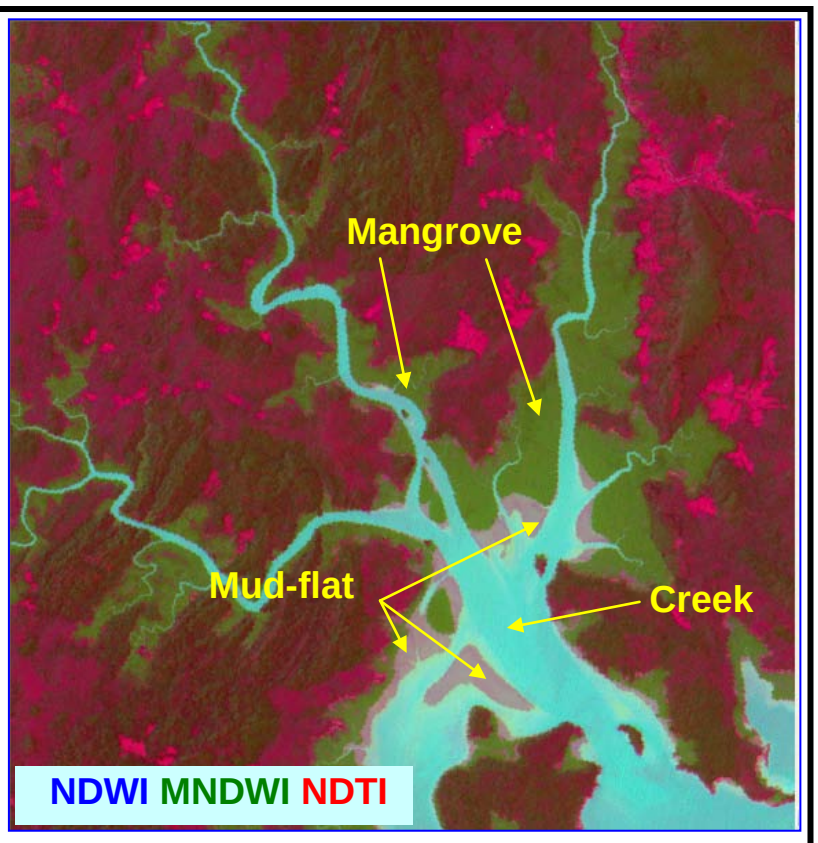
5.7 Map composition and output

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

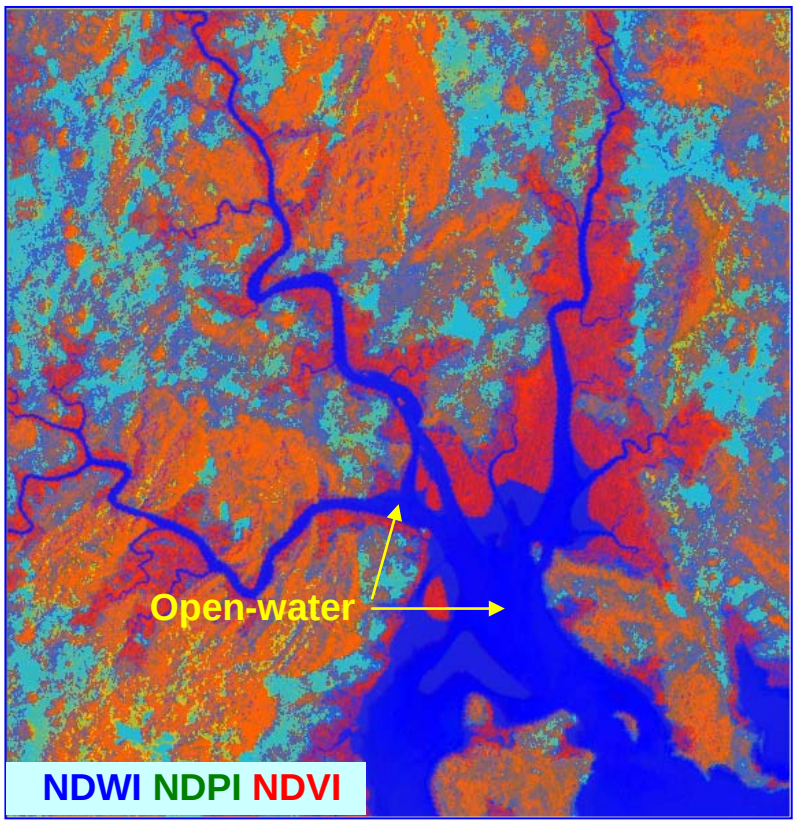
Part of North Andaman showing wetland complex of Mangroves, Mud-flats and Creek forming Estuarine Complex (Post-monsoon, 2006)



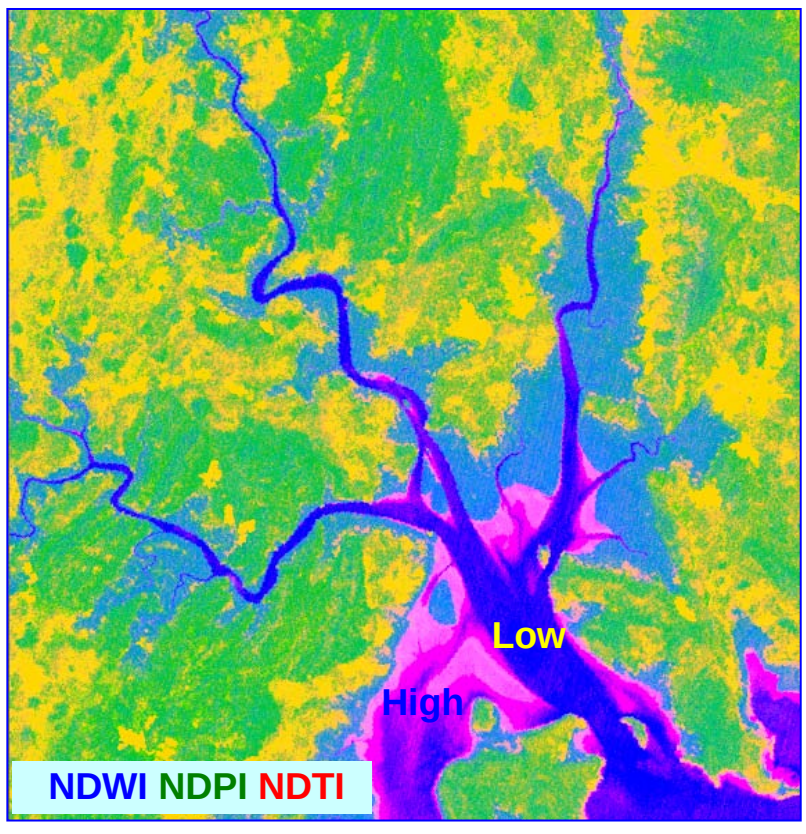




Useful for wetland boundary delineation



Useful for wetland open water delineation



Useful for qualitative turbidity delineation

Figure 9: Various combinations of the indices/spectral bands used to discriminate wetland structural 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 location accuracy. In addition, GIS database(s) contents have been also evaluated for accuracy. To ensure the reliability of wetland status data, the project adhered to established quality assurance and quality control measures for data collection, analysis, verification and reporting.

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

1. Image-Image Geo-referencing/Data generation

2. Reference layer preparation using NWIA post monsoon and pre-monsoon LISS-III data.

3. Wetland mapping using visual/digital interpretation techniques.

4. Geo-data base creation and organization

5. Output products.

6.1 Data verification and quality assurance of output digital data files

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

MAPS AND STATISTICS

7.0 WETLANDS OF UNION TERRITORIES : MAPS AND STATISTICS

Area estimates of various wetland categories for Union Territories have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total wetland area estimated is 243200 ha that is around 23.65 per cent of the geographic area. Union Territory-wise wetland summary is shown in Table 4. The major wetland types are Coral reefs, Inter-tidal mud flats, rivers, mangroves, lakes/ponds and tanks.

Table-4: Union Territory-wise wetland distribution

Sr. No.	Union Territory	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of geographic area
1	Chandigarh	114	350	0.14	3.07
2	Daman and Diu	112	2068	0.85	18.46
3	Dadra and Nagar Haveli	487	2070	0.85	4.25
4	Lakshdweep	828*	79568	32.72	96.13
5	Puducherry	492	6335	2.60	12.88
6	Andaman and Nicobar Islands	8249	152809	62.83	18.52
	Total	**10282**	**243200**	**100.00**	**23.65**

** GIS area considered for analysis*

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

7.1 **Chandigarh**

Total 20 wetlands are mapped including 9 small wetlands (< 2.25 ha) with 350 ha area**.** Rivers/ streams contributed 47.71% to the total wetland area. The Lakes/Ponds with 160 ha (45.71% area) is the second major wetland category, followed by tanks/ponds with 14 ha area i.e. 4 %. Details of wetland statistics is given in Table- 5.

Open water spread of the wetlands is significantly higher in post monsoon (242 ha) than during pre monsoon (225 ha). Aquatic vegetation is slightly more during pre monsoon (19 ha) than in post monsoon (10 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 5: Area estimates of wetlands in Chandigarh

Area in ha

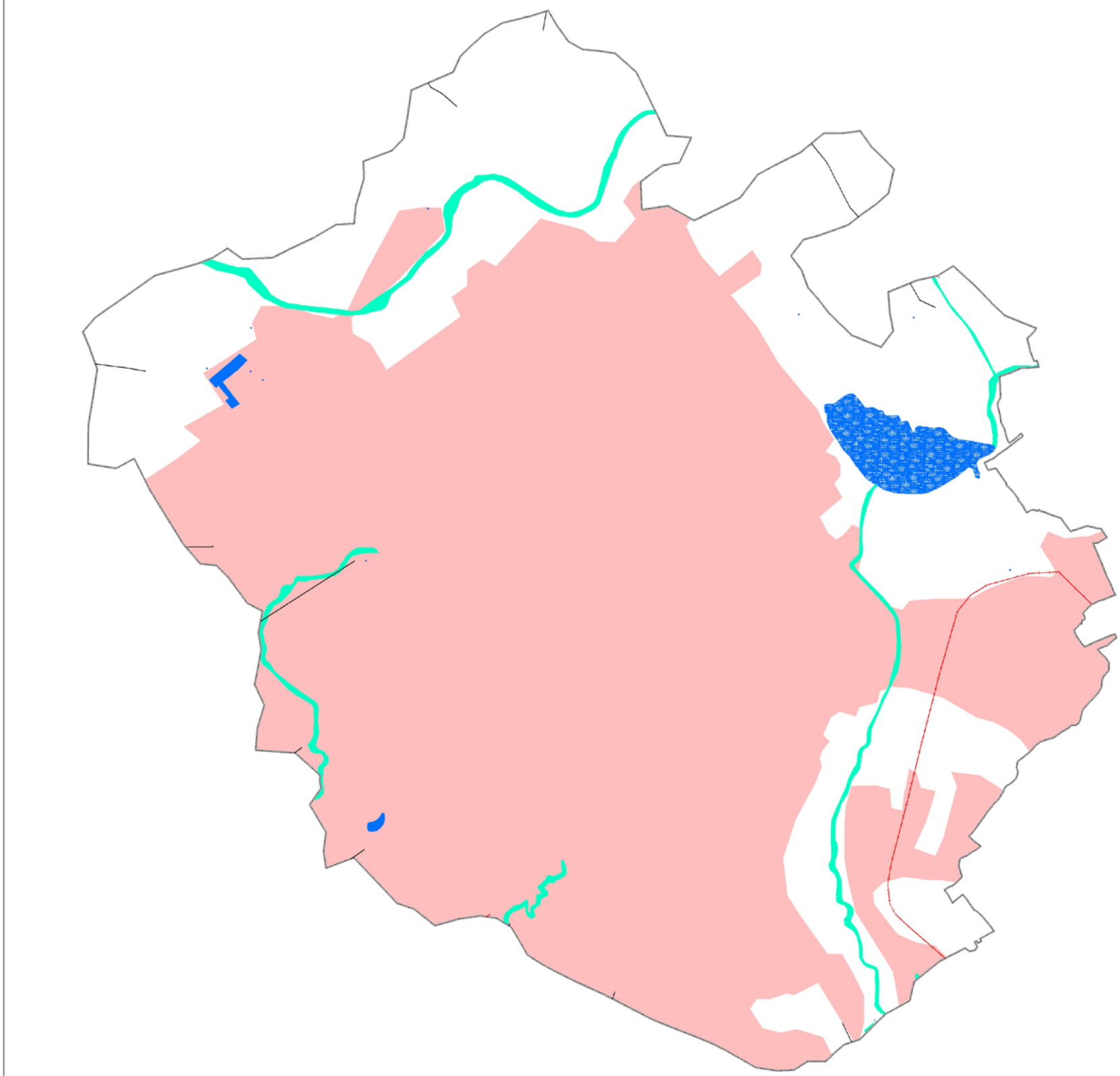
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	160	45.71	155	138
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	8	167	47.71	78	80
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	2	14	4.00	9	7
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**11**	**341**	**97.43**	**242**	**225**
		Sub-Total	**11**	**341**	**97.43**	**242**	**225**
		Wetlands (<2.25 ha), mainly Tanks	9	9	2.57	-	-
		Total	**20**	**350**	**100.00**	**242**	**225**

Area under Aquatic Vegetation	10	19

Area under turbidity levels		
Low	65	70
Moderate	177	155
High	-	-

State : Chandigarh

WETLAND MAP

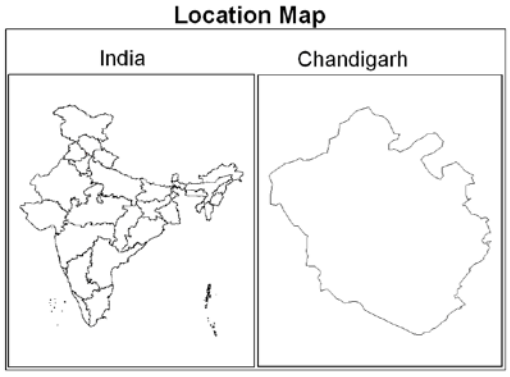


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.5 1 2 3 4 Kilometers

Data Source :

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

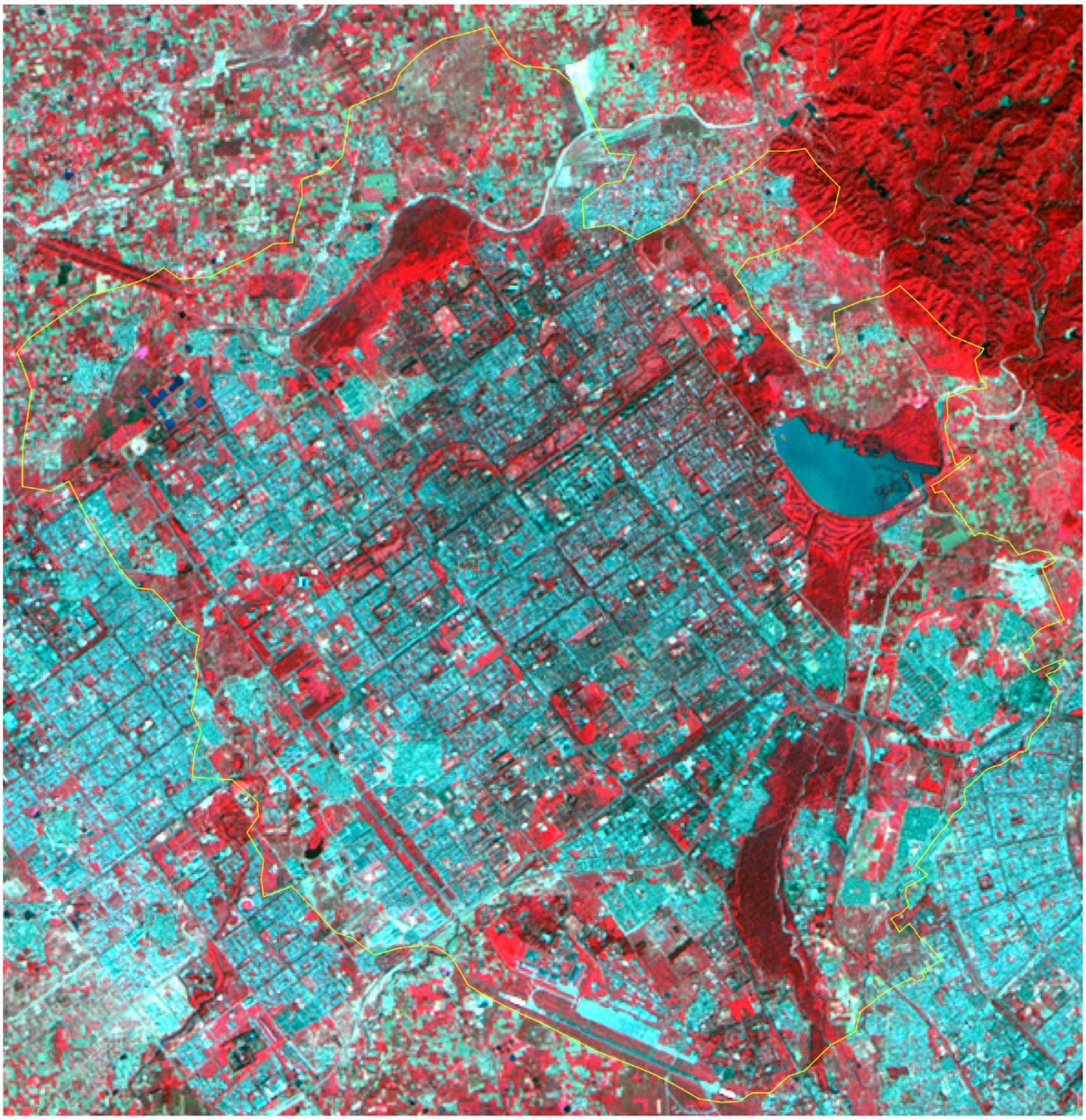
Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By :

Ministry of Environment and Forests
Government of India

State : Chandigarh



IRS P6 LISS-III post monsoon data (2006)

7.2 Daman and Diu

Total 62 wetlands are mapped including 10 small wetlands (< 2.25 ha) with 2068 ha area**.** Intertidal mud flats contributed 50.97% to the total wetland area. The river/stream with 380 ha (18.38% area) is the second major wetland category, followed by sand/beach with 2047 ha area i.e. 9.86 %. Details of wetland statistics is given in Table- 6.

Open water spread of the wetlands is significantly higher in post monsoon (570 ha) than during pre monsoon (262 ha), indicating the rainfall dependence of the wetlands in the area. Aquatic vegetation is slightly more during pre monsoon (59 ha) than in post monsoon (54 ha).

There are two districts in Union territory of Daman and Diu. District-wise wetland summary is given in Table 7.

Table 6: Area estimates of wetlands in Daman & Diu

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	1106	River/Stream	4	380	18.38	341	223
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	5	125	6.04	92	0
4	1202	Tanks/Ponds	15	88	4.26	60	28
		Total - Inland	**24**	**593**	**28.68**	**493**	**251**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	3	24	1.16	24	7
6	2103	Sand/Beach	7	204	9.86	0	0
7	2104	Intertidal mud flats	9	1054	50.97	0	0
8	2105	Salt Marsh	1	57	2.76	0	0
9	2106	Mangroves	7	63	3.05	0	0
	2200	**Coastal Wetlands - Man-made**					
10	2201	Salt pans	1	63	3.05	53	4
11	2202	Aquaculture ponds	-	-	-	-	-
		Total - Coastal	**28**	**1465**	**70.84**	**77**	**11**
		Sub-Total	**52**	**2058**	**99.52**	**570**	**262**
		Wetlands (<2.25 ha), mainly Tanks	10	10	0.48	-	-
		Total	**62**	**2068**	**100.00**	**570**	**262**

Area under Aquatic Vegetation	54	59

Area under turbidity levels		
Low	265	137
Moderate	299	118
High	6	7

Table-7: District-wise wetland Area in Daman and Diu

Sr. No.	District	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of district Geographic area
1	Diu	40	901	43.57	22.53
2	Daman	72	1167	56.43	16.21
	Total	112	2068	100.00	18.46

7.2.1 Diu

Total 30 wetlands are mapped including 2 small wetlands (< 2.25 ha) with 901 ha area**.** Intertidal mud flats contributed 27.41% to the total wetland area. The sand/beach with 186 ha (20.64% area) is the second major wetland category, followed by river/steam with 145 ha area i.e. 16.09 %. Details of wetland statistics is given in Table- 8.

Open water spread of the wetlands is significantly higher in post monsoon (339 ha) than during pre monsoon (62 ha), indicating the rainfall dependence of the wetlands in the district. Aquatic vegetation is slightly more during post monsoon (35 ha) than in pre monsoon (32 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 8: Area estimates of wetlands in Diu

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	1106	River/Stream	1	145	16.09	145	51
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	5	125	13.87	92	0
4	1202	Tanks/Ponds	4	34	3.77	25	0
		Total - Inland	**10**	**304**	**33.74**	**262**	**51**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	3	24	2.66	24	7
6	2103	Sand/Beach	6	186	20.64	-	-
7	2104	Inter-tidal mud flats	5	247	27.41	-	-
8	2105	Salt Marsh	1	57	6.33	-	-
9	2106	Mangroves	2	18	2.00	-	-
	2200	**Coastal Wetlands - Man-made**					
10	2201	Salt pans	1	63	6.99	53	4
11	2202	Aquaculture ponds	-	-	-	-	-
		Total - Coastal	**18**	**595**	**66.04**	**77**	**11**
		Sub-Total	**28**	**899**	**99.78**	**339**	**62**
		Wetlands (<2.25 ha), mainly Tanks	2	2	0.22	-	-
		Total	**30**	**901**	**100.00**	**339**	**62**

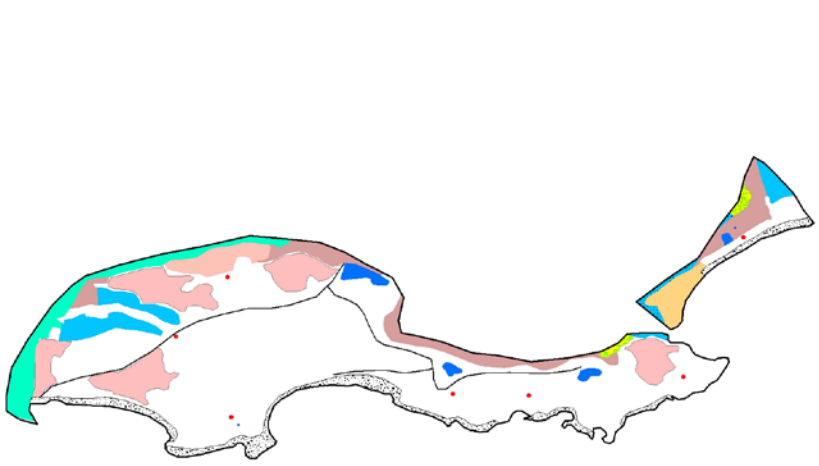
Area under Aquatic Vegetation	35	32

Area under turbidity levels		
Low	116	7
Moderate	223	55
High	-	-

State : Daman & diu

WETLAND MAP

District : Diu

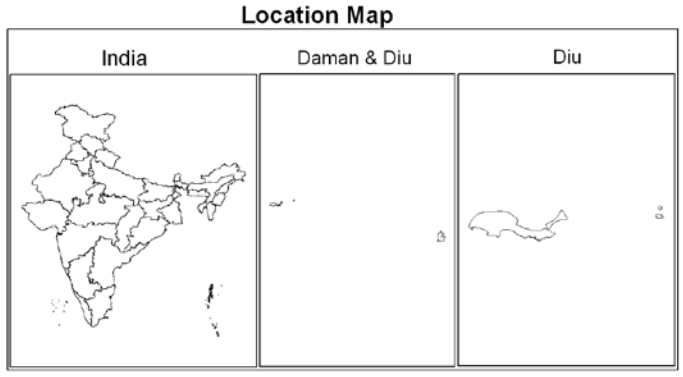


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.5 1 2 3 4
Kilometers

Data Source

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

Prepared By

Space Applications Centre (ISRO), Ahmedabad

Sponsored By

Ministry of Environment and Forests
Government of India

State : Daman & diu

District : Diu

IRS P6 LISS-III post monsoon data (2006)

7.2.2 Daman

Total 32 wetlands are mapped including 8 small wetlands (< 2.25 ha) with 1167 ha area**.** Intertidal mud flats contributed 69.15% to the total wetland area. The river/steam with 235 ha (20.14% area) is the second major wetland category, followed by tanks/ponds with 54 ha area i.e. 4.63 %. Thus, the district is dominated by man made wetlands. Details of wetland statistics is given in Table- 9.

Open water spread of the wetlands is significantly higher in post monsoon (231 ha) than during pre monsoon (200 ha), indicating the rainfall dependence of the wetlands in the state. Aquatic vegetation is slightly more during pre monsoon (26 ha) than in post monsoon (19 ha). The qualitative turbidity of water is low in both the seasons.

Table 9: Area estimates of wetlands in Daman

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	1106	River/Stream	3	235	20.14	196	172
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	-	-	-	-	-
4	1202	Tanks/Ponds	11	54	4.63	35	28
		Total - Inland	**14**	**289**	**24.76**	**231**	**200**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	-	-	-	-	-
6	2103	Sand/Beach	1	18	1.54	-	-
7	2104	Intertidal mud flats	4	807	69.15	-	-
8	2105	Salt Marsh	-	-	-	-	-
9	2106	Mangroves	5	45	3.86	0	0
	2200	**Coastal Wetlands - Man-made**					
10	2201	Salt pans	-	-	-	-	-
11	2202	Aquaculture ponds	-	-	-	-	-
		Total - Coastal	**10**	**870**	**74.55**	**0**	**0**
		Sub-Total	**24**	**1159**	**99.31**	**231**	**200**
		Wetlands (<2.25 ha), mainly Tanks	8	8	0.69	-	-
		Total	**32**	**1167**	**100.00**	**231**	**200**

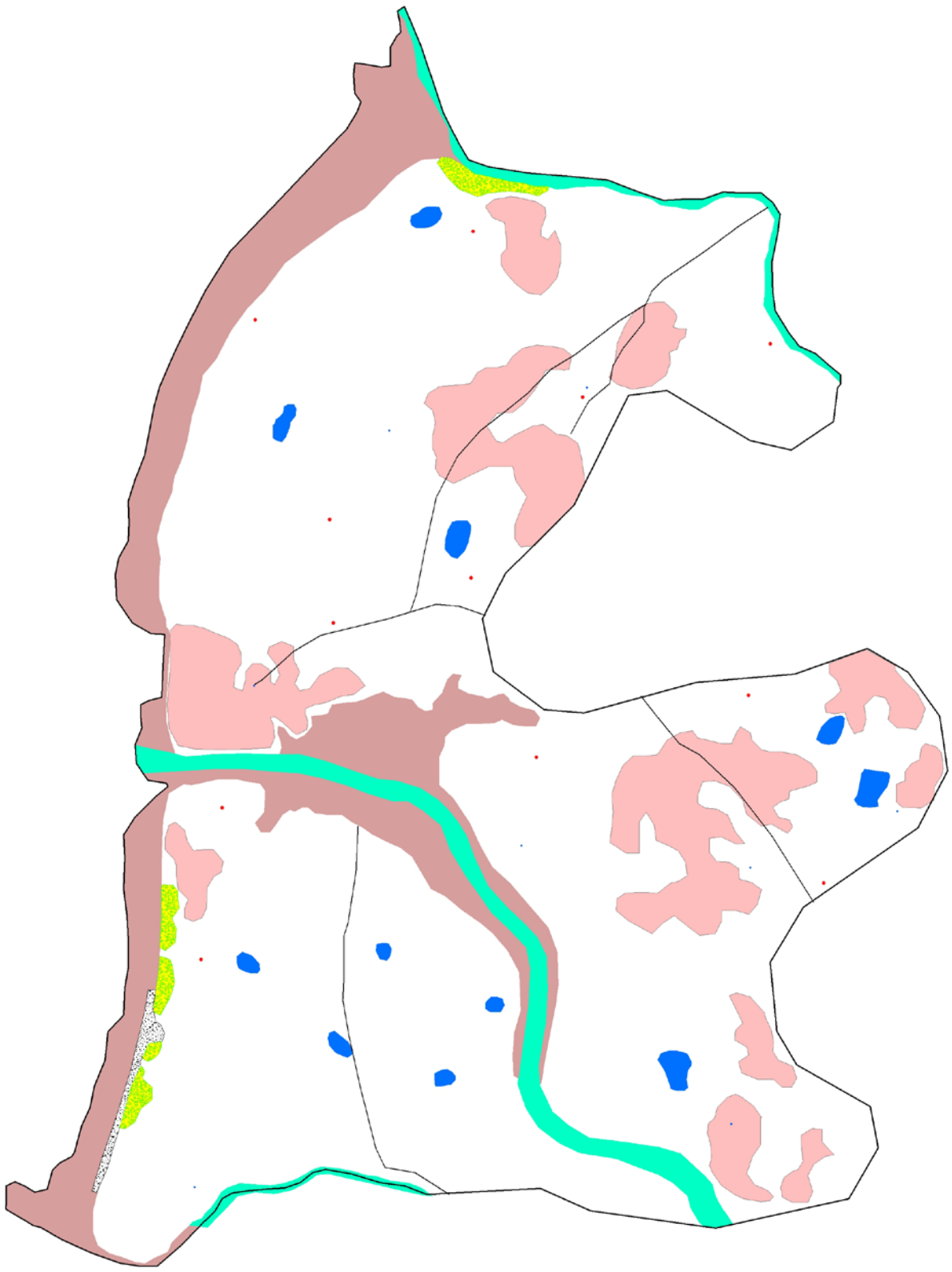
Area under Aquatic Vegetation	19	26

Area under turbidity levels		
Low	149	130
Moderate	76	63
High	6	7

State : Daman & diu

WETLAND MAP

District : Daman

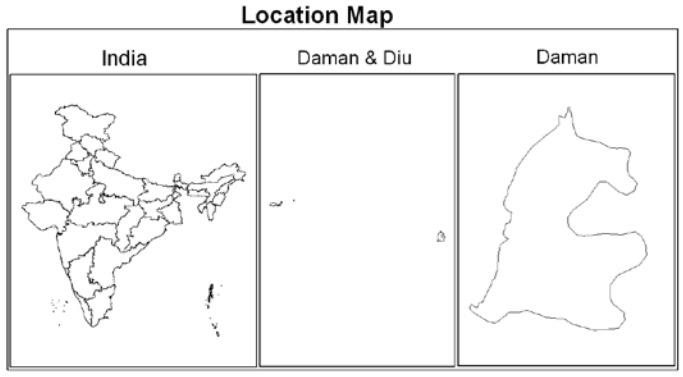


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.250.5 1 1.5 2 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 : Daman & diu

District : Daman

IRS P6 LISS-III post monsoon data (2006)

7.3 Dadra and Nagar Haveli

Total 52 wetlands are mapped including 39 small wetlands (< 2.25 ha) with 2070 ha area**.** Reservoirs/Barrages contributed 62.13% to the total wetland area. The river/steam with 732 ha (35.36% area) is the second major wetland category, followed by tanks/ponds with 13 ha area i.e. 0.63 %. Thus, the Dadra and Nagar Haveli is dominated by man made wetlands. Details of wetland statistics is given in Table- 10.

Open water spread of the wetlands is significantly higher in post monsoon (1915 ha) than during pre monsoon (1131 ha), indicating the rainfall dependence of the wetlands in the state. Aquatic vegetation is 145 ha in pre monsoon. The qualitative turbidity of water is low in both the seasons.

Table 10: Area estimates of wetlands in Dadra & Nagar Haveli

Area in ha

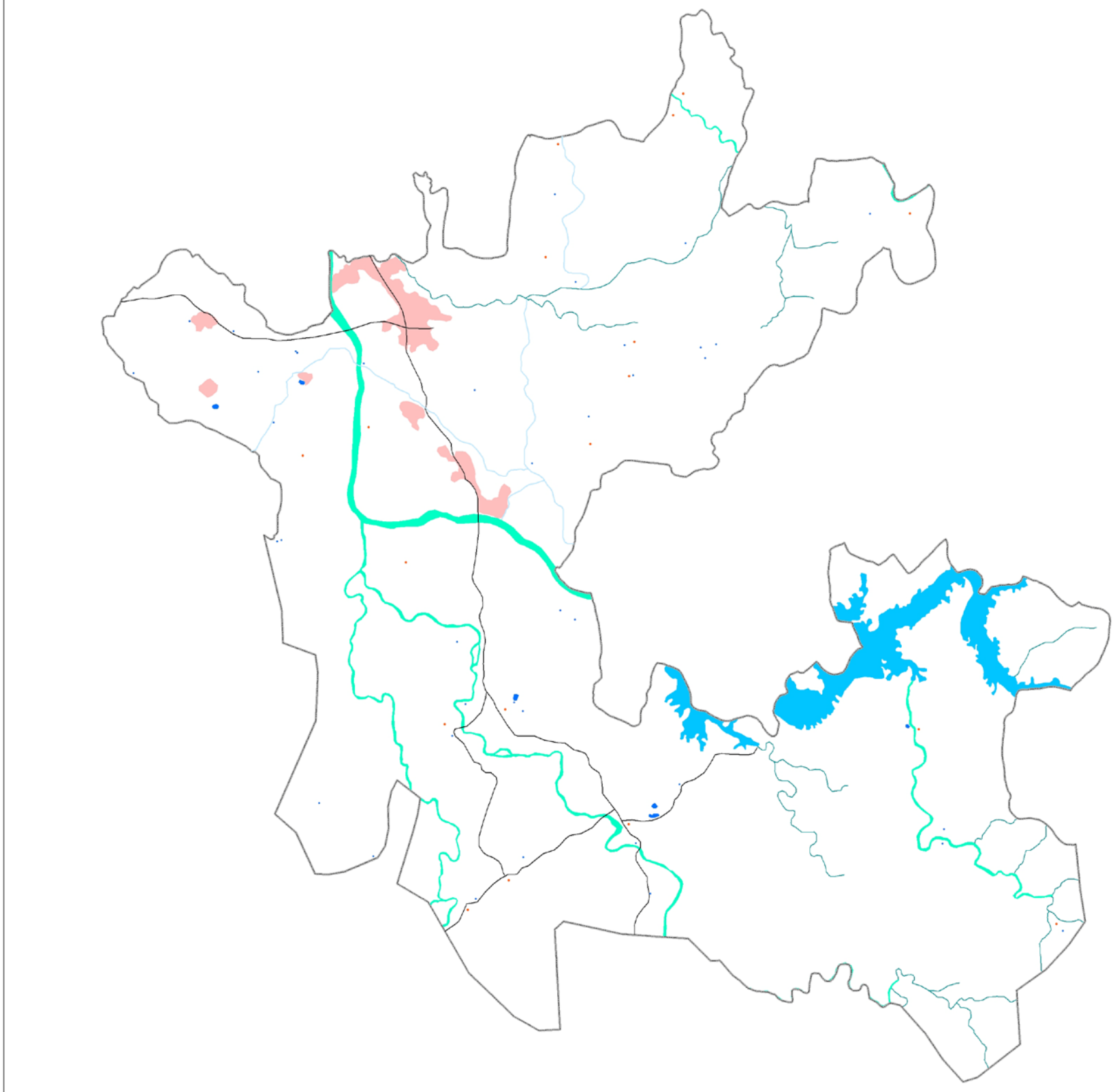
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1106	River/Stream	6	732	35.36	623	314
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	1	1286	62.13	1286	812
4	1202	Tanks/Ponds	6	13	0.63	6	5
5	1203	Waterlogged	-	-	-	-	-
		Total - Inland	**13**	**2031**	**98.12**	**1915**	**1131**
		Sub-Total	**13**	**2031**	**98.12**	**1915**	**1131**
		Wetlands (<2.25 ha), mainly Tanks	39	39	1.88	-	-
		Total	**52**	**2070**	**100.00**	**1915**	**1131**

Area under Aquatic Vegetation	-	145

Area under turbidity levels		
Low	1286	812
Moderate	629	319
High	-	-

State : Dadra & Nagar Haveli

WETLAND MAP

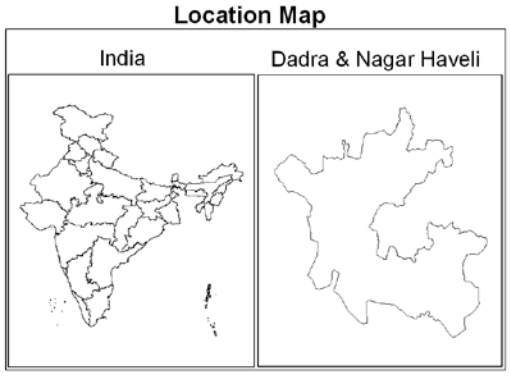


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 1.25 2.5 5 7.5 10 Kilometers

Data Source

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

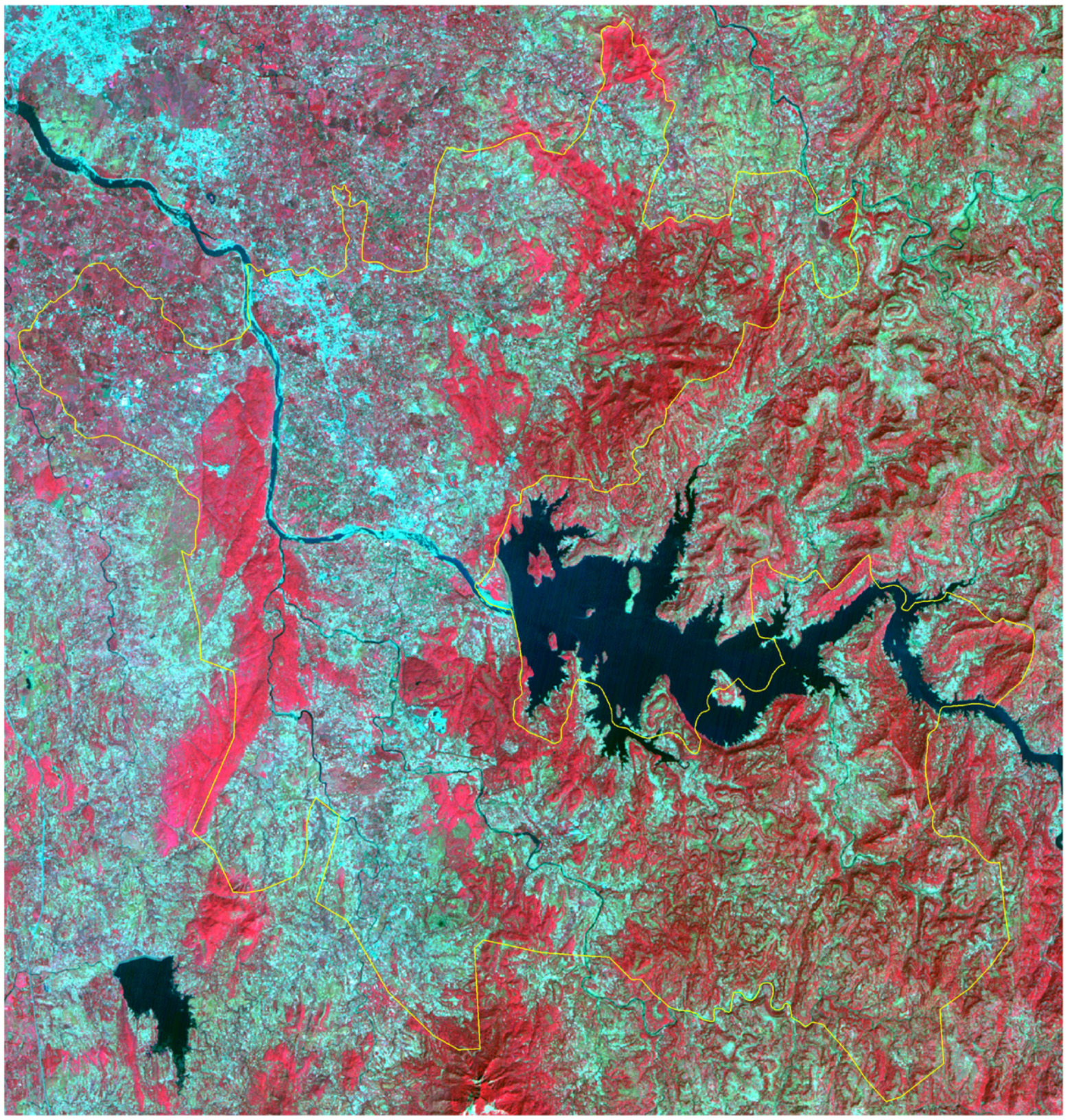
Prepared By

Space Applications Centre (ISRO), Ahmedabad

Sponsored By

Ministry of Environment and Forests
Government of India

State : Dadra & Nagar Haveli



IRS P6 LISS-III post monsoon data (2006)

7.4 Lakshadweep

Area estimates of various wetland categories for Lakshadweep have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. In the state of Lakshadweep 48 wetlands have been delineated. Total wetland area estimated is 79587 ha. Coastal-Natural wetlands are the only wetlands in these islands. There are only three wetland types namely; Coral, Lagoon and Sand/Beach. Coral contributed 69.33% to the total wetland area. The Lagoons with 23674 ha (29.75% area) is the second major wetland category, followed by sand/beach with 733 ha area i.e. 0.92 %. Details of wetland statistics is given in Table- 11. The qualitative turbidity of water is low in both the seasons.

In every coral-growing area and in particularly in oceanic coral reefs two diametrically opposed processes are continuosly in operation. One is constructive depending the growth of coral and associated plants such as Nullipore. Other is the geological formation of conglomerate rocks and sandstones from the coral or other calcareous debris, which is destructive to the activities of animals that feed upon coral or animals and plants that bore into coral and so render it less solid and more liable for destruction due to erosion by waves and curresnts, and change in temperature and salinity etc (Sewell, 1935). Coral reefs are of three types namely; fringing reefs, barrier reef and atolls. Atolls rest on the summits of submerged volcanoes and usually oval or circular in shape with a central lagoon. Almost all the atolls of Lakshadweep are oriented northeast-southwest with an island towards the east, a broad, well developed reef to the west and a lagoon in between. The lagoons are open in to sea through several channels. The coral diversity is good comprising 70 species belonging to 26 genera. Of these 36 species were add latter to the inventory of Minicoy (Wafar, 1986). Several types of primary producers may be observed in the coral ecosystem. The zooxanthelle exists with coral polyps in a symbiotic mode. Boring filamentous algae are found have associated with corals. Benthic macroalgae such as sea grasses are the prolific primary producers on lagoon floor at Karavatti Island. The corals form an abode to pelagic fish resource (Rashmi and Rajesh, 1992). Corals are the most dominating of the three wetland types and accounts for 55179 ha of area that amounts to ~69 % of wetland area in Lakshadweep. There are two uncharted atolls namely; Cheriyapaniyam and Baliyapaniayam which were not shown in the Survey of India topographical maps were mapped.

Lagoons may be formed by estuary outlets and delta channels completely blocked by sandbars, sandspits or sanddunes which limits access to sea. Nevertheless, as a rule lagoon will have mixing of freshwater brought by rivers and saltwater due to its access to sea. This results in complex environment wherin diversity of organisms range from freshwater type to marine through another group of organisms those show adaptability to both. However, in Lakshdweep the lagoons are very different from the mainland in the sense that they are actually coral reef lagoons wherein the water body gets enclosed in an atoll or within a barrier reef. The depth of the lagoon is appreciable and available literature indicates that the floor of these lagoons mainly contain the coral debris and calcareous sand (Gazetter of India, 1977; Anon., 1987). The smaller lagoons of Chetlat, Kiltan, Amini and Kadmat are substantially filled with sediments and show an average depth of 1 – 2.5 m while the larger ones like Bangaram, Suheli Par and Minicoy are devoid of sediments and show greater depth ranging from 10-16 m. Lagoon stands next to coral comprising 23674 ha of area. It accounts for ~30 % of wetland area followd by Sand/Beach (733 ha). The lagoons are the only category considered for open wate spread in pre-monsoon and post-monsoon. The open water spread (23674 ha) of lagoons remained unchanged in bioth thye seasons owing to thier contact with the sea, which allows movement water

perpetually. The qualitative turbidity remained low in both seasons indicating the tranqility of lagoons on these islands. Further, the is absence of aquatic vegetation adds to the clarity of water.

Table 11: Area estimates of wetlands in Lakshadweep

Area in ha

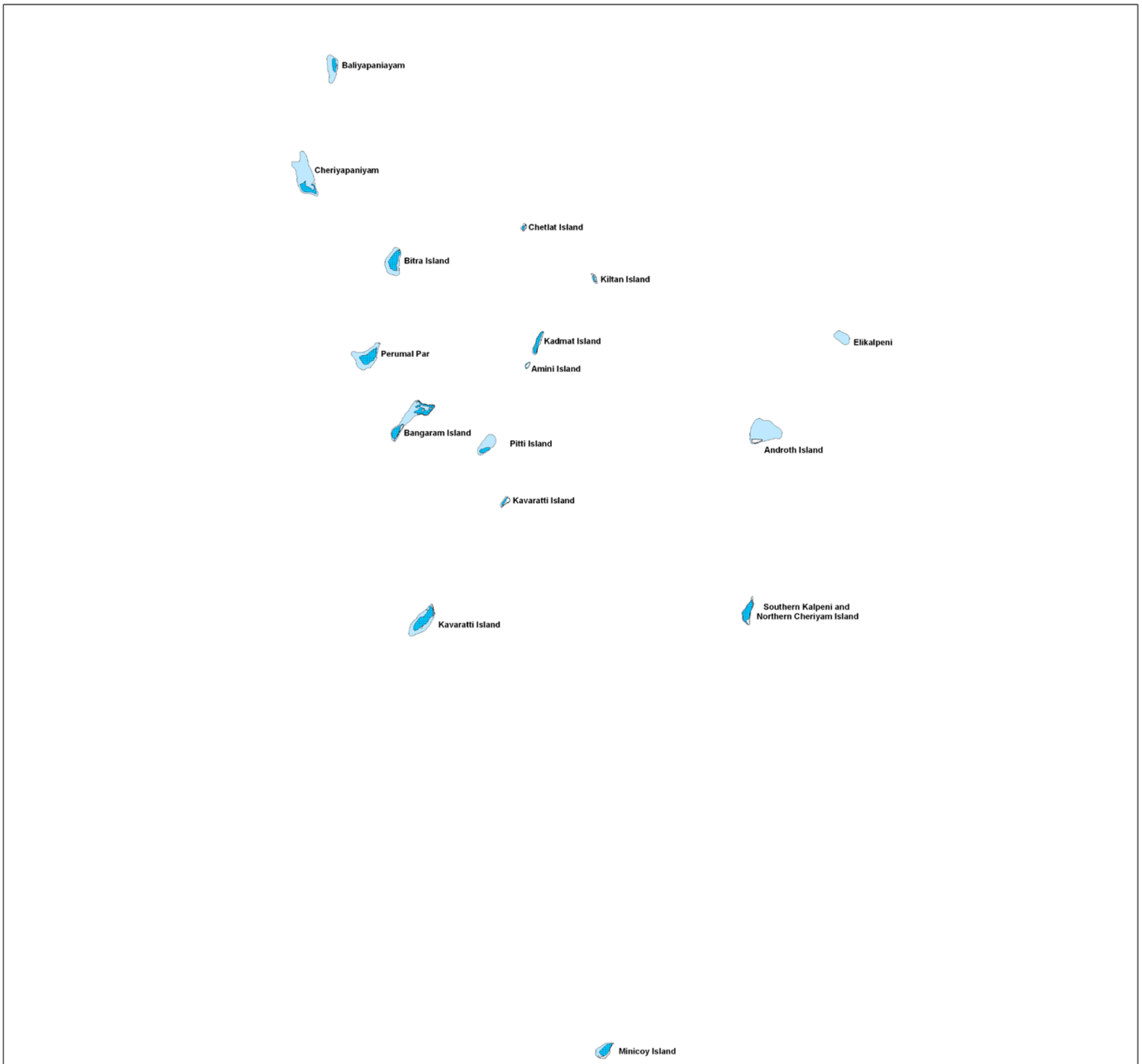
Sr. No.	Wettcode	Category	Number	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-Monsoon Area
	2100	**Coastal Wetlands - Natural**					
1	2101	Lagoons	15	23674	29.75	23674	23674
2	2102	Creeks	-	-	-	-	-
3	2103	Sand/Beach	18	733	0.92	-	-
4	2104	Intertidal mud flats	-	-	-	-	-
5	2106	Mangroves	-	-	-	-	-
6	2107	Coral	15	55179	69.33		
	2200	**Coastal Wetlands - Man-made**					
7	2201	Salt pans	-	-	-	-	-
8	2202	Aquaculture ponds	-	-	-	-	-
		Total - Coastal	**48**	**79586**	**100.00**	**23674**	**23674**
		Sub-Total	**48**	**79586**	**100.00**	**23674**	**23674**
		Wetlands (<2.25 ha), mainly Tanks	-	-	-	-	-
		Total	**48**	**79586**	**100.00**	**23674**	**23674**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	23674	23674
Moderate	-	-
High	-	-

UT : Lakshdweep Islands

WETLAND MAP

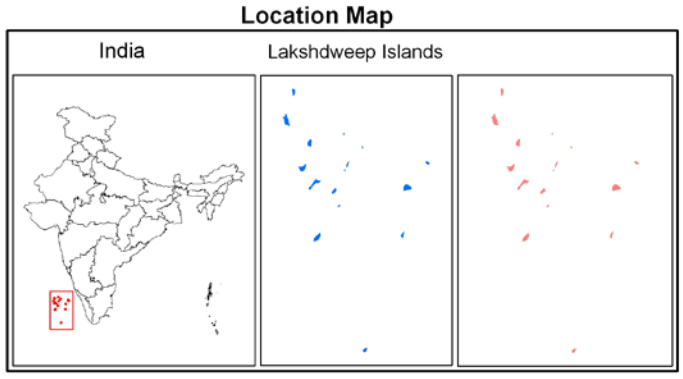


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 25 50 100
Kilometers

Data Source :

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

Prepared By :

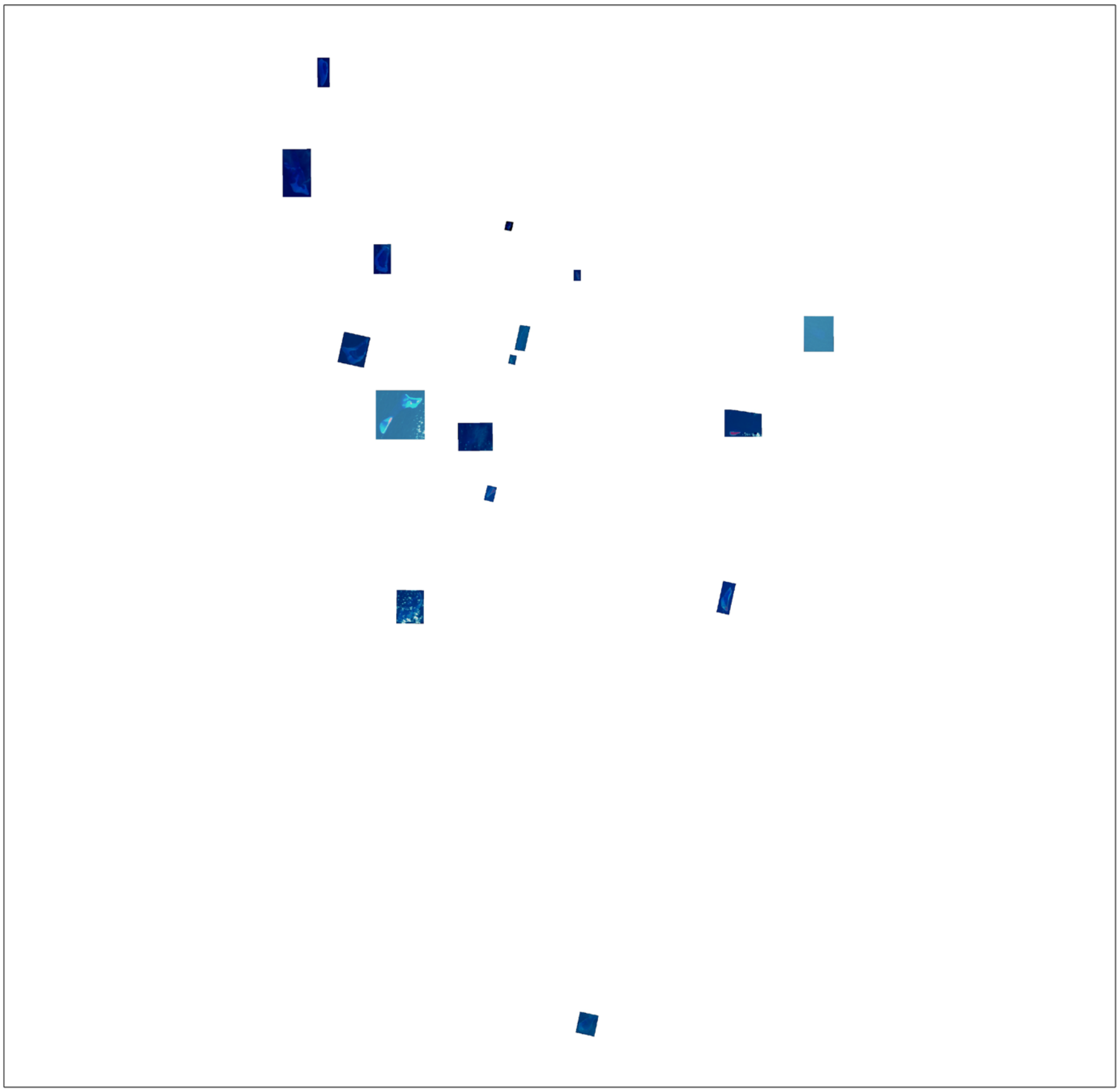
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

Ministry of Environment and Forests
Government of India

UT : Lakshdweep Islands

WETLAND MAP



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

7.5 Puducherry (Pondicherry)

Total 259 wetlands are mapped including 144 small wetlands (< 2.25 ha) with 6335 ha area**.** River/stream contributed 33.35% to the total wetland area. The lakes/ponds with 1120 ha (17.68% area) is the second major wetland category, followed by tanks/ponds with 867 ha area i.e. 13.69 %. Thus, the Puducherry is dominated by inland wetlands. Details of wetland statistics is given in Table- 12. Open water spread of the wetlands is significantly higher in post monsoon (4028 ha) than during pre monsoon (2535 ha), indicating the rainfall dependence of the wetland. Aquatic vegetation is almost double during pre monsoon (1753 ha) than in post monsoon (622 ha). The qualitative turbidity of water is moderate both the seasons.

There are four districts in Union territory of Puducherry. District-wise wetland summary is given in Table 13.

Table 12: Area estimates of wetlands in Puducherry

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	19	1120	17.68	943	305
2	1105	Waterlogged	1	20	0.32	13	2
3	1106	River/Stream	15	2113	33.35	2040	1790
	1200	**Inland Wetlands -Man-made**					
4	1201	Reservoirs/Barrages	-	-	-	-	-
5	1202	Tanks/Ponds	45	867	13.69	705	232
		Total - Inland	**80**	**4120**	**65.04**	**3701**	**2329**
	2100	**Coastal Wetlands - Natural**					
6	2102	Creeks	6	212	3.35	212	194
7	2103	Sand/Beach	7	809	12.77	-	-
8	2104	Intertidal mud flats	10	505	7.97	-	-
9	2105	Salt marsh	1	66	1.04	-	-
10	2106	Mangroves	6	285	4.50	-	-
	2200	**Coastal Wetlands - Man-made**					
11	2201	Salt pans	-	-	-	-	-
12	2202	Aquaculture ponds	5	194	3.06	115	12
		Total - Coastal	**35**	**2071**	**32.69**	**327**	**206**
		Sub-Total	**115**	**6191**	**97.73**	**4028**	**2535**
		Wetlands (<2.25 ha), mainly Tanks	144	144	2.27	-	-
		Total	**259**	**6335**	**100.00**	**4028**	**2535**

Area under Aquatic Vegetation	622	1753

Area under turbidity levels		
Low	1186	515
Moderate	2748	1968
High	94	52

Table-13: District-wise wetland Area in Puducherry

Sr. No.	District	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of district Geographic area
1	Yanam	30	1191	18.80	39.70
2	Puducherry	293	3506	55.34	11.97
3	Mahe	9	6	0.09	0.67
4	Karaikal	160	1632	25.76	10.20
	Total	492	6335	100.00	12.49

7.5.1 Yanam

Total 22 wetlands are mapped including 8 small wetlands (< 2.25 ha) with 1191 ha area**.** River/stream contributed 66.83% to the total wetland area. The mangroves with 285 ha (23.93% area) is the second major wetland category, followed by Intertidal mud flats with 87 ha area i.e. 7.3%. Details of wetland statistics is given in Table- 14.

Open water spread of the wetlands is significantly higher in post monsoon (802 ha) than during pre monsoon (630 ha). Aquatic vegetation is slightly more during post monsoon (294 ha) than in pre monsoon (289 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 14: Area estimates of wetlands in Yanam

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	2	796	66.83	796	618
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	2	15	1.26	6	12
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**4**	**811**	**68.09**	**802**	**630**
	2100	**Coastal Wetlands - Natural**					
11	2101	Lagoons	-	-	-	-	-
12	2102	Creeks	-	-	-	-	-
13	2103	Sand/Beach	-	-	-	-	-
14	2104	Intertidal mud flats	4	87	7.30	-	-
15	2105	Salt Marsh	-	-	-	-	-
16	2106	Mangroves	6	285	23.93	-	-
17	2107	Coral Reefs	-	-	-	-	-
	2200	**Coastal Wetlands - Man-made**					
18	2201	Salt pans	-	-	-	-	-
19	2202	Aquaculture ponds	-	-	-	-	-
		Total - Coastal	**10**	**372**	**31.23**	**0**	**0**
		Sub-Total	**14**	**1183**	**99.33**	**802**	**630**
		Wetlands (<2.25 ha), mainly Tanks	8	8	0.67	-	-
		Total	**22**	**1191**	**100.00**	**802**	**630**

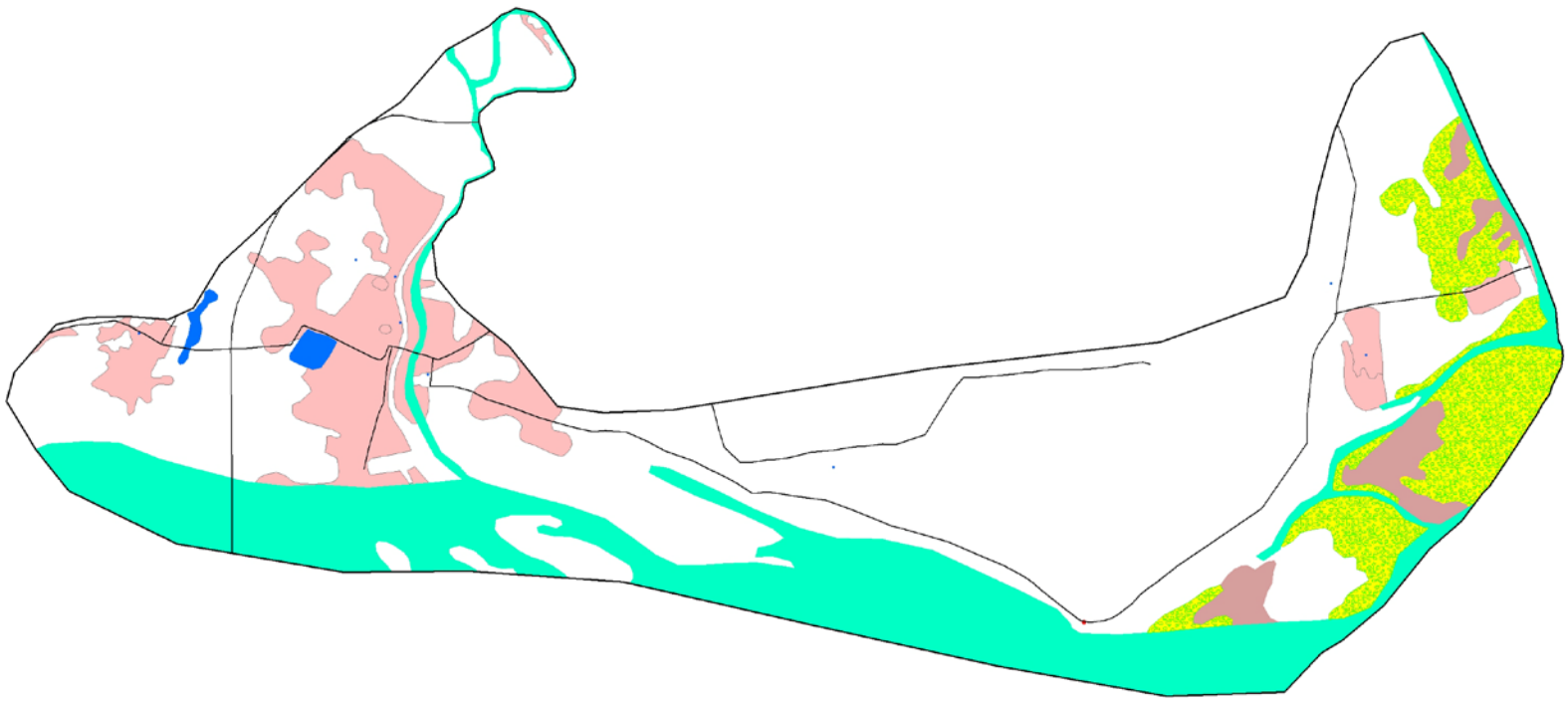
Area under Aquatic Vegetation	294	289

Area under turbidity levels		
Low	-	-
Moderate	796	619
High	6	11

State : Pondicherry

WETLAND MAP

District : Yanam

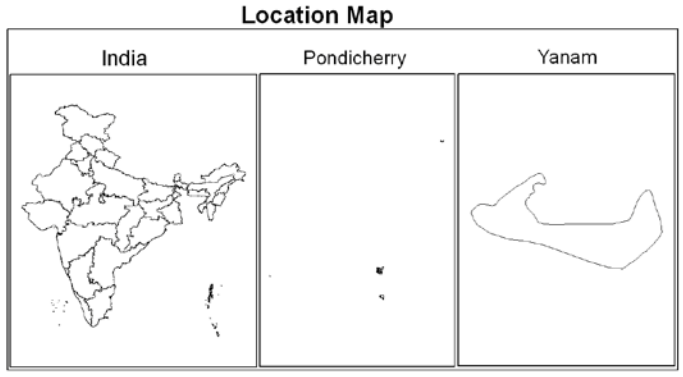


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.250.5 1 1.5 2 Kilometers

Data Source :

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

Prepared By :

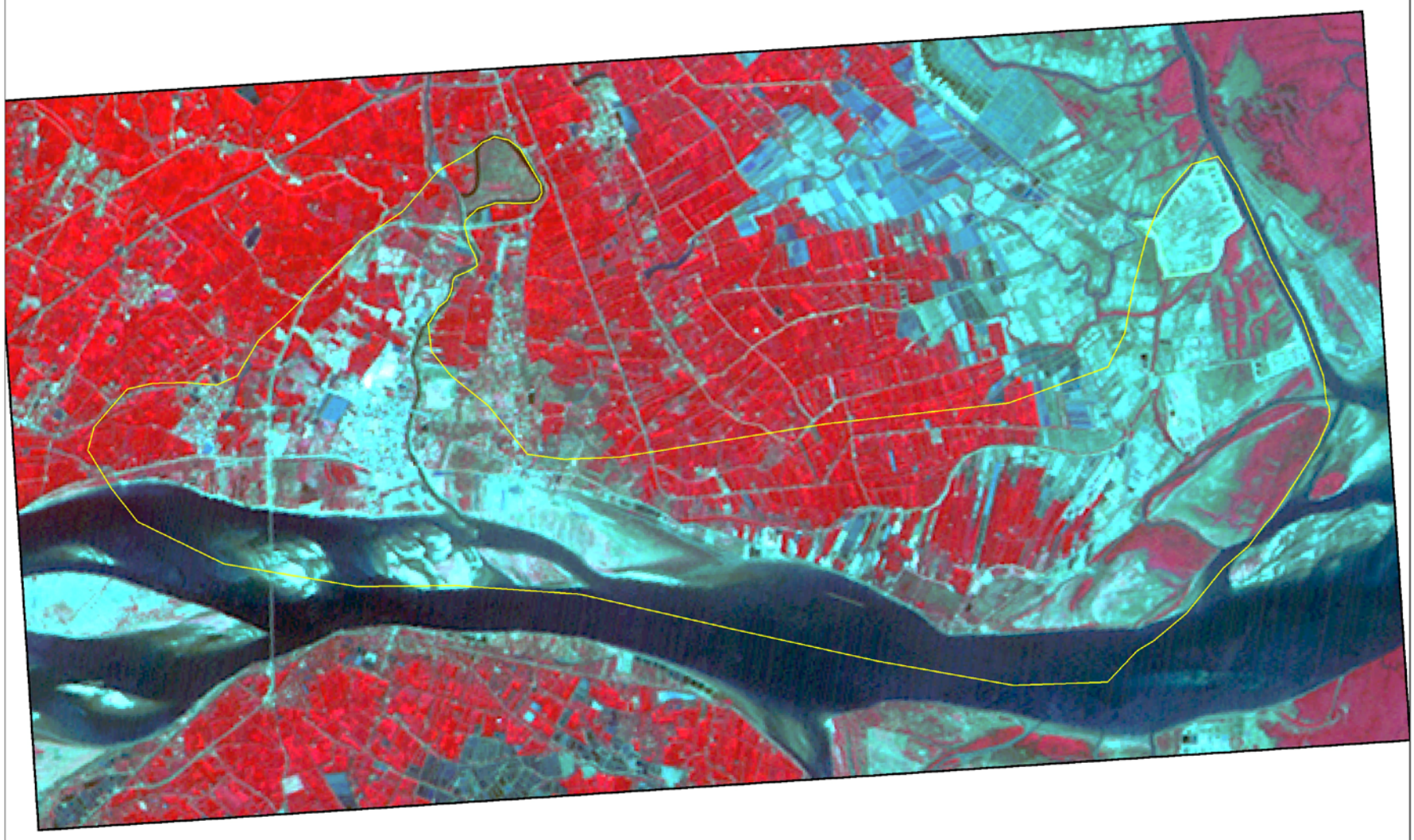
Space Applications Centre (ISRO), Ahmedabad

Sponsored By :

Ministry of Environment and Forests
Government of India

State : Pondicherry

District : Yanam



IRS P6 LISS-III post monsoon data (2006)

7.5.2 Puducherry

Total 115 wetlands are mapped including 39 small wetlands (< 2.25 ha) with 3506 ha area**.** Lakes/ponds contributed 31.95% to the total wetland area. The river/stream with 893 ha (25.47% area) is the second major wetland category, followed by tanks/ponds with 787 ha area i.e. 22.45. Details of wetland statistics is given in Table- 15.

Open water spread of the wetlands is significantly higher in post monsoon (2659 ha) than during pre monsoon (1553 ha), indicating the rainfall dependence of the wetlands in the district. Aquatic vegetation is more during pre monsoon (1442 ha) than in post monsoon (328 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 15: Area estimates of wetlands in Puducherry

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	19	1120	31.95	943	305
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	20	0.57	13	2
6	1106	River/Stream	7	893	25.47	893	893
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	35	787	22.45	635	178
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**62**	**2820**	**80.43**	**2484**	**1378**
	2100	**Coastal Wetlands - Natural**					
11	2101	Lagoons	-	-	-	-	-
12	2102	Creeks	5	173	4.93	173	173
13	2103	Sand/Beach	6	377	10.75	-	-
14	2104	Intertidal mud flats	1	29	0.83	-	-
15	2105	Salt Marsh	1	66	1.88	-	-
16	2106	Mangroves	-	-	-	-	-
17	2107	Coral Reefs	-	-	-	-	-
	2200	**Coastal Wetlands - Man-made**					
18	2201	Salt pans	-	-	-	-	-
19	2202	Aquaculture ponds	1	2	0.06	2	2
		Total - Coastal	**14**	**647**	**18.45**	**175**	**175**
		Sub-Total	**76**	**3467**	**98.89**	**2659**	**1553**
		Wetlands (<2.25 ha), mainly Tanks	39	39	1.11	-	-
		Total	**115**	**3506**	**100.00**	**2659**	**1553**

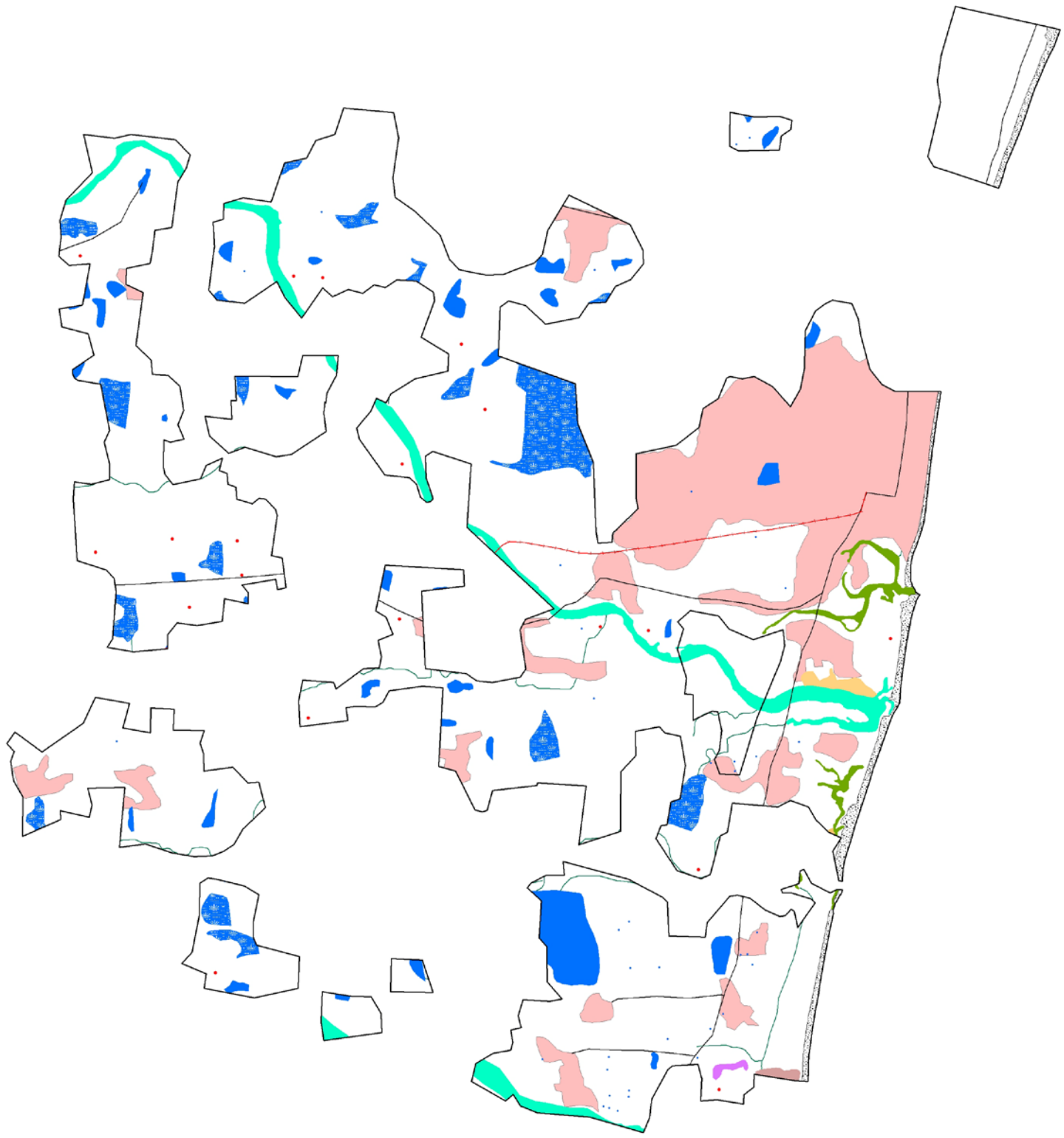
Area under Aquatic Vegetation	328	1442

Area under turbidity levels		
Low	1131	485
Moderate	1509	1066
High	19	2

State : Pondicherry

WETLAND MAP

District : Pondicherry

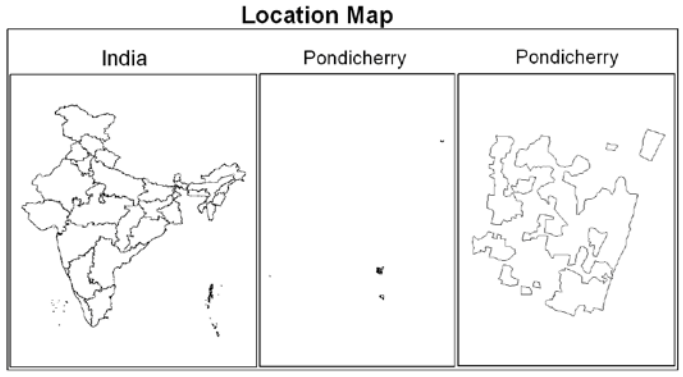


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.5 1 2 3 4

Kilometers

Data Source :

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

Prepared By :

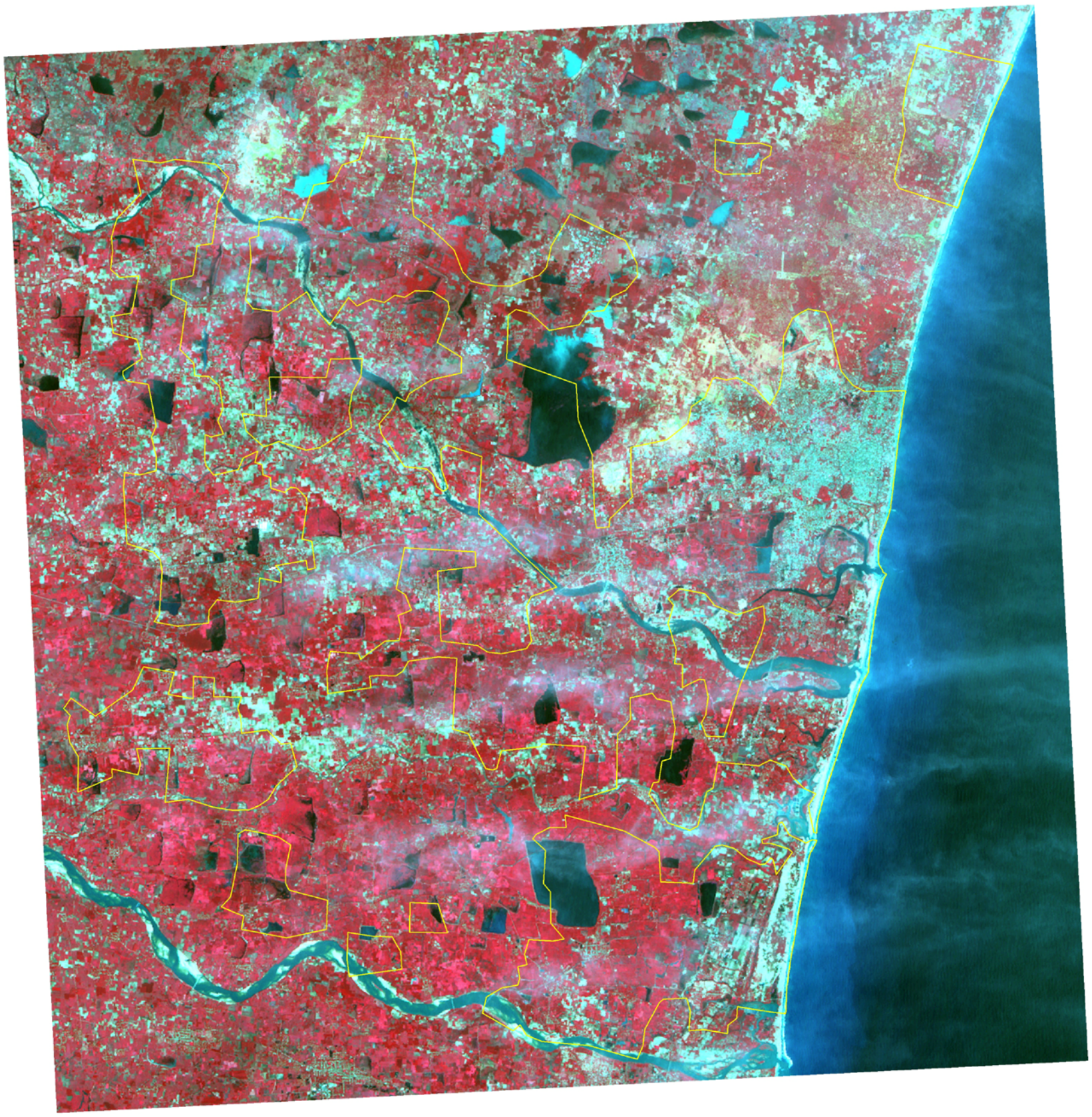
Space Applications Centre (ISRO), Ahmedabad

Sponsored By :

Ministry of Environment and Forests
Government of India

State : Pondicherry

District : Pondicherry



IRS P6 LISS-III post monsoon data (2006)

7.5.3 Mahe

Total 4 wetlands are mapped including 3 small wetlands (< 2.25 ha) with 6 ha area. River/steam contributed 50% to the total wetland area. Details of wetland statistics is given in Table- 16.

Open water spread of the wetlands is significantly higher in post monsoon (3 ha). The qualitative turbidity of water is low in post monsoon seasons.

Table 16: Area estimates of wetlands in Mahe

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	1	3	50.00	3	0
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**1**	**3**	**50.00**	**3**	**0**
	2100	**Coastal Wetlands - Natural**					
11	2101	Lagoons	-	-	-	-	-
12	2102	Creeks	-	-	-	-	-
13	2103	Sand/Beach	-	-	-	-	-
14	2104	Intertidal mud flats	-	-	-	-	-
15	2105	Salt Marsh	-	-	-	-	-
16	2106	Mangroves	-	-	-	-	-
17	2107	Coral Reefs	-	-	-	-	-
	2200	**Coastal Wetlands - Man-made**					
18	2201	Salt pans	-	-	-	-	-
19	2202	Aquaculture ponds	-	-	-	-	-
		Total - Coastal	**0**	**0**	**0.00**	**0**	**0**
		Sub-Total	**1**	**3**	**50.00**	**3**	**0**
		Wetlands (<2.25 ha), mainly Tanks	3	3	50.00	-	-
		Total	**4**	**6**	**100.00**	**3**	**0**

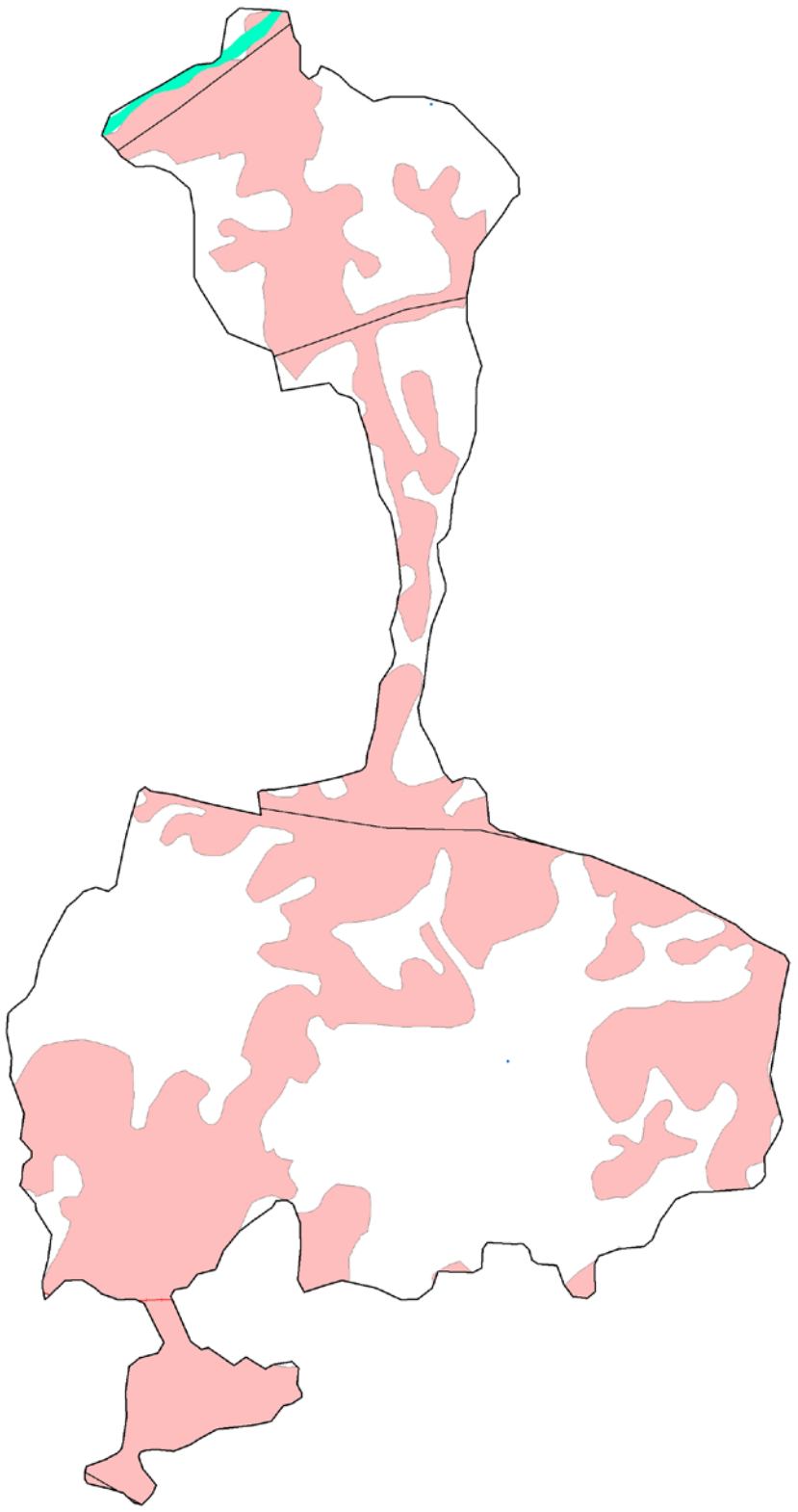
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	3	-
Moderate	-	-
High	-	-

State : Pondicherry

WETLAND MAP

District : Mahe

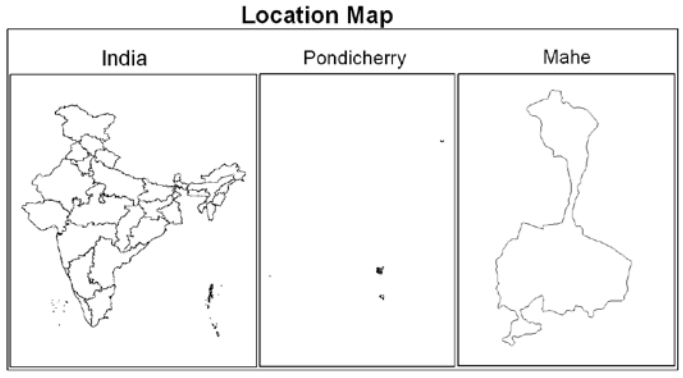


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

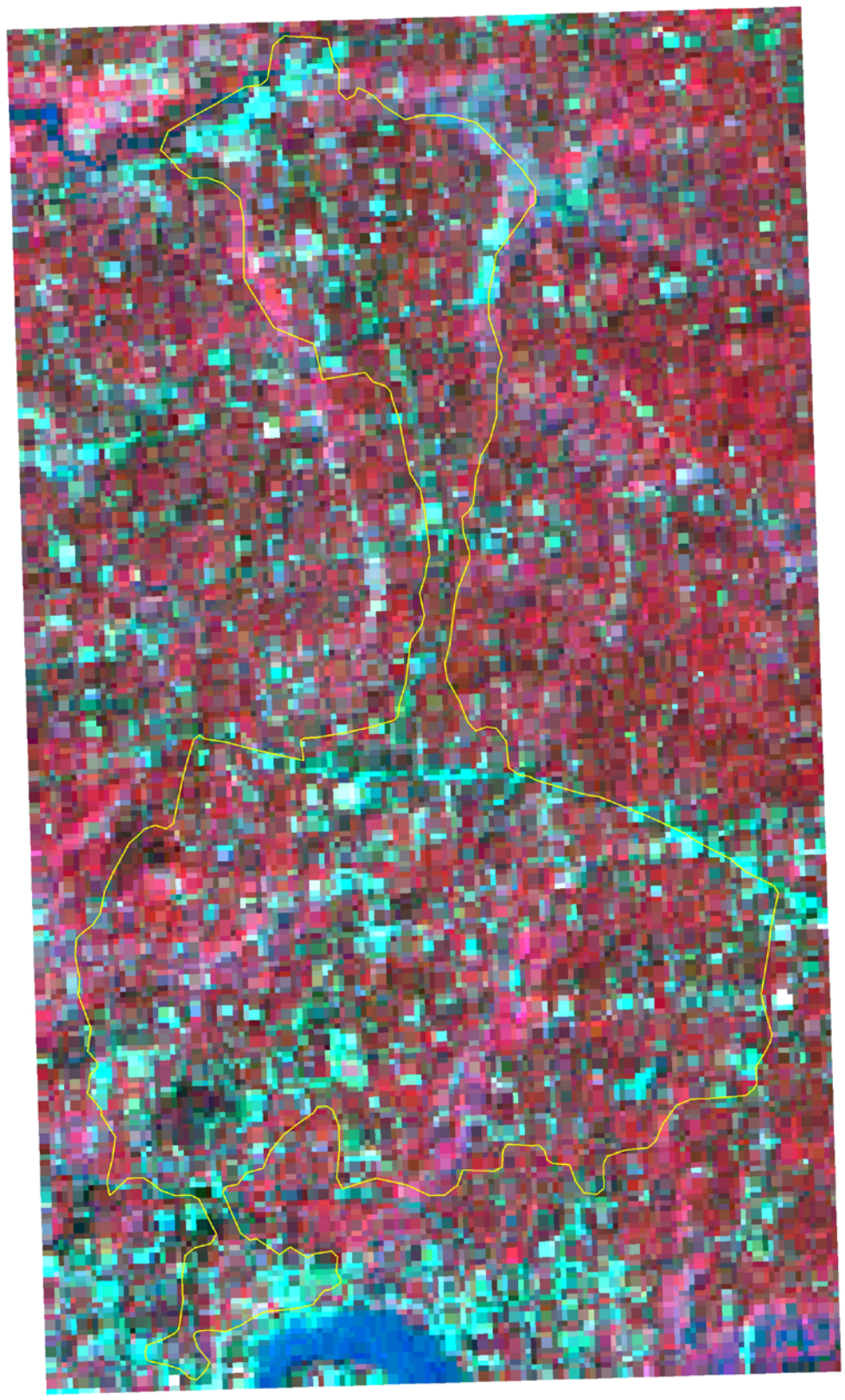
Space Applications Centre (ISRO), Ahmedabad

Sponsored By :

Ministry of Environment and Forests
Government of India

State : Pondicherry

District : Mahe



IRS P6 LISS-III post monsoon data (2006)

7.5.4 Karaikal

Total 114 wetlands are mapped including 94 small wetlands (< 2.25 ha) with 1632 ha area. Sand/Beach contributed 26.47% to the total wetland area. The river/stream with 421 ha (25.80% area) is the second major wetland category, followed by Intertidal mud flats with 389 ha area i.e. 23.84. Details of wetland statistics is given in Table- 17.

Open water spread of the wetlands is significantly higher in post monsoon (564 ha) than during pre monsoon (352 ha), indicating the rainfall dependence of the wetlands in the district. Aquatic vegetation is only in pre monsoon (22 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 17: Area estimates of wetlands in Karaikal

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-Bow Lakes/Cutt-Off Meanders	-	-	-	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Riverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	5	421	25.80	348	279
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	8	65	3.98	64	42
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**13**	**486**	**29.78**	**412**	**321**
	2100	**Coastal Wetlands - Natural**					
11	2101	Lagoons	-	-	-	-	-
12	2102	Creeks	1	39	2.39	39	21
13	2103	Sand/Beach	1	432	26.47	0	0
14	2104	Intertidal mud flats	5	389	23.84	0	0
15	2105	Salt Marsh	-	-	-	-	-
16	2106	Mangroves	-	-	-	-	-
17	2107	Coral Reefs	-	-	-	-	-
	2200	**Coastal Wetlands - Man-made**					
18	2101	Salt pans	-	-	-	-	-
19	2202	Aquaculture ponds	4	192	11.76	113	10
		Total - Coastal	**7**	**1052**	**64.46**	**152**	**31**
		Sub-Total	**20**	**1538**	**94.24**	**564**	**352**
		Wetlands (<2.25 ha), mainly Tanks	94	94	5.76	-	-
		Total	**114**	**1632**	**100.00**	**564**	**352**

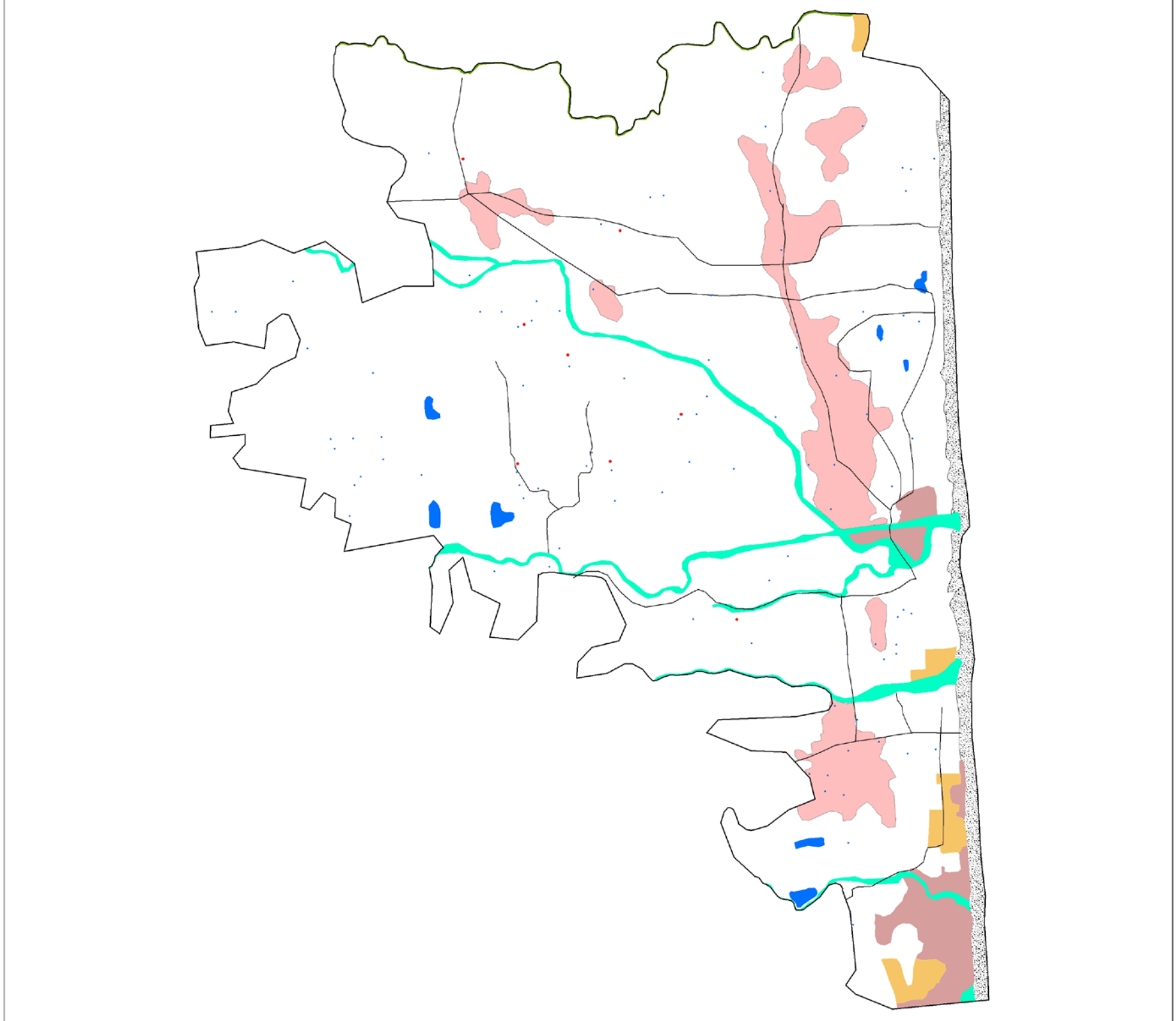
Area under Aquatic Vegetation	0	22

Area under turbidity levels		
Low	52	30
Moderate	443	283
High	69	39

State : Pondicherry

WETLAND MAP

District : Karaikal

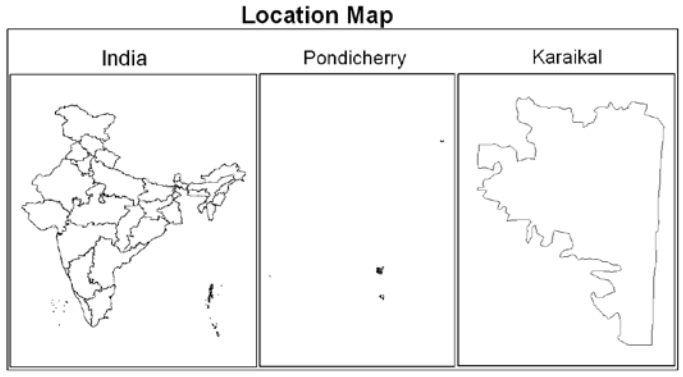


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.5 1 2 3 4 Kilometers

Data Source :

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

Prepared By :

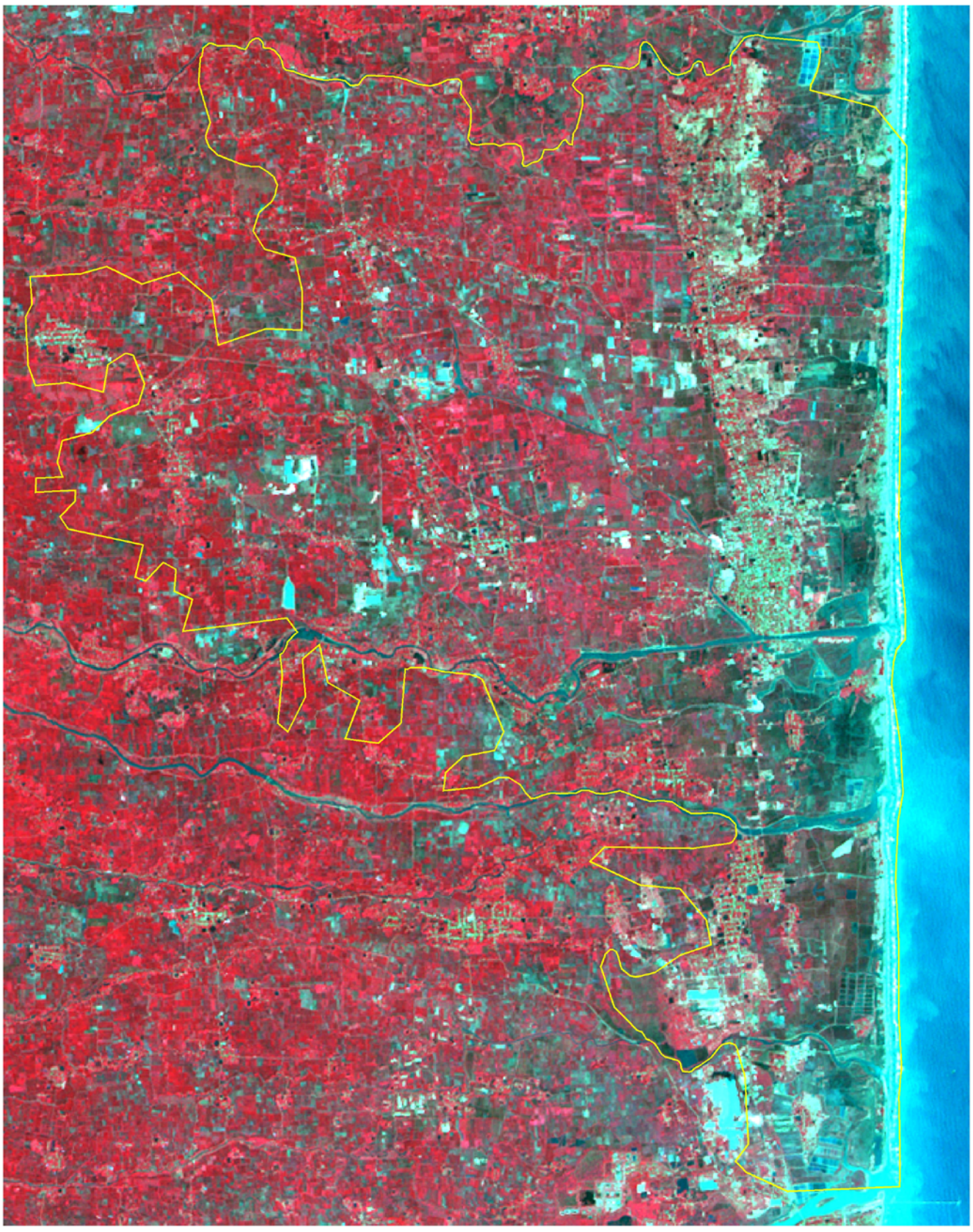
Space Applications Centre (ISRO), Ahmedabad

Sponsored By :

Ministry of Environment and Forests
Government of India

State/Union Territory : Pondicherry

District : Karaikal



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

7.6 Andaman & Nicobar Islands

Area estimates of various wetland categories for Andaman and Nicobar have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. In the state of Andaman and Nicobar 2459 wetlands have been delineated in addition to 94 wetlands smaller than 2.25 ha. Total wetland area estimated is 152809 ha (Table 18). Coastal-Natural wetlands are dominant in the islands which account for 95.47 % of wetland area. Even though the inland wetlands comprise about 4.5 % of wetland area, singularly the River/Stream accounts for 95.07 % area (6571 ha out of 6912 ha) of inland wetlands.

The major wetland types are Mangrove (66101 ha) followed by coral (49378 ha), Intertidal mud-flats (12399 ha). Sand/Beach accounts for 10063ha. Graphical distribution of wetland type is shown in figure 10. In terms of open water area, the inland wetlands dominated with 6400 ha in post-monsoon and 6616 ha in pre-monsoon seasons compared to 1822 ha and 1844 ha respectively for coastal wetlands. The details of type-wise aerial extents of wetland is given in the table 18.

Salt Marsh and Mangroves are the only wetland types that have vegetation. Together the two classes comprise 68269 ha in post-monsoon season while it has shown an increase to 68352 ha in pre-monsoon. Of the two wetland types with vegetation, Mangroves account for 66101 ha and remained unchanged in both post- as well pre-monsoon seasons. However, due to receding flooding in pre-monsoon the Salt Marsh had shown a substantial increase in the area from 2168 ha (post-monsoon) to 2251 ha.

There are two districts in Union territory of Andaman and Nicobar Islands. District-wise wetland summary is given in Table 19.

Table 18: Area estimates of wetlands in Andaman & Nicobar Islands

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	6	45	0.03	41	45
2	1106	River/Stream	46	6571	4.30	6359	6571
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	7	280	0.18	103	104
4	1202	Tanks/Ponds	11	16	0.01	16	16
		Total - Inland	**70**	**6912**	**4.52**	**6519**	**6736**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	3	56	0.04	56	56
6	2102	Creeks	119	1777	1.16	1766	1788
7	2103	Sand/Beach	367	10063	6.59	-	-
8	2104	Intertidal mud flats	395	12399	8.11	-	-
9	2105	Salt Marsh	322	6029	3.95	-	-
10	2106	Mangroves	678	66101	43.26	-	-
11	2107	Coral Reefs	505	49378	32.31	-	-
		Sub-Total	**2459**	**152715**	**99.94**	**8341**	**8580**
		Wetlands (<2.25 ha)	94	94	0.06	-	-
		Total	**2553**	**152809**	**100.00**	**8341**	**8580**

Area under Aquatic Vegetation	68269	68352

Area under turbidity levels		
Low	965	1898
Moderate	6749	6006
High	627	676

Table-19: District-wise wetland Area in Andaman and Nicobar Islands

Sr. No.	District	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of district geographic area
1	Aadamans	6408	128088	83.82	19.99
2	Nicobars	1841	24721	16.18	13.43
	Total	**8249**	**152809**	**100**	18.52

State : Andaman & Nicobar Islands

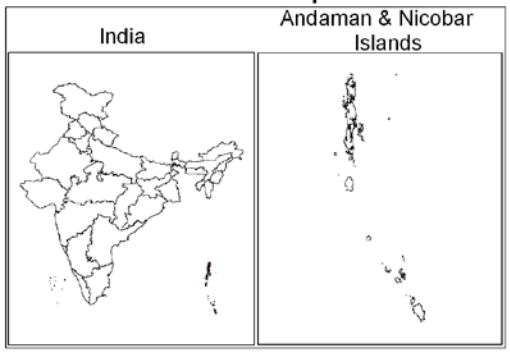
WETLAND MAP

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

Legend

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

Location Map



0 20 40 80 120 160
Kilometers

Data Source

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

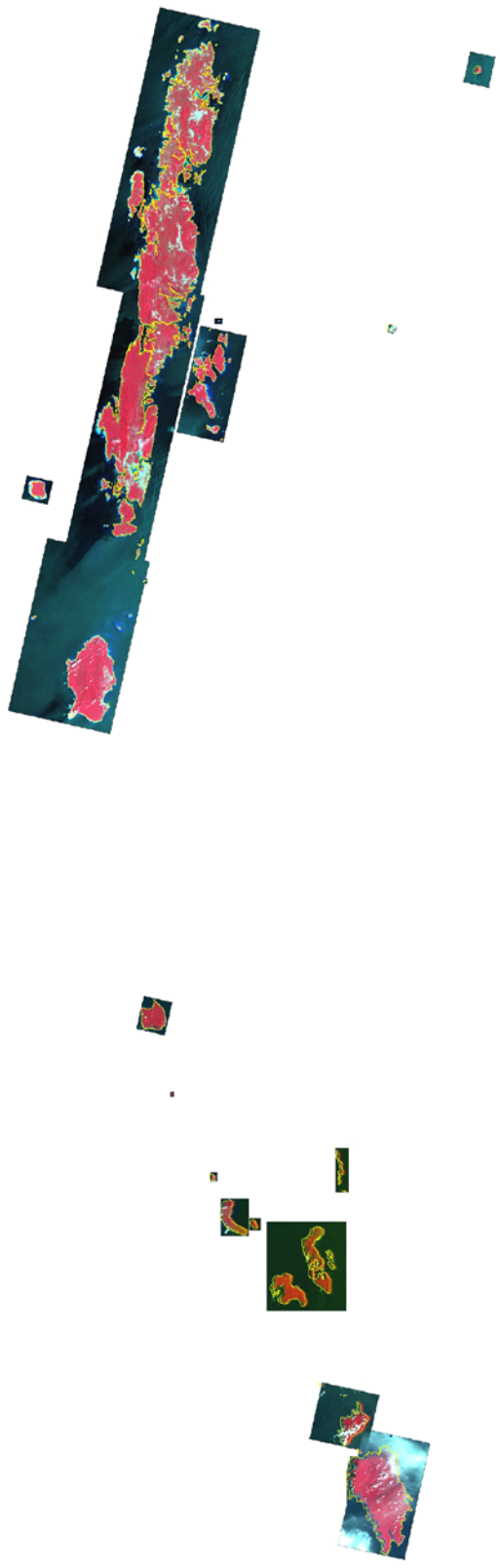
Prepared By

Space Applications Centre (ISRO), Ahmedabad

Sponsored By

Ministry of Environment and Forests
Government of India

State : Andaman & Nicobar Islands



IRS P6 LISS-III post monsoon data (2006)

7.6.1 Andamans

The Andaman group of islands has Landfall Island on its extreme north followed by North, middle and south Andaman. All these are separated by shallow seas together known as Great Andaman. Further south lie Little Andaman along with several islands and many of them are very small. The total geographic area of Andaman is 6408 Sq. km out of which the wetlands account for 128019 ha (Table 20) which turns out to be 20.20 %. In the Andaman district, 2082 wetlands have been delineated in addition to 69 wetlands smaller than 2.25 ha. The coastal wetlands dominate the wetland extent accounting for almost 95 % of area (121506 ha) out of 128019 ha. Even though the inland wetlands comprise about 5 % of wetland area, the River/Stream occupies the largest area (6204 ha). The major wetland types are Mangrove (65892 ha) followed by coral (41220 ha), Intertidal mud-flats (5858 ha) and Salt Marsh (3575 ha). Sand/Beach accounts for 3205 ha. In terms of open water spread, inland wetlands are the largest. Together, they account for 6325 ha in post-monsoon and 6337 ha in pre-monsoon.

Salt Marsh and Mangroves are the only wetland types that have vegetation. Together they comprise 66434 ha in post-monsoon season and which has shown increase to 66481 ha in pre-monsoon. Of the two wetland types with vegetation, Mangroves account for 65892 ha and remained unchanged in both the seasons. However, in pre-monsoon the Salt Marsh had shown an increase in the area from 542 ha (post-monsoon) to 589 ha.

The extent of open water in post-monsoon of 2006 is 8077 ha which comprised 944 ha of low, 6681 ha of moderate and 452 ha of high turbidity classes. The extent under turbidity classes changed considerably in the pre-monsoon of 2007 which is estimated as 1898 ha of low, 5732 ha of moderate and 474 ha of high turbidity out of 8104 ha of open water features. The open water features dominated by Moderate turbidity in both the seasons appears to be mainly because of River/Stream and Creek as inferred from Table 20.

Table 20: Area estimates of wetlands in Andamans

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	4	13	0.01	9	13
2	1106	River/Stream	42	6204	4.84	6197	6204
	1200	**Inland Wetlands -Man-made**					
3	1201	Reservoirs/Barrages	7	280	0.22	103	104
4	1202	Tanks/Ponds	11	16	0.01	16	16
		Total - Inland	**64**	**6513**	**5.08**	**6325**	**6337**
	2100	**Coastal Wetlands - Natural**					
5	2101	Lagoons	2	54	0.04	54	54
6	2102	Creeks	108	1702	1.33	1698	1713
7	2103	Sand/Beach	211	3205	2.50	-	-
8	2104	Inter-tidal mud flats	301	5858	4.57	-	-
9	2105	Salt Marsh	284	3575	2.79	-	-
10	2106	Mangroves	666	65892	51.44	-	-
11	2107	Coral Reefs	446	41220	32.18	-	-
		Total - Coastal	**2018**	**121506**	**94.86**	**1752**	**1767**
		Sub-Total	**2082**	**128019**	**99.95**	**8077**	**8104**
		Wetlands (<2.25 ha)	69	69	0.05	-	-
		Total	**2151**	**128088**	**100.00**	**8077**	**8104**

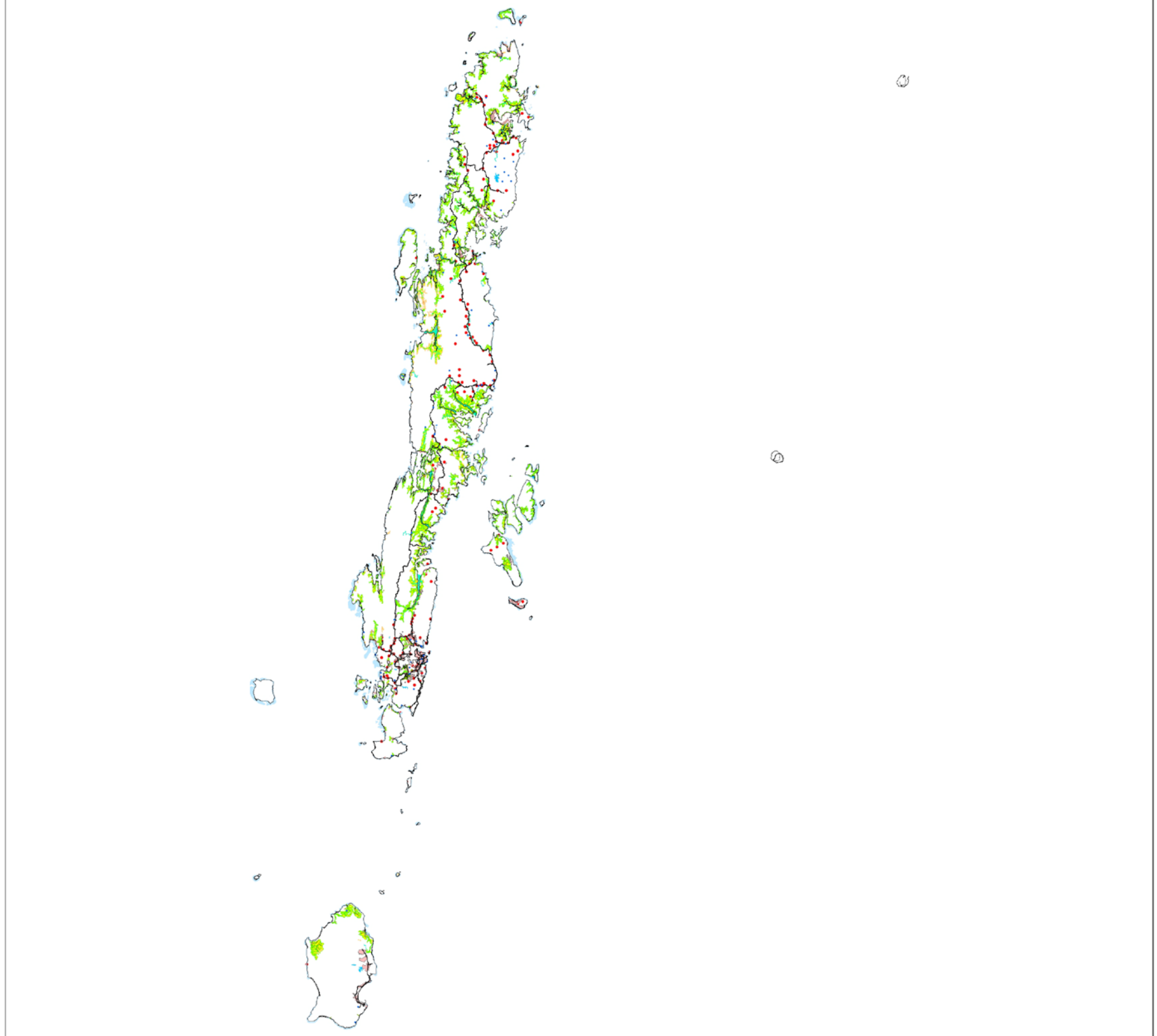
Area under Aquatic Vegetation	66434	66481

Area under turbidity levels		
Low	944	1898
Moderate	6681	5732
High	452	474

UT : Andaman & Nicobar Islands

WETLAND MAP

District : Andamans

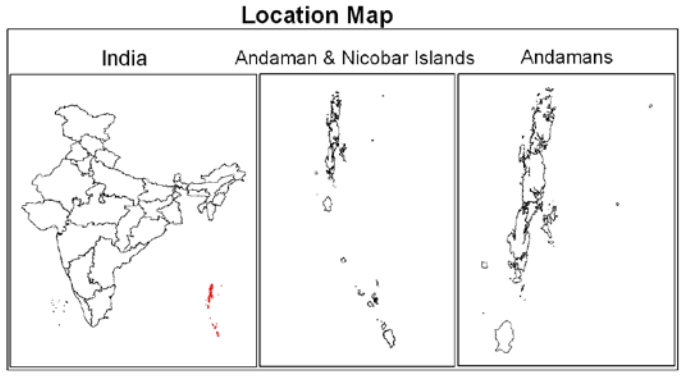


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 10 20 40 60 80

Kilometers

Data Source :

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

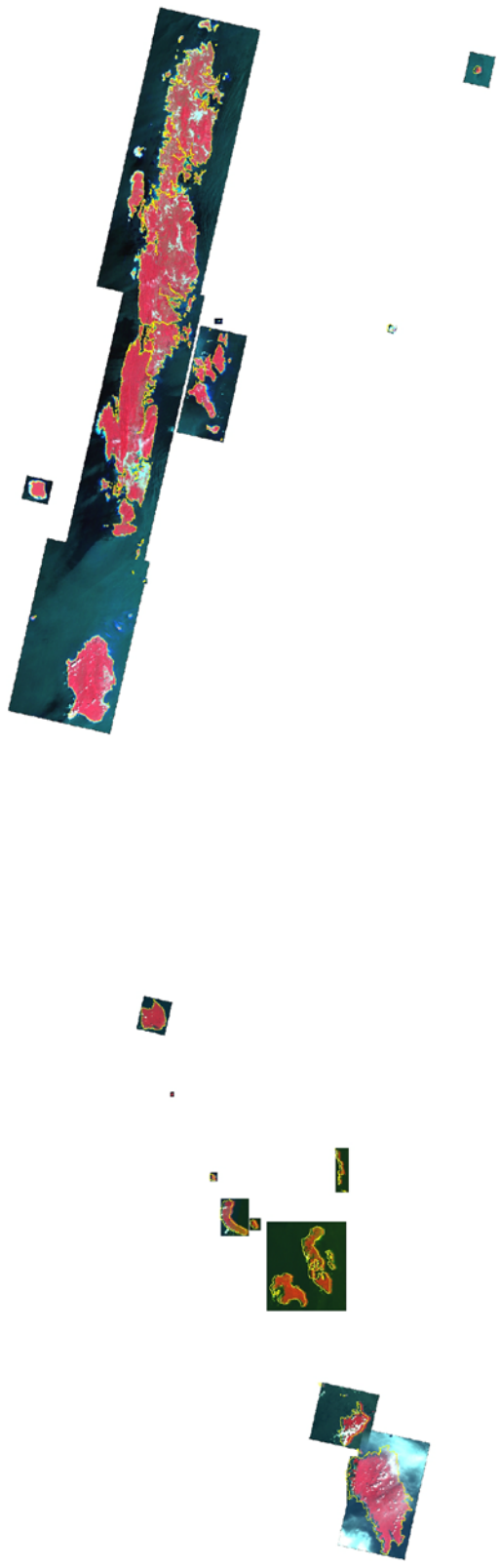
Prepared By :

Space Applications Centre (ISRO), Ahmedabad

Sponsored By :

Ministry of Environment and Forests
Government of India

State : Andaman & Nicobar Islands



IRS P6 LISS-III post monsoon data (2006)

7.6.2 Nicobars

The Nicobar group lies south of the Andaman. The northernmost island is Car Nicobar and the southernmost is island is Great Nicobar. Pygmalion Point which has been renamed as 'Indira Point' is the southernmost tip of India. Nicobar occupies 1841 Sq. km of area out of total 8249 Sq. km geographical area of Andaman and Nicobar Islands. The tiny uninhabited Barren Island has an active volcano, which is the only one of its kind in the region. In the Nicobar district, 377 wetlands have been delineated in addition to 25 wetlands smaller than 2.25 ha.

The major wetland types are Coral, (8185 ha) followed by sand/beach (6858 ha) and Intertidal Mud-flats (6541 ha). The Intertidal Mud-flats occupy ~26.5 % of wetland area in Nicobar compared to ~4.6 % in the case of Andaman. Compared to coastal wetlands (24297 ha), which account for ~98.5 % of total wetland area, the inland wetlands account for ~2 %. Mangrove, which dominated the Andaman district (51.47 %) accounts for 209 ha of area in Nicobar which is less than 1 % of wetland area. Similar is the case with creek, which is also less than 1 %. Details of wetlands and their type-wise aerial extents in both the seasons is given in the table 21.

Salt Marsh and Mangroves are the only wetland types that have vegetation. Together they comprise 1835 ha in post-monsoon and 1871 ha in pre-monsoon. Both the wetland types with vegetation the mangrove remained unchanged in both the seasons.

As mentioned earlier, wetlands where open water features have not been manifested on satellite data were excluded in spite of the fact that these wetlands are associated with water. Overall six wetland types are assessed for turbidity namely Lake/Pond, River/Stream, Lagoon, Creak. The extent of open water in post-monsoon of 2006 is 264 ha which comprised 21 ha of low, 68 ha of moderate and 175 ha of high turbidity classes. The extent under turbidity classes changed considerably in the pre-monsoon of 2007 which is estimated as 274 ha of moderate and 202 ha of high turbidity out of 476 ha of open water features. The open water features dominated by Moderate turbidity in pre-monsoon season appears to be mainly because of River/Stream.

Table 21: Area estimates of wetlands in Nicobars

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	32	0.13	32	32
2	1106	River/Stream	4	367	1.48	162	367
		Total - Inland	**6**	**399**	**1.61**	**194**	**399**
	2100	**Coastal Wetlands - Natural**					
3	2101	Lagoons	1	2	0.01	2	2
4	2102	Creeks	11	75	0.30	68	75
5	2103	Sand/Beach	156	6858	27.74	-	-
6	2104	Intertidal mud flats	94	6541	26.46	-	-
7	2105	Salt Marsh	38	2454	9.93	-	-
8	2106	Mangroves	12	209	0.85	-	-
9	2107	Coral Reefs	59	8158	33.00	-	-
		Total - Coastal	**371**	**24297**	**98.28**	**70**	**77**
		Sub-Total	**377**	**24696**	**99.90**	**264**	**476**
		Wetlands (<2.25 ha)	25	25	0.10	-	-
		Total	**402**	**24721**	**100.00**	**264**	**476**

Area under Aquatic Vegetation	1835	1871

Area under turbidity levels		
Low	21	-
Moderate	68	274
High	175	202

UT : Andaman & Nicobar Islands

WETLAND MAP

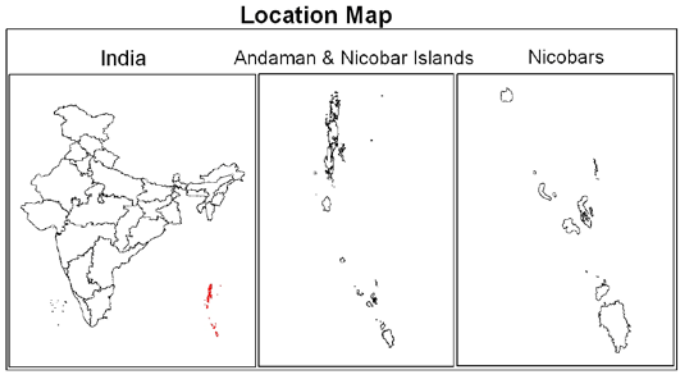
District : Nicobars

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

Legend

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

Location Map



0 5 10 20 30 40 Kilometers

Data Source :

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

Prepared By :

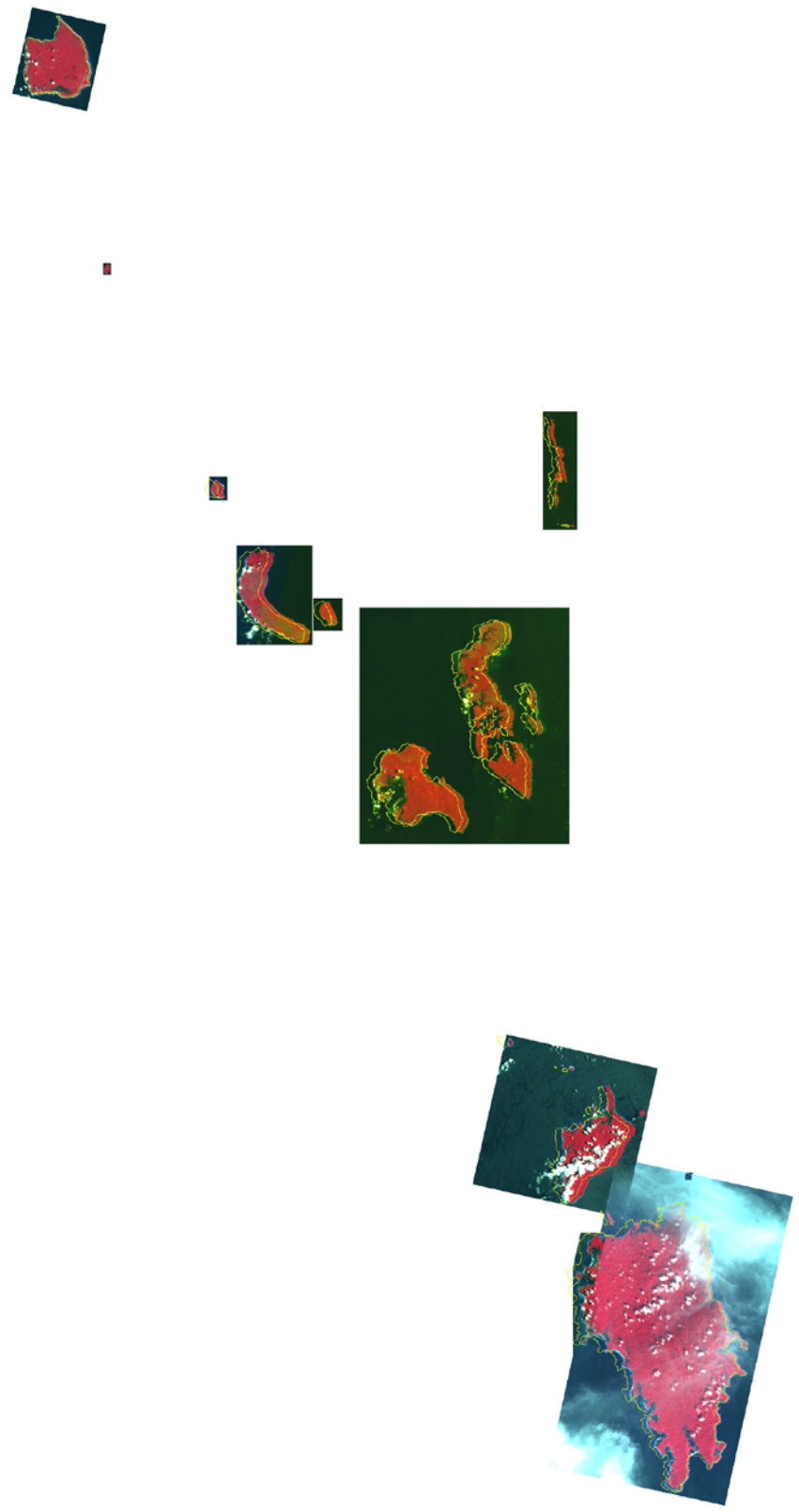
Space Applications Centre (ISRO), Ahmedabad

Sponsored By :

Ministry of Environment and Forests
Government of India

UT : Andaman & Nicobar Islands

District : Nicobars

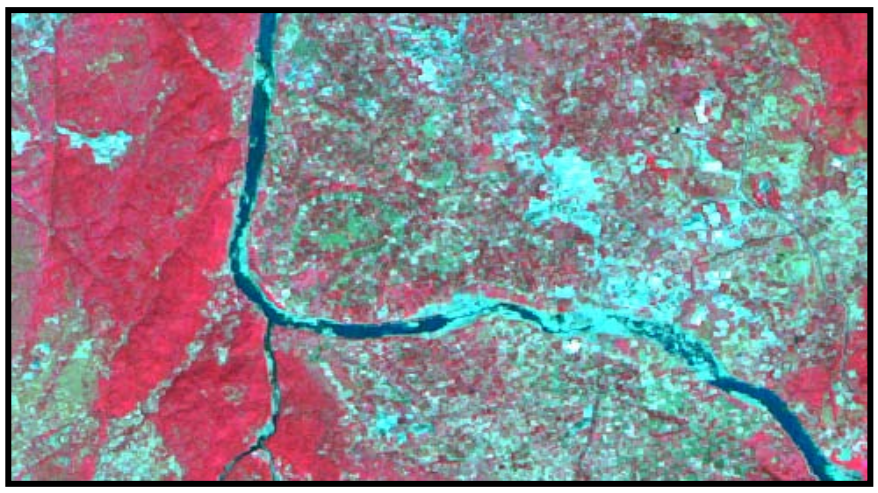


IRS P6 LISS-III post monsoon data (2006)

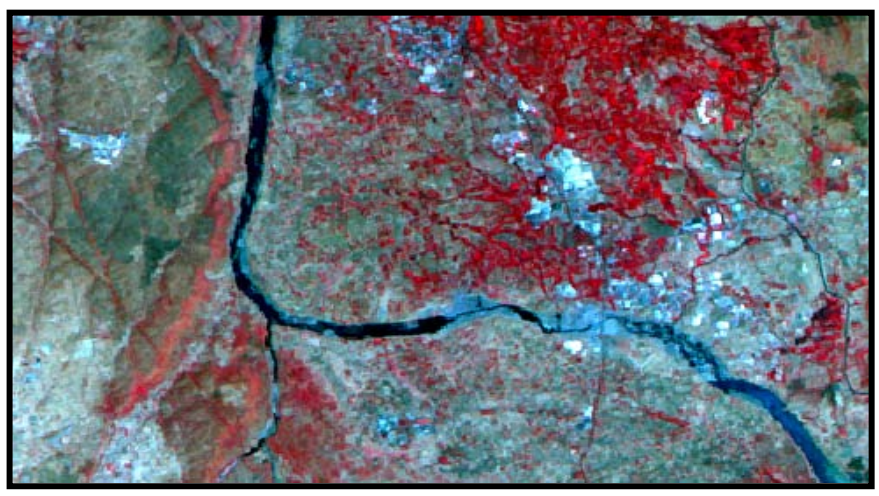
MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF UNION TERRITORIES

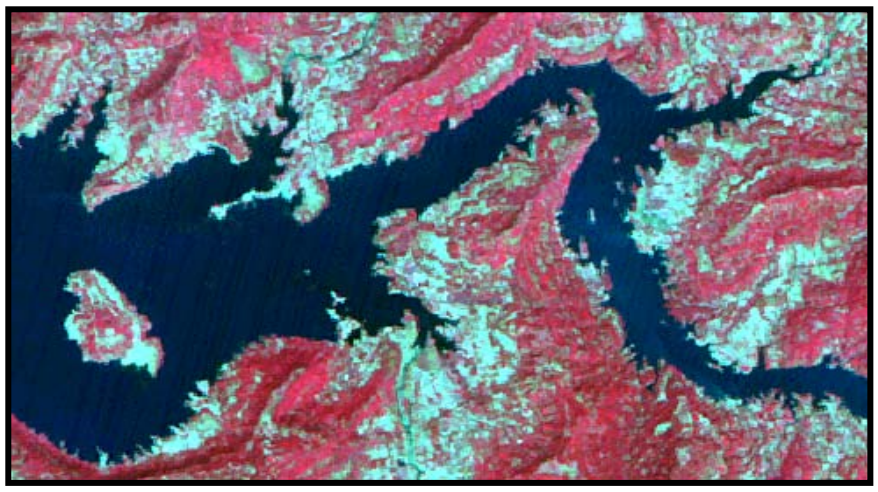
Major wetland types observed in the Union Territories are Tanks/ponds, Mangroves, Coral, Intertidal Mud-flats, Sand/Beach, River/Stream and Reservoirs. The manifestation of major wetland types on satellite imagery are given in Plate-1a,1b and 1c. Ground truth data was collected for selected wetland sites. Standard procedure was adopted to record the field data. The location of the features was recorded using GPS. Field photographs and ground truth data of different wetland types are shown in Plates 2a, 2b, and 2c.



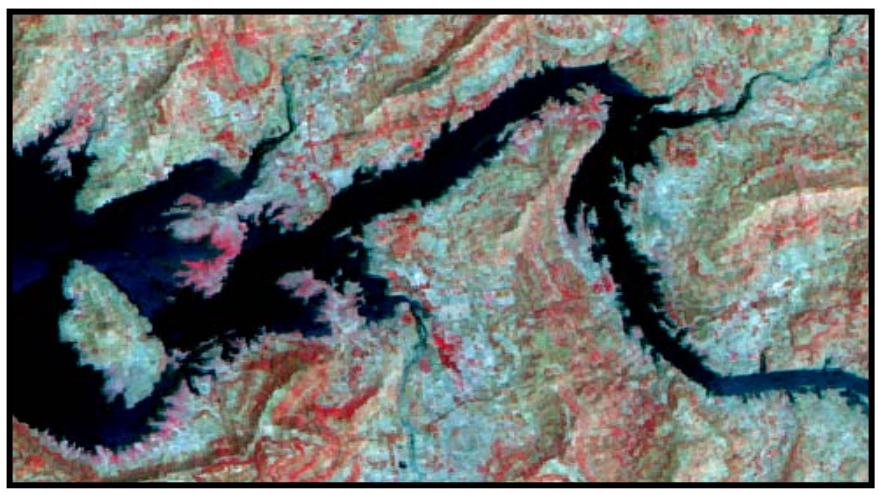
Damanganga River
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)



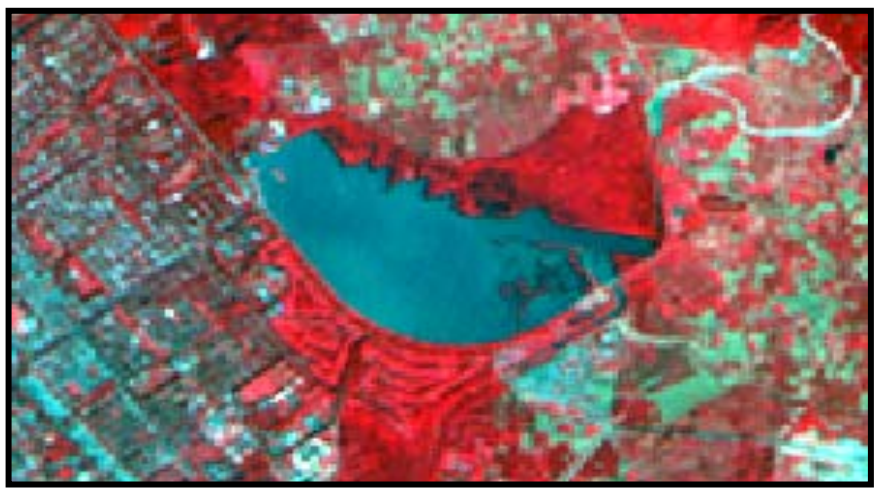
Damanganga River
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)



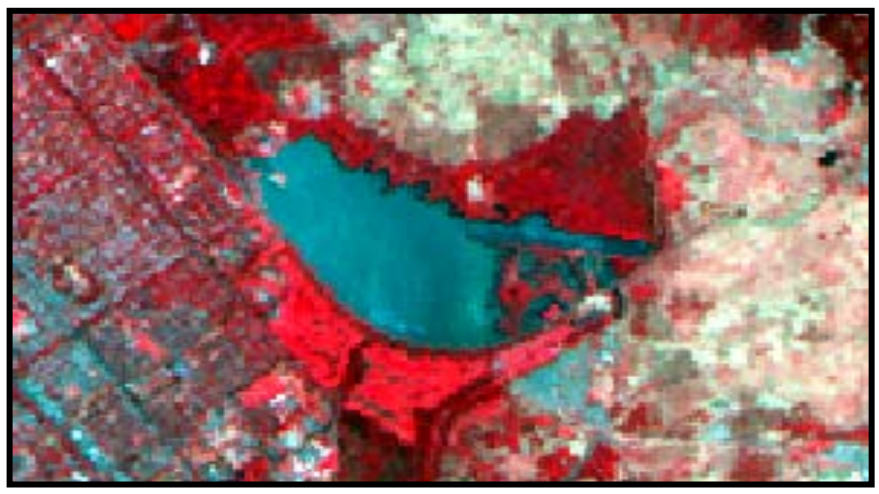
Part of Damanganga Reservoir in Daman
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)



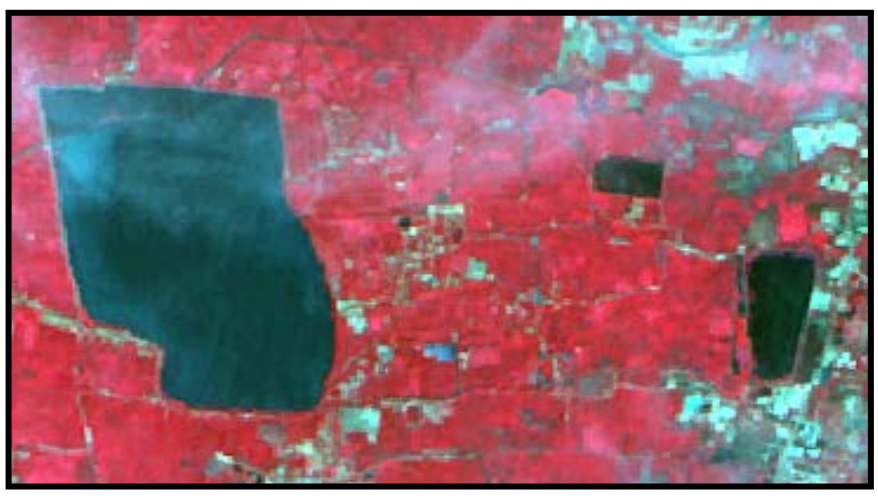
Part of Damanganga Reservoir in Daman
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)



Sukhana Lake, Chandigarh
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)



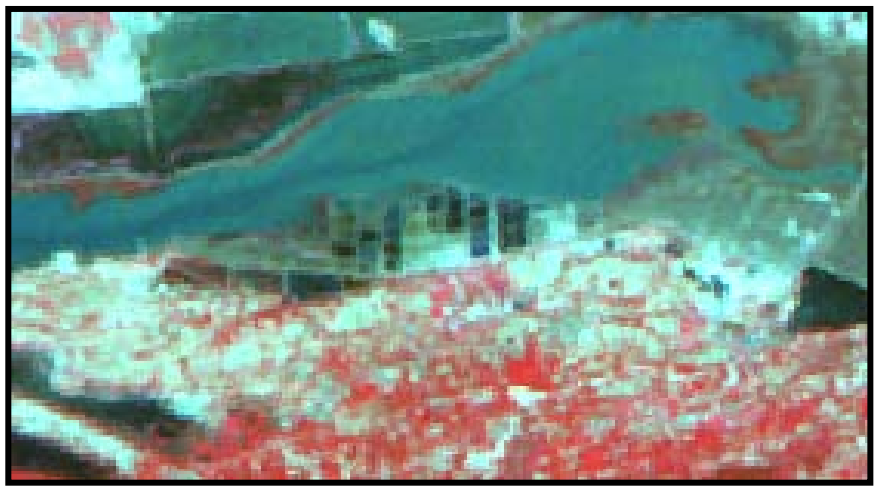
Sukhana Lake, Chandigarh
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)



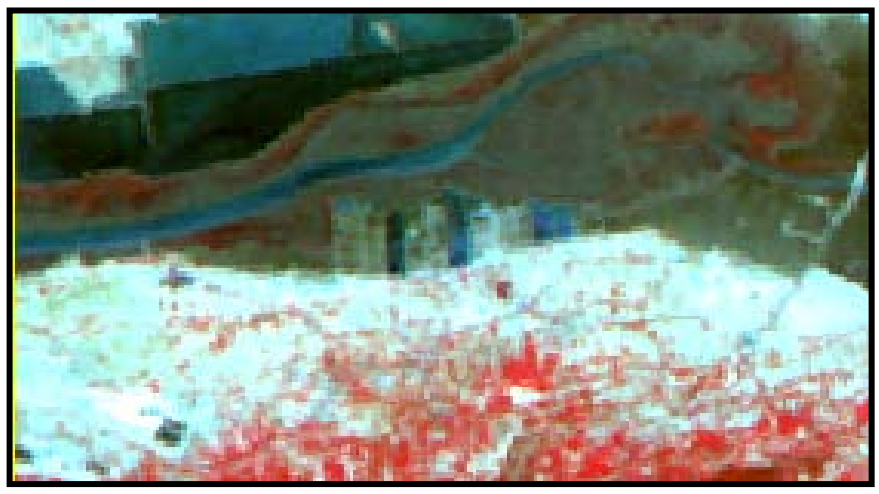
Tanks/Ponds in Pondicherry
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)

Tanks/Ponds in Pondicherry
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)

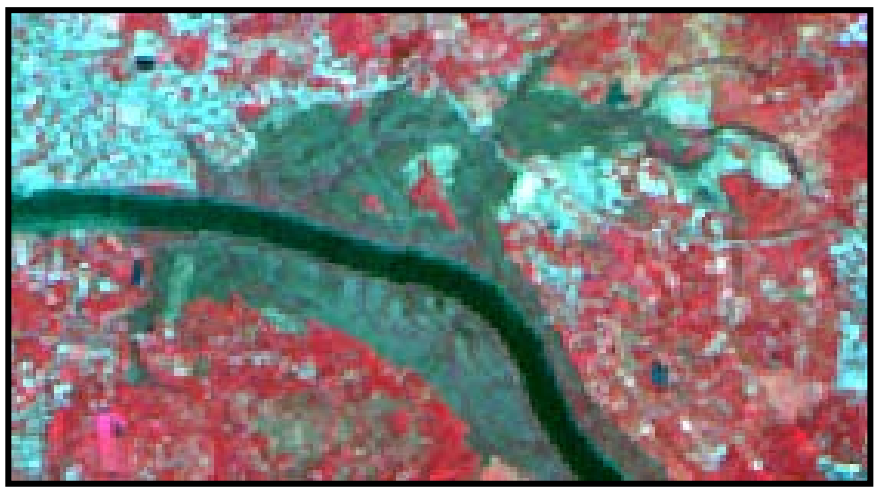
Plate – 1a: Major wetland types of Union Territories



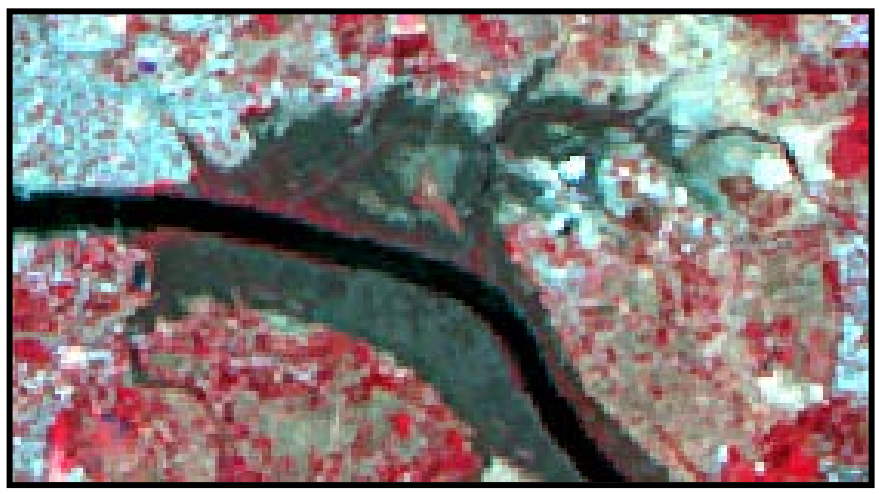
Salt Pans, Diu
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)



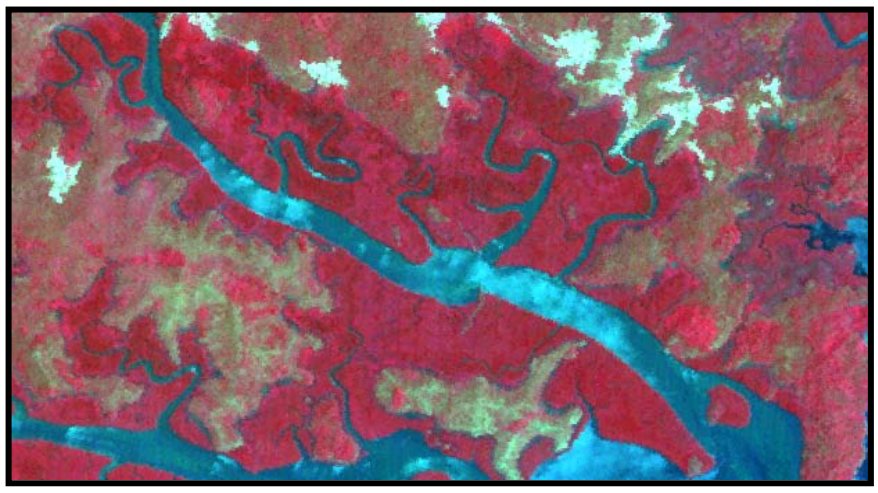
Salt Pans, Diu
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)



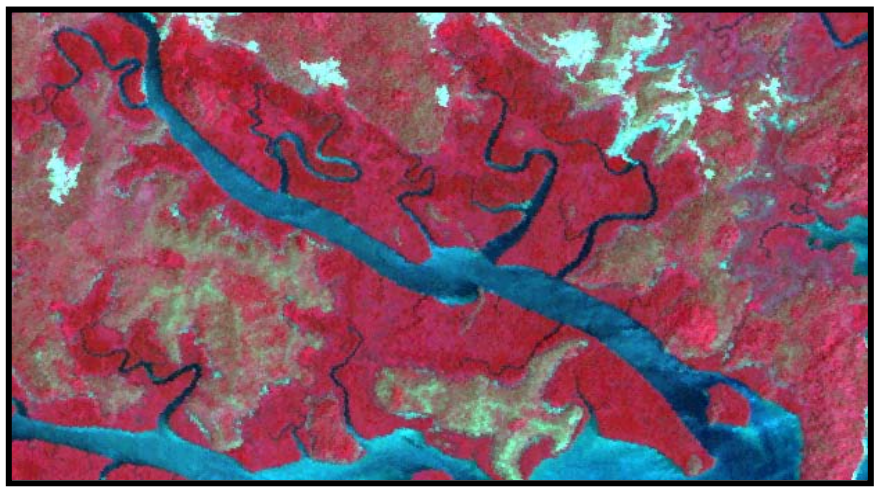
Intertidal Mud-Flat in Daman
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)



Intertidal Mud-Flat in Daman
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)



Mangroves, Andaman
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)



Mangroves, Andaman
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)

Creek in Pondicherry
(IRS-P6 LISS-III FCC, Post-monsoon, 2006)

Creek in Pondicherry
(IRS-P6 LISS-III FCC, Pre-monsoon, 2007)

Plate – 1b: Major wetland types of Union Territories

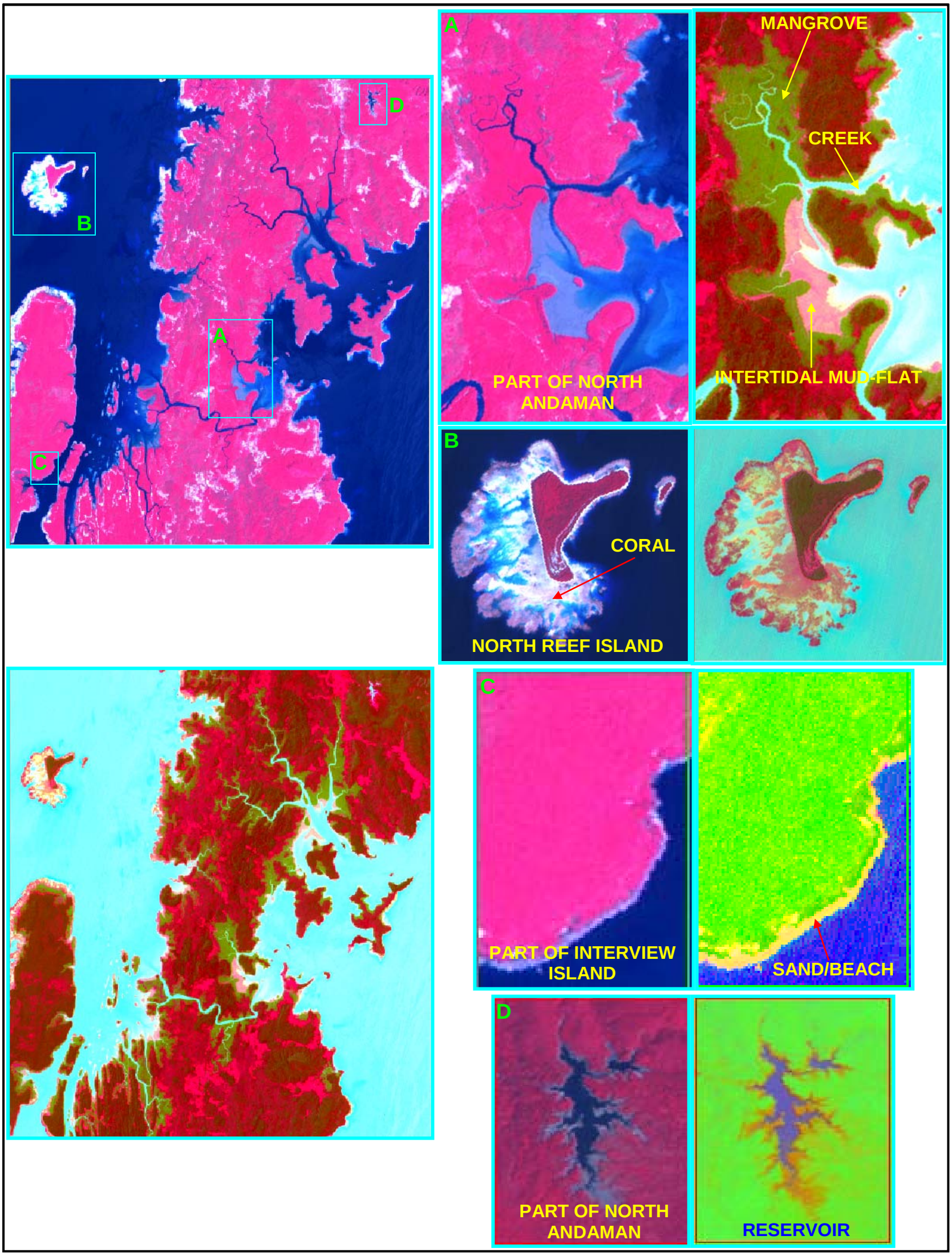


Plate – 1c: Major wetland types of Union Territories

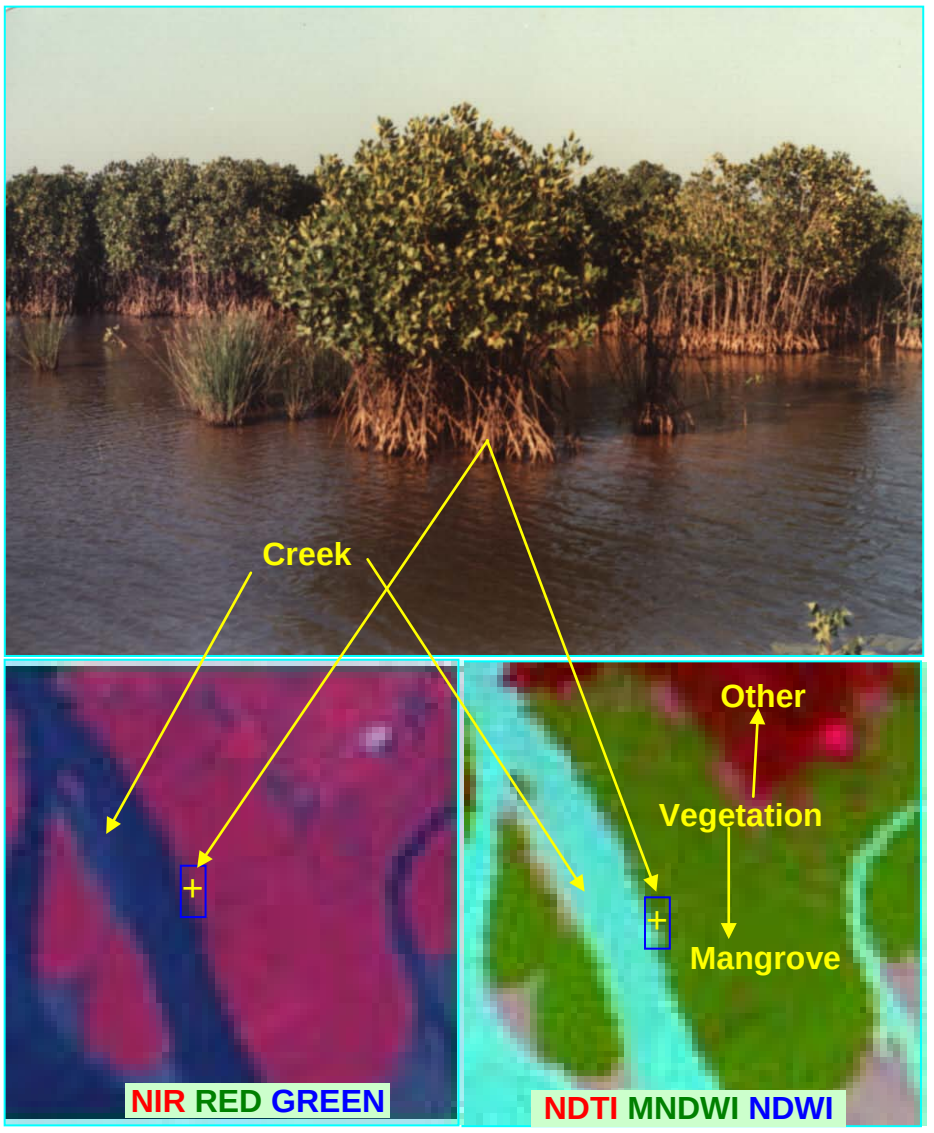
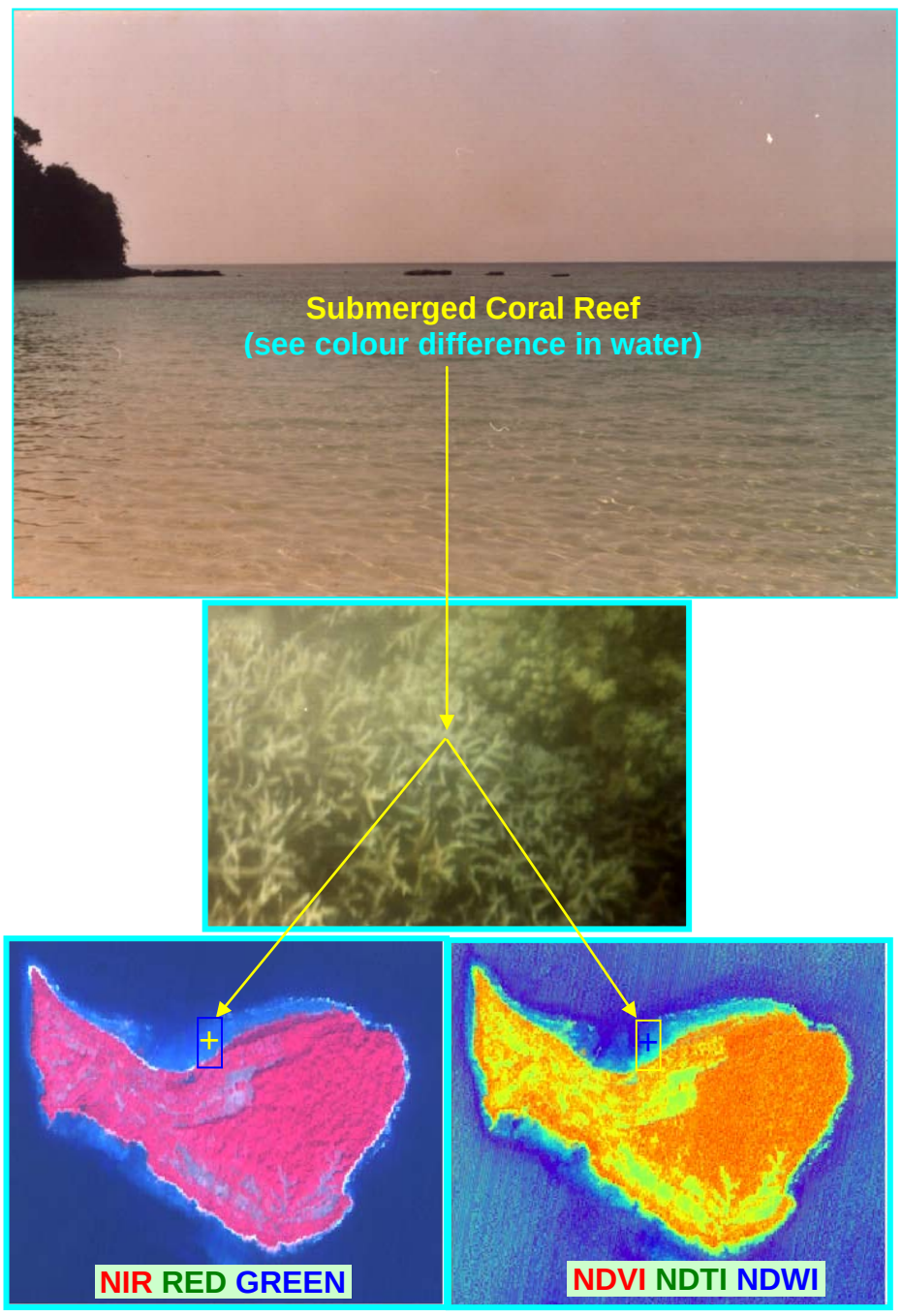
Sr. No.	Site Description	Wetland Category
1	Location: 92:55:10.34 E 13:03:42.23 N Part of North Andaman Mangrove vegetation along the creek. Combination indices (NDTI MNDWI NDWI) aids in enhancement and delineation of Mangroves from other vegetation. The Mangrove appears green and creeks with water appear cyan in colour.	
2	Location: 93:02:32.76 E 11:50:29.18 N Part of Neill Island Submerged Coral Reef. FCC gives substantial signature to delineate the submerged Coral. The use of a combination of indices (NDVI NDTI NDWI) aids in enhancement and delineation of submerged Coral from deeper water and clear demarcation is possible from land.	

Plate 2a: Field photographs and their manifestation on LISS-III imagery of various wetland types – Mangrove and Coral in Andaman and Nicobar Islands

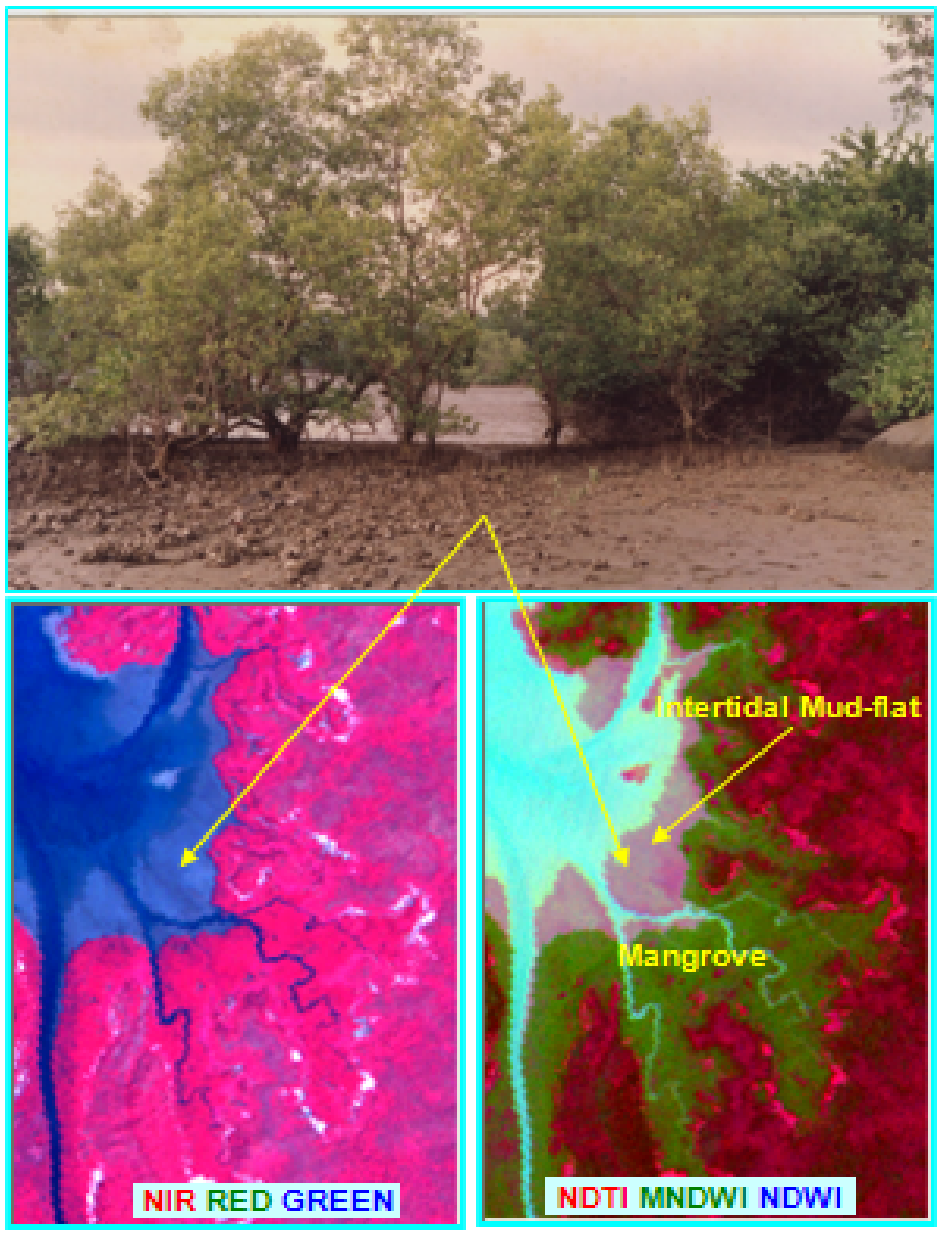
Sr. No.	Site Description	Wetland Category
1	Location: 92:46:58.96 E 12:51:42.11 N Part of Middle Andaman Intertidal Mud-flat with Mangrove vegetation along the creek. Combination indices (NDTI MNDWI NDWI) aids in enhancement and delineation of Intertidal Mud-flats and Mangroves from others. The Intertidal Mud-flats appears grayish-pink on indices image. Molluscs (Oysters and bivalves) are seen on the mud while low density mangroves in the background.	
2	Location: 92:24:08.80 E 10:39:20.45 N Part of Little Andaman Sand/Beach It is clear on LISS-III FCC. However, a combination indices (NDTI MNDWI NDWI) aids in enhancement and delineation of Sand/Beach from coral which often confuses the signature. Sand/beach manifests itself as bright and generally linear feature.	

Plate 2b: Field photographs and their manifestation on LISS-III imagery of various wetland types – Intertidal Mud-flat and Sand/Beach in Andaman and Nicobar Islands

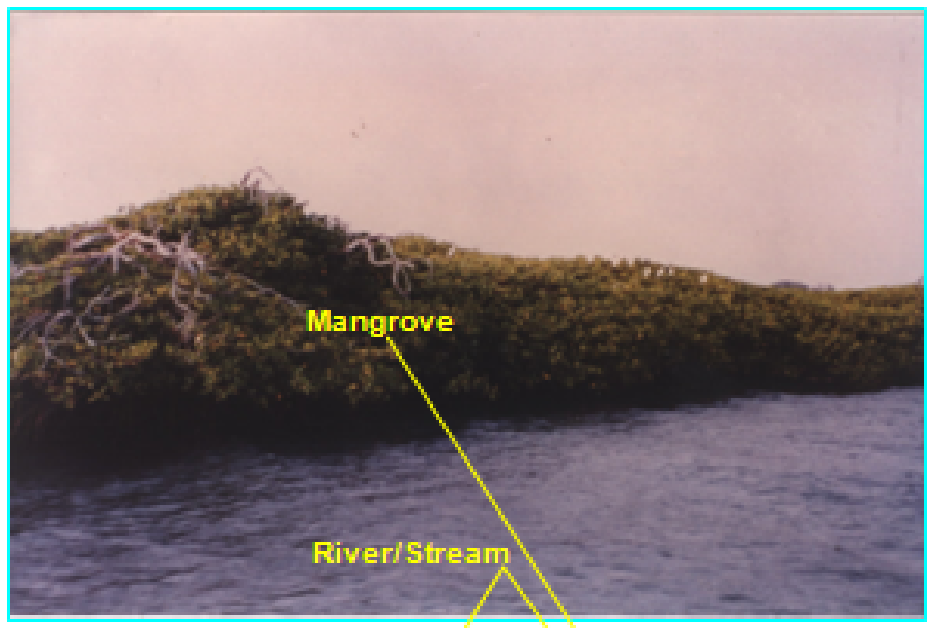
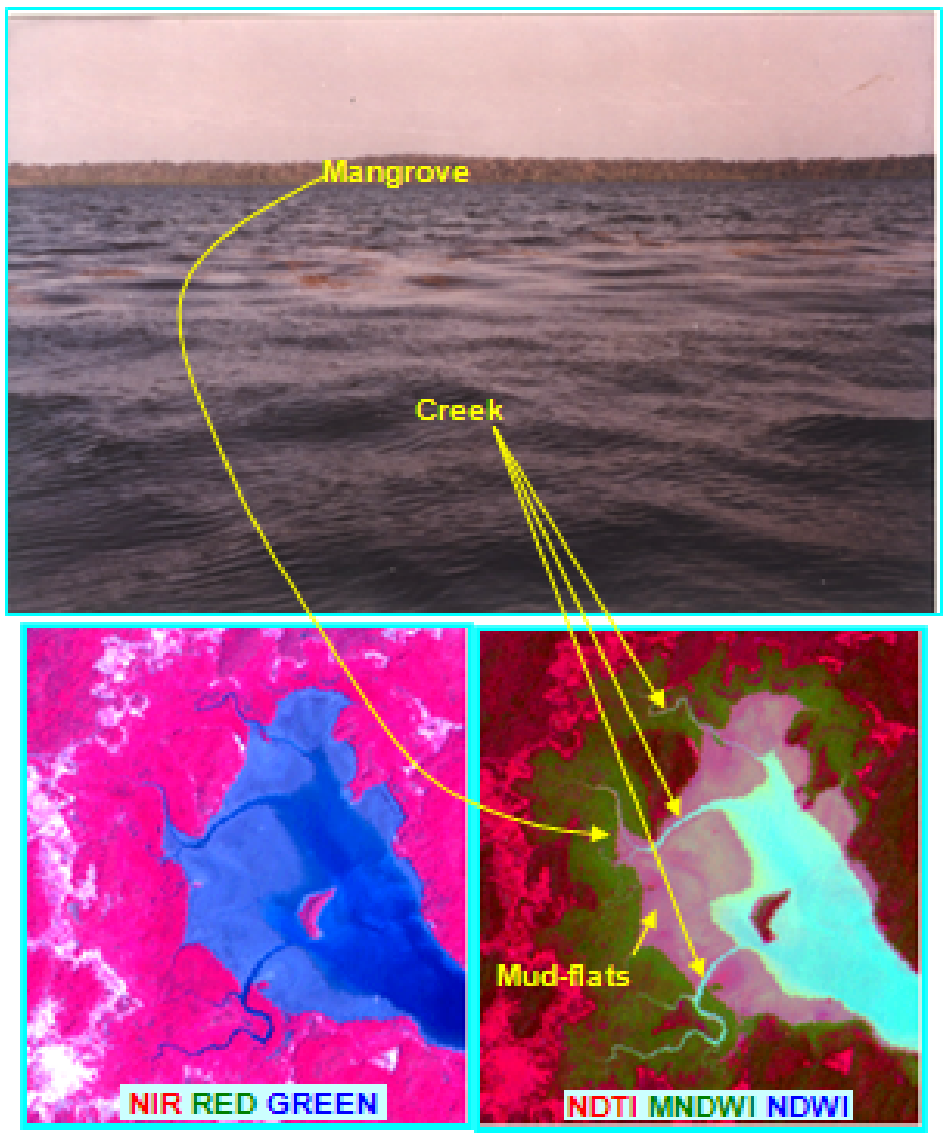
Sr. No.	Site Description	Wetland Category
1	Location: 92:46:42.78 E 12:39:45.90 N Part of Middle Andaman Rive/Stream supporting the Mangrove vegetation. River/stream forms complex estuarine wetland ecosystem that support Mangroves and also forms tidal mud-flats of varying sizes. Combination indices (NDTI MNDWI NDWI) aids in enhancement and delineation of Mangroves from other vegetation. The Mangrove appears green and River/Stream with water appears cyan in colour.	
2	Location: 92:57:36.20 E 13:19:39.86 N Part of North Andaman Creek supporting the Mangrove vegetation. Creeks forms complex estuarine wetland ecosystem that support Mangroves and also forms extensive tidal mud-flats of varying sizes. Combination indices (NDTI MNDWI NDWI) aids in enhancement. Mangrove appears green and Creek with water appears cyan and Intertidal Mud-flats appears grayish-pink on indices image. .	

Plate 2c: Field photographs and their manifestation on LISS-III imagery of various wetland types – River/Stream, Creek, Mangrove and Intertidal Mud-flats in Andaman and Nicobar Islands

IMPORTANT WETLANDS

9.0 IMPORTANT WETLANDS OF UNION TERRITORIES

Chandigarh

Sukhna, a freshwater lake, situated near Chandigarh, is an important wetland of Chandigarh. Extensive field work was carried out for Sukhna wetland area. Wetland map have been prepared for 5km buffer area. Details of the wetlands and wetland maps of 5 km buffer area are shown in plates 3, 4 and 5.

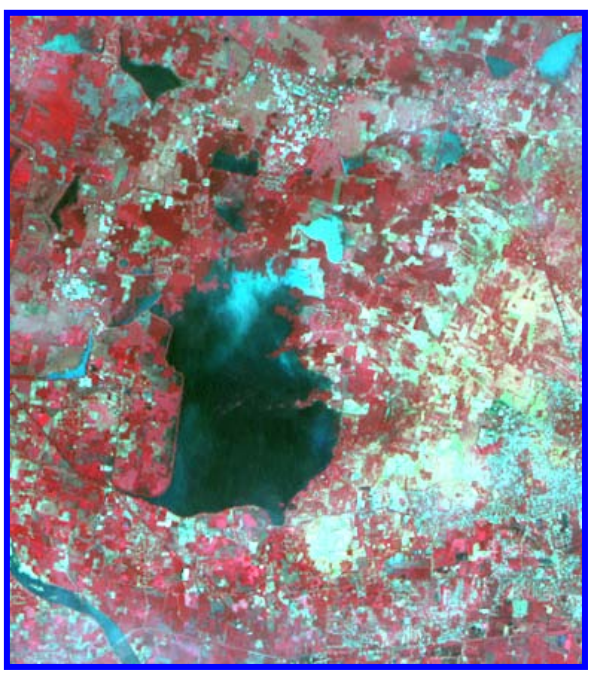
Andaman and Nicobar Islands

These islands have the distinction of harbouring biologically rich flora and fauna of terrestrial and aquatic (marine). Wandur Marine National Park, Lohabarruk Saltwater Crocodile Sanctuary and North Reef Island Sanctuary are some of the important wetland area of Andaman and Nicobar Islands. Details of each with a map are shown in plates 6-11 along with the LISS-III image of post-monsoon season.

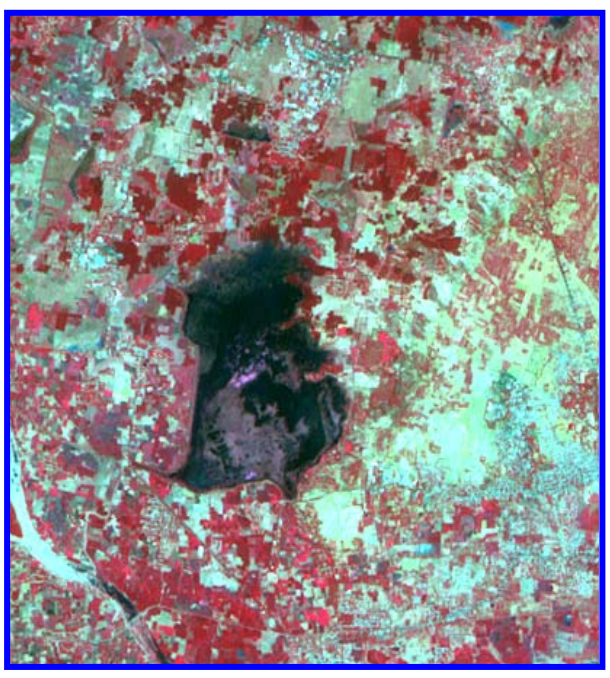
Puducherry

Ousteri lake is located at 30^{o} 44' 9" to 30^{o} 44' 54" N Latitude and 76^{o} 48' 36" to 76^{o} 50' 3" E Longitude near the village Oussudueri, partly in Tamil Nadu state and partly in Pondicherry Union Territory. is the most important freshwater lake of Pondicherry region. Total wetland area is 159.8 ha. The water in Ousteri lake comes from the following sources: (i) the run-off from the lake basin and direct interception by the water body; (ii) the water which is diverted by the Suthukenni check dam through the Suthukenni channel to the lake.

Ousteri is a major wintering spot for a large number of migratory birds and is a rich source of inland fisheries. Main bird species observed are dabbling ducks (mainly *Anas querquedula. A. penelope, A. acuta,* and *A. clypeata*), *Phalacrocorax* spp., *Egretta* spp., *Ardea cinerea, Anastomus oscitans, Ciconia ciconia, Threskiornis melanocephalus, Plegadis falcinellus, Aythya farina, A.fuligula, Fulica atra, Himantopus himantopus* and other shorebirds. Ousteri Tank benefits from its proximity to Kaliveli Tank, and when the latter dries out, some species such as egrets, storks, and ibises, move to Ousteri.



Post monsoon data (2006)



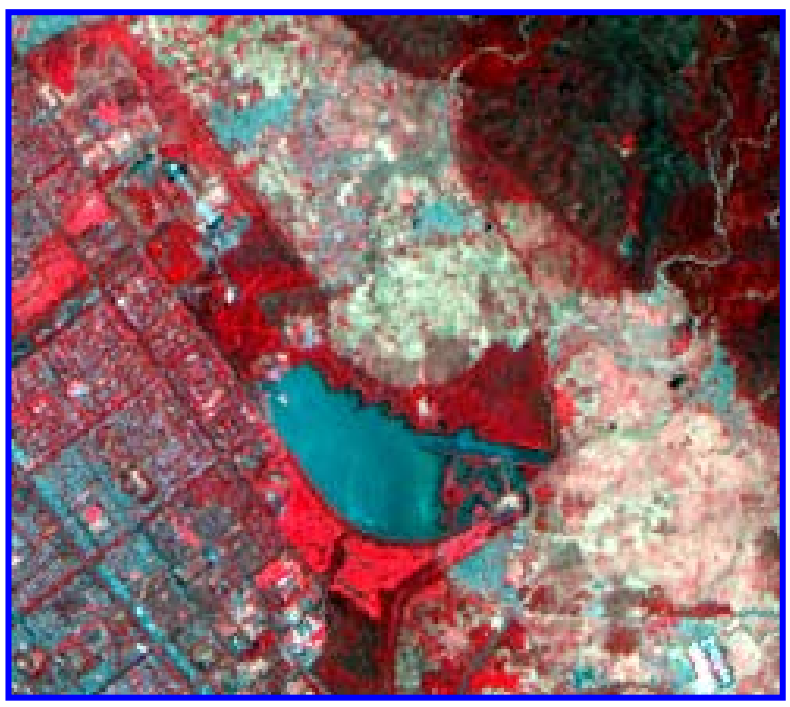
Pre monsoon data (2007)

Ousteri Lake, Puducherry

9.1 Sukhna Lake

Name	**Sukhna Lake**
Location	30^{o} 44' 9" to 30^{o} 44' 54" N Latitude and 76^{o} 48' 36" to 76^{o} 50' 3" E Longitude
Area	159.8 ha
Wetland Type	Lake
Climate	The average annual rainfall in the region is around 700 mm, extending from July to mid October. The temperature ranges from an average minimum of 6ºC, occasionally dropping below the freezing point of water, in winter to a maximum of 45ºC in summer. Hence, water temperature and water depth also vary according to season.
Description	Sukhna, a freshwater lake, situated near Chandigarh, is fed with rain water from Shivalik hills through Sukhna nadi, Kansal nadi, and their tributaties. It is a shallow lake about 2.5 m deept with a submerged area of 153 ha. Sedimentation and weed infestation pose a great threat to the ecological status of Sukhna wetland. The land use indicates that major portion of the catchment is under forest.
Turbidity	Moderate

Post monsoon data (2006)



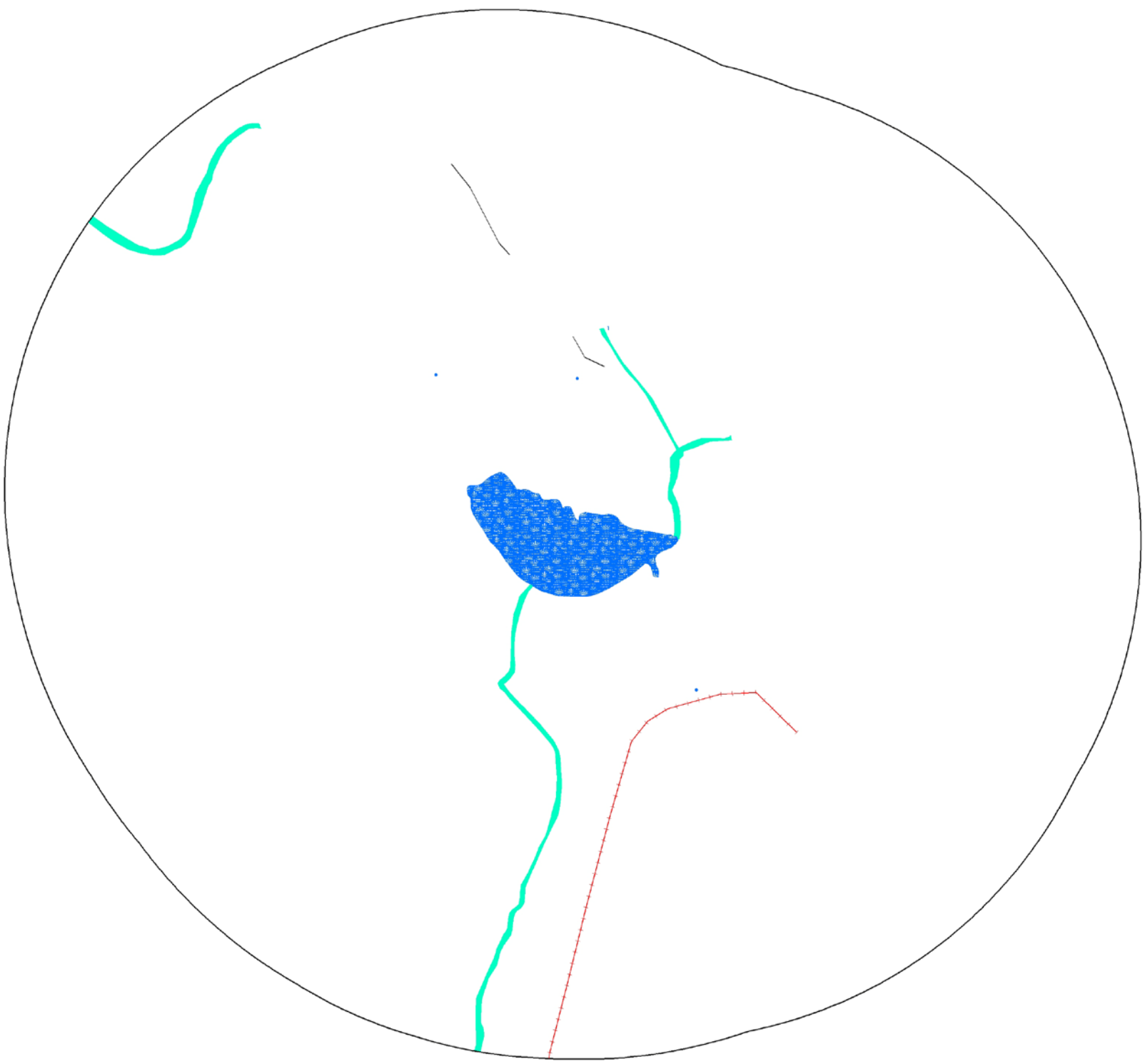
Pre monsoon data (2007)

Plate 3: Sukhna Lake

State / Union Territory : Chandigarh

WETLAND MAP

Sukhna Lake



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

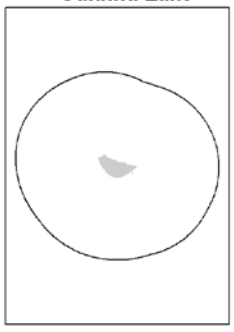
Legend

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

Location Map

India

Sukhna Lake



1 0.5 0 1 2 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

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

State / Union Territory : Chandigarh

Sukhna Lake

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

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

9.2 Wandur Marine National Park

Wandur Marine National Park (MNP) in 1986 encompasses area between 92° 30’ to 92° 40 E Longitudes and 11° 22 to 11° 36 N Latitudes accounting for an area of 282 Sq. km (Anon., 1993; Negi, 1995) falling along the south-west coast of South Andaman immediately north of Rutland Island. This is perhaps the least disturbed group of islands that includes Tarmugli, Alexandra, Red skin, Hobday, Boat, Malay, Jolly Boys islands and islets of Pluto, Snob, Belle, Chester and Grub comprising coastal tracts lying between 0 to 85 m above MSL and also sea. The importance attached to this MNP is due to the submerged coral reefs and many marine species. Larger area is considered for the extraction of wetland estimates for this MNP. Coral is the most dominating category in the MNP comprising 68.79 % accounts for 4480 ha of area out of 6513 ha of total (Table 22). Coral is followed by Mangrove (10.53 ha) and Intertidal Mud-flat (519 ha). The detail of type-wise wetland area estimation is given in the table 22. Wetland map of Wandur Marine National Park is shown in Plate 6 and Plate 7 shows IRS LISS-III image of the Park.

Table 22: Area estimates of wetlands in Wandur Marine National Park

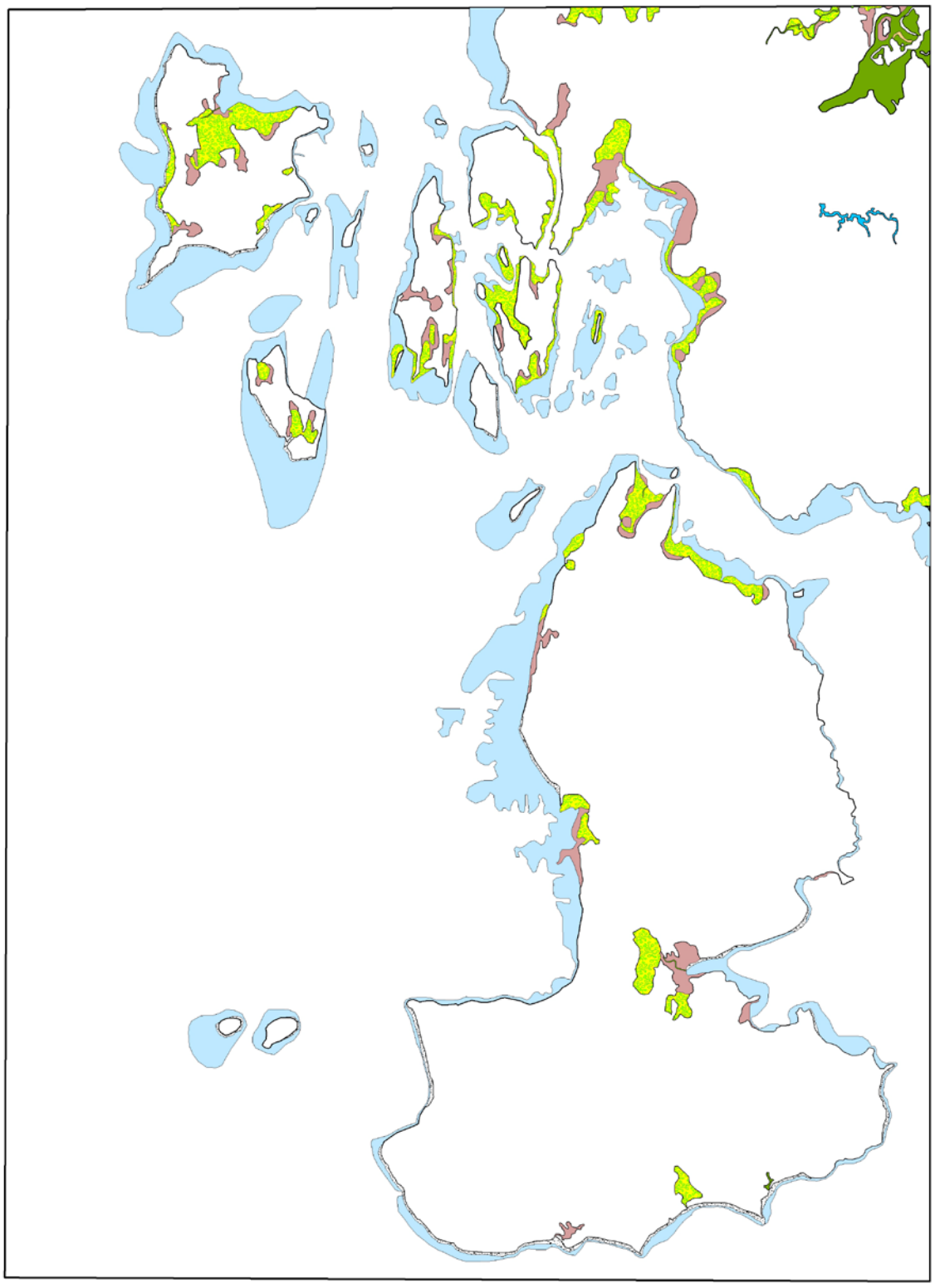
Area in ha

Sr. No.	Wetland code	Wetland Category	No. of wetlands	Wetland Area	% of wetland area
	1200	**Inland Wetlands -Man-made**			
1	1201	Reservoir/Barrage	1	20	0.31
		Sub-total	**1**	**20**	0.31
	2100	**Coastal Wetlands - Natural**			0.00
2	2102	Creek	8	226	3.47
3	2103	Sand/Beach	20	212	3.26
4	2104	Intertidal Mud-flat	48	519	7.97
5	2105	Salt Marsh	1	3	0.05
6	2106	Mangrove	48	1053	16.17
7	2107	Coral	47	4480	68.79
		Sub-total	**172**	**6493**	99.69
		Total	**173**	**6513**	**100.00**

UT : Andaman and Nicobar Islands

WETLAND MAP

Wandur Marine National Park

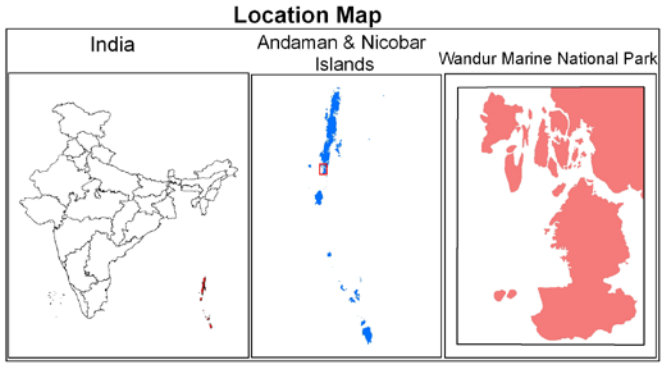


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



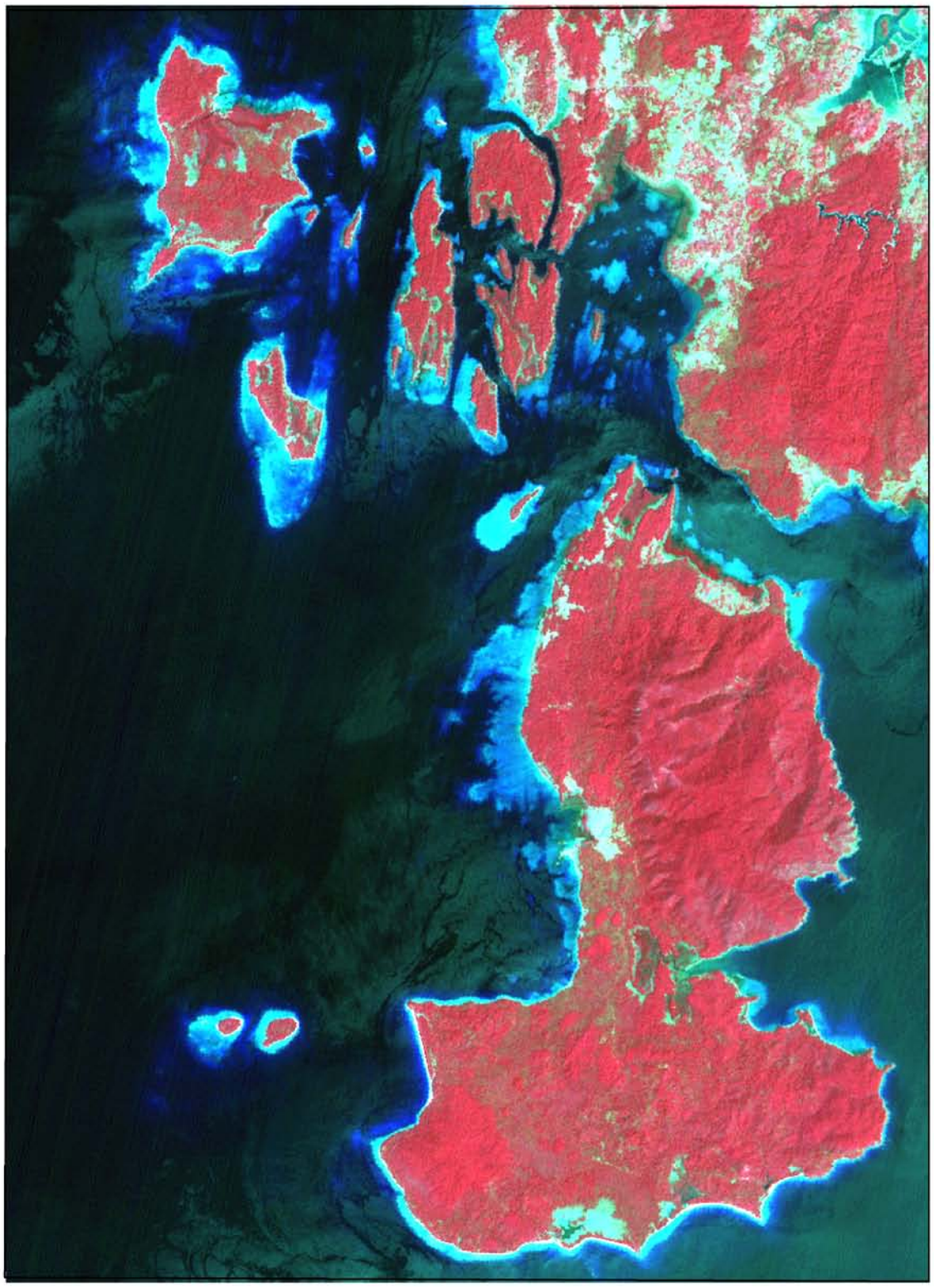
0 1 2 4 Kilometers

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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 6: Wetland map of Wandur Marine National Park



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

Plate 7: IRS P6 LISS-III Post-monsoon image of Wandur Marine National Park

9.3 Lohabarruk Saltwater Crocodile Sanctuary

The Lohabarruk saltwater crocodile sanctuary was established in 1983. The area is bound between 92°35’ and 92°39’ E Longitudes and 11°35’ and 11°40’ N Latitudes. The declaration of this sanctuary owes to the objective of protecting the saltwater crocodile. The surveys in 1975-77 reported an estimated 80 breeding females, a much depleted population considering the associated habitat (Whitaker and Zai, 1979). The female nests in cane, bamboo and tiger fern behind mangroves which are also freshwater drainages that settlers choose as suitable rice growing areas. The Species can comeback provided the habitat destruction/modification is halted. There are difficulties in populating crocodiles, especially because the ‘salty’ will, on rare occasions attack human being. It is expected that a conservative average of 30 surviving hatchlings from each nest. The coast is dominated with submerged coral reefs which accounts for 68.21 % of the wetland area (table 23). The mangroves constitute 23.44 % area. The other two categories are Intertidal Mud-flats (96 ha) and Sand/Beach (19 ha). The wetland map is given in the plate 8 and Plate 9 shows IRS LISS-III image of the Sanctuary.

Table 23: Area estimates of wetlands in Lohabarruk Saltwater Crocodile Sanctuary

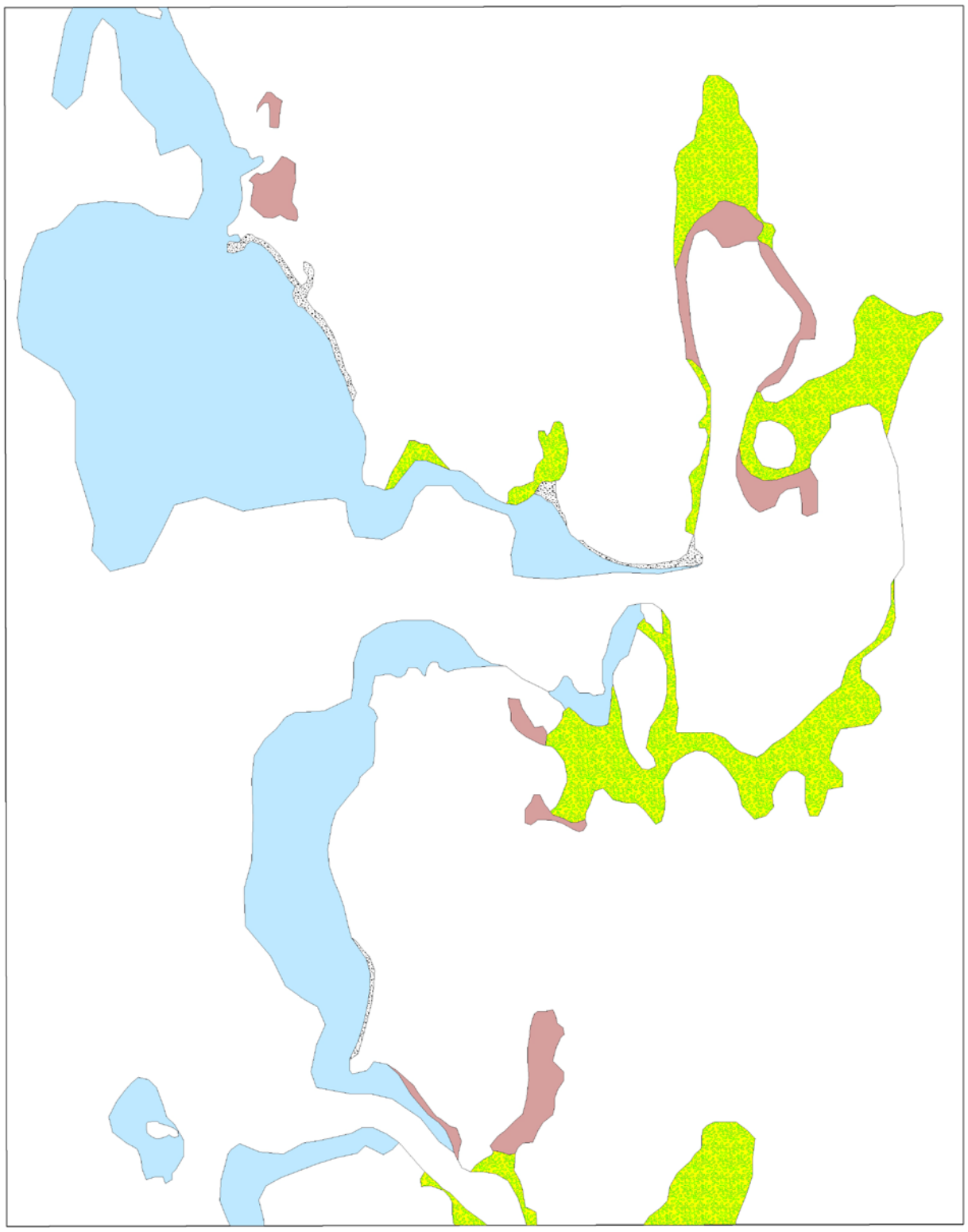
Area in ha

Sr. No.	Wetland code	Wetland Category	No. of wetlands	Wetland Area	% of wetland area
1	2103	Sand/Beach	4	19	1.38
2	2104	Intertidal Mud-flat	8	96	6.97
3	2106	Mangrove	9	323	23.44
4	2107	Coral	5	940	68.21
		Total	**26**	**1378**	**100.00**

UT : Andaman and Nicobar Islands

WETLAND MAP

Lohabarruk Crocodile Sanctuary

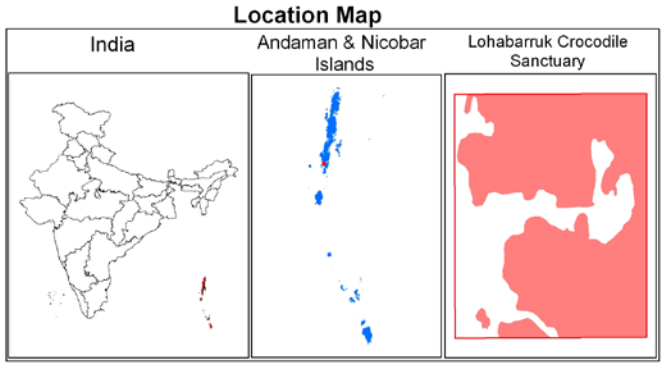


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.4 0.8 1.6
Kilometers

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

Prepared By :
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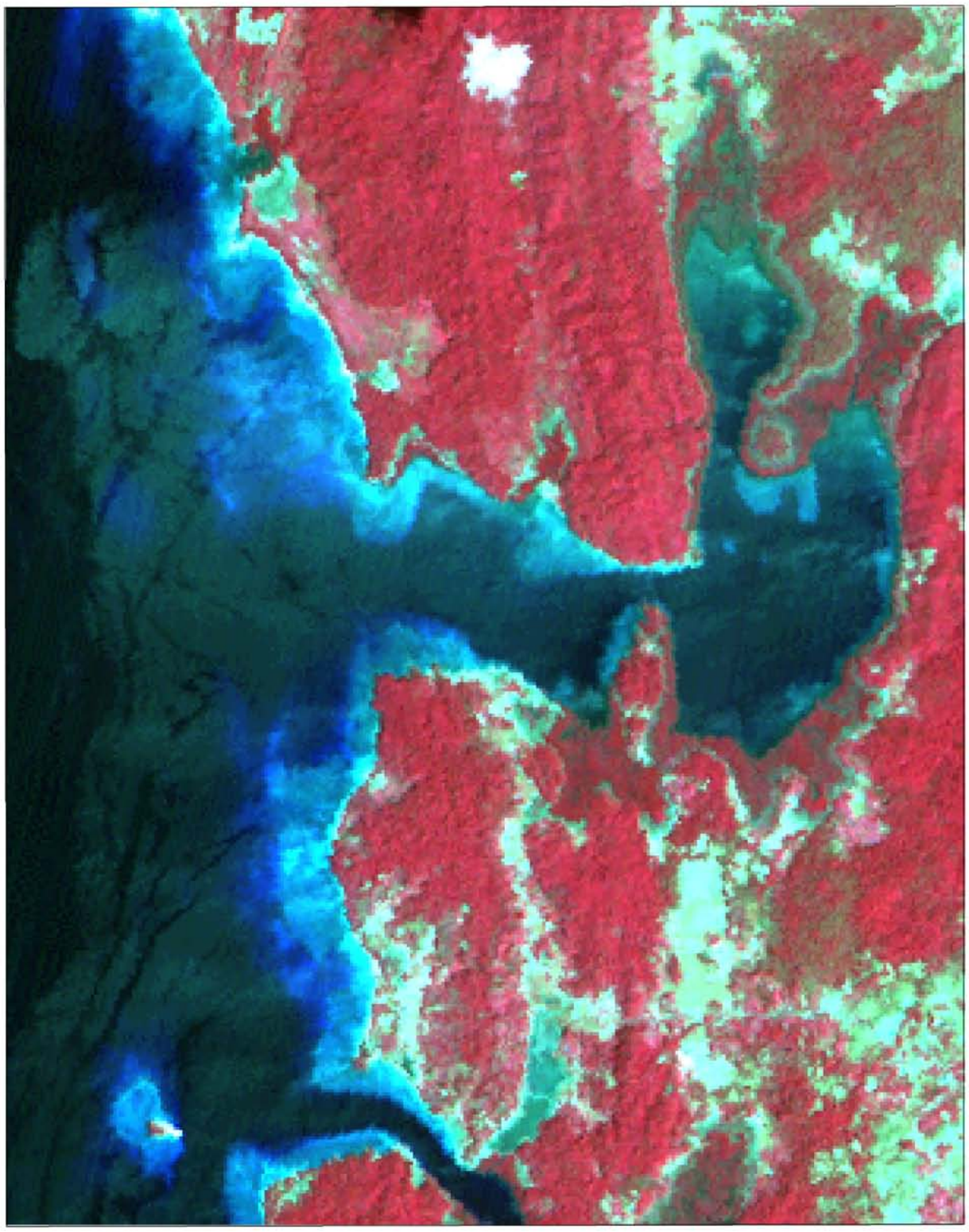
Plate 8: Wetland map of Lohabarruk Saltwater Crocodile Sanctuary



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

Plate 9: IRS P6 LISS-III Post-monsoon image of Lohabarruk Saltwater Crocodile Sanctuary

9.4 North Reef Island Sanctuary

This sanctuary bounded by 92° 41’ to 92° 43’ E Longitudes and 13° 04’ to 13° 05’ N Latitudes was declared in 1977 as prime habitat for Andaman Teal and Nicobar Pigeon besides a vast expanse of Coral reef. Dolphins and whales are important marine animals besides many species of mammals and turtles. Coral reef is the largest category of wetlands, which constitutes 1154 ha (95.53 %) out of the total wetland area of 1208 ha (Table 24). The wetland map is given in the plate 10 and Plate 11 shows IRS LISS-III image of the Sanctuary.

Table 24: Area estimates of wetlands in North Reef Island Sanctuary

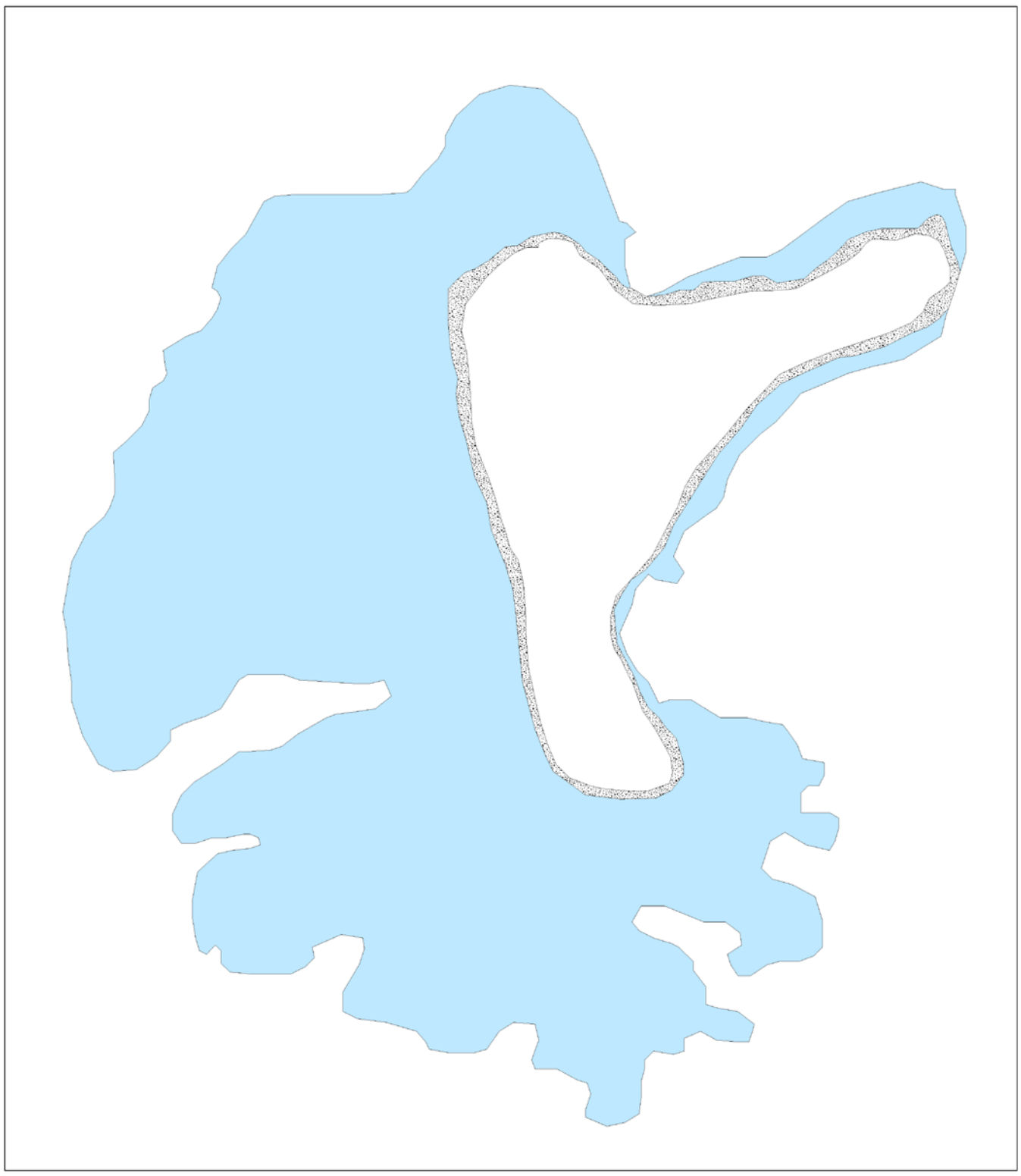
Area in ha

Sr. No.	Wetland code	Wetland Category	No. of wetlands	Wetland Area	% of wetland area
1	2103	Sand/Beach	1	54	4.47
2	2107	Coral	2	1154	95.53
		Total	**3**	**1208**	**100.00**

UT : Andaman and Nicobar Islands

WETLAND MAP

North Reef Island Sanctuary

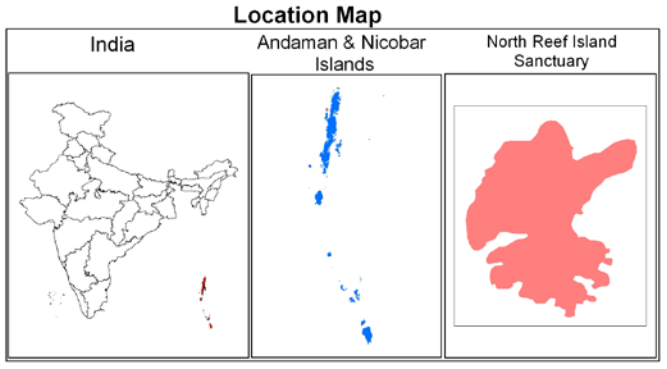


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.25 0.5 1 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:
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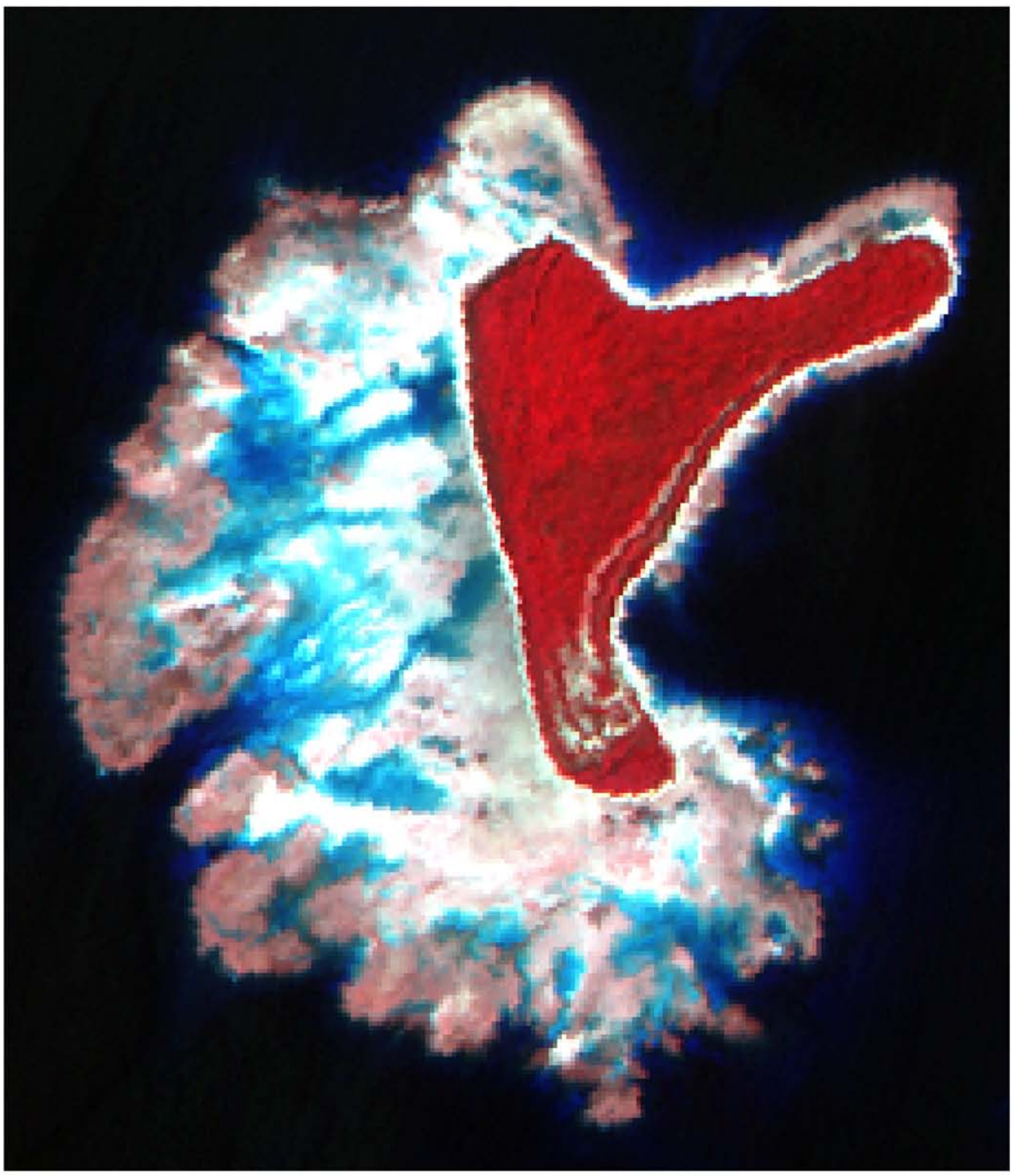
Government of India

Plate 10: Wetland map of North Reef Island Sanctuary



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

Plate 11: IRS P6 LISS-III Post-monsoon image of North Reef Island Sanctuary

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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 non-vegetated, 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 (Glossary of Geology, 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 (Glossary of Geology, 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 (Glossary of Geology, 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 Encyclopedia of Environmental Sciences, 1974), **Ash pond/Cooling pond** The water body created for discharging effluents in industry, especially in thermal power plants (Encyclopedic Directory of Environment, 1988) and **Cooling pond**: An artificial lake used for the natural cooling of condenser-cooling water serving a conventional power station (Encyclopedic 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 water-logging 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 (Glossary of Geology, 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 non-vegetated 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 non-vegetated 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 foraminifera. 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 (Glossary of Geology, 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 (Encyclopedic Directory of Environment, 1988). Aquaculture ponds are geometrical in shape usually square or rectangular. Tone is blue.

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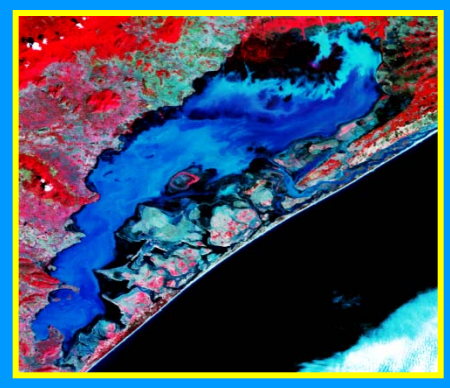

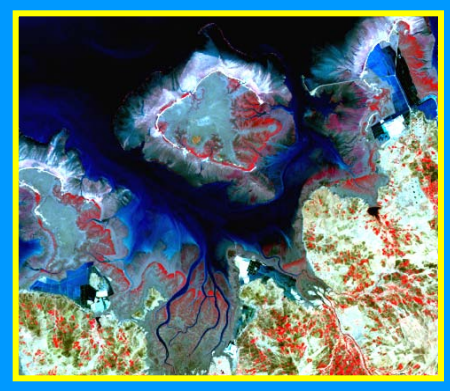

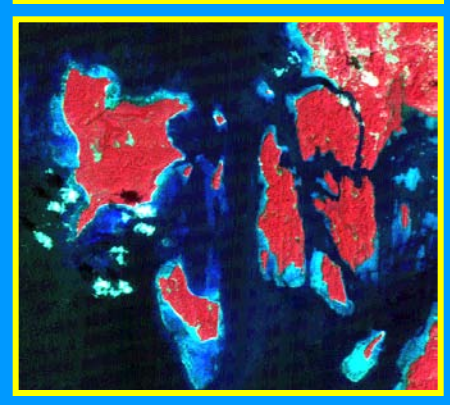

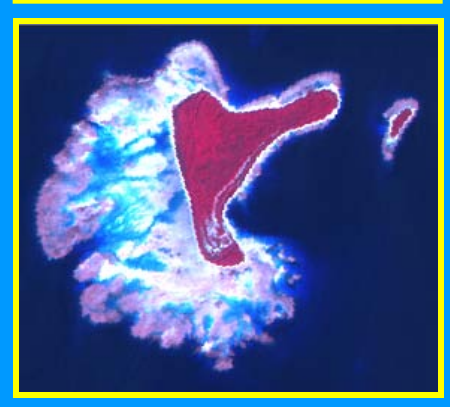

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