NATIONAL WETLAND ATLAS:

ANDAMAN AND NICOBAR ISLANDS

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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NATIONAL WETLAND ATLAS

Andaman & Nicobar Islands

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Ministry of Environment and Forests, Government of India

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

Space Applications Centre (ISRO), Ahmedabad

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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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सत्यमेव जयते

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FOREWORD

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

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

January 25, 2010

(Ranganath R. Navalgund)

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

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

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

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

(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 Andaman & Nicobar Islands, 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. Maps, thus essential for monitoring and quantifying change over time scale, assist in decision making. The technique used in the preparation of map started with ground survey. The Survey of India (SOI)

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).

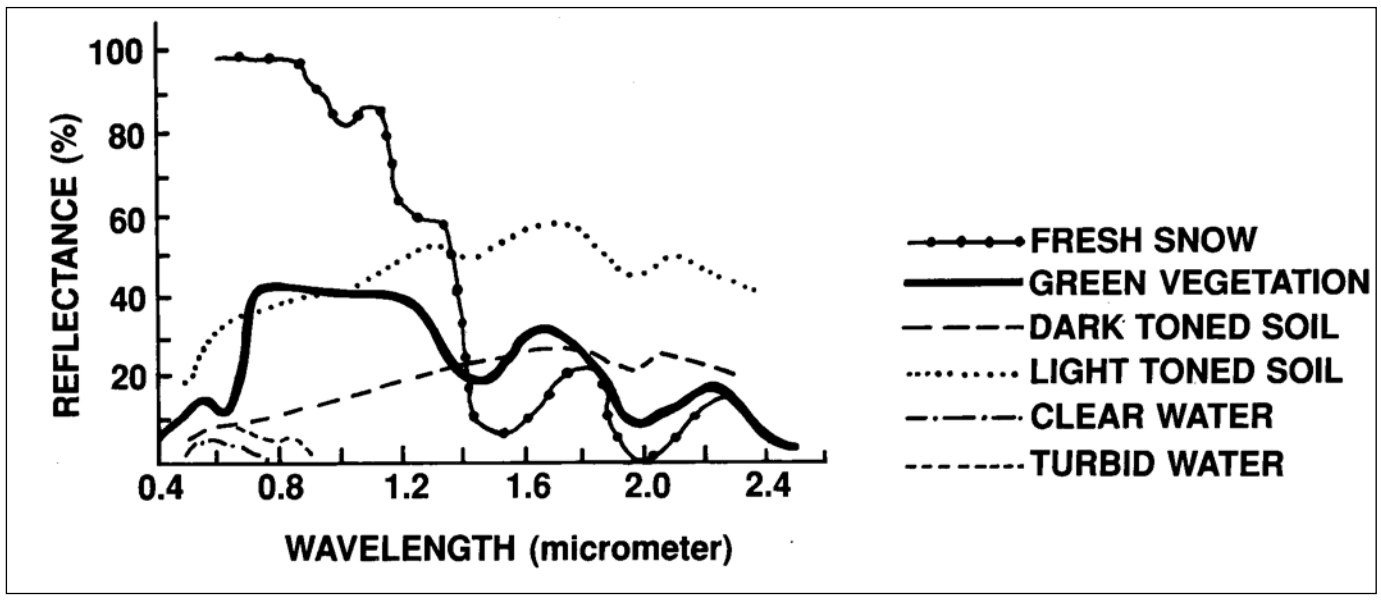
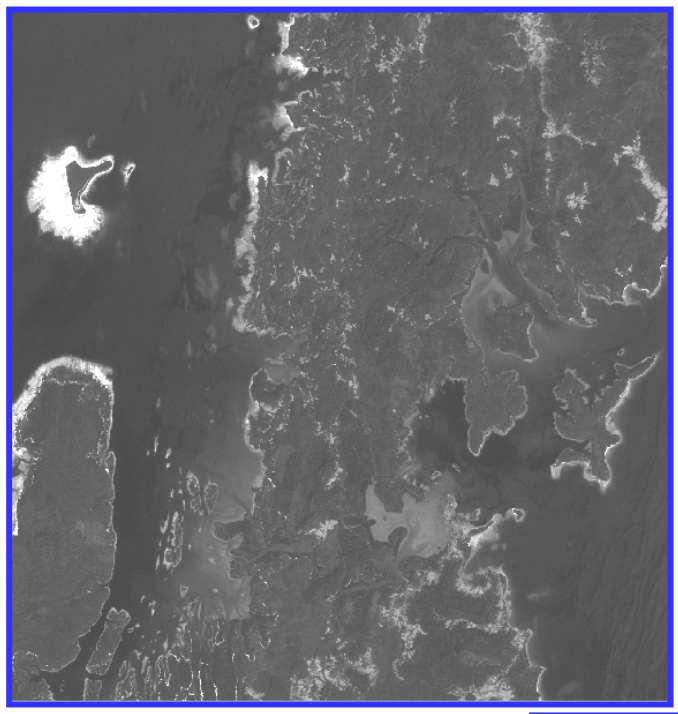


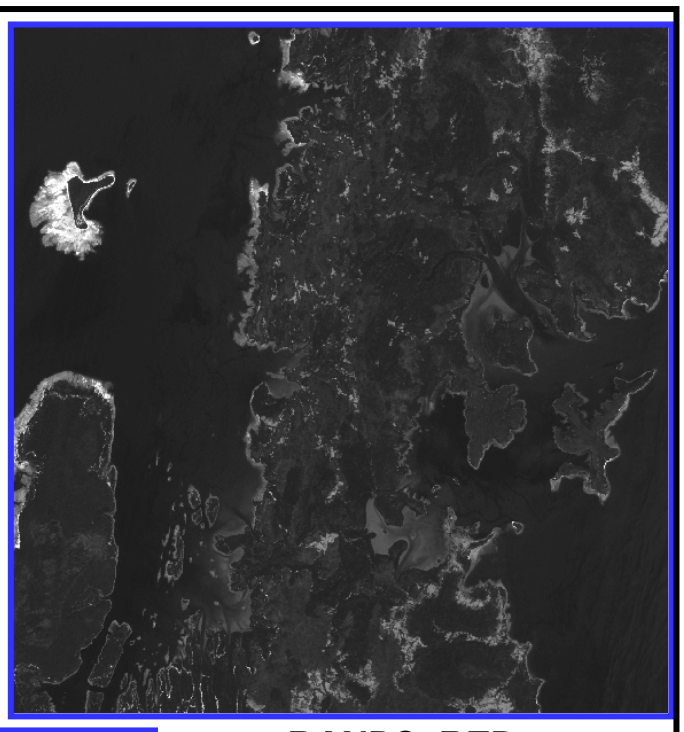
Figure 1: Spectral Signature of various targets

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 (IRS) satellites. Since the launch of the first satellite IRS 1A in 1987, India has now a number of satellites providing data in multi-spectral bands with different spatial resolution. IRS P6/RESOURCESAT 1 is the current generation satellite that provides multi-spectral images in spatial resolution of 5.8 m (LISS IV), 23.5 m (LISS III) and 56m (AWiFS). Over the past few decades, Indian remote sensing data has been successfully used in various fields of natural resources.

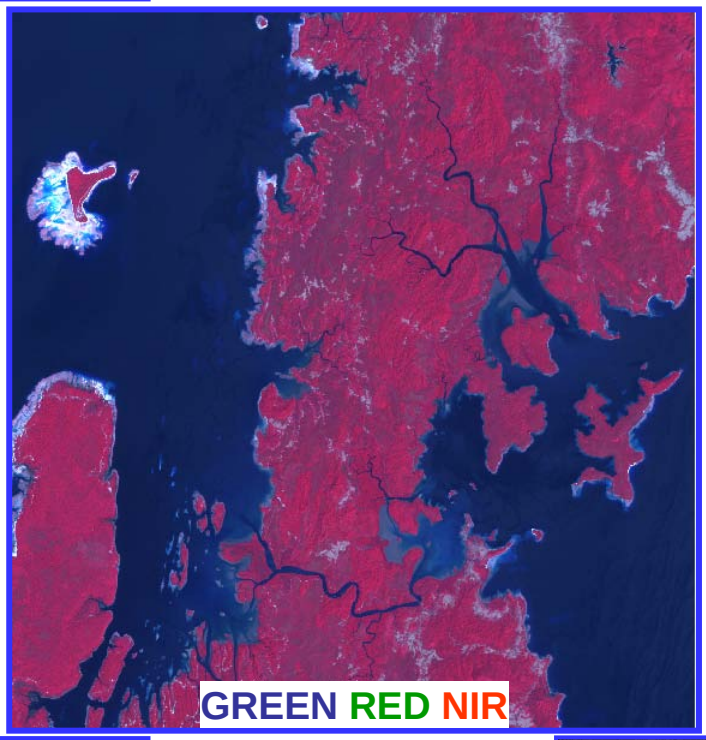
Development of technologies like Geographic Information System (GIS) has enhanced the use of RS data to obtain accurate geospatial database. GIS specialises in handling related, spatially referenced data, combining mapped information with other data and acts as analytical tool for research and decision 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.



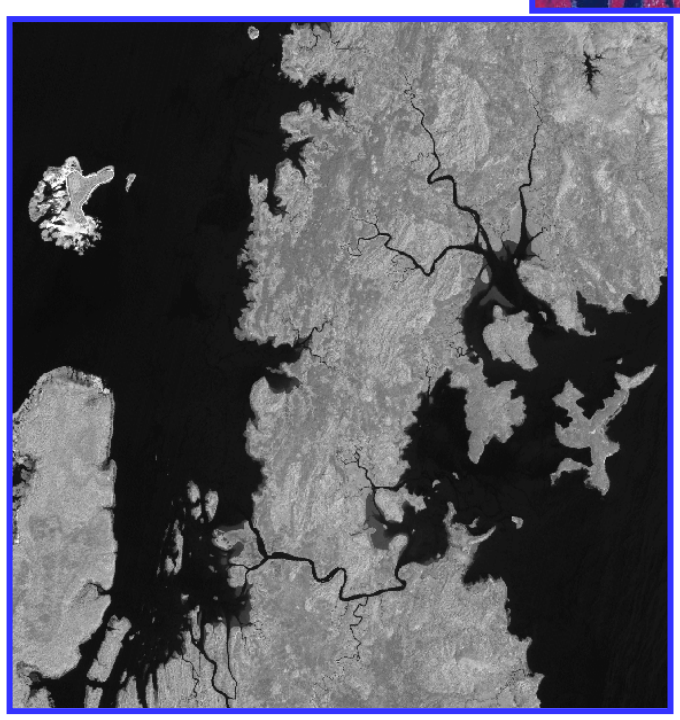
BAND1: GREEN



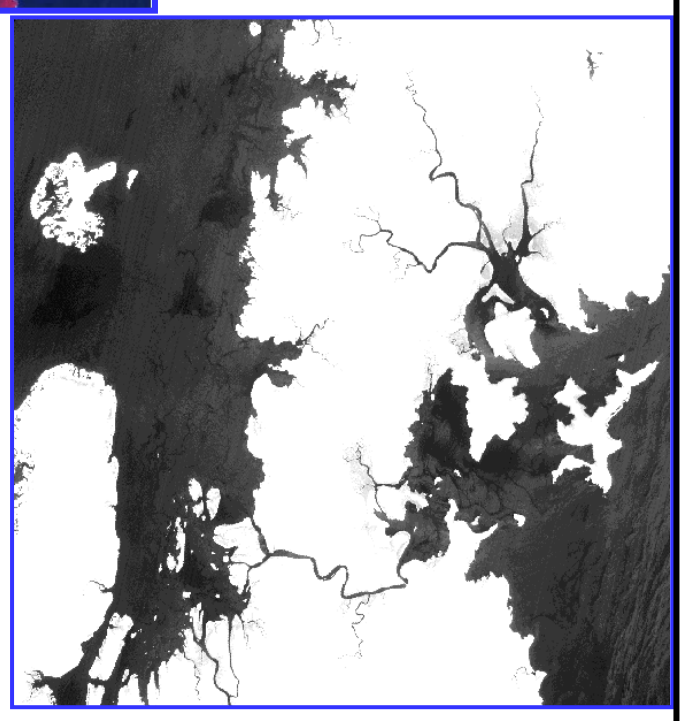
BAND2: RED



LISS-III FCC



BAND3: NIR



BAND4: SWIR

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

1.3 Wetland Inventory of India

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

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

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

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

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

The first scientific mapping of wetlands of India was carried out during1992-93 by Space Applications Centre (ISRO), Ahmedabad, at the behest of the Ministry of Environment and Forests (MoEF), Govt. of India using remote sensing data from Indian Remote Sensing (IRS) satellite. The mapping was done at 1:250,000 scale using IRS 1A LISS-I/II data of 1992-93 timeframe under the Nation-wide Wetland Mapping Project. Since, no suitable wetland classification existed for comprehensive inventory of wetlands in the country at that time; the project used a classification system based on Ramsar Convention definition of wetlands. The classification considers all parts of a water mass including its ecotonal area as wetland. In addition, fish and shrimp ponds, saltpans, reservoirs, gravel pits were also included as wetlands. This inventory put the wetland extent (inland as well as coastal) at about 8.26 million ha (Garg *et al*, 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 Andaman & Nicobar Islands.

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.

2.2.1 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).

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

Table 1: Wetland Classification System and coding

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

* Wetland type code

3.0 STUDY AREA

The Andaman and Nicobar Islands, Union Territory, 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 covered by fifty three 1:50,000 scale SOI topographical maps that form the spatial frame work for mapping (Figure 4). 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 (Anon, 2006).

Physiography

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.

Soils

Soil show considerable variability from heavy clay to clayey loams, sandy loams and sand. Depth of soil depends on the slope, with deep alluvial deposits often found along the lower reaches of creeks. Soils lack in humus due to continuous leaching by heavy rainfall. Due to poor water retentivity of soil and slope characteristics, availability of fresh water is a limiting factor for development of these islands.

Climate

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%.

National Parks, Sanctuaries and Biosphere Reserves

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 Table-2.

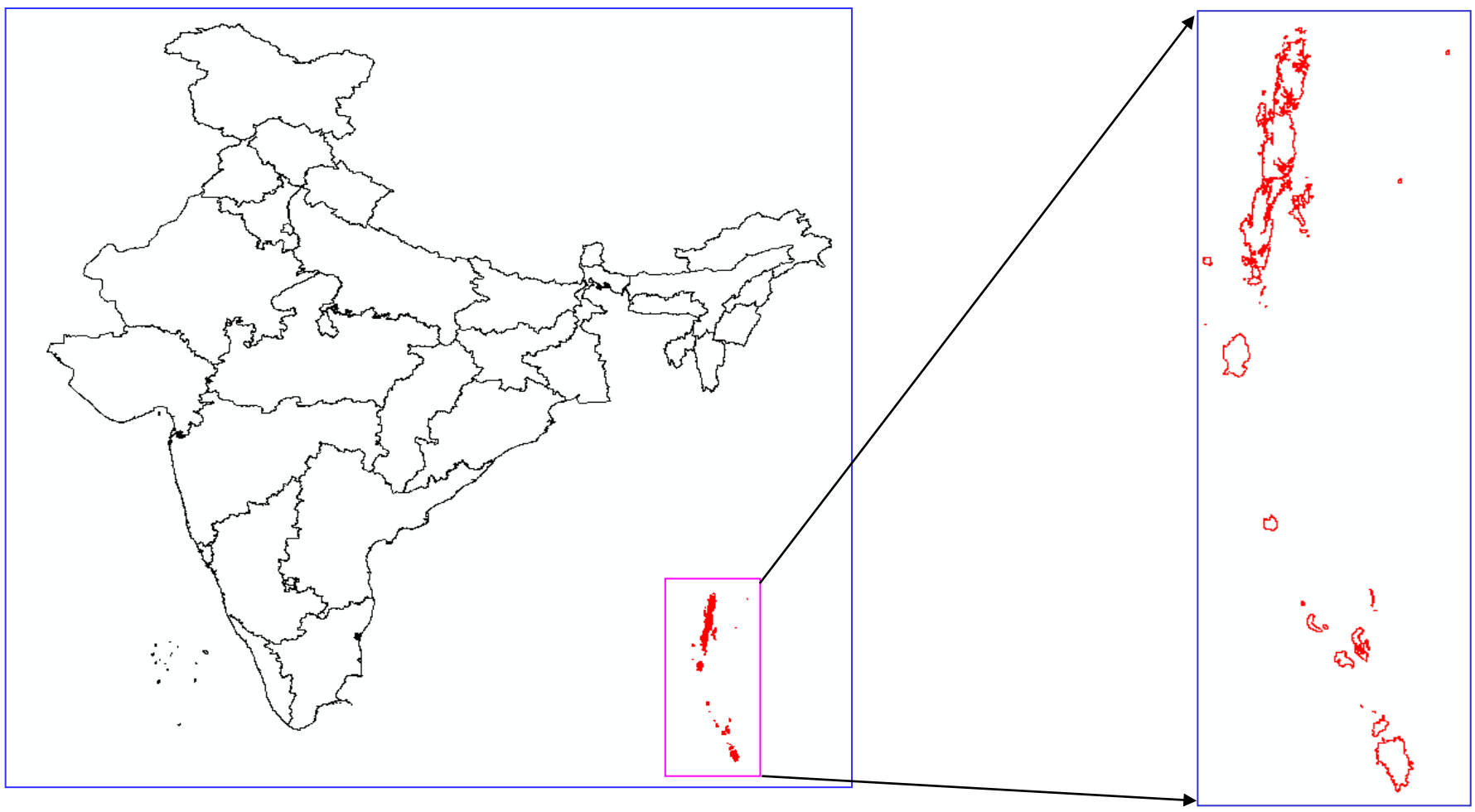


Figure 3: Location map

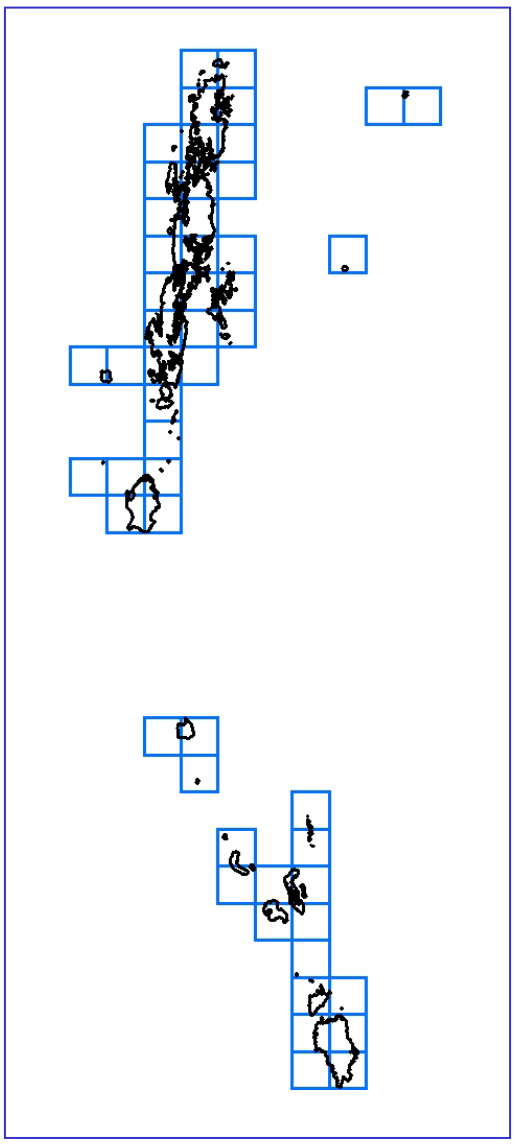


Figure 4: Spatial Framework of Andaman & Nicobar Islands

Table-2: 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).

4.0 DATA USED

Remote sensing data

IRS P6 LISS III data was used to map the wetlands. IRS P6 LISS III provides data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The state of Andaman & Nicobar Islands is covered in 10 IRS LISS III scene (Figure 5). Two date data, one acquired during March and another during January were used to capture the pre-monsoon and post-monsoon hydrological variability of the wetlands respectively (Table-3). Figure 6 shows the overview of the study area as seen in the LISS III FCC of post- monsoon pre-monsoon data respectively.

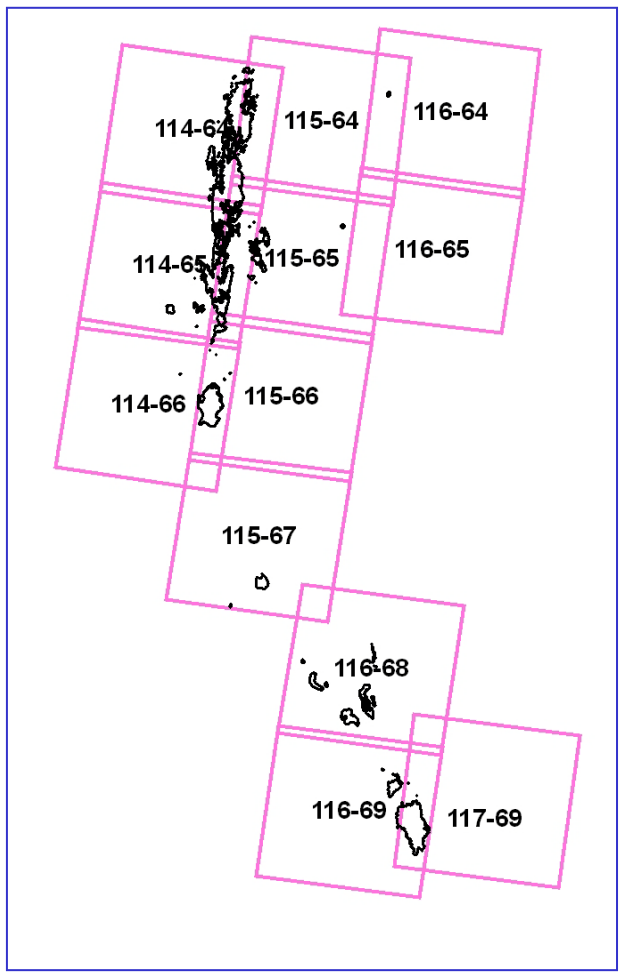


Figure 5: IRS P6 LISS-III coverage (path-row) of Andaman & Nicobar Islands

Table-3: Satellite data used

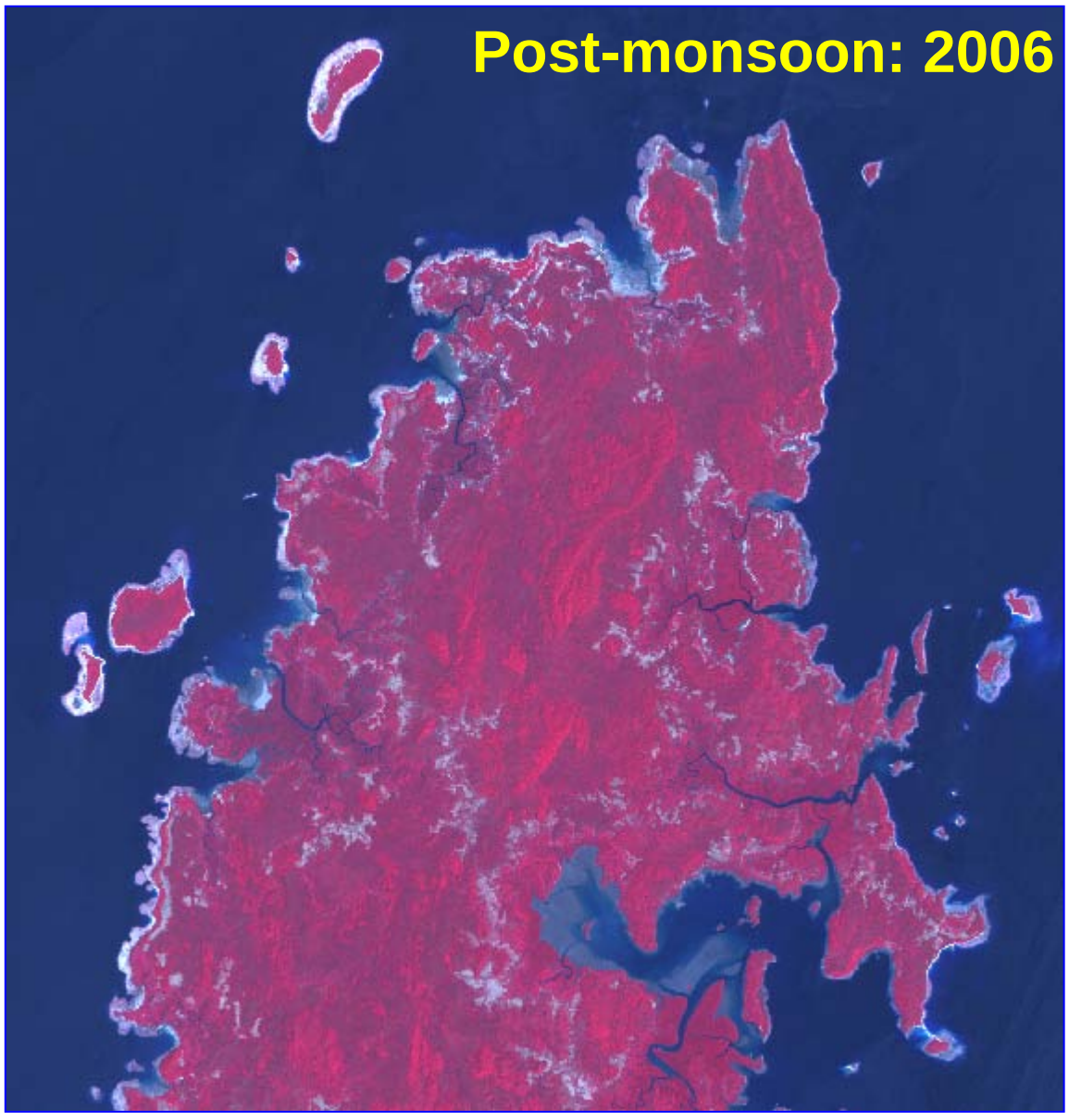
Sr. No.	Satellite/Sensor	Path	Row	Date
1	P6-LISS-III	114	064	06-02-2006 & 21-03-2007
2	P6-LISS-III	114	065	06-02-2006 & 21-03-2207
3	P6-LISS-III	114	066	06-02-2006 & 21-03-2007
4	P6-LISS-III	115	064	20-12-2006 & 02-03-2007
5	P6-LISS-III	115	065	02-03-2007
6	P6-LISS-III	115	067	02-11-2006 & 02-03-2007
7	P6-LISS-III	115	068	02-11-2006 & 02-03-2007
8	P6-LISS-III	116	068	07-04-2007
9	P6-LISS-III	116	069	05-04-2006
10	P6-LISS-III	117	069	26-02-2005 & 25-12-2007

Ground truth data

Remote sensing techniques require certain amount of field observation called “ground truth” in order to convert into meaningful information. Such work involves visiting a number of test sites, usually taking the satellite data. The location of the features is recorded using the GPS. The field data has been collected during various other projects in the area has been utilized. Field photographs are also taken to record the status of wetland.

Other data

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



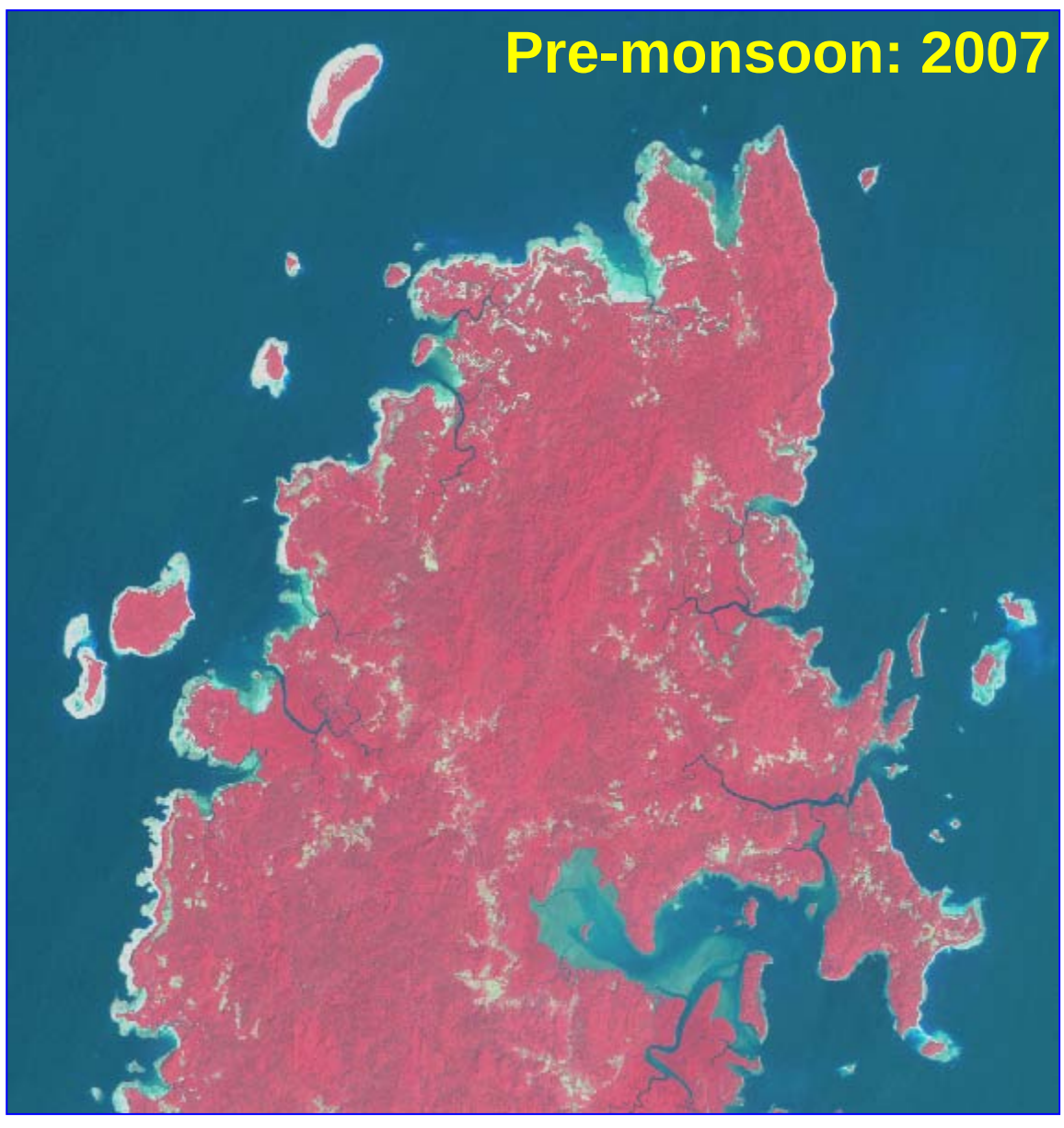


Figure 6 : IRS LISS-III FCC (January 2006 and March 2007)

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.

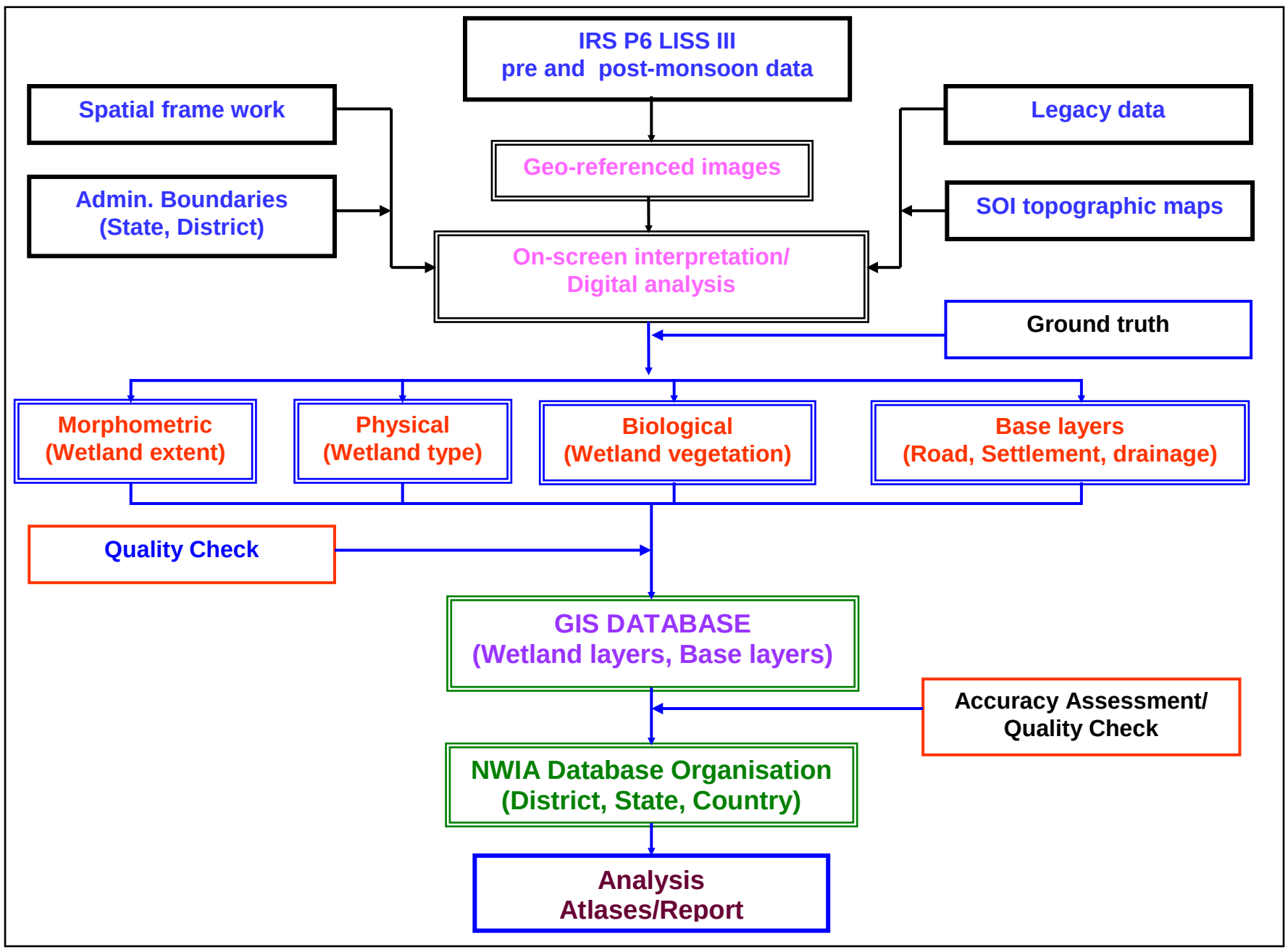


Figure 7: Flow chart of the methodology used

5.1 Creation of spatial framework

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

5.2 Geo-referencing of satellite data

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

5.3 Mapping of wetlands

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

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

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

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

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

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

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. Visually, the FCC of NDTI, MNDWI and NDWI on RED, GREEN and BLUE planes allows the discrimination wetland classes like mangroves, mudflats and creeks easy.

- Extraction of open water :
  MNDWI was used within the wetland mask to delineate the water and no-water areas. Visually, the FCC of NDVI, NDPI and MNDWI on RED, GREEN and BLUE planes allows the discrimination of open water easy.

- 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. Visually, the FCC of NDTI, MNDWI and NDWI on RED, GREEN and BLUE planes allows the discrimination wetland classes like mangroves easy from non-wetland areas.

- 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 4.

Table 4: Qualitative turbidity based on Mean and Standard deviation observed in the MNDWI image

Sr. No.	Conditional criteria	Qualitative Turbidity
1.	<= μ - 1σ	High/Bottom reflectance
2.	> -1σ to <= +1σ	Moderate
3.	> +1σ	Low

5.4 Conversion of raster into a vector layer

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

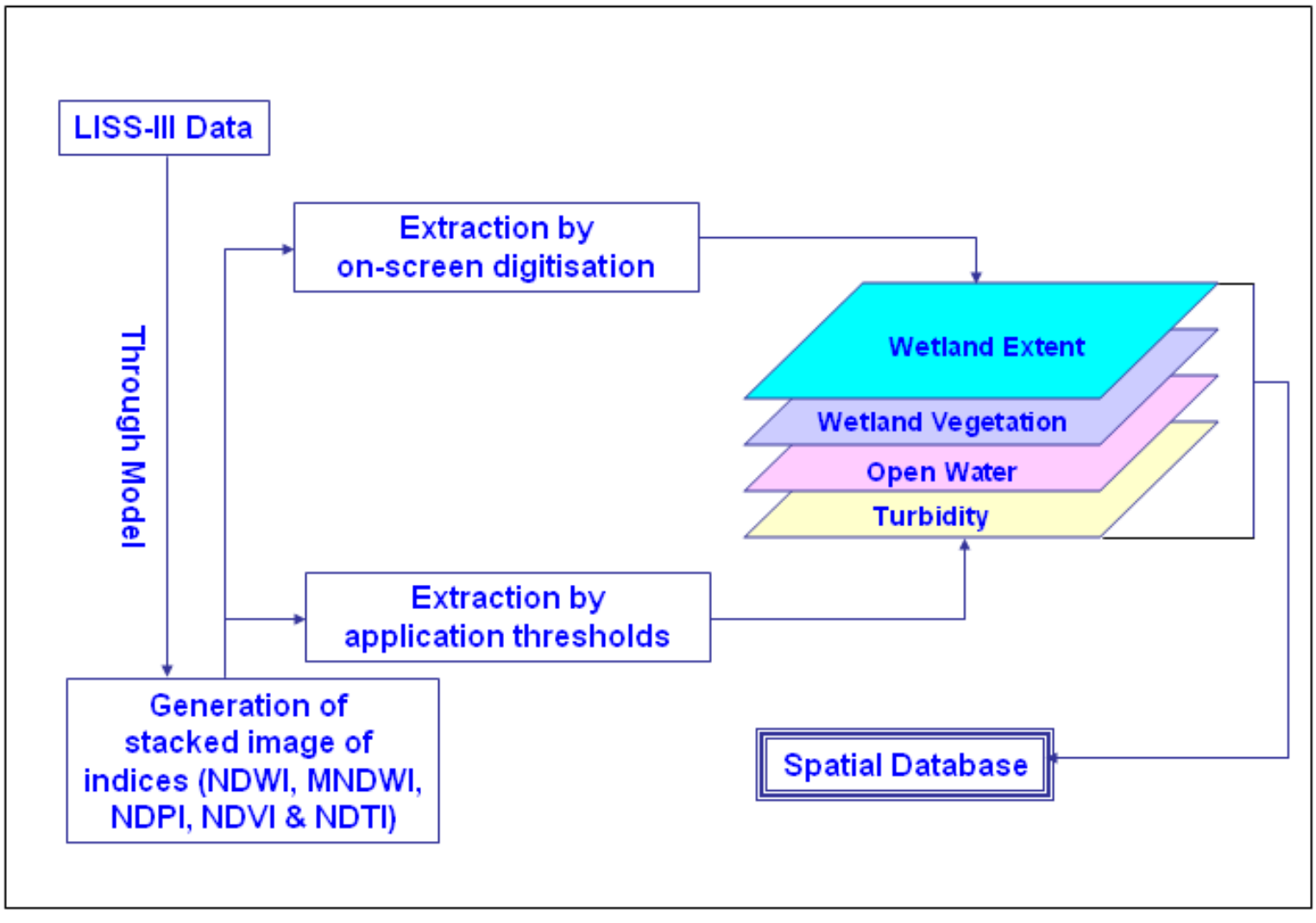


Figure 8: Steps in the extraction of wetland structural components

5.5 *Generation of reference layers*

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

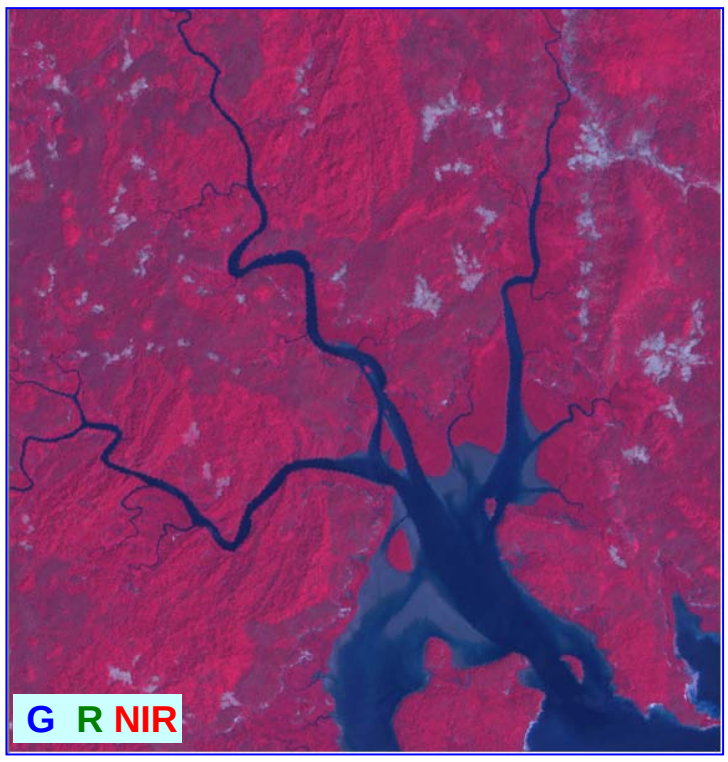
5.6 *Coding and attribute scheme*

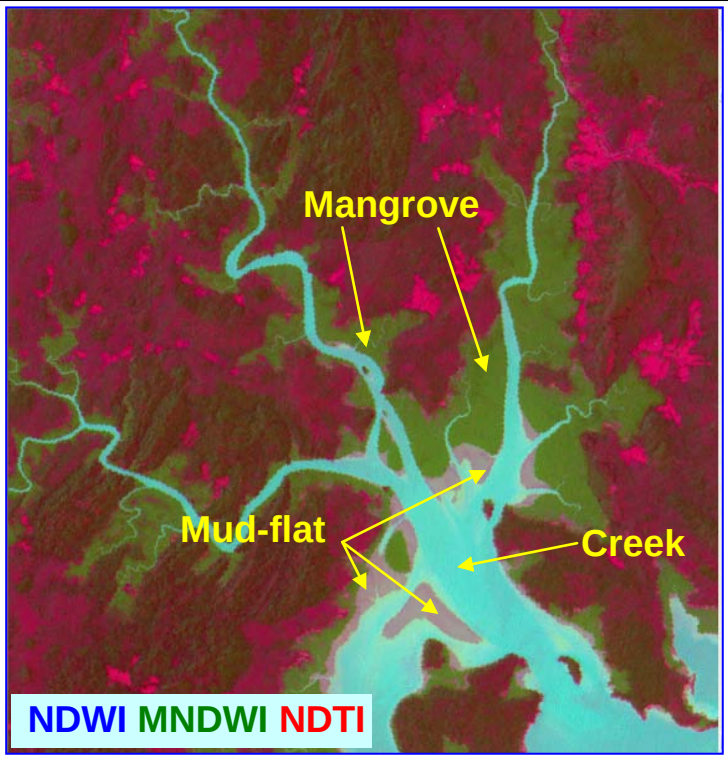
Feature codification scheme for every input element has been worked out keeping in view the nationwide administrative as well as natural hierarchy (State-district-taluka) within the feature class for each of the theme. All data elements are given a unique name/code, which are self explanatory with short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

5.7 Map composition and output

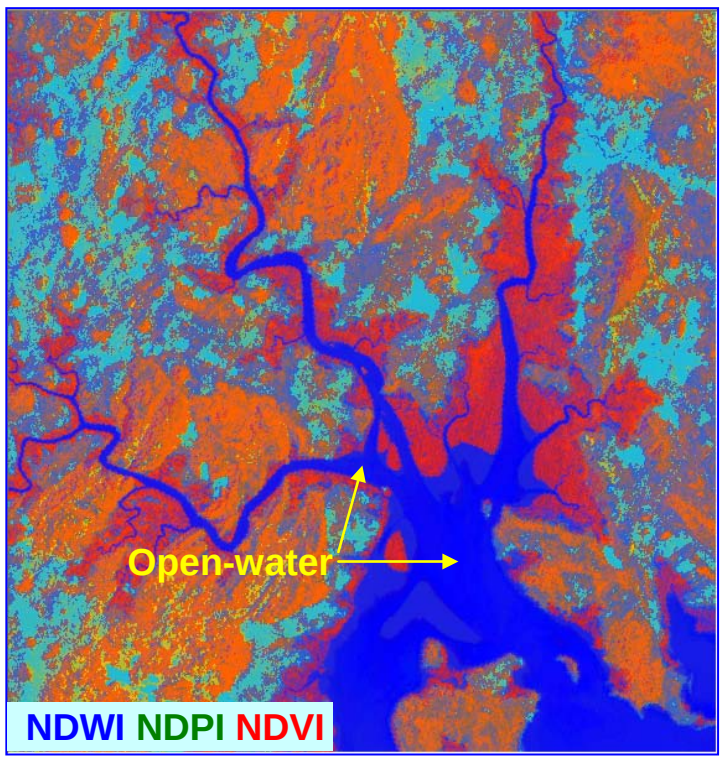
Map composition for atlas has been done at district and state level. A standard color scheme has been used for the wetland classes and other layers. The digital files are made at 1:50,000 scale. The hard copy outputs are taken on A3 size.

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

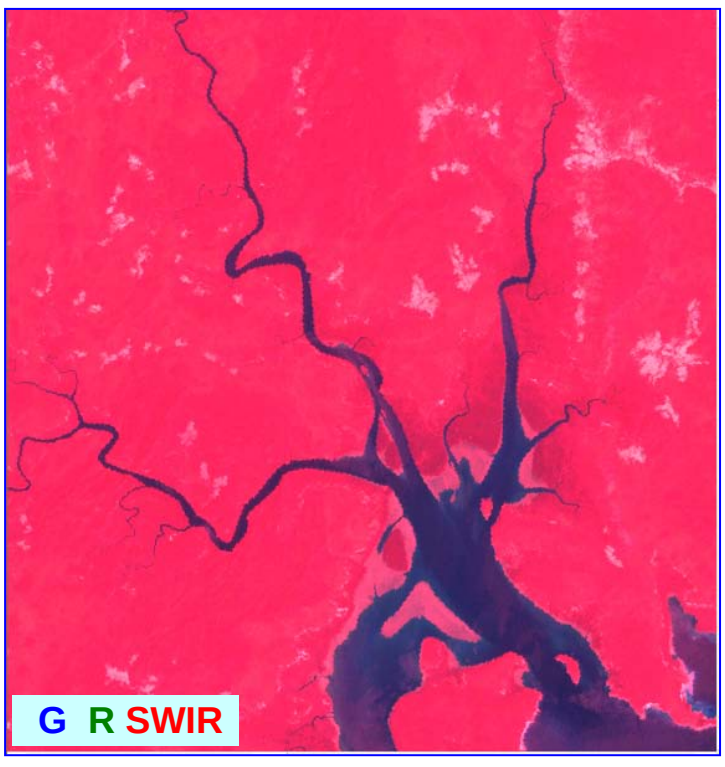


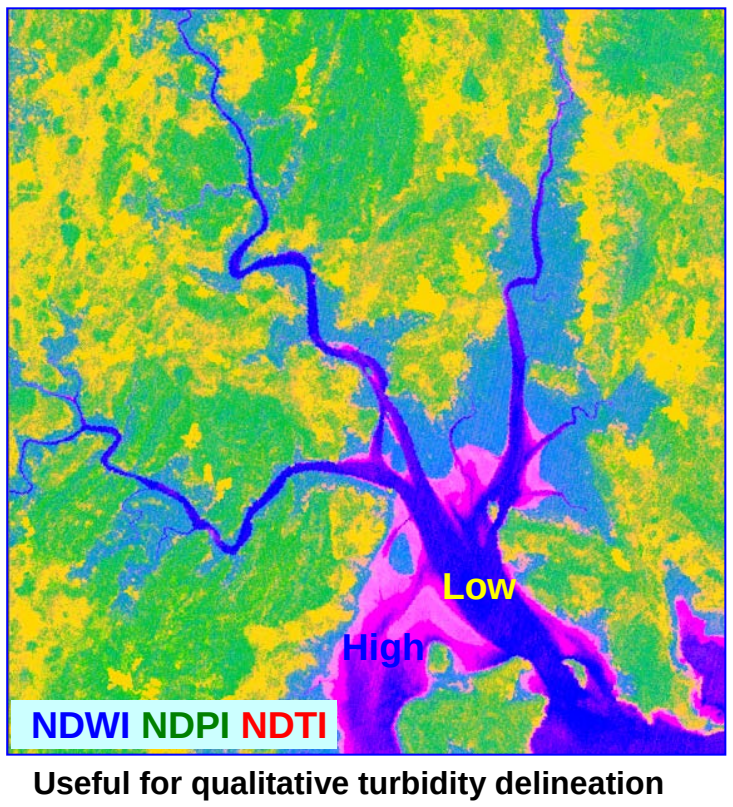


Useful for wetland boundary delineation



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 locational accuracy. In addition, GIS database(s) contents have been also evaluated for accuracy. To ensure the reliability of wetland status data, the project adhered to established quality assurance and quality control measures for data collection, analysis, verification and reporting.

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

1. Image-to-Image Geo-referencing/Data generation

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

3. Wetland mapping using visual/digital interpretation techniques.

4. Geo-data base creation and organization

5. Output products.

6.1 Data verification and quality assurance of output digital data files

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

MAPS AND STATISTICS

7.0 WETLANDS OF ANDAMAN AND NICOBAR ISLANDS: MAPS AND STATISTICS

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 5). 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 10063 ha. Graphical distribution of wetland type is shown in figure 10. In terms of open water area, the inland wetlands dominated with 6519 ha in post-monsoon and 6736 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 5.

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 (Table 5). 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.

Table 5: Area estimates of wetlands in Andaman and 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	505	49378	32.31	-	-
		Total - Coastal	**2389**	**145803**	**95.42**	**1822**	**1844**
		Sub-Total	**2459**	**152715**	**99.94**	**8341**	**8580**
		Wetlands (<2.25 ha), mainly Tanks	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

For assessment of qualitative turbidity based on signature statistics of MNDWI image for open water features has been considered as explained in the methodology. Accordingly, 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, Reservoir/Barrage, Tank/Pond, Lagoon, Creak. The extent of open water in post-monsoon of 2006 is 8341 ha (Table 5) which comprised 965 ha of low, 6749 ha of moderate and 627 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, 6006 ha of moderate and 676 ha of high turbidity out of 8580 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 5. This could be because unsettled sediments, due to rainfall runoff during south-westerly as well as north-easterly monsoon pattern of the area. A detail of type-wise turbidity status of wetlands is given in the table 5.

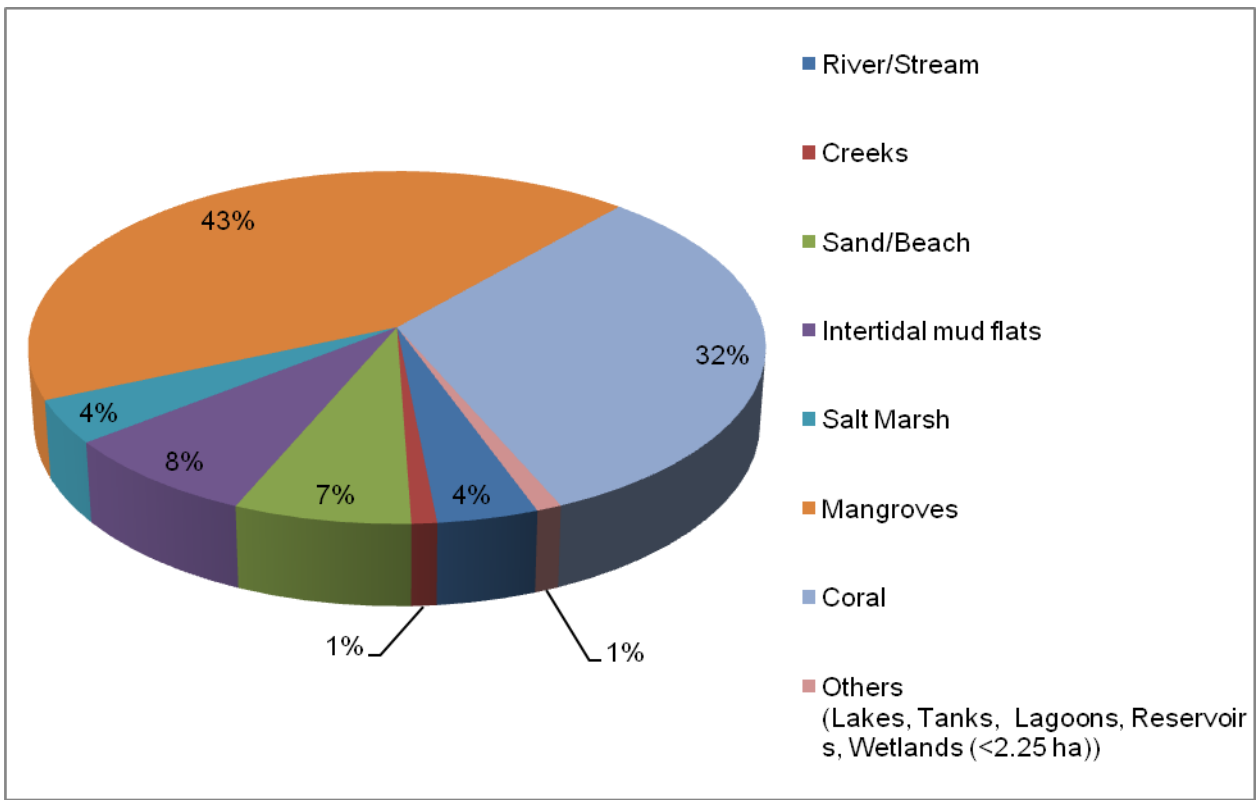


Figure 10: Type-wise wetland distribution in Andaman and Nicobar

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The Union Territory has two districts Andaman and Nicobar. They are separated by a channel of 145 km wide known as 10 degree channel. The district-wise wetland area estimates is shown in Table 6.Wetland statistics followed by wetland map and corresponding satellite data for each district is given to have a fairly good idea about the distribution pattern and density of wetlands in the district.

Table 6: District-wise wetland area

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

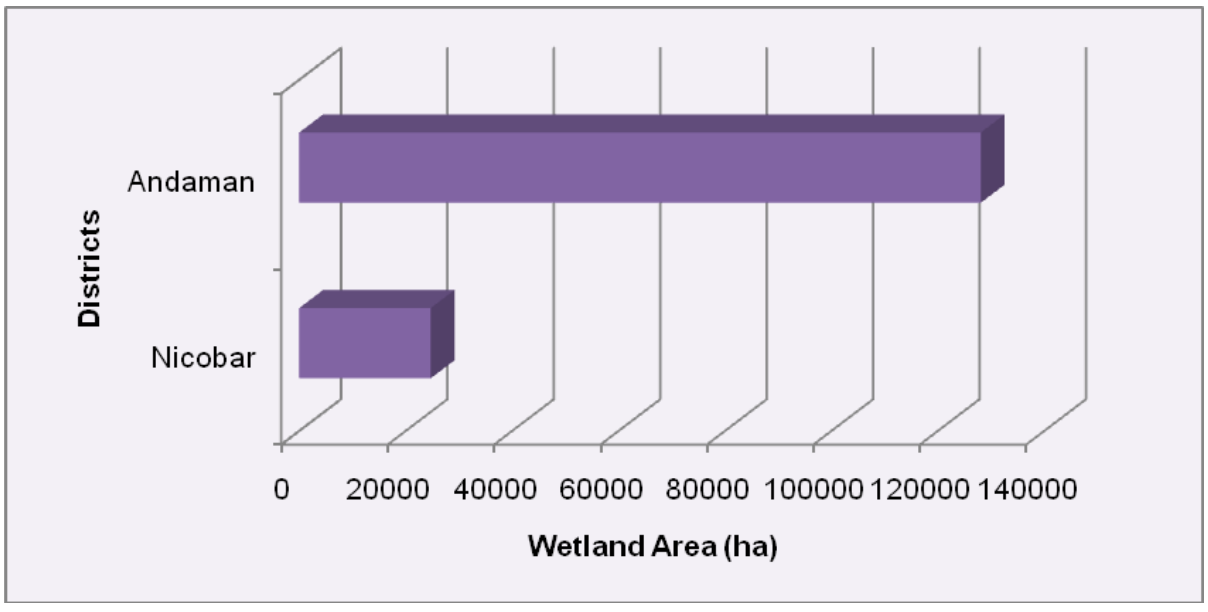
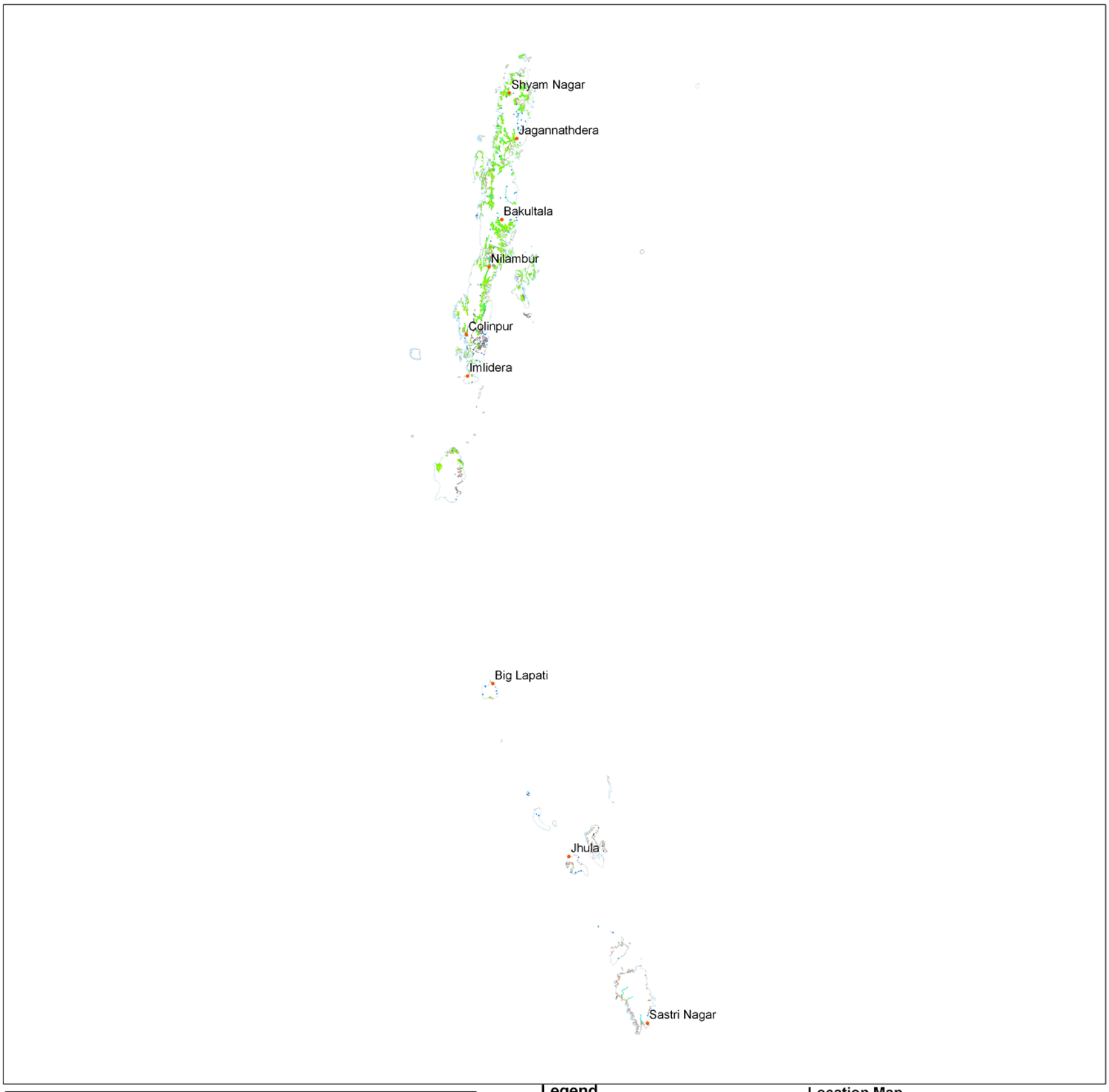


Figure 11: District-wise wetland distribution

UT : Andaman and Nicobar Islands

WETLAND MAP

District :Andaman & Nicobar

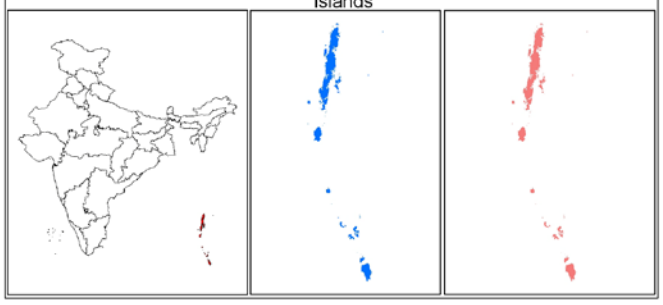


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

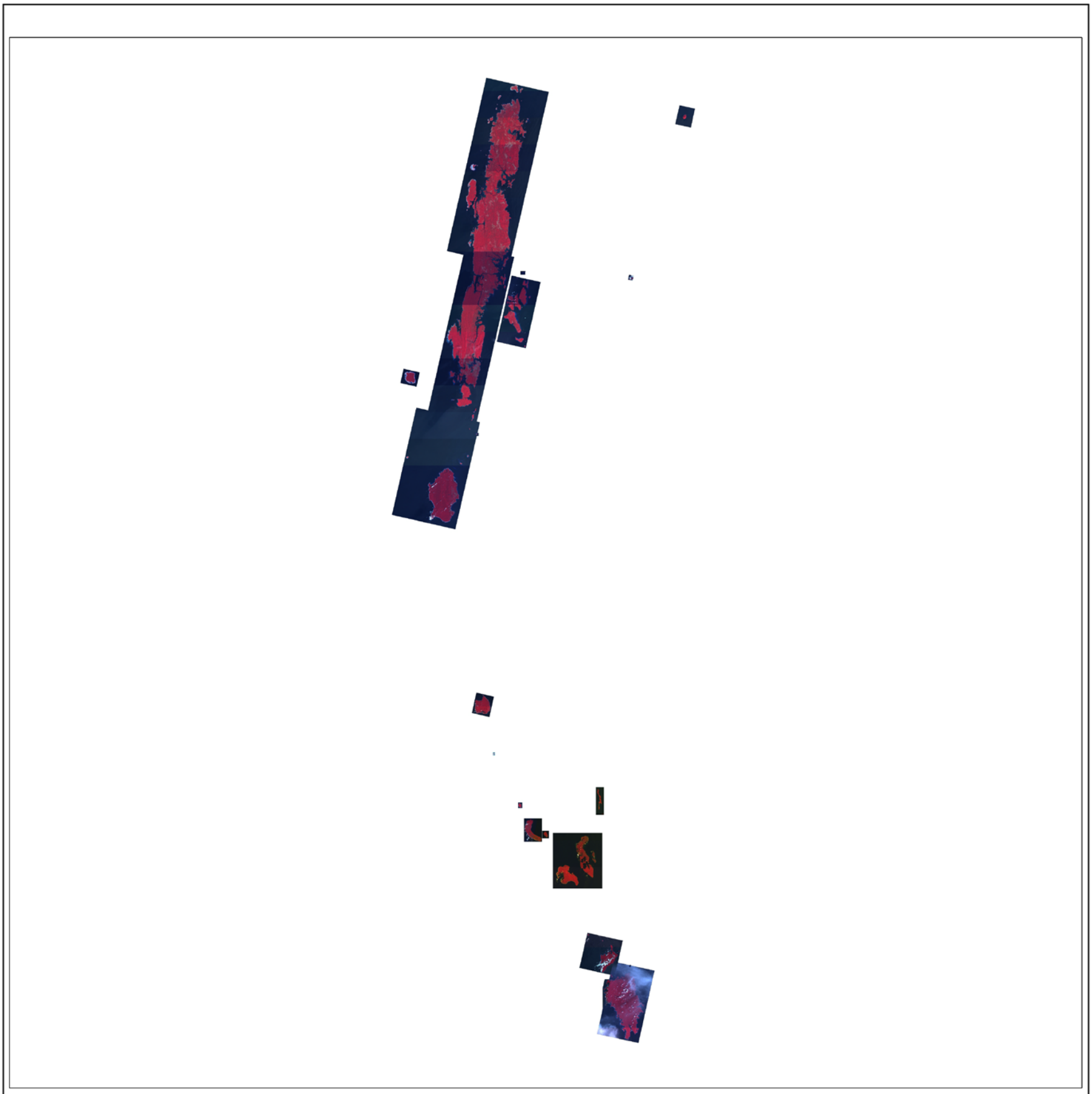


0 45 90 180 Kilometers

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



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

7.1.1 Andaman

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 7) 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.

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, Reservoir/Barrage, Tank/Pond, Lagoon, Creak. 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 7.

Table 7: Area estimates of wetlands in Andaman

Area in ha

Sr. No.	Wettcode	Category	Number	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	Intertidal mud flats	301	5858	4.57	-	-
9	2105	Salt Marsh	284	3575	2.79	-	-
10	2106	Mangroves	666	65892	51.44	-	-
11	2107	Coral	446	41220	32.18	-	-
		Total - Coastal	**2018**	**121506**	**94.86**	**1752**	**1767**
		Sub-Total	**2082**	**128019**	**99.95**	**8077**	**8104**
		Wetlands (<2.25 ha), mainly Tanks	69	69	0.05	-	-
		Total	**2151**	**128088**	**100.00**	**8077**	**8104**

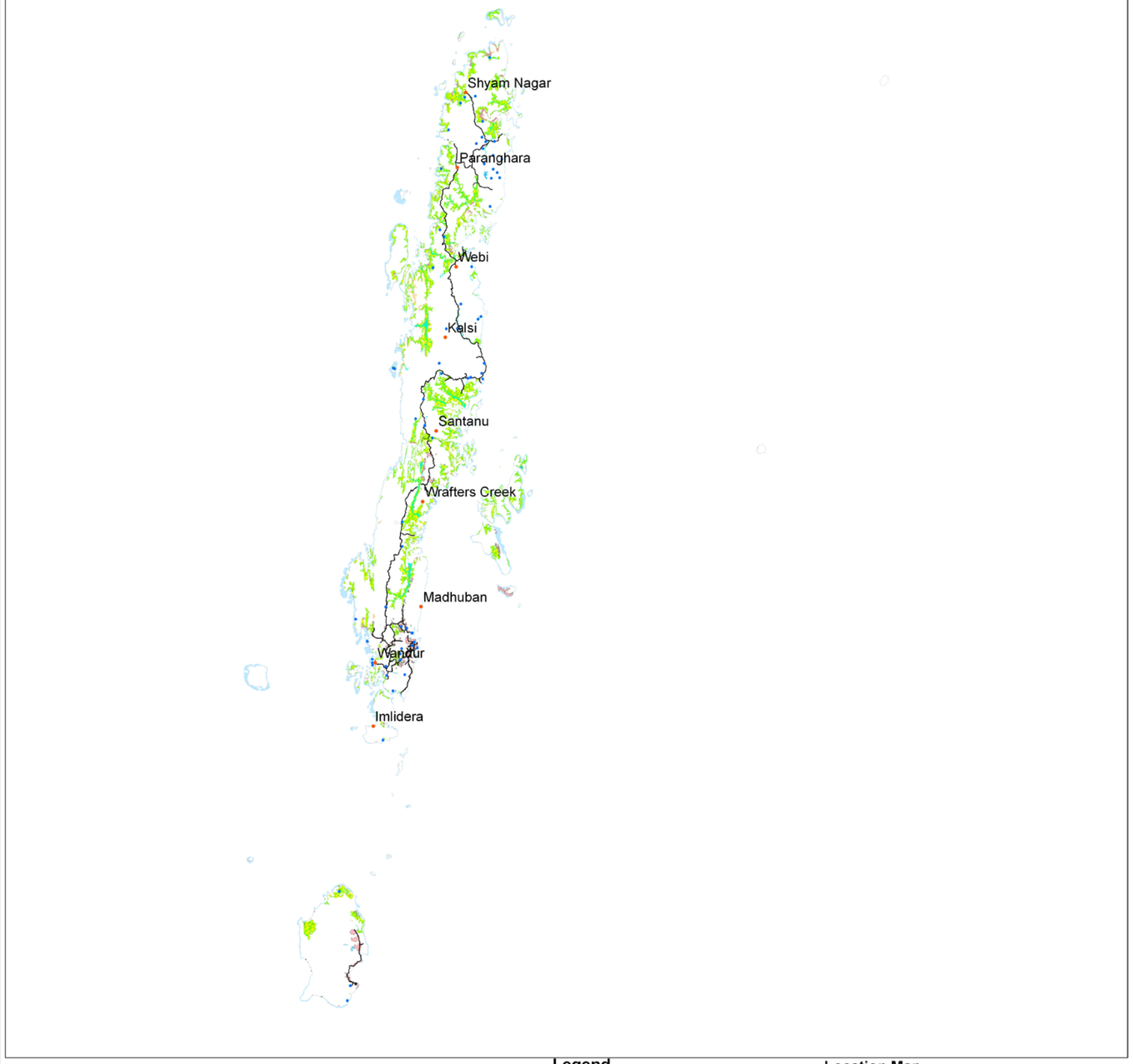
Area under Aquatic Vegetation	66434	66481

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

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

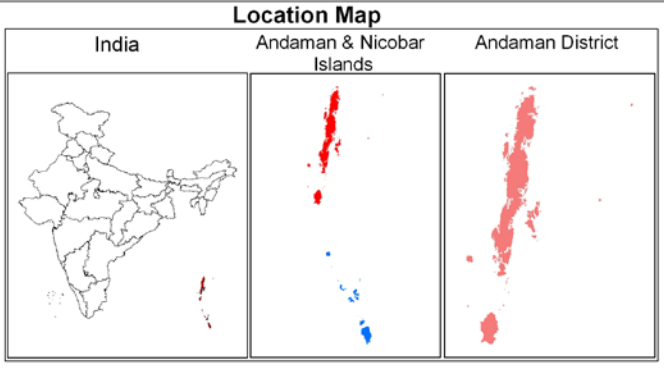


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

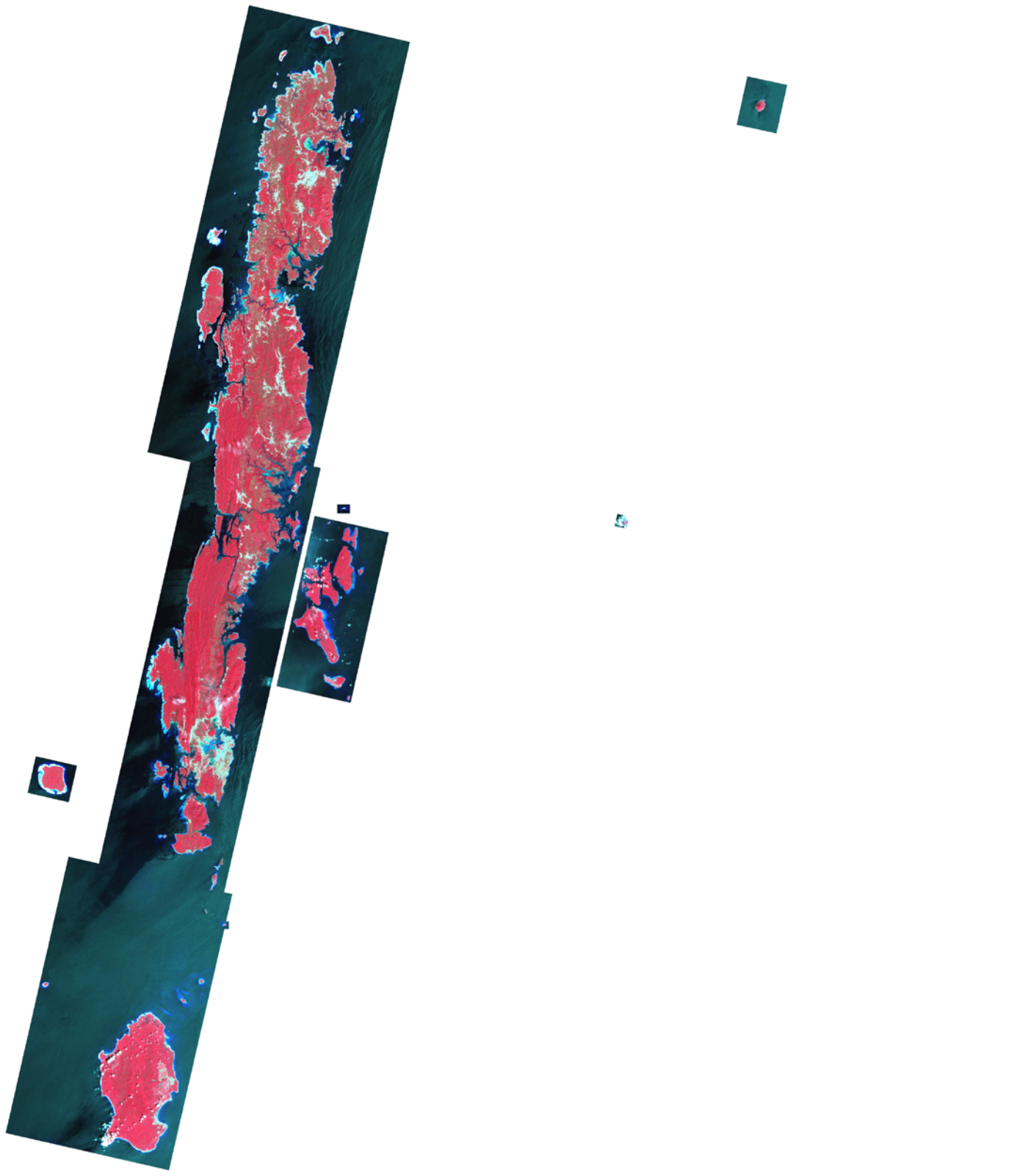


0 25 50 100 Kilometers

Data Source :
IRS P6 LISS 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



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

7.1.2 Nicobar

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 8.

Table 8: Area estimates of wetlands in Nicobar

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	59	8158	33.00	-	-
		Total - Coastal	**371**	**24297**	**98.28**	**70**	**77**
		Sub-Total	**377**	**24696**	**99.90**	**264**	**476**
		Wetlands (<2.25 ha), mainly Tanks	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

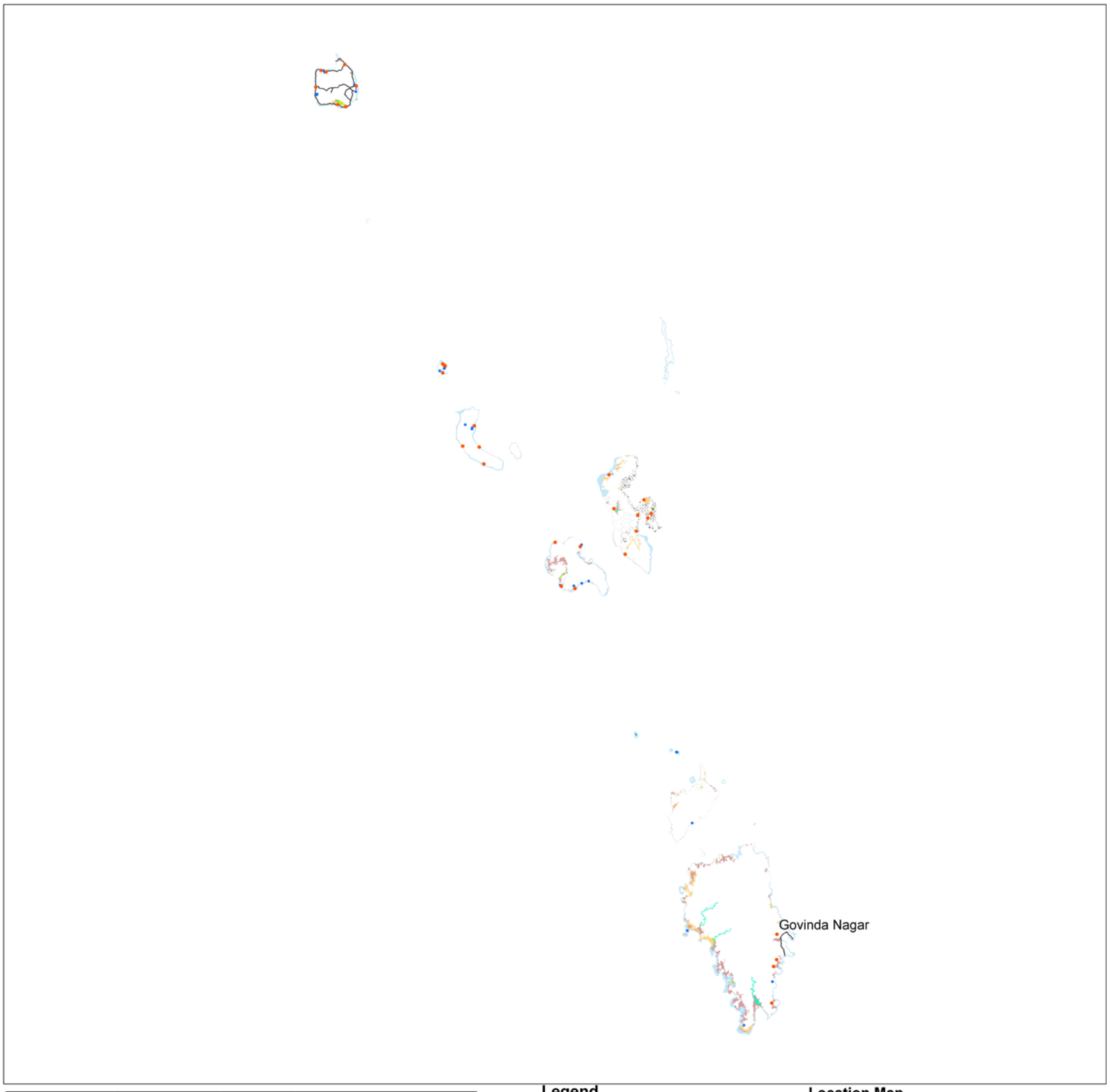
Salt Marsh and Mangroves are the only wetland types that have vegetation. Together they comprise 1835 ha in post-monsoon and 1871 ha in Pre-monsoon compared to Andaman where they accounted for 66434 ha in post-monsoon season and 66481 ha in Pre-monsoon. Both the wetland types with vegetation the mangrove remained unchanged in both the seasons. However, in Pre-monsoon the Salt Marsh had shown a marginal increase in the area from 1626 ha (post-monsoon) to 1662 ha.

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. Low turbidity has not been recorded in Pre-monsoon season. The open water features dominated by Moderate turbidity in Pre-monsoon season appears to be mainly because of River/Stream as inferred from Table 8. Turbidity status of various wetlands under low, moderate and high turbidity is given in the Table 8.

UT : Andaman and Nicobar Islands

WETLAND MAP

District :Nicobar

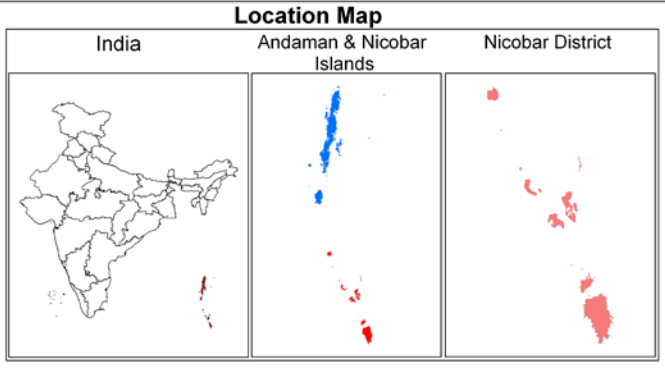


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 III data (Pre-monsoon and Post-monsoon Season 2006-07)

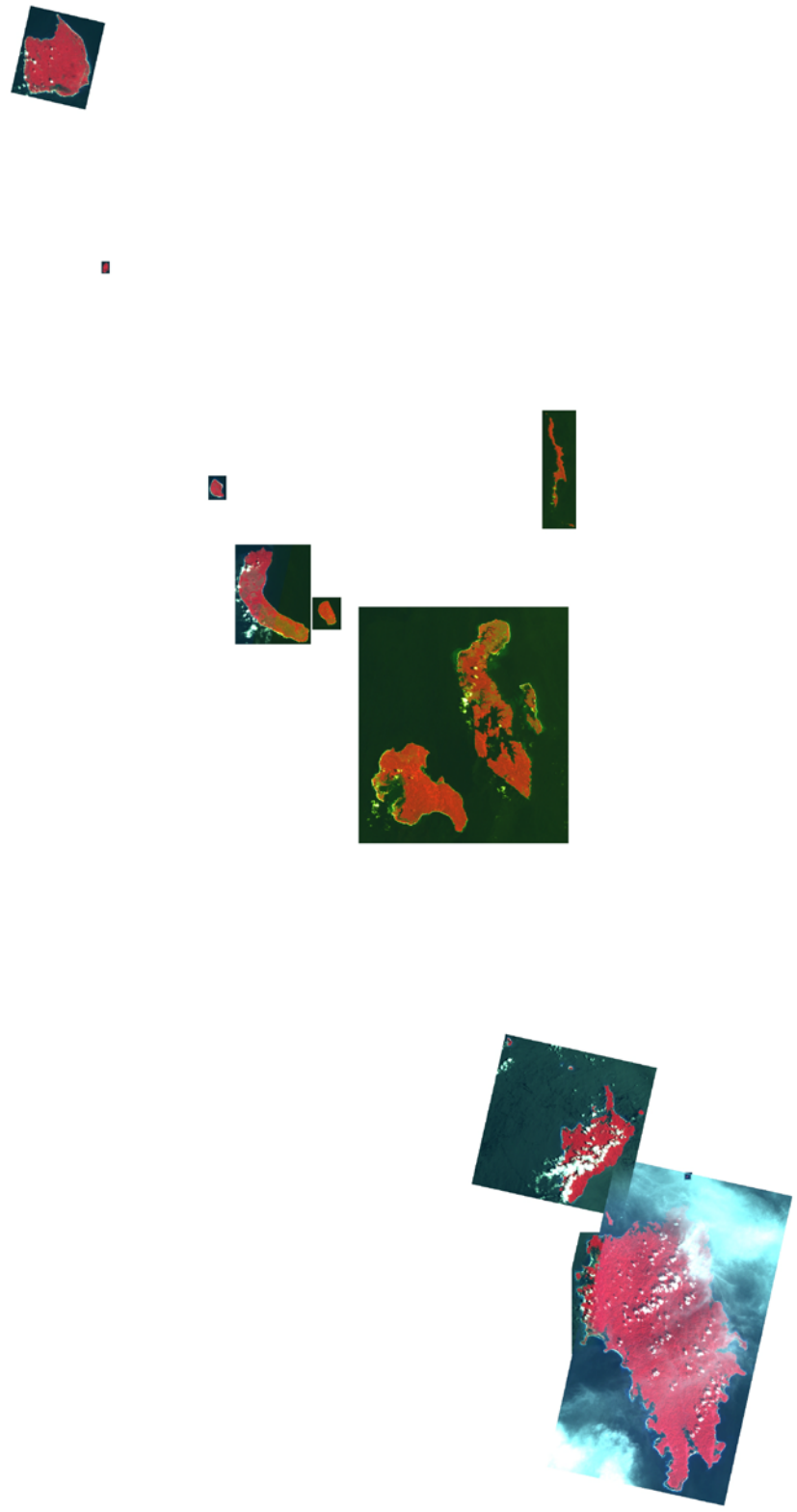
Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District :Nicobar



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

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF ANDAMAN AND NICOBAR ISLANDS

Major wetland types observed in the state are Mangroves, Coral, Intertidal Mud-flats, Sand/Beach and River/Stream. The manifestation of major wetland types on satellite imagery and their enhancement using certain combination of indices are given in Plate-1. Ground truth data was collected for selected wetland sites. Standard procedure was adopted to record the field data. Field photographs were also taken to record the status of the wetland category like status of aquatic vegetation and water. 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.

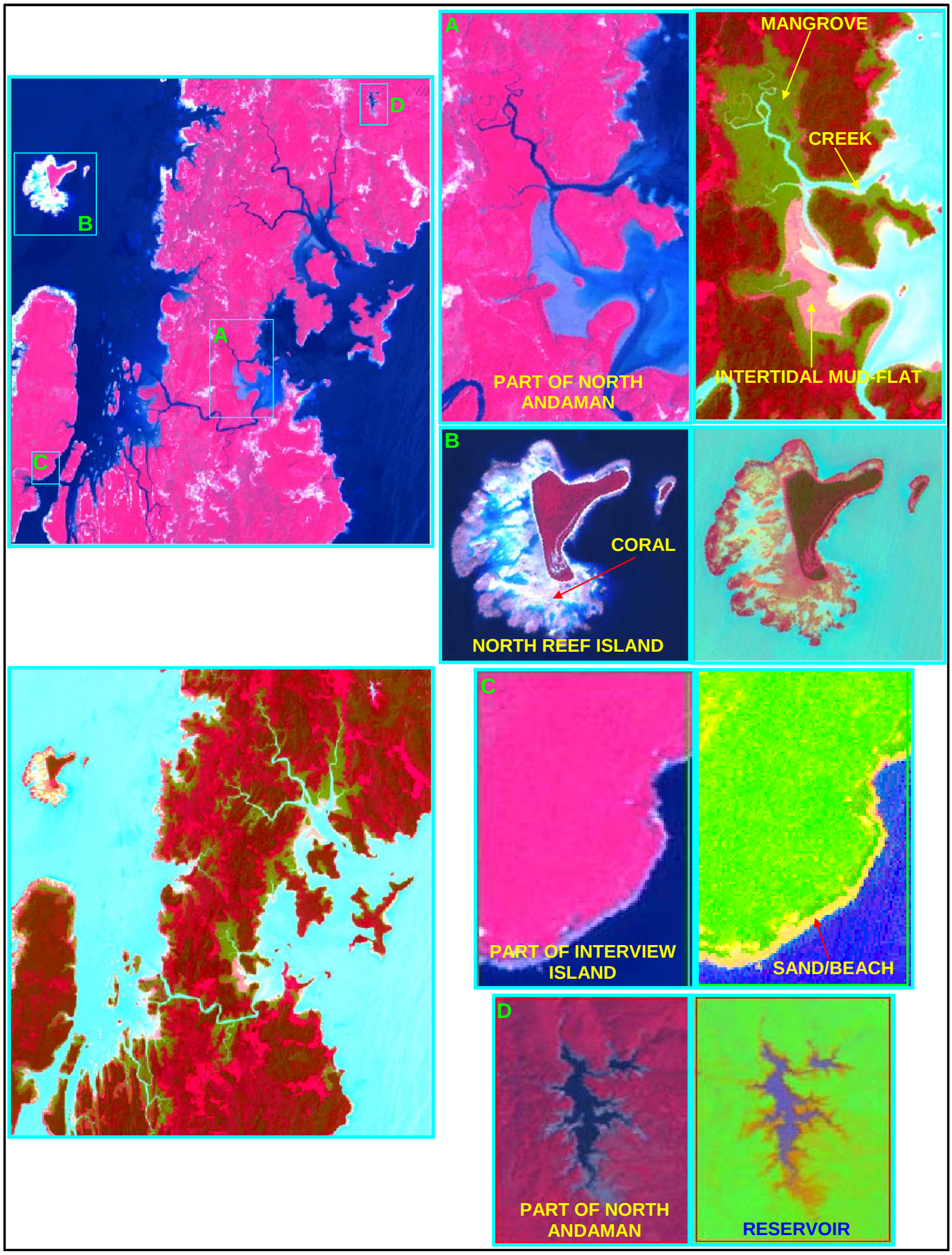


Plate - 1: Major wetland types of Andaman and Nicobar Islands

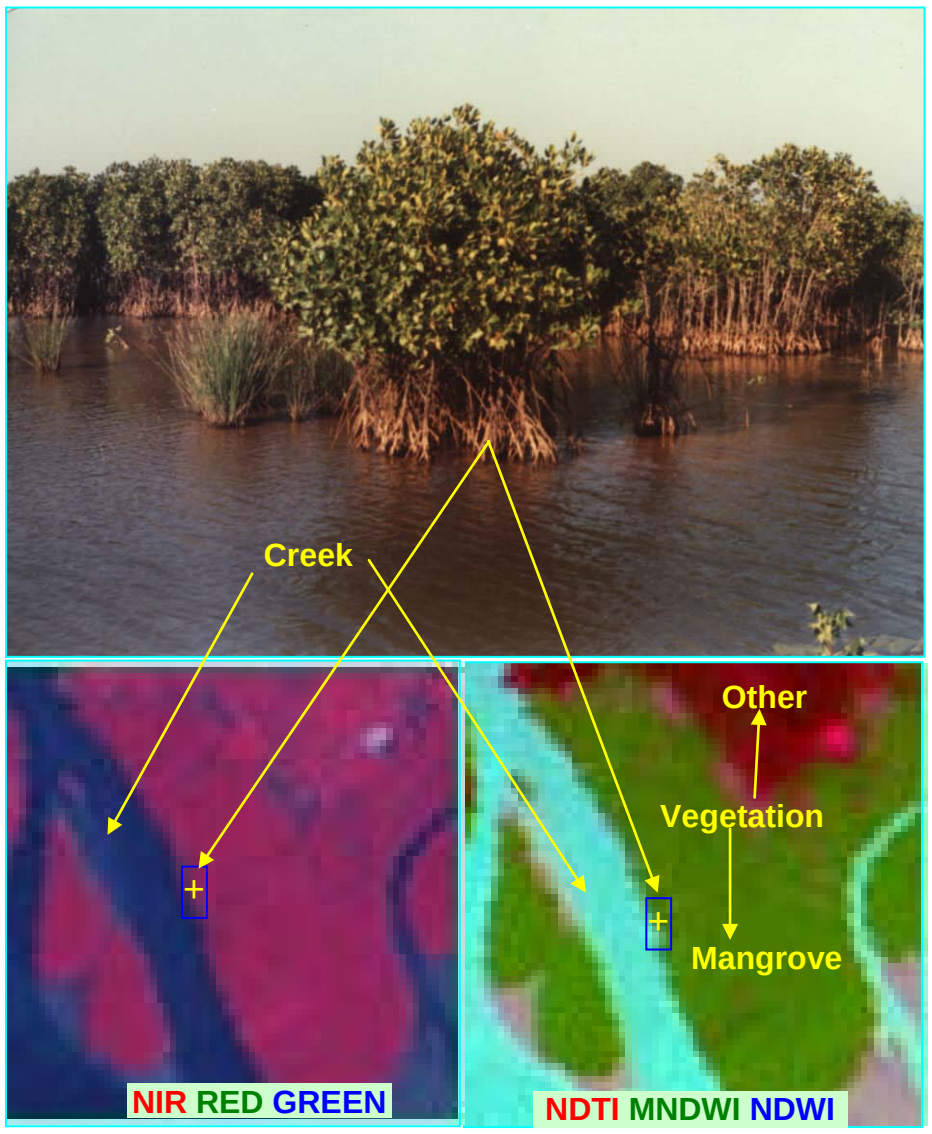
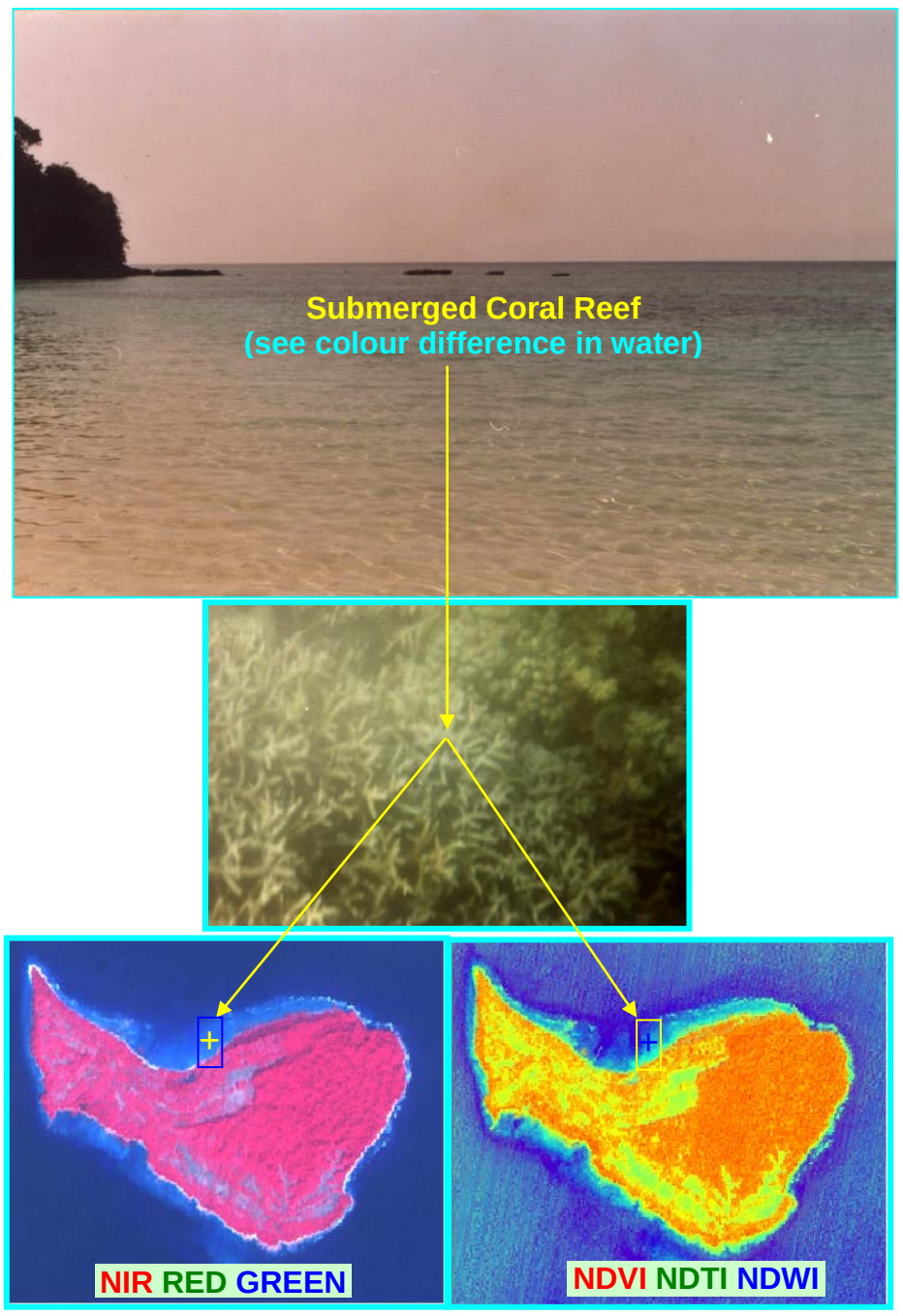
Sr. No.	Site Description	Wetland Category
1	Location: 92:55:10.34 E 13:03:42.23 N Part of North Andaman Mangrove vegetation along the creek. Combination indices (NDTI MNDWI NDWI) aids in enhancement and delineation of Mangroves from other vegetation. The Mangrove appears green and creeks with water appear 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

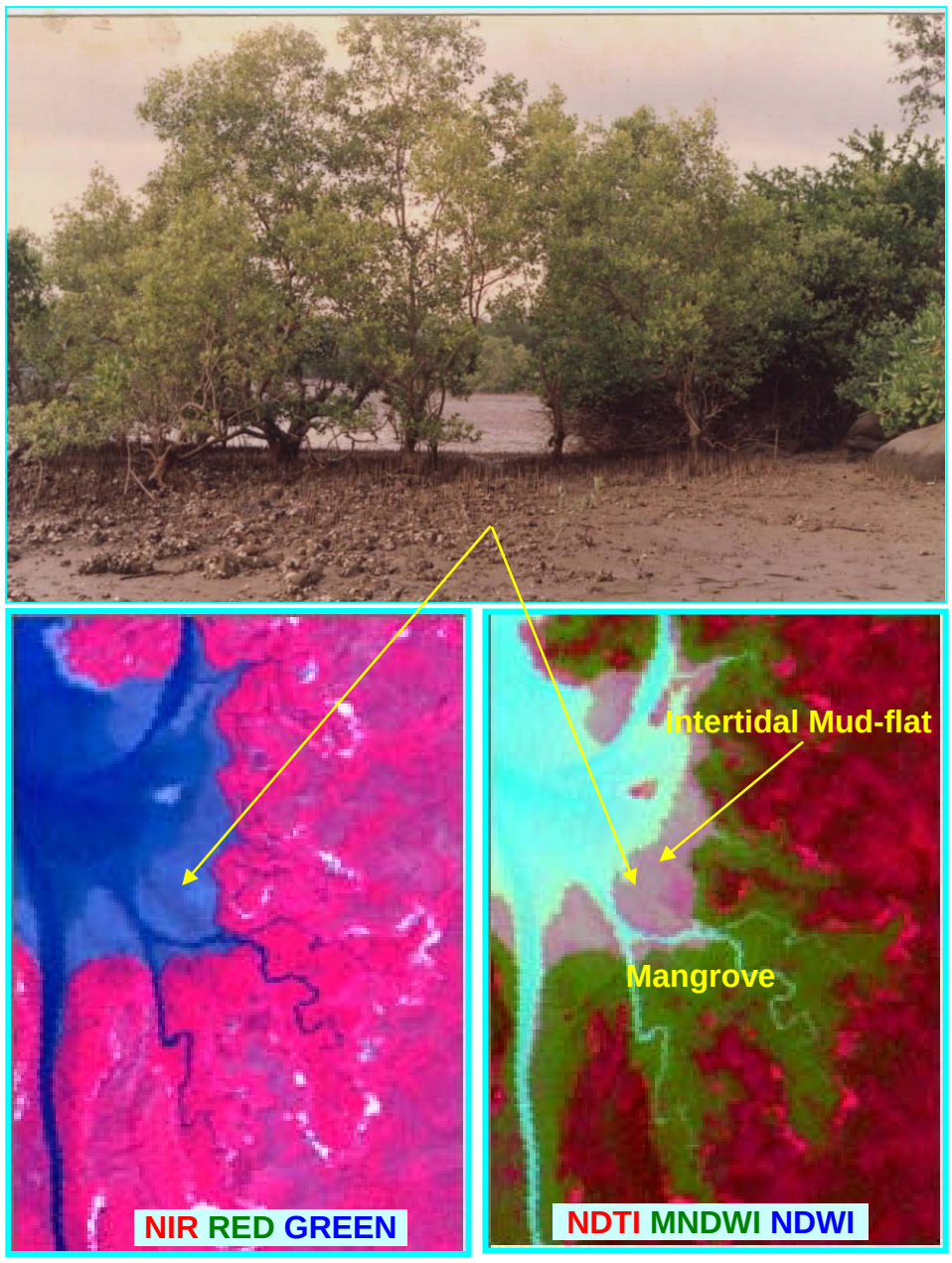
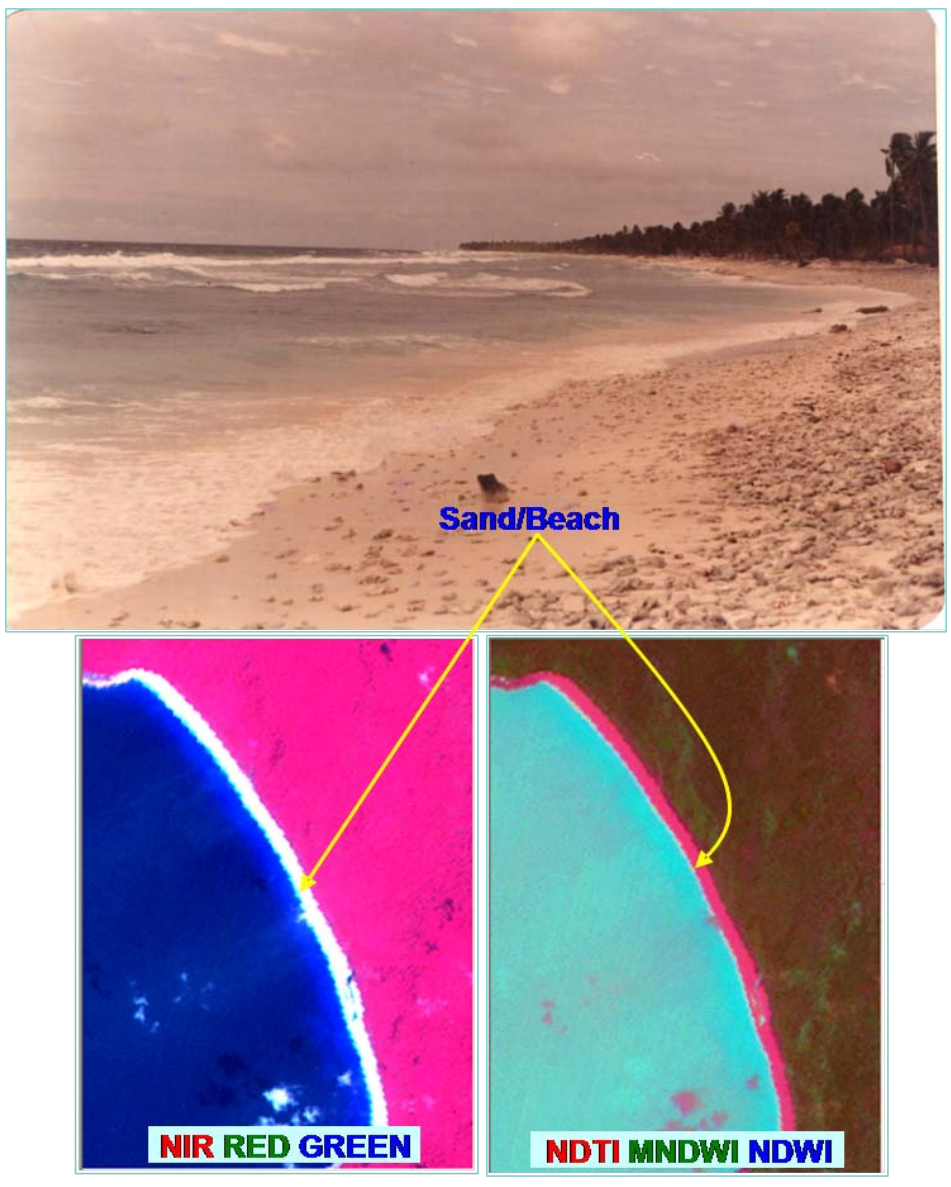
Sr. No.	Site Description	Wetland Category
1	Location: 92:46:58.96 E 12:51:42.11 N Part of Middle Andaman Intertidal Mud-flat with Mangrove vegetation along the creek. Combination indices (NDTI MNDWI NDWI) aids in enhancement and delineation of Intertidal Mud-flats and Mangroves from others. The Intertidal 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

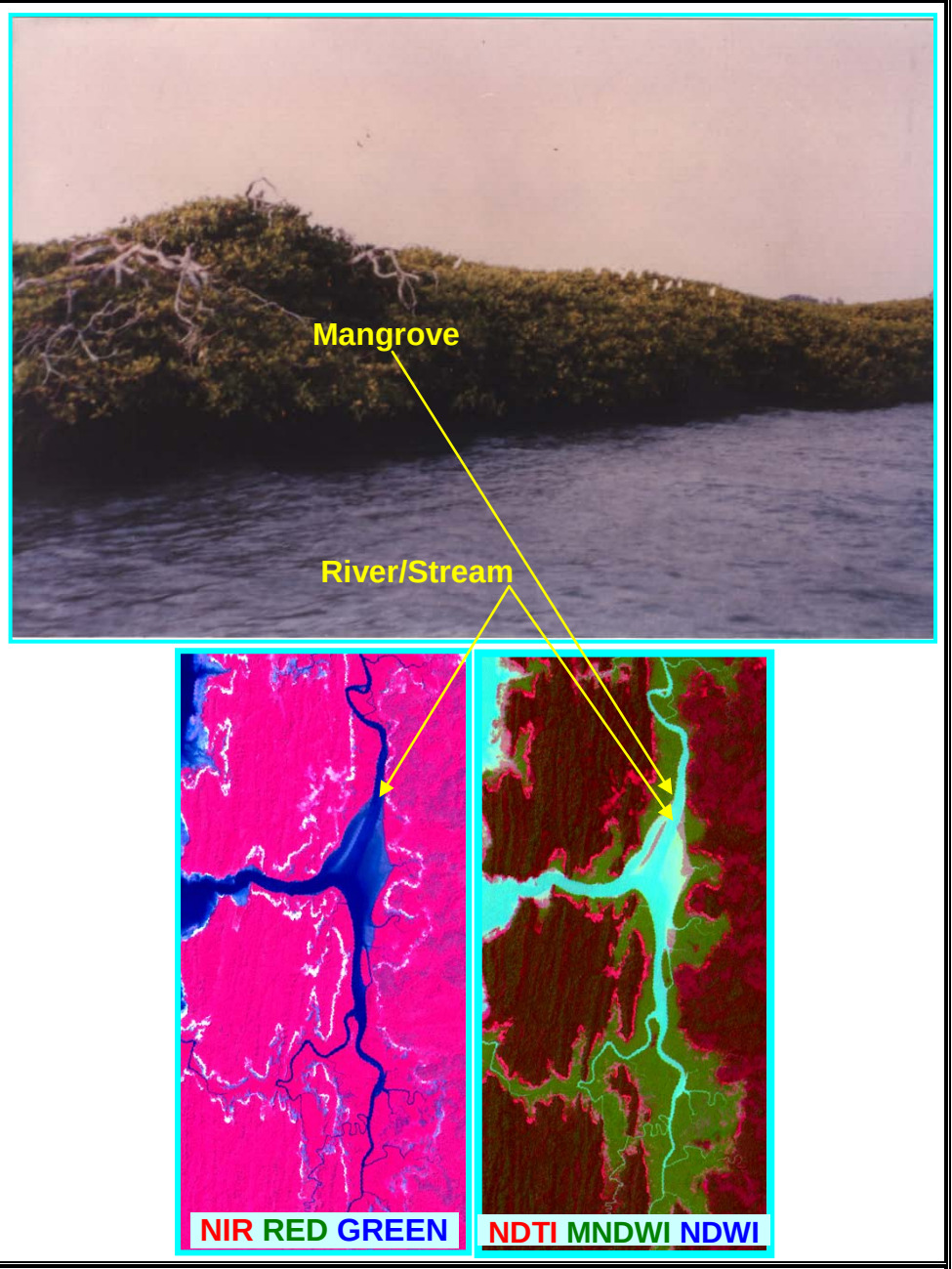
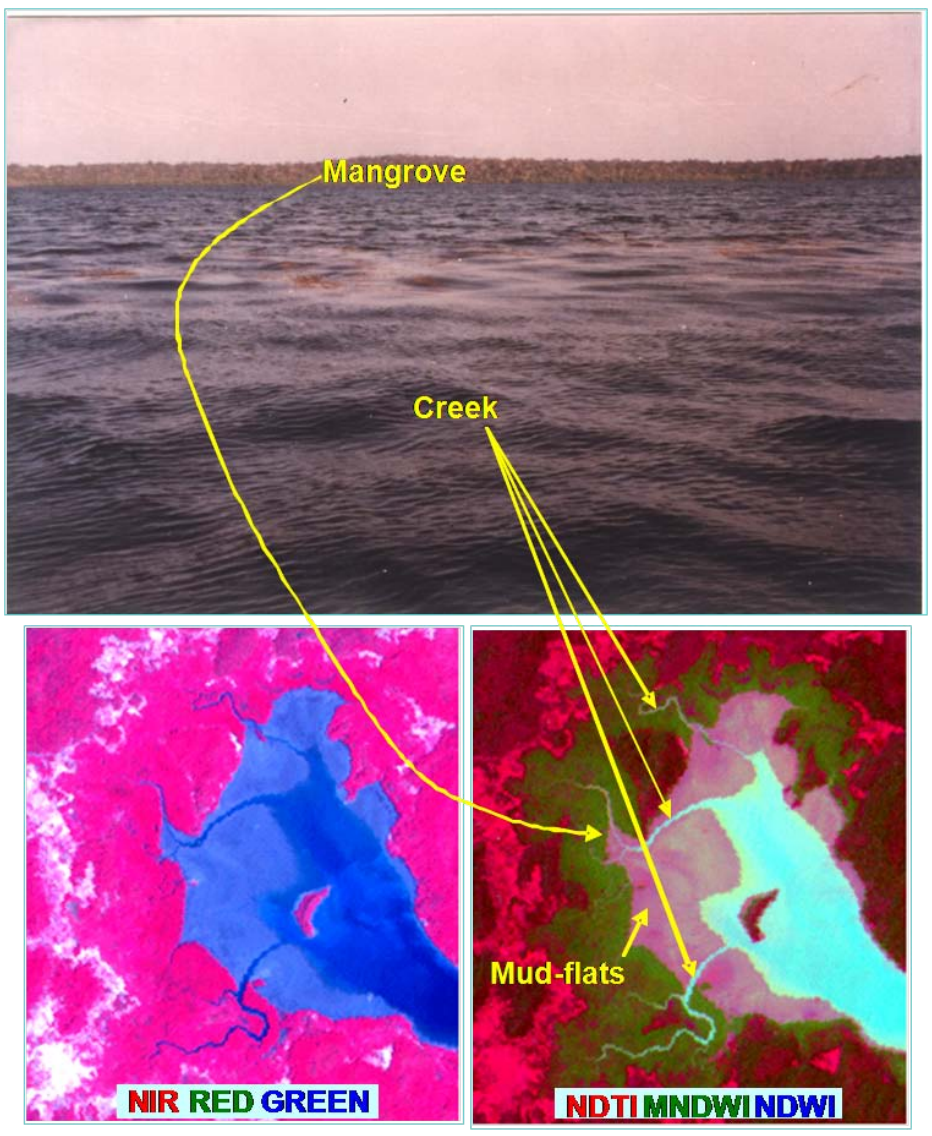
Sr. No.	Site Description	Wetland Category
1	Location: 92:46:42.78 E 12:39:45.90 N Part of Middle Andaman Rive/Stream supporting the Mangrove vegetation. River/stream forms complex estuarine wetland ecosystem that support Mangroves and also forms tidal mud-flats of varying sizes. Combination indices (NDTI 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 OF ANDAMAN AND NICOBAR ISLANDS

IMPORTANT WETLANDS OF ANDAMAN AND NICOBAR ISLANDS

These islands have the distinction of harbouring biologically rich flora and fauna of terrestrial and aquatic (marine). The following are some of these which include coastal and mangrove habitats. Details of each with a map are shown in Plates 3-9 along with the LISS-III image of post-monsoon season.

9.1 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 9). 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 9.

Table 9: 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**

9.2 Button Islands National Park

The National Park comprises three islands (North, Middle and South Button Islands). These islands show exhibit typical tropical oceanic climate with average temperatures ranging from 20 C to 30 C and receives bulk of the rainfall during June to October. Besides a variety of submerged corals, Dolphin, Dugong and Blue whale are important marine animals for conservation. These islands also forms abode to many species of avifauna and fishes. Coral dominate the islands as submerged fringing types, which accounts for 76 % (Table 10) area (51 ha). The other two wetland types are Mangroves (3 ha) and Sand/Beach (13 ha). The wetland map based on LISS-III imagery of 2006-07 along with the image is given in the plate 4.

Table 10: Area estimates of wetlands in Button Islands National Park

Area in ha

Sr. No.	Wetland code	Wetland Category	No. of wetlands	Wetland Area	% of wetland area
1	2103	Sand/Beach	3	13	19.40
2	2106	Mangrove	1	3	4.48
3	2107	Coral	2	51	76.12
		Total	**6**	**67**	**100.00**

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 11). The mangroves constitute 23.44 % area. The other two categories are Intertidal Mud-flats (96 ha) and Sand/Beach (19 ha). The wetland map based on LISS-III imagery of 2006-07 along with the image is given in the plate 5.

Table 11: 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**

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 12). The wetland map based on LISS-III imagery of 2006-07 along with the image is given in the plate 6.

Table 12: 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**

9.5 South Reef Island Sanctuary

South Reef Island Sanctuary is a small island declared as sanctuary to protect the coral and marine animals. Coral accounts for the maximum area (53 ha) out of the totals wetland area of 60 ha (Table 13). The wetland map based on LISS-III imagery of 2006-07 along with the image is given in the plate 7.

Table 13: Area estimates of wetlands in South 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	7	11.67
2	2107	Coral	1	53	88.33
		Total	**2**	**60**	**100.00**

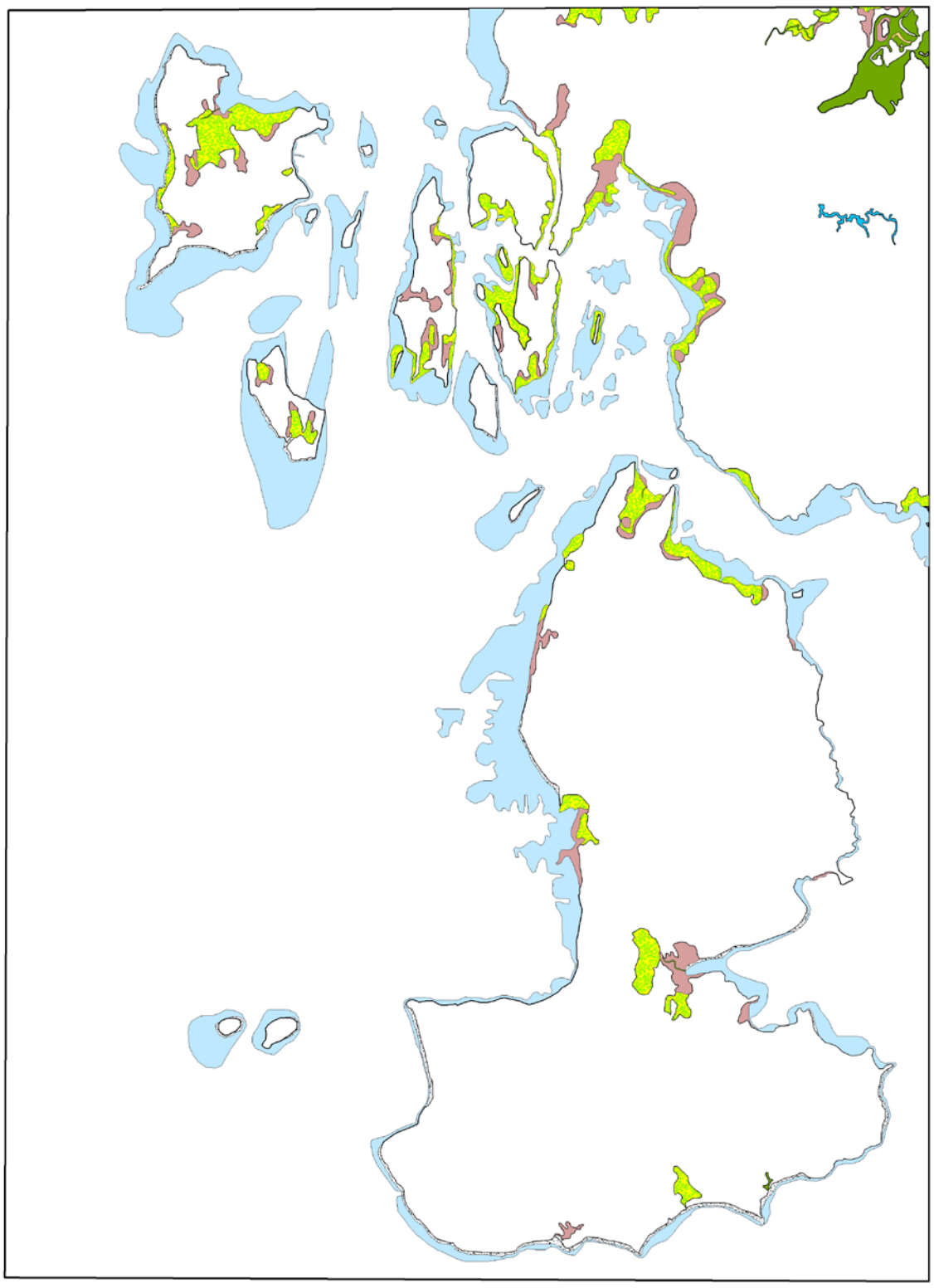
9.6 South Sentinel Island

This is primarily a marine sanctuary set up in 1977. The bounds are between 92° 12' and 92° 14' E longitudes and 10° 57' to 10° 59' N Latitudes. Two wetland categories were observed namely; Coral and Sand/Beach accounting for 229 ha and 71 ha out of 300 ha of wetland area. The animals of particular importance are blue whale, dolphin, dugong, green sea turtle, olive ridley turtle, leather-backed turtle and sea eagle besides a variety of coral. The flora comprises mainly of sea weeds. The wetland map based on LISS-III imagery of 2006-07 along with the image is given in the plate 8.

UT : Andaman and Nicobar Islands

WETLAND MAP

Wandur Marine National Park

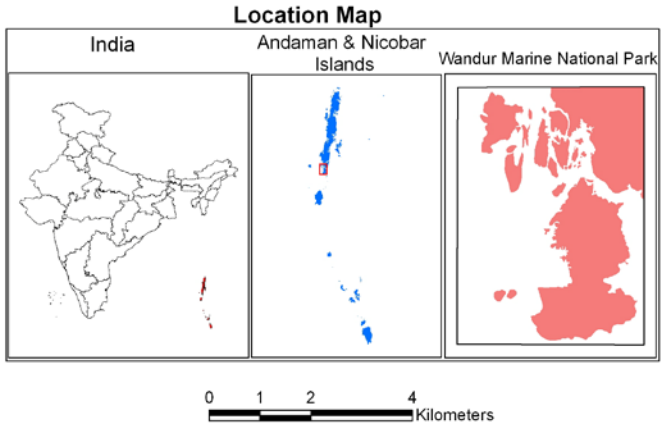


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

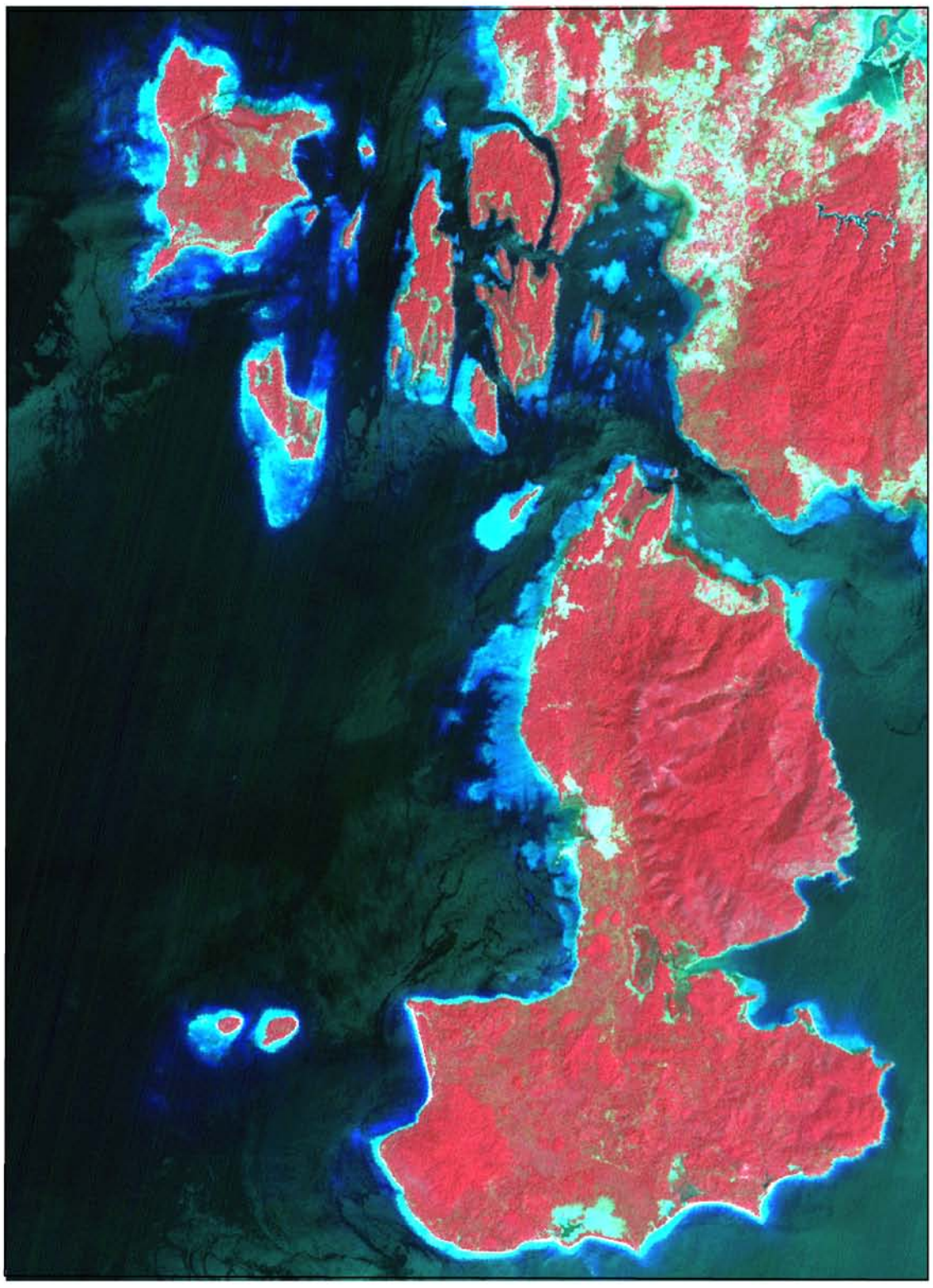


Data Source :
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 3: Wetland map of Wandur Marine National Park based on the analysis of IRS P6 LISS-III data of 2006-07

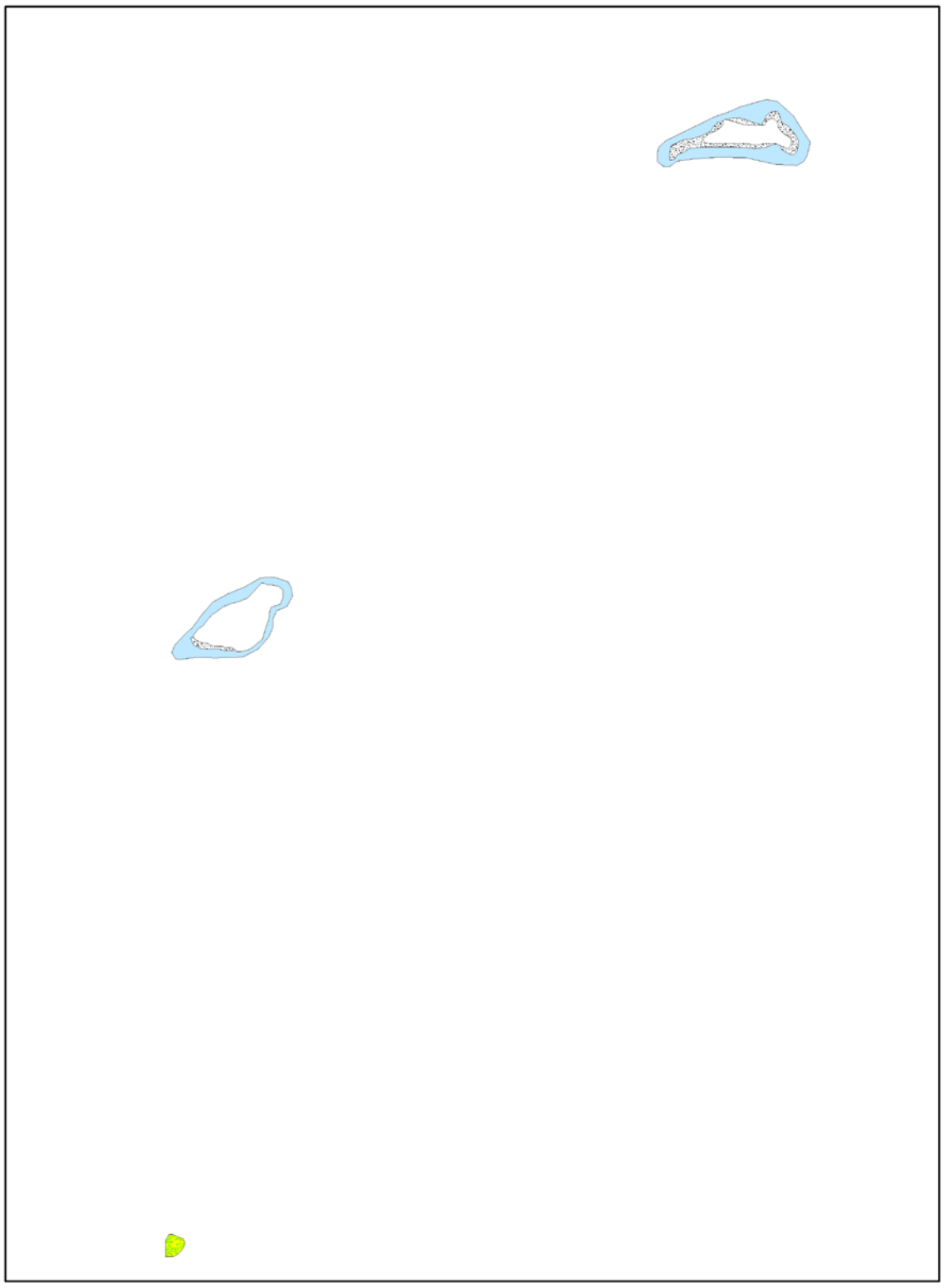


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

Button Islands National Park

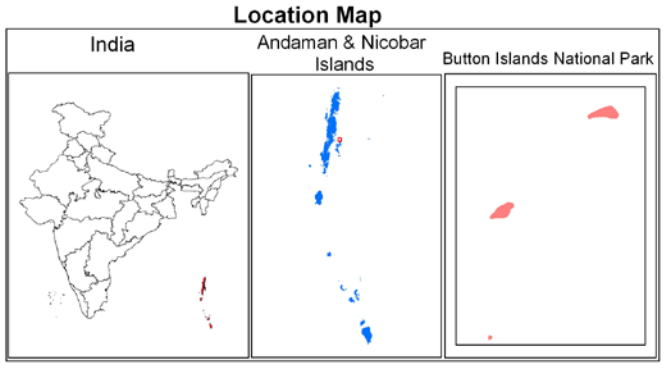


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



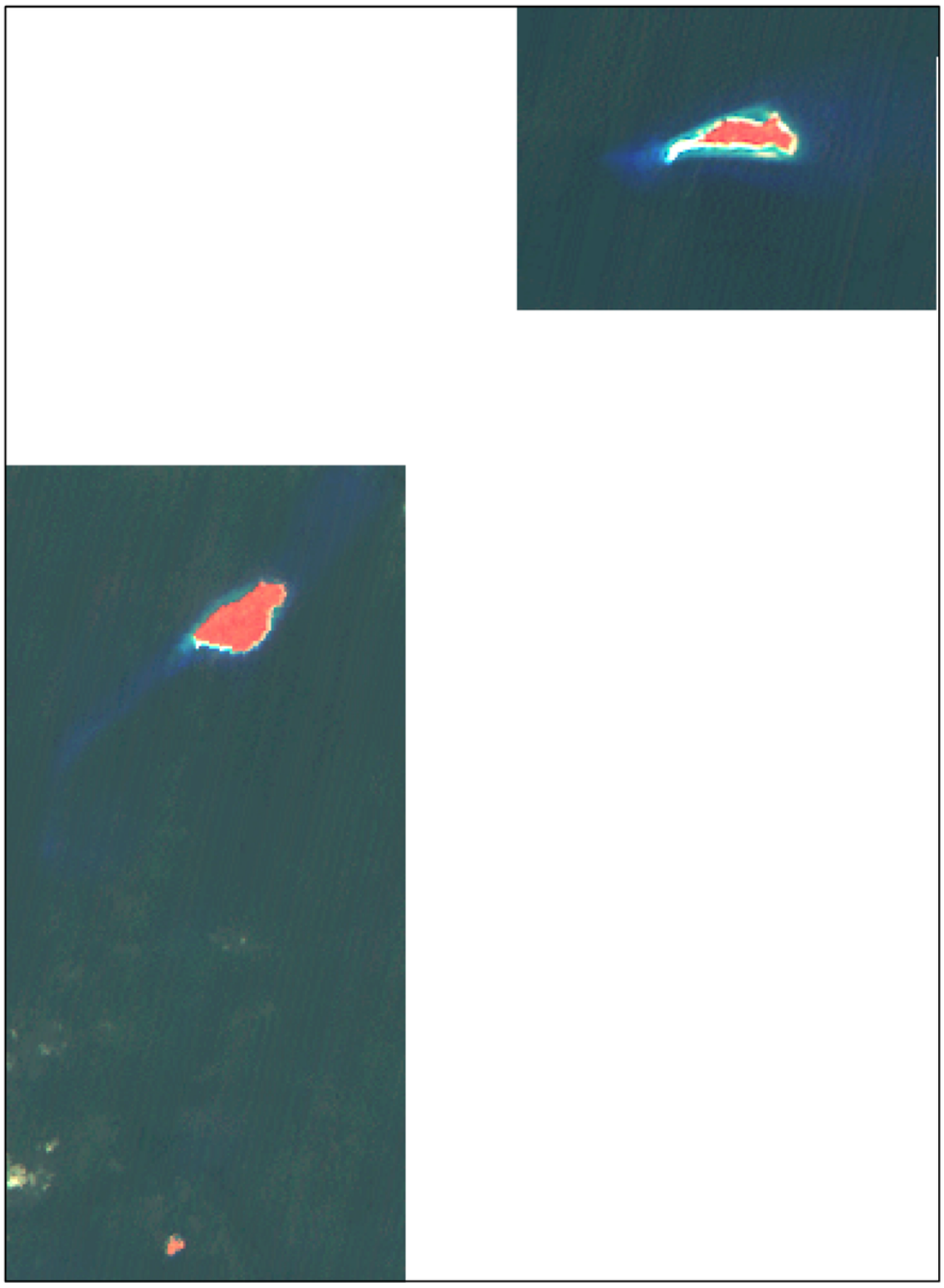
0 0.5 1 2 Kilometers

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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 4: Wetland map of Button Islands National Park based on the analysis of IRS P6 LISS-III data of 2006-07

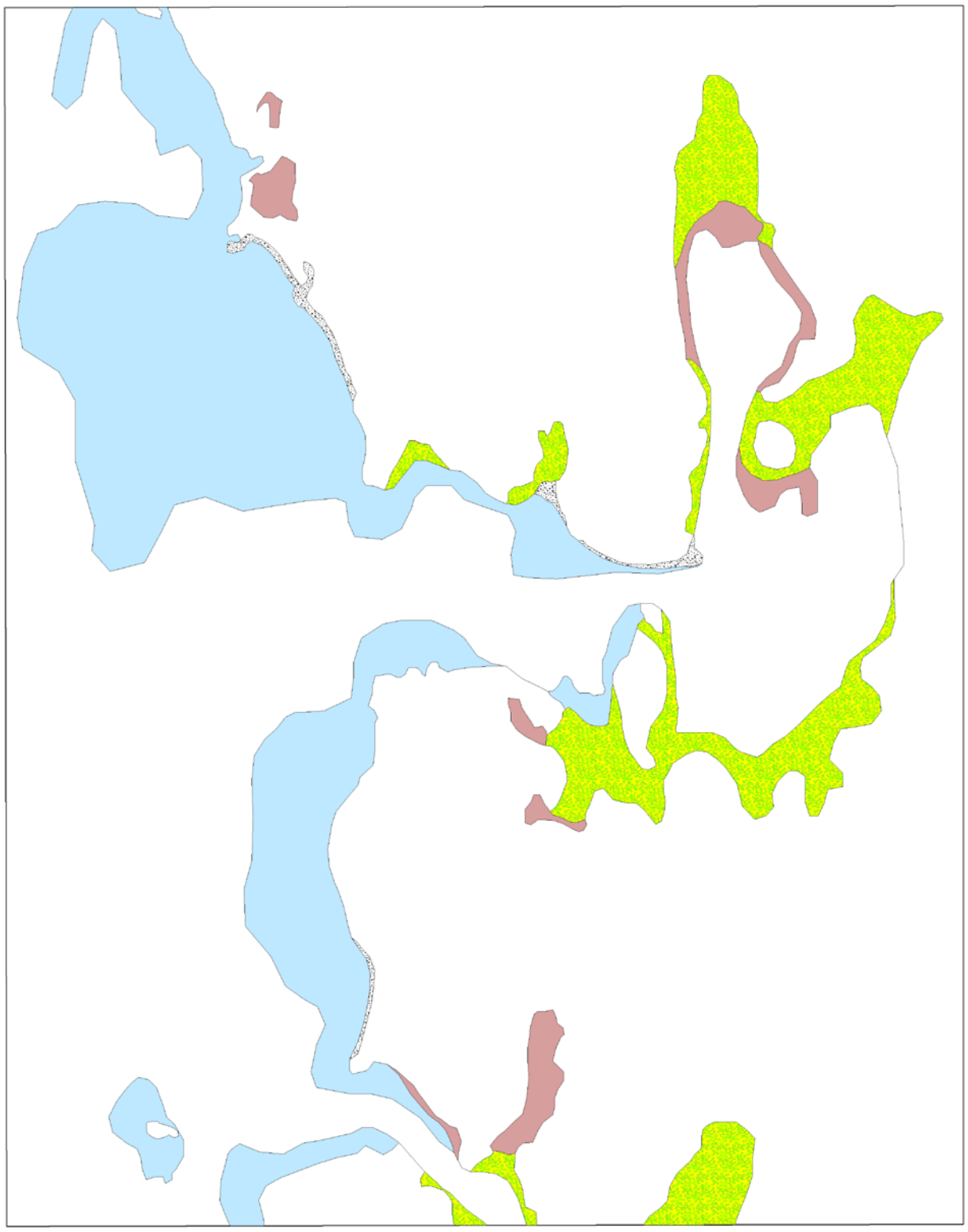


IRS P6 LISS-III Pre-monsoon data (2007)

UT : Andaman and Nicobar Islands

WETLAND MAP

Lohabarruk Crocodile Sanctuary

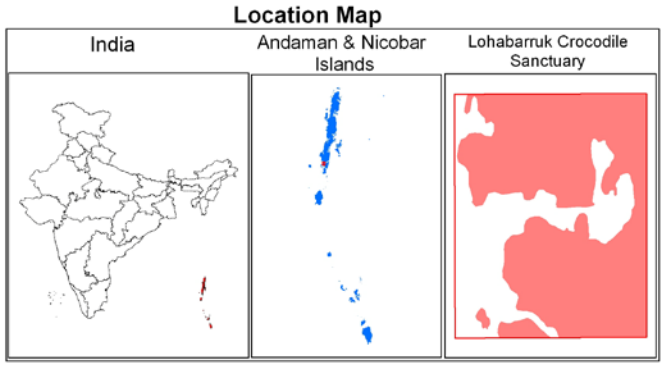


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



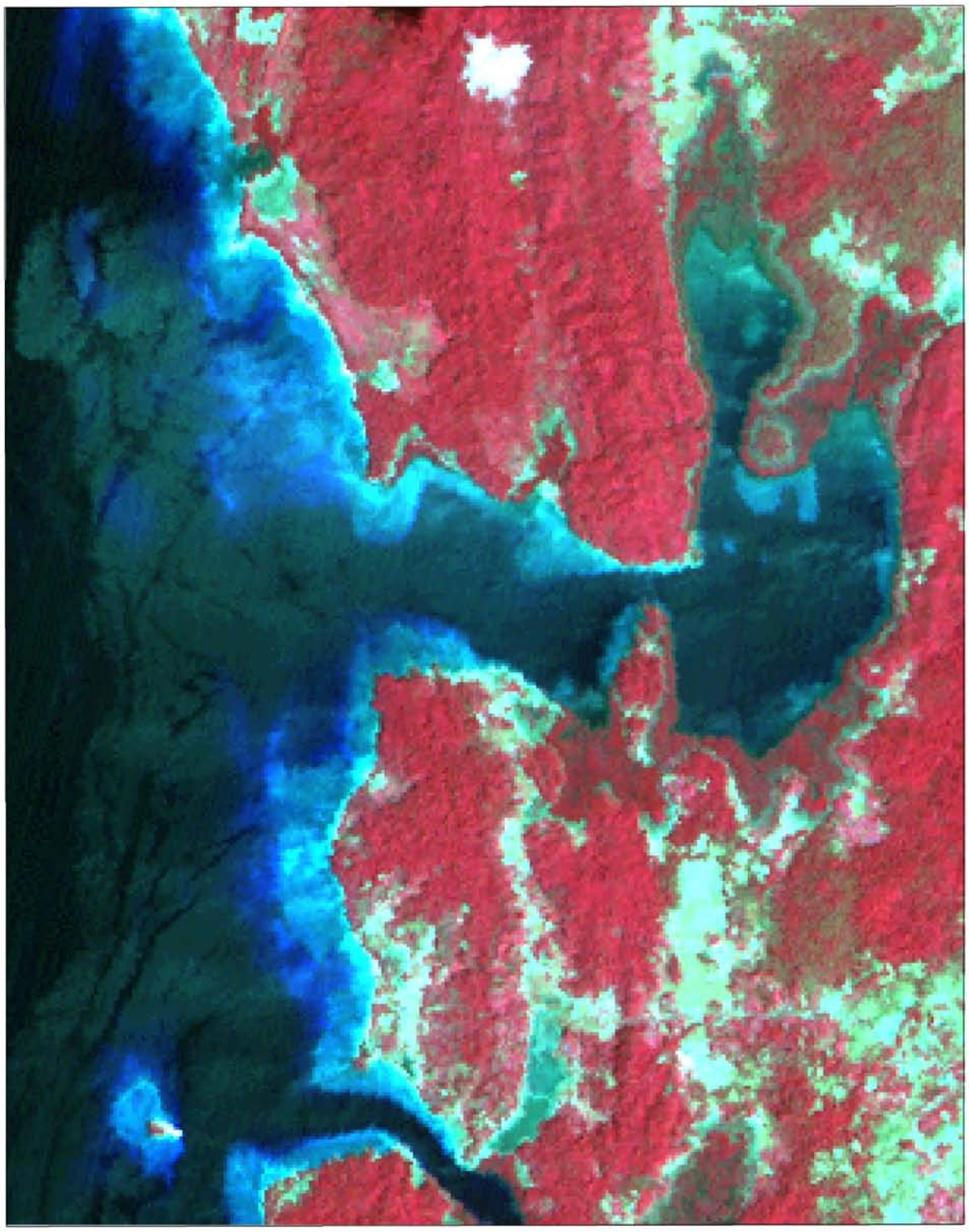
0 0.4 0.8 1.6 Kilometers

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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 5: Wetland map of Lohabarruk Saltwater Crocodile Sanctuary based on the analysis of IRS P6 LISS-III data of 2006-07

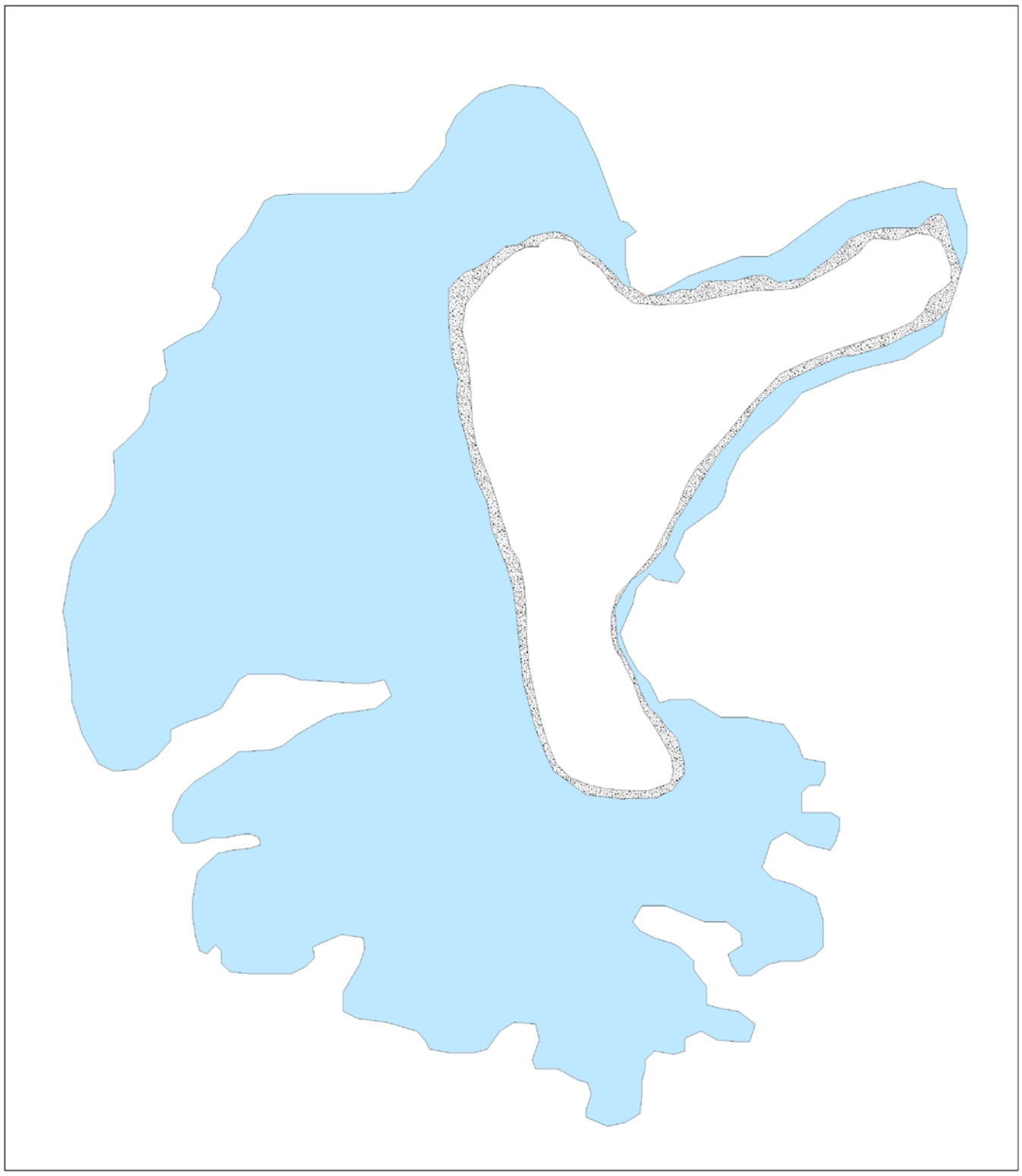


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

North Reef Island Sanctuary

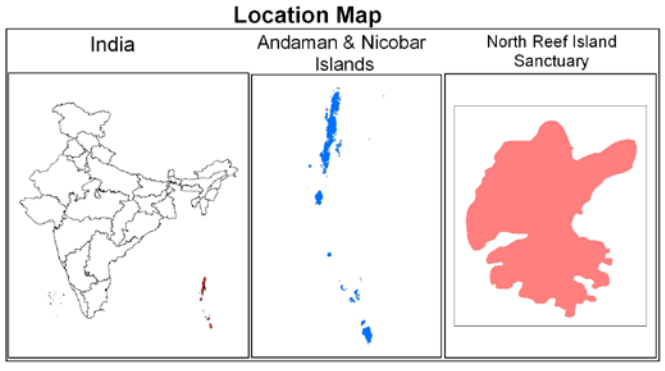


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



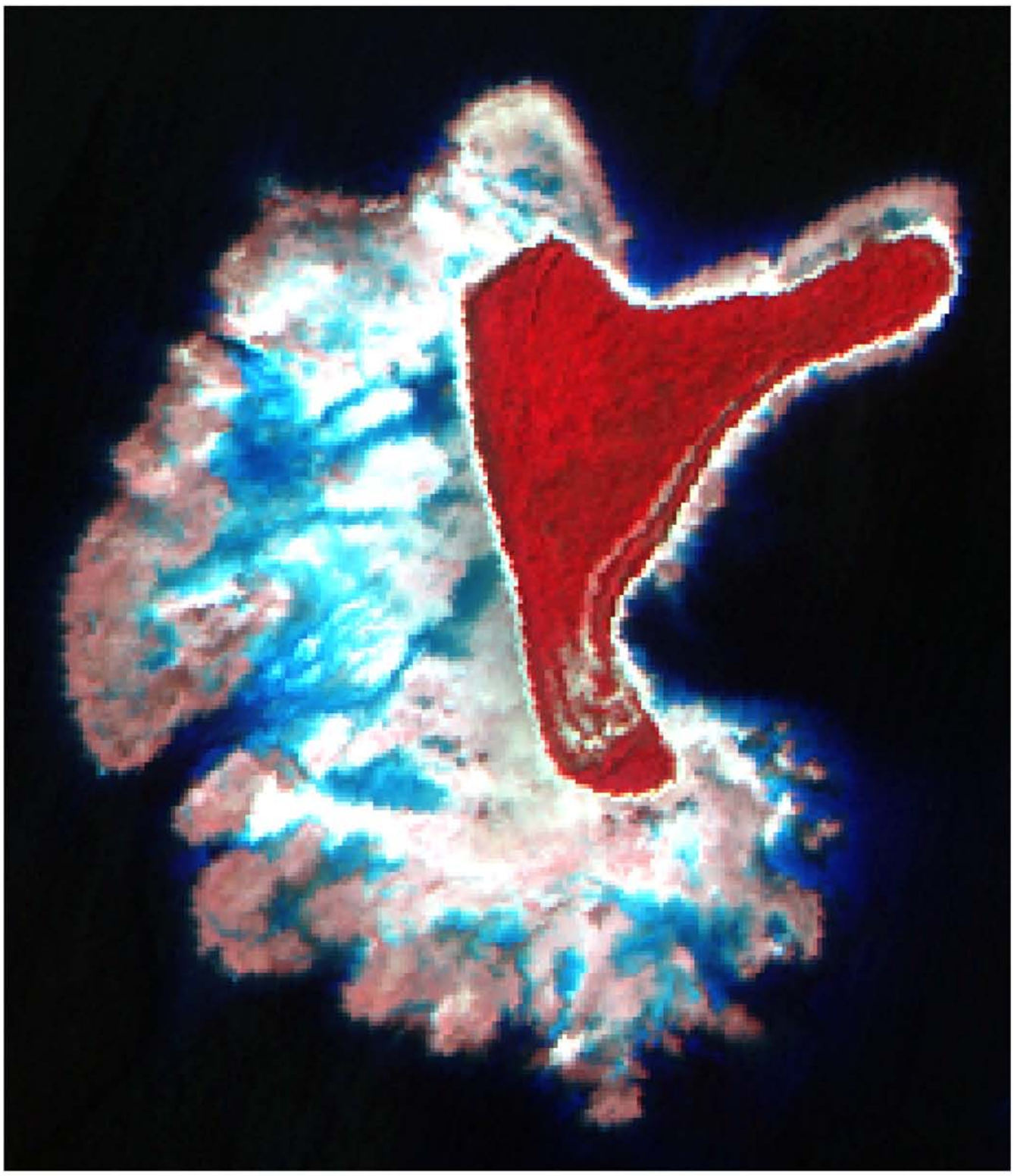
0 0.25 0.5 1 Kilometers

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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 6: Wetland map of North Reef Island Sanctuary based on the analysis of IRS P6 LISS-III data of 2006-07

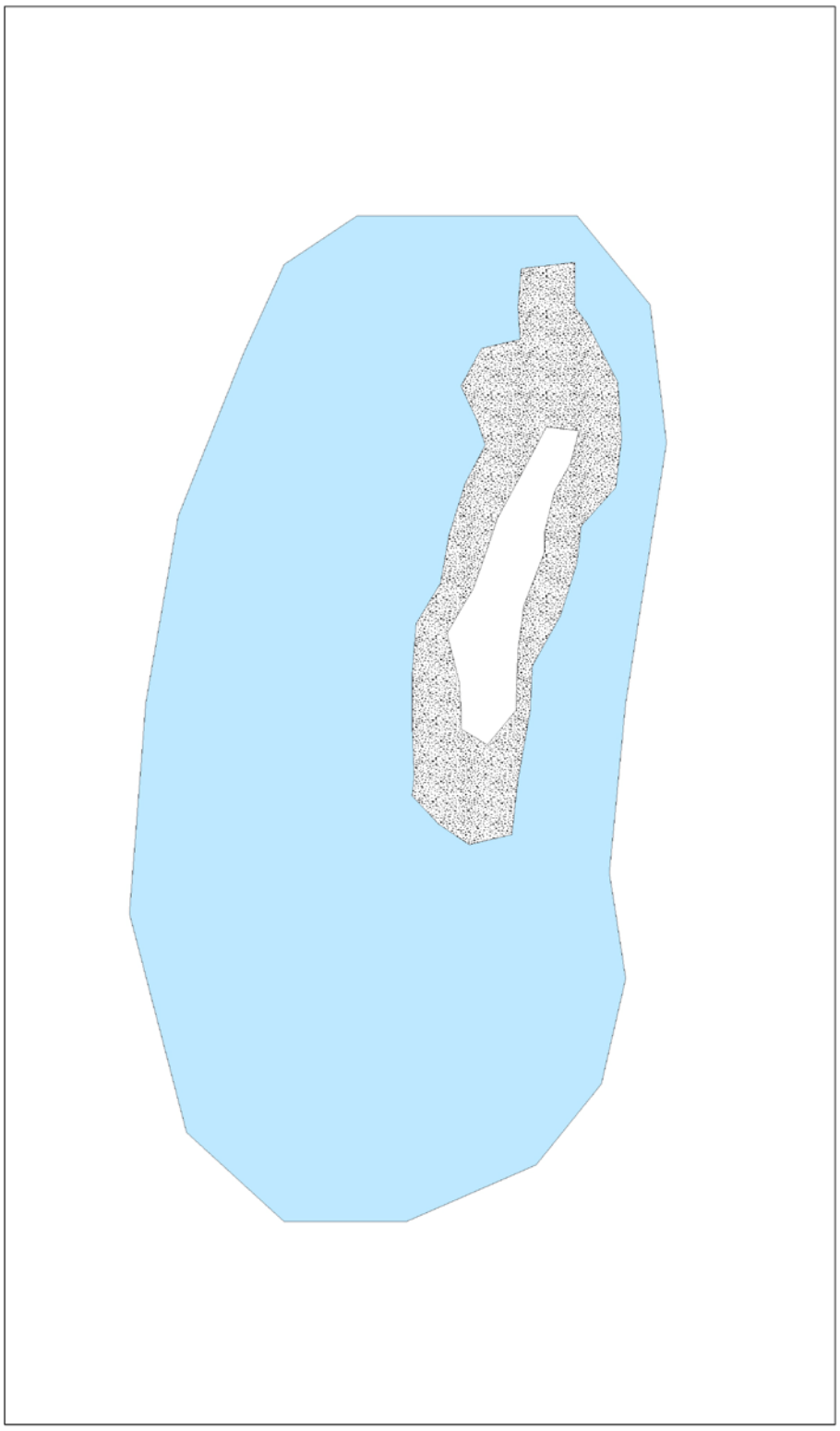


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

South Reef Island Sanctuary

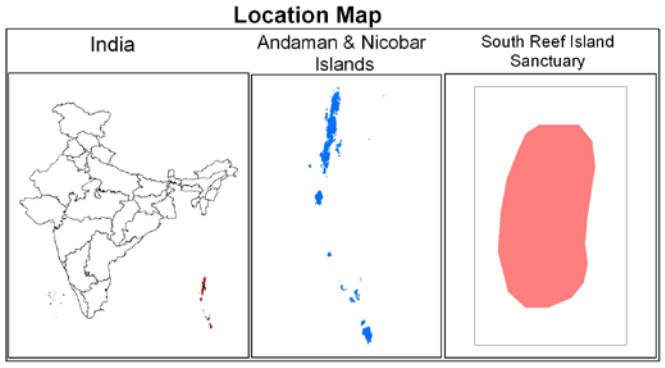


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



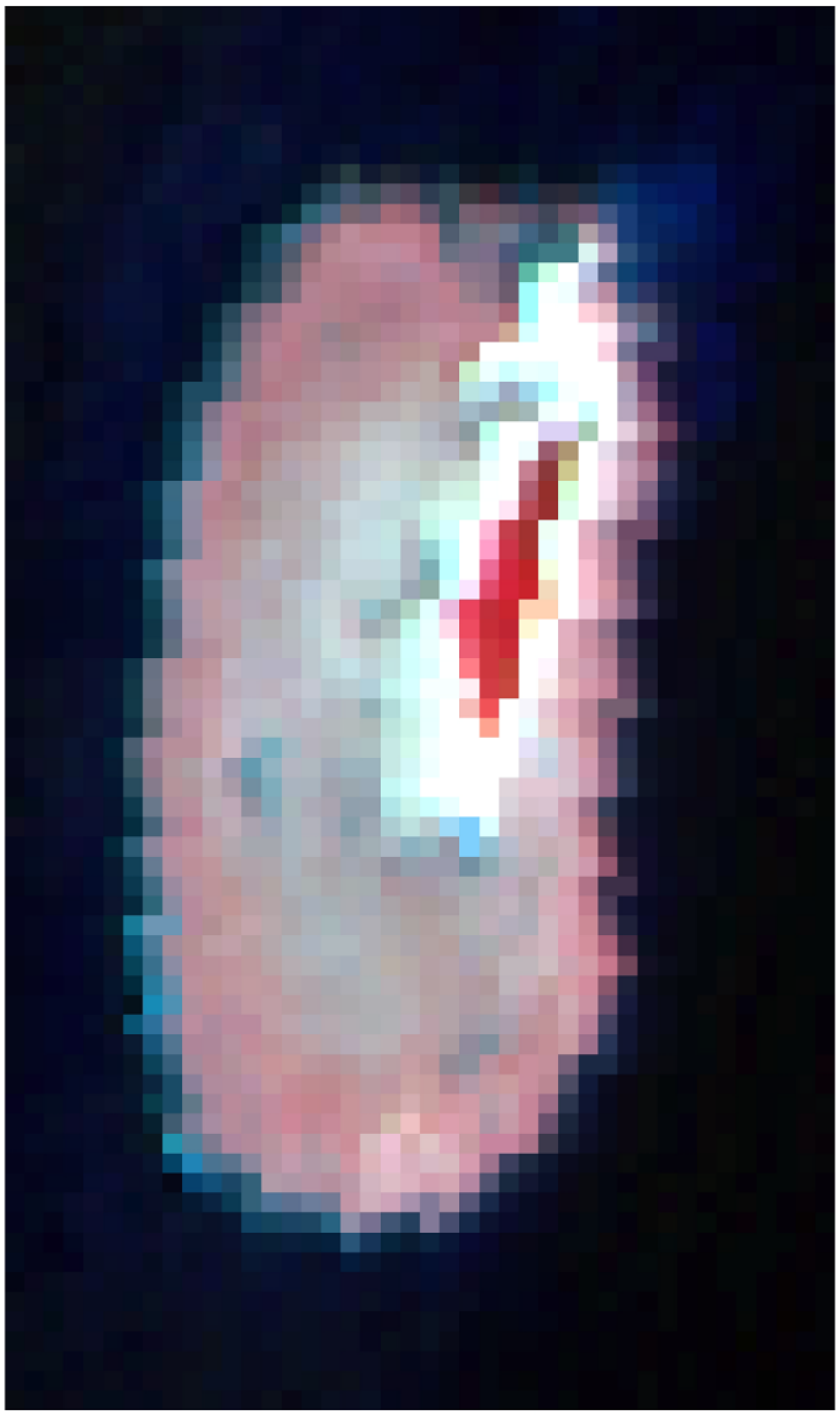
0 0.045 0.09 0.18
Kilometers

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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad

Sponsored By:
Ministry of Environment and Forests
Government of India

Plate 7: Wetland map of South Reef Island Sanctuary based on the analysis of IRS P6 LISS-III data of 2006-07

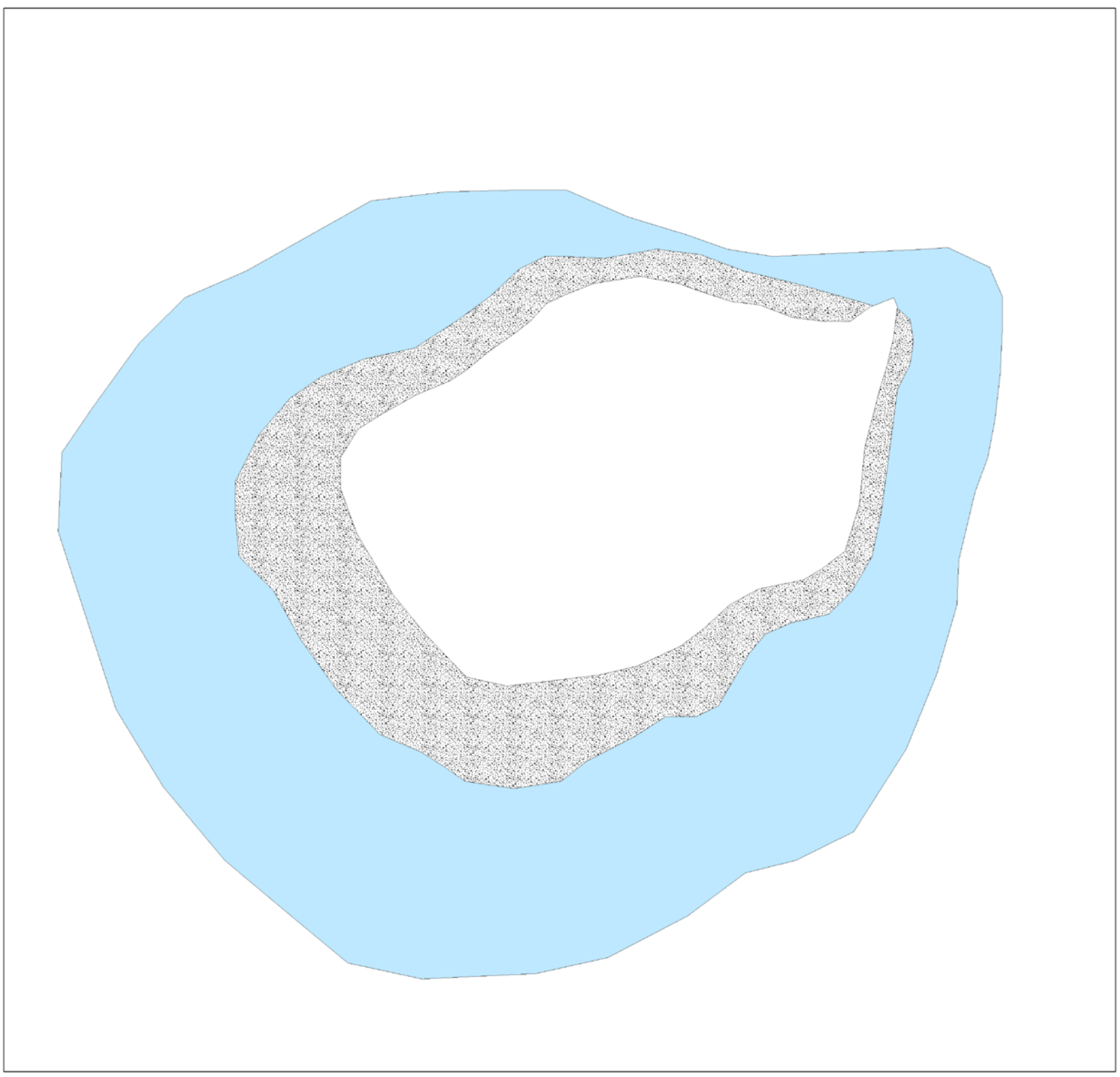


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

South Sentinel Island Sanctuary

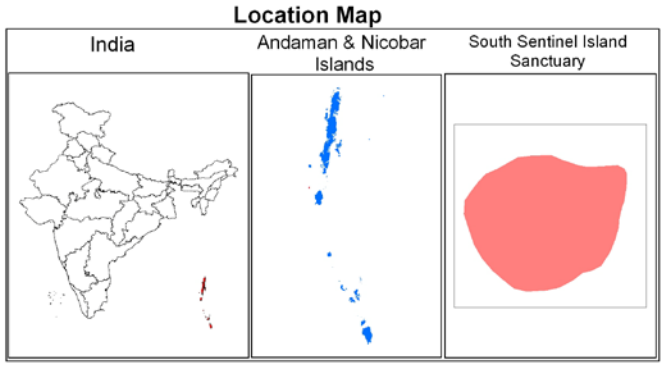


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



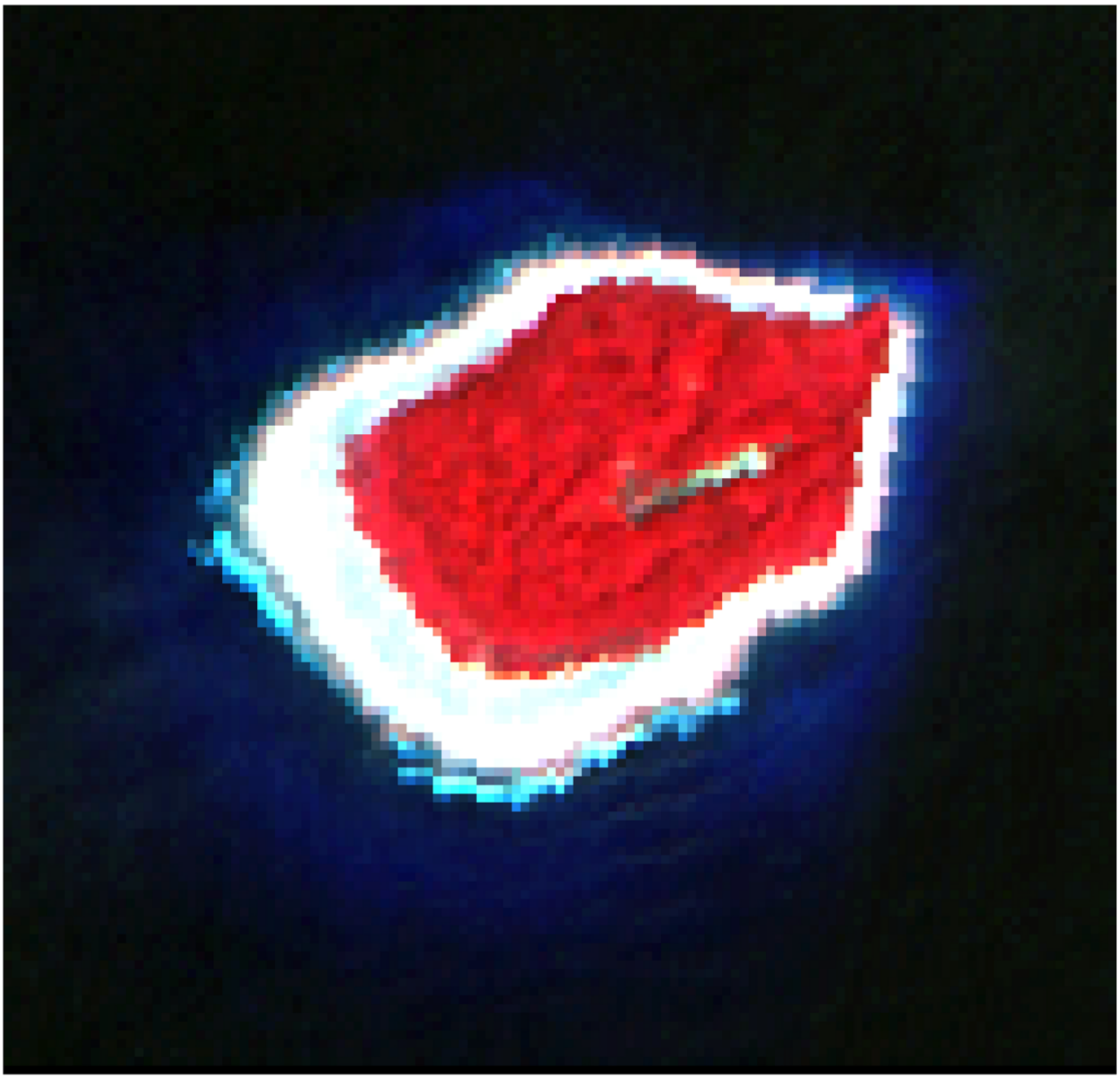
0 0.050.1 0.2 Kilometers

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

Plate 8: Wetland map of South Sentinel Island Sanctuary based on the analysis of IRS P6 LISS-III data of 2006-07



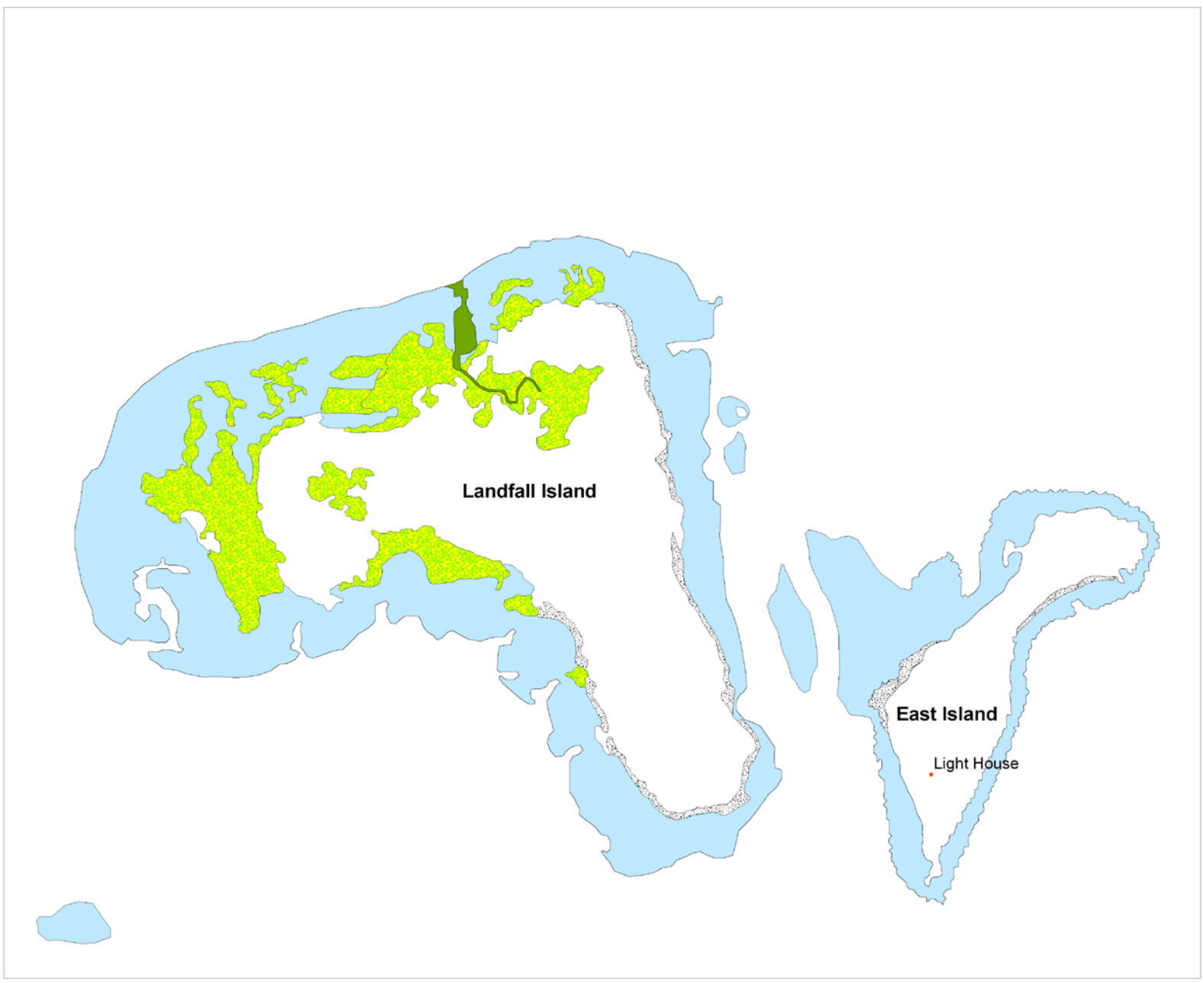
IRS P6 LISS-III Post-monsoon data (2006)

SEGREGATED ISLAND(s)-WISE WETLAND MAPS

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

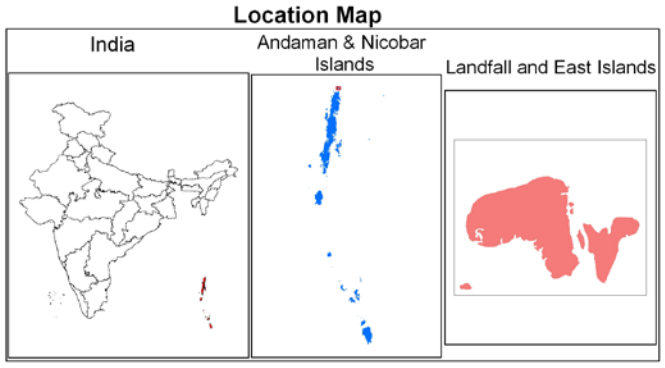


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 0.5 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

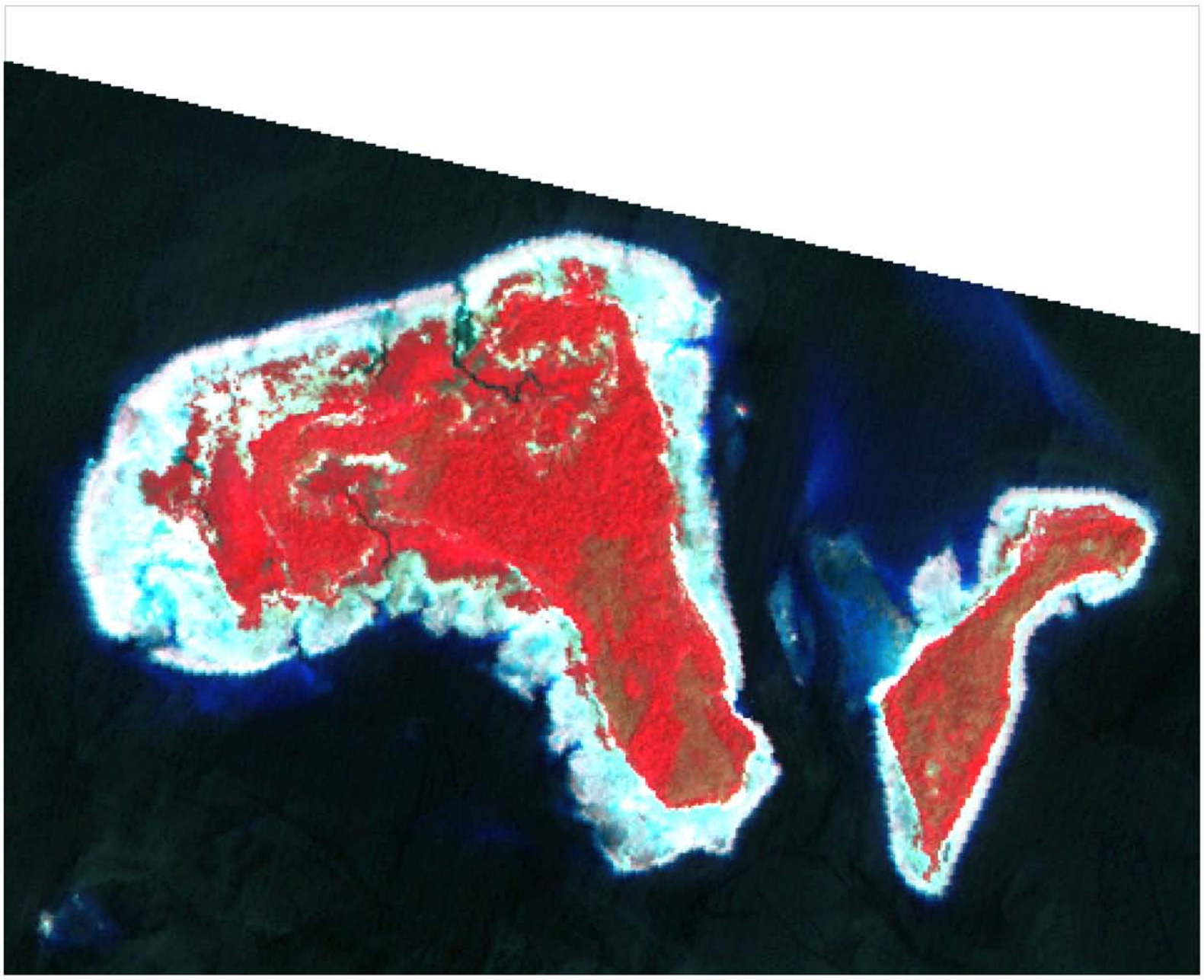
Sponsored By:

Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

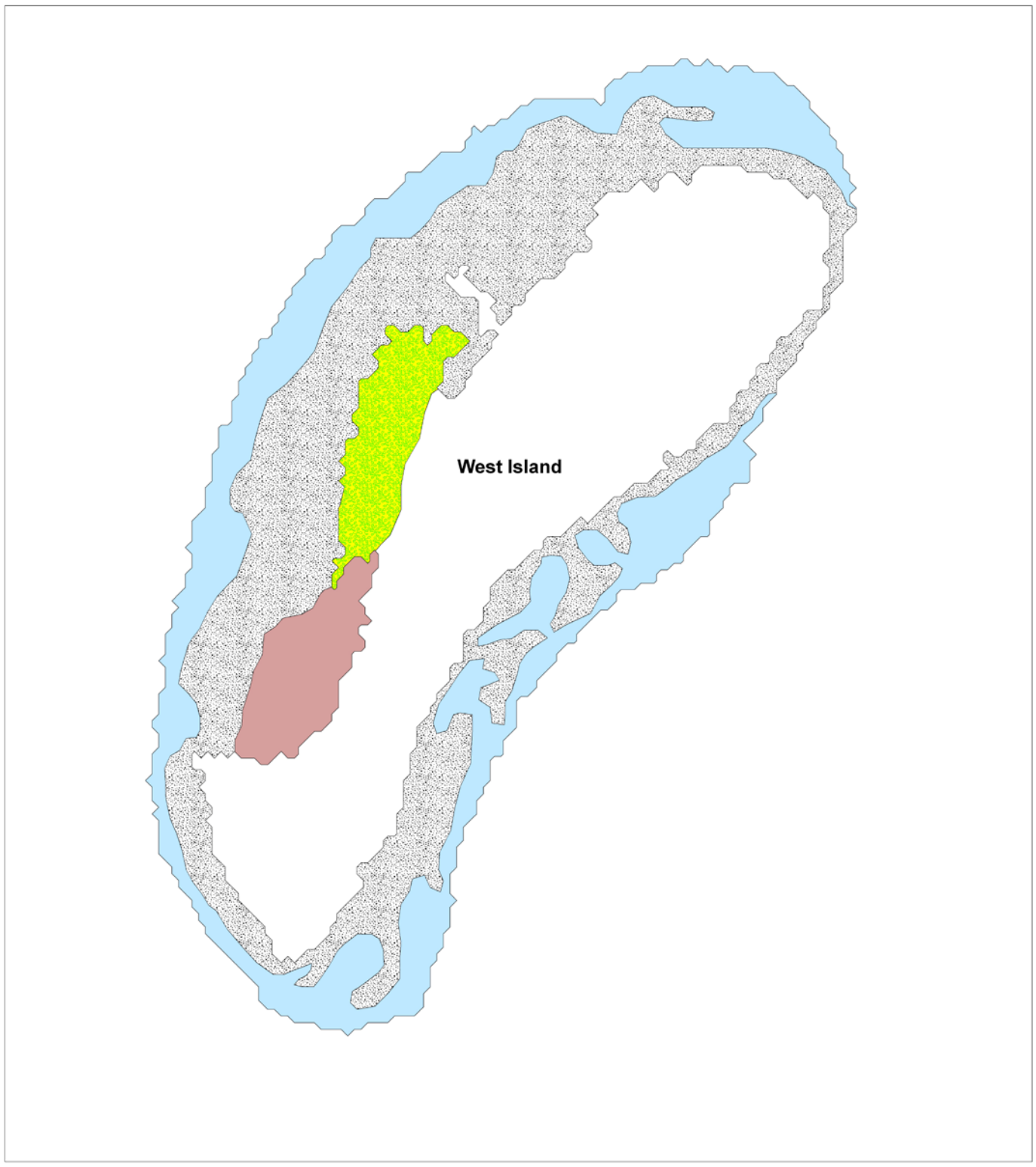


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

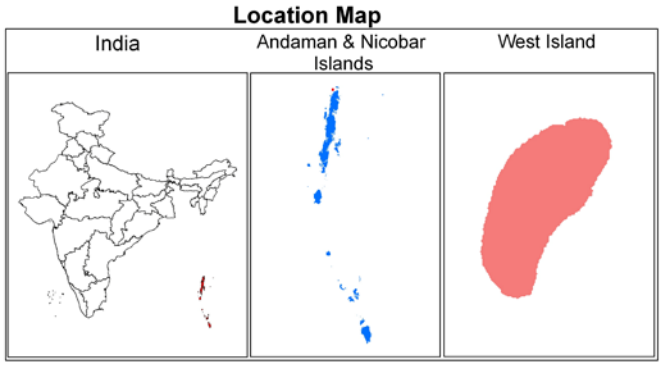


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

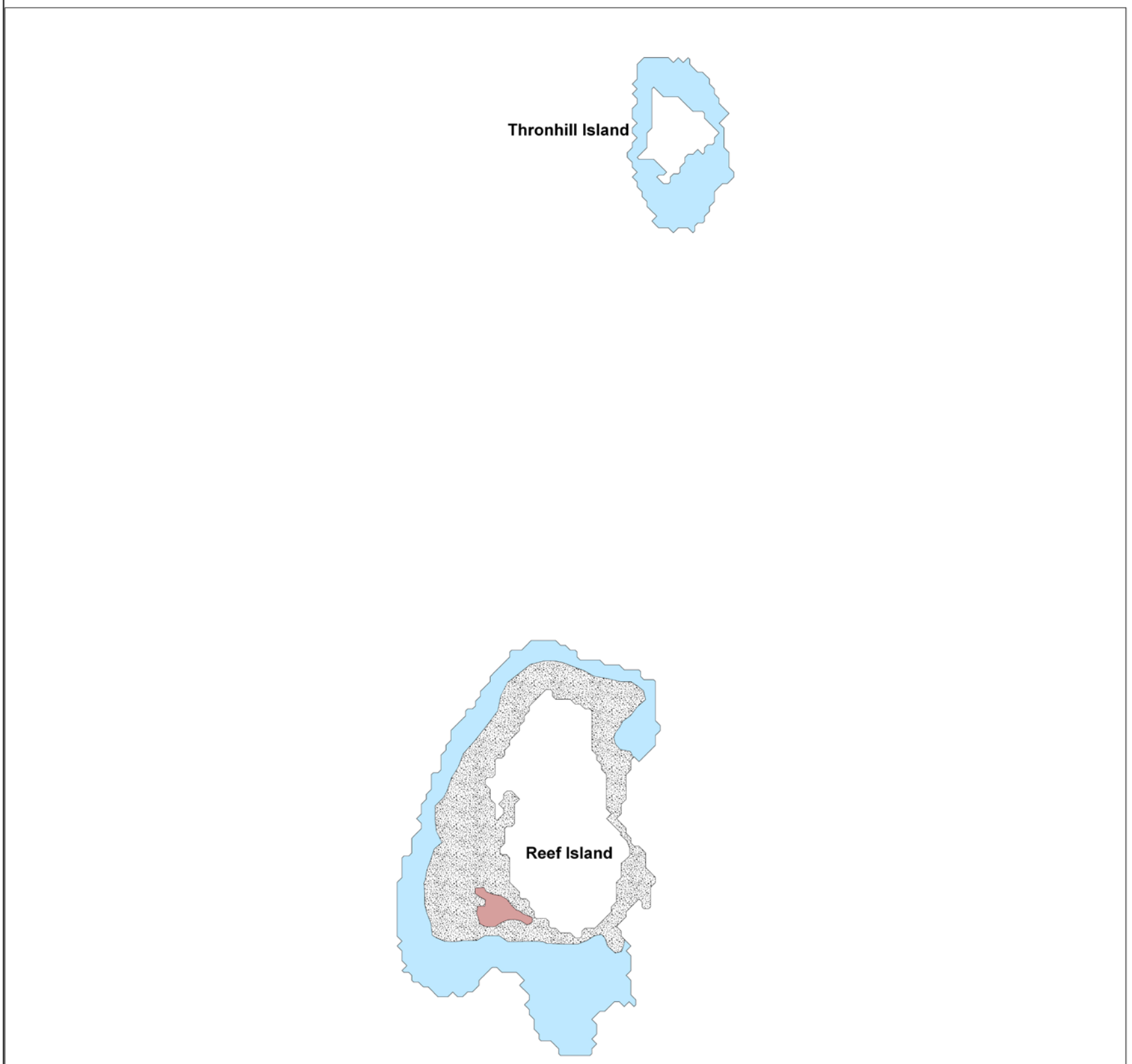
District : Andaman

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

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

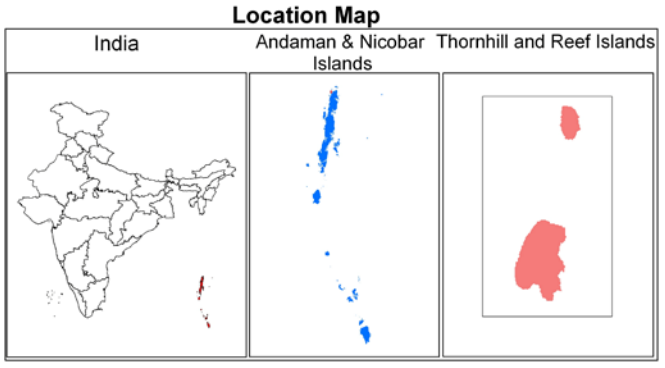


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

Sponsored By:

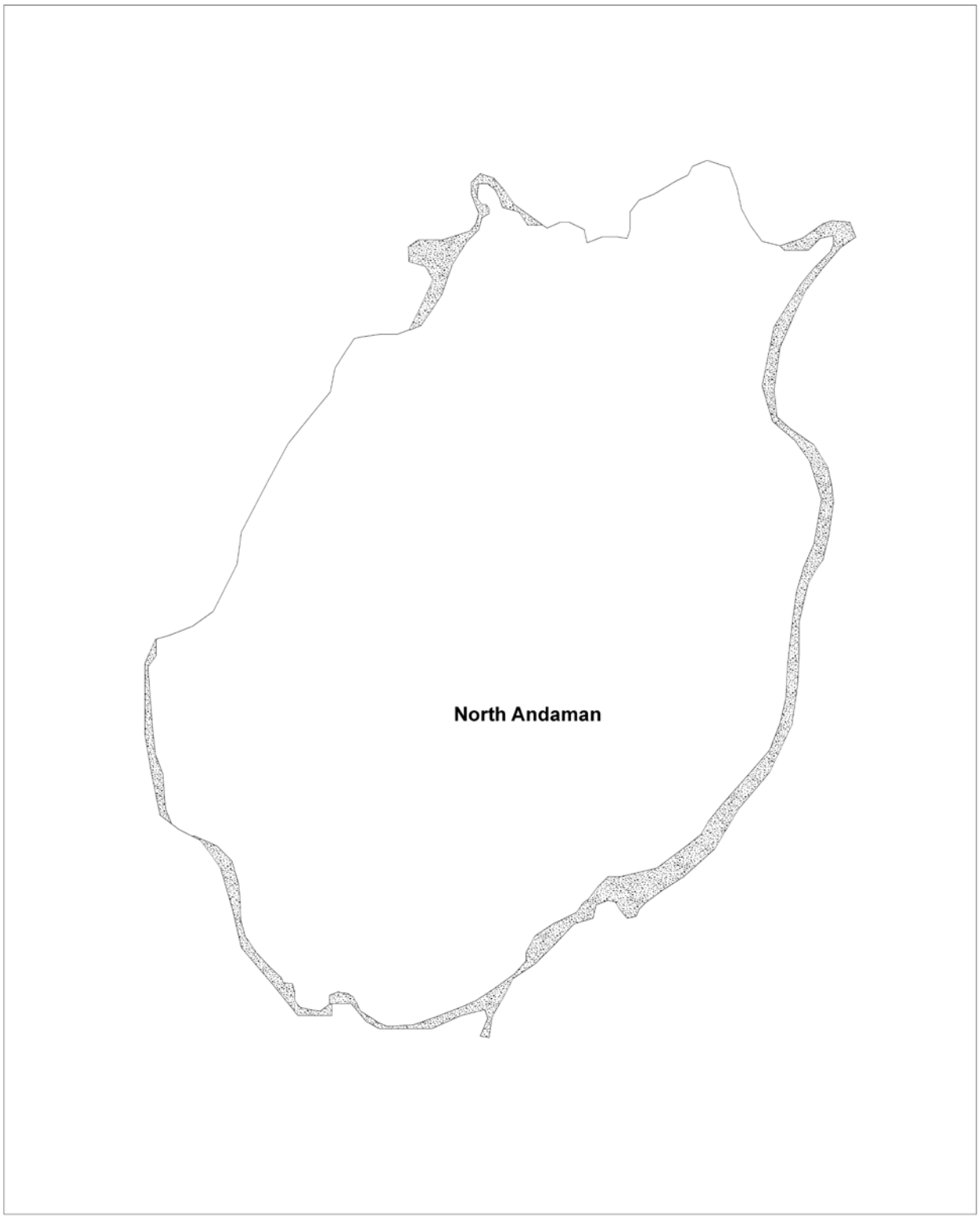
Ministry of Environment and Forests
Government of India

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

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

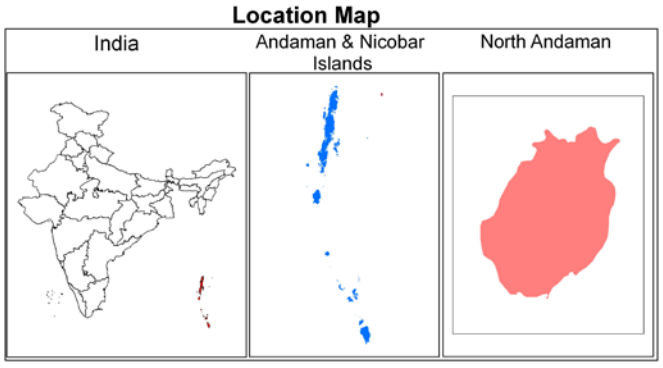


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 0.35 0.7 1.4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

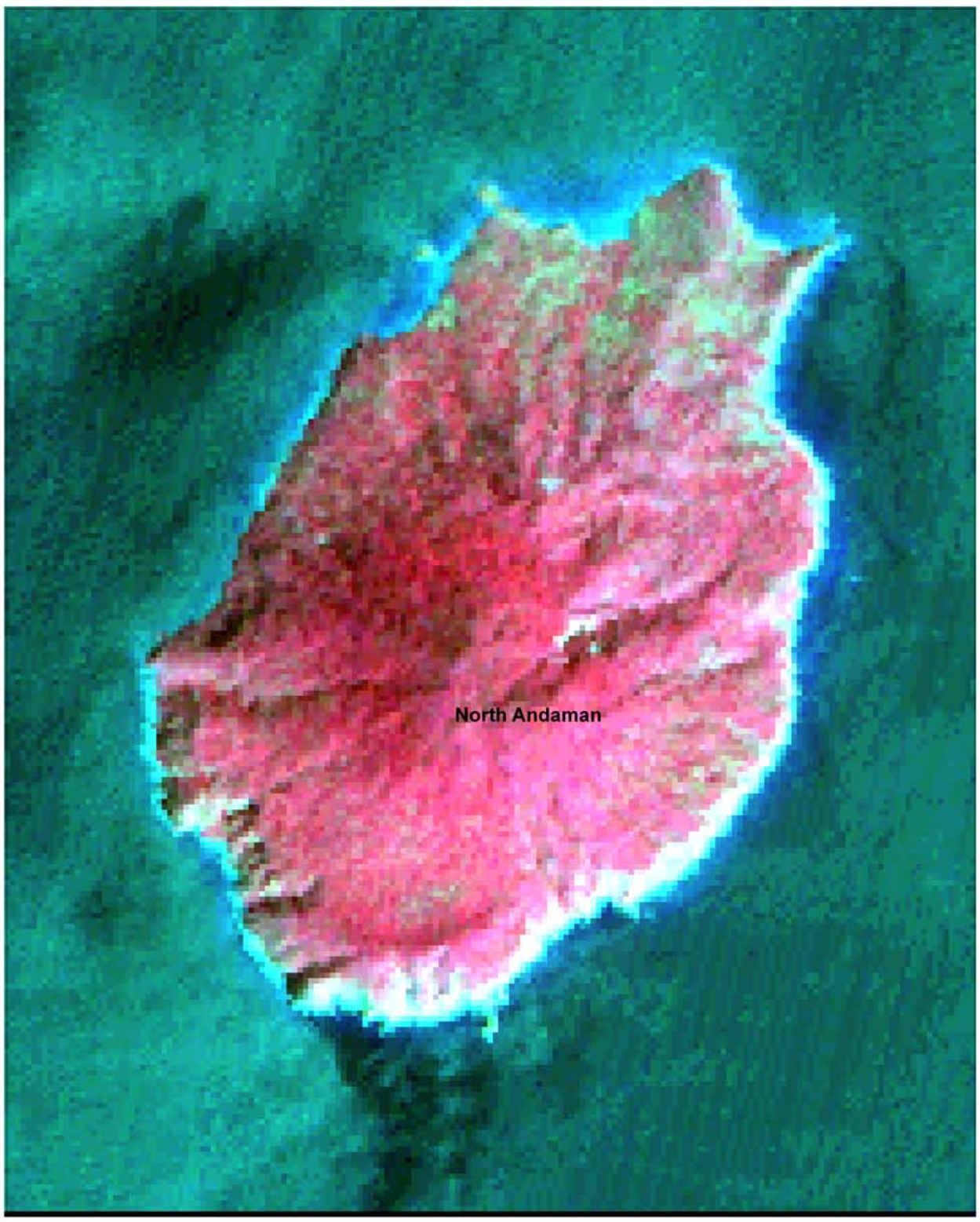
Sponsored By:

Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

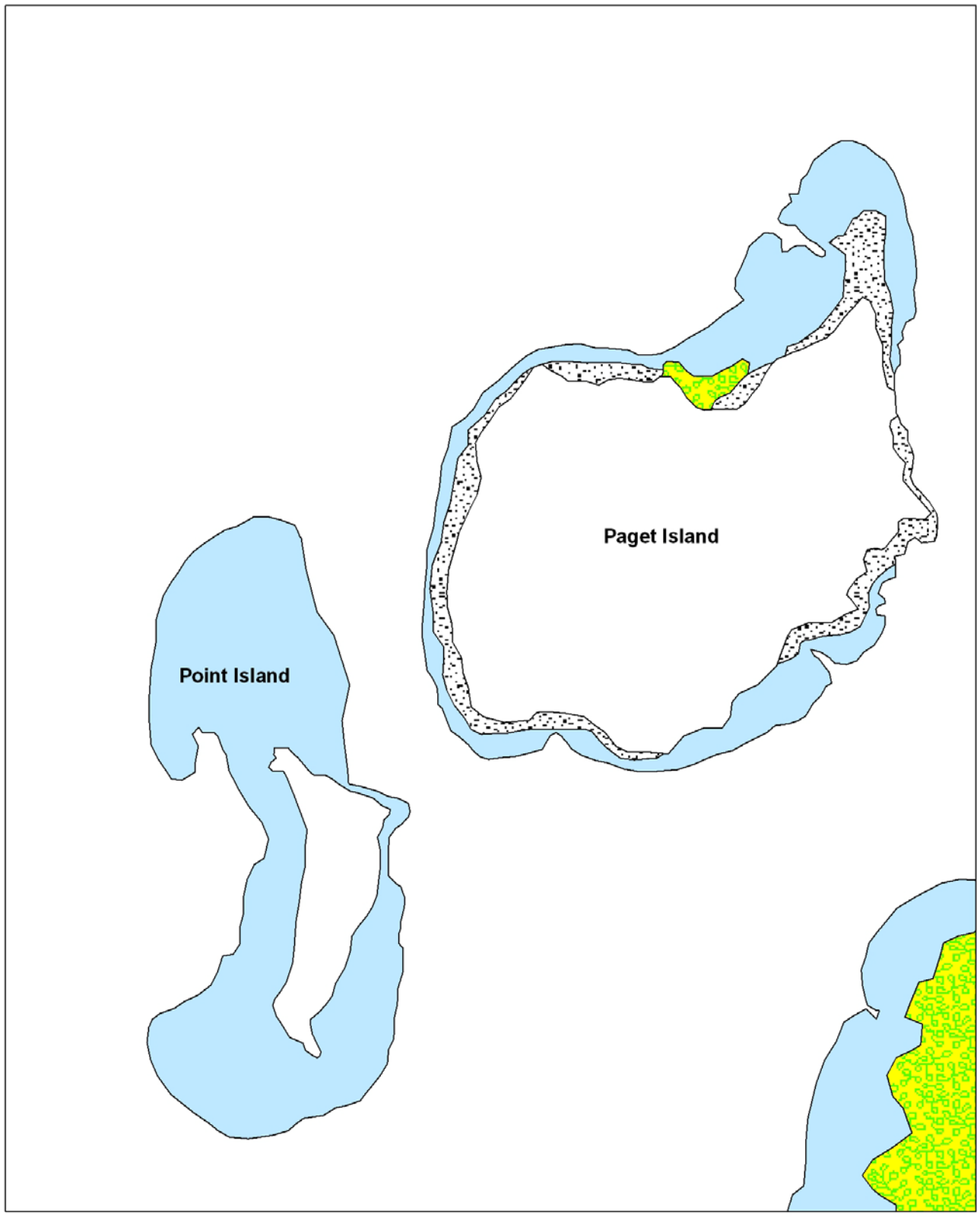


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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
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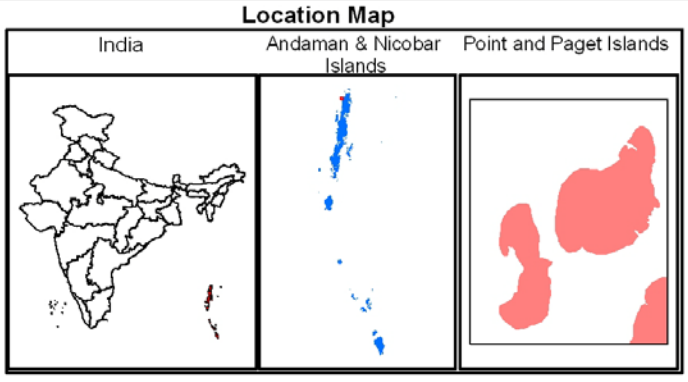
		Man-made	
2201			Salt pans
2202			Aquaculture ponds

Legend

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

Location Map



0 0.5 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

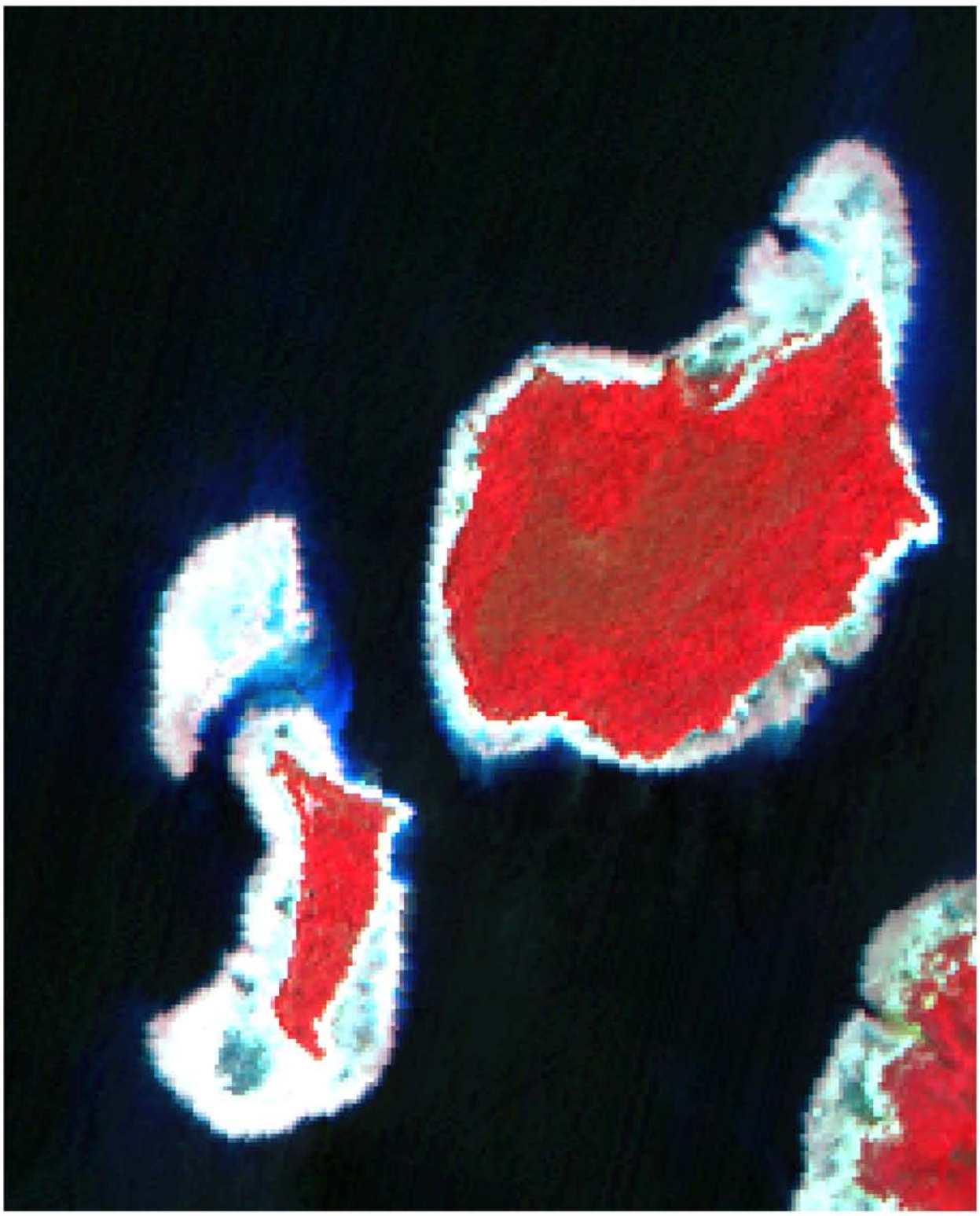
Sponsored By:

Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

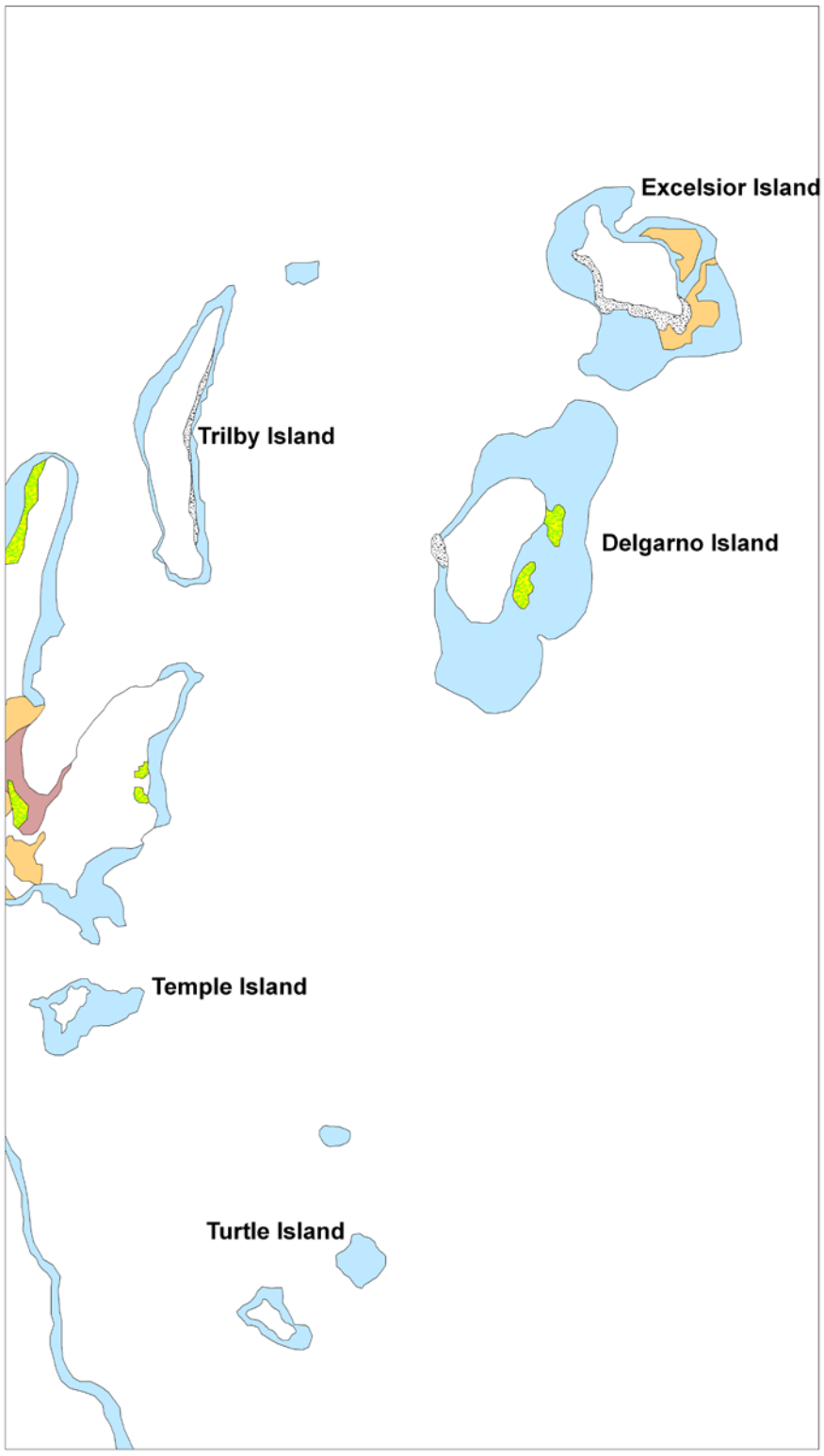


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
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	1101			Lakes/Ponds
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Legend

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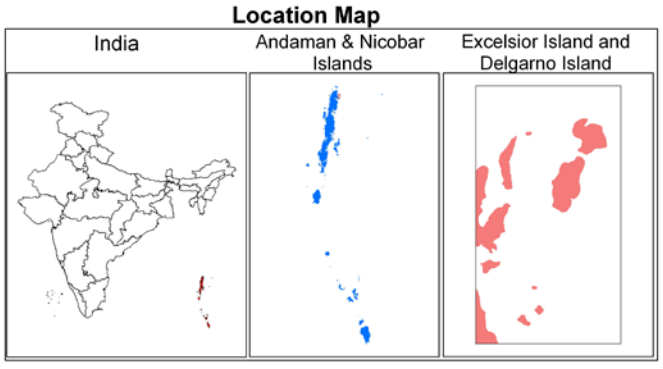

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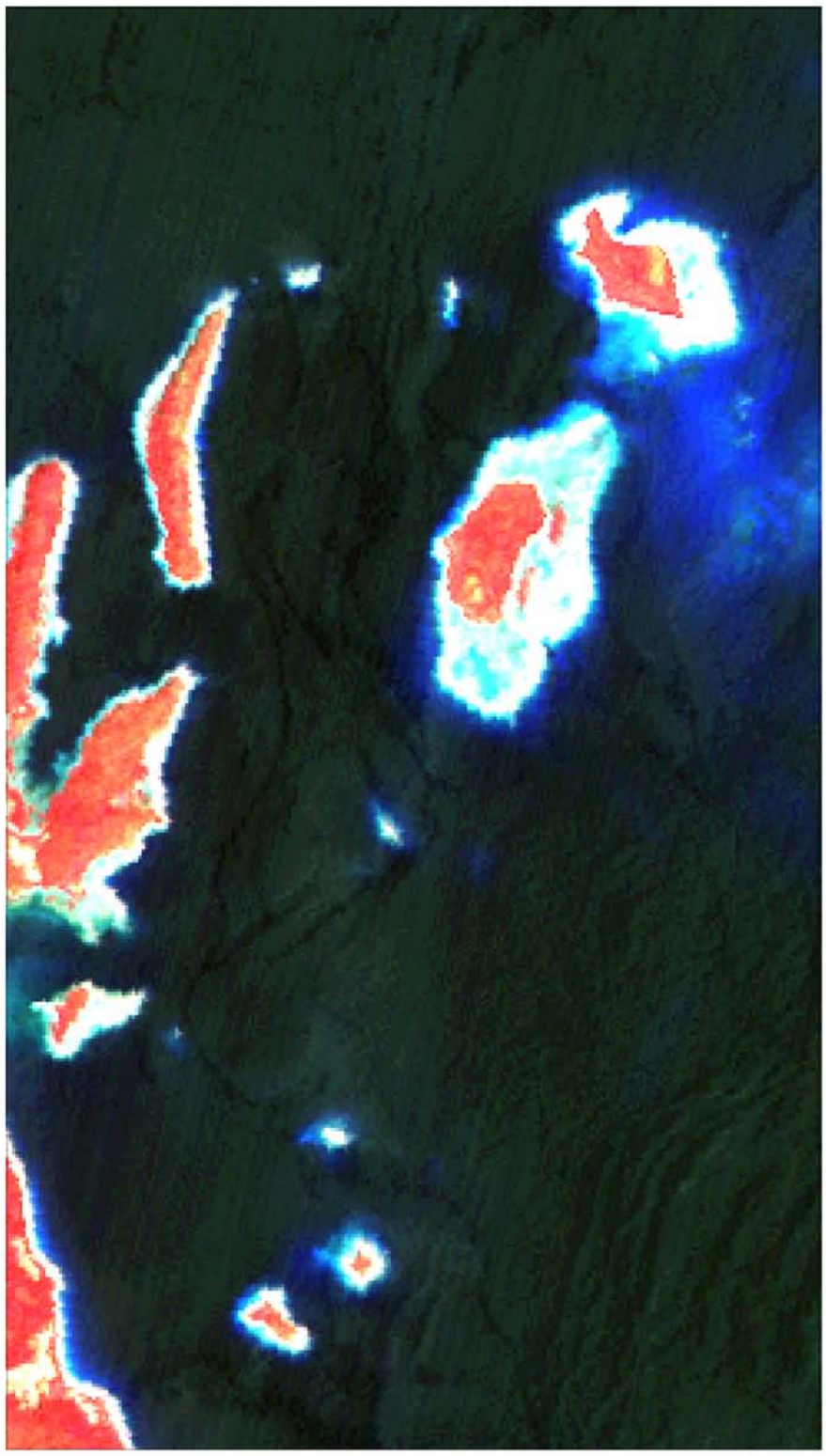
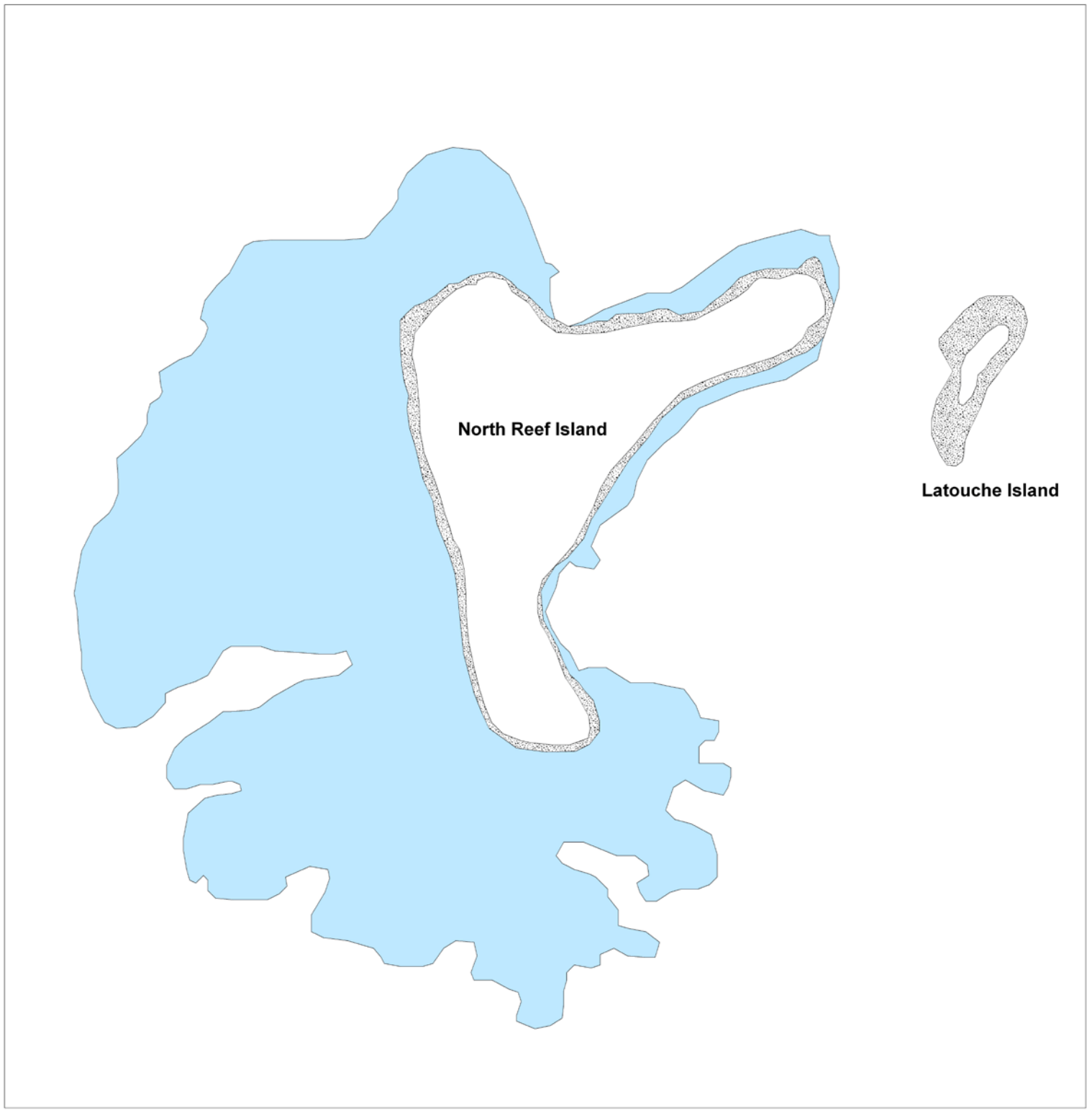


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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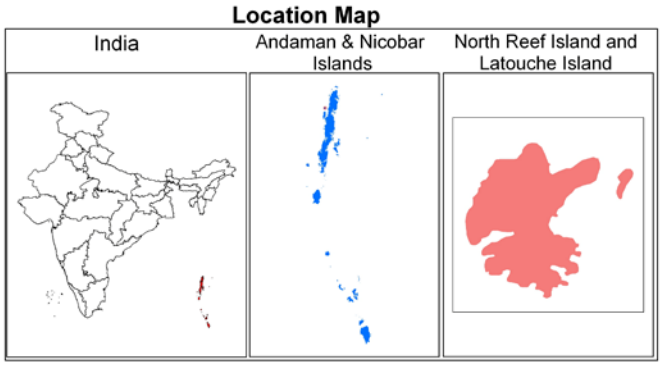

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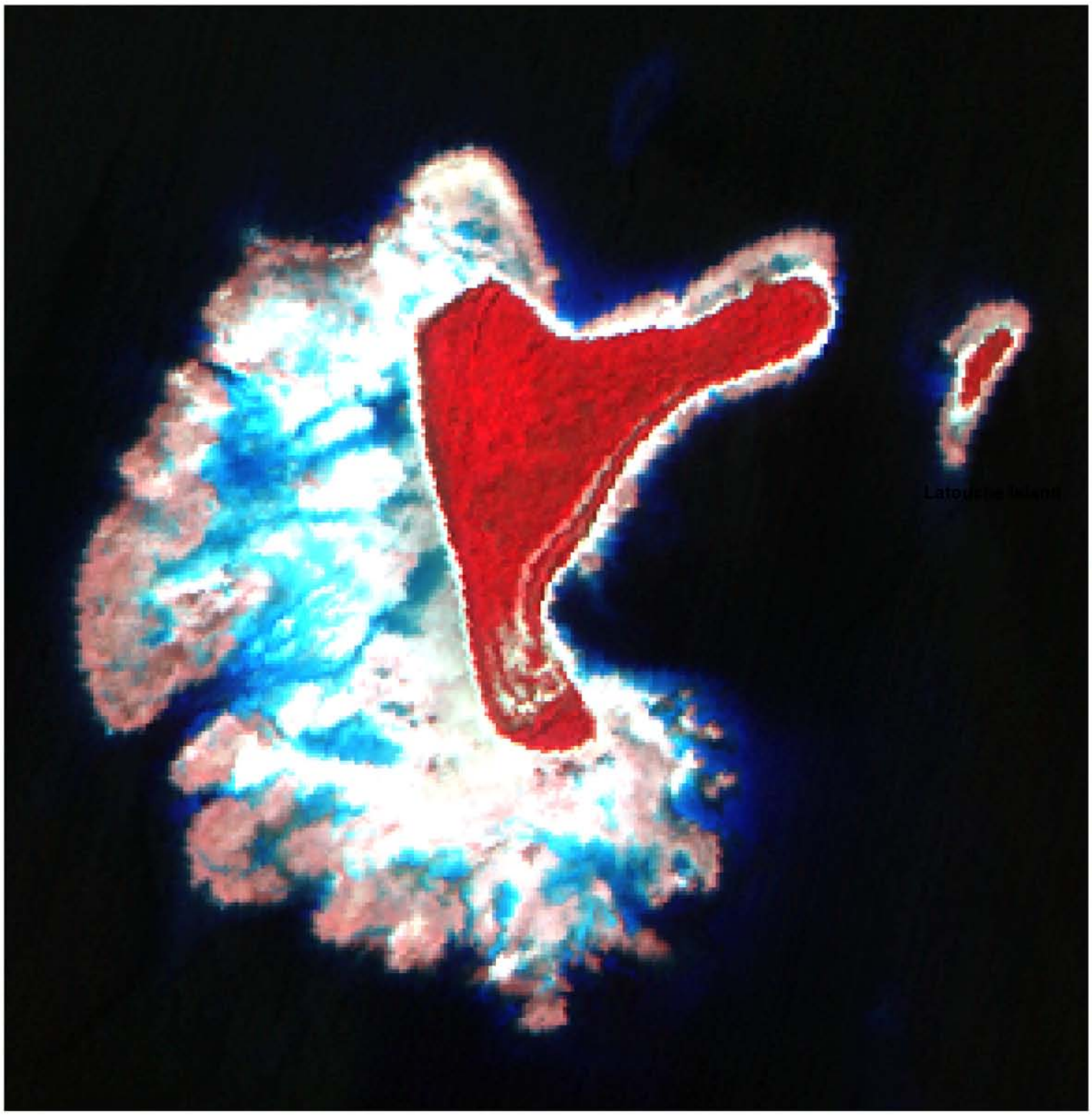

IRS P6 LISS-III Postmonsoon data (2006)

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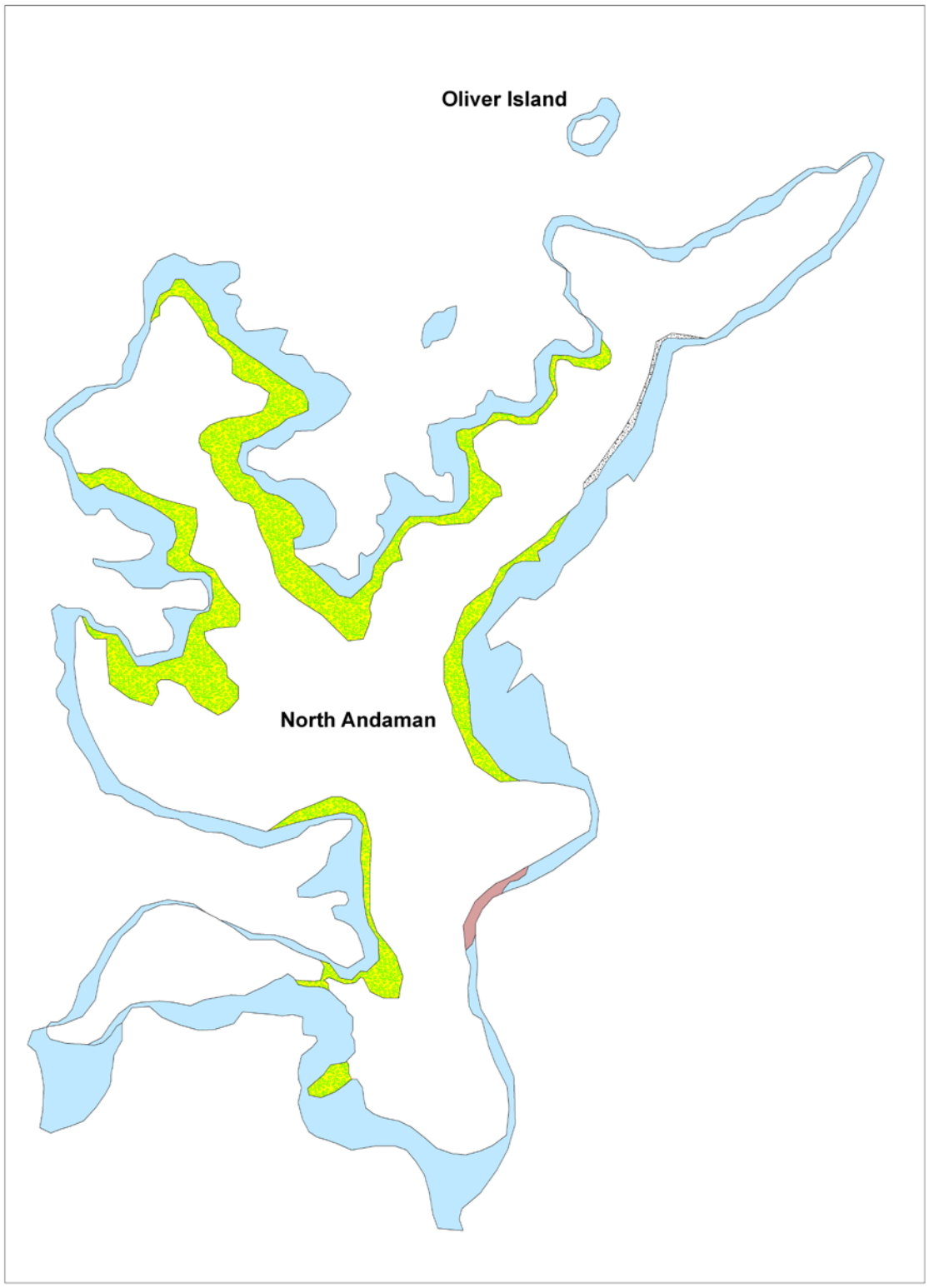
WETLAND MAP

District : Andaman



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Legend

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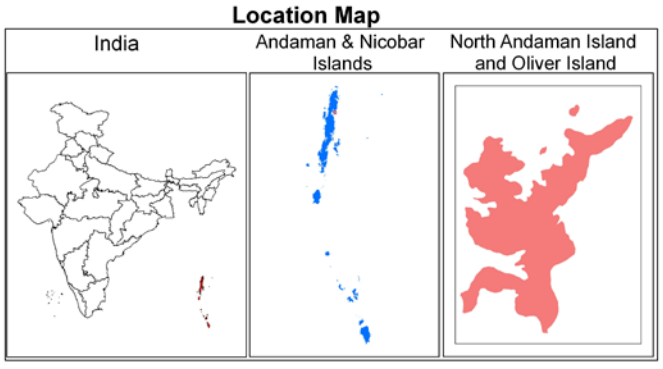

0 0.5 1 2
Kilometers

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WETLAND MAP

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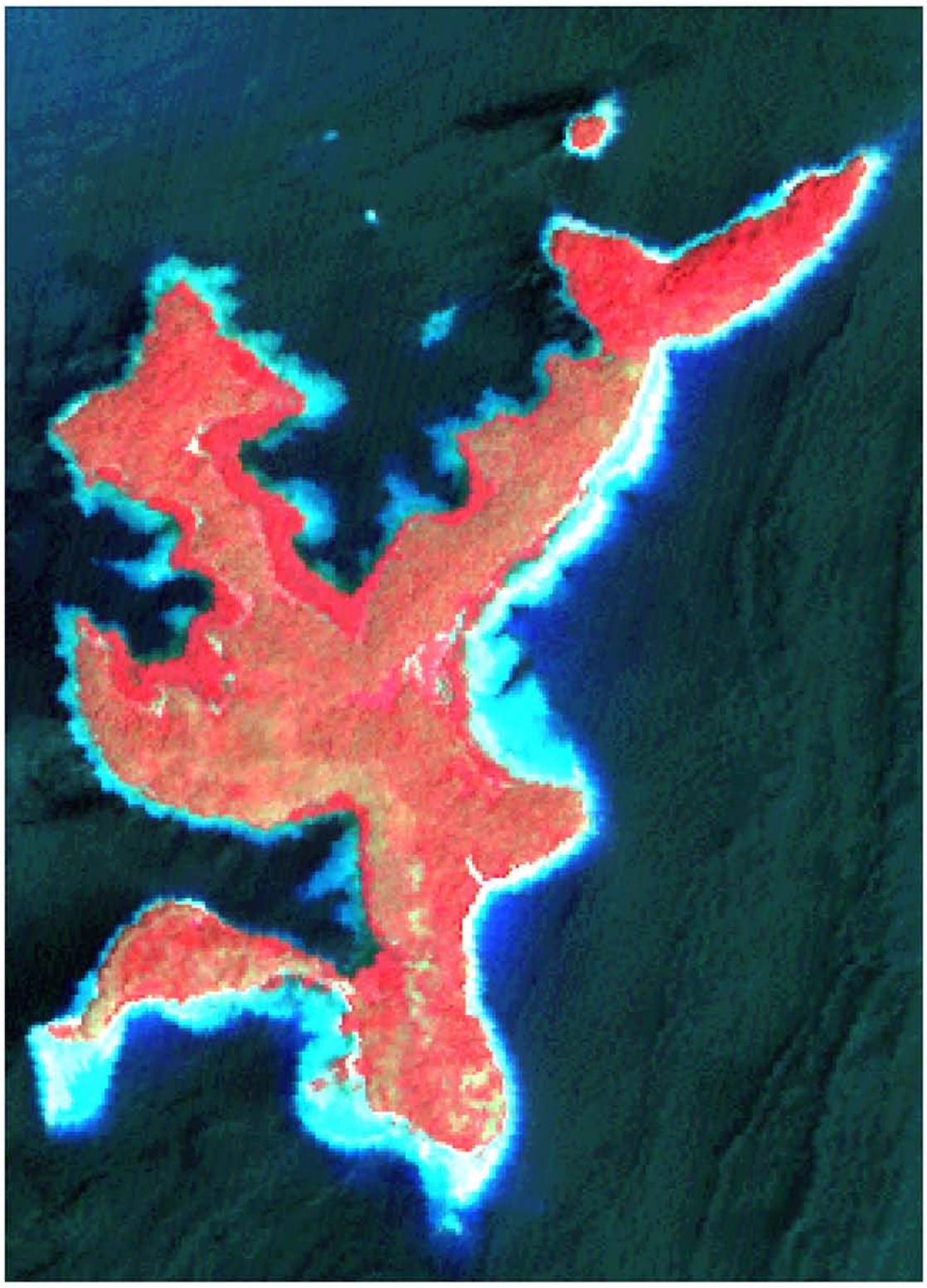
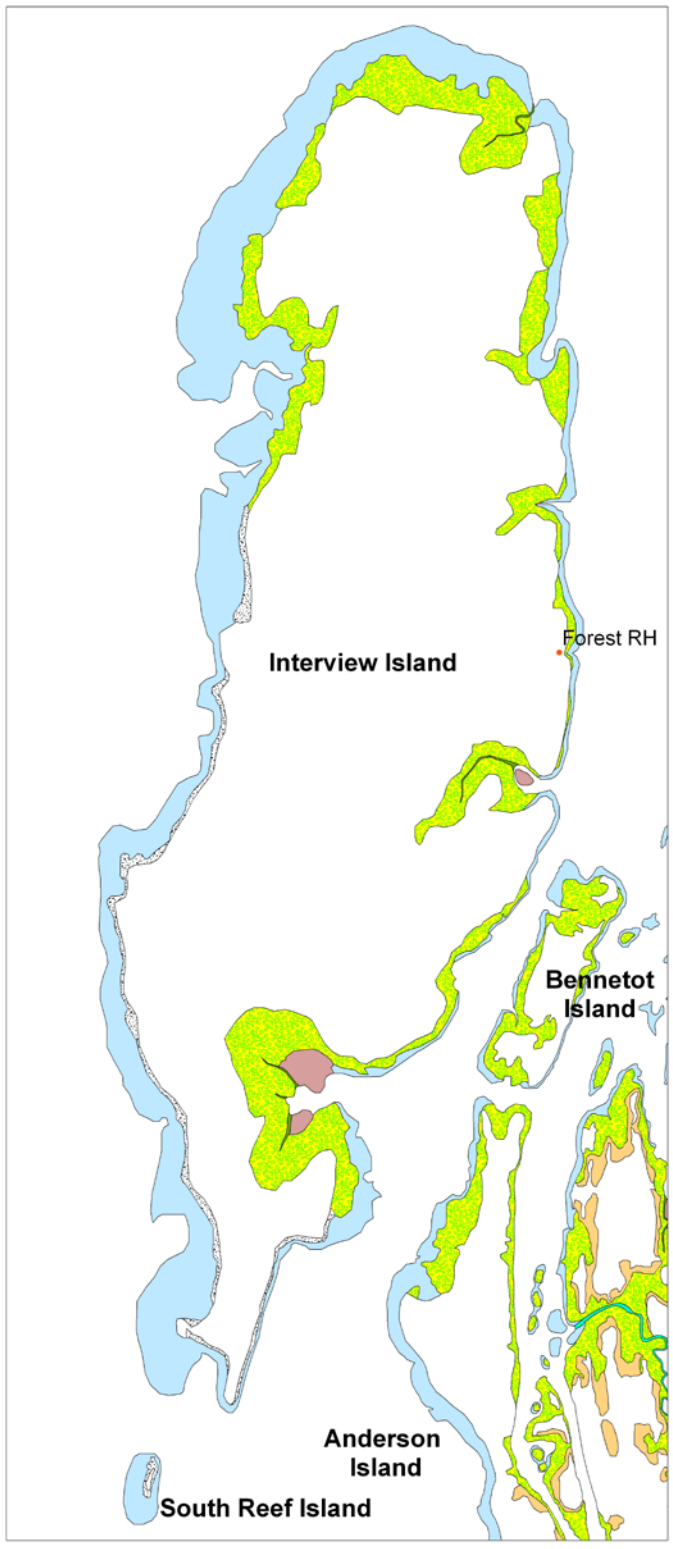


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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Legend

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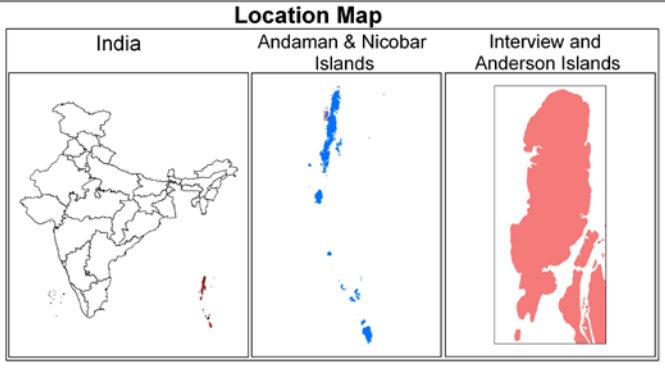
Location Map



0 1.25 2.5 5 Kilometers

Data Source :

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

Prepared By :

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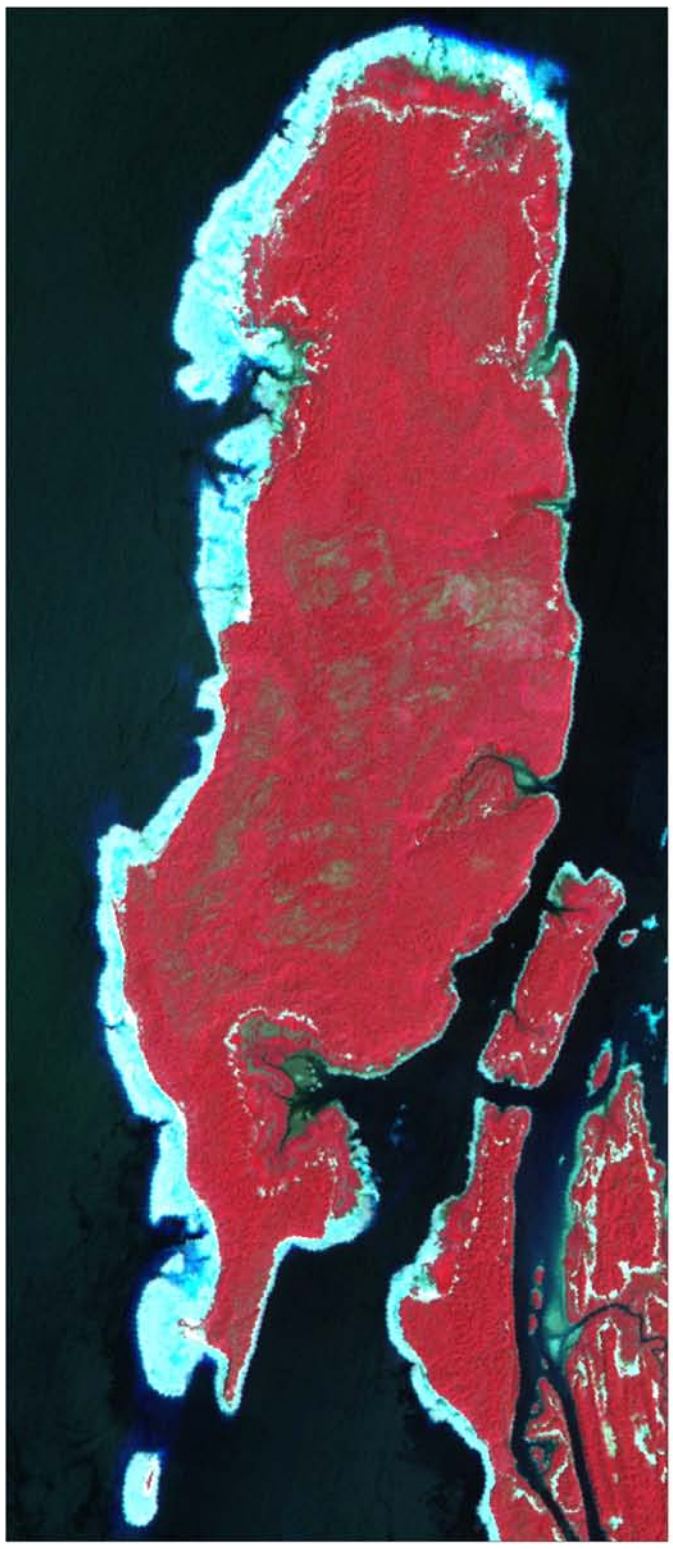
Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

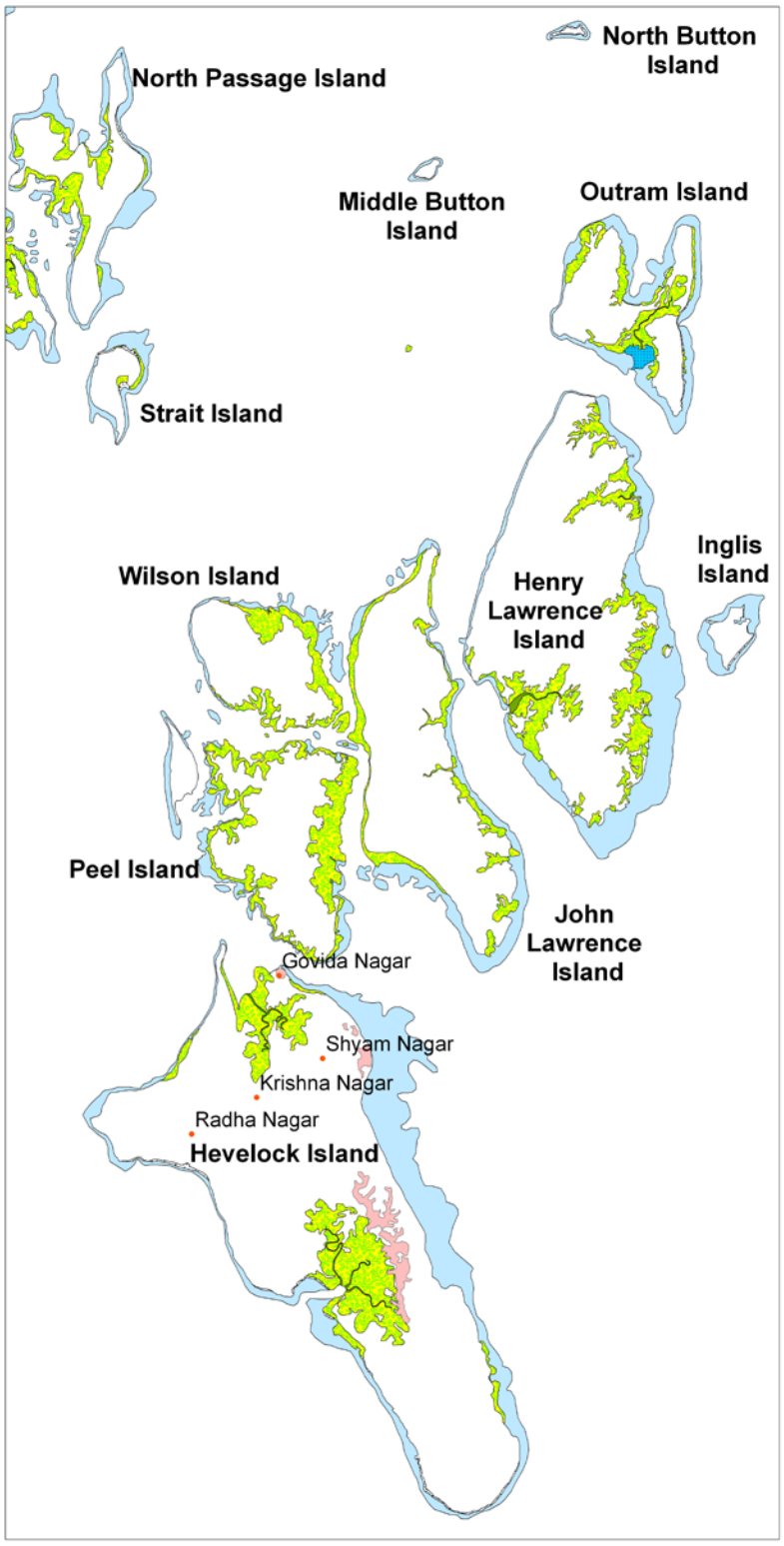


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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Legend

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- Roads
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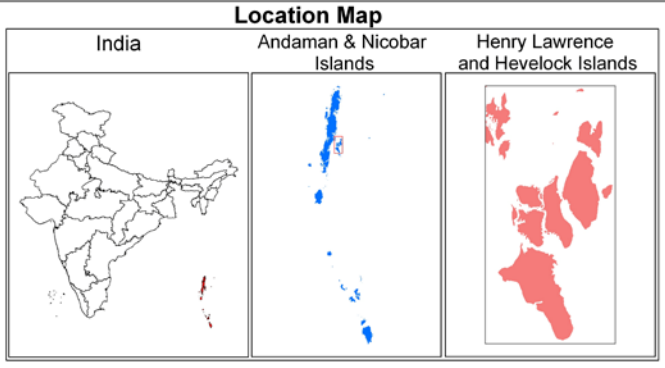
Location Map



0 2.5 5 10 Kilometers

Data Source :

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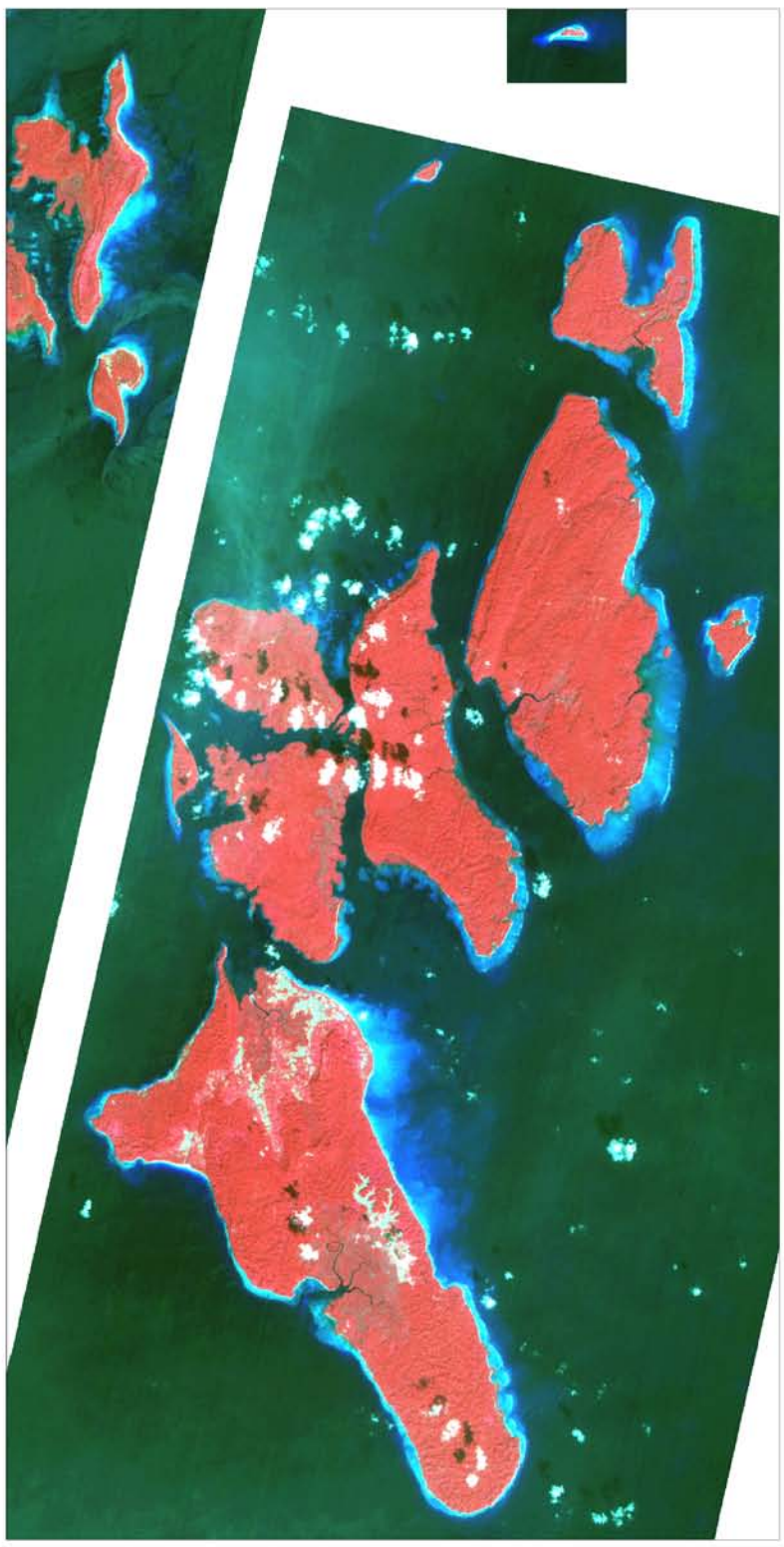
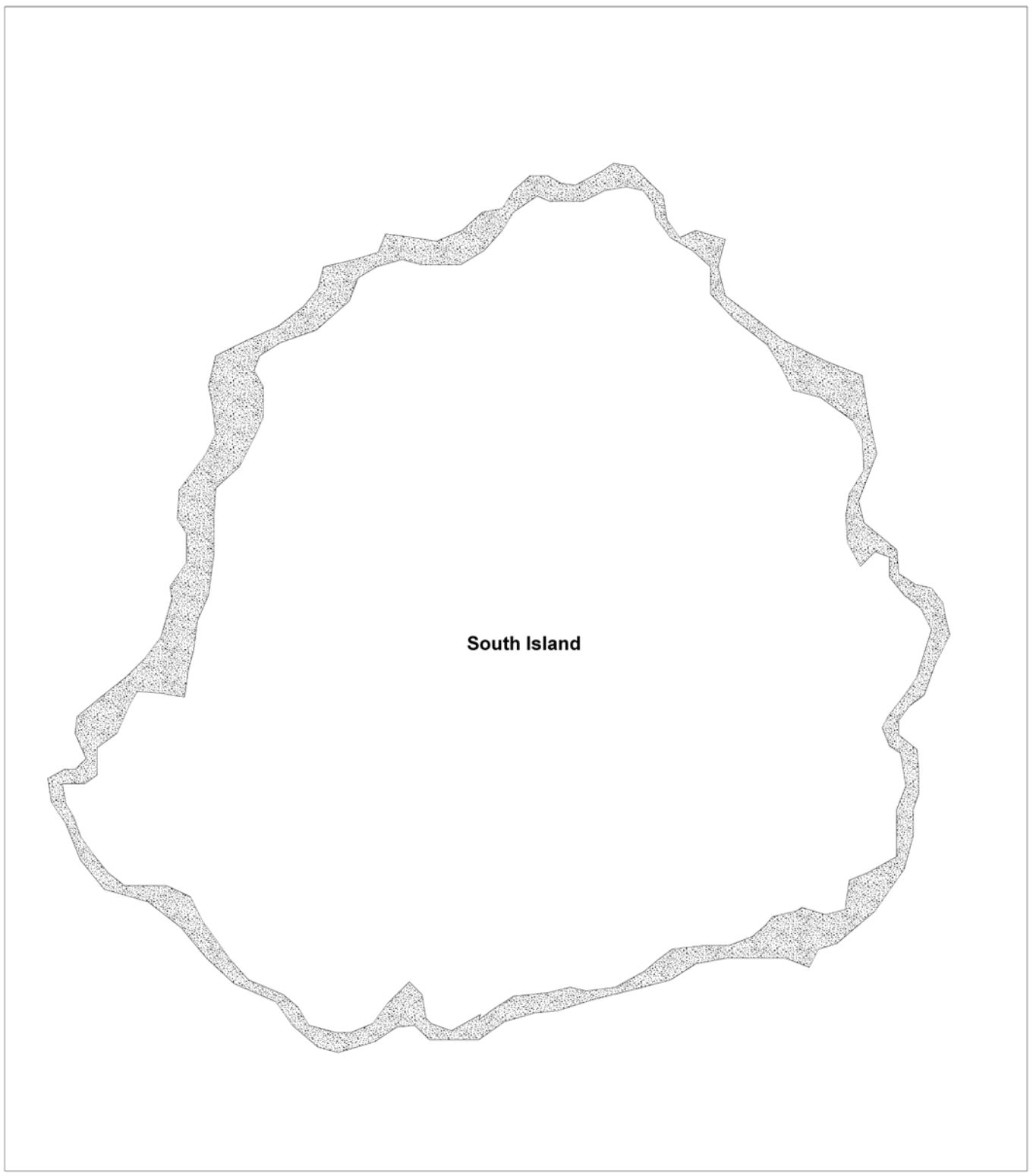


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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Legend

- Wetlands (<2.25ha)
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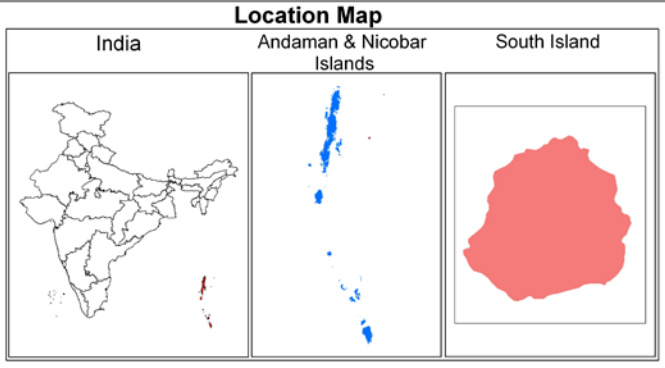
Location Map



0 0.25 0.5 1 Kilometers

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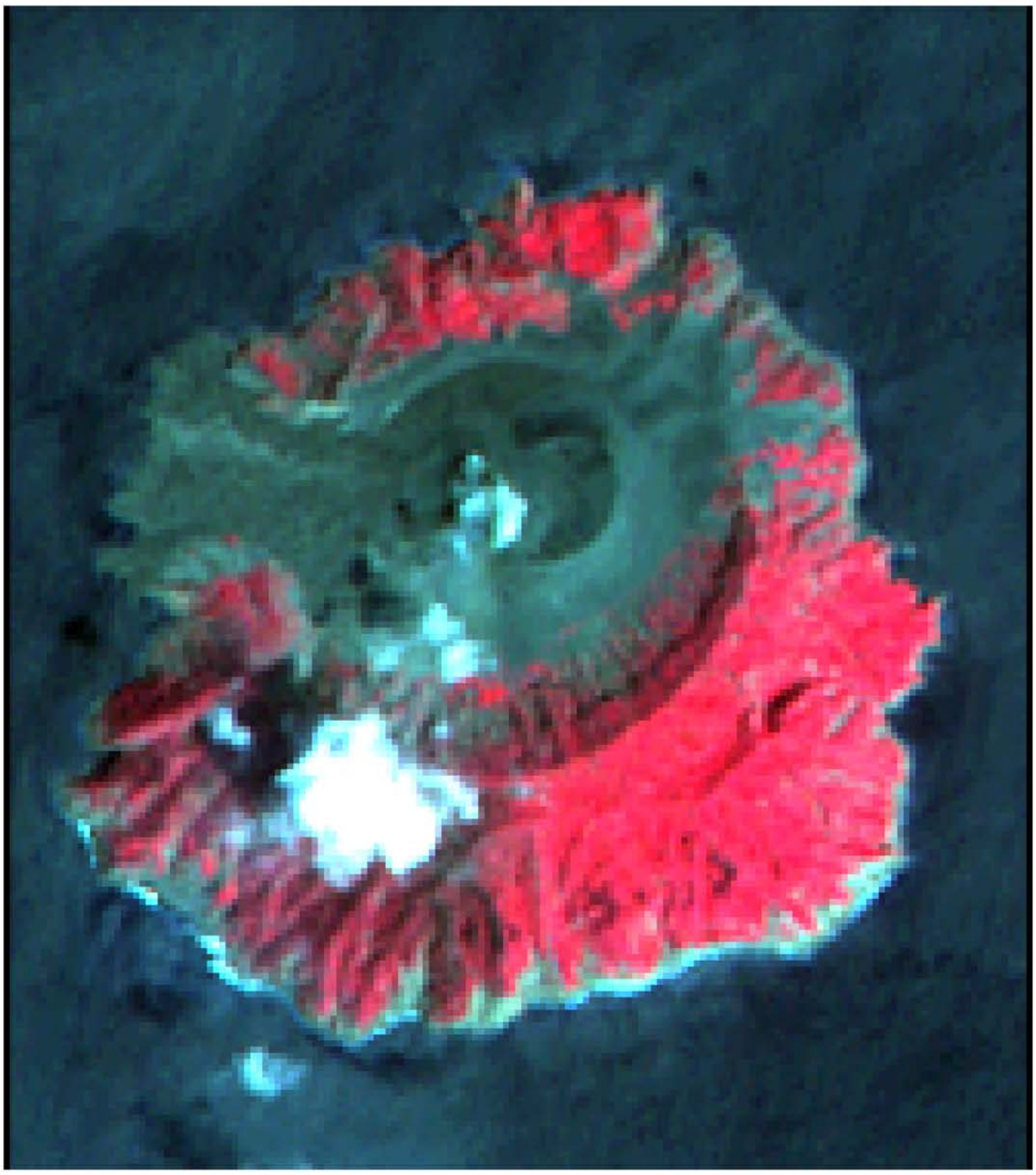

IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

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Legend

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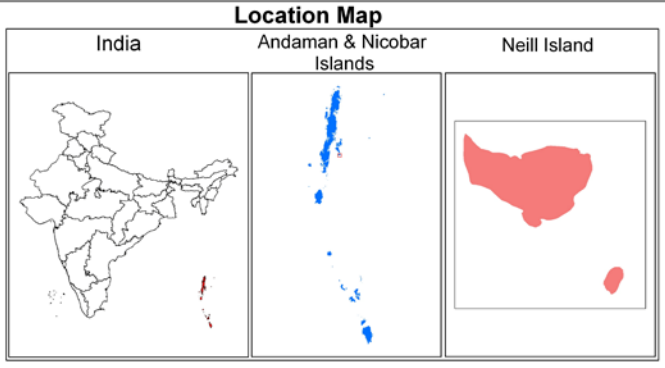

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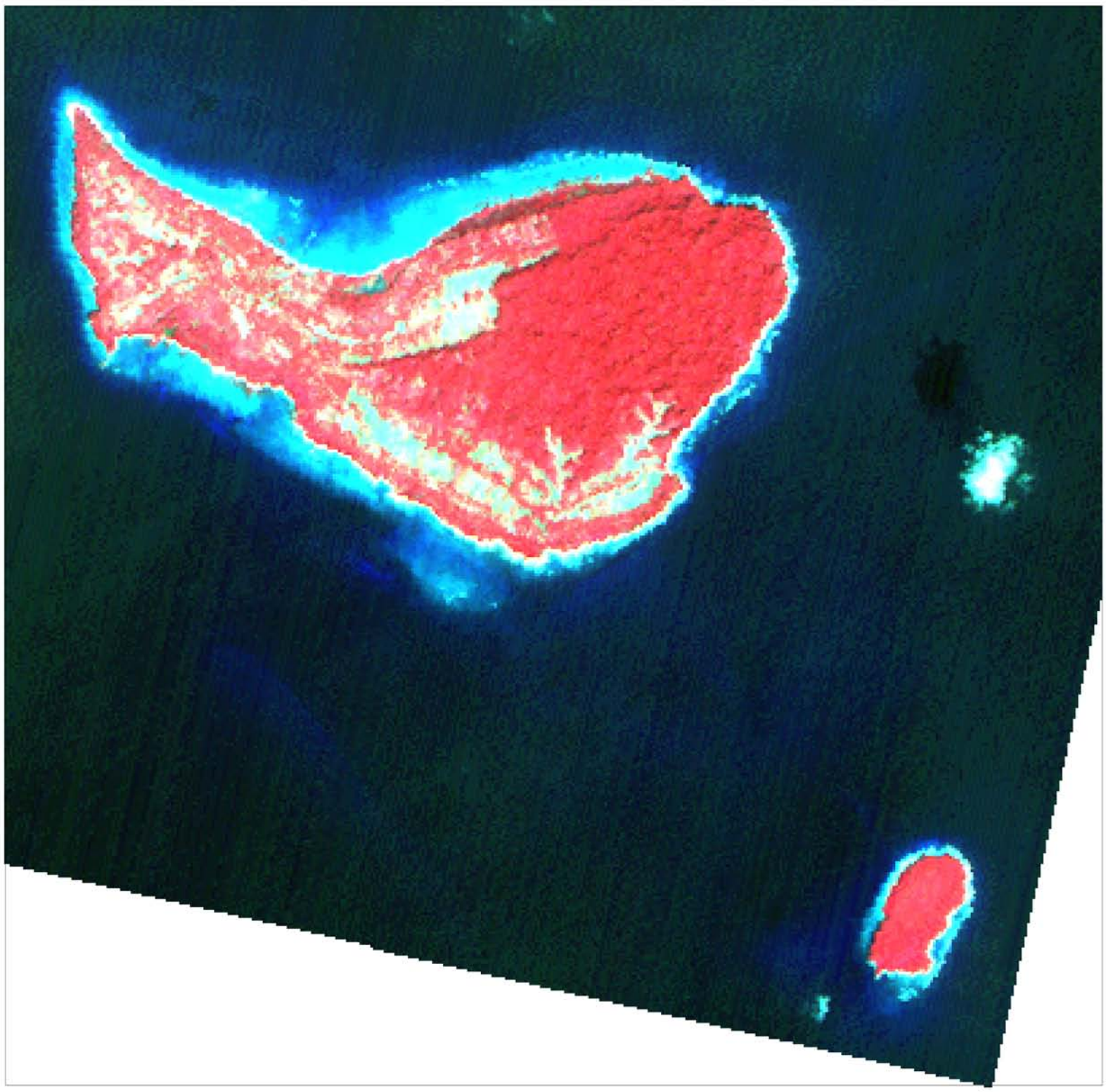

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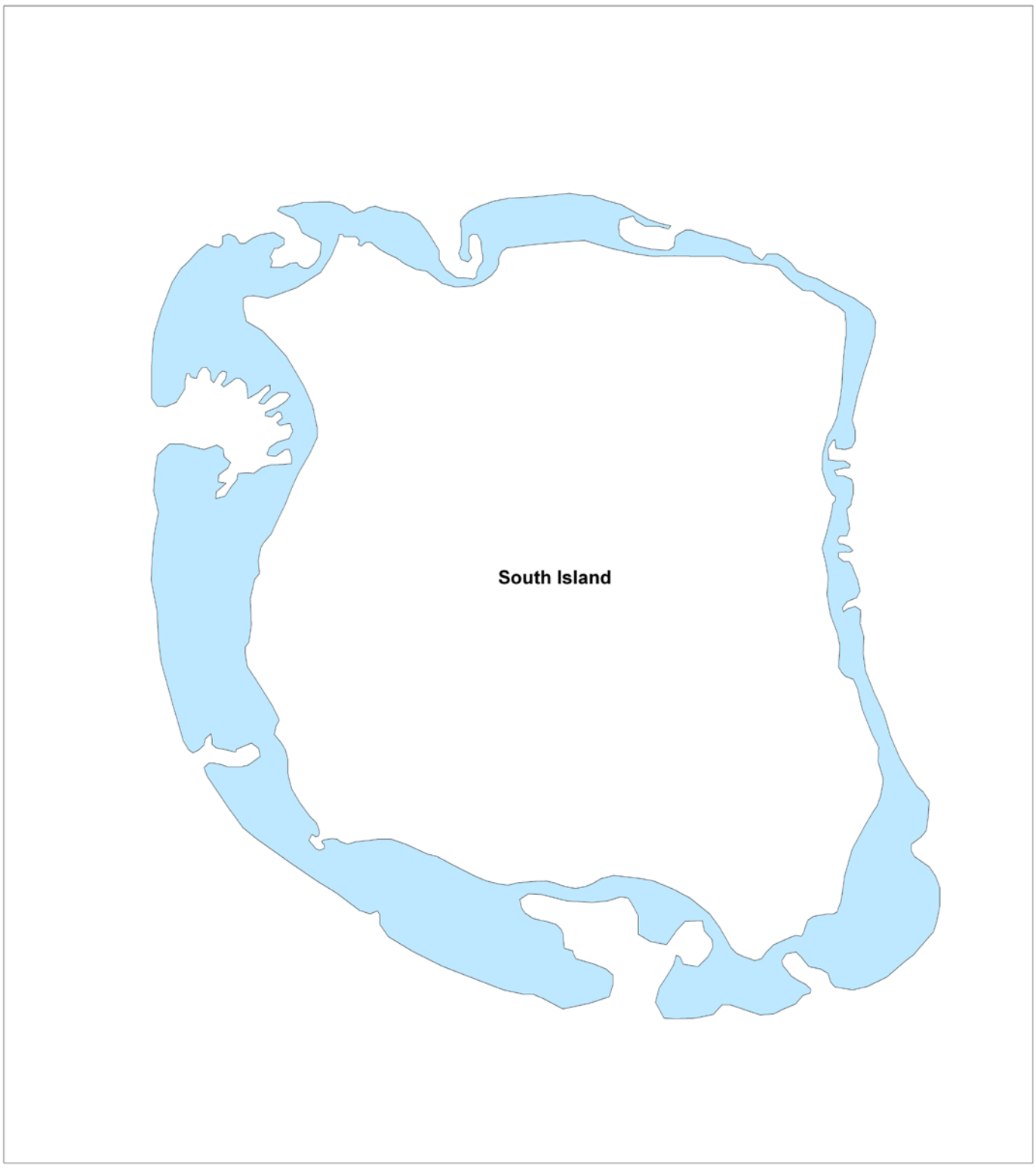

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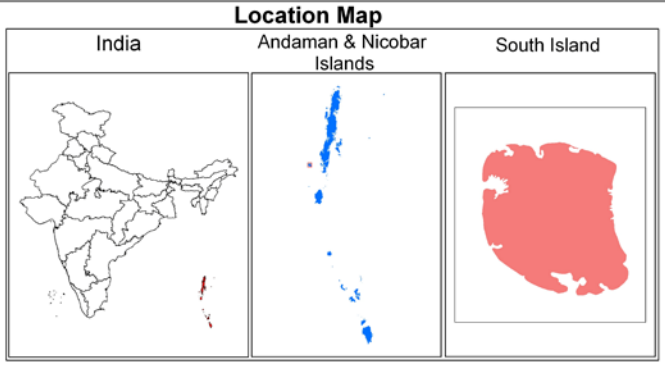

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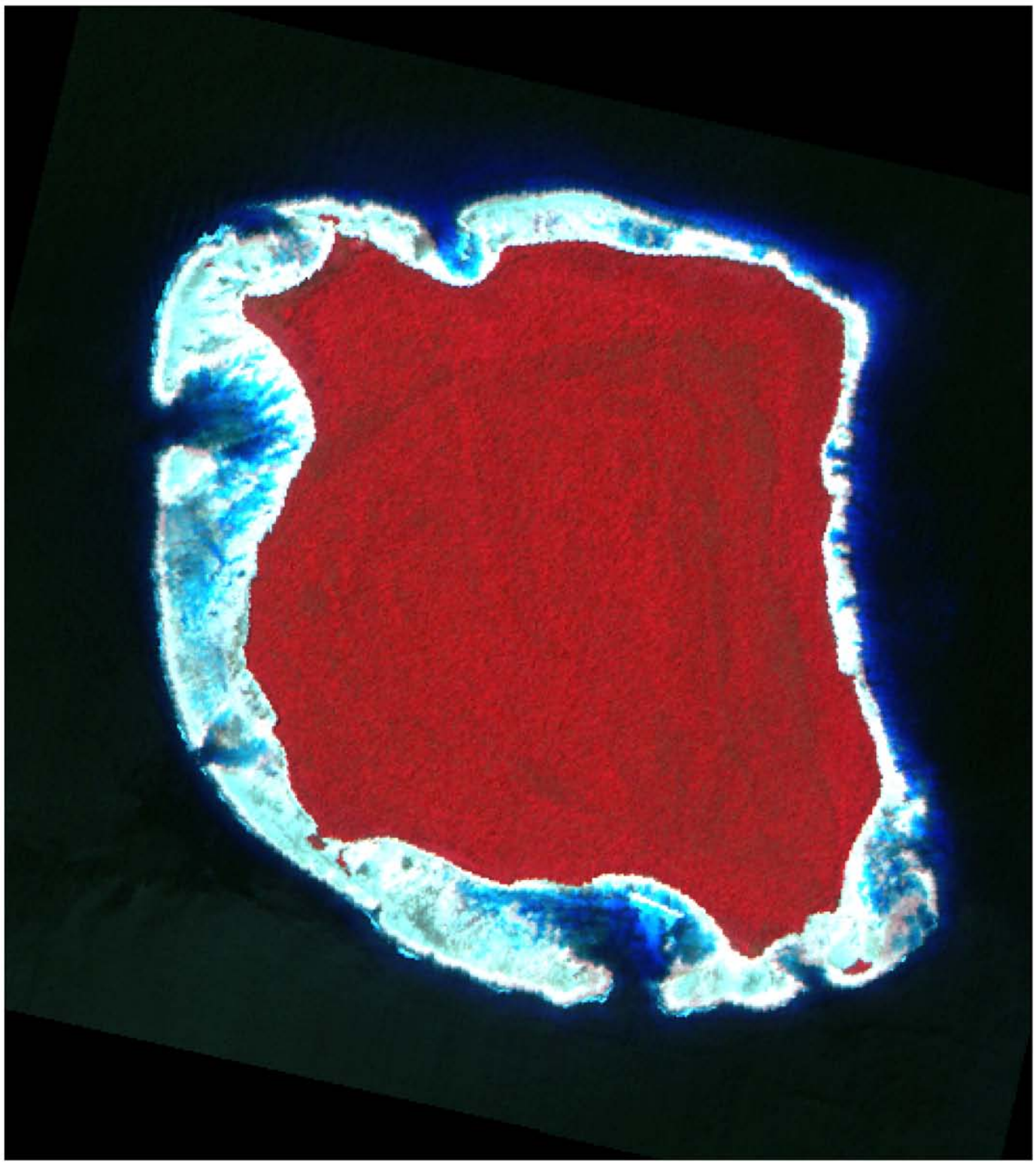

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WETLAND MAP

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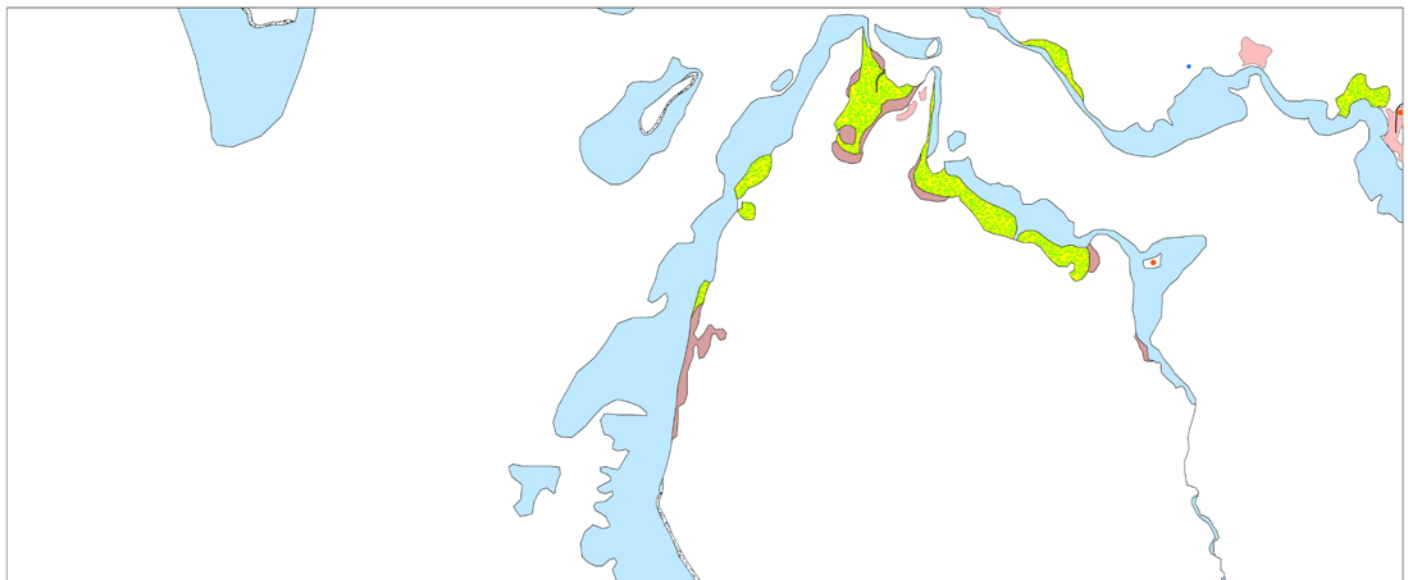

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Legend

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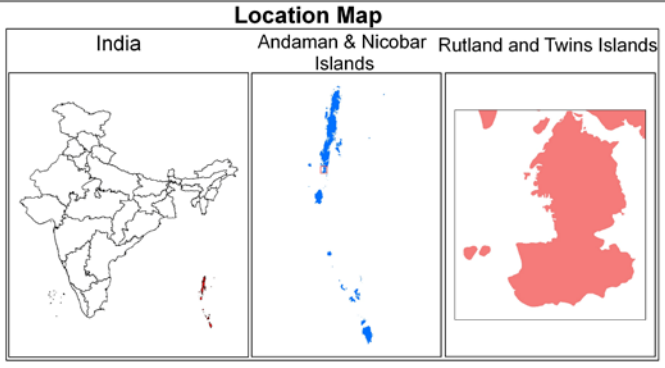

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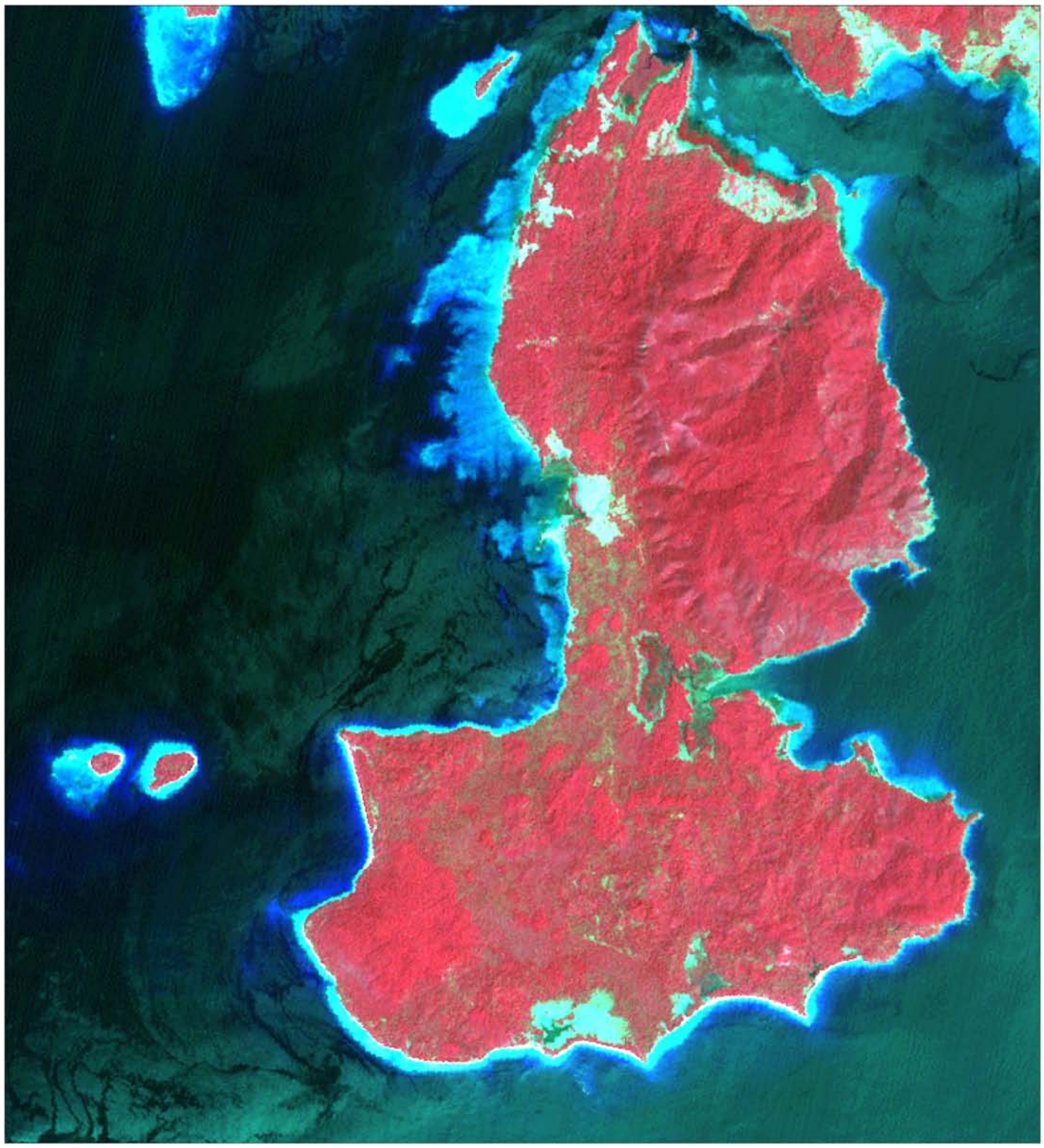

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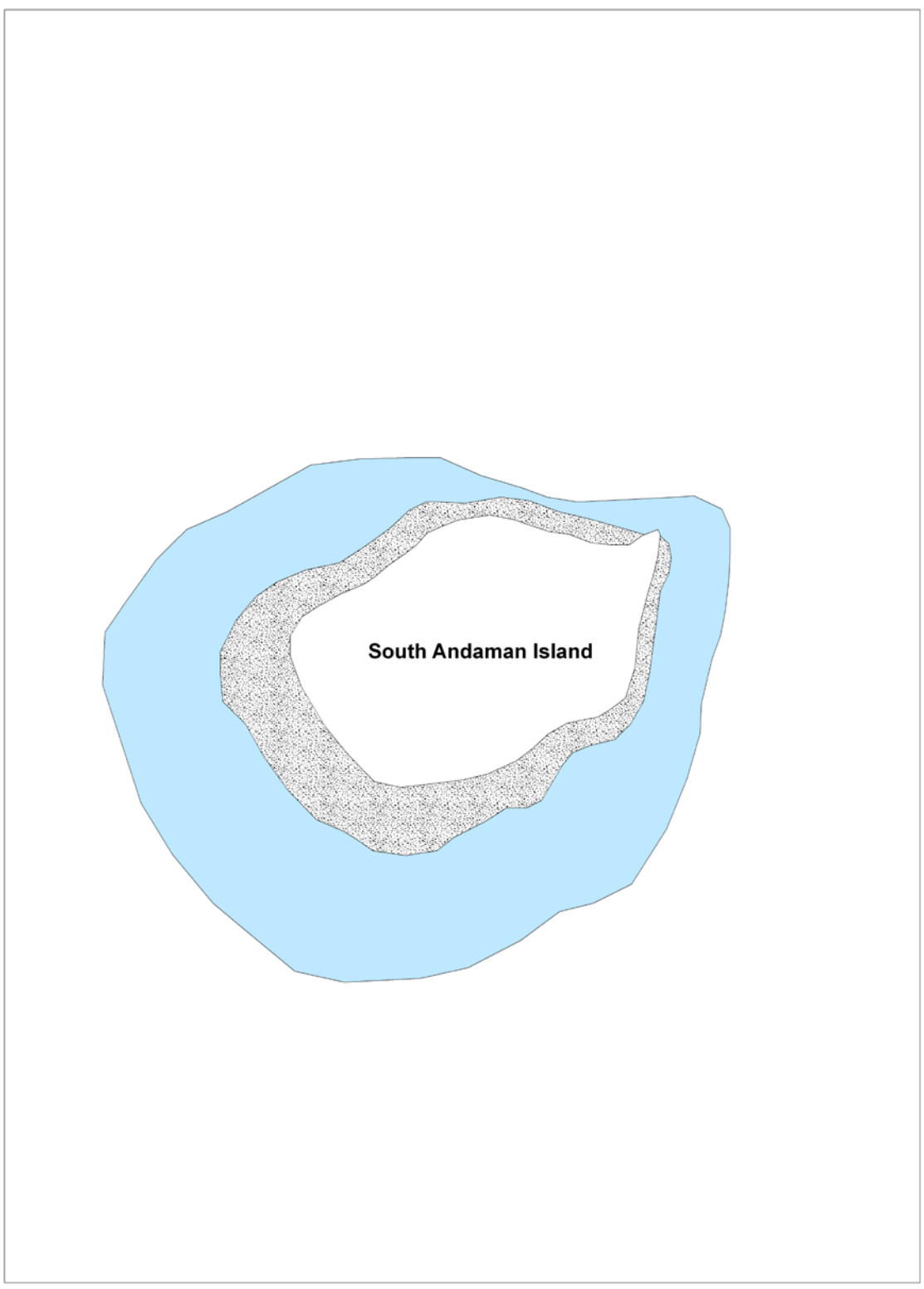
WETLAND MAP

District : Andaman

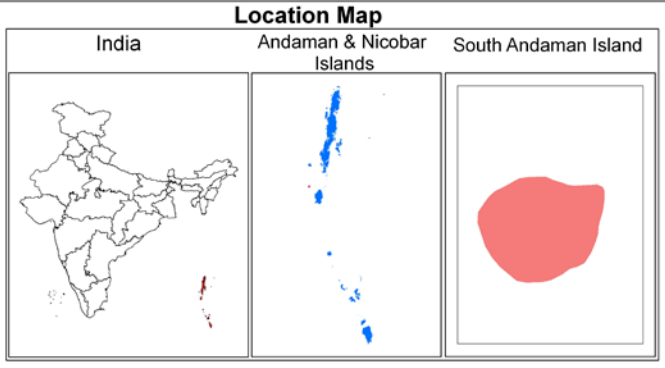


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

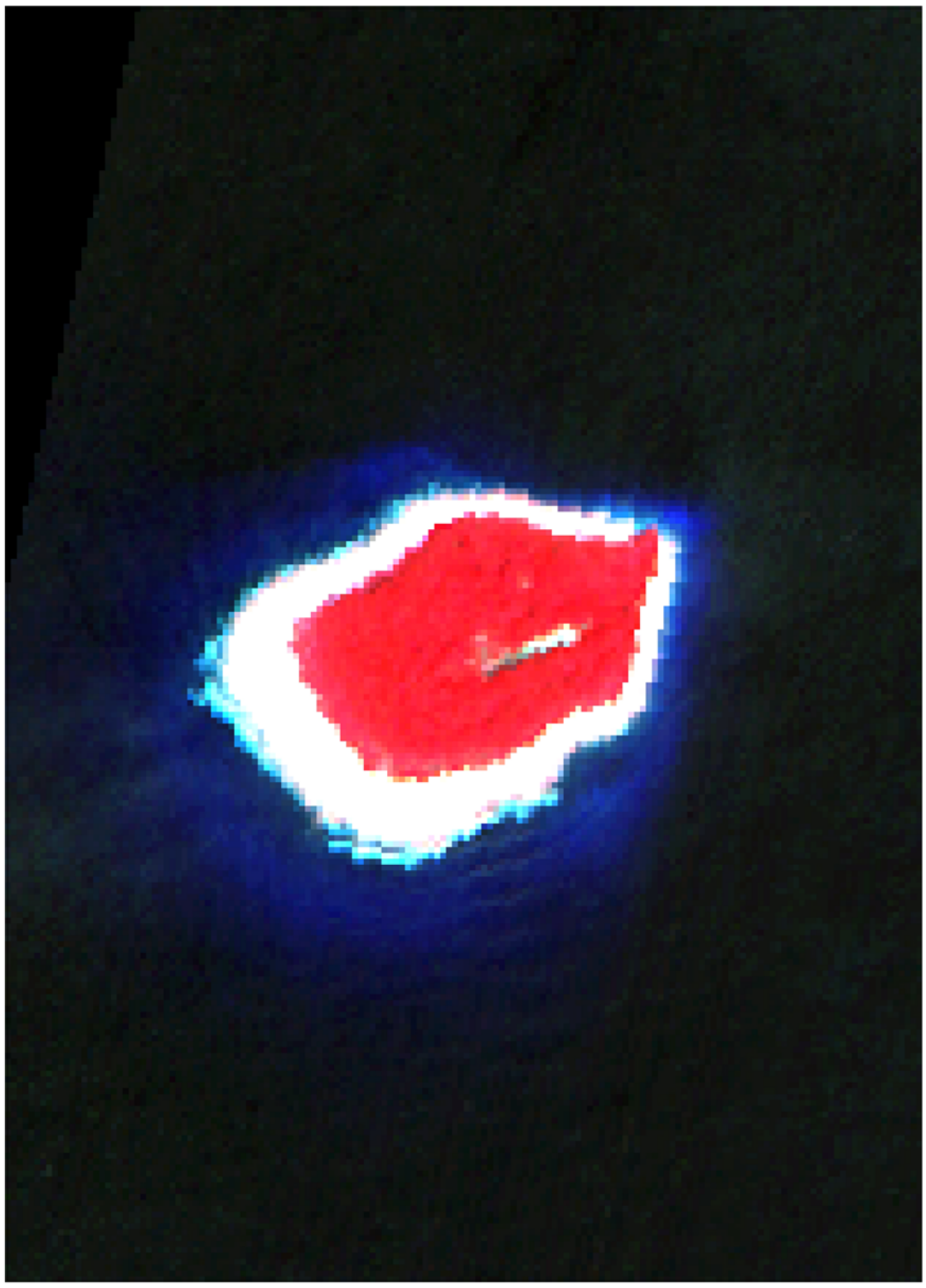
Sponsored By:

Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

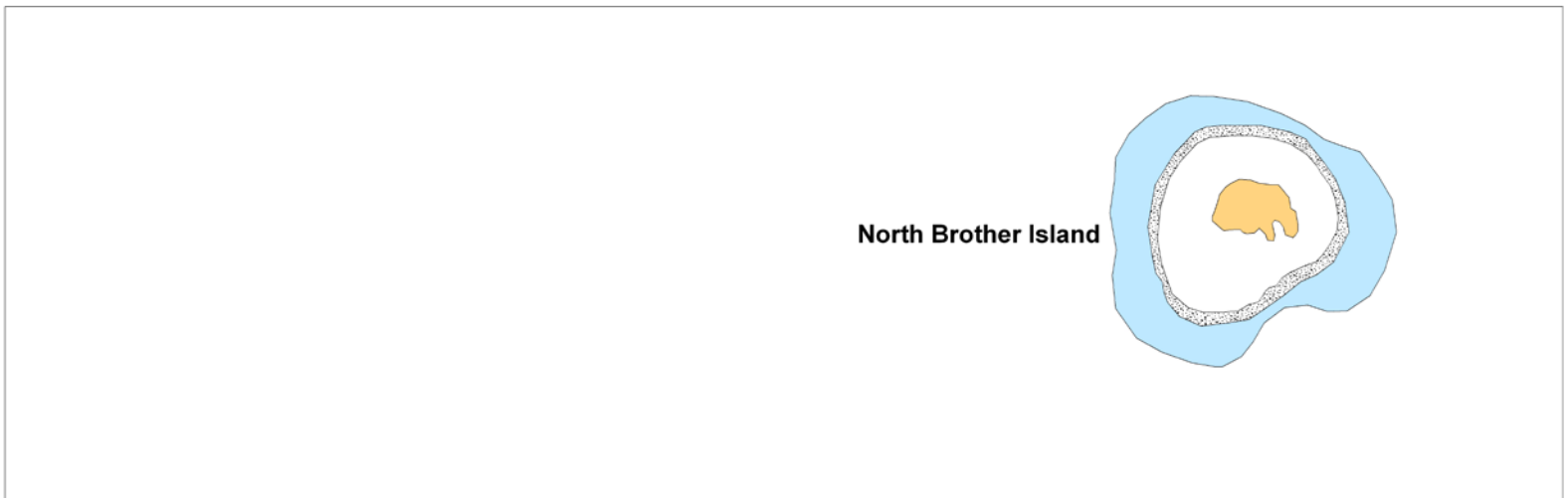


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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Legend

- Wetlands (<2.25ha)
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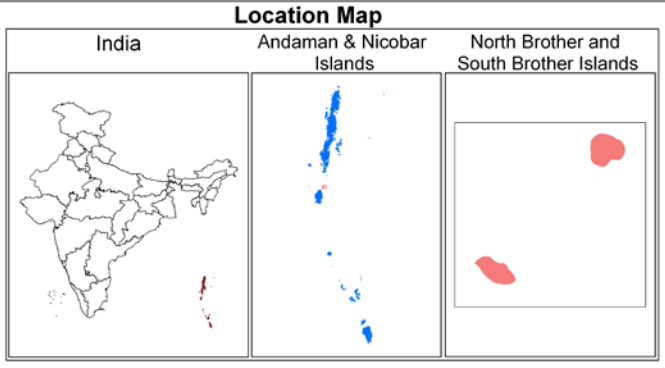
Location Map



0 0.5 1 2 Kilometers

Data Source :

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

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Government of India

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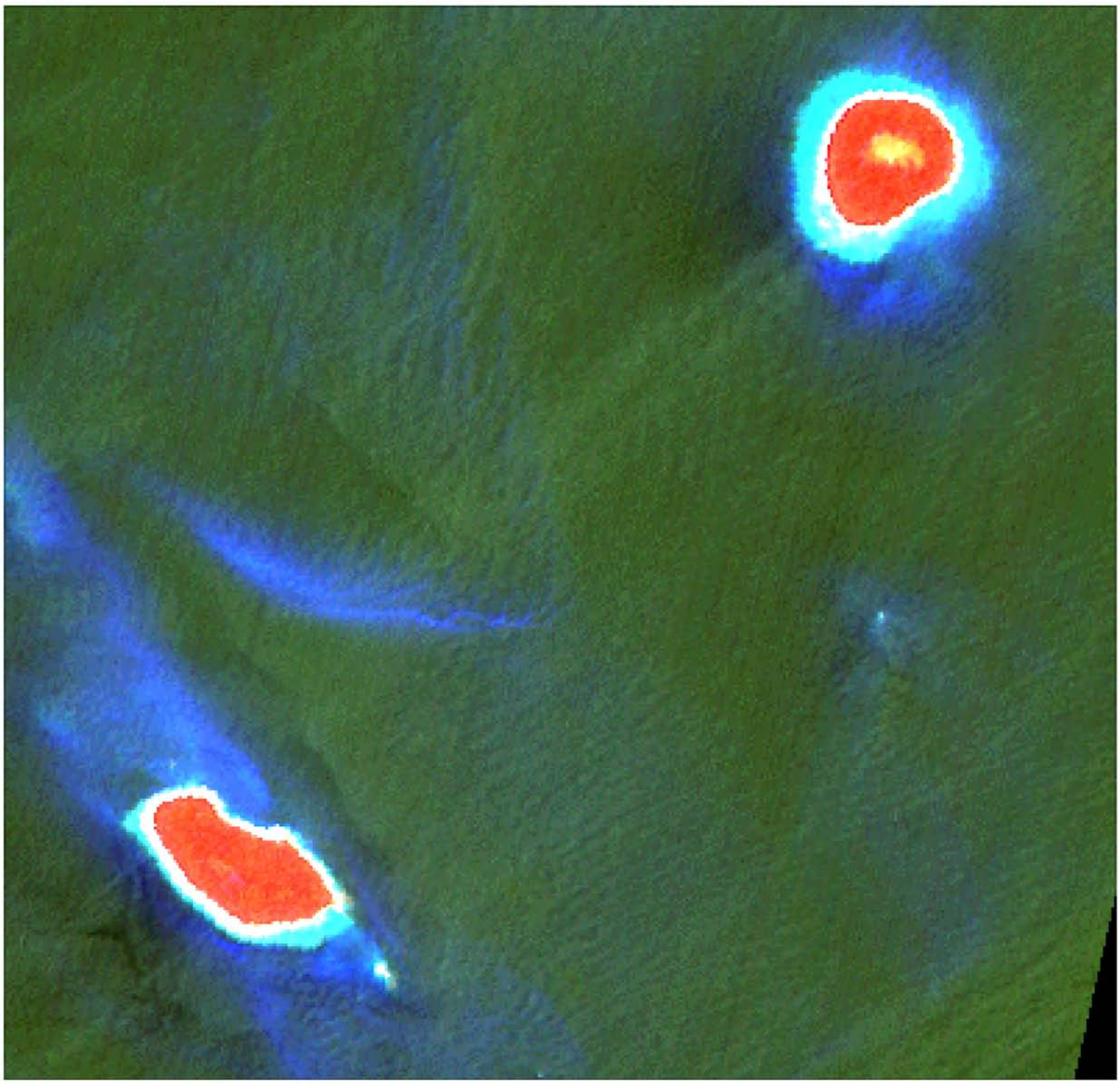
WETLAND MAP

District : Andaman

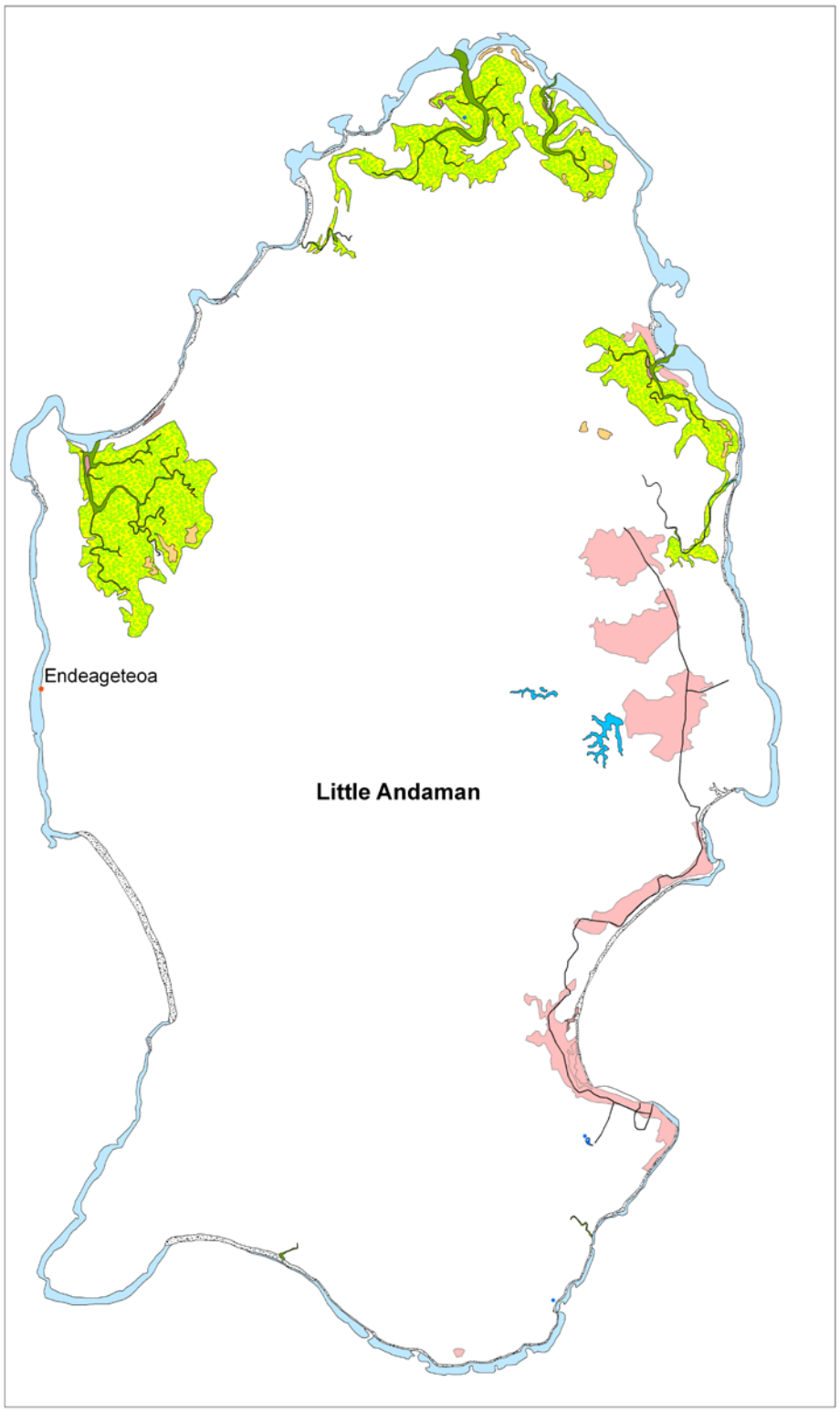


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



Symbol	Typecode	Level I	Level II	Level III
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Legend

- Wetlands (<2.25ha)
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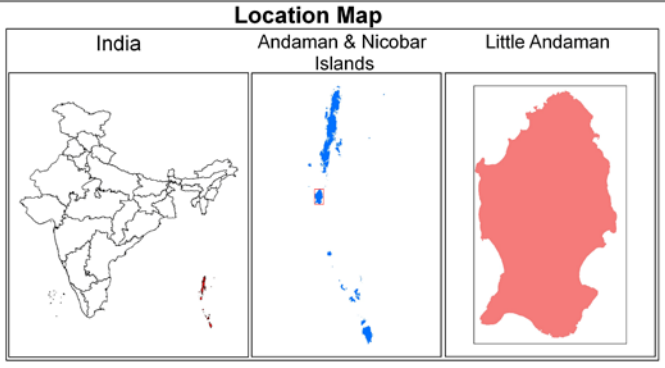
Location Map



0 2.5 5 10 Kilometers

Data Source :

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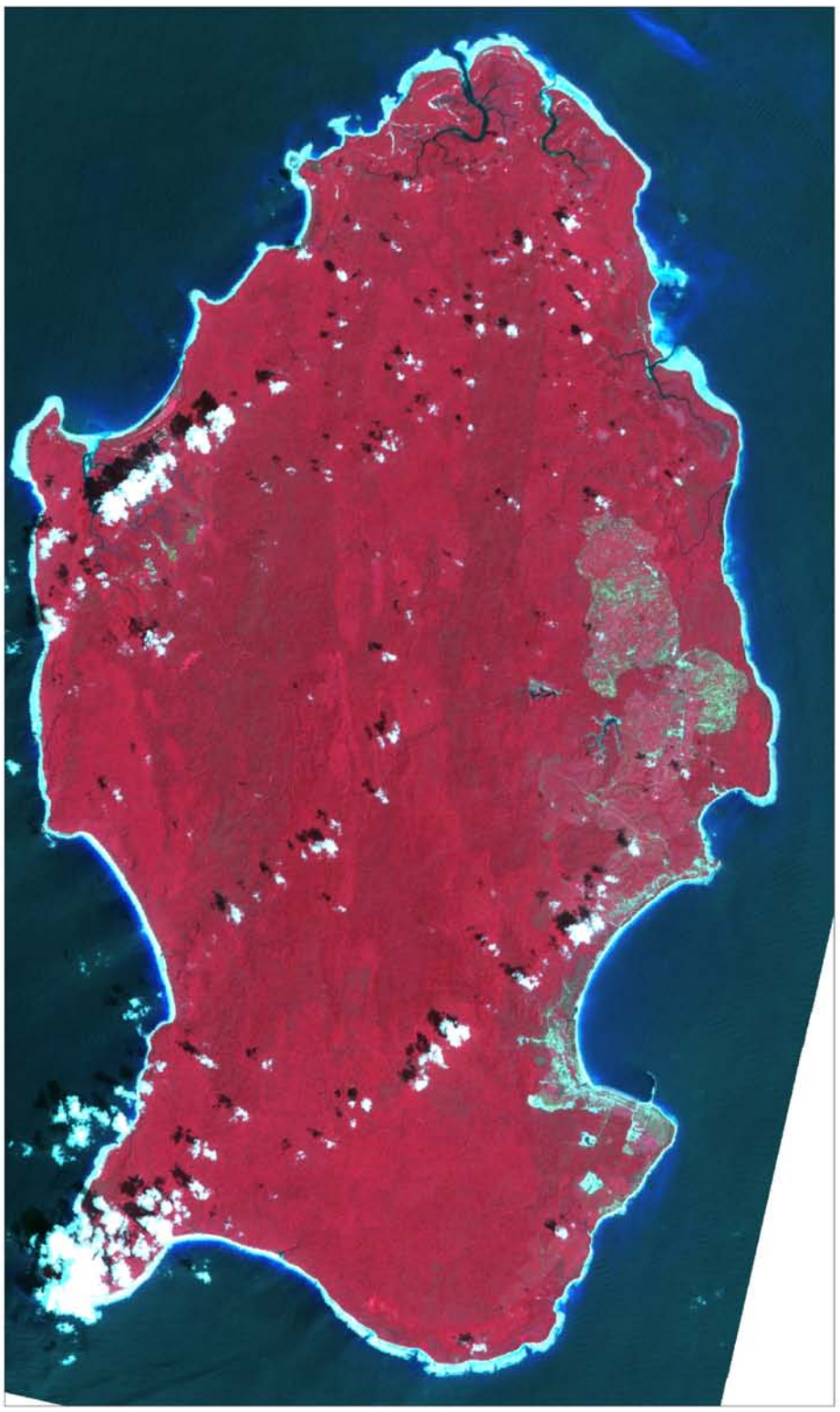
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman

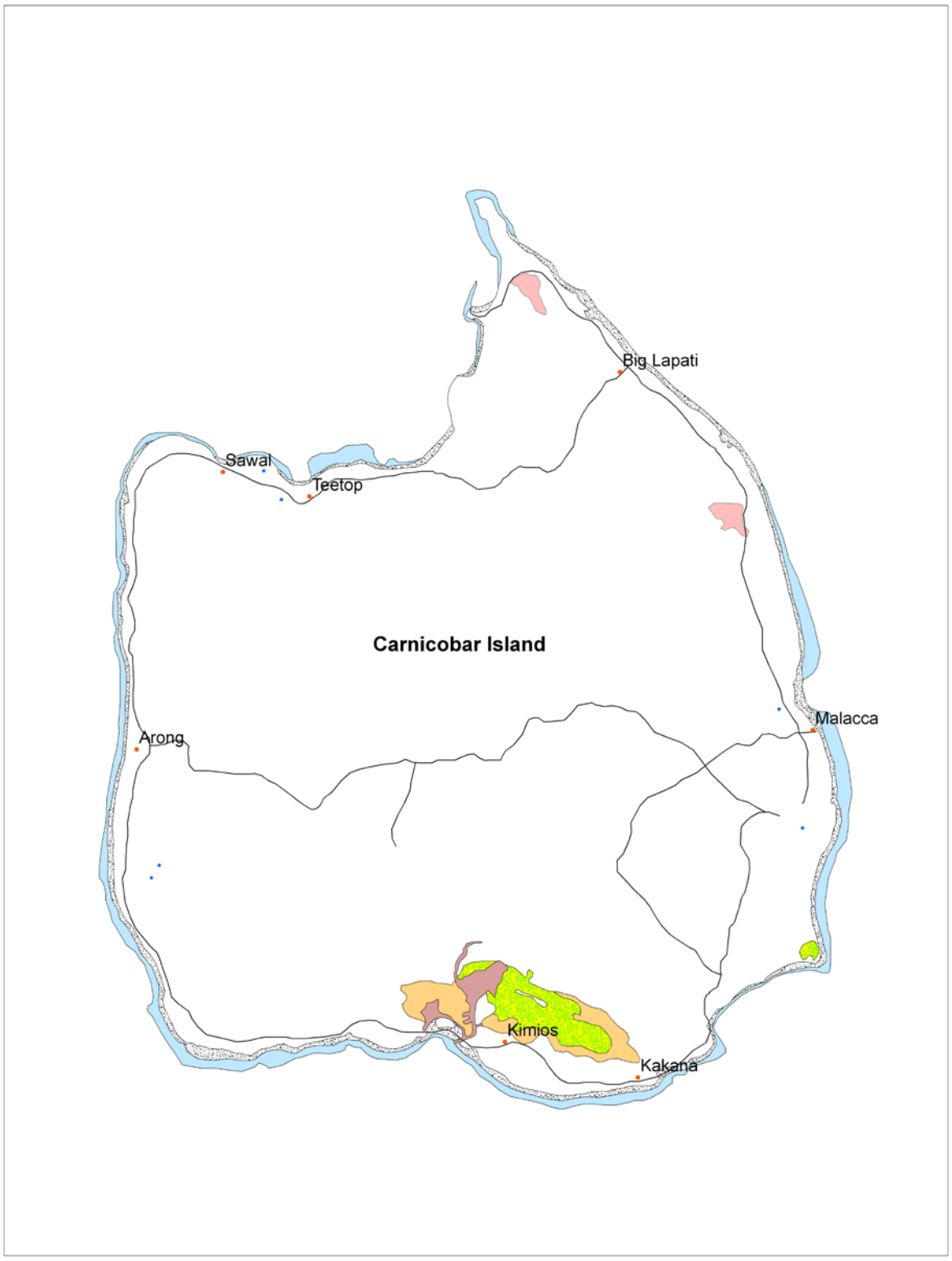


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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		Inland Wetlands		
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	1101			Lakes/Ponds
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Legend

- Wetlands (<2.25ha)
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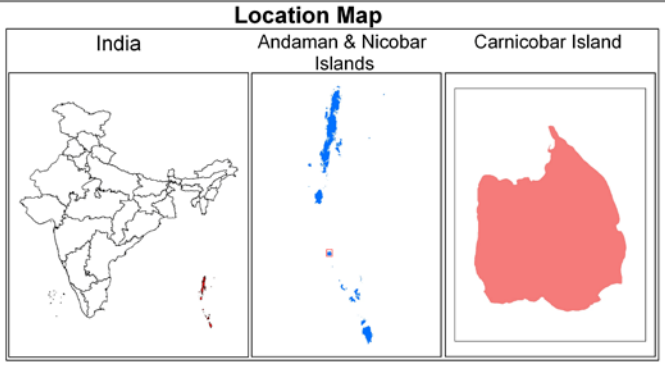
- Town/Settlements

Location Map



0 1.25 2.5 5 Kilometers

Data Source :

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WETLAND MAP

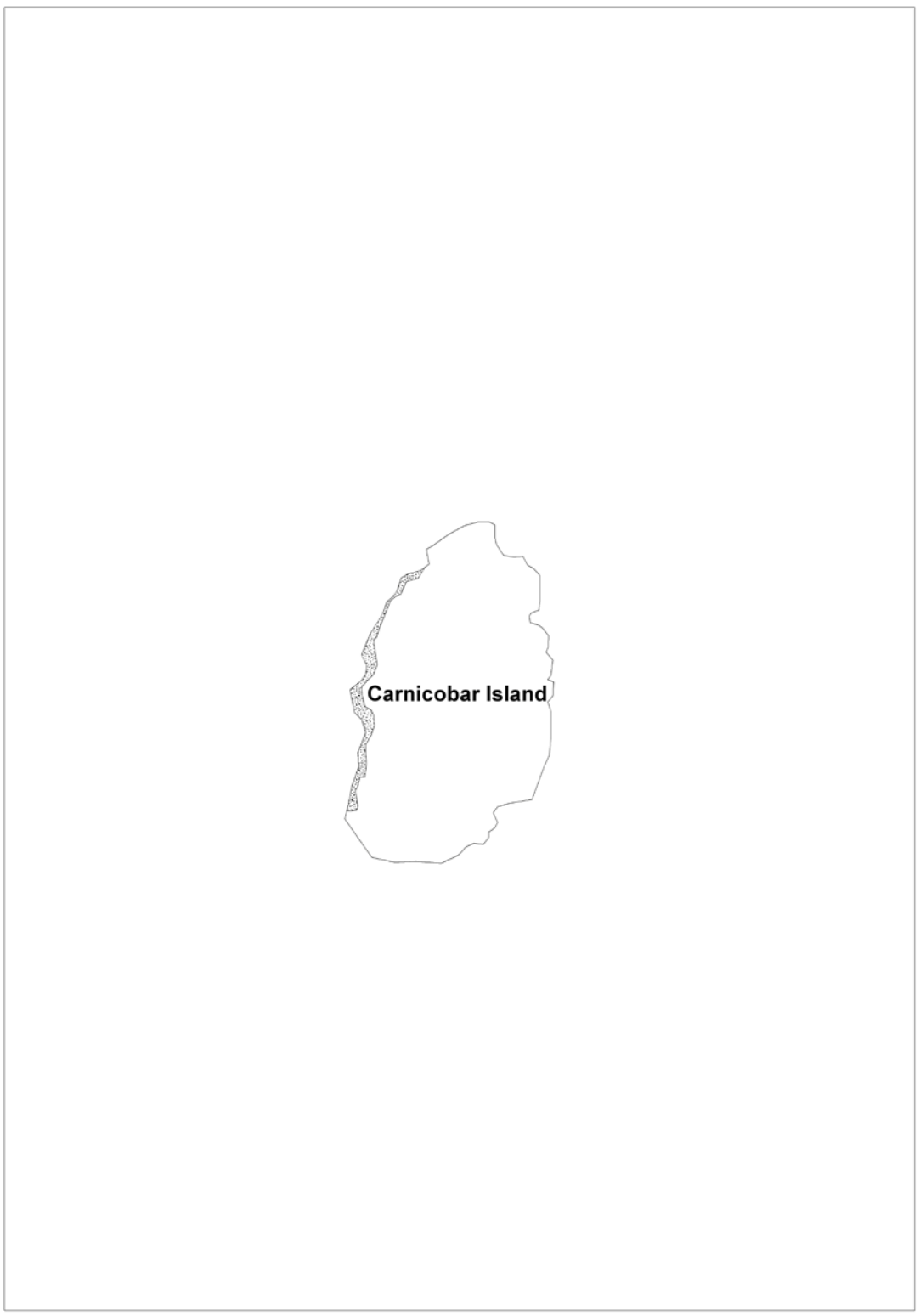
District : Nicobar

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

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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Legend

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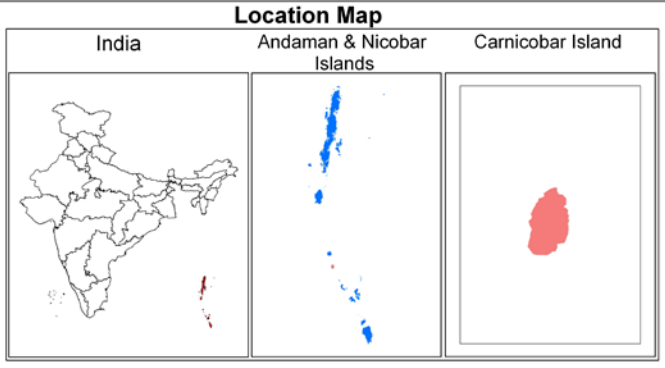
Location Map



0 0.5 1 2 Kilometers

Data Source :

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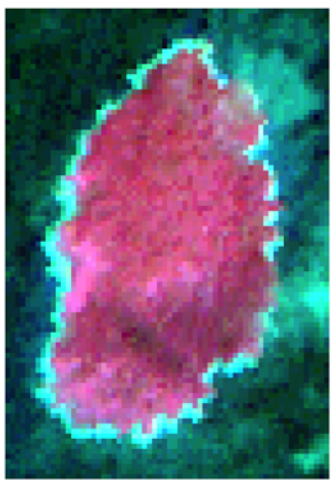
UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar

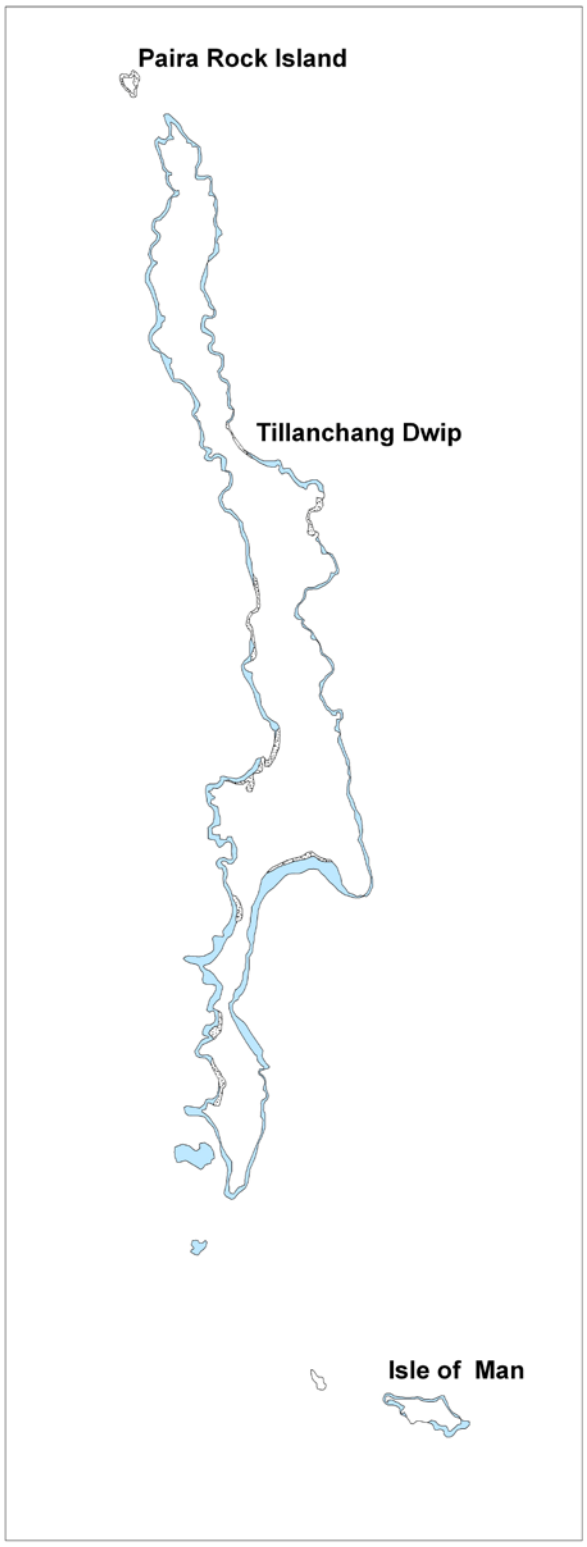


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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Legend

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- Settlements
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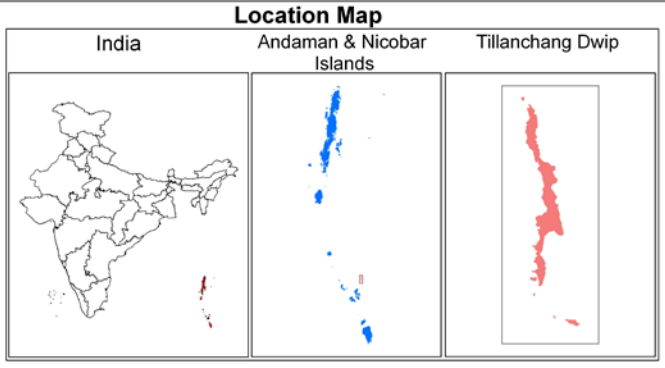

0 1.25 2.5 5 Kilometers

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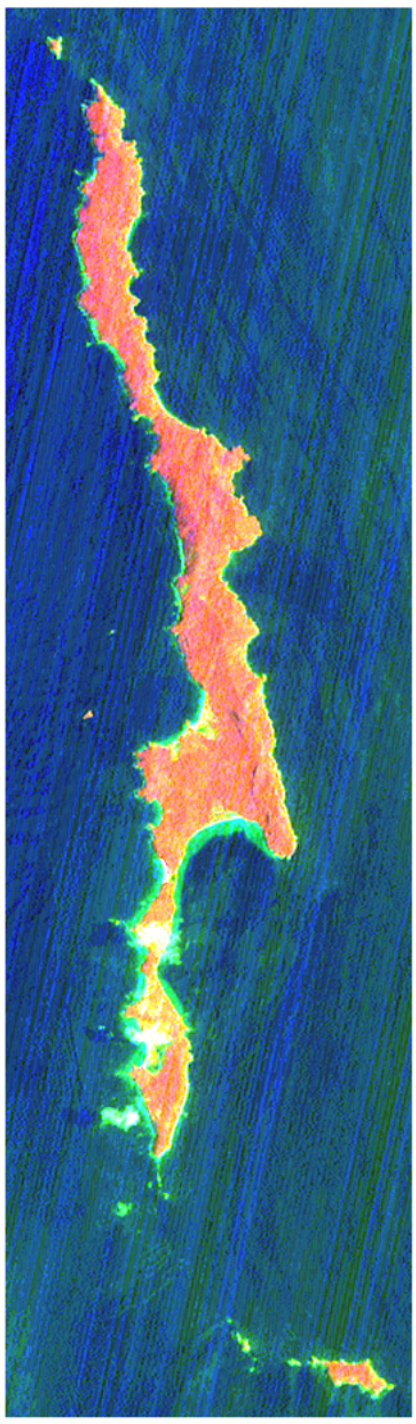
WETLAND MAP

District : Nicobar

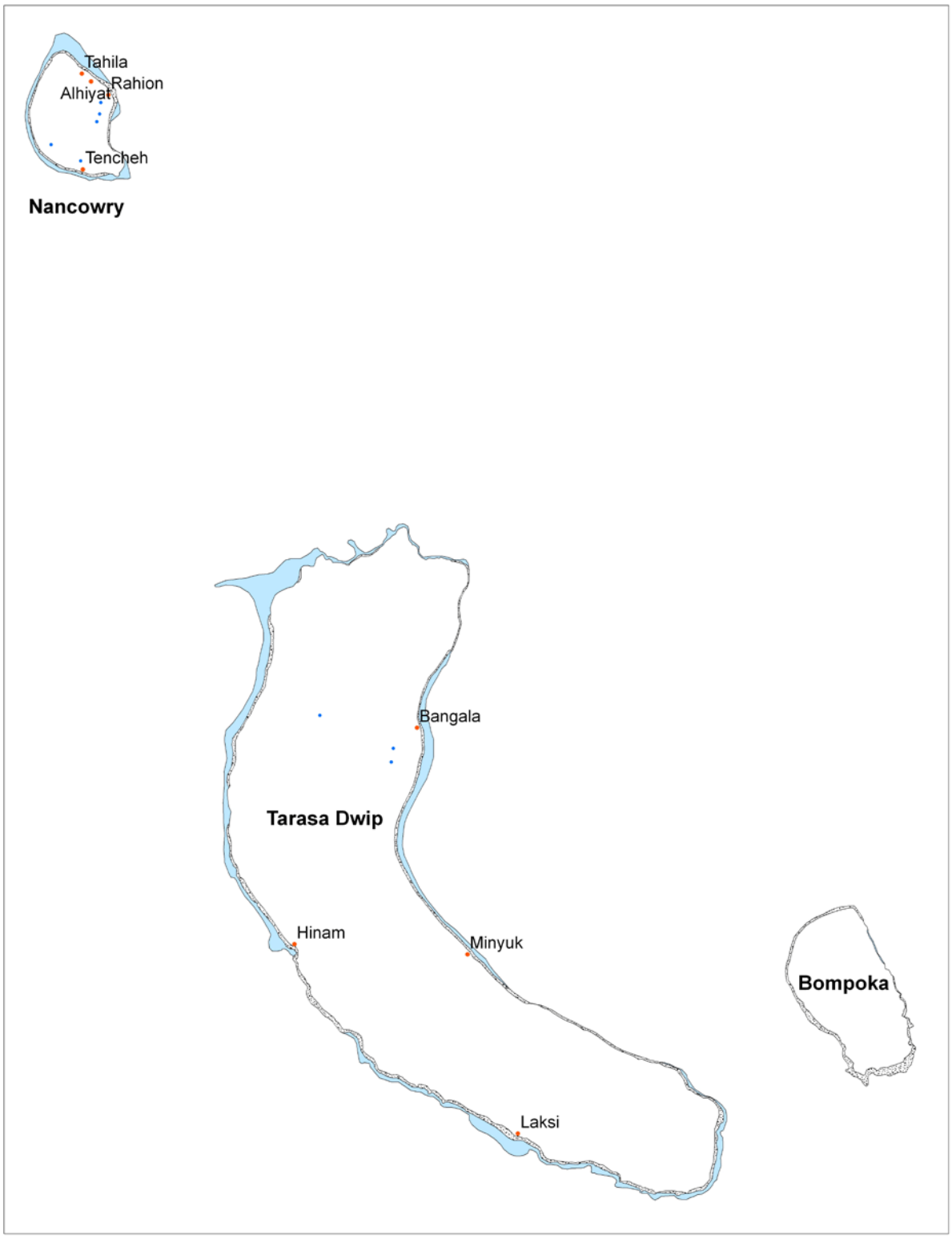


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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Legend

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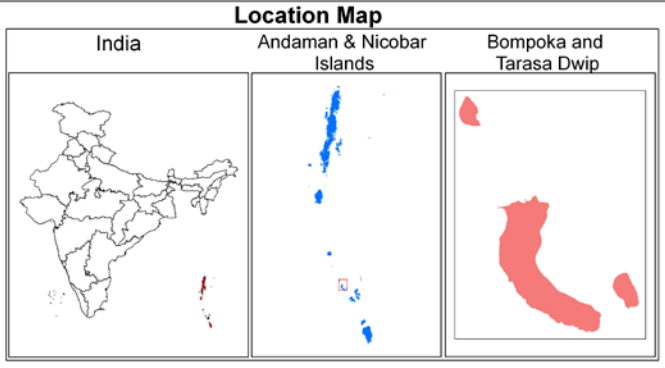

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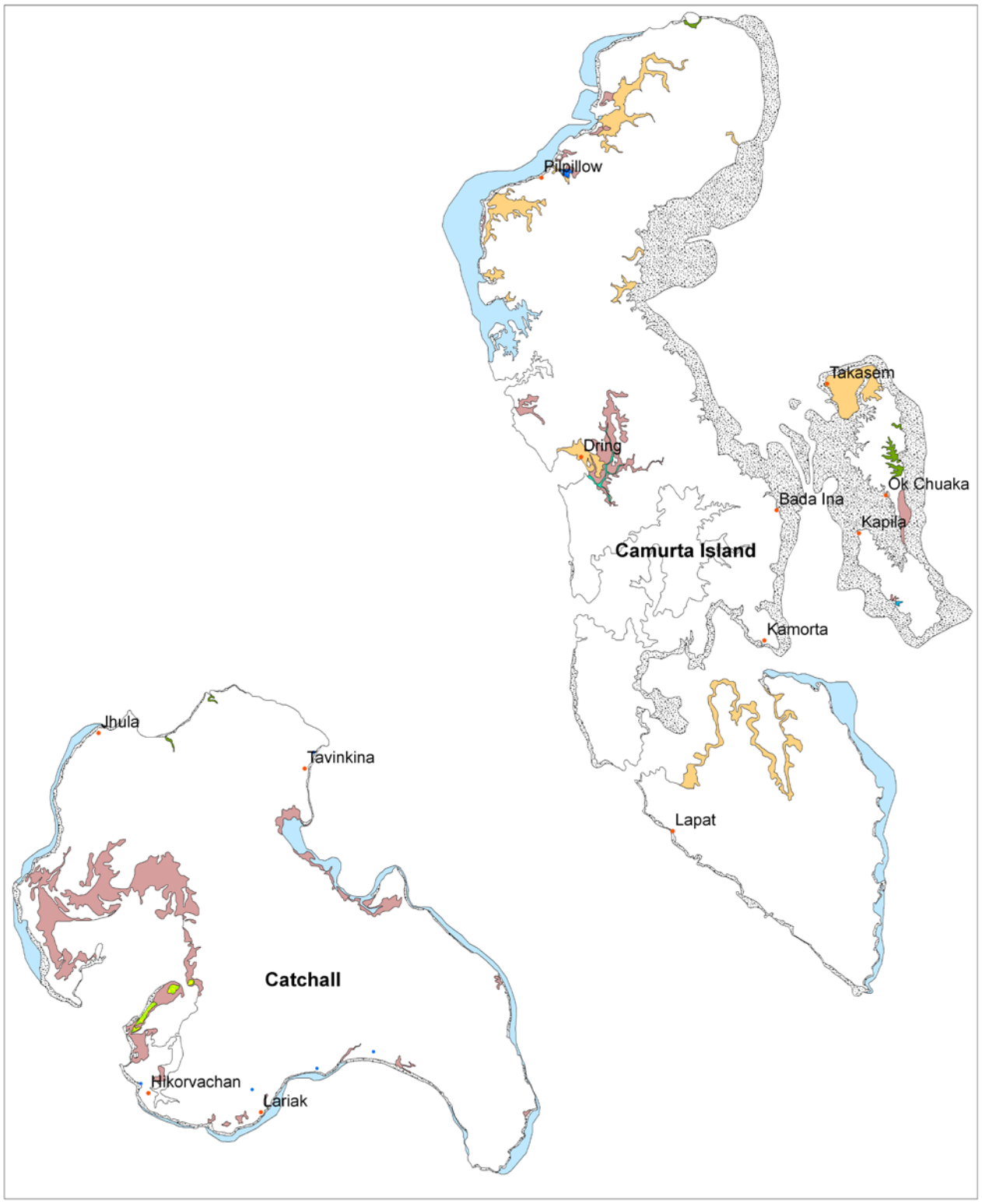
IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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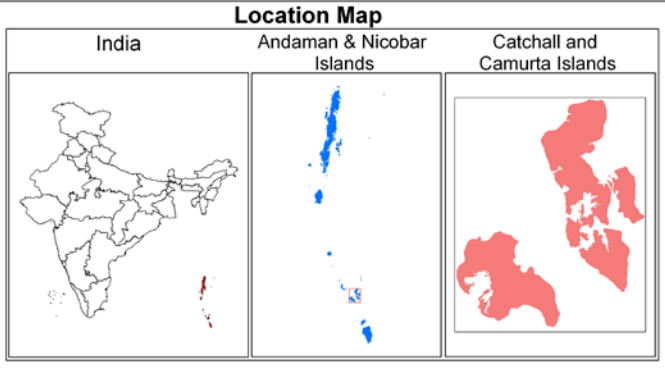
Legend

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

Location Map



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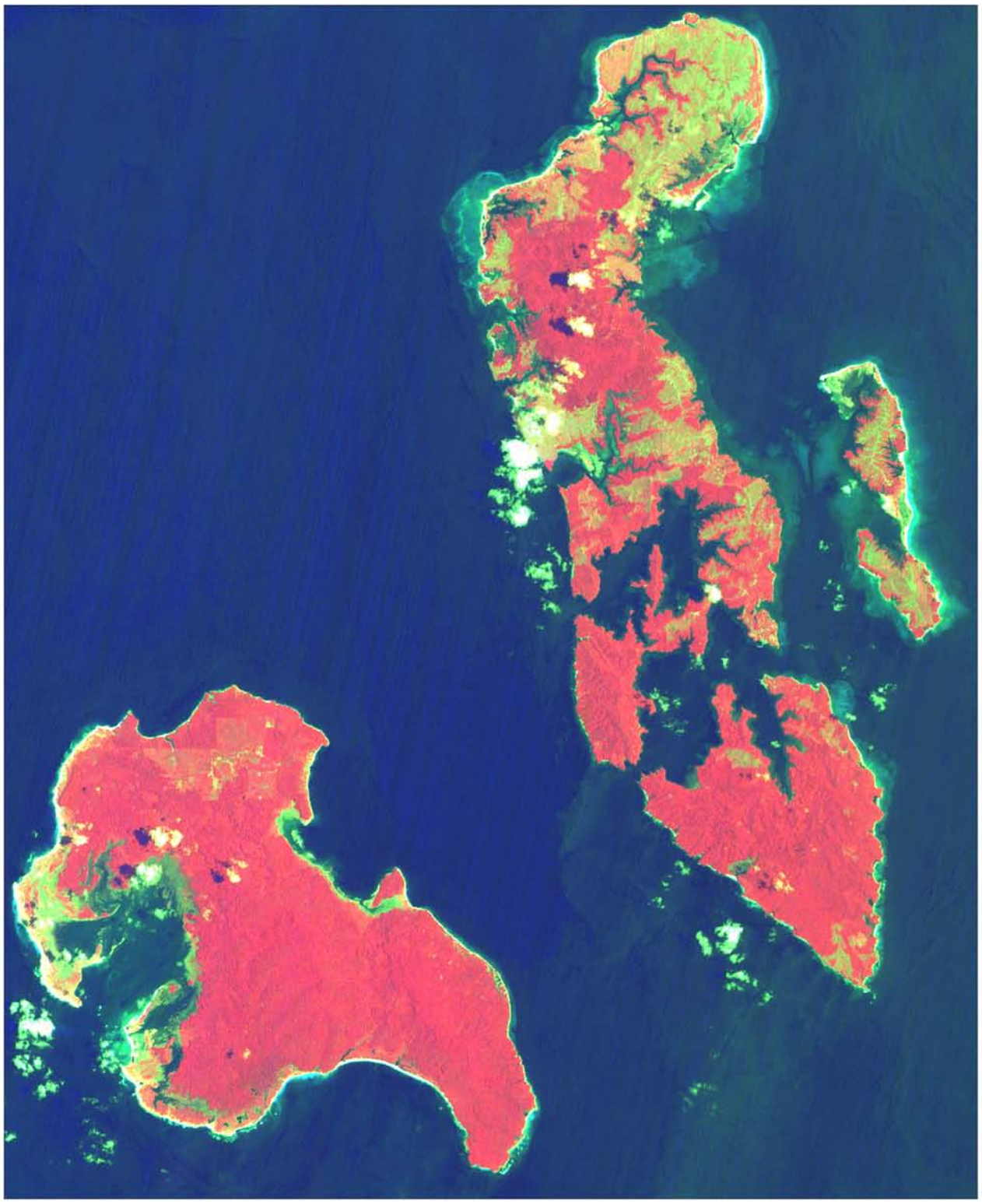
WETLAND MAP

District : Nicobar

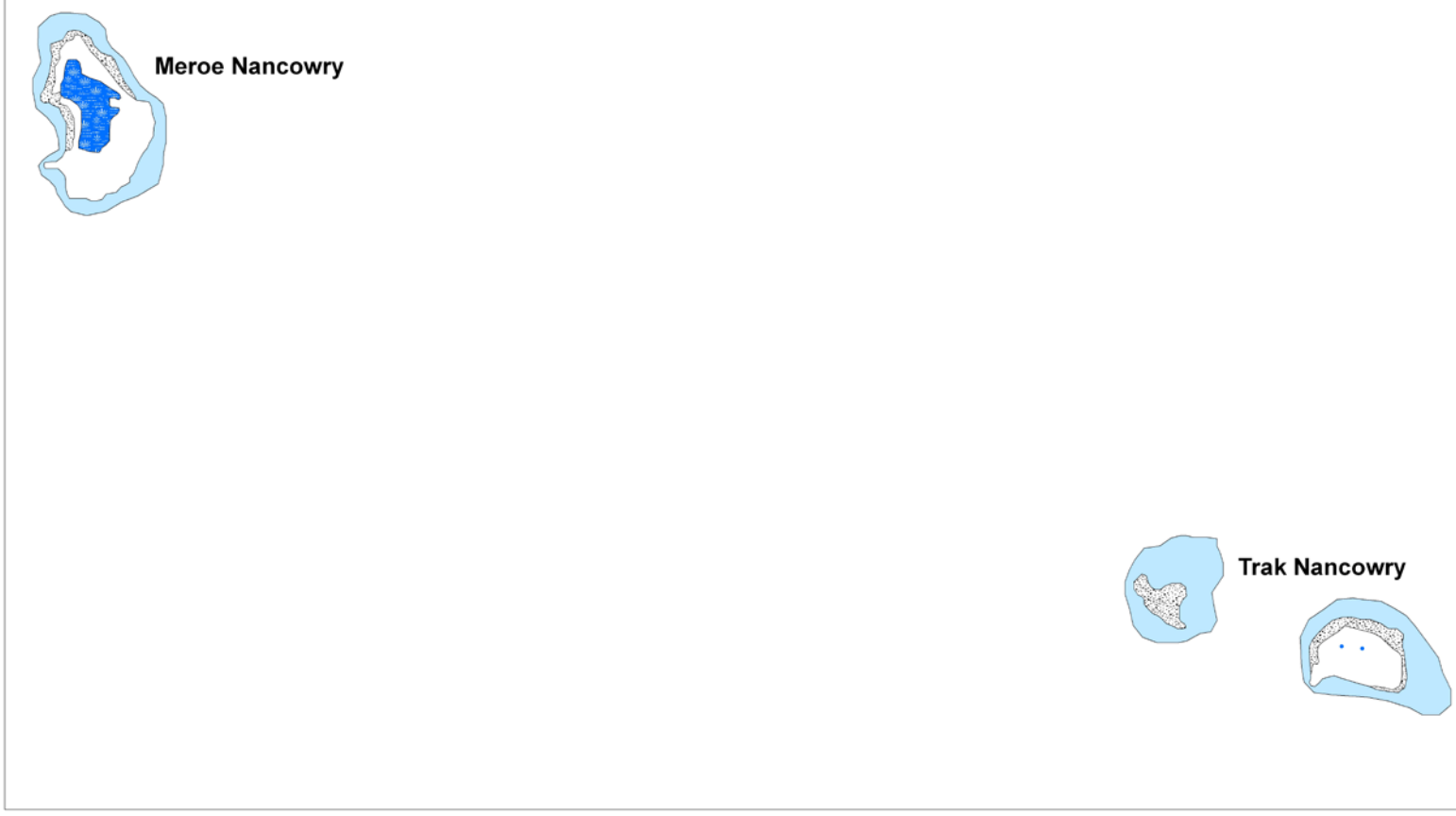


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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Legend

- Wetlands (<2.25ha)
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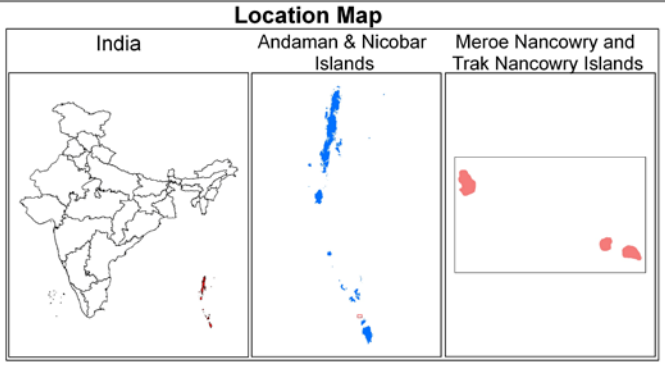
Location Map



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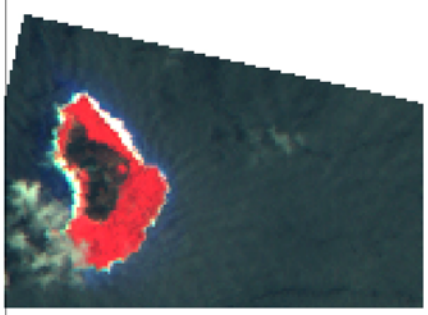

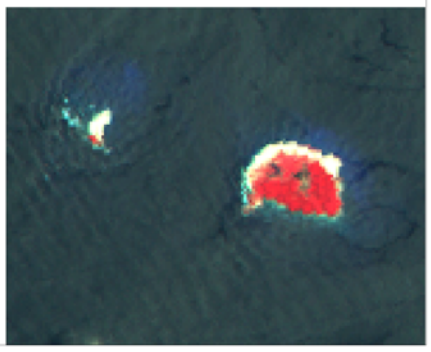

IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar

Menchal Nancowry

Kabra Nancowry

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Legend

- Wetlands (<2.25ha)
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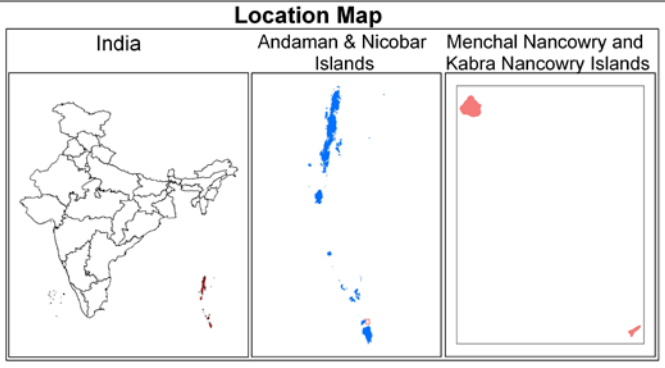
Location Map



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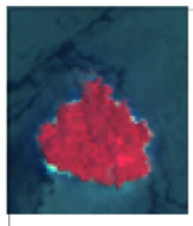
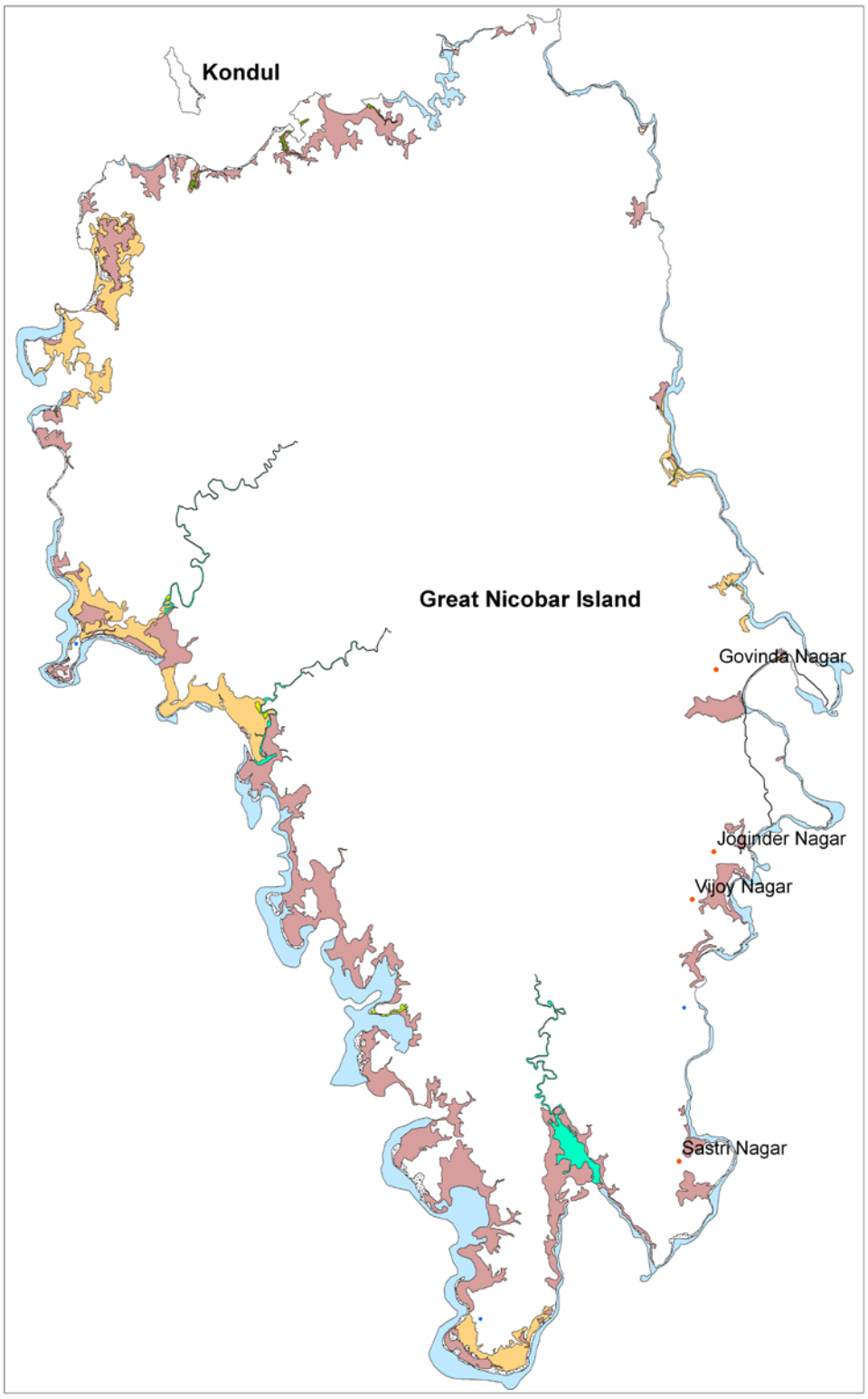


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar

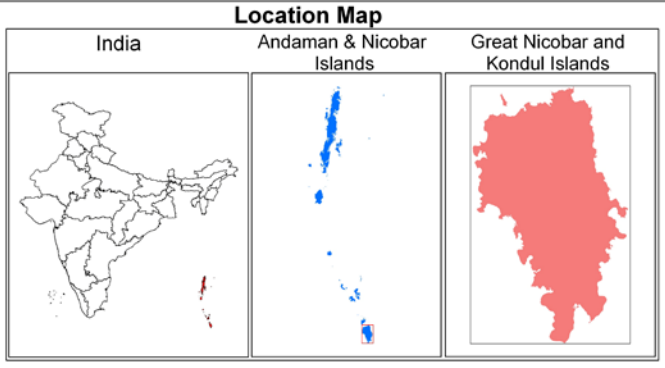


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

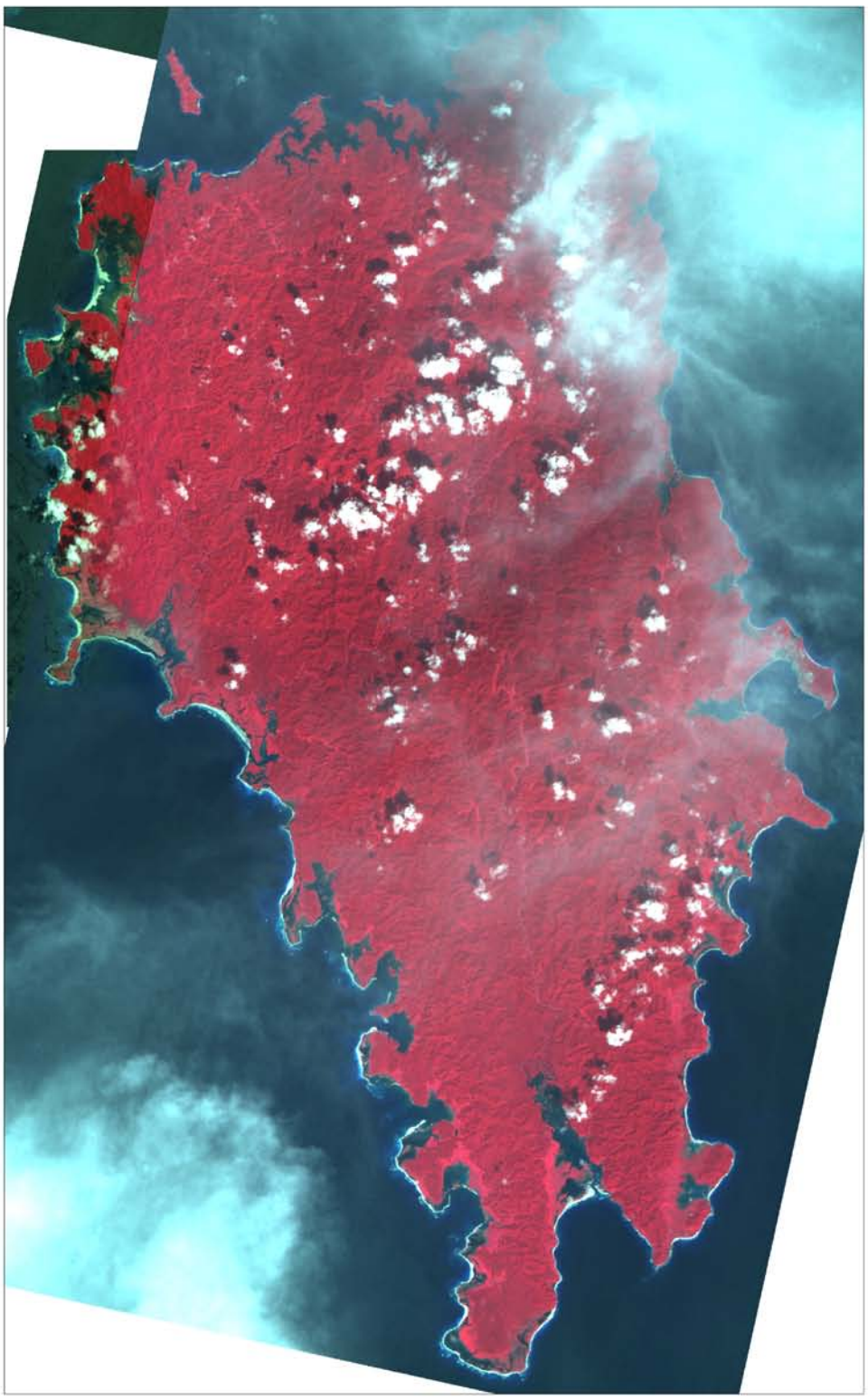
Sponsored By:

Ministry of Environment and Forests
Government of India

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar

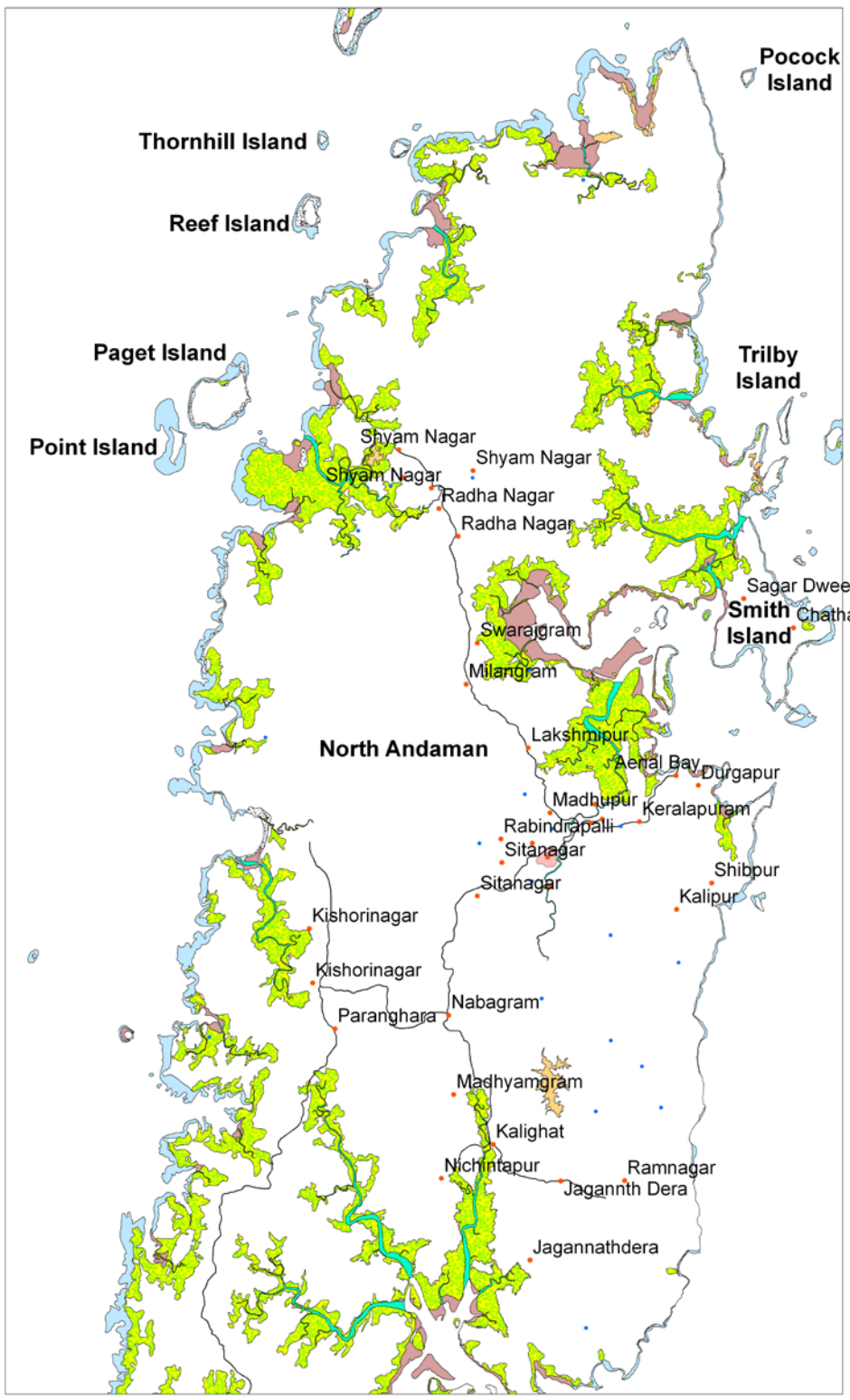


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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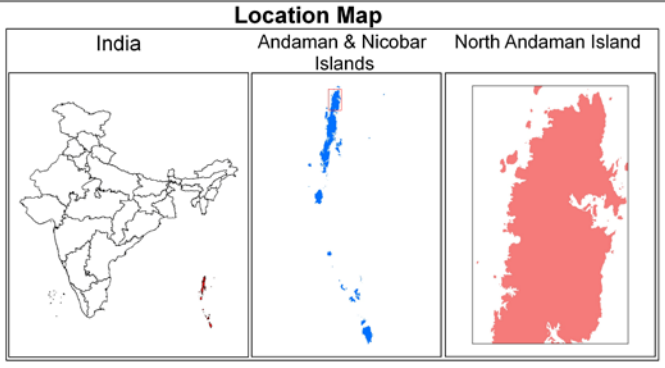

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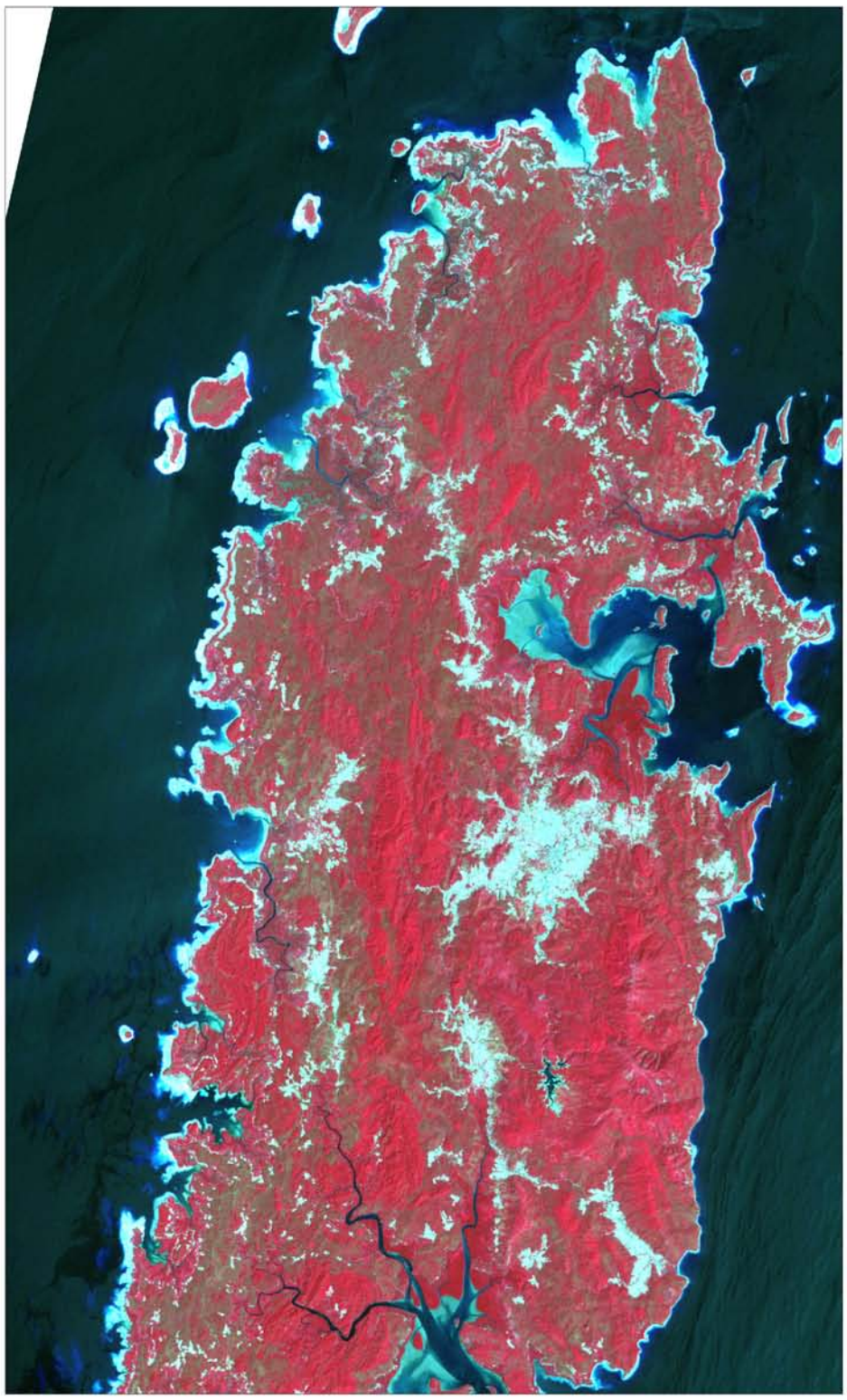
WETLAND MAP

District : Andaman

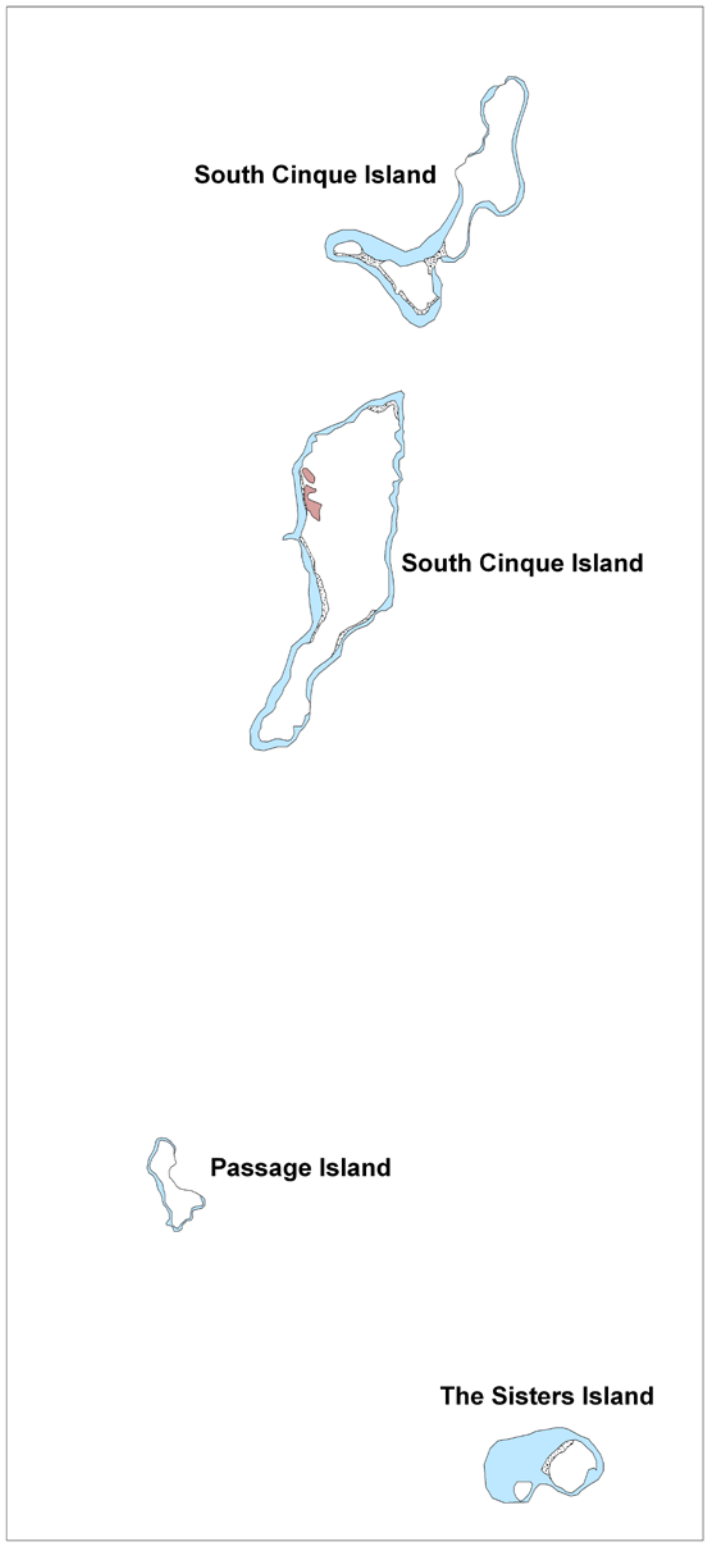


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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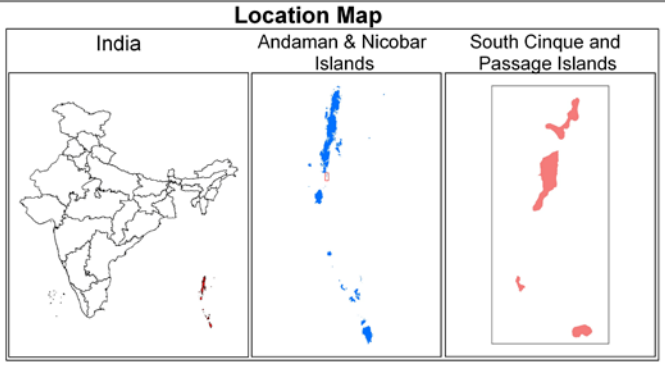

0 1.25 2.5 5 Kilometers

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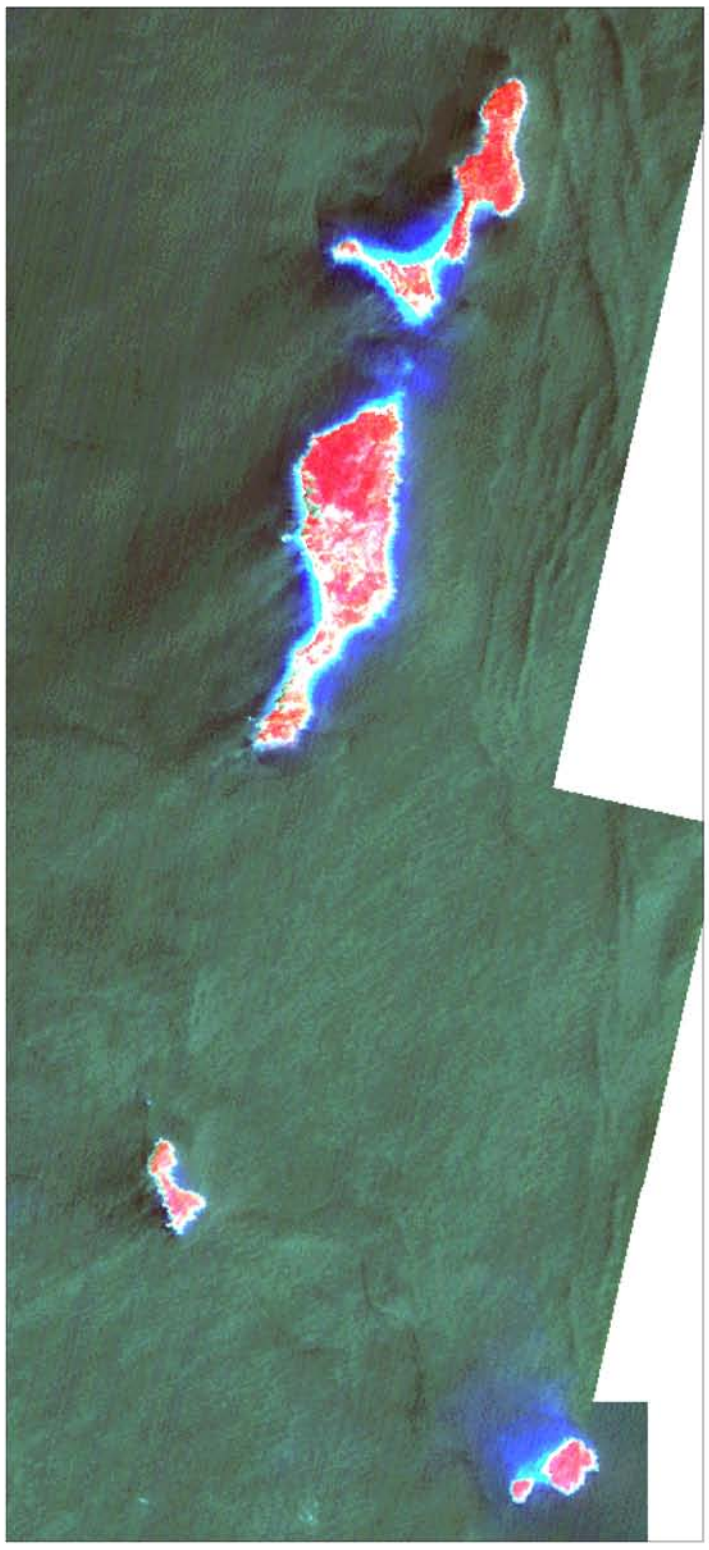
WETLAND MAP

District : Andaman

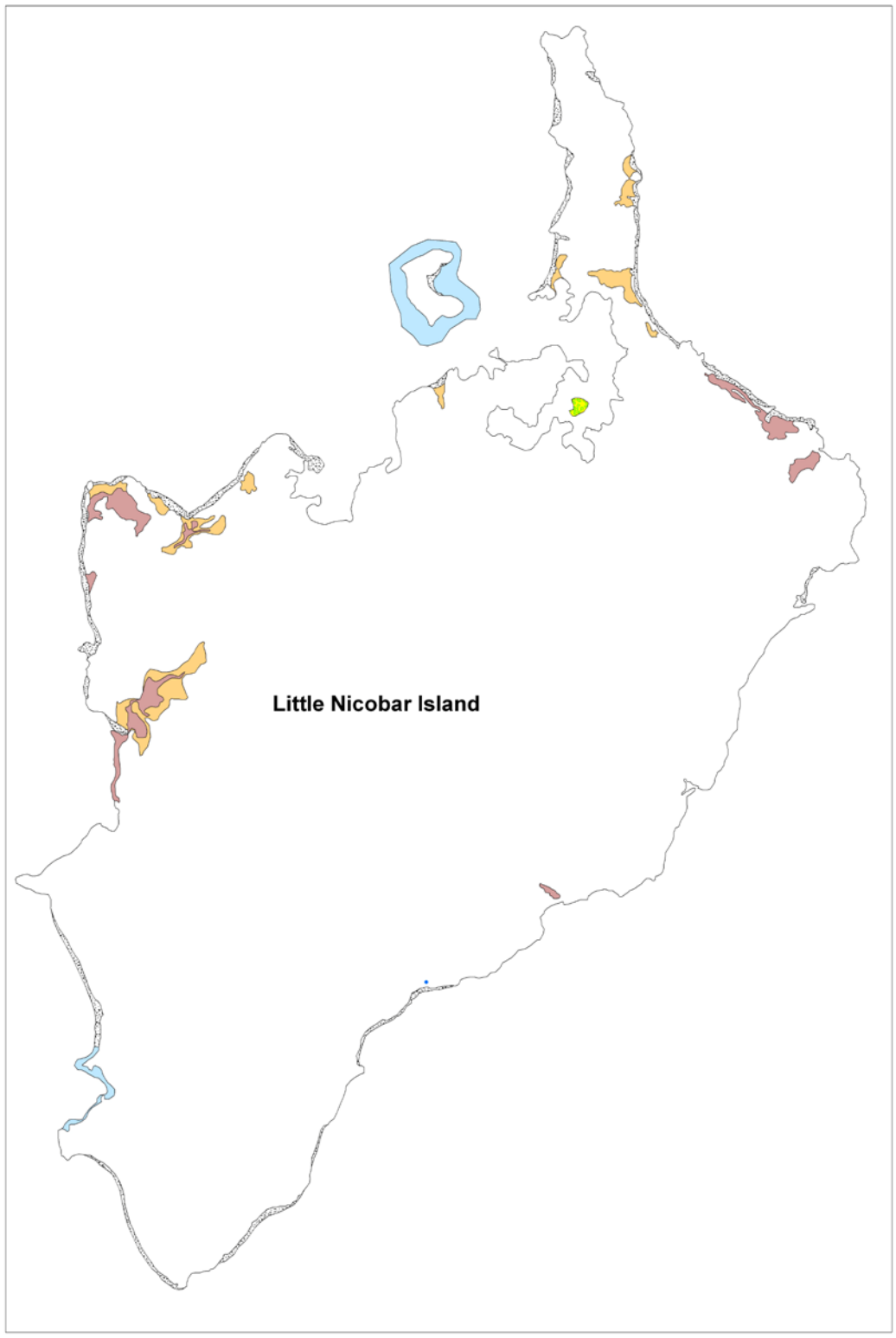


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Nicobar



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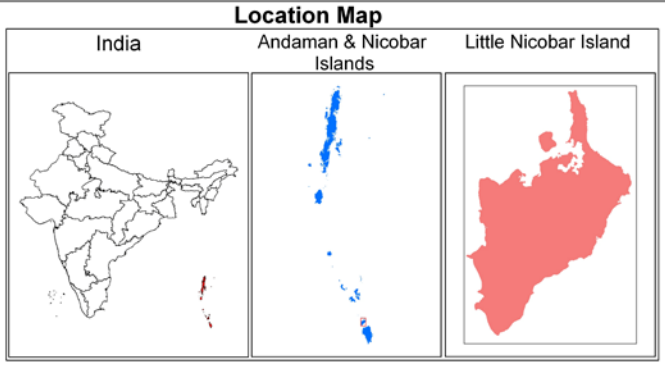

0 1.25 2.5 5 Kilometers

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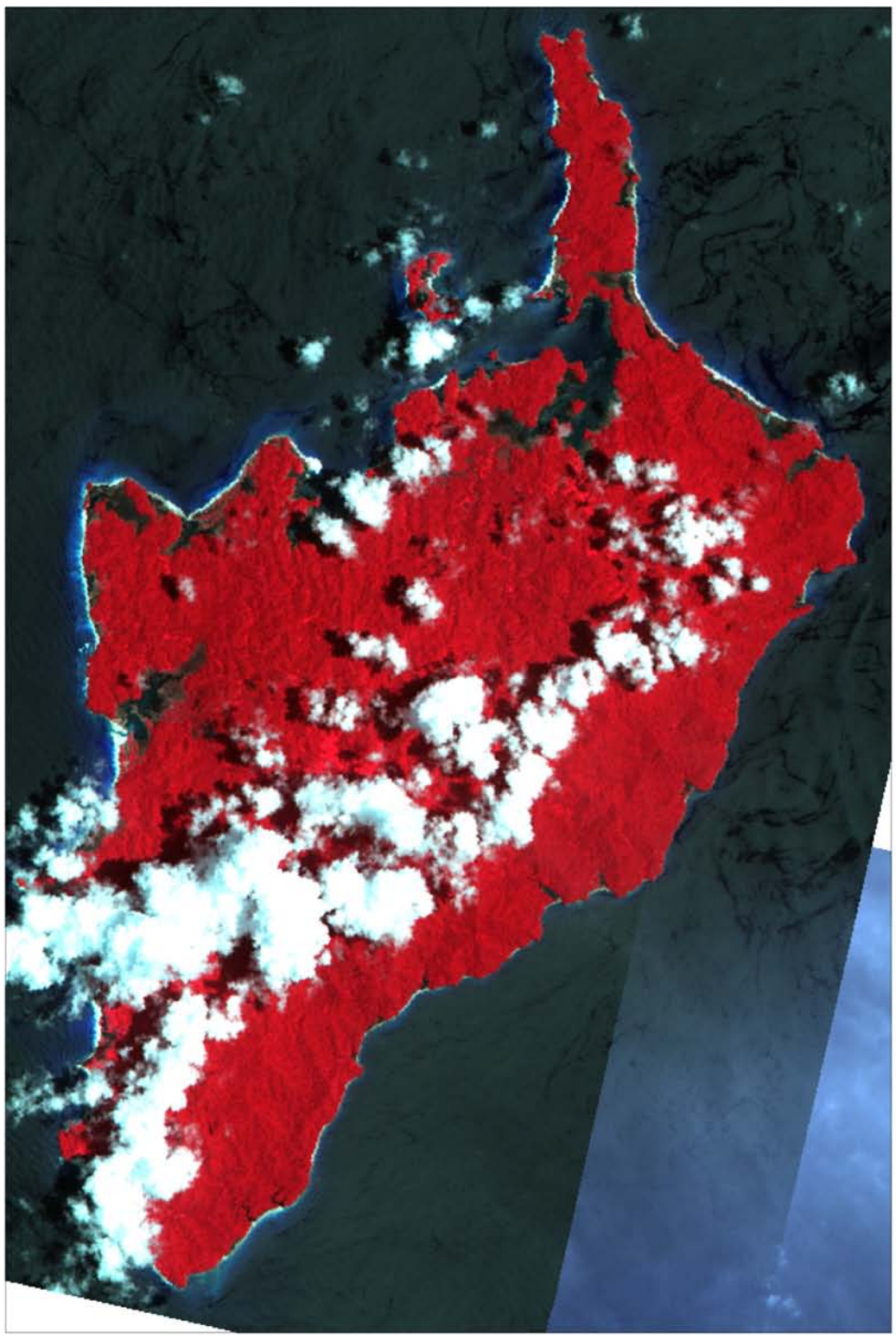
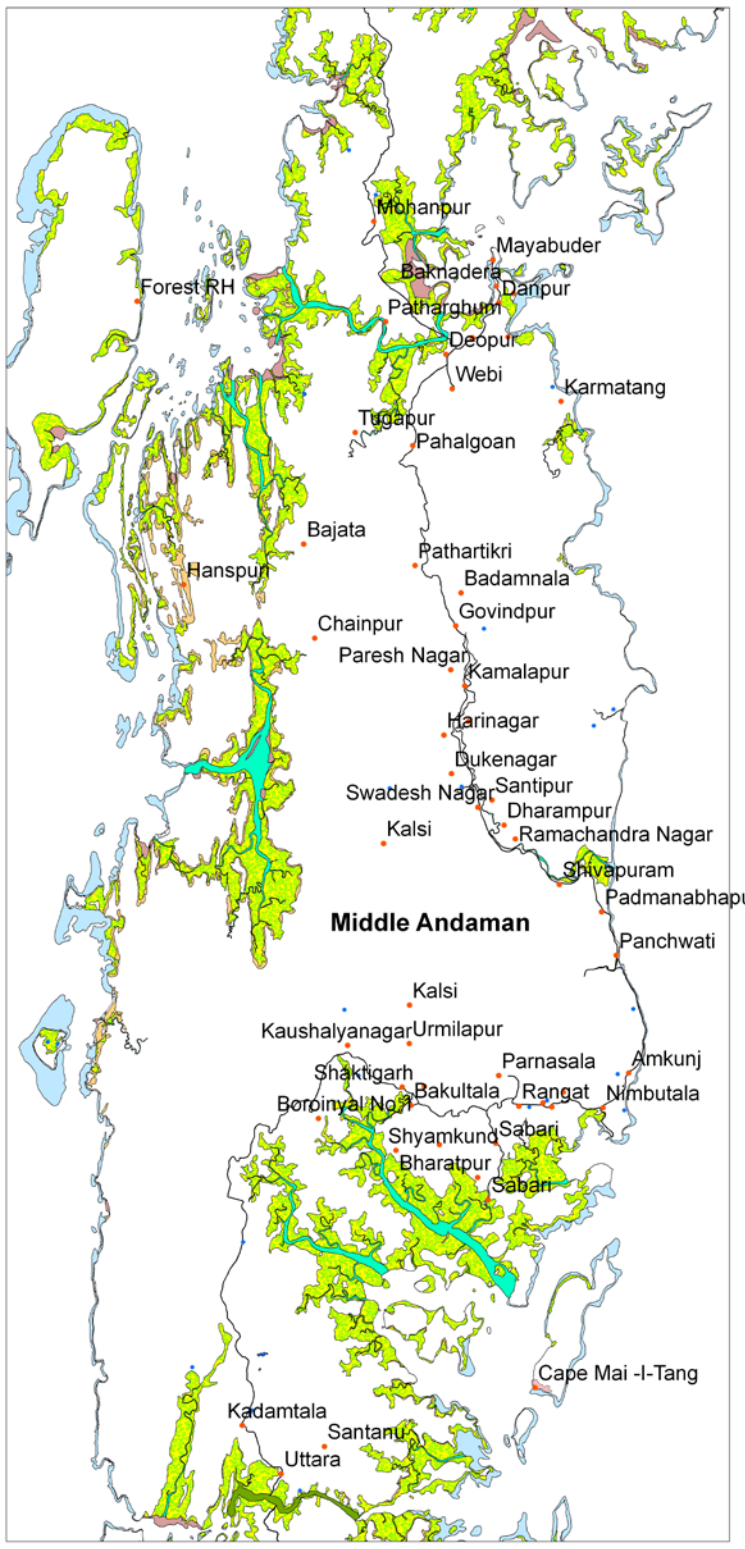


IRS P6 LISS-III Post-monsoon data (2006)

UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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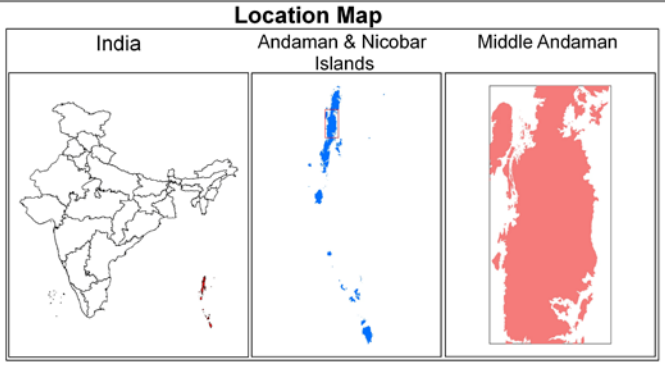

0 5 10 20 Kilometers

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Ministry of Environment and Forests
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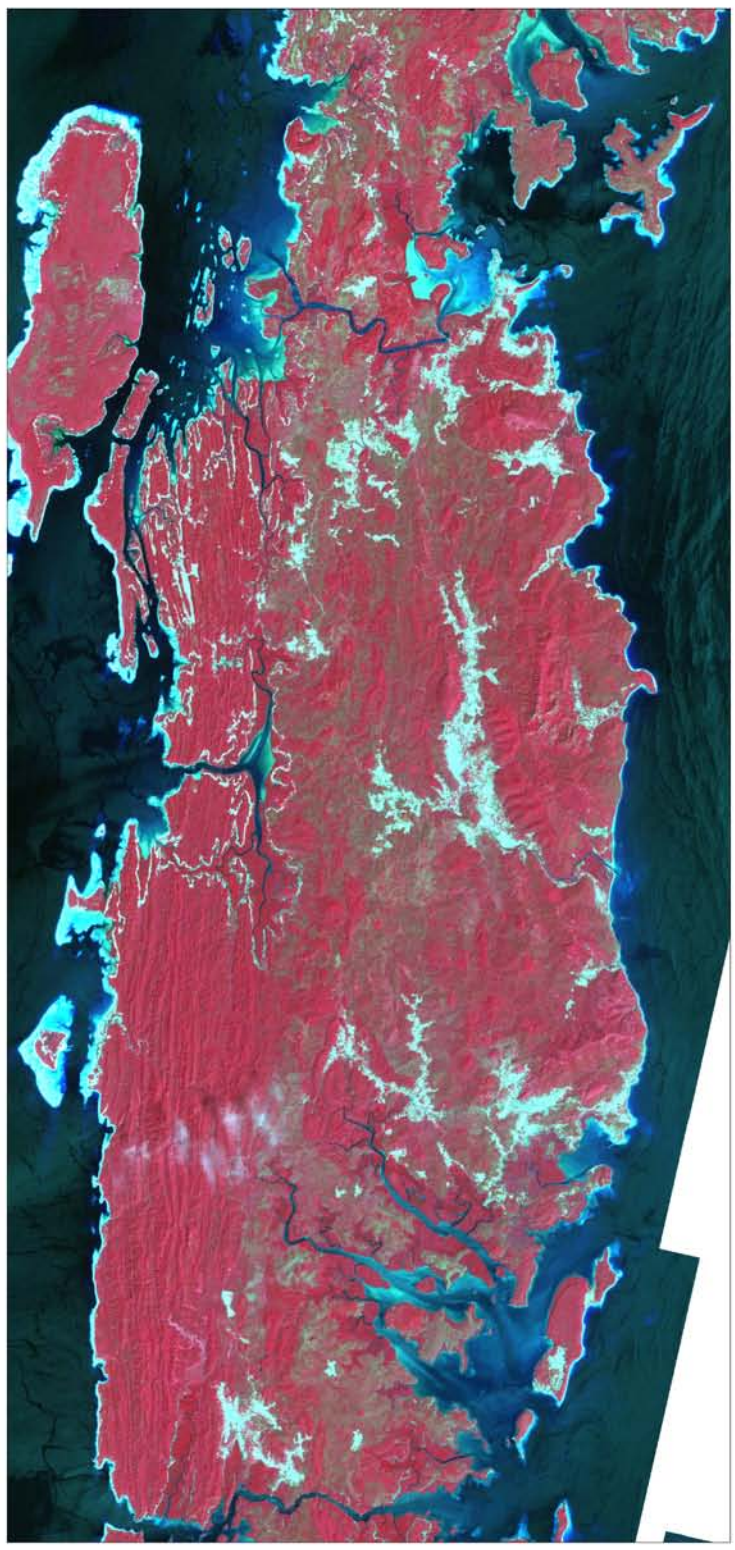
UT : Andaman and Nicobar Islands

WETLAND MAP

District : Andaman



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

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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:

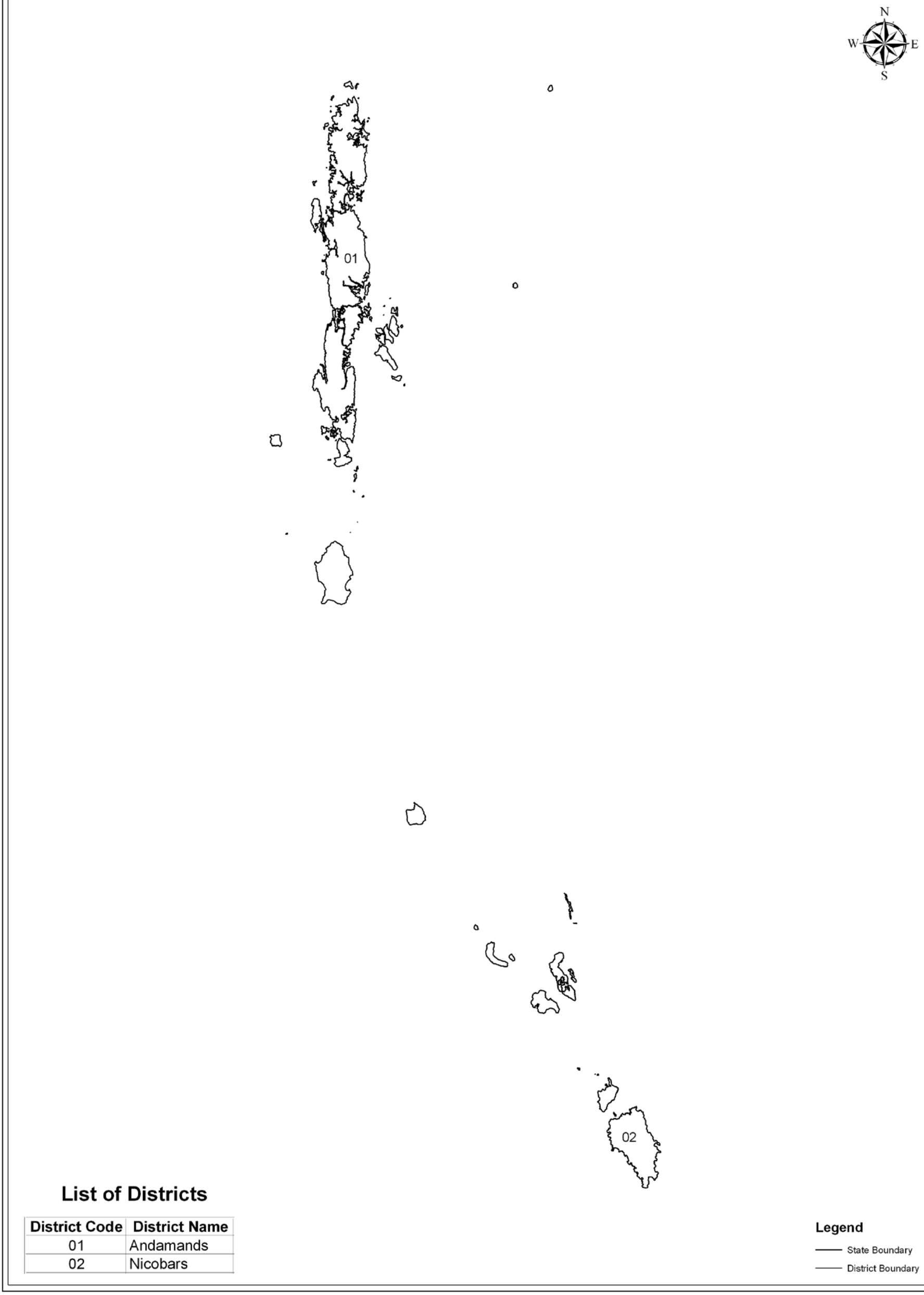
Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different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

Annexure – II
Details of District information followed in the atlas

State/UT : Andaman & Nicobar Islands

District Boundary Map



List of Districts

District Code	District Name
01	Andamands
02	Nicobars

Legend

State Boundary

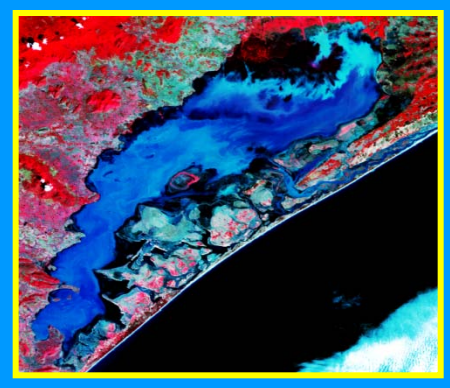
District Boundary

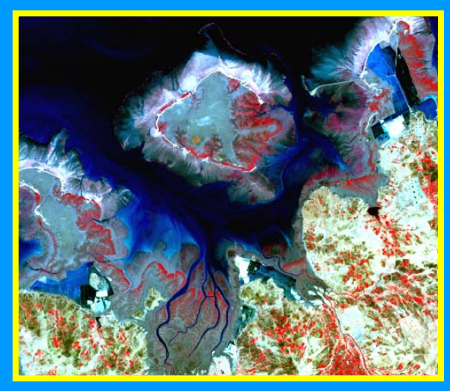
Source : Survey of India (Surveyed in 2004 and published in 2005)

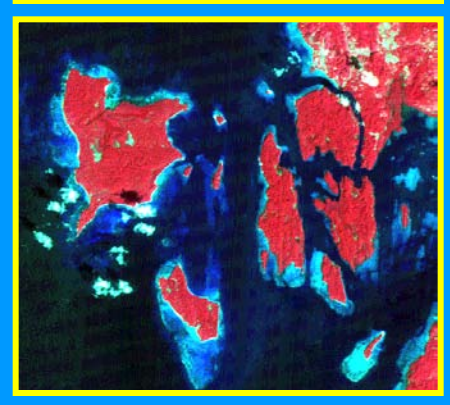
Space Applications Centre (SAC) is one of the major centres of the Indian Space Research Organisation (ISRO). It is a unique centre dealing with a wide variety of disciplines comprising design and development of payloads, societal applications, capacity building and space sciences, thereby creating a synergy of technology, science and applications. The Centre is responsible for the development, realisation and qualification of communication, navigation, earth & planetary observation, meteorological payloads and related data processing and ground systems. Several national level application programmes in the area of natural resources, weather and environmental studies, disaster monitoring/mitigation, etc are also carried out. It is playing an important role in harnessing space technology for a wide variety of applications for societal benefits.

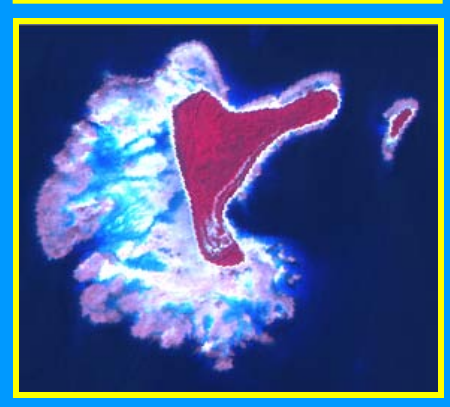
SAC is a host institution for the training programmes related to Satellite Communication, Satellite Meteorology and global change under the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations (UN).

http://www.isro.org









Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015