



# NATIONAL WETLAND ATLAS: *GUJARAT*



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**

## ***GUJARAT***

**Sponsored by  
Ministry of Environment and Forests, Government of India**

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

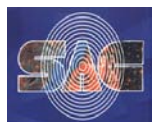
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and**

**Bhaskaracharya Institute for Space Applications and Geo-informatics(BISAG), Gandhinagar**

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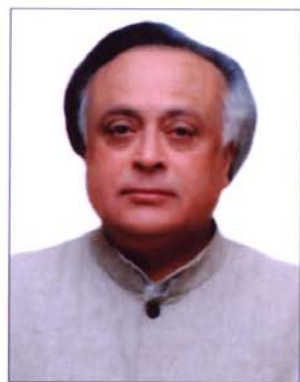
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जयराम रमेश  
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## MESSAGE

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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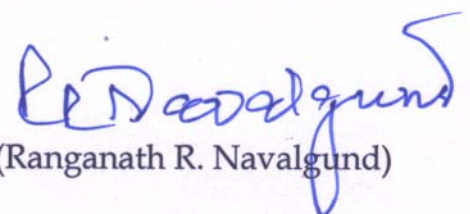
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## FOREWORD

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 compiled 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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## 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 Gujarat, 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), lacustrine (lakes), riverine (along rivers and streams), palustrine ('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](http://www.MAweb.org)). The Millennium Assessment (MA) uses the following typology to categorise ecosystem services:

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

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

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

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

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

### 1.2 Mapping and Geospatial Technique

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

technique. Remote sensing is now recognised as an essential tool for viewing, analyzing, characterizing, and making decisions about land, water and atmospheric components.

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

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

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

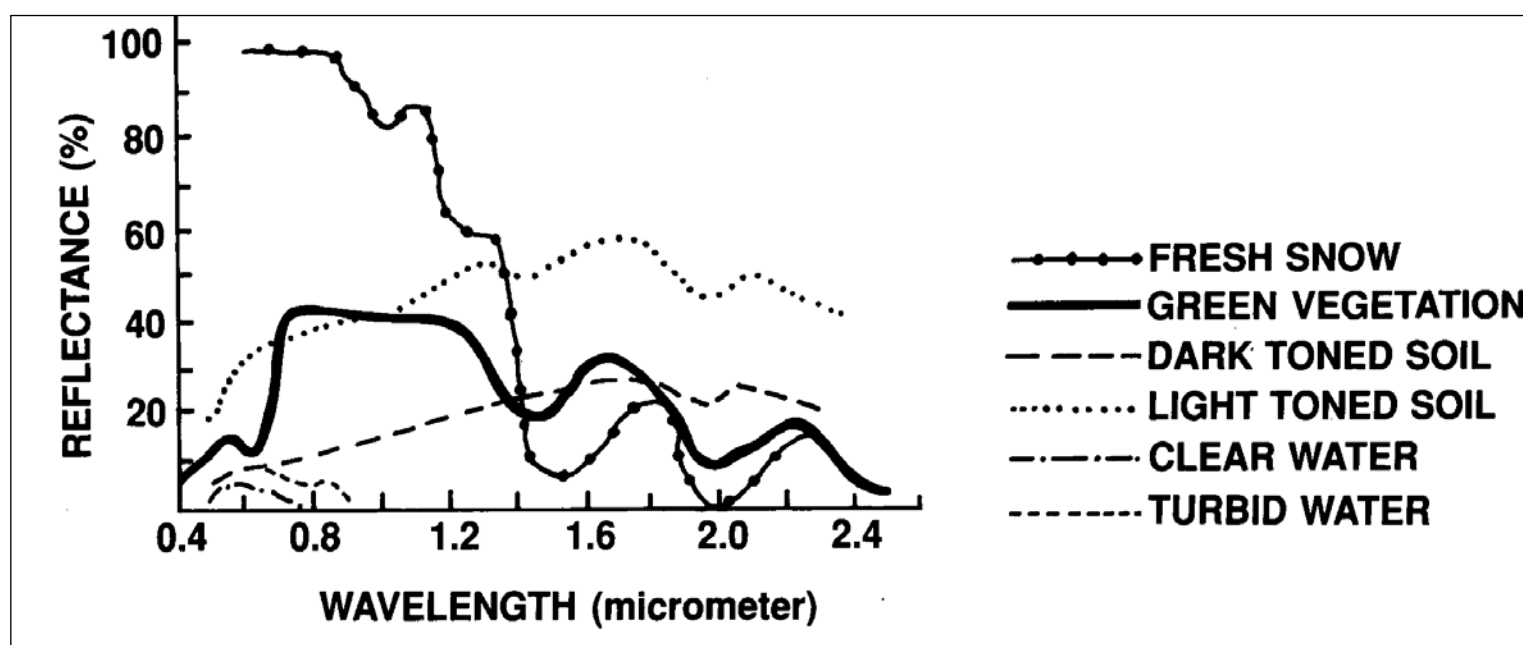
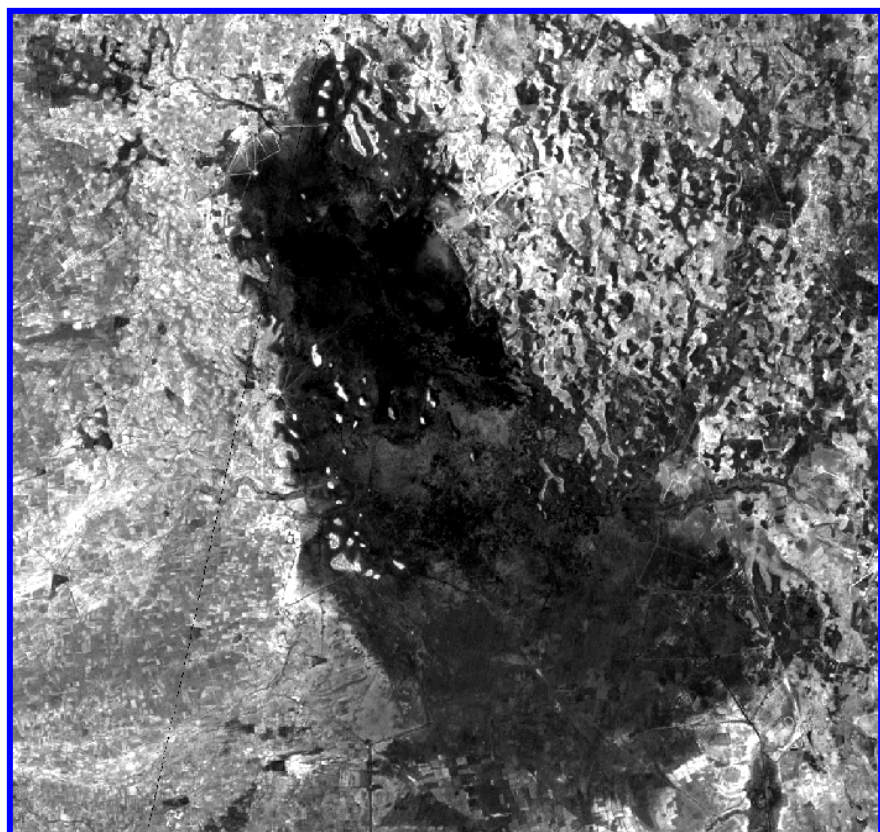
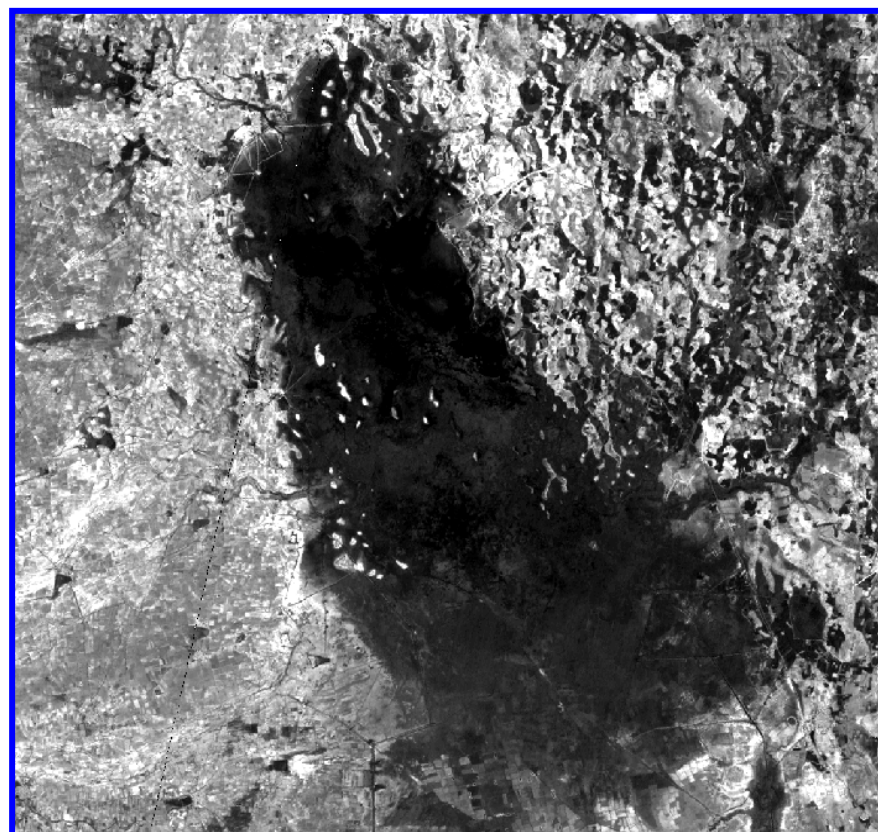


Figure 1: Spectral Signature of various targets

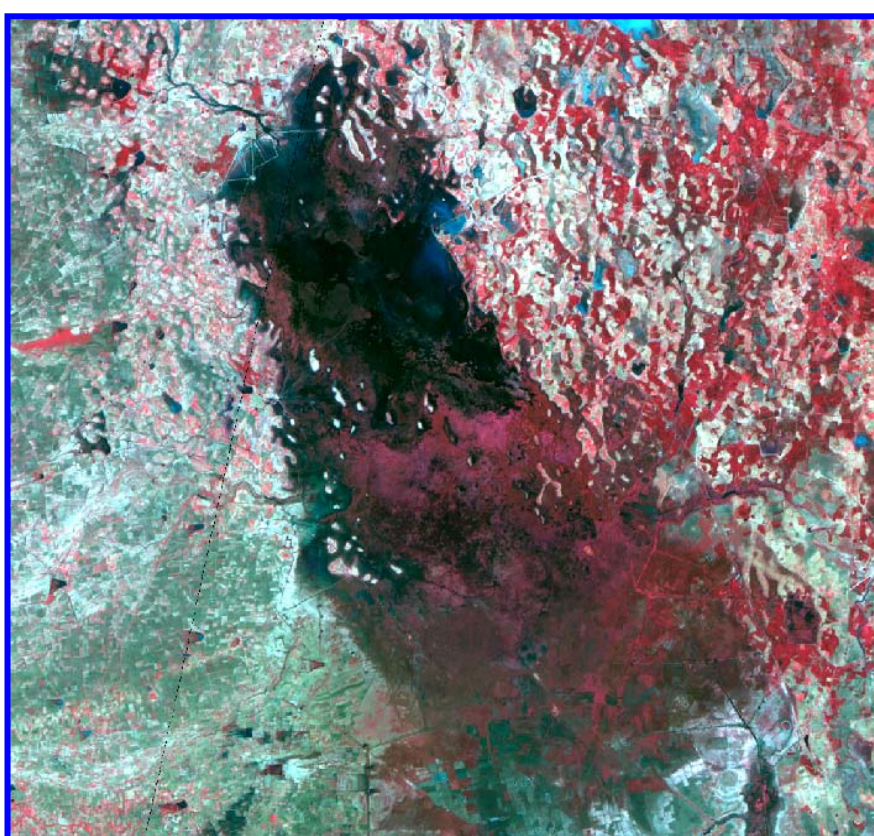




**GREEN**



**RED**



**IRS LISS-III FCC**

**NIR**

**SWIR**

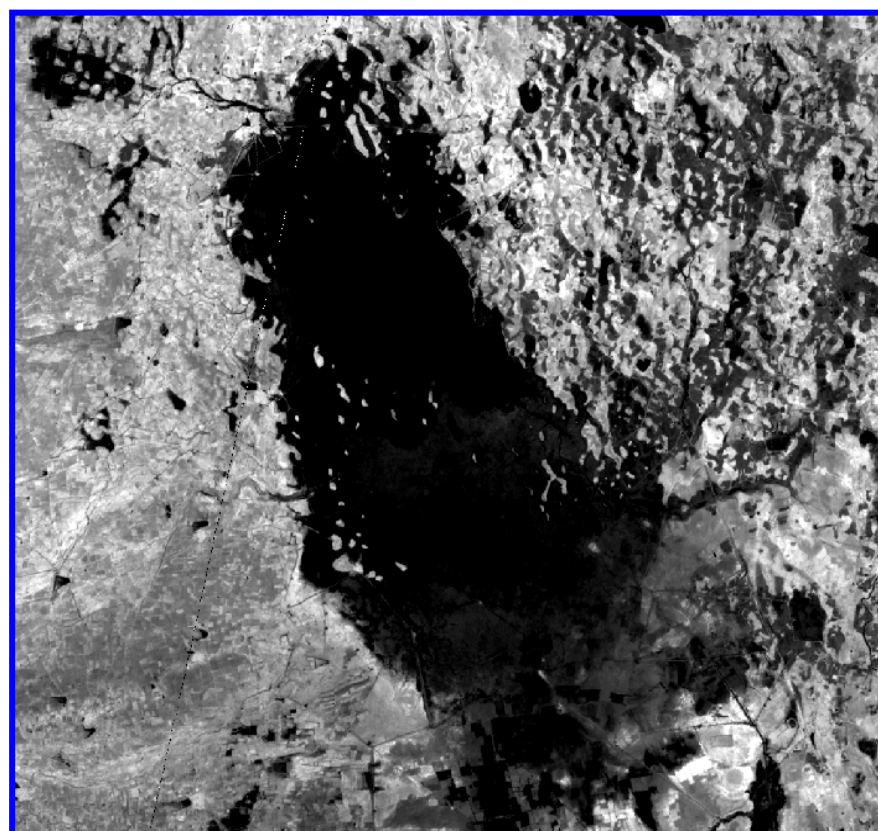
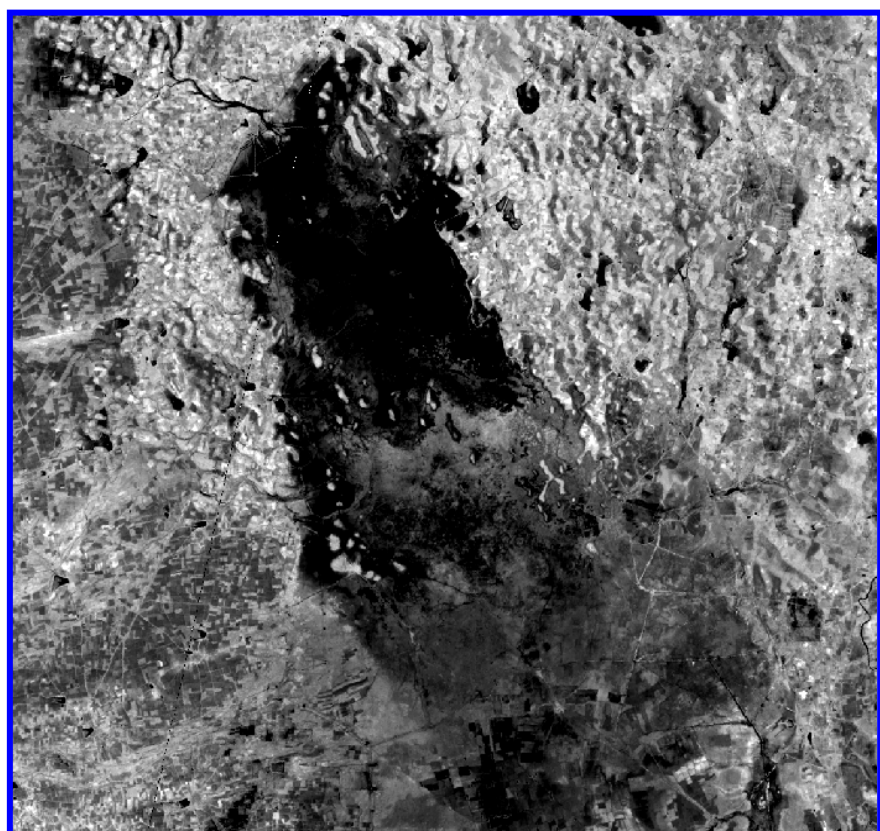


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC



### 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, peat-lands, coral reefs, and numerous human-made wetland, such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans reservoirs, gravel pits, sewage farms, and canals. The Ministry of Environment and Forests has identified a number of wetlands for conservation and management under the National Wetland Conservation Programme and some financial assistance is being provided to State Governments for various conservation activities through approval of the Management Action Plans. The need to have an updated map database of wetlands that will support such actions has long been realized.

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

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

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

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

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

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

## **2.0 NATIONAL WETLAND INVENTORY AND ASSESSMENT (NWIA) PROJECT**

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

The main objectives of the project are:

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

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

### **2.1 Wetland Classification System**

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

### **2.2 Spatial Framework and GIS Database**

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

Following wetland layers are generated for each inland wetland:

- Wetland extent: As wetlands encompass open water, aquatic vegetation (submerged, floating and emergent), the wetland boundary should ideally include all these. Satellite image gives a clear signature of the wetland extent from the imprint of water spread over the years.
- Water spread: There are two layers representing post-monsoon and pre-monsoon water spread during the year of data acquisition.
- Aquatic vegetation spread: The presence of vegetation in wetlands provides information about its trophic condition. As is known, aquatic vegetation is of four types, viz. benthic, submerged, floating

and emergent. It is possible to delineate last two types of vegetation using optical remote sensing data. A qualitative layer pertaining to presence of vegetation is generated for each season (as manifested on pre-monsoon and post-monsoon imagery).

- Turbidity of open water: A layer pertaining to a qualitative turbidity rating is generated. Three qualitative turbidity ratings ( low, medium and high) is followed for pre- and post-monsoon turbidity of lakes, reservoirs, barrages and other large wetlands.
- Small wetlands (smaller than minimum mappable unit: < 2.25 ha) are mapped as point features.
- Base layers like major road network, railway, settlements, and surface drainage are created (either from the current image or taken from other project data base).

Table 1: Wetland Classification System and coding

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

\* Wetland type code

### 3.0 STUDY AREA

The state of Gujarat is situated on the west coast of India, bounded by the Arabian Sea in the West, Rajasthan in the North and North-East, and Madhya Pradesh in the East and Maharashtra in the South and South East. The state also shares an international border with Pakistan at the north western fringe. It is situated between 20°6' and 24°7' N latitudes and 68° 10' and 74° 28' E longitudes (Figure - 3).

Total geographic area of Gujarat state is 1,96,024 km<sup>2</sup> (6% of the total area of India). As per the 2001 census data, the population of the state was 50,596,992. The density of population is 258 persons per km<sup>2</sup> and literacy rate of the state was 69.97%. The total number of districts in Gujarat is 25. Gandhinagar, the capital of Gujarat is a beautiful planned city. Gujarat is one of the most prosperous states of the country owing to its booming economy and industry. The state provides about 19.8% of the country's total industrial output and is the most industrialized state of the country.

On the basis of geographical features, Gujarat is divided into four regions, namely;

- i) North Gujarat region
- ii) South Gujarat region
- iii) Saurashtra peninsular region, and
- iv) Kachchh region, which is partly desert and partly marshland.

Across the state four different climatical conditions exist, namely, extremely arid, arid, semi-arid and humid(sub-humid tropical monsoon type). However, a major part of the state(14 districts) experience semi-arid climate; only two southern districts of Dangs and Valsad have humid climate. Three districts – Jamnagar, Rajkot and Surendranagar have semi-arid to arid climate while Kachchh district has extremely arid climate. Gujarat mainland region receives an average annual rainfall of 800 to 2000 mm, while Saurashtra has an average annual rainfall of 400 to 800 mm. The average annual rainfall in Kachchh is less than 400 mm. The incidence and distribution of rainfall, particularly in Saurashtra and Kachchh regions and in the northern part of Gujarat region, is highly erratic. As a result, these regions are very often subject to drought. In south Gujarat region, rainfall distribution is more or less uniform, with occasional heavy rainfall. Most of the rain (90-95% of the annual total) falls during the period of June to September, when the southwest monsoon prevails.

The state has the longest coastline of about 1600 km, which is one third of the coastal length of the country comprising two gulfs (Gulf of Kachchh and Gulf of Khambhat). The sea-water ingress onto the land due to the existence of highly cavernous and permeable limestone in the coastal region.

Water resources in Gujarat are concentrated primarily in the southern and central part of the mainland. Saurashtra and Kachchh in the northern mainland, with exceptionally high irrigation needs, have limited surface and groundwater resources. Groundwater and surface water are the two different sources from which water is utilized for irrigation purposes. These two sources are mainly replenished by rainfall and stream flows.

Gujarat is a unique state that has many kinds of habitats. These varied landforms include dry deciduous forests, majestic grasslands, wetlands, marine ecosystems and rich moist deciduous forests. These habitats are home to some extremely rare wildlife. The Asiatic Lion is found only in Gir. The Wild Ass in the Rann of Kachchh, the rare great Indian bustard in the bird reserves, the world's only four-horned antelope and the Black Buck are some other valued species protected in Gujarat. The dugong and the rare boralia species also find a safe haven here.

Though there are a number of rivers and streams in the state, a large proportion of it retains water for the brief period of a year. Major rivers like the Narmada, the Tapti, the Mahi and the Sabarmati play important role in nurturing the biodiversity and people of Gujarat throughout the year. There are few medium, minor and desert rivers also maintain biodiversity in the state.

The spatial framework of Gujarat was prepared using 15' x 15' grid. The state is covered by 323 Survey of India topographic maps on 1:50,000 scale that form the spatial frame work for mapping (Figure 4).

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





Figure 3: Location map

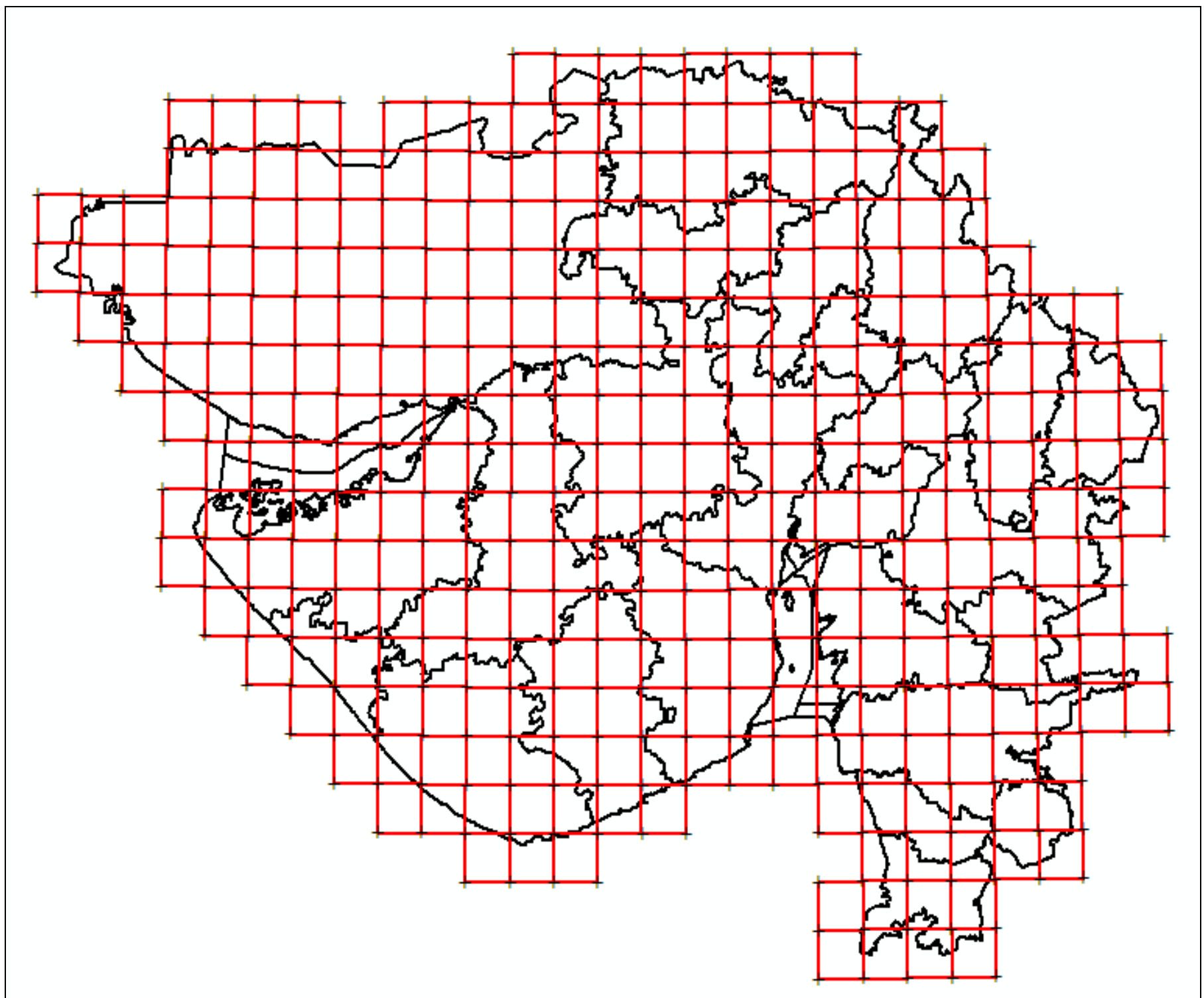


Figure 4: Spatial framework of Gujarat

## 4.0 DATA USED

### 4.1 Remote sensing data

IRS P6 LISS III data was used to map the wetlands. IRS P6 LISS III provide data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23.5 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The state of Gujarat is covered in 22 IRS LISS III scene (Figure 5). Two date data, one acquired during March and another during January were used to capture the pre-monsoon and post-monsoon hydrological variability of the wetlands respectively (Table-2). Figure 6 shows the overview of the part of Gujarat as seen in the LISS III FCC of post- monsoon and pre-monsoon data respectively.

### 4.2 Ground truth data

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

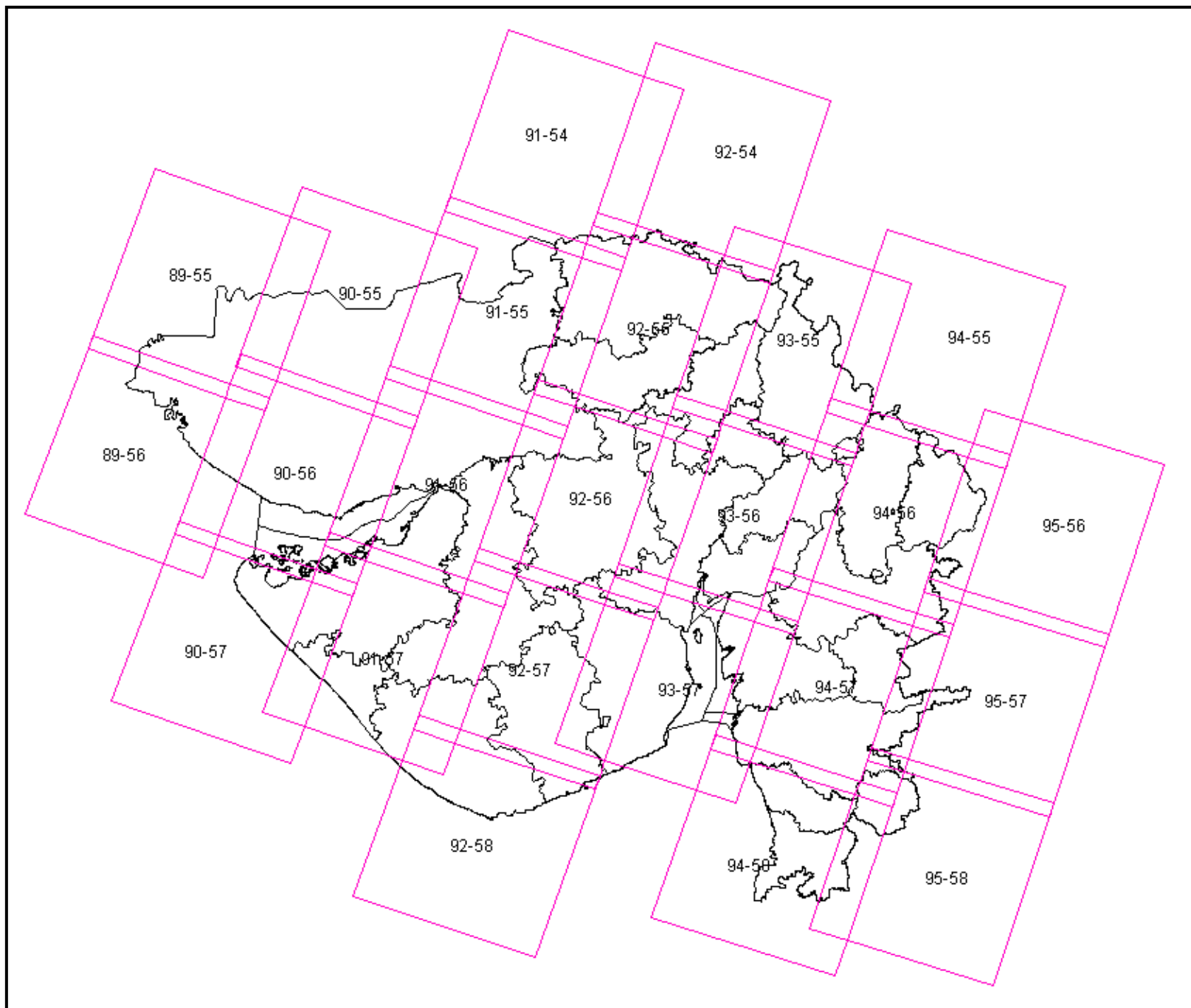


Figure 5: IRS P6 LISS-III coverage of Gujarat

### 4.3 Other data

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

Table-2: Satellite data used

Sr. No.	Sensor	Path-Row	Date of acquisition	
			Post-monsoon	Pre-monsoon
1	LISS-III	89-55	Oct 23, 2006	May 3, 2007
2	LISS-III	89-56	Oct 23, 2006	May 3, 2007
3	LISS-III	90-55	Oct 28, 2006	May 8, 2007
4	LISS-III	90-56	Oct 28, 2006	Apr 14, 2007
5	LISS-III	90-57	Oct 28, 2006	Apr 14, 2007
6	LISS-III	91-55	Nov 26, 2006	May 13, 2007
7	LISS-III	91-56	Nov 26, 2006	May 13, 2007
8	LISS-III	91-57	Nov 26, 2006	Apr 19, 2007
9	LISS-III	92-55	Oct 14, 2006	May 18, 2007
10	LISS-III	92-56	Oct 14, 2006	May 18, 2007
11	LISS-III	92-57	Oct 14, 2006	Apr 24, 2007
12	LISS-III	92-58	Oct 14, 2006	Apr 24, 2007
13	LISS-III	93-55	Oct 19, 2006	May 23, 2007
14	LISS-III	93-56	Oct 19, 2006	May 23, 2007
15	LISS-III	93-57	Oct 19, 2006	May 23, 2007
16	LISS-III	94-55	Oct 24, 2006	May 4, 2007
17	LISS-III	94-56	Oct 24, 2006	May 4, 2007
18	LISS-III	95-57	Dec 16, 2006	Apr 15, 2007
19	LISS-III	95-58	Dec 16, 2006	Apr 15, 2007
20	LISS-III	95-56	Oct 5, 2006	May 9, 2007
21	LISS-III	93-54	Oct19, 2006	May 23, 2007
22	LISS-III	94-57	Nov 17, 2006	May 4, 2007



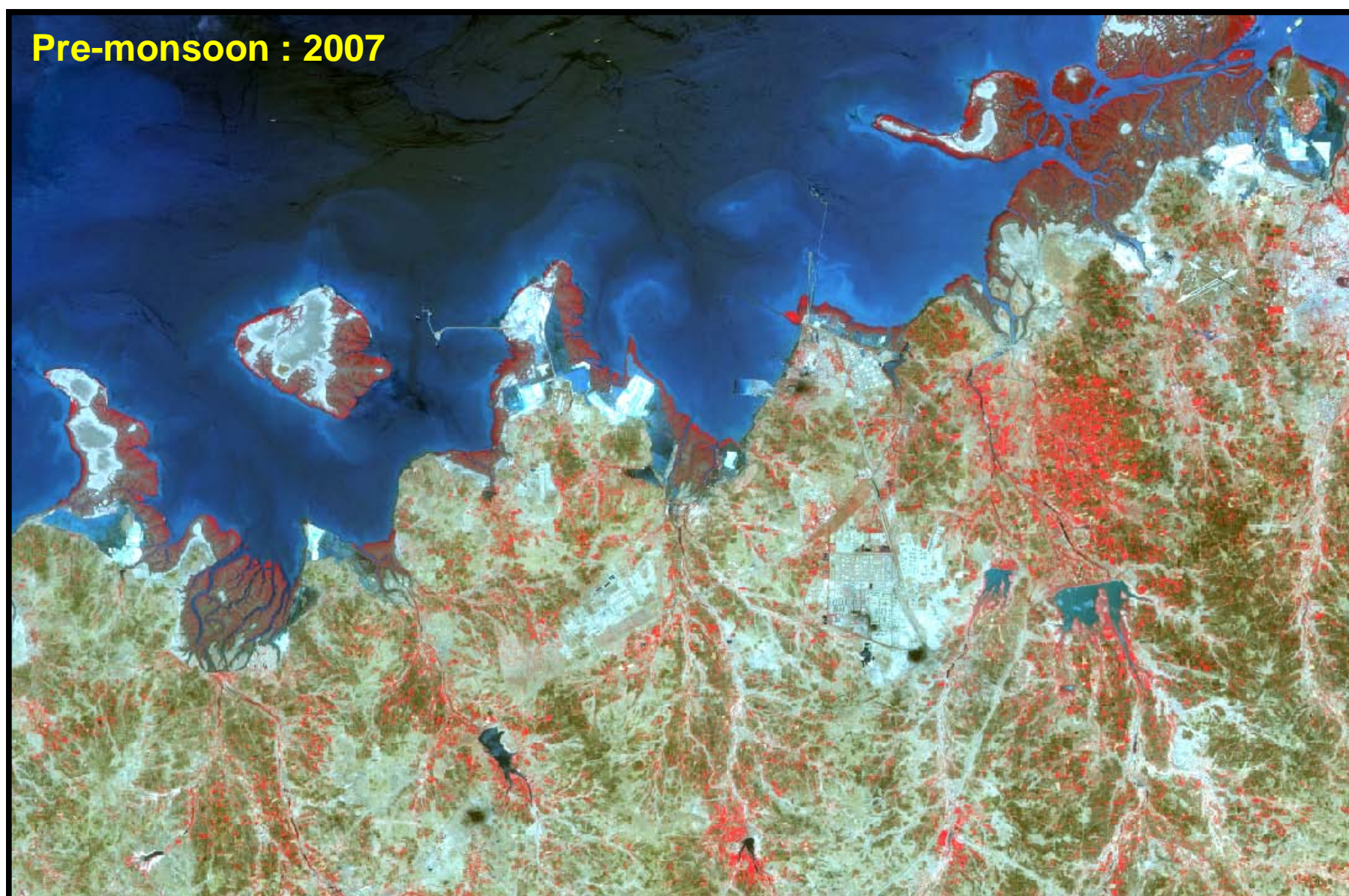
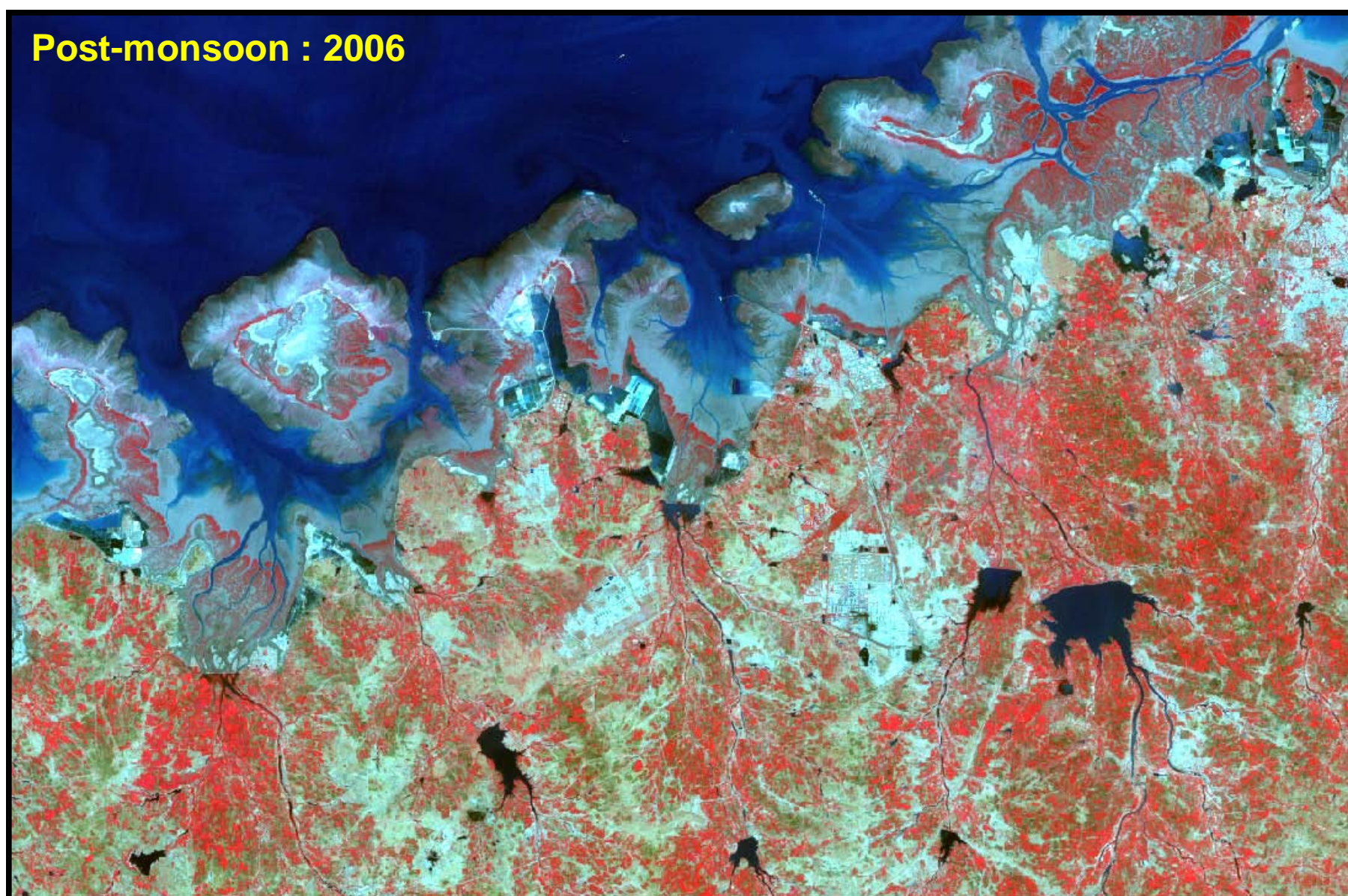


Figure 6: IRS LISS-III FCC (Post-monsoon and Pre-monsoon), Part of Gujarat state



## 5.0 METHODOLOGY

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

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

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

### 5.1 Creation of Spatial Framework

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

### 5.2 Geo-referencing of Satellite Data

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

### 5.3 Mapping of Wetlands

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

In this project, five indices known in literature that enhances various wetland characteristics were used (McFeetres, 1986; Xu Hanqiu, 2006; Lacaux *et al*, 2007; Townshend and Justice, 1986; Tucker and Sellers, 1986) as given below:

- i) Normalised Difference Water Index (NDWI) =  $(\text{Green} - \text{NIR}) / (\text{Green} + \text{NIR})$
- ii) Modified Normalised Difference Water Index (MNDWI) =  $(\text{Green} - \text{MIR}) / (\text{Green} + \text{MIR})$
- iii) Normalised Difference Vegetation Index (NDVI) =  $(\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$
- iv) Normalised Difference Pond Index (NDPI) =  $(\text{MIR} - \text{Green}) / (\text{MIR} + \text{Green})$
- v) Normalised Difference Turbidity Index (NDTI) =  $(\text{Red} - \text{Green}) / (\text{Red} + \text{Green})$

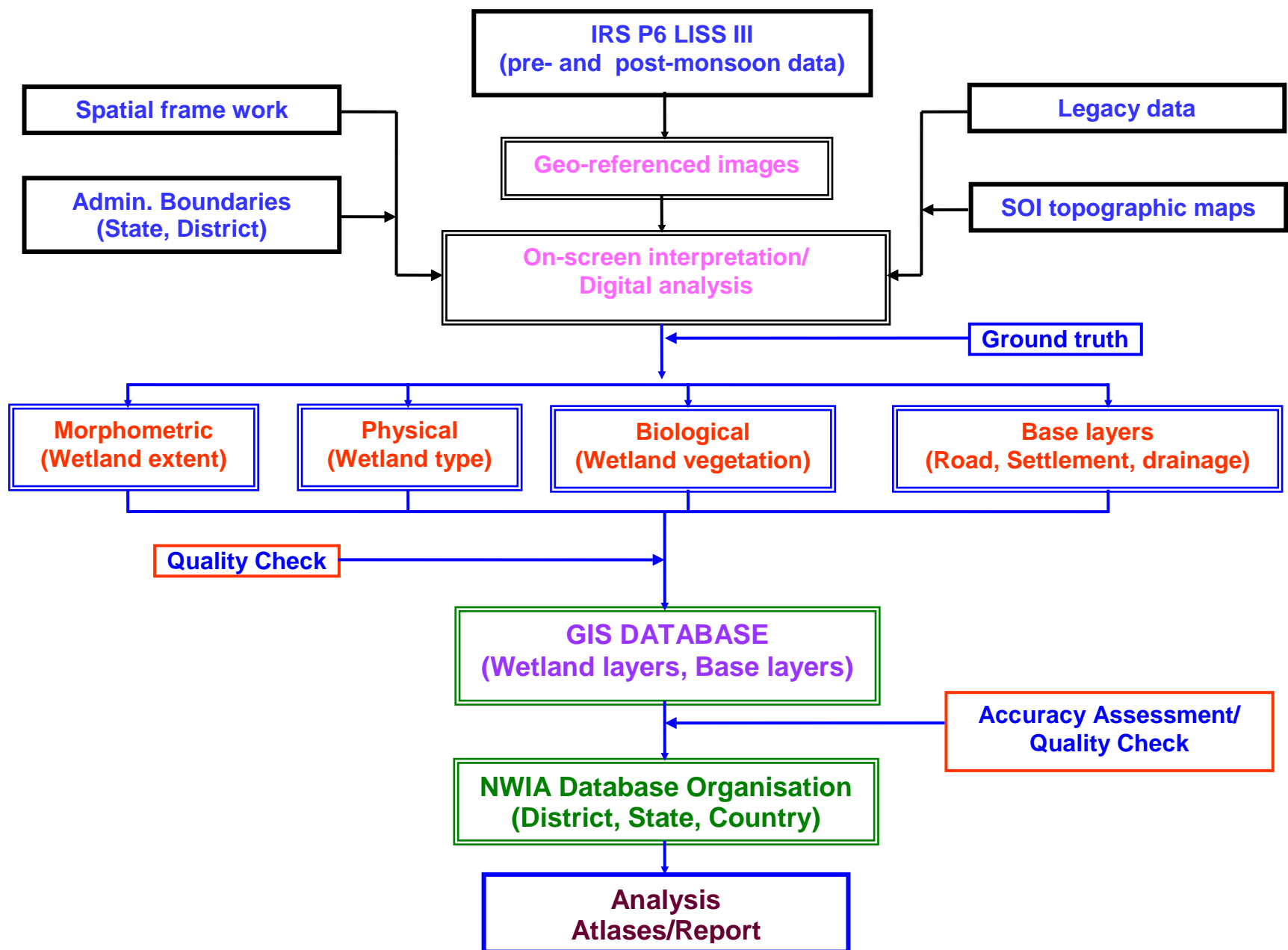


Figure 7: Flow chart of the methodology used

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

- Extraction of wetland extent :  
MNDWI, NDPI and NDVI image was used to extract the wetland boundary through suitable hierarchical thresholds.
- Extraction of open water :  
MNDWI was used with in the wetland mask to delineate the water and no-water areas.
- Extraction of wetland vegetation :  
NDPI and NDVI image was used to generate the vegetation and no-vegetation areas within a wetland using a suitable threshold.
- Turbidity information extraction :  
MNDWI image was used to generate qualitative turbidity level (high, moderate and low) based on following steps:
  - a) Conversion of post- and pre-monsoon water spread polygons into Area of Interest (Aoi).
  - b) Grouping of all Aois excluding all non-wetland areas into a single entity.
  - c) Generate a signature statistics like minimum, maximum, mean and standard deviations.
  - d) Generate a raster turbidity image through a model for Aoi only with *conditional* categorisation.
  - e) Convert the raster into vector and update the attributes or edit the water spread layer (copied as turbidity layer) in polygon mode so as to retain all the attributes.
  - f) Assign turbidity classes as per the table 3.

Table 3: Qualitative turbidity ratings

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

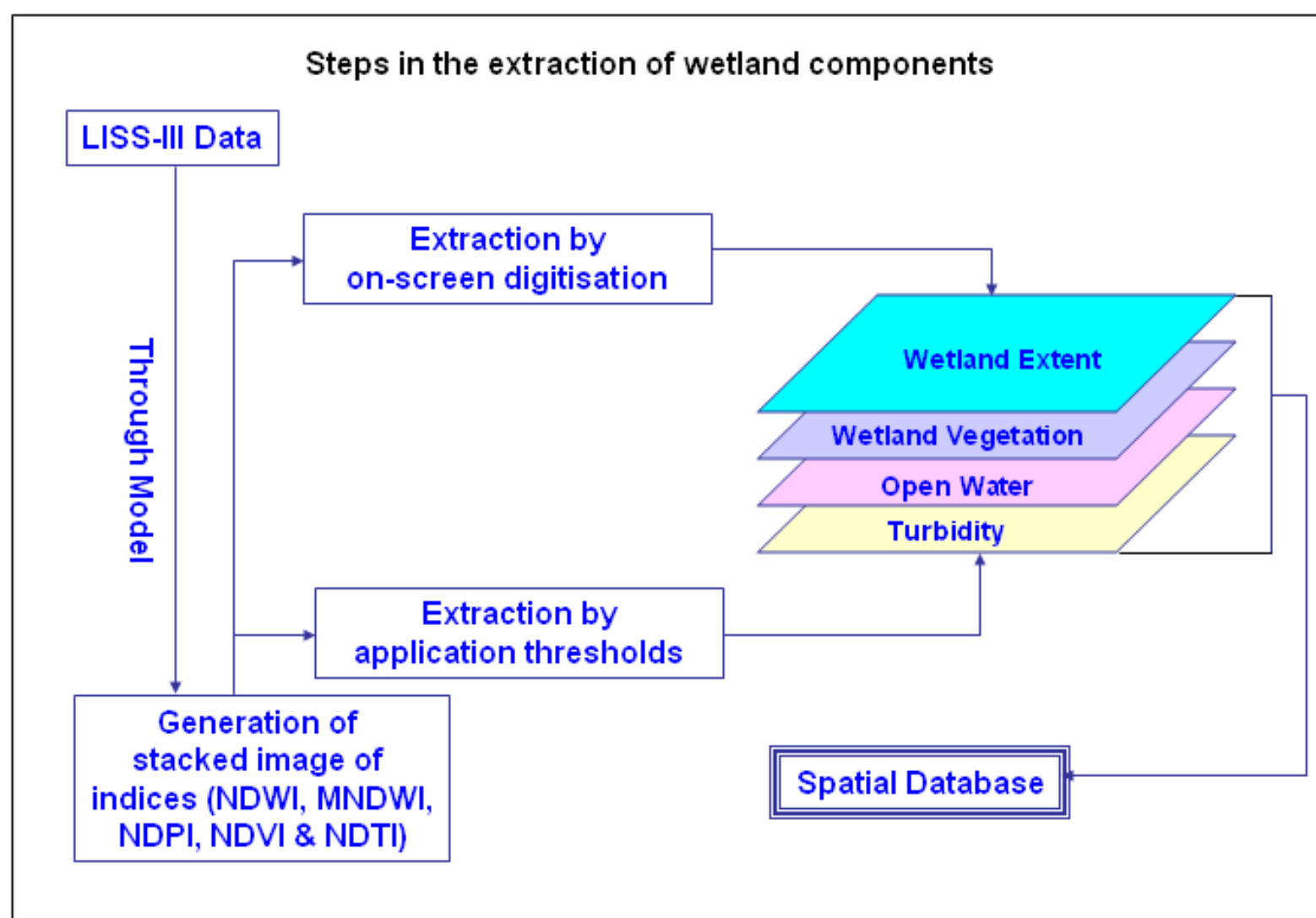


Figure 8: Steps in the extraction of wetland components

#### 5.4 Conversion of the Raster (indices) into a Vector Layer

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

#### 5.5 Generation of Reference Layers

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

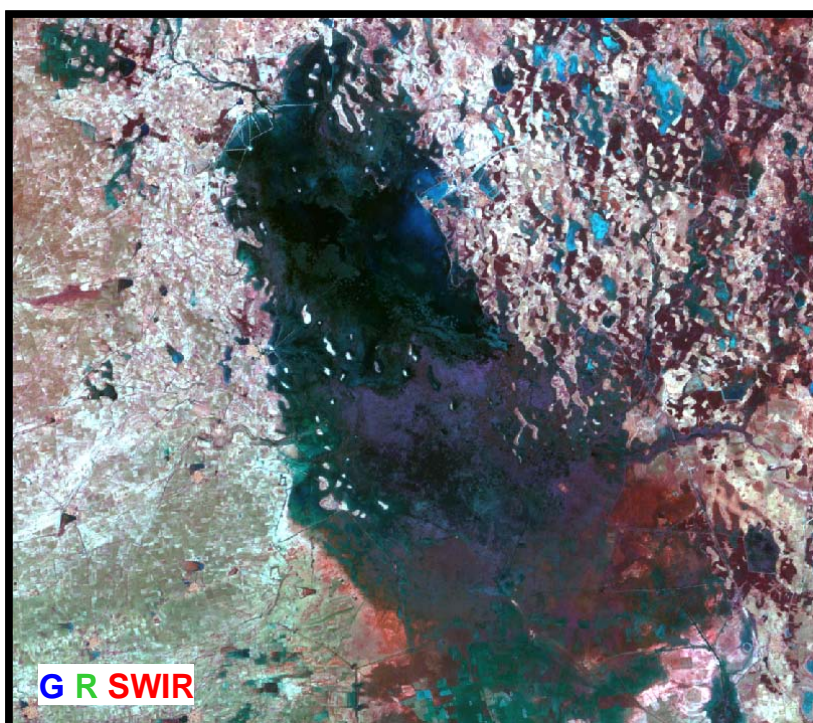
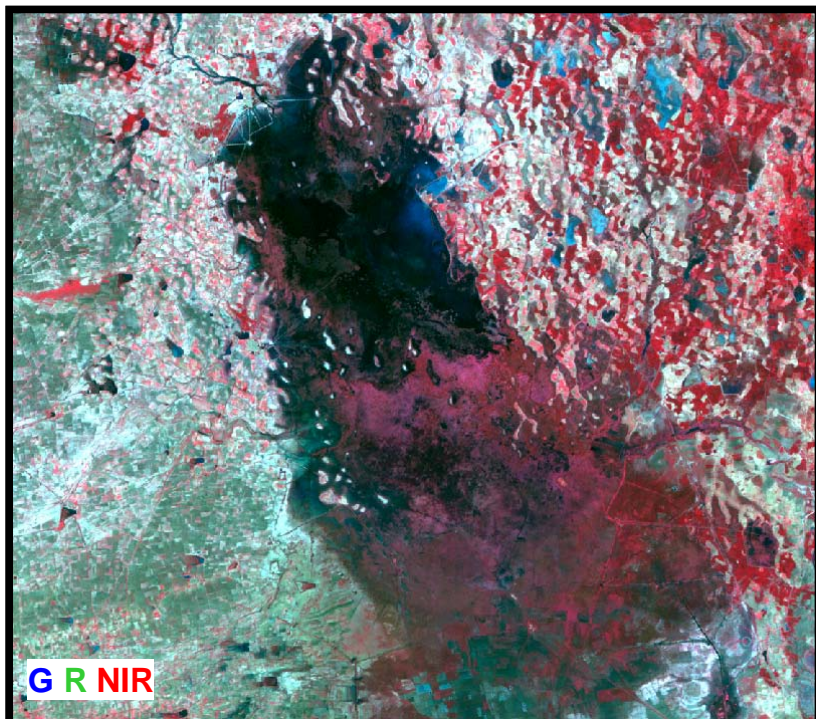
#### 5.6 Coding and Attribute Scheme

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

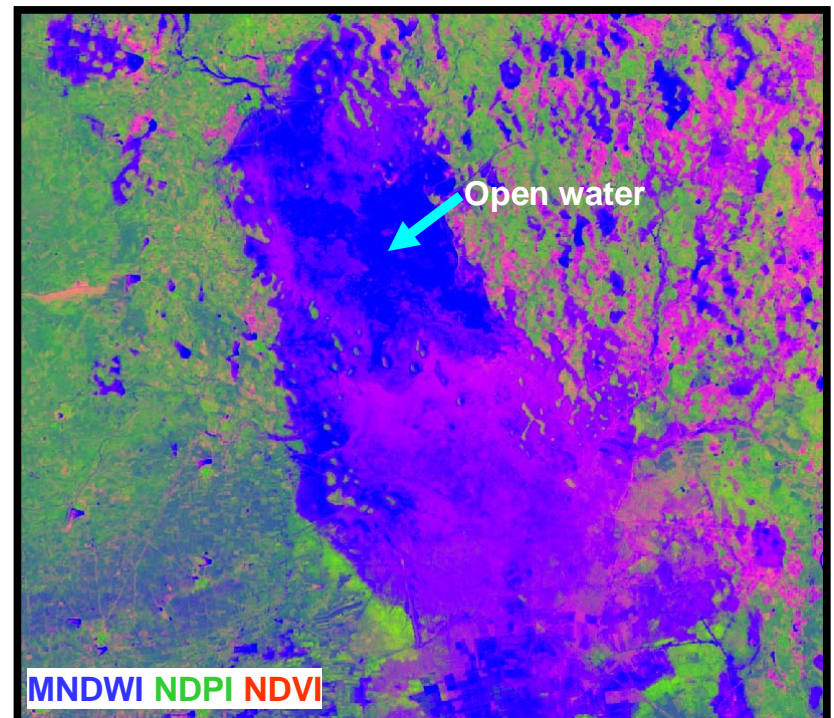
#### 5.7 Map composition and output

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

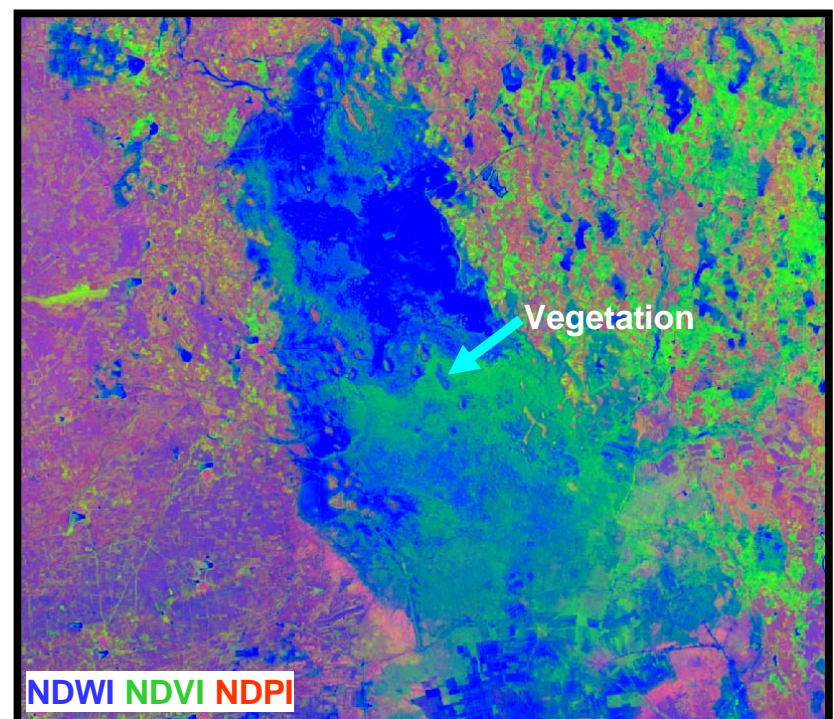




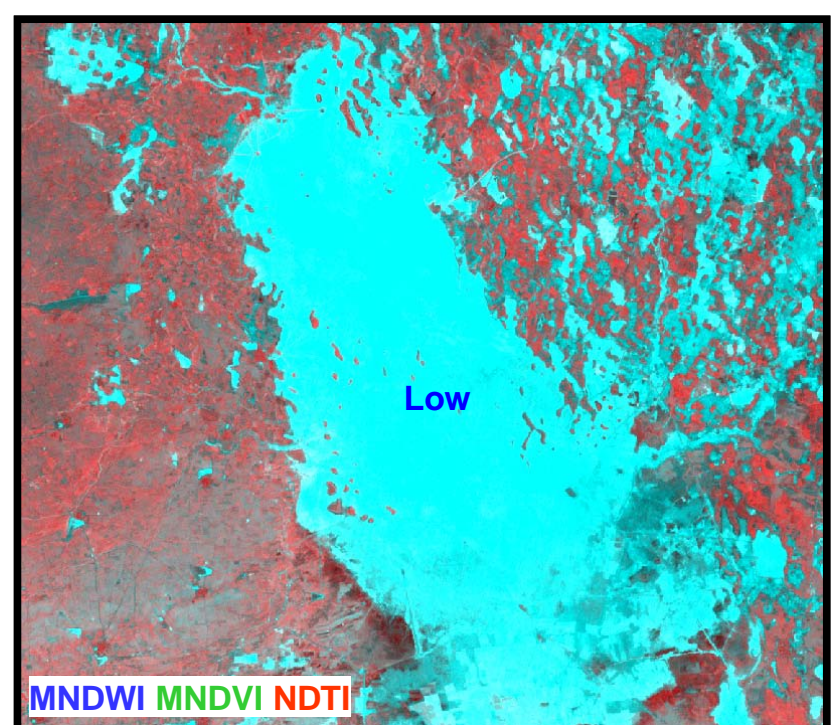
Nalsarovar,  
IRS LISS III data, 10 October 2006



Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features



Useful for qualitative turbidity delineation

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



## **6.0 ACCURACY ASSESSMENT**

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

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

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

### **6.1 Data verification and quality assurance of output digital data files**

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

# **MAPS AND STATISTICS**



## 7.0 WETLANDS OF GUJARAT: MAPS AND STATISTICS

Area estimates of various wetland categories for Gujarat have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total 14183 wetlands have been mapped at 1:50,000 scale in the state. In addition, 9708 small wetlands (< 2.25 ha) have also been identified. Total wetland area estimated is 3474950 ha (Table 4), which accounts for about 17.56 % of geographical area of the state. The major wetland types include Intertidal mud flats (2260365 ha), River/Stream (275877 ha), Reservoirs/Barrages (248979 ha), Creeks (149898 ha) and Salt Marsh (144268 ha). The coastal wetlands dominate in the state. Some of the unique wetlands like corals and mangroves are found in Gujarat state. Graphical distribution of wetland type is shown in Figure 10.

The water spread of wetlands is low during pre monsoon, particularly; it is significant in case of Inland wetlands indicating rain fed nature of the wetlands. Area under aquatic vegetation is slightly more in pre-monsoon season (205159 ha) than in post monsoon (152318 ha). Turbidity of water is in general high in both the seasons.

Table 4: Area estimates of wetlands in Gujarat

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	40	23550	0.68	8507	1873
2	1102	Ox-bow lakes/ Cut-off meanders	1	6	0.00	6	0
3	1105	Waterlogged	278	20660	0.59	11081	2406
4	1106	River/Stream	1039	275877	7.94	86467	47983
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
5	1201	Reservoirs/Barrages	1214	248979	7.16	233209	98187
6	1202	Tanks/Ponds	8818	73873	2.13	59621	14387
7	1203	Waterlogged	34	13951	0.40	9382	167
8	1204	Salt pans	9	1295	0.04	1143	46
		<b>Total - Inland</b>	<b>11433</b>	<b>658191</b>	<b>18.94</b>	<b>409416</b>	<b>165049</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
9	2101	Lagoons	32	22289	0.64	15228	9882
10	2102	Creeks	170	149898	4.31	149252	149660
11	2103	Sand/Beach	66	6508	0.19	-	-
12	2104	Intertidal mud flats	1066	2260365	65.05	513166	352494
13	2105	Salt Marsh	318	144268	4.15	-	-
14	2106	Mangroves	746	90475	2.60	-	-
15	2107	Coral Reefs	50	33547	0.97	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
16	2201	Salt pans	209	90878	2.62	57809	49914
17	2202	Aquaculture ponds	93	8823	0.25	5884	5482
		<b>Total - Coastal</b>	<b>2750</b>	<b>2807051</b>	<b>80.78</b>	<b>741339</b>	<b>567432</b>
		<b>Sub-Total</b>	<b>14183</b>	<b>3465242</b>	<b>99.72</b>	<b>1150755</b>	<b>732481</b>
		Wetlands (<2.25 ha), mainly Tanks	9708	9708	0.28	-	-
		<b>Total</b>	<b>23891</b>	<b>3474950</b>	<b>100.00</b>	<b>1150755</b>	<b>732481</b>

<b>Area under Aquatic Vegetation</b>	152318	205159
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<b>Area under turbidity levels</b>		
Low	331081	145292
Moderate	136136	83970
High	683538	503219

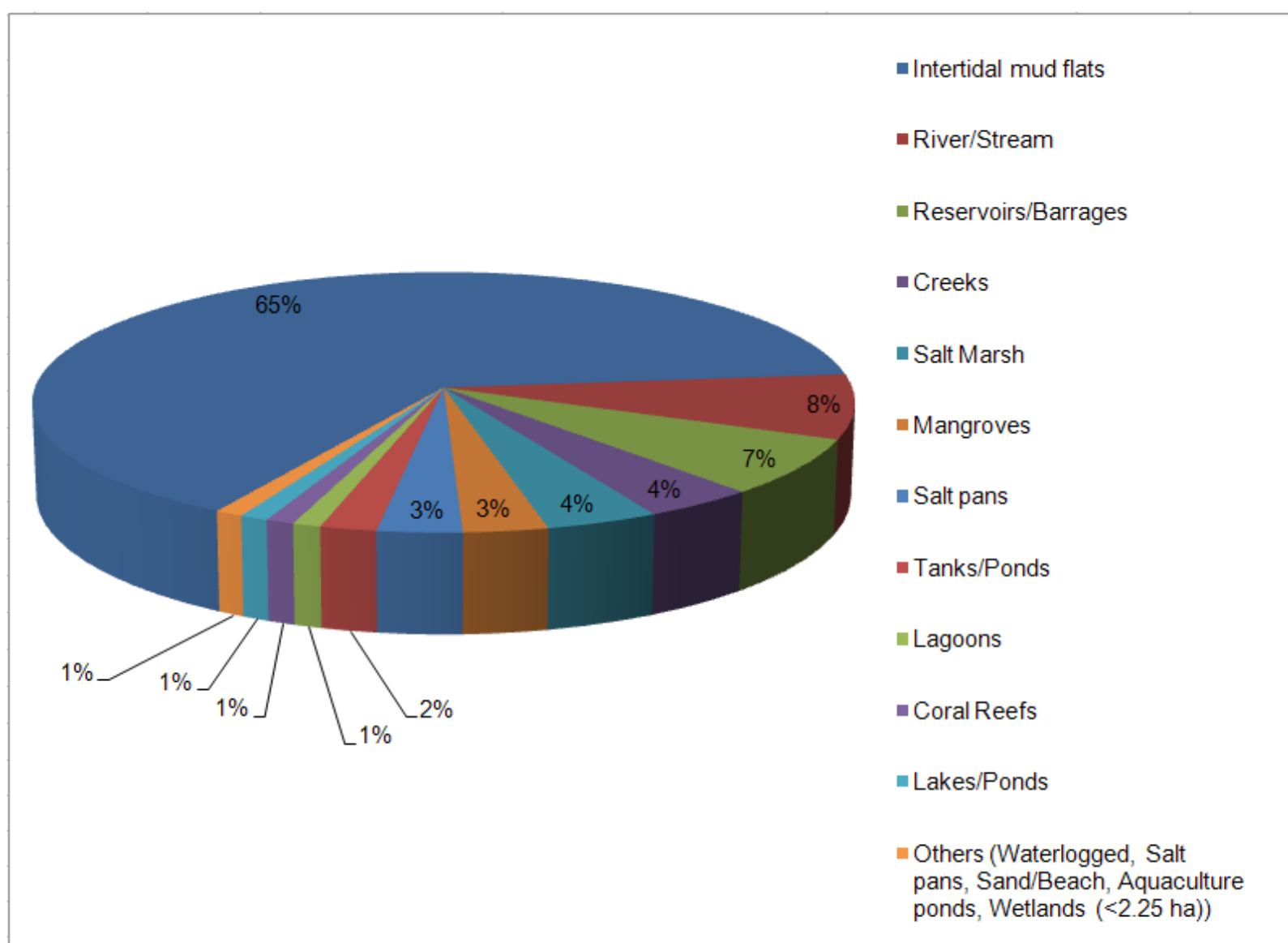


Figure 10: Type-wise wetland distribution in Gujarat

## 7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has 25 districts. The geographic area varied from 45652 sq. km (Kachchh) to 649 sq. km (Gandhinagar). The wetland area in each district as per cent of total state wetland area ranged from 0.13% (The Dangs) to 67.94 % (Kachchh). The wetland area in the districts as per cent of geographic area varied from 1.93% (Mehsana) to 51.72 % (Kachchh). Kachchh, Jamnagar, Bharuch, Bhavnagar and Surat are wetland rich districts mainly due to coastal wetlands. Coral is one of the special wetland types found only in the district of Jamnagar lying in the Gulf of Kachchh. The area occupied by Coral is around 33,547 ha, scattered over 50 sites. Mangrove is another special wetland type found in 13 districts, covering an area of 90475 ha. However, maximum mangrove area is observed in Kachchh district having 50197 ha, followed by Jamnagar district with 18537 ha. Salt marsh is observed in 15 districts. Maximum area under this is observed in Bhavnagar district (25374 ha), followed by Ahmedabad district (22858 ha). There are 8818 Tanks/pond (man made) distributed through out the state covering an area of 73,873 ha. Maximum number are observed in the Kachchh district (1438 with 14449 ha area), followed by Surendranagar district (719 with 7941 ha area). Least number of Tanks is observed in the district of Dangs (only 3). Patan, Surendranagar and Ahmedabad districts are rich in natural Lakes/pond with 9, 8 and 7 numbers each out of the total 40 mapped in the state.

District-wise wetland area estimates is given in Table-5 and graphical distribution of wetlands is shown in Figure - 11.

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

Table-5: District-wise wetland area

Sr. No.	District	Geographic Area	Wetland Area	% of total wetland area	% of district geographic area
		(sq. km)	(ha)		
1	Kachchh	45652	2360909	67.94	51.72
2	Banaskantha	12703	43491	1.25	3.42
3	Patan	5738	34268	0.99	5.97
4	Mehsana	4386	8462	0.24	1.93
5	Sabarkantha	7390	42653	1.23	5.77
6	Gandhinagar	649	4263	0.12	6.57
7	Ahmadabad	8707	63303	1.82	7.27
8	Surendranagar	10489	52896	1.52	5.04
9	Rajkot	11203	55820	1.61	4.98
10	Jamnagar	14125	198657	5.72	14.06
11	Porbandar	2294	22199	0.64	9.68
12	Junagadh	8839	30563	0.88	3.46
13	Amreli	6760	28505	0.82	4.22
14	Bhavnagar	11155	85895	2.47	7.7
15	Anand	2942	67570	1.94	22.97
16	Kheda	4215	14415	0.41	3.42
17	Panch Mahals	5219	38049	1.09	7.29
18	Dohad	3642	15092	0.43	4.14
19	Vadodara	7794	35553	1.02	4.56
20	Narmada	2749	22501	0.65	8.19
21	Bharuch	6524	112453	3.24	17.24
22	Surat	7657	86062	2.48	11.24
23	The Dangs	1764	4368	0.13	2.48
24	Navsari	2211	23888	0.69	10.8
25	Valsad	3034	23116	0.67	7.62
	<b>TOTAL</b>	<b>197841</b>	<b>3474951</b>	<b>100</b>	<b>14.06</b>



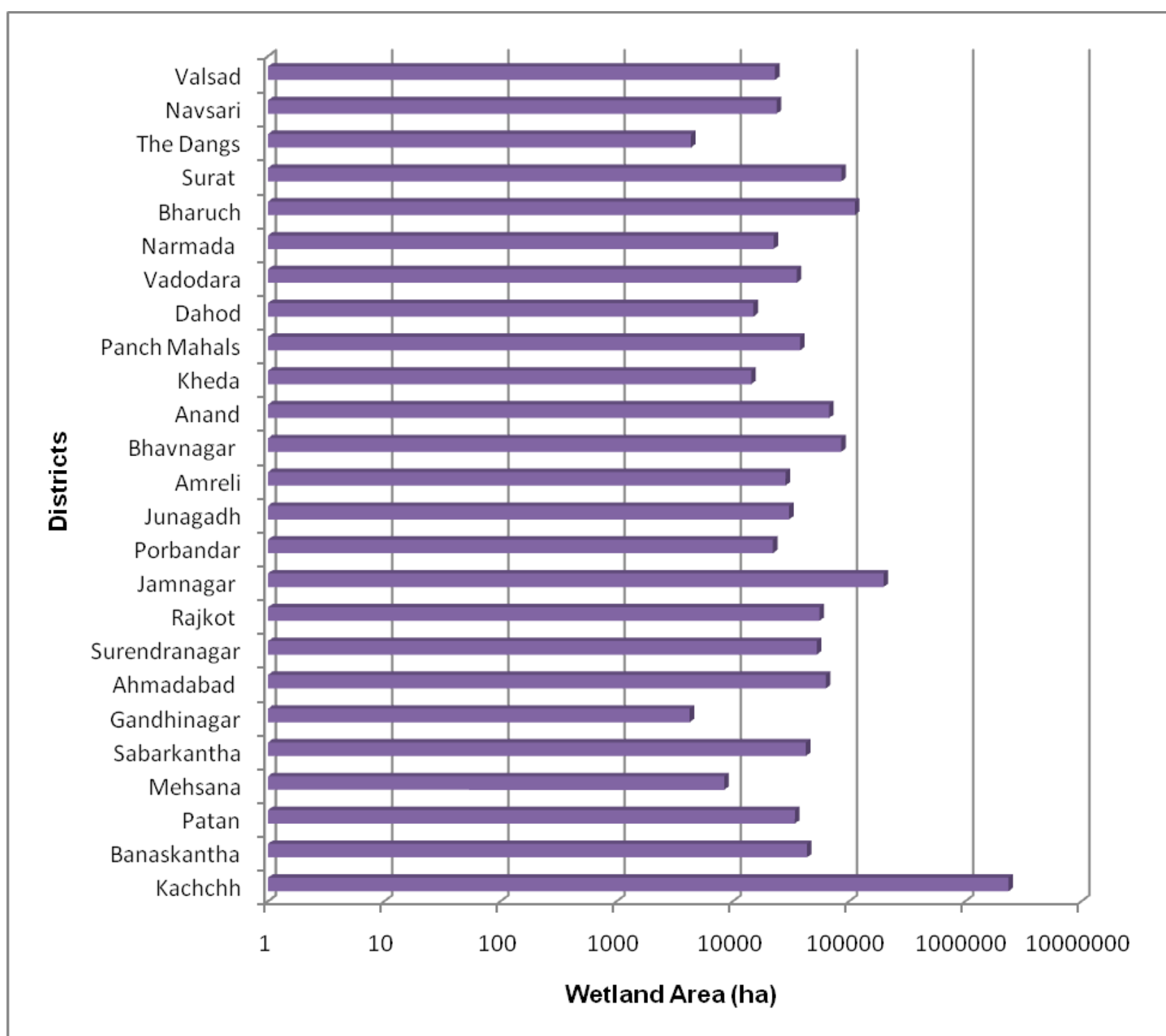
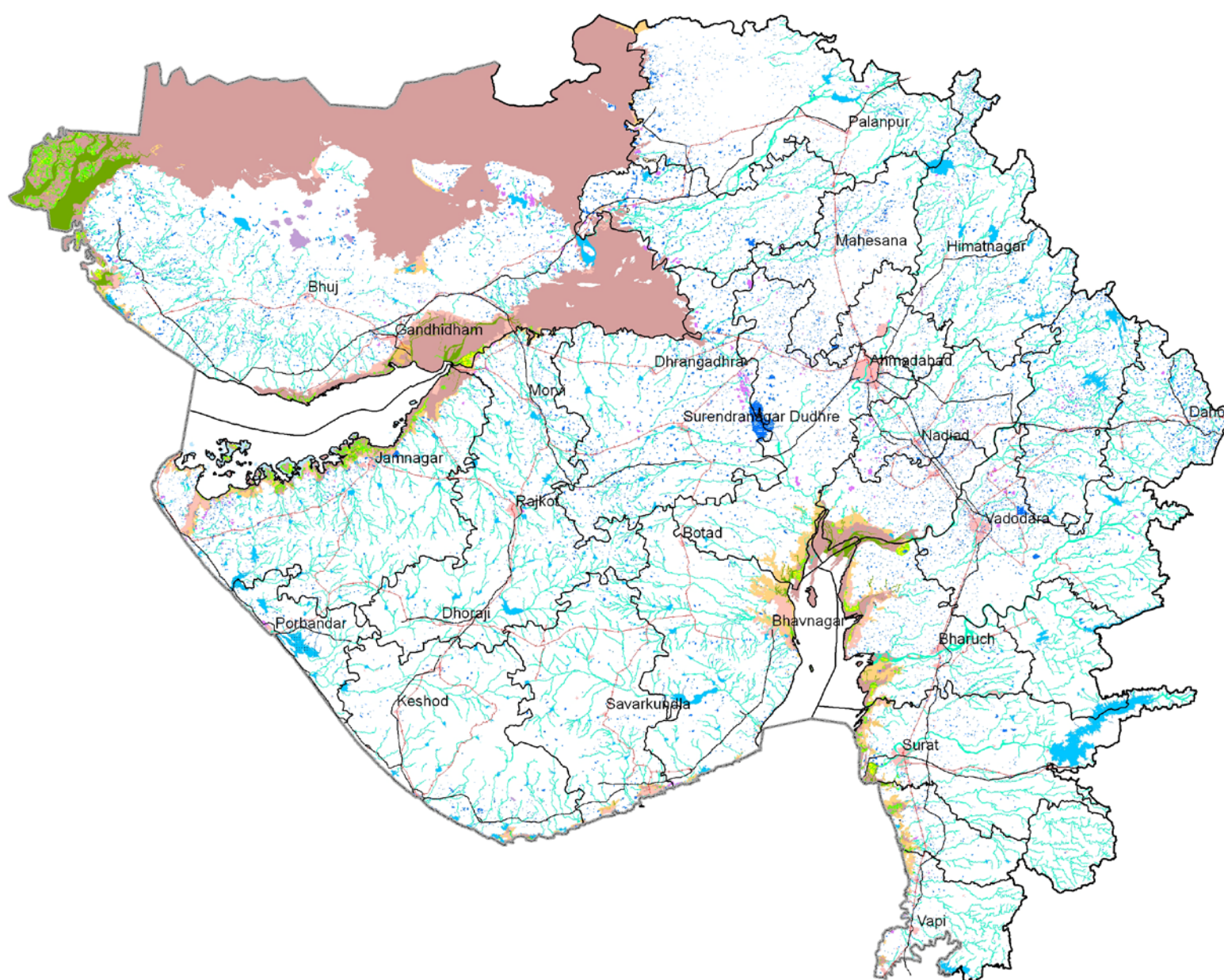


Figure 11: District-wise wetland distribution



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)
- Drainage (line)
- Major Roads
- Railway
- Settlements
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

## Location Map



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

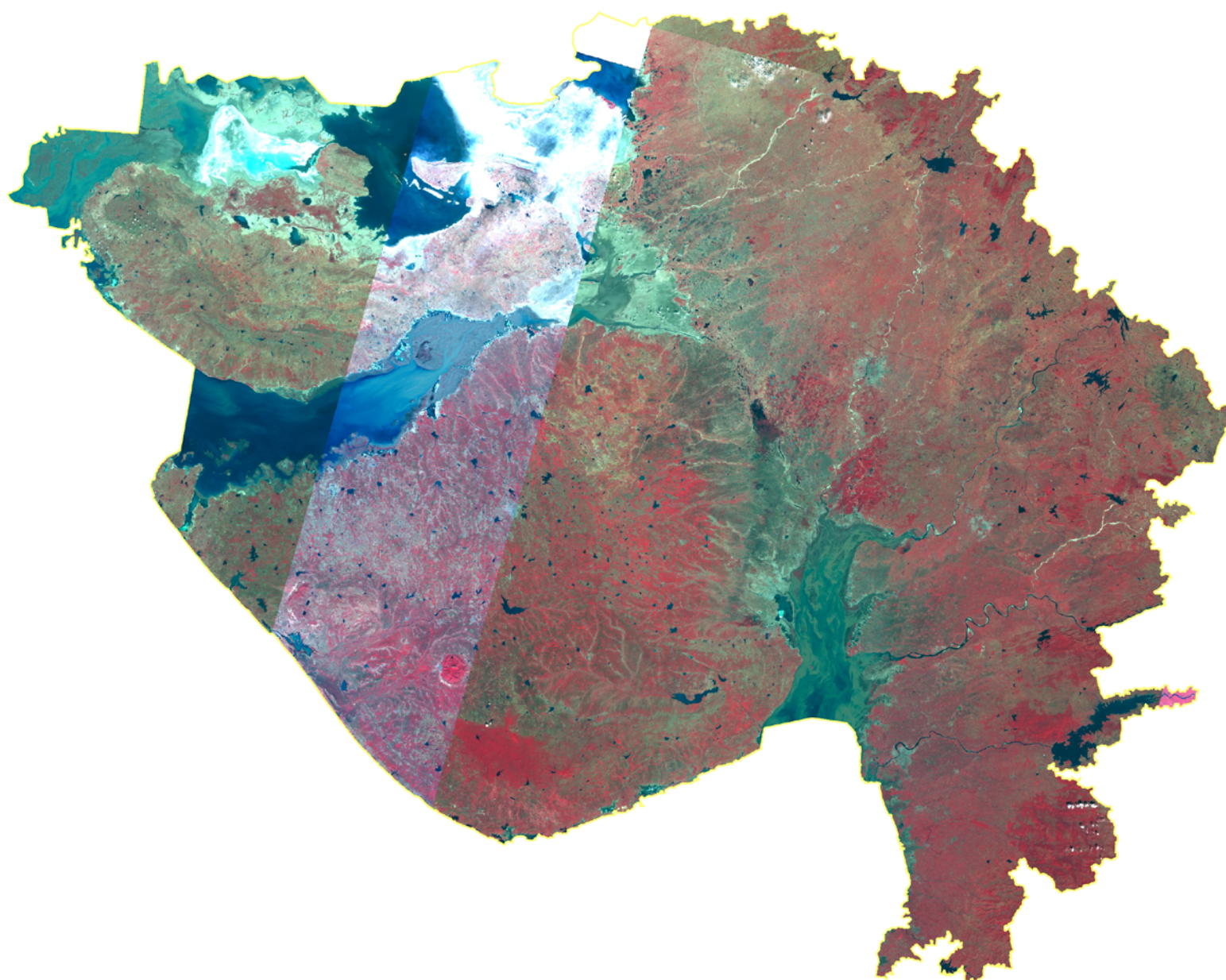
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Ministry of Environment and Forests  
Government of India





State : Gujarat



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

### 7.1.1 Kachchh

Kachchh district is surrounded by the Gulf of Kachchh and the Arabian Sea in south and west, while northern and eastern parts are surrounded by the Great and Small Rann (seasonal wetlands) of Kachchh. When there were not many dams built on its rivers, the Rann of Kachchh remained wetlands for a large part of the year. Bhuj is the district head quarters of Kachchh district. The district covers an area of 45, 652 sq. km with total population of 15, 26,321 according to 2001 census.

Kachchh district has the largest share of wetlands in the state of Gujarat. Total 4659 wetlands are mapped including 1304 small wetlands (< 2.25 ha) with 2360909 ha area. Inland wetlands contribute 3.5% of the total wetland area and coastal wetlands contribute 96.5% of the total wetland area. Major wetland category found in the district is Inter-tidal mud flats, creeks, mangroves and Salt pans. Details of area estimates of wetlands in Kachchh district is shown in Table-6. The wetland area is high due to inter tidal mud flats of little rann of Kachchh and great rann of Kachchh area. The area is generally flooded between May and October when sea water, driven by high winds and tides from the Arabian Sea and monsoon run-off from the hills of Gujarat and Rajasthan, mix together over the plains. For the remainder of the year, the Rann is a vast expanse of sun-baked mud and sand with halite and gypsum efflorescences.

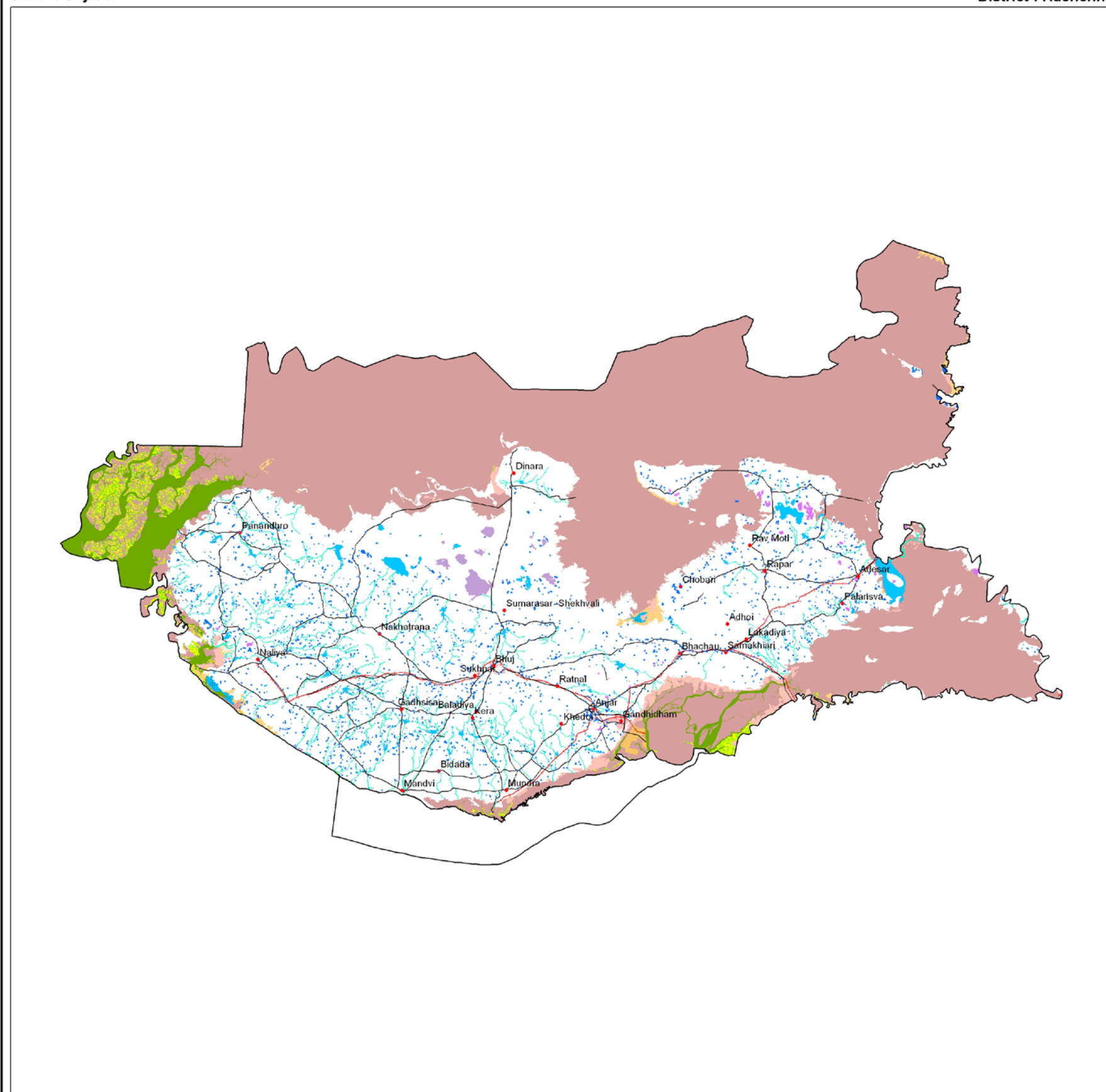
Area under aquatic vegetation in post-monsoon is about 59132 ha and slightly high during pre monsoon (60381 ha). Open water spread of the wetlands is significantly higher in post monsoon (709817 ha) than during pre monsoon (499905 ha), indicating the rainfall dependence of the wetlands in the district. Most of the open water area is under high turbidity during both seasons.

Table 6: Area estimates of wetlands in Kachchh

Table 6: Area estimates of Wetlands in Rajasthan						Area in ha	
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	3	203	0.01	204	-
2	1105	Waterlogged	38	4188	0.18	2956	96
3	1106	River/Stream	224	20322	0.86	1924	1497
	1200	Inland Wetlands -Man-made					
4	1201	Reservoirs/Barrages	259	29995	1.27	25338	4860
5	1202	Tanks/Ponds	1438	14449	0.61	12311	1675
6	1203	Waterlogged	10	12281	0.52	8620	-
		Total - Inland	1972	81438	3.45	51353	8128
	2100	Coastal Wetlands - Natural					
7	2101	Lagoons	5	3838	0.16	2601	2204
8	2102	Creeks	95	120751	5.11	120754	120694
9	2103	Sand/Beach	18	1927	0.08	-	-
10	2104	Intertidal mud flats	653	2044824	86.61	513166	352494
11	2105	Salt Marsh	55	16895	0.72	-	-
12	2106	Mangroves	459	50197	2.13	-	-
	2200	Coastal Wetlands - Man-made					
13	2201	Salt pans	97	34819	1.47	18564	13043
14	2202	Aquaculture ponds	1	4916	0.21	3379	3342
		Total - Coastal	1383	2278167	96.50	658464	491777
		Sub-Total	3355	2359605	99.94	709817	499905
		Wetlands (<2.25 ha), mainly Tanks	1304	1304	0.06	-	-
		Total	4659	2360909	100.00	709817	499905

<b>Area under Aquatic Vegetation</b>	59132	60381
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<b>Area under turbidity levels</b>		
Low	31796	8507
Moderate	31856	17902
High	646165	473496

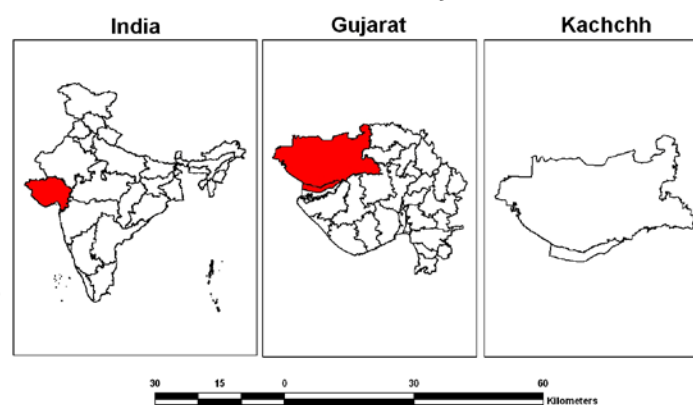


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

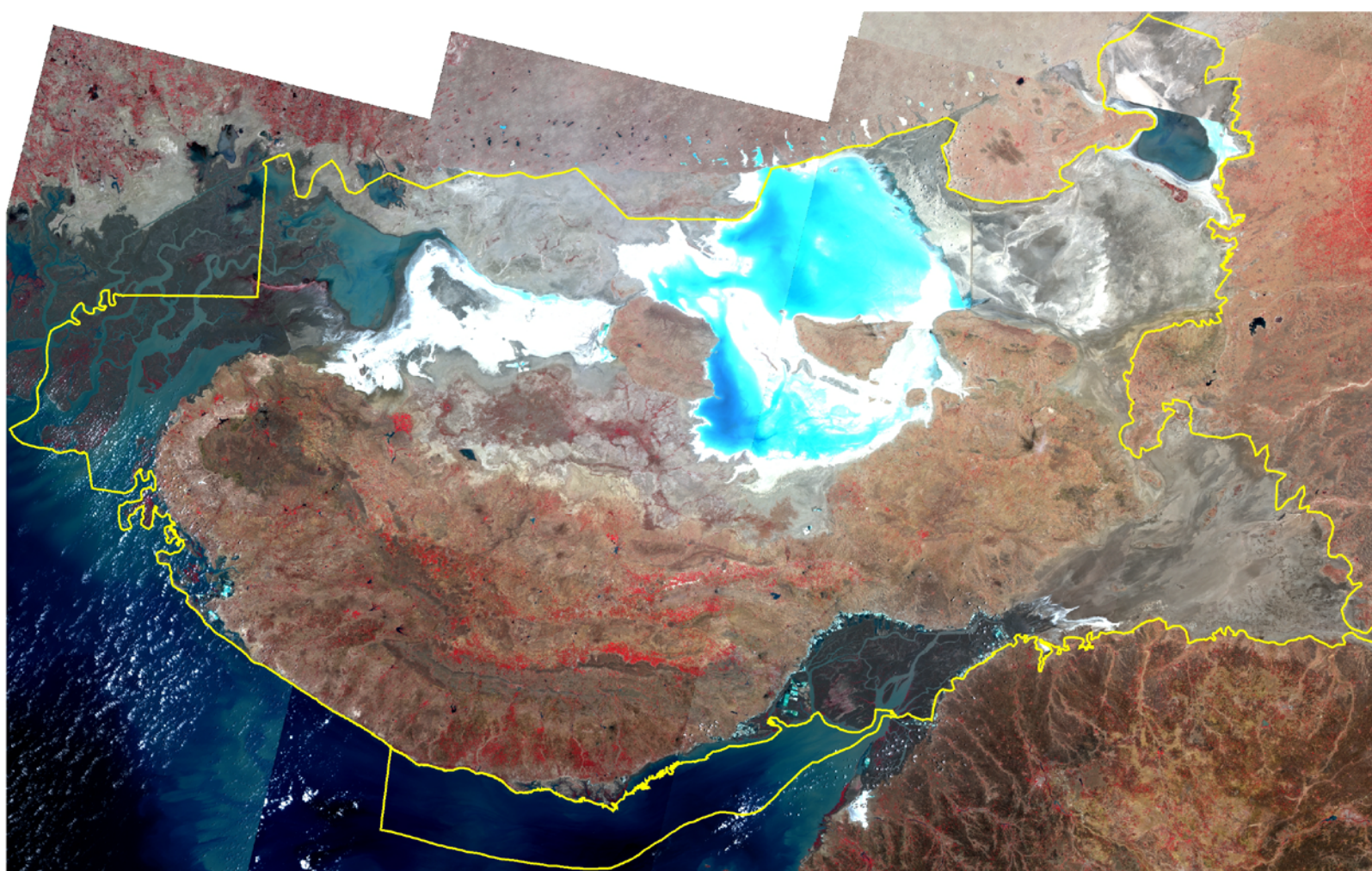
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### 7.1.2 Banaskantha

Banaskantha is located in the northeast of the state. The district gets its name from the West Banas River which runs through the valley between Mount Abu and Aravalli Range, entering into the plains of Gujarat in this region and flowing towards the Rann of Kachchh. The district is bounded by Rajasthan in the north, Sabarkantha district in east, Kachchh in west and Patan and Mehsana district in the south. The administrative headquarters is at Palanpur, the main town of the district. Banaskantha covers an area of 10,757 sq. km with a total population of 25,02,843 according to 2001 census. In the year 2000, Banashkantha was divided into two districts, one is Banashkantha and the other is Patan district.

Total 1477 wetlands are mapped including 454 small wetlands (< 2.25 ha) with 43491 ha area. Major wetland category of the district is Rivers/streams, Reservoirs, Mud flats, and Salt marsh. Wetlands are more concentrated in the western and eastern part of the district. Details of area estimates of wetlands in Banaskantha district is shown in Table-7.

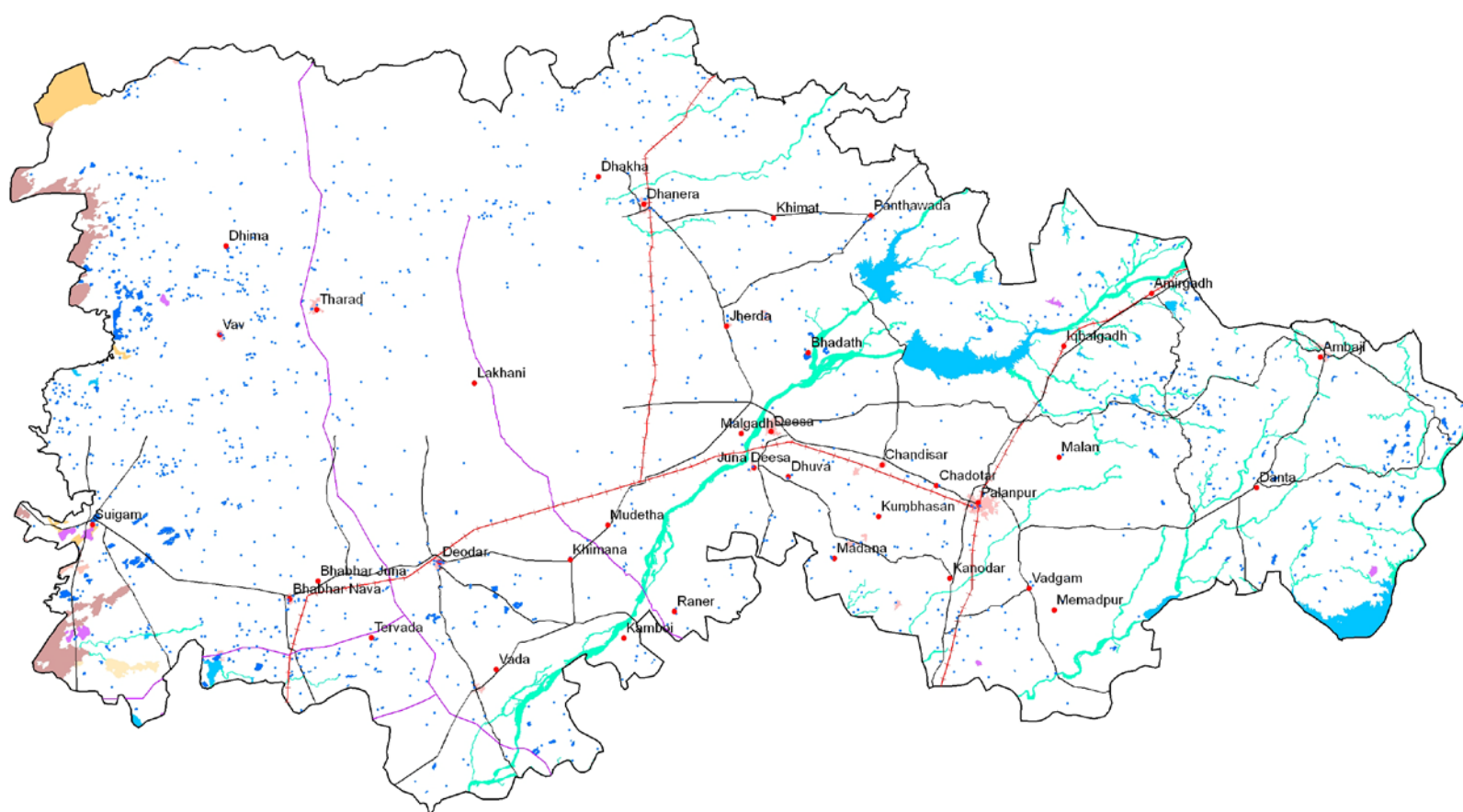
Area under aquatic vegetation in post-monsoon is about 1255 ha and increased significantly during pre monsoon (5040 ha). Open water spread of the wetlands is significantly higher in post monsoon (17718 ha) than during pre monsoon (4684 ha), indicating the rainfall dependence of the wetlands in the district. Most of the open water area is under low turbidity during both seasons.

Table 7: Area estimates of wetlands in Banaskantha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water Post-monsoon Area	Open Water Pre-monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	3	330	0.76	224	5
2	1105	Waterlogged	10	840	1.93	430	33
3	1106	River/Stream	49	14806	34.04	2050	161
	1200	Inland Wetlands -Man-made					
4	1201	Reservoirs/Barrages	23	10784	24.80	10599	4115
5	1202	Tanks/Ponds	327	3876	8.91	3309	331
6	1204	Salt pans	4	826	1.90	826	39
		Total - Inland	416	31462	72.34	17438	4684
	2100	Coastal Wetlands - Natural					
7	2104	Intertidal mud flats	25	7023	16.15	-	-
8	2105	Salt Marsh	9	3703	8.51	-	-
	2200	Coastal Wetlands - Man-made					
9	2201	Salt pans	4	280	0.64	280	-
		Total - Coastal	38	11006	25.31	280	-
		Sub-Total	454	42468	97.65	17718	4684
		Wetlands (<2.25 ha), mainly Tanks	1023	1023	2.35	-	-
		Total	1477	43491	100.00	17718	4684

<b>Area under Aquatic Vegetation</b>	1255	5040
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<b>Area under turbidity levels</b>		
Low	13883	4314
Moderate	3315	308
High	520	62

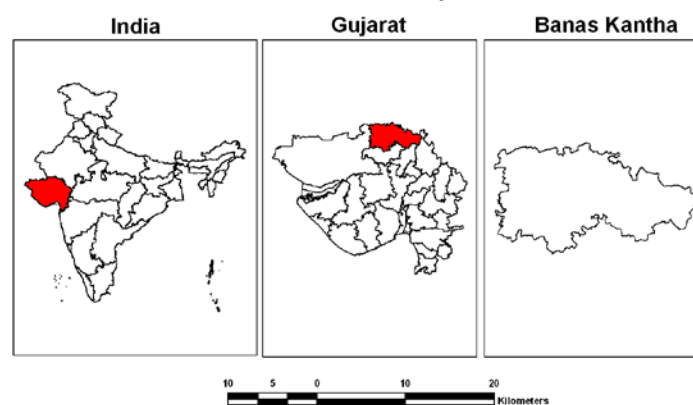


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



## Data Source :

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

## Prepared By :

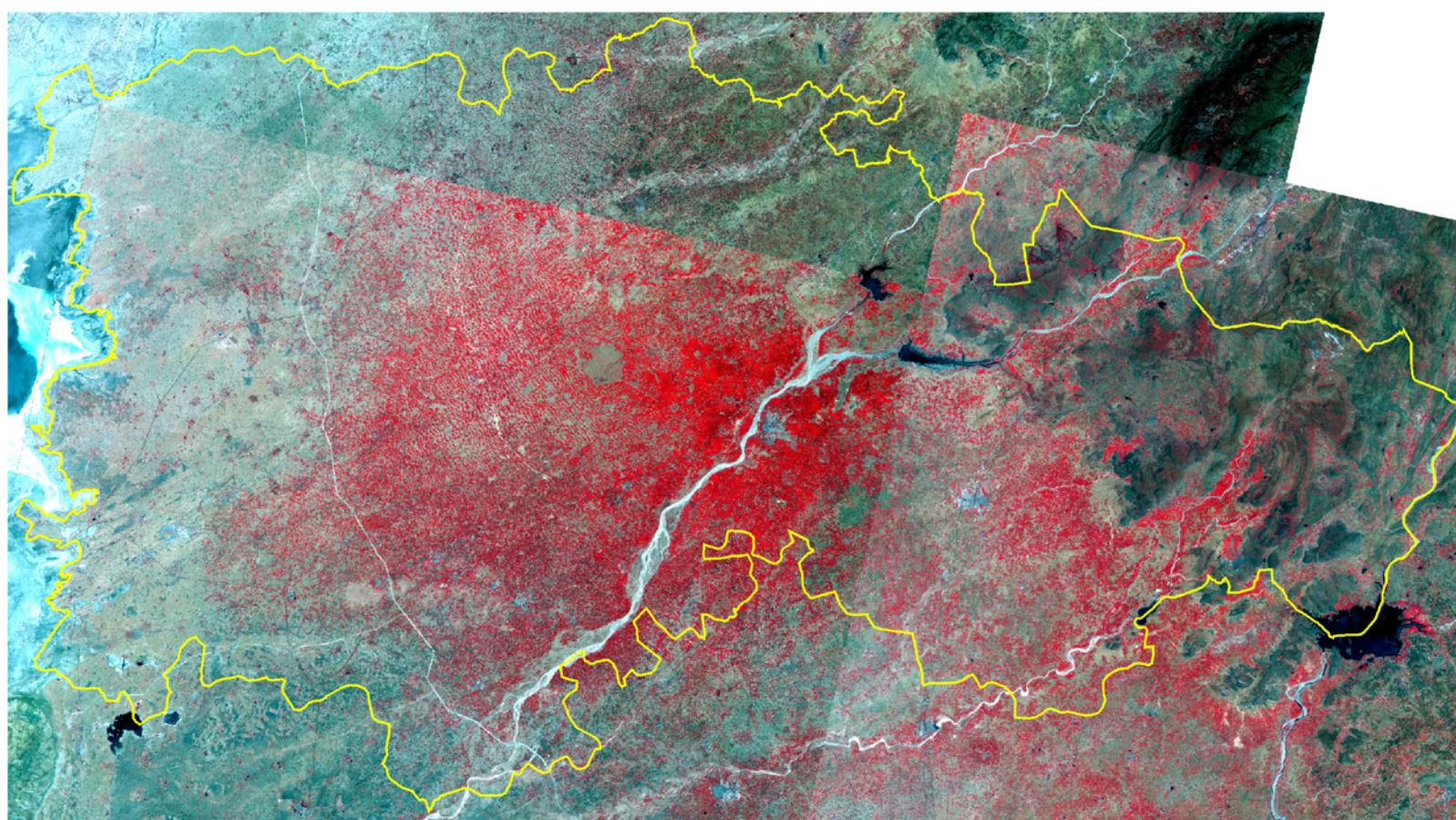
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### 7.1.3 Patan

Patan district is located in the northern part of the state with its head quarters at Patan town. The district covers an area of 5730 sq. km with total population of 11, 81,941. The district is surrounded by Banas Kantha district in the north and northeast, Mehsan in its south and southeast and Kachchh and Little Rann of Kachchh in the east.

Total 1037 wetlands are mapped including 416 small wetlands (< 2.25 ha) with 34268 ha area. Major wetland category of the district is Mud flats, Rivers/streams, Reservoirs and Tanks/ponds. Wetlands are more concentrated in the western part of the district. Details of area estimates of wetlands in Patan district is shown in Table-8.

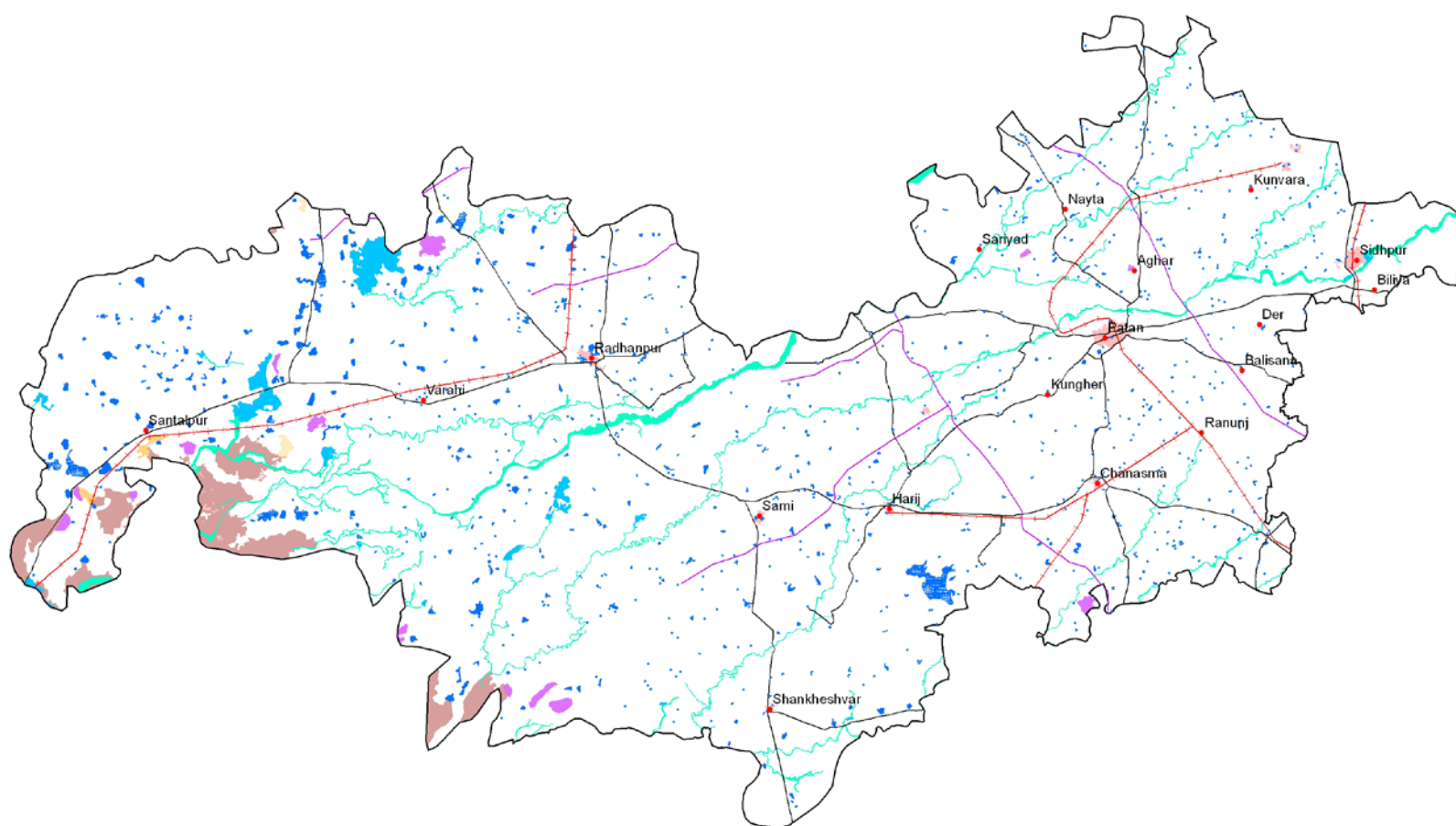
Area under aquatic vegetation in post-monsoon is about 2973 ha and slightly less during pre monsoon (1280 ha). Open water spread of the wetlands is significantly higher in post monsoon (11595 ha) than during pre monsoon (2593 ha). Turbidity of water is low to moderate in both the seasons.

Table 8: Area estimates of wetlands in Patan

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	9	1725	5.03	587	4
2	1105	Waterlogged	19	1947	5.68	1766	113
3	1106	River/Stream	31	9430	27.52	1657	255
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	25	3922	11.45	3670	1403
5	1202	Tanks/Ponds	484	5035	14.69	3621	818
6	1204	Salt pans	2	294	0.86	294	-
		<b>Total - Inland</b>	<b>570</b>	<b>22353</b>	<b>65.23</b>	<b>11595</b>	<b>2593</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
7	2104	Intertidal mud flats	34	11004	32.11	-	-
8	2105	Salt Marsh	2	392	1.14	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
9	2201	Salt pans	15	103	0.30	-	-
		<b>Total - Coastal</b>	<b>51</b>	<b>11499</b>	<b>33.56</b>	<b>-</b>	<b>-</b>
		<b>Sub-Total</b>	<b>621</b>	<b>33852</b>	<b>98.79</b>	<b>11595</b>	<b>2593</b>
		Wetlands (<2.25 ha), mainly Tanks	416	416	1.21	-	-
		<b>Total</b>	<b>1037</b>	<b>34268</b>	<b>100.00</b>	<b>11595</b>	<b>2593</b>

<b>Area under Aquatic Vegetation</b>	2973	1280
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<b>Area under turbidity levels</b>		
Low	5644	1603
Moderate	5245	856
High	706	134

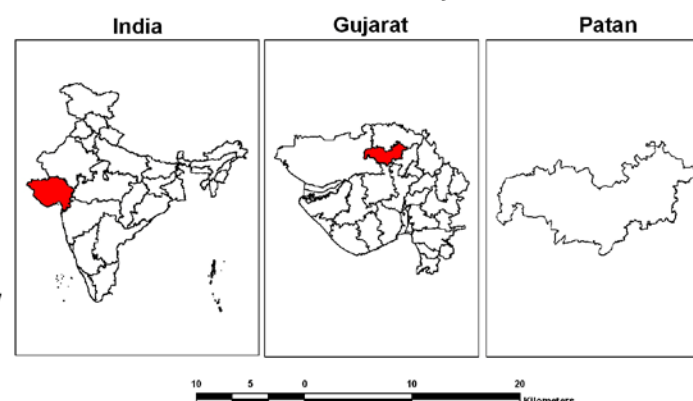


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

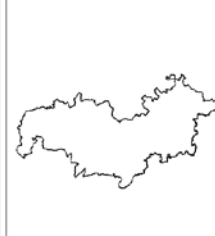
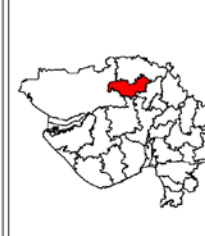
## Location Map



India

Gujarat

Patan



10 5 0 10 20  
Kilometers

Data Source :

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

Prepared By :

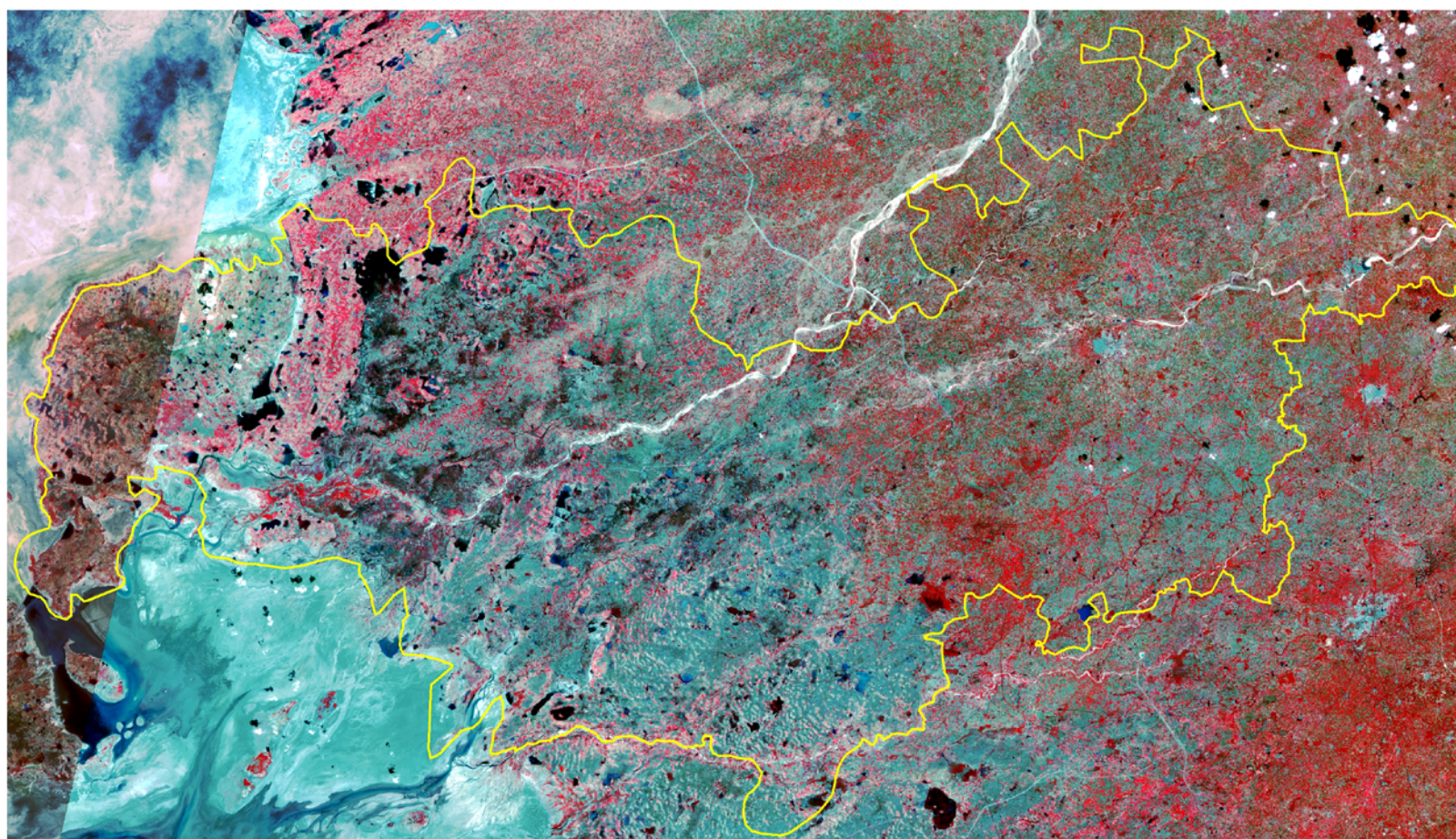
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#### 7.1.4 Mehsana

Mehsana is an administrative district of Gujarat with its head quarters located at Mehsana city. The district is bounded by Banaskantha district in the north, Patan and Surendranagar districts in the west, Gandhinagar and Ahmedabad districts in south and Sabarkantha district in the east. The total area covered by the district is 4,384 sq. km with total population of 18,37,696.

Total 987 wetlands are mapped including 521 small wetlands (< 2.25 ha) with 8462 ha area. Major wetland category of the district is Rivers/ streams, Tanks/ponds, and Reservoirs. Thol Sanctuary is located in southern part of the district. Thol lake in the centre of the sanctuary which is the main attraction apart from birds and trees. Details of area estimates of wetlands in Mehsana district is shown in Table-9.

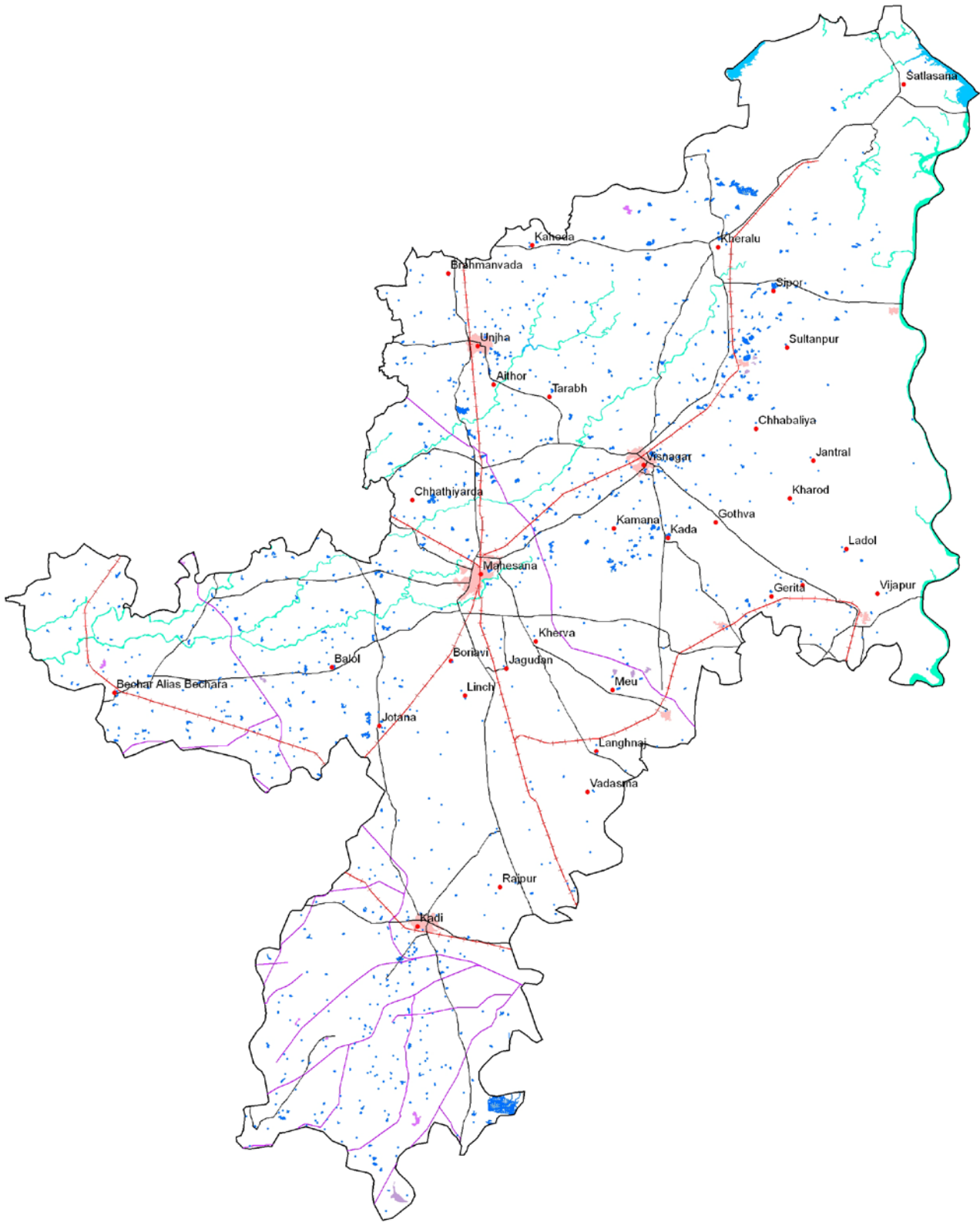
Area under aquatic vegetation in post-monsoon is about 677 ha and high during pre monsoon (1867 ha). Open water spread of the wetlands is higher in post monsoon (4395 ha) than during pre monsoon (1702 ha). The turbidity of water is in general low to moderate in both the seasons.

Table 9: Area estimates of wetlands in Mehsana

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	513	6.06	513	32
2	1105	Waterlogged	7	126	1.49	85	11
3	1106	River/Stream	15	3799	44.89	933	503
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	4	895	10.58	894	644
5	1202	Tanks/Ponds	430	2412	28.50	1940	512
6	1203	Waterlogged	8	196	2.32	30	-
		<b>Sub-Total</b>	<b>466</b>	<b>7941</b>	<b>93.84</b>	<b>4395</b>	<b>1702</b>
		Wetlands (<2.25 ha), mainly Tanks	521	521	6.16	-	-
		<b>Total</b>	<b>987</b>	<b>8462</b>	<b>100.00</b>	<b>4395</b>	<b>1702</b>

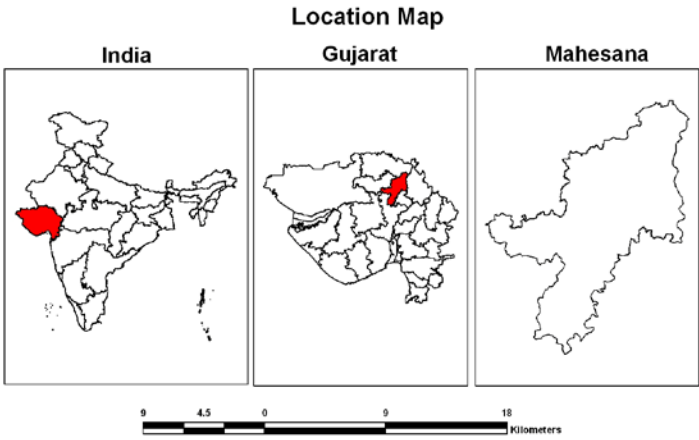
<b>Area under Aquatic Vegetation</b>	677	1867
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<b>Area under turbidity levels</b>		
Low	2289	918
Moderate	1395	653
High	711	131



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

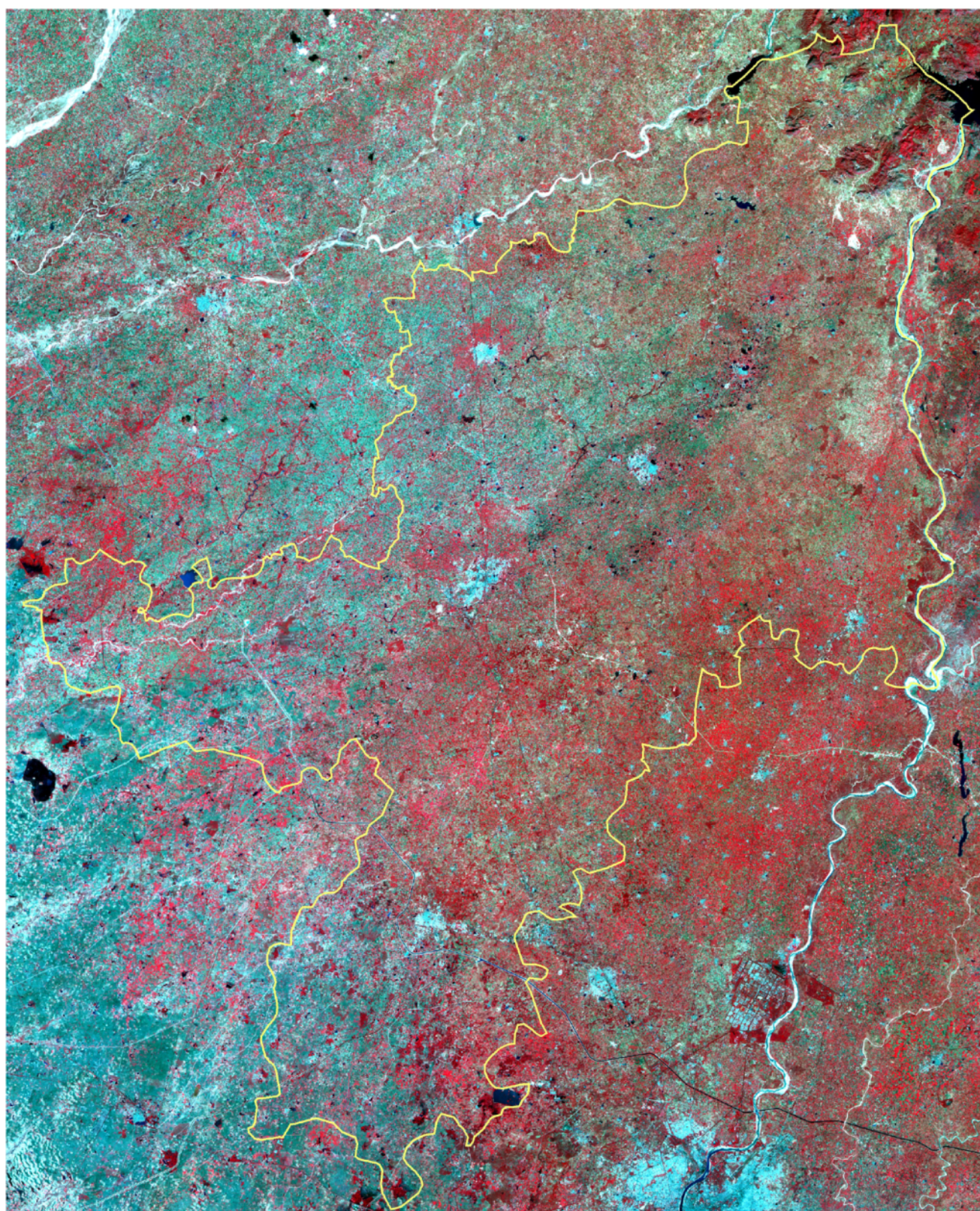
- Legend**
- Wetlands (<2.25ha)
  - Settlements
  - Roads
  - Railway
  - Canals
  - Drainage (line)
  - Town/Settlements
  - District boundary
  - State boundary
  - International boundary



Data Source :
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)
Prepared By :
Space Applications Centre (ISRO), Ahmedabad and Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar
Sponsored By :
Ministry of Environment and Forests Government of India









### 7.1.5 Sabarkantha

Sabarkantha is a district of Gujarat in the northeastern part of the state. The district head quarters are located at Himmatnagar which is 80 kms from Ahmedabad. The district is bounded by Rajasthan to the northeast, Banaskantha and Mehsana districts to the west, Gandhinagar and Kheda districts to the south and Panchmahal district to the east. Sabarkantha covers an area of 7,390 sq. km with total population of 20, 83,416 according to 2001 census.

Total 1260 wetlands are mapped including 548 small wetlands (< 2.25 ha) with 42653 ha area. Major wetland category of the district is Reservoirs, Rivers/streams, and Tanks/ponds. District has large number of small reservoirs. Details of area estimates of wetlands in Sabarkantha district is shown in Table-10.

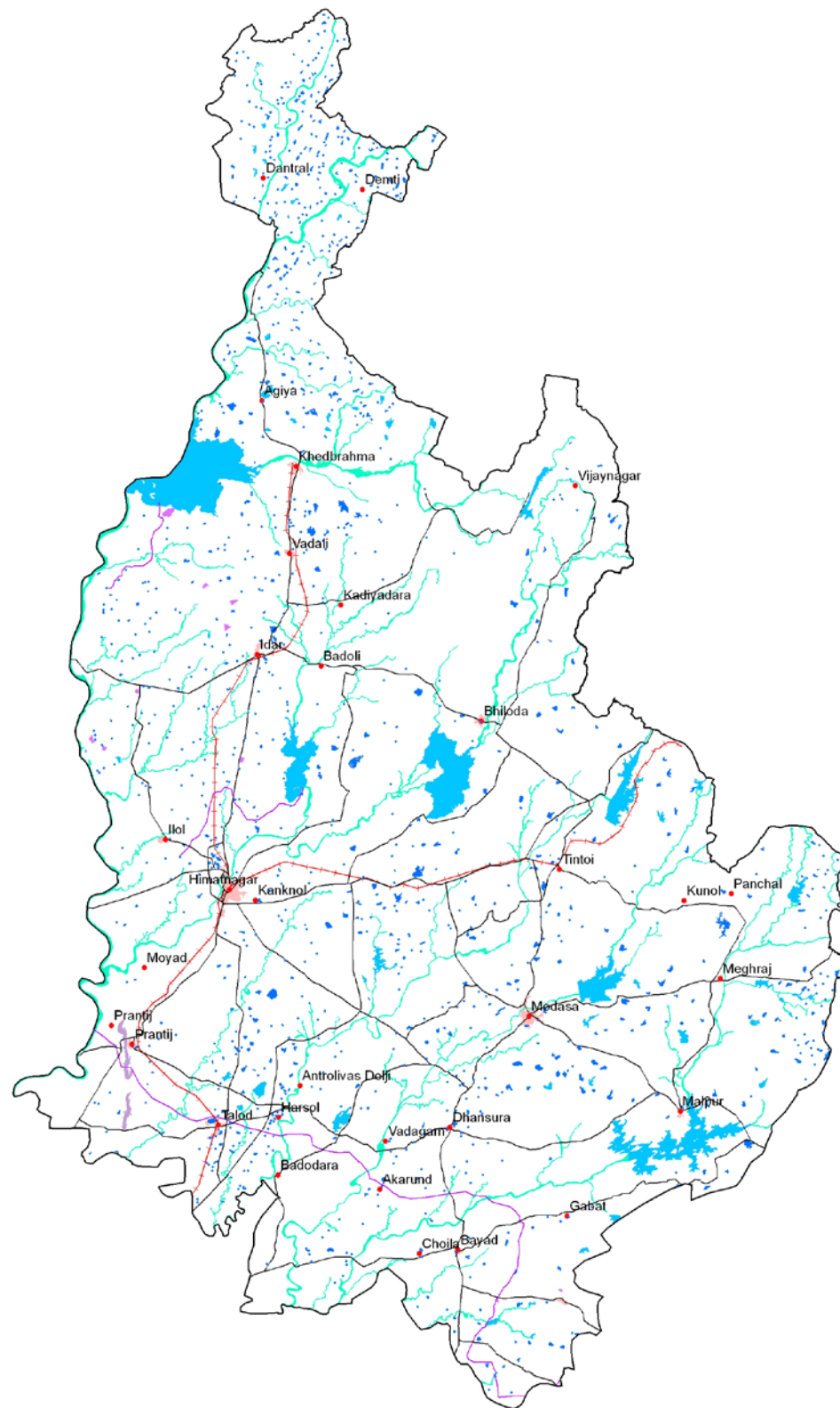
Area under aquatic vegetation in post-monsoon is about 1759 ha and high during pre monsoon (10775 ha). Open water spread of the wetlands is significantly higher in post monsoon (29976 ha) than during pre monsoon (12632 ha). Most of the open water area is under low turbidity during both seasons.

Table 10: Area estimates of wetlands in Sabarkantha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	229	0.54	229	89
2	1105	Waterlogged	10	230	0.54	125	6
3	1106	River/Stream	36	16057	37.65	5687	1235
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	62	20002	46.89	19626	10488
5	1202	Tanks/Ponds	600	5035	11.80	4128	775
6	1203	Waterlogged	2	552	1.29	181	39
		<b>Sub-Total</b>	<b>712</b>	<b>42105</b>	<b>98.72</b>	<b>29976</b>	<b>12632</b>
		Wetlands (<2.25 ha), mainly Tanks	548	548	1.28	-	-
		<b>Total</b>	<b>1260</b>	<b>42653</b>	<b>100.00</b>	<b>29976</b>	<b>12632</b>

<b>Area under Aquatic Vegetation</b>	1759	10775
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<b>Area under turbidity levels</b>		
Low	25277	10928
Moderate	3703	1592
High	996	112

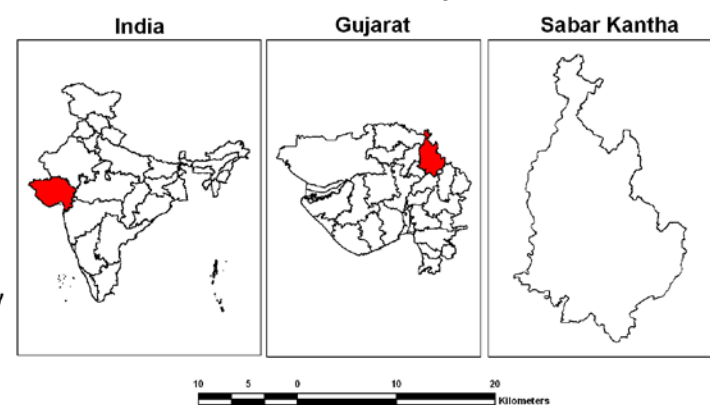


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

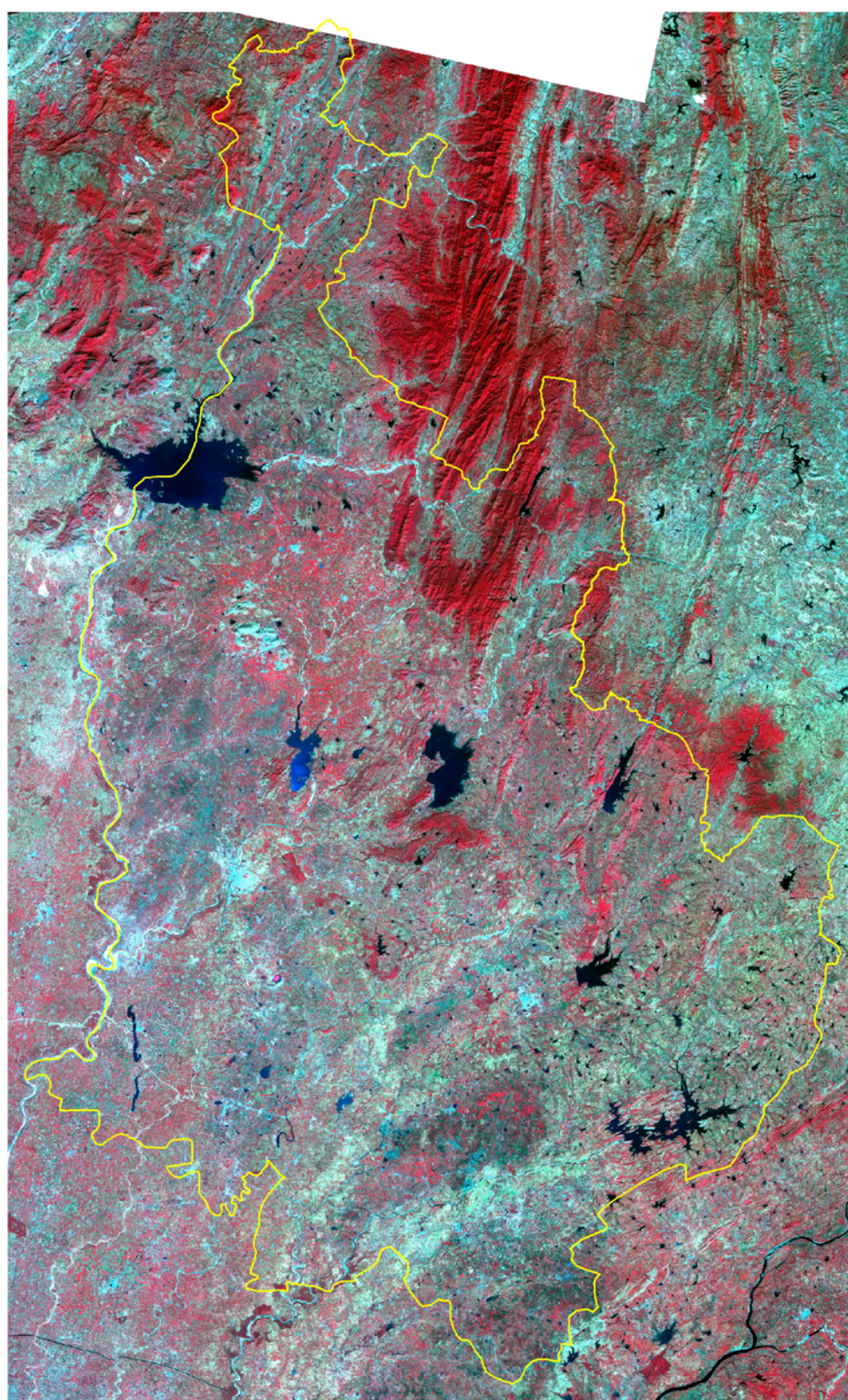
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### 7.1.6 Gandhinagar

Gandhinagar is an administrative district of Gujarat with its headquarters in Gandhinagar city, the state capital. It covers an area of 2163 square kilometers with a total population of 13,34,455 according to 2001 census. The district includes four taluks - Gandhinagar, Kalol, Dehgam and Mansa - and 216 villages. Gandhinagar is bounded by the districts of Sabarkantha to the northeast, Kheda to the southeast, Ahmedabad to the southwest, and Mehsana to the northwest.

Total 327 wetlands are mapped including 185 small wetlands (< 2.25 ha) with 4263 ha area. Major wetland category of the district is Rivers/ streams, and Tanks/ponds. Details of area estimates of wetlands in Gandhinagar district is shown in Table-11.

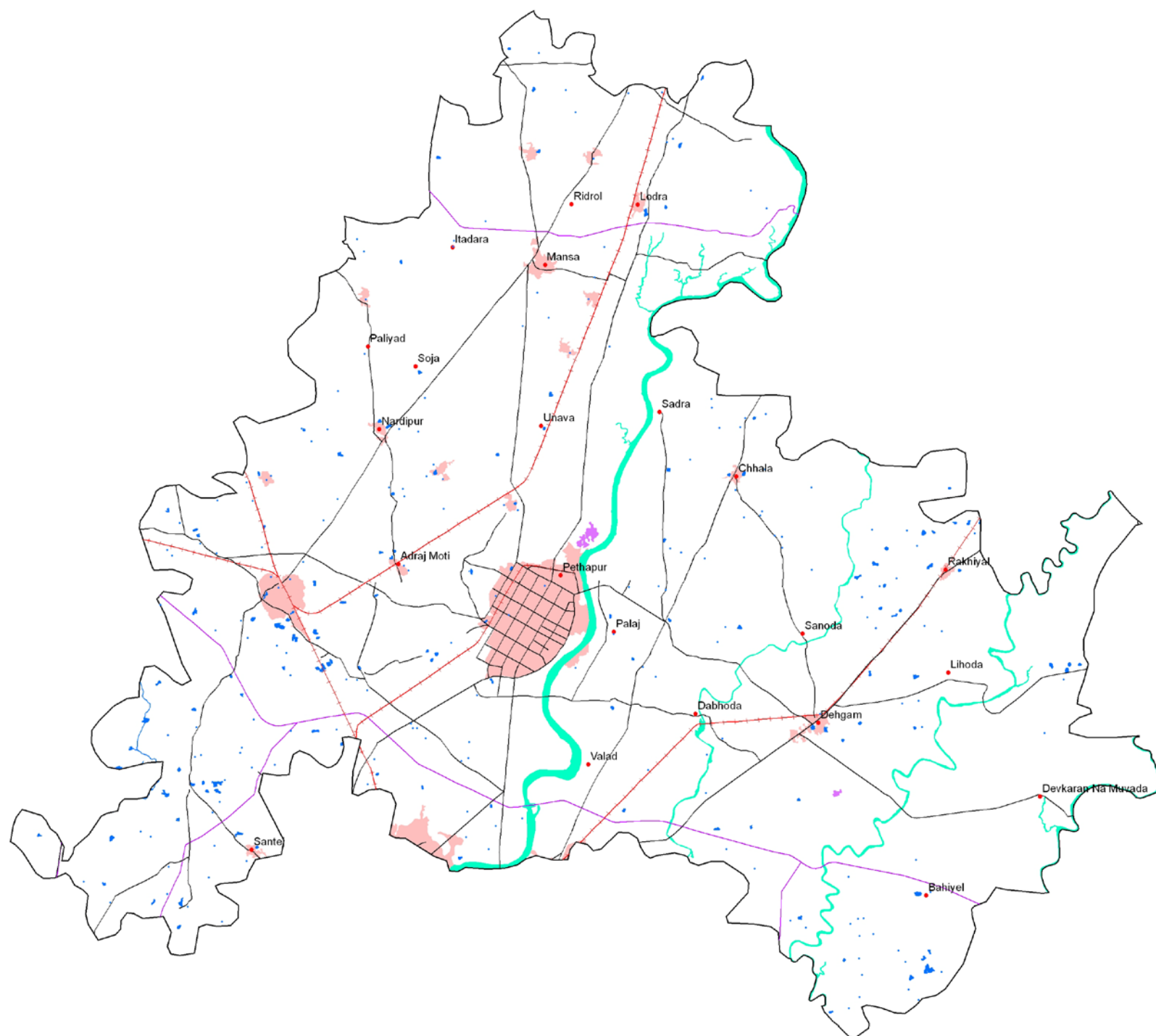
Area under aquatic vegetation in post-monsoon is about 118 ha and slightly high during pre monsoon (140 ha). Open water spread of the wetlands is significantly higher in post monsoon (1973 ha) than during pre monsoon (360 ha). The turbidity of water is mainly low during post monsoon and moderate during pre monsoon.

Table 11: Area estimates of wetlands in Gandhinagar

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	4	13	0.30	13	-
2	1105	Waterlogged	2	94	2.21	94	42
3	1106	River/Stream	4	3431	80.48	1444	182
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1202	Tanks/Ponds	132	540	12.67	422	136
		<b>Sub-Total</b>	<b>142</b>	<b>4078</b>	<b>95.66</b>	<b>1973</b>	<b>360</b>
		Wetlands (<2.25 ha), mainly Tanks	185	185	4.34	-	-
		<b>Total</b>	<b>327</b>	<b>4263</b>	<b>100.00</b>	<b>1973</b>	<b>360</b>

<b>Area under Aquatic Vegetation</b>	118	140
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<b>Area under turbidity levels</b>		
Low	1503	99
Moderate	225	204
High	245	57

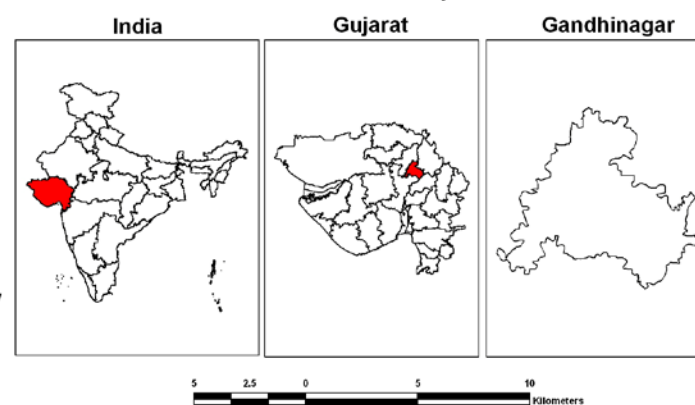


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



## Data Source :

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

## Prepared By :

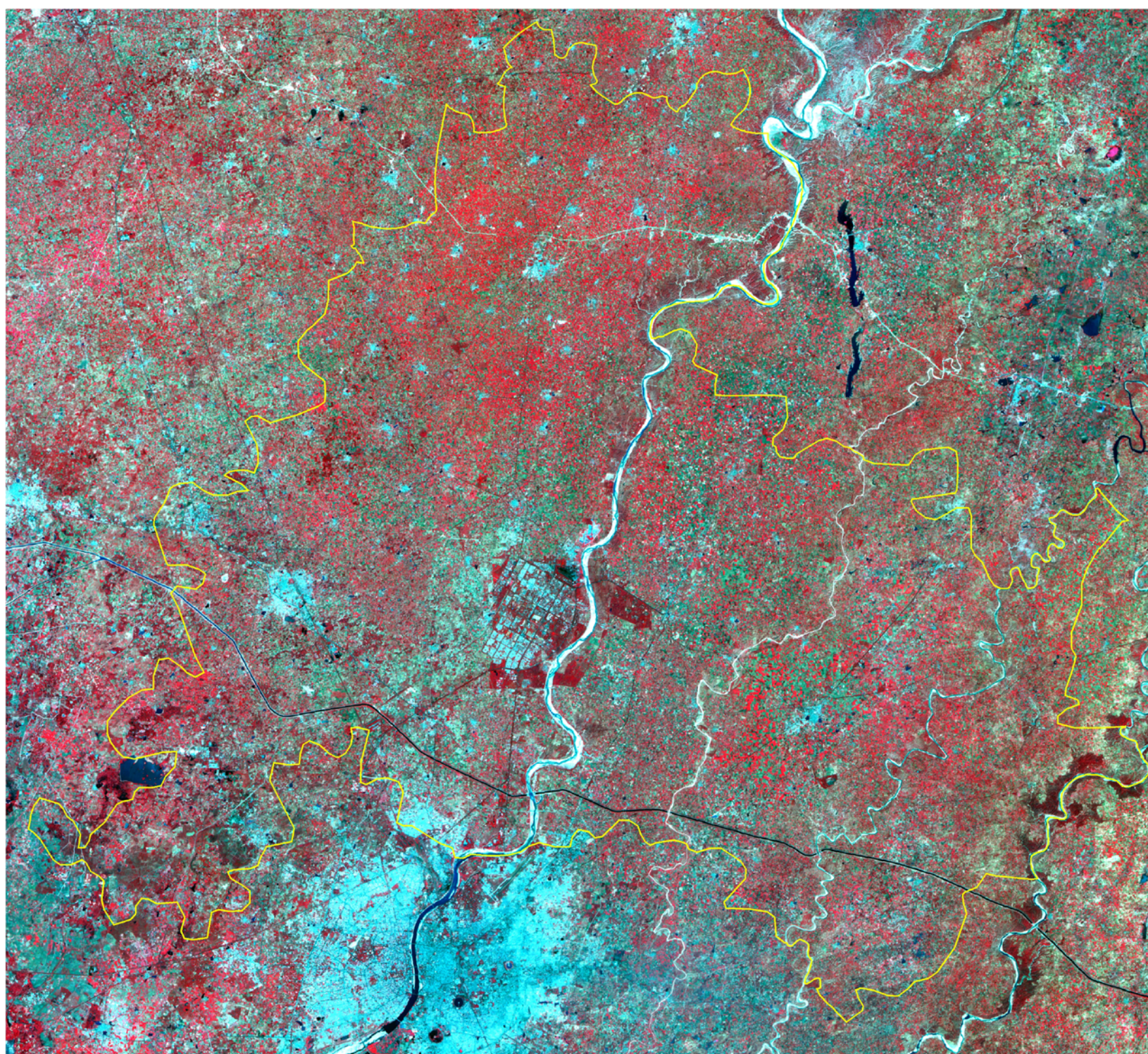
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### 7.1.7 Ahmedabad

Ahmedabad is located in Central Gujarat. The district is bound by Mehsana and Gandhinagar districts in the north, Sabarkantha district in the north-east and Kheda district and Gulf of Khambhat in the south. The western side of the district is bordered by Bhavnagar and Surendranagar district. Ahmedabad city is its district headquarters and was also the state's capital from May 1960 to May 1970, before it was shifted to the new township at Gandhinagar. Ahmedabad is the largest city in Gujarat. Total geographic area of Ahmedabad is 8086.81 km<sup>2</sup>. As per the 2001 census data, the population of the district was 58,16,519.

Total 1255 wetlands are mapped including 568 small wetlands (< 2.25 ha) with 63303 ha area. Inland wetlands contribute 40 % of the total wetland area and coastal wetlands contribute 60% of the total wetland area. Major wetland categories of the district are Salt marsh, Rivers/ streams, Inter-tidal mud flats, Lakes/ponds and mangroves. Wetlands are more concentrated in the southern part of the district. Part of Nal Sarovar is located in the district which is a famous bird sanctuary. Details of area estimates of wetlands in Ahmedabad district is shown in Table-12.

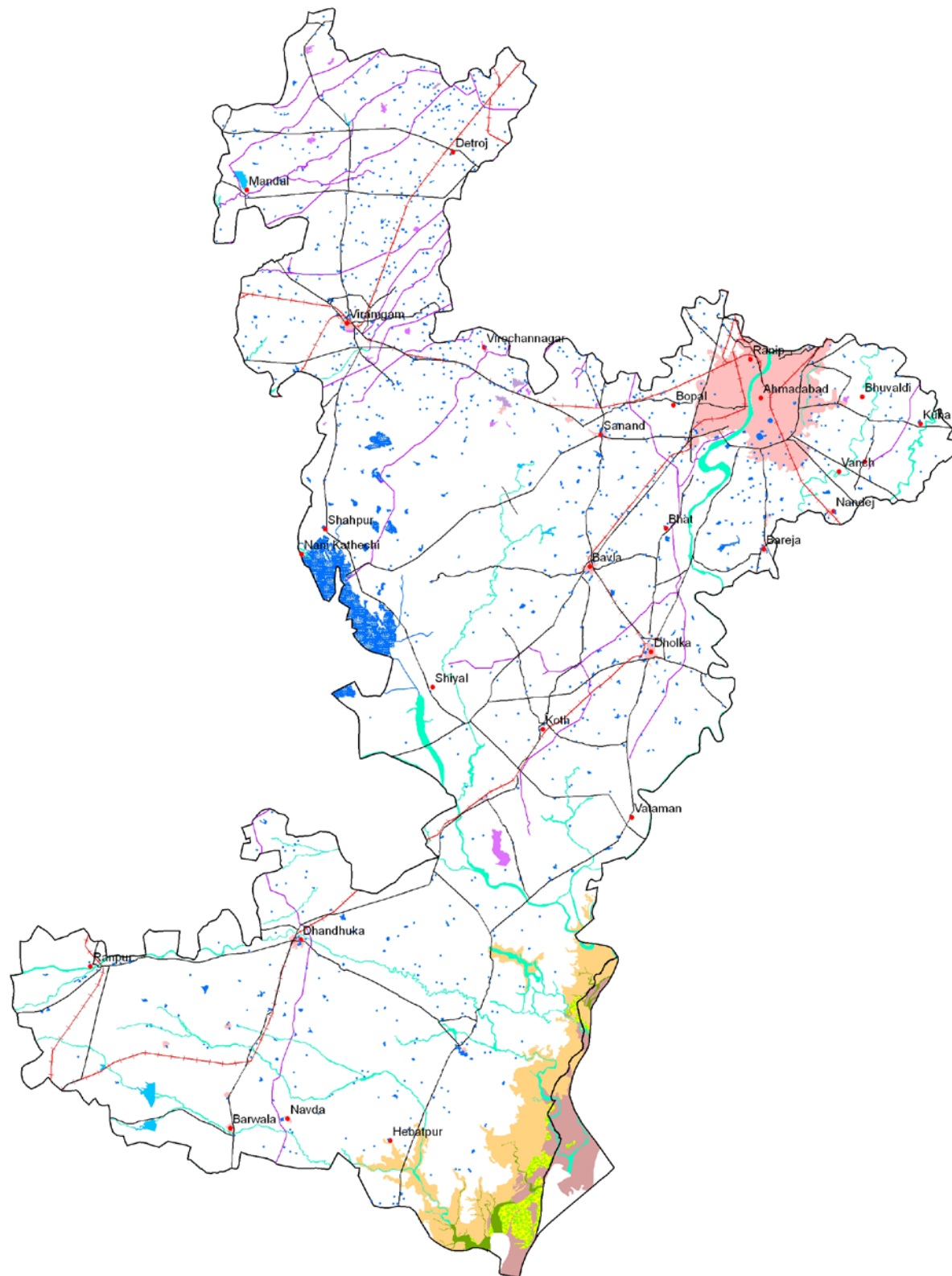
Area under aquatic vegetation in post-monsoon is about 11204 ha and slightly less during pre-monsoon (7200 ha). Open water spread of the wetlands is significantly higher in post monsoon (11363 ha) than during pre monsoon (5836 ha).

Table 12: Area estimates of wetlands in Ahmedabad

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	7	7551	11.93	2455	268
2	1105	Waterlogged	24	1045	1.65	353	130
3	1106	River/Stream	30	11310	17.87	3377	2620
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	10	966	1.53	752	62
5	1202	Tanks/Ponds	544	3589	5.67	2546	959
6	1203	Waterlogged	4	323	0.51	95	14
		<b>Total - Inland</b>	<b>619</b>	<b>24784</b>	<b>39.15</b>	<b>9578</b>	<b>4053</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
7	2102	Creeks	5	1785	2.82	1785	1783
8	2104	Intertidal mud flats	21	9368	14.80	-	-
9	2105	Salt Marsh	24	22858	36.11	-	-
10	2106	Mangroves	18	3940	6.22	-	-
		<b>Total - Coastal</b>	<b>68</b>	<b>37951</b>	<b>59.95</b>	<b>1785</b>	<b>1783</b>
		<b>Sub-Total</b>	<b>687</b>	<b>62735</b>	<b>99.10</b>	<b>11363</b>	<b>5836</b>
		Wetlands (<2.25 ha), mainly Tanks	568	568	0.90	-	-
		<b>Total</b>	<b>1255</b>	<b>63303</b>	<b>100.00</b>	<b>11363</b>	<b>5836</b>

<b>Area under Aquatic Vegetation</b>	11204	7200
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<b>Area under turbidity levels</b>		
Low	5597	2673
Moderate	3715	1497
High	2051	1666

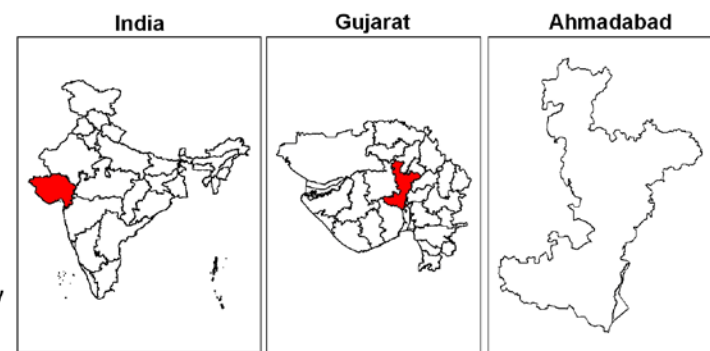


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



10 5 0 10 20  
Kilometers

## Data Source :

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

## Prepared By :

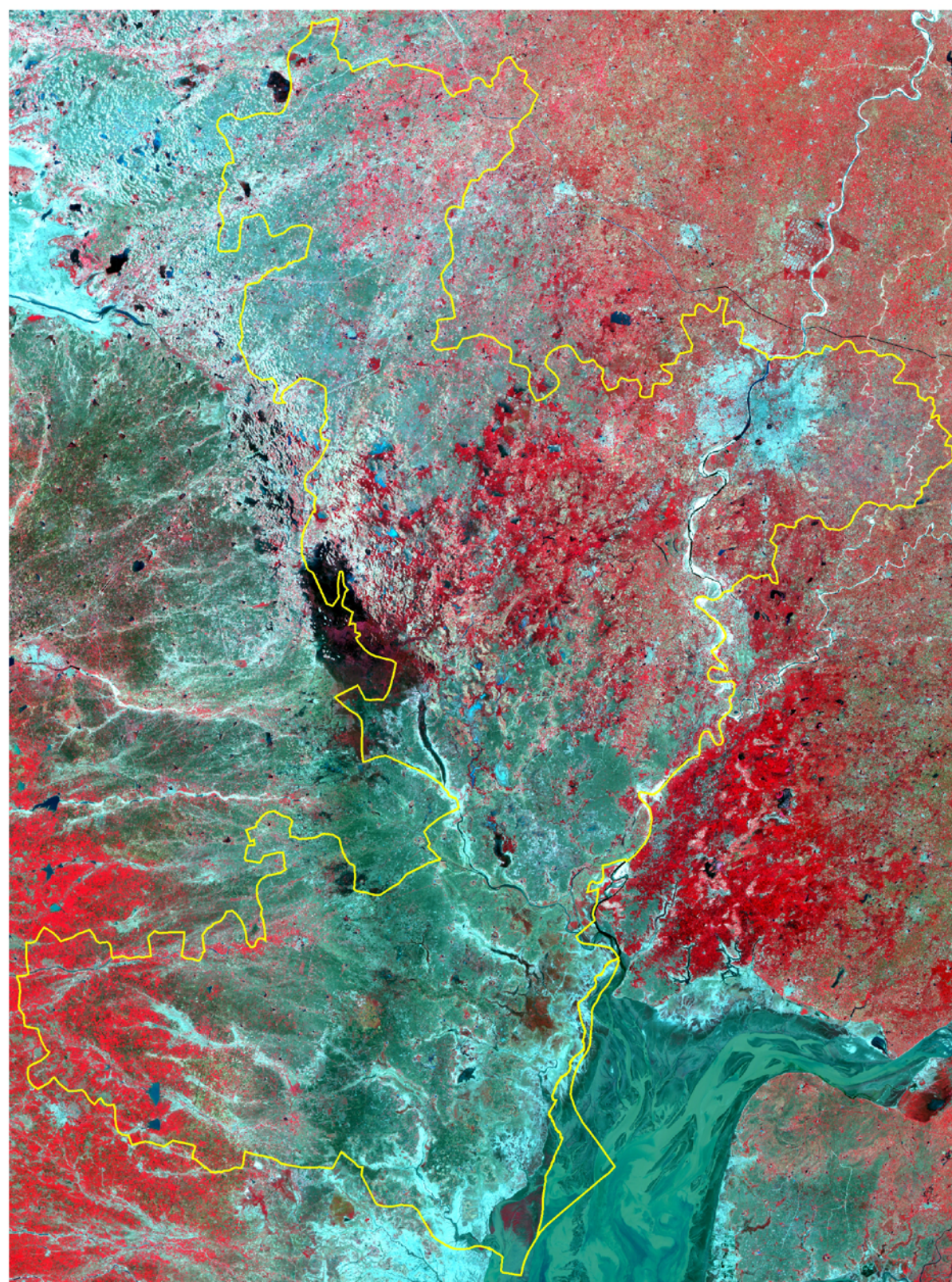
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### 7.1.8 Surendranagar

Surendranagar is an administrative district of Gujarat with its head quarters located at the same city of Surendranagar. The district occupies an area of 10,489 sq. km with total population of 14, 10,680 according to 2001 census. Surendranagar is famous for its cotton production and salt supply. A group of big companies have their industries at Surendranagar city. There are some worth visiting sites situated in and around the district like Wild Ass Sanctuary and Nal sarovar Bird Sanctuary.

Total 1460 wetlands are mapped including 450 small wetlands (< 2.25 ha) with 52896 ha area. Major wetland categories of the district are Rivers/ streams, Reservoirs, Lakes and Tanks/ponds. Part of Nal Sarovar is located in the district which is a famous bird sanctuary. Details of area estimates of wetlands in Surendranagar district is shown in Table-13.

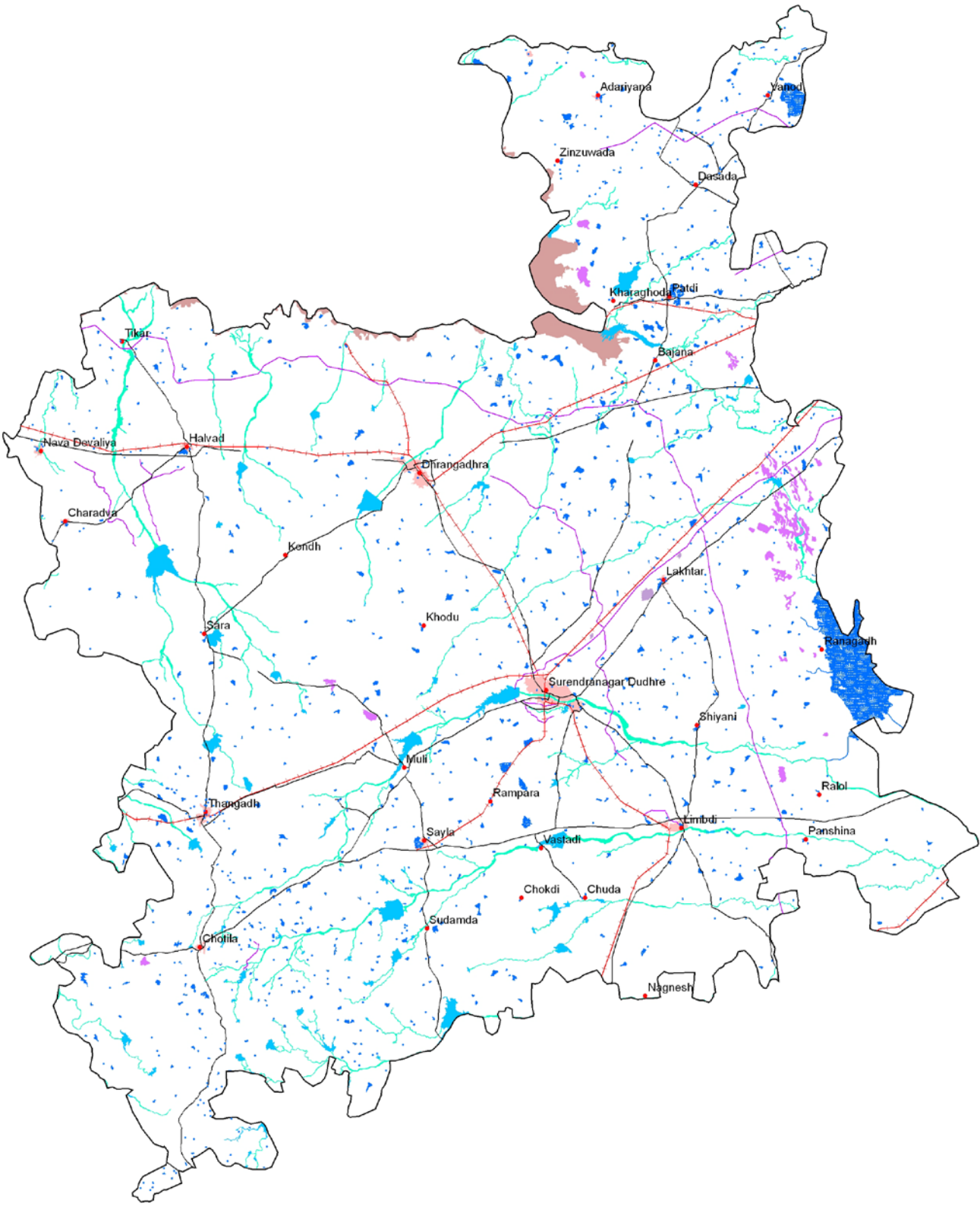
Area under aquatic vegetation in post-monsoon is about 14377 ha. Open water spread of the wetlands is significantly higher in post monsoon (18406 ha) than during pre monsoon (4424 ha), indicating the rainfall dependence of the wetlands in the district. Major portion of the open water area is under low turbidity during both seasons.

Table 13: Area estimates of wetlands in Surendranagar

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	8	8815	16.66	1422	197
2	1105	Waterlogged	43	4264	8.06	1207	206
3	1106	River/Stream	108	12462	23.56	1496	372
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	100	10047	18.99	8931	1467
5	1202	Tanks/Ponds	719	7941	15.01	5150	1020
6	1203	Waterlogged	3	251	0.47	200	11
		<b>Total - Inland</b>	<b>981</b>	<b>43780</b>	<b>82.77</b>	<b>18406</b>	<b>3273</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
7	2104	Intertidal mud flats	29	8666	16.38	-	-
		<b>Total - Coastal</b>	<b>29</b>	<b>8666</b>	<b>16.38</b>	<b>-</b>	<b>-</b>
		<b>Sub-Total</b>	<b>1010</b>	<b>52446</b>	<b>99.15</b>	<b>18406</b>	<b>3273</b>
		Wetlands (<2.25 ha), mainly Tanks	450	450	0.85	-	-
		<b>Total</b>	<b>1460</b>	<b>52896</b>	<b>100.00</b>	<b>18406</b>	<b>3273</b>

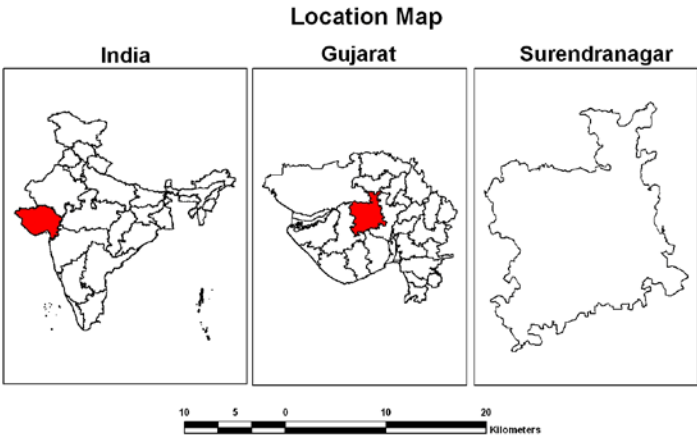
<b>Area under Aquatic Vegetation</b>	14377	4424
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<b>Area under turbidity levels</b>		
Low	11826	1988
Moderate	4878	1067
High	1702	218



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

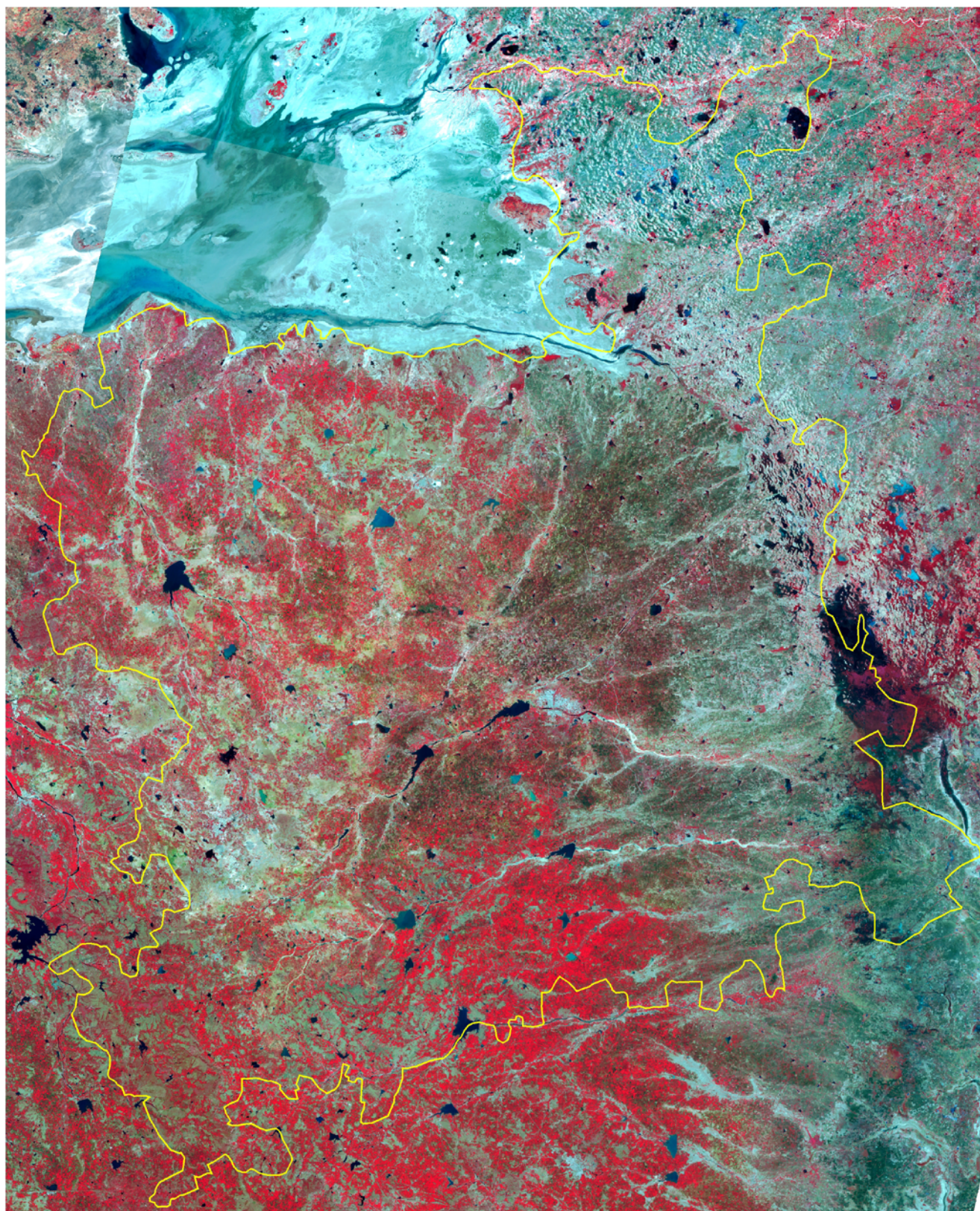
- Legend**
- Wetlands (<2.25ha)
  - Settlements
  - Roads
  - Railway
  - Canals
  - Drainage (line)
  - Town/Settlements
  - District boundary
  - State boundary
  - International boundary



Data Source :
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)
Prepared By :
Space Applications Centre (ISRO), Ahmedabad and Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar
Sponsored By :
Ministry of Environment and Forests Government of India









### 7.1.9 Rajkot

Rajkot is one of the most advanced districts of Gujarat owing to its large industries. The administrative head quarters are located at Rajkot city. The district is surrounded by Kachchh in the north, Surendranagar, Bhavnagar in the east, Amreli, Junagadh in the south and Jamnagar in the west.

Total 1398 wetlands are mapped including 475 small wetlands (< 2.25 ha) with 55820 ha area. Inland wetlands contribute 83.7 % of the total wetland area and coastal wetlands contribute 16.3 % of the total wetland area. Major wetland categories of the district are Reservoirs, Rivers/streams, Salt pans and Tanks/ponds. District has 180 small and 14 medium size reservoirs. Details of area estimates of wetlands in Rajkot district is shown in Table-14.

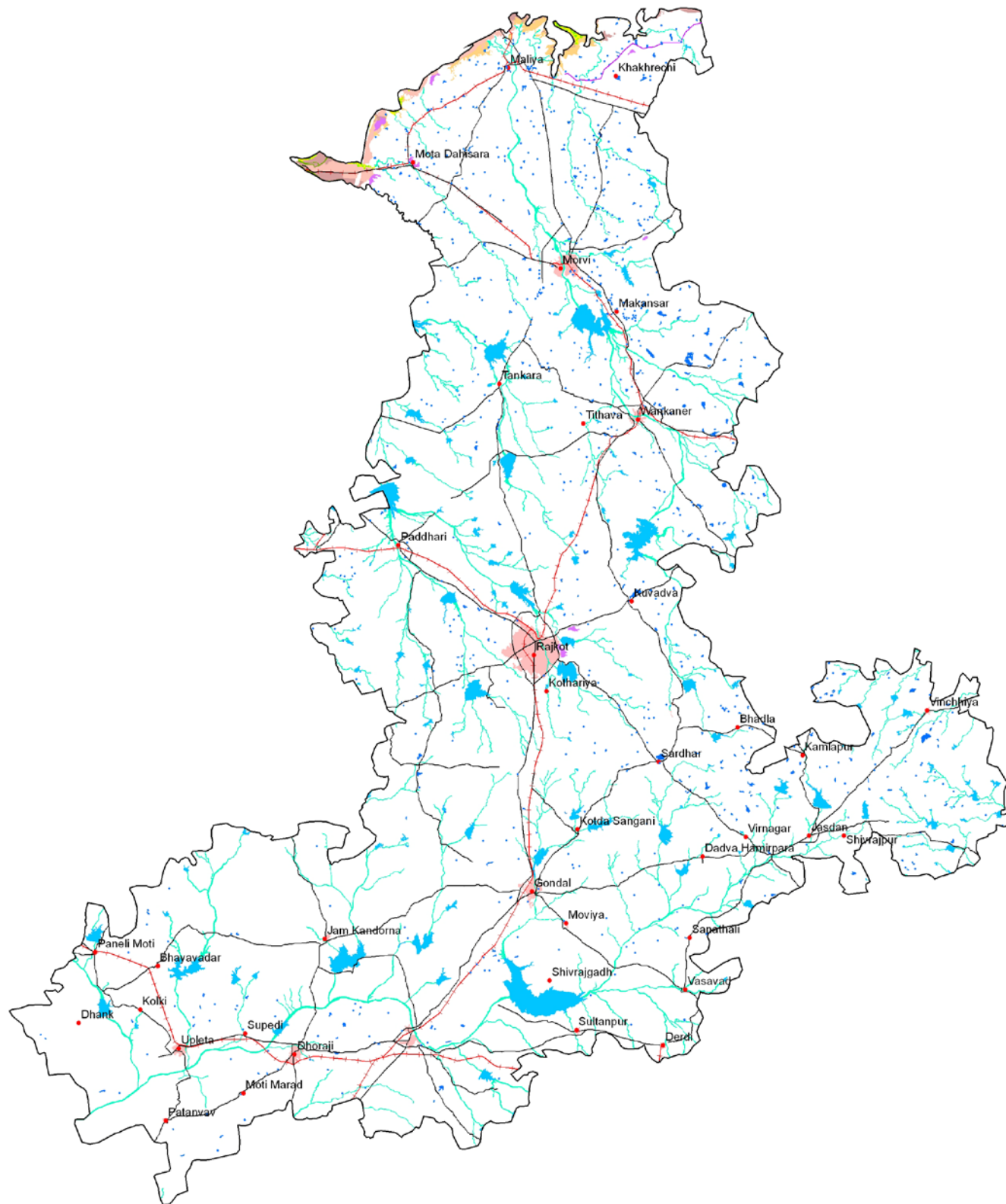
Area under aquatic vegetation in post-monsoon is about 2708 ha and high during pre-monsoon (10485 ha). Open water spread of the wetlands is significantly higher in post monsoon (31722 ha) than during pre monsoon (11087 ha), indicating the rainfall dependence of the wetlands in the district. Major portion of the open water area is under low turbidity during both seasons.

Table 14: Area estimates of wetlands in Rajkot

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	1	143	0.26	83	-
2	1105	Waterlogged	9	634	1.14	477	75
3	1106	River/Stream	193	19441	34.83	5448	3473
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	204	22838	40.91	21187	6733
5	1202	Tanks/Ponds	426	3190	5.71	3057	312
		<b>Total - Inland</b>	<b>833</b>	<b>46246</b>	<b>82.85</b>	<b>30252</b>	<b>10593</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
6	2102	Creeks	2	308	0.55	308	308
7	2104	Intertidal mud flats	29	2117	3.79	-	-
8	2105	Salt Marsh	32	2475	4.43	-	-
9	2106	Mangroves	12	733	1.31	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
10	2201	Salt pans	15	3466	6.21	1162	186
		<b>Total - Coastal</b>	<b>90</b>	<b>9099</b>	<b>16.30</b>	<b>1470</b>	<b>494</b>
		<b>Sub-Total</b>	<b>923</b>	<b>55345</b>	<b>99.15</b>	<b>31722</b>	<b>11087</b>
		Wetlands (<2.25 ha), mainly Tanks	475	475	0.85	-	-
		<b>Total</b>	<b>1398</b>	<b>55820</b>	<b>100.00</b>	<b>31722</b>	<b>11087</b>

<b>Area under Aquatic Vegetation</b>	2708	10485
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<b>Area under turbidity levels</b>		
Low	23796	7644
Moderate	7029	3040
High	897	403

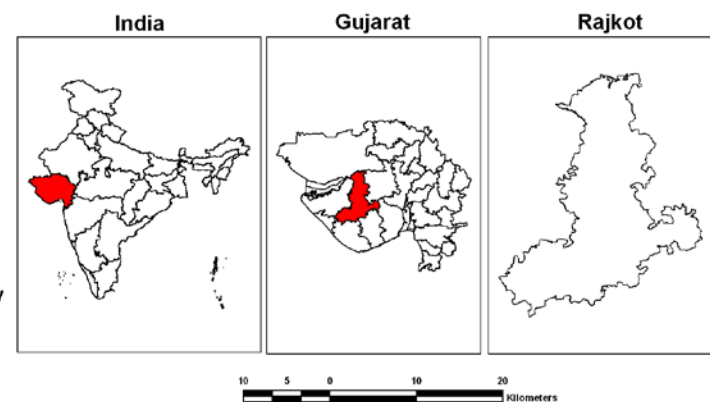


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad  
and  
Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar

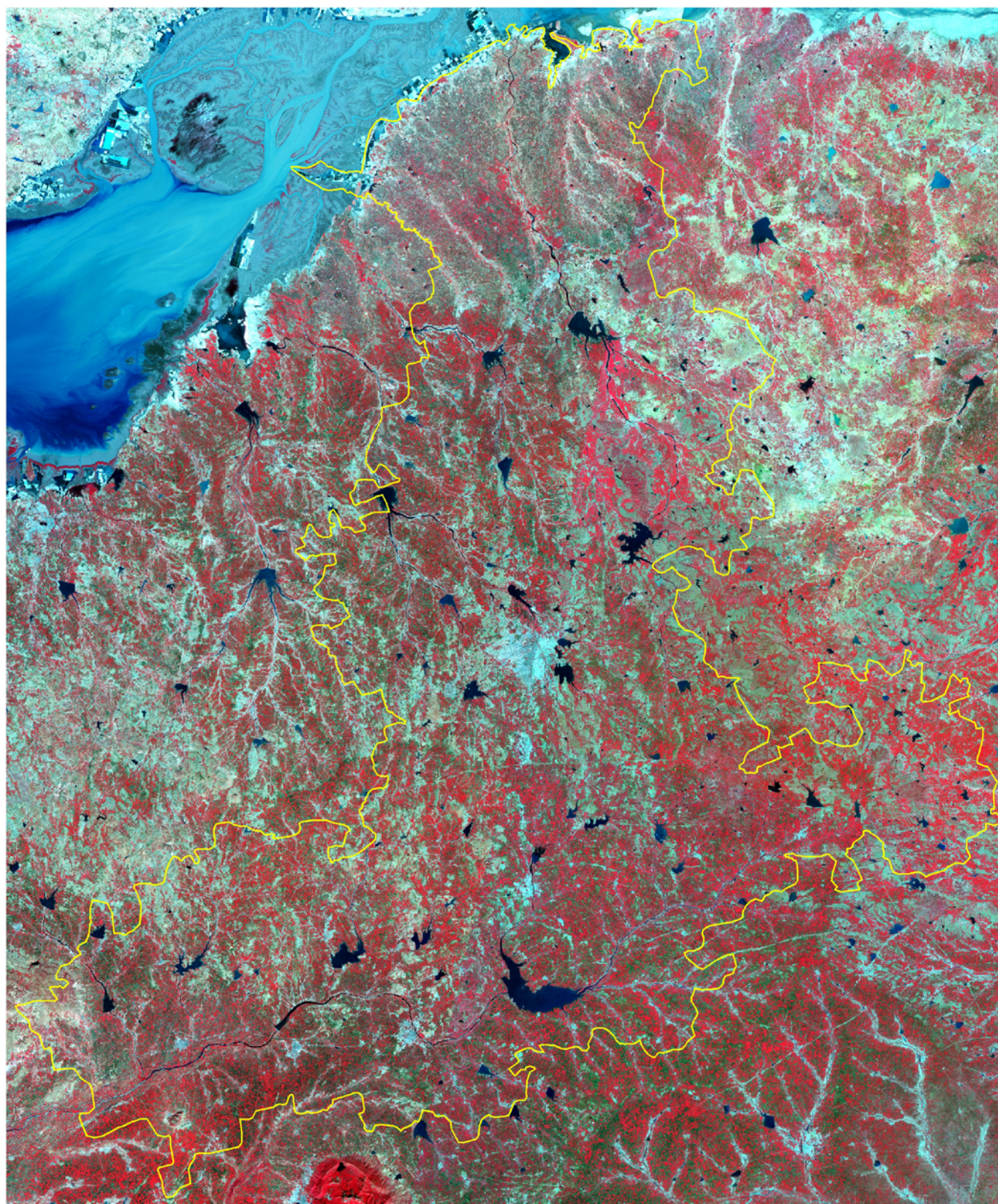
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Government of India











### 7.1.10 Jamnagar

Jamnagar is one of the most industrialized districts of Gujarat with its head quarter located at Jamnagar city. The district covers an area of 14,125 sq. km with total population of 19,04,278 according to the 2001 census. Jamnagar is one of the main tourist centre of the state.

Total 2079 wetlands are mapped including 736 small wetlands (< 2.25 ha) with 198657 ha area. Inland wetlands contributes 20 % of the total wetland area and coastal wetlands contributes 80% of the total wetland area. Major wetland categories of the district are Inter-tidal mud flats, Coral reefs, Mangroves, Reservoirs and Salt marsh. District is famous for Marine National Park and Marine sanctuary located in Southern part of Gulf of Kachchh. Details of area estimates of wetlands in Jamnagar district is shown in Table-15.

Area under aquatic vegetation in post-monsoon is about 21003 ha and slightly high during pre monsoon (23887 ha). Open water spread of the wetlands is significantly higher in post monsoon (47008 ha) than during pre monsoon (27837 ha). Major portion of the open water area is under low to moderate turbidity during both seasons.

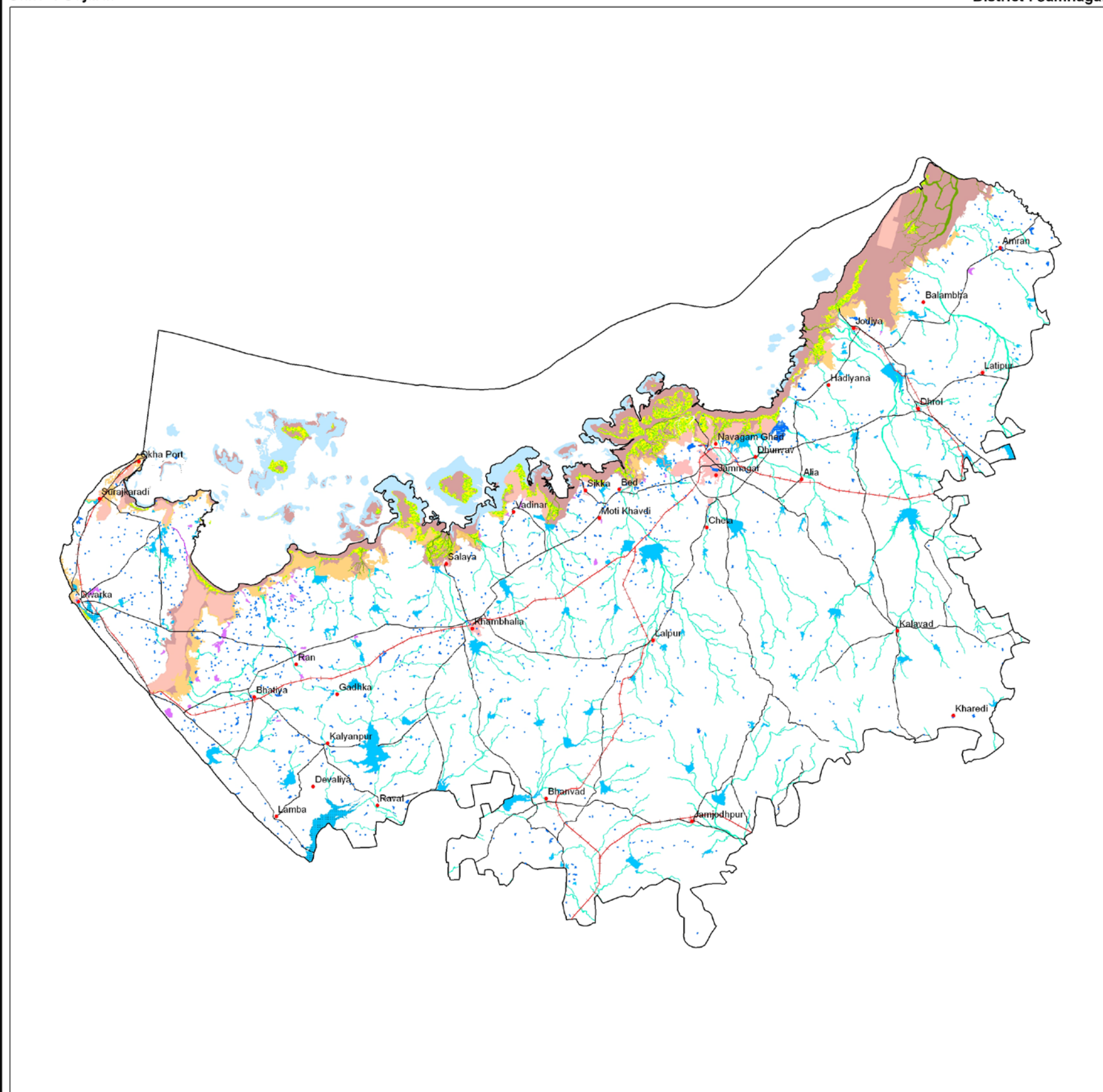
Table 15: Area estimates of wetlands in Jamnagar

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	1	595	0.30	595	173
2	1105	Waterlogged	46	1329	0.67	996	246
3	1106	River/Stream	209	15625	7.87	3278	2313
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	209	18516	9.32	17202	5476
5	1202	Tanks/Ponds	379	2536	1.28	2422	398
		<b>Total - Inland</b>	<b>844</b>	<b>38601</b>	<b>19.43</b>	<b>24493</b>	<b>8606</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
6	2101	Lagoons	10	2979	1.50	2310	1439
7	2102	Creeks	40	3141	1.58	3137	3134
8	2103	Sand/Beach	12	1079	0.54	-	-
9	2104	Intertidal mud flats	176	63830	32.13	-	-
10	2105	Salt Marsh	73	18316	9.22	-	-
11	2106	Mangroves	116	18537	9.33	-	-
12	2107	Coral Reefs	50	33547	16.89	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
13	2201	Salt pans	20	17494	8.81	16671	14323
14	2202	Aquaculture ponds	2	397	0.20	397	335
		<b>Total - Coastal</b>	<b>499</b>	<b>159320</b>	<b>80.20</b>	<b>22515</b>	<b>19231</b>
		<b>Sub-Total</b>	<b>1343</b>	<b>197921</b>	<b>99.63</b>	<b>47008</b>	<b>27837</b>
		Wetlands (<2.25 ha), mainly Tanks	736	736	0.37	-	-
		<b>Total</b>	<b>2079</b>	<b>198657</b>	<b>100.00</b>	<b>47008</b>	<b>27837</b>

<b>Area under Aquatic Vegetation</b>	21003	23887
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<b>Area under turbidity levels</b>		
Low	21164	7627
Moderate	22169	17010
High	3675	3200



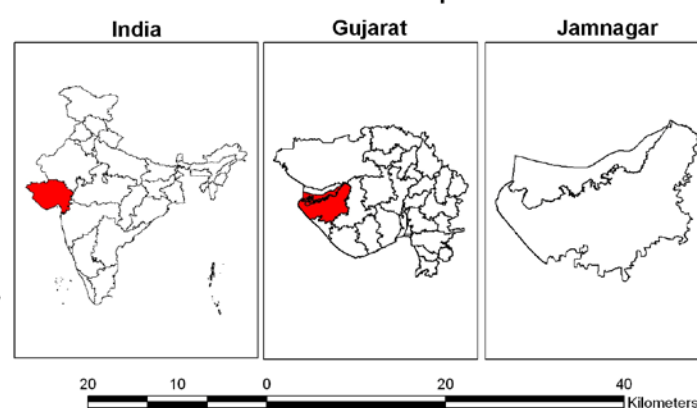


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



20 10 0 20 40 Kilometers

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

Prepared By :  
Space Applications Centre (ISRO), Ahmedabad  
and  
Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar

Sponsored By :  
Ministry of Environment and Forests  
Government of India









### 7.1.11 Porbandar

Porbandar is an administrative district of Gujarat located in the western part of the state with its head quarters located at Porbandar town. The district covers an area of 2298 sq. km with total population 5, 36, 854 square kilometers. Porbandar was carved out of Junagadh district. There are some worth visiting wetland sites in and around Porbandar.

Total 226 wetlands are mapped including 95 small wetlands (< 2.25 ha) with 22199 ha area. Inland wetlands contribute 27.3% of the total wetland area and coastal wetlands contribute 72.7% of the total wetland area. Major wetland categories of the district are Lagoons, Rivers/ streams, Reservoirs and Sand/beach. Details of area estimates of wetlands in Porbandar district is shown in Table-16.

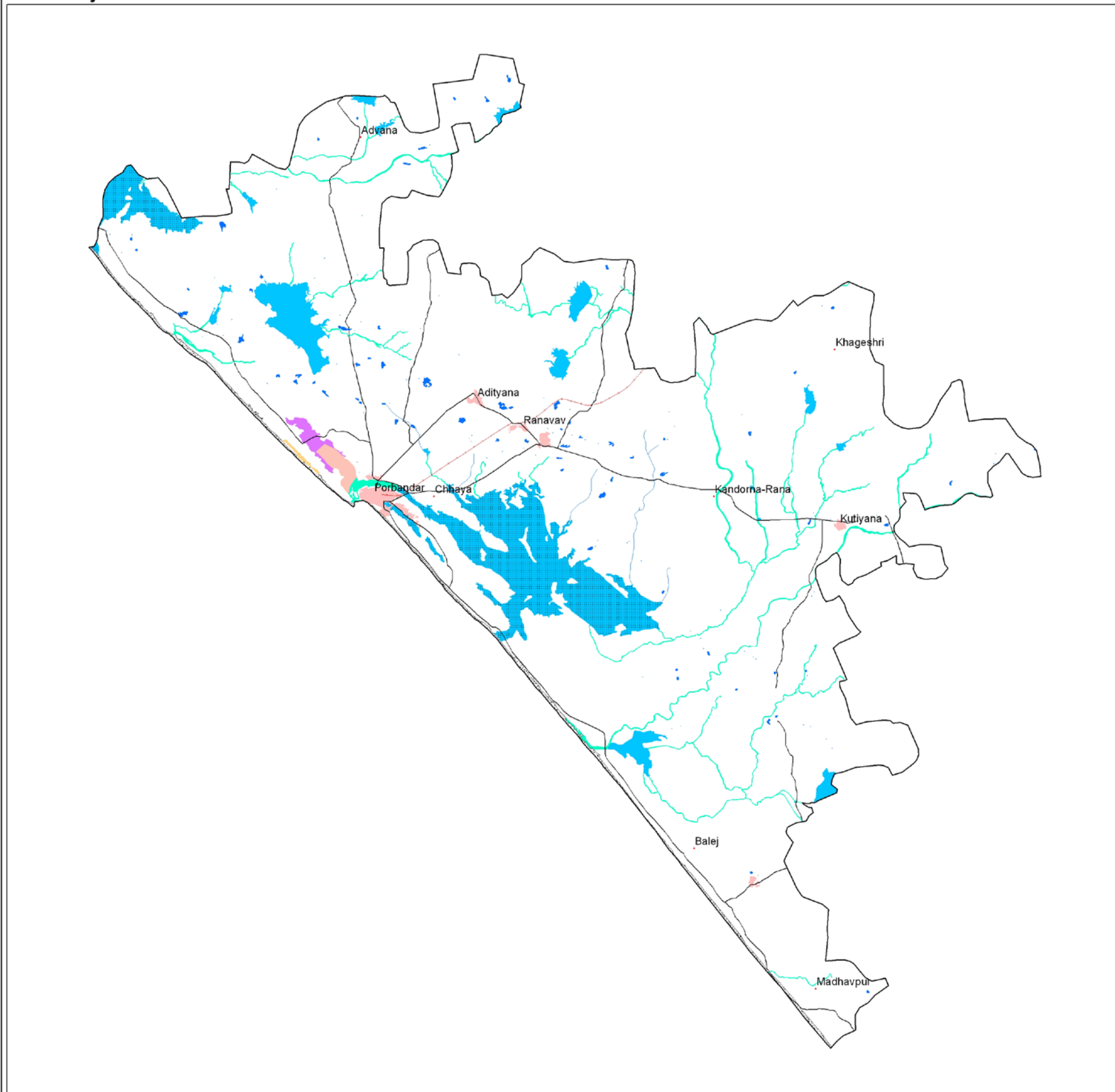
Area under aquatic vegetation in post-monsoon is about 5451 ha. Open water spread of the wetlands is significantly higher in post monsoon (13390 ha) than during pre monsoon (7376 ha). Major portion of the open water area is under low turbidity during both seasons.

Table 16: Area estimates of wetlands in Porbandar

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1105	Waterlogged	1	472	2.13	196	-
2	1106	River/Stream	29	2700	12.16	780	535
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
3	1201	Reservoirs/Barrages	18	4556	20.52	3771	1652
4	1202	Tanks/Ponds	70	468	2.11	468	107
		<b>Total - Inland</b>	<b>118</b>	<b>8196</b>	<b>36.92</b>	<b>5215</b>	<b>2294</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
5	2101	Lagoons	8	11780	53.07	7647	4692
6	2103	Sand/Beach	3	1524	6.87	-	-
7	2105	Salt Marsh	1	76	0.34	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
8	2201	Salt pans	1	528	2.38	528	390
		<b>Total - Coastal</b>	<b>13</b>	<b>13908</b>	<b>62.65</b>	<b>8175</b>	<b>5082</b>
		<b>Sub-Total</b>	<b>131</b>	<b>22104</b>	<b>99.57</b>	<b>13390</b>	<b>7376</b>
		Wetlands (<2.25 ha), mainly Tanks	95	95	0.43	-	-
		<b>Total</b>	<b>226</b>	<b>22199</b>	<b>100.00</b>	<b>13390</b>	<b>7376</b>

<b>Area under Aquatic Vegetation</b>	5451	1880
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<b>Area under turbidity levels</b>		
Low	11769	6709
Moderate	1510	651
High	111	16

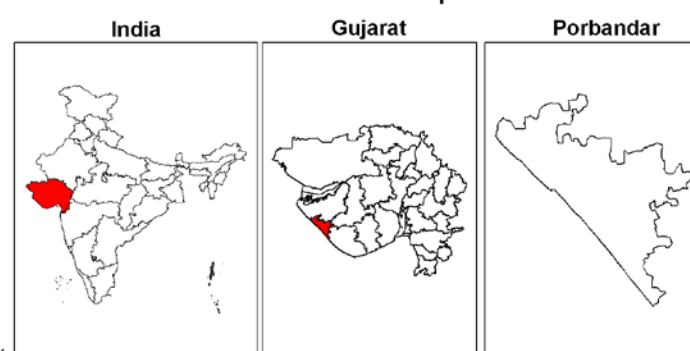


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map

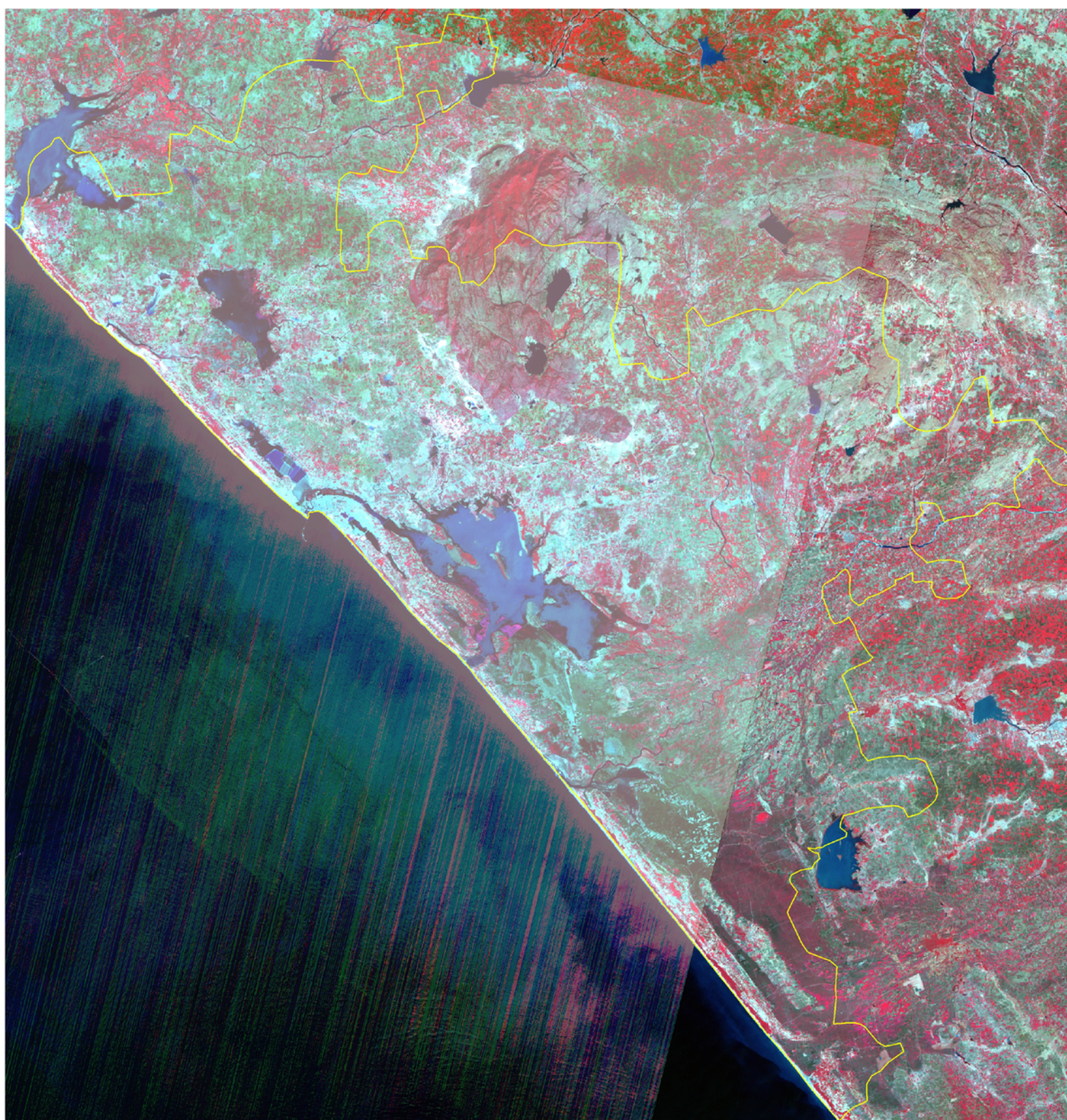


7.5 3.75 0 7.5 15 Kilometers

Data Source :
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)
Prepared By :
Space Applications Centre (ISRO), Ahmedabad and Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar
Sponsored By :
Ministry of Environment and Forests Government of India









### 7.1.12 Junagadh

The district of Junagadh is located in the western part of Gujarat with its head quarters at Junagadh town. The district is bordered by Rajkot in the North, Porbandar in the North-West, Amreli in the East and Arabian Sea bordering in South and West. The district covers an area of 8846 sq. km with total population of 24,48,427 according to 2001 census. Gir National Park is located in the district. Junagadh is one of the main tourist centre of the state.

Total 626 wetlands are mapped including 279 small wetlands (< 2.25 ha) with 30563 ha area. Inland wetlands contribute 70% of the total wetland area and coastal wetlands contribute 30% of the total wetland area. Major wetland categories of the district are Rivers/streams, Reservoirs Inter-tidal mud flats, Salt pans and Lagoons. District has 48 small/medium size reservoirs. Details of area estimates of wetlands in Junagadh district is shown in Table-17.

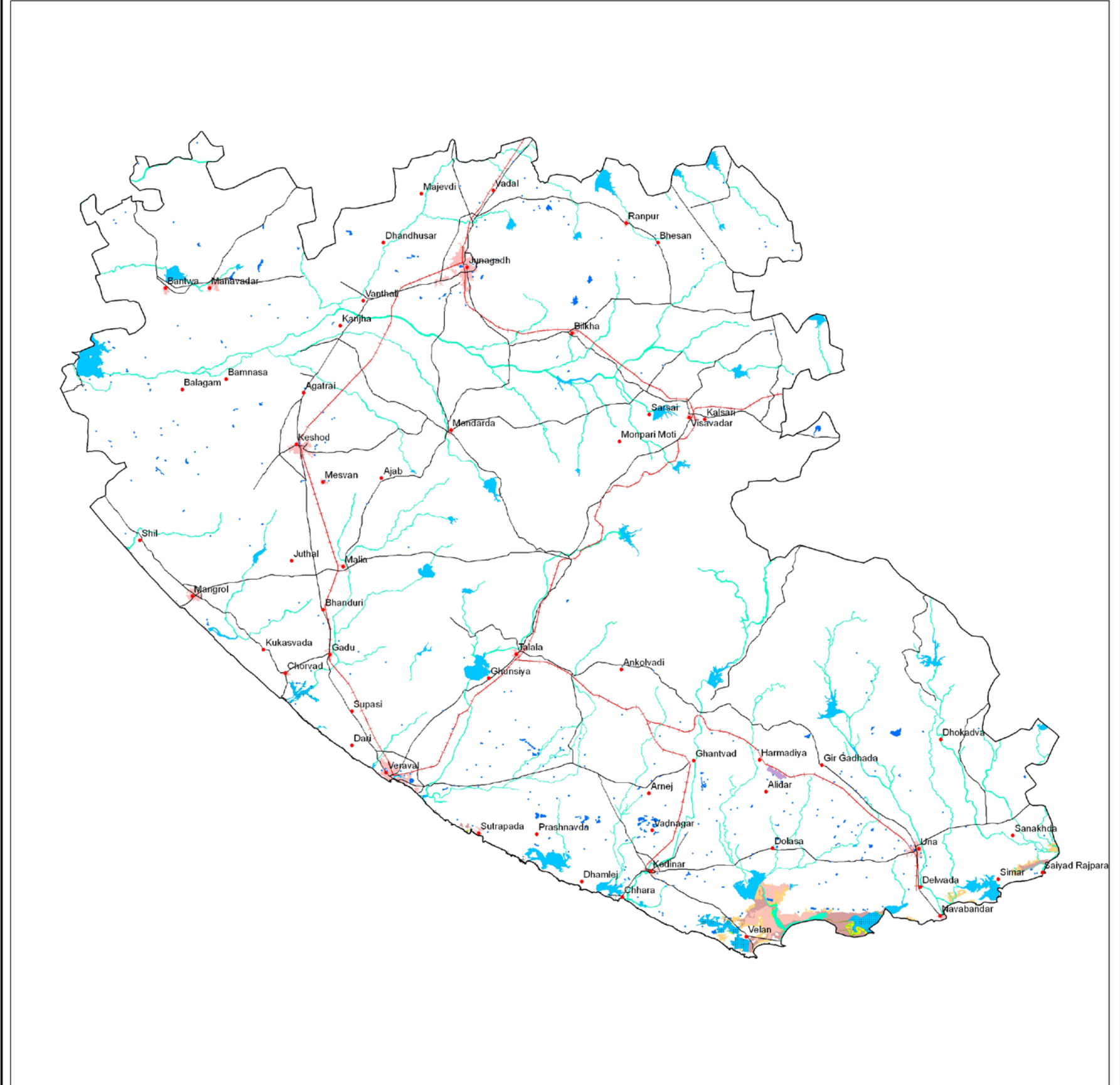
Area under aquatic vegetation in post-monsoon is about 3121 ha and slightly high during pre monsoon (4687 ha). Open water spread of the wetlands is significantly higher in post monsoon (13622 ha) than during pre monsoon (6119 ha), indicating the rainfall dependence of the wetlands in the district.

Table 17: Area estimates of wetlands in Junagadh

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1106	River/Stream	62	9996	32.71	1367	721
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
2	1201	Reservoirs/Barrages	48	9729	31.83	7416	2559
3	1202	Tanks/Ponds	155	1272	4.16	1242	315
4	1203	Waterlogged	1	184	0.60	184	65
		<b>Total - Inland</b>	<b>266</b>	<b>21181</b>	<b>69.30</b>	<b>10209</b>	<b>3660</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
5	2101	Lagoons	5	2061	6.74	1534	1122
6	2102	Creeks	4	46	0.15	46	46
7	2103	Sand/Beach	16	1242	4.06	-	-
8	2104	Intertidal mud flats	19	2062	6.75	-	-
9	2105	Salt Marsh	22	1608	5.26	-	-
10	2106	Mangroves	11	251	0.82	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
11	2201	Salt pans	4	1833	6.00	1833	1291
		<b>Total - Coastal</b>	<b>81</b>	<b>9103</b>	<b>29.78</b>	<b>3413</b>	<b>2459</b>
		<b>Sub-Total</b>	<b>347</b>	<b>30284</b>	<b>99.09</b>	<b>13622</b>	<b>6119</b>
		Wetlands (<2.25 ha), mainly Tanks	279	279	0.91	-	-
		<b>Total</b>	<b>626</b>	<b>30563</b>	<b>100.00</b>	<b>13622</b>	<b>6119</b>

<b>Area under Aquatic Vegetation</b>	3121	4687
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<b>Area under turbidity levels</b>		
Low	9572	3795
Moderate	3748	2205
High	302	119

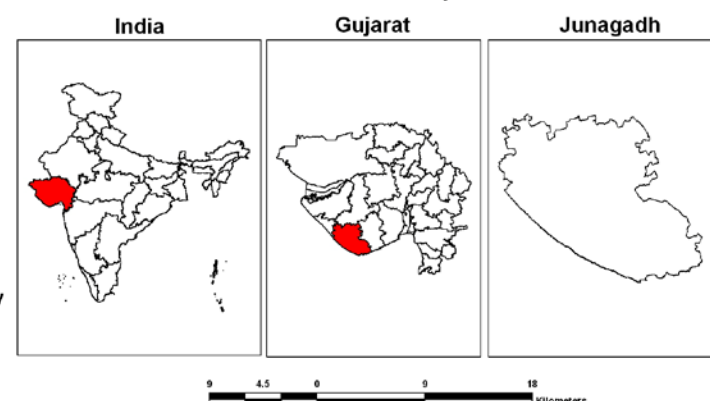


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



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

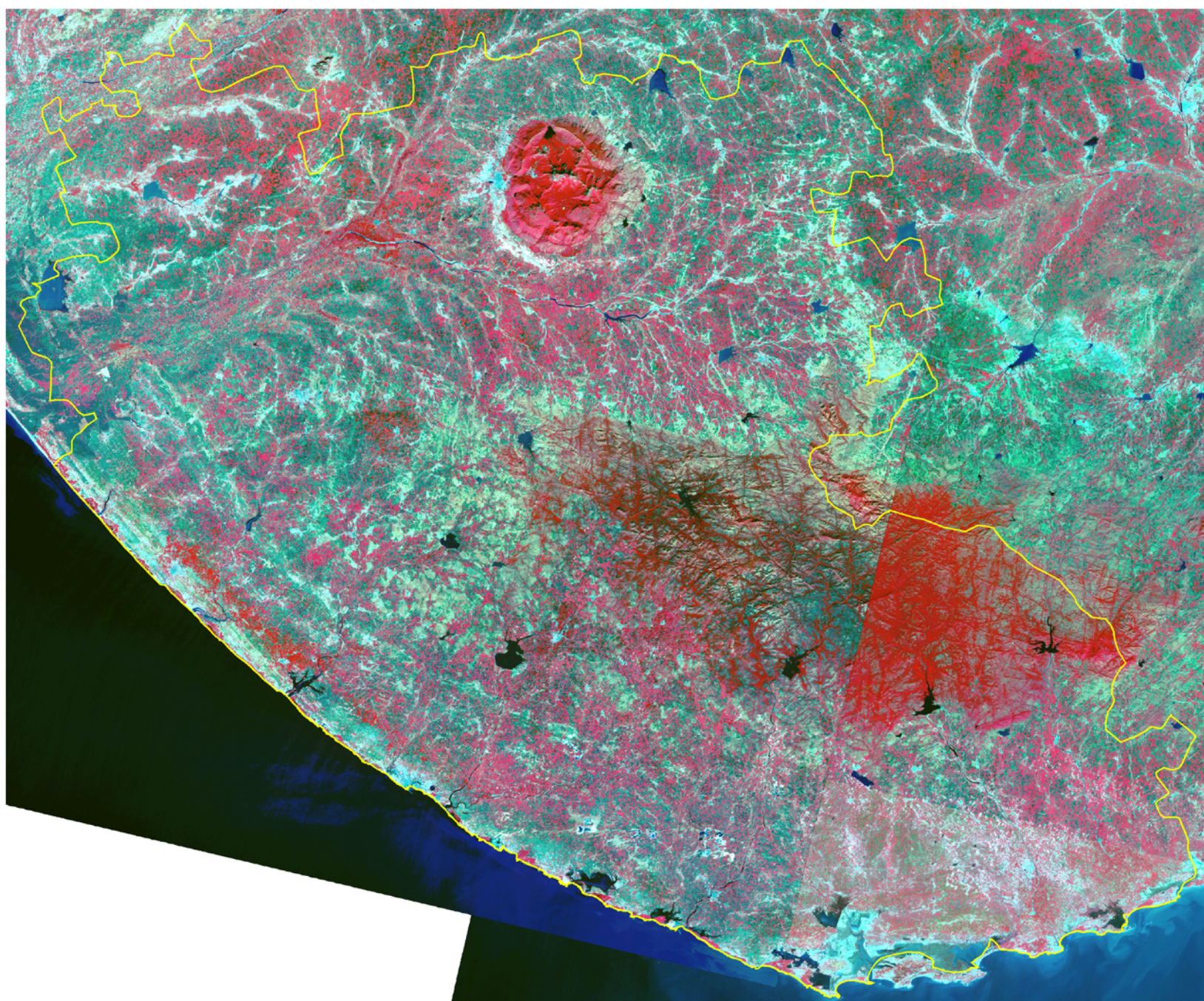
Prepared By :  
Space Applications Centre (ISRO), Ahmedabad  
and  
Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar

Sponsored By :  
Ministry of Environment and Forests  
Government of India











### 7.1.13 Amreli

Amreli is located near the Gulf of Khambhat in Arabian Sea. The district is bounded by Bhavnagar in the East, Junagadh in the West, Rajkot in the North and Arabian Sea in the South. The district head quarter is located at the same town of Amreli. Total geographic area of Amreli is 7381.17 km<sup>2</sup>. As per the 2001 census data, the population of the district was 13,93,295. The density of population was 188 persons per km<sup>2</sup> and literacy rate of the district was 67.72%. Amreli is also important from tourism point of view. Part of the Gir National Park is located in this district.

Total 516 wetlands are mapped including 149 small wetlands (< 2.25 ha) with 28505 ha area. Inland wetlands contribute 64.5% of the total wetland area and coastal wetlands contribute 35.5% of the total wetland area. Major wetland categories of the district are Rivers/streams, Reservoirs, Salt pans, and Inter-tidal mud flats. Details of area estimates of wetlands in Amreli district is shown in Table-18.

Area under aquatic vegetation in post-monsoon is about 761 ha and high during pre monsoon (2105 ha). Open water spread of the wetlands is significantly higher in post monsoon (11349 ha) than during pre monsoon (4649 ha).

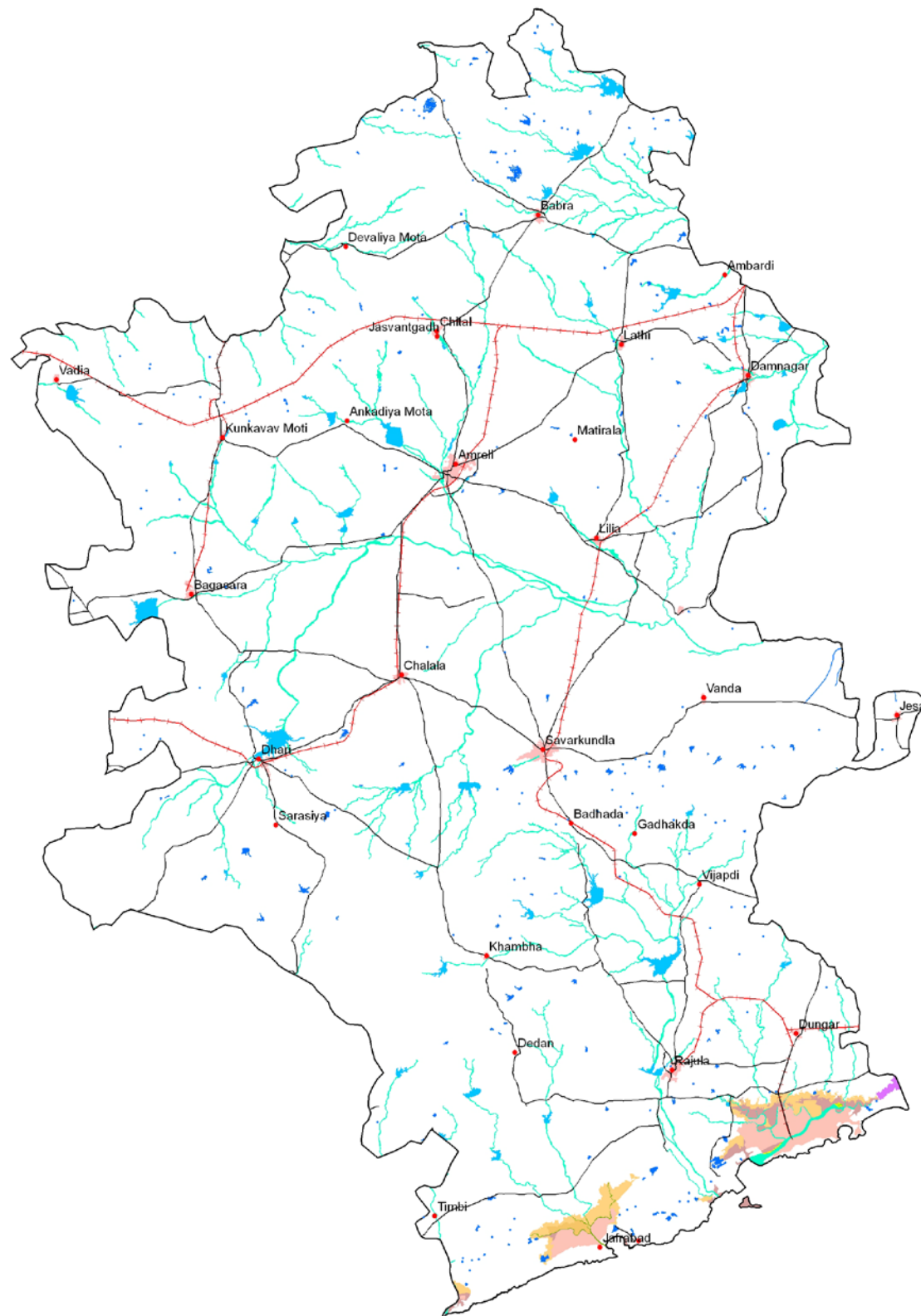
Table 18: Area estimates of wetlands in Amreli

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	266	0.93	266	55
2	1105	Waterlogged	1	204	0.72	-	-
3	1106	River/Stream	100	11226	39.38	2208	150
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	66	5169	18.13	4775	838
5	1202	Tanks/Ponds	141	1362	4.78	1150	202
		<b>Total - Inland</b>	<b>310</b>	<b>18227</b>	<b>63.94</b>	<b>8399</b>	<b>1245</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
6	2102	Creeks	1	139	0.49	139	139
7	2103	Sand/Beach	3	118	0.41	-	-
8	2104	Intertidal mud flats	21	1807	6.34	-	-
9	2105	Salt Marsh	22	3331	11.69	-	-
10	2106	Mangroves	2	55	0.19	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
11	2201	Salt pans	7	4354	15.27	2486	2940
12	2202	Aquaculture ponds	1	325	1.14	325	325
		<b>Total - Coastal</b>	<b>57</b>	<b>10129</b>	<b>35.53</b>	<b>2950</b>	<b>3404</b>
		<b>Sub-Total</b>	<b>367</b>	<b>28356</b>	<b>99.48</b>	<b>11349</b>	<b>4649</b>
		Wetlands (<2.25 ha), mainly Tanks	149	149	0.52	-	-
		<b>Total</b>	<b>516</b>	<b>28505</b>	<b>100.00</b>	<b>11349</b>	<b>4649</b>

<b>Area under Aquatic Vegetation</b>	761	2105
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<b>Area under turbidity levels</b>		
Low	5480	883
Moderate	5544	3618
High	325	148



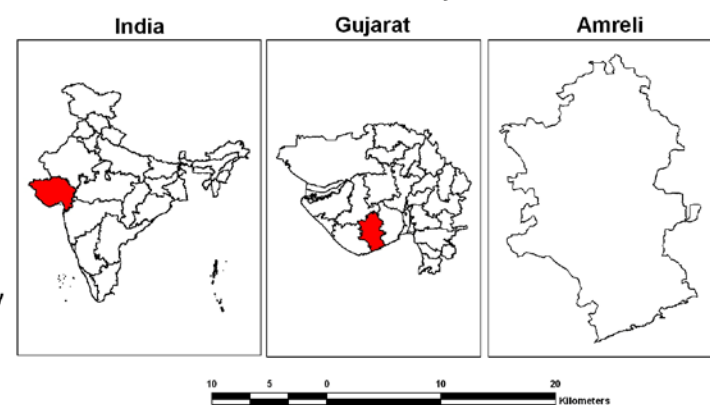


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

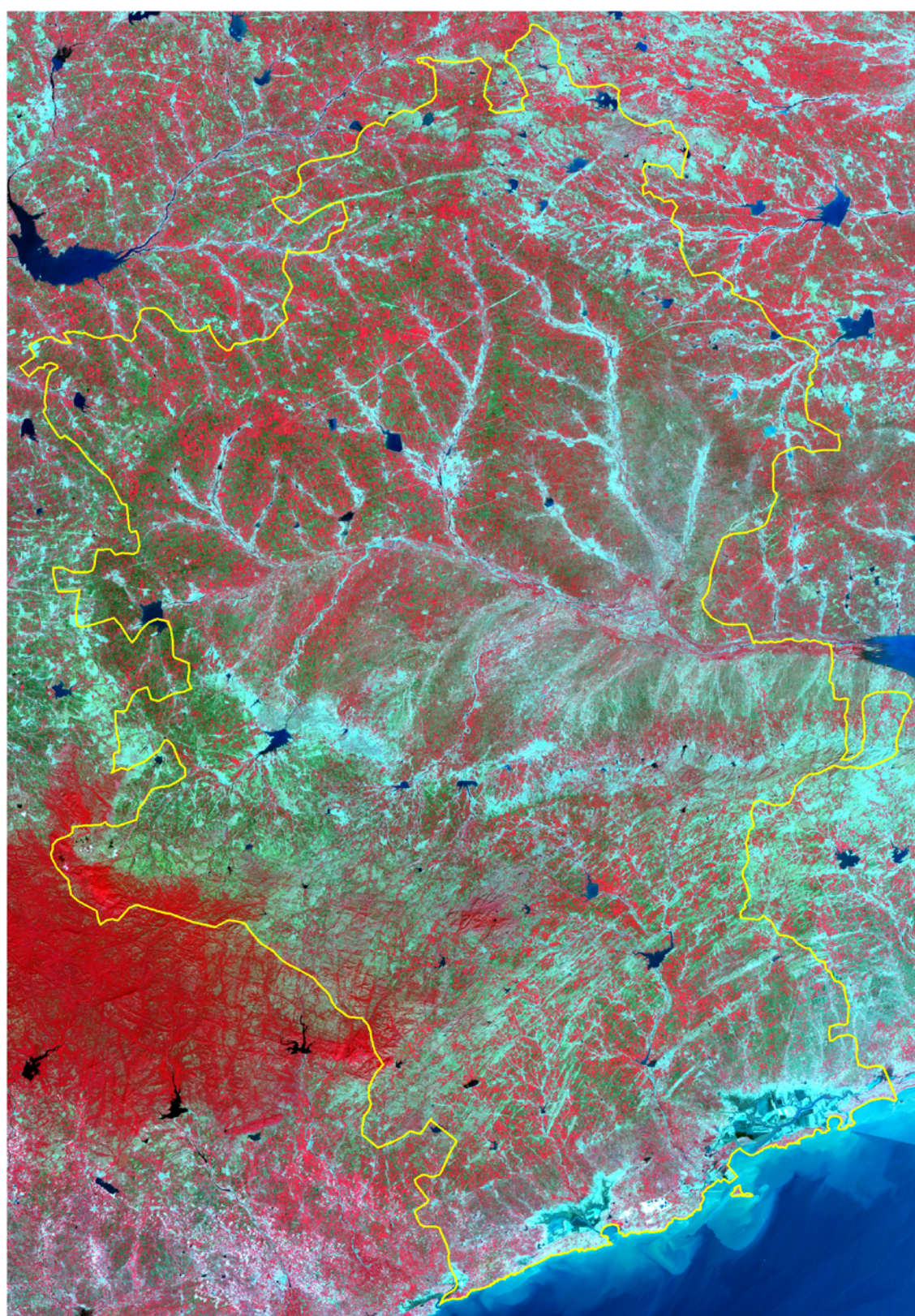
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Sponsored By :

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Government of India









### 7.1.14 Bhavnagar

Bhavnagar is a peninsular district of Western Gujarat bordered by Ahmedabad and Surendranagar districts in the North, the Gulf of Cambay in the East and South, and Amreli and Rajkot districts in the West. Bhavnagar city is its administrative headquarters. The district covers an area of 9,981 sq. km with total population of 24,69,264 according to 2001 census.

Total 724 wetlands are mapped including 202 small wetlands (< 2.25 ha) with 85895 ha area. Inland wetlands contribute 39% of the total wetland area and coastal wetlands contribute 61% of the total wetland area. Major wetland categories of the district are Salt marsh, Reservoirs, Rivers/ streams, Salt pans and Inter-tidal mud flats. Details of area estimates of wetlands in Bhavnagar district is shown in Table-19.

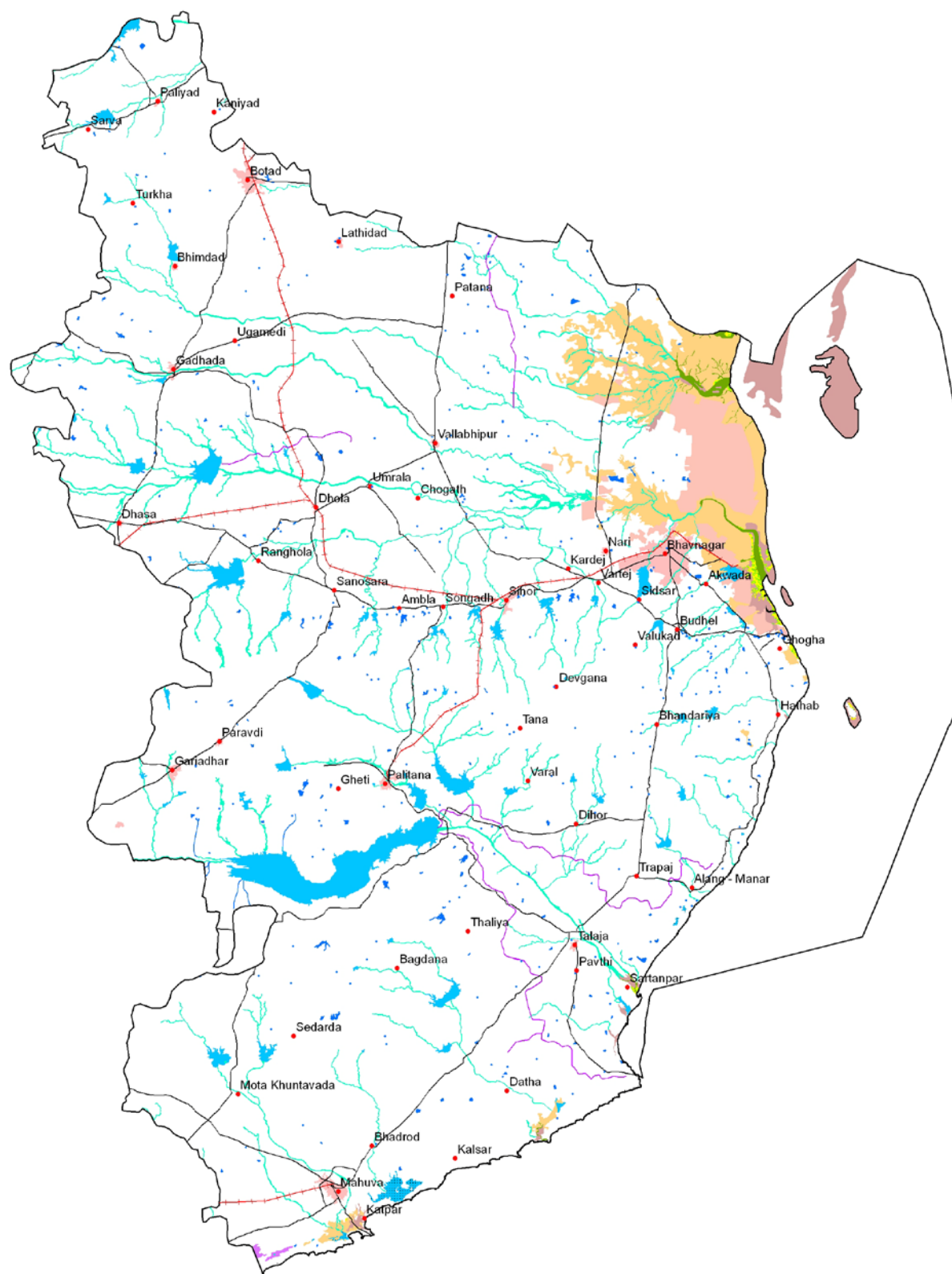
Area under aquatic vegetation in post-monsoon is about 2919 ha and high during pre monsoon (13009 ha). Open water spread of the wetlands is significantly higher in post monsoon (34588 ha) than during pre monsoon (17515 ha).

Table 19: Area estimates of wetlands in Bhavnagar

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1105	Waterlogged	2	234	0.27	-	-
2	1106	River/Stream	103	14238	16.58	3526	856
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
3	1201	Reservoirs/Barrages	73	16664	19.40	15612	2501
4	1202	Tanks/Ponds	205	1818	2.12	1455	250
		<b>Total - Inland</b>	<b>383</b>	<b>32954</b>	<b>38.37</b>	<b>20593</b>	<b>3607</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
5	2101	Lagoons	7	989	1.15	672	131
6	2102	Creeks	13	1708	1.99	1709	1708
7	2103	Sand/Beach	11	352	0.41	-	-
8	2104	Intertidal mud flats	30	9704	11.30	-	-
9	2105	Salt Marsh	44	25374	29.54	-	-
10	2106	Mangroves	16	1058	1.23	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
11	2201	Salt pans	18	13554	15.78	11614	12069
		<b>Total - Coastal</b>	<b>139</b>	<b>52739</b>	<b>61.40</b>	<b>13995</b>	<b>13908</b>
		<b>Sub-Total</b>	<b>522</b>	<b>85693</b>	<b>99.76</b>	<b>34588</b>	<b>17515</b>
		Wetlands (<2.25 ha), mainly Tanks	202	202	0.24	-	-
		<b>Total</b>	<b>724</b>	<b>85895</b>	<b>100.00</b>	<b>34588</b>	<b>17515</b>

Area under Aquatic Vegetation	2919	13009
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Area under turbidity levels		
Low	17959	3001
Moderate	15545	13624
High	1084	890

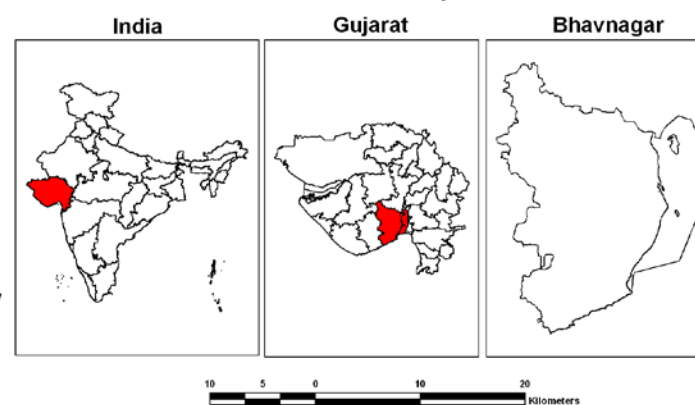


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



## Data Source :

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

## Prepared By :

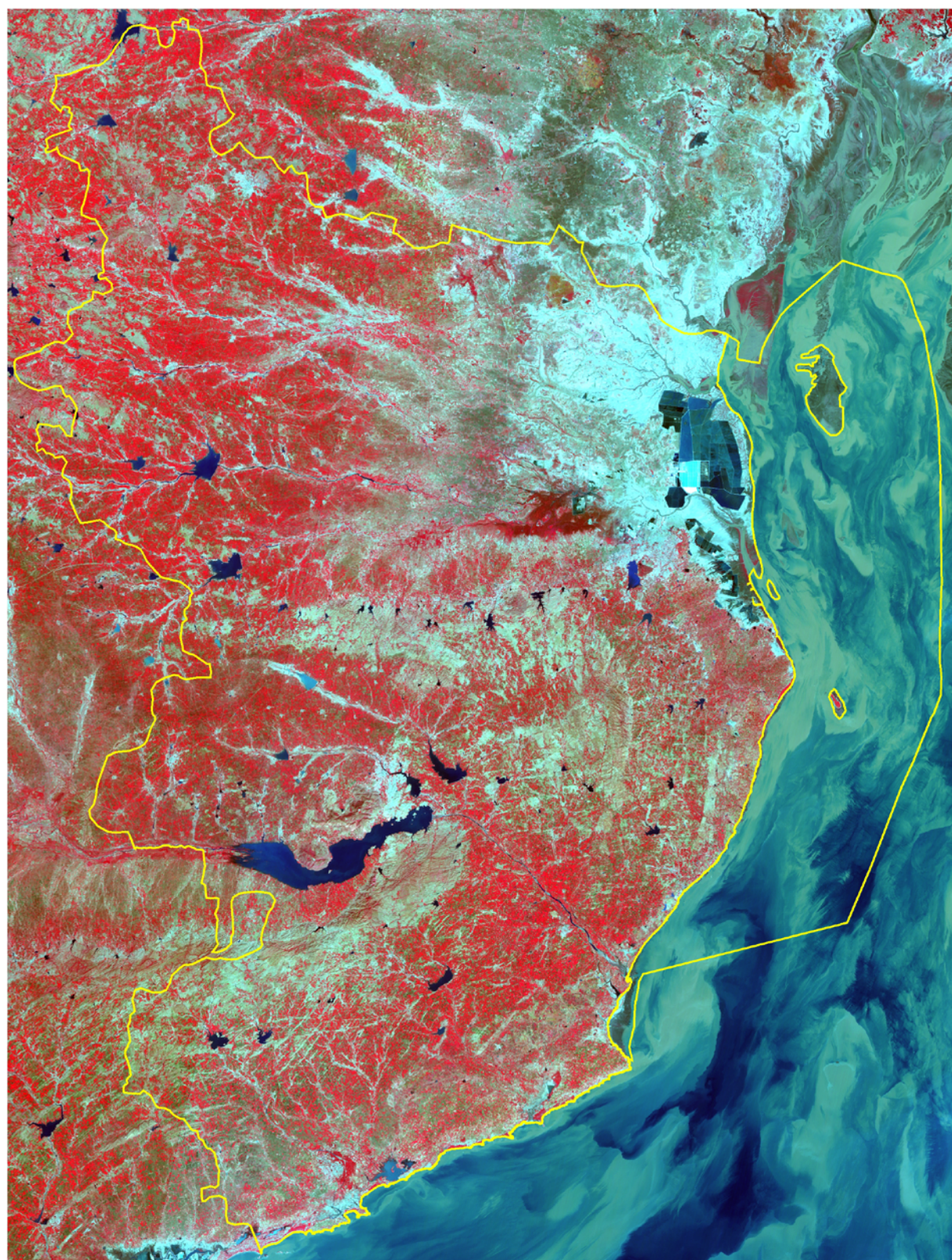
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### 7.1.15 Anand

The district of Anand is one of the 25 administrative districts of Gujarat which was carved out of the Kheda district in 1997. Anand town is its district head quarters and is the major town. Anand is bounded by Kheda to the north, Vadodara to the east, Ahmedabad to the west, and the Gulf of Cambay to the south. The total area covered by the district is 2941 sq. km and population is 18,56,712 according to 2001 census.

Total 713 wetlands are mapped including 306 small wetlands (< 2.25 ha) with 67570 ha area. Inland wetlands contribute 13% of the total wetland area and coastal wetlands contribute 87% of the total wetland area. Major wetland categories of the district are Inter-tidal mud flats, mangroves, creeks, and Rivers/ streams. Details of area estimates of wetlands in Anand district is shown in Table-20.

Area under aquatic vegetation in post-monsoon is about 2149 ha and slightly high during pre monsoon (2092 ha). Open water spread during post-monsoon is about 13765 ha and 13657 ha during pre-monsoon.

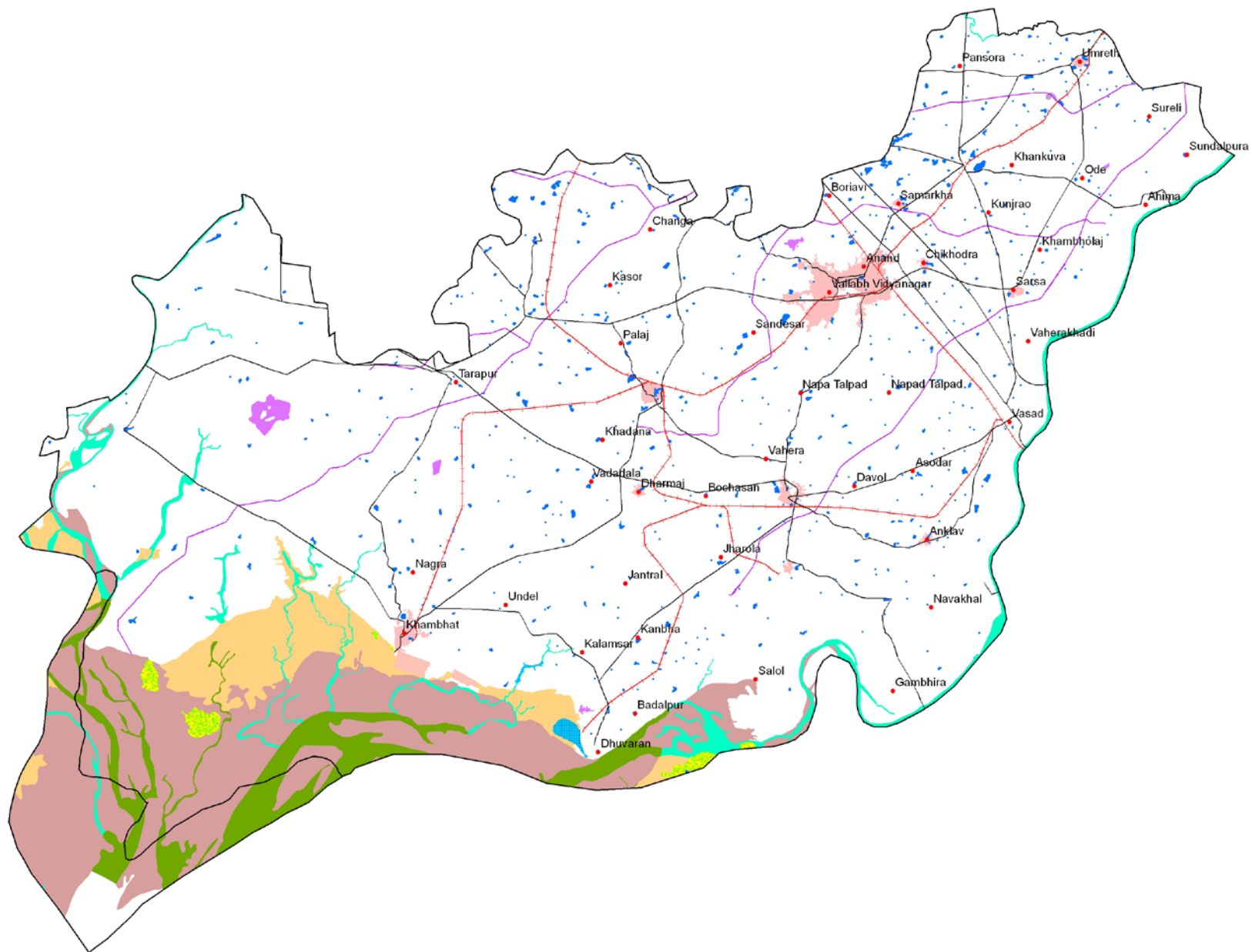
Table 20: Area estimates of wetlands in Anand

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	23	0.03	-	-
2	1105	Waterlogged	6	634	0.94	109	389
3	1106	River/Stream	16	6081	9.00	2640	2628
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	1	52	0.08	52	-
5	1202	Tanks/Ponds	311	1730	2.56	1177	528
6	1203	Waterlogged	1	35	0.05	35	-
		<b>Total - Inland</b>	<b>337</b>	<b>8555</b>	<b>12.66</b>	<b>4013</b>	<b>3545</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
7	2101	Lagoons	1	294	0.44	294	294
8	2102	Creeks	8	9395	13.90	9395	9395
9	2104	Intertidal mud flats	33	36340	53.78	-	-
10	2105	Salt Marsh	19	11210	16.59	-	-
11	2106	Mangroves	7	1047	1.55	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
12	2201	Salt pans	2	423	0.63	63	423
		<b>Total - Coastal</b>	<b>70</b>	<b>58709</b>	<b>86.89</b>	<b>9752</b>	<b>10112</b>
		<b>Sub-Total</b>	<b>407</b>	<b>67264</b>	<b>99.55</b>	<b>13765</b>	<b>13657</b>
		Wetlands (<2.25 ha), mainly Tanks	306	306	0.45	-	-
		<b>Total</b>	<b>713</b>	<b>67570</b>	<b>100.00</b>	<b>13765</b>	<b>13657</b>

<b>Area under Aquatic Vegetation</b>	2149	2092
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<b>Area under turbidity levels</b>		
Low	2959	2773
Moderate	1268	1437
High	9538	9447



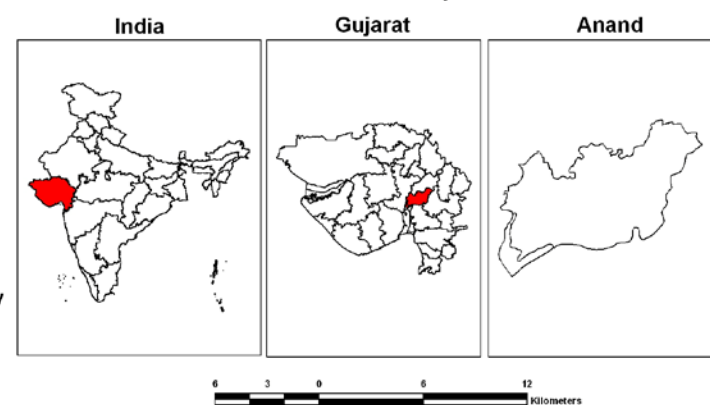


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



## Data Source :

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

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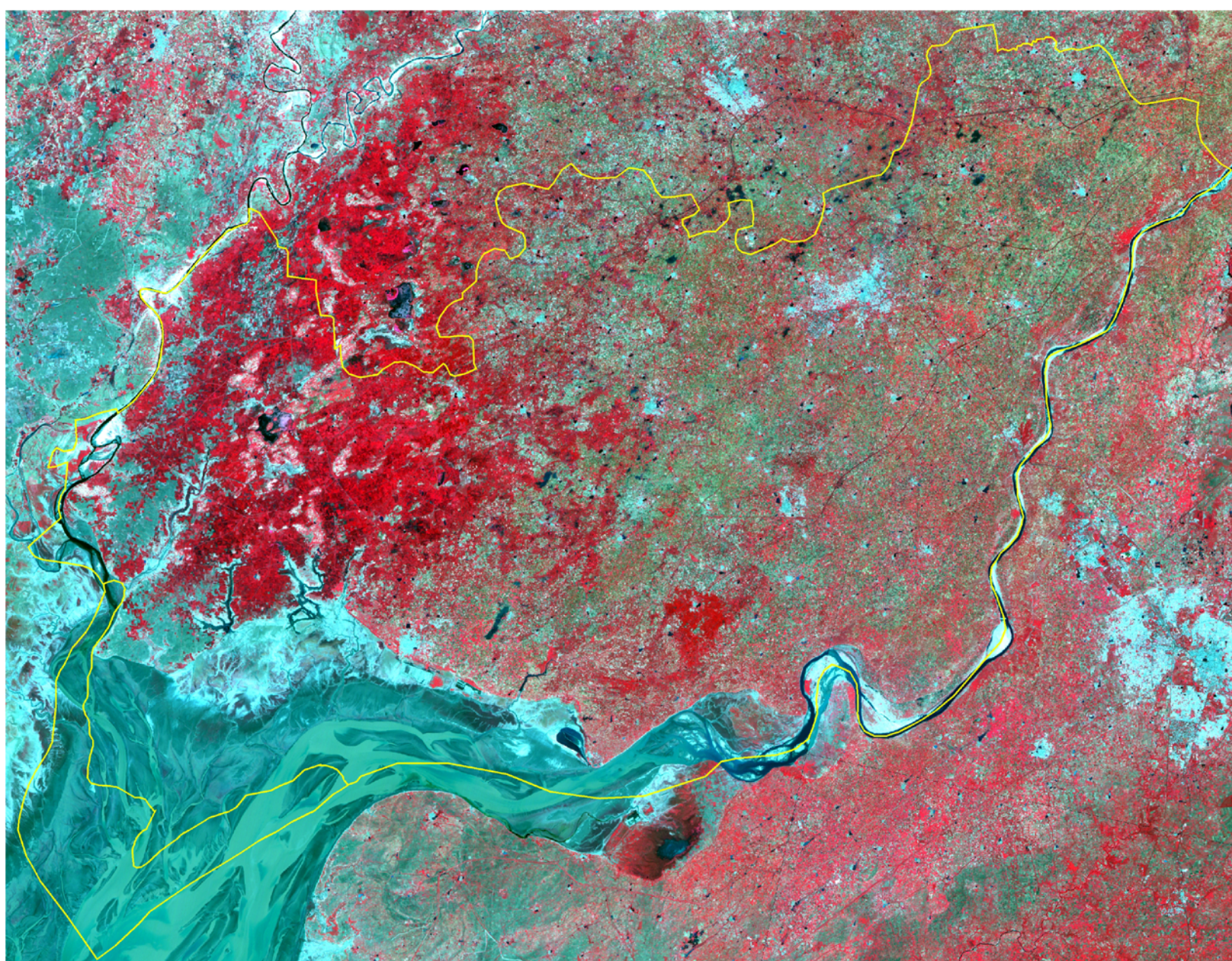
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### 7.1.16 Kheda

The district of Kheda covers an area of 4,219 sq. km with total population of 20,24,216 according to 2001 census. Kheda city is the administrative headquarters of the district. The district has over 600 villages. It has common borders with Gandhinagar and Sabarkantha in the north, Panchmahal in the east, Ahmedabad in the west, and Anand and Vadodara in the south. Anand district was carved out of Kheda district in 1997.

Total 858 wetlands are mapped including 385 small wetlands (< 2.25 ha) with 14415 ha area. Major wetland category of the district are Rivers/ streams, Tanks/ponds, waterlogged and Reservoirs. Details of area estimates of wetlands in Kheda district is shown in Table-21.

Area under aquatic vegetation in post-monsoon is about 2447 ha and slightly high during pre-monsoon (3387 ha). Open water spread of the wetlands is much higher in post-monsoon (8076 ha) than pre-monsoon (3252 ha),

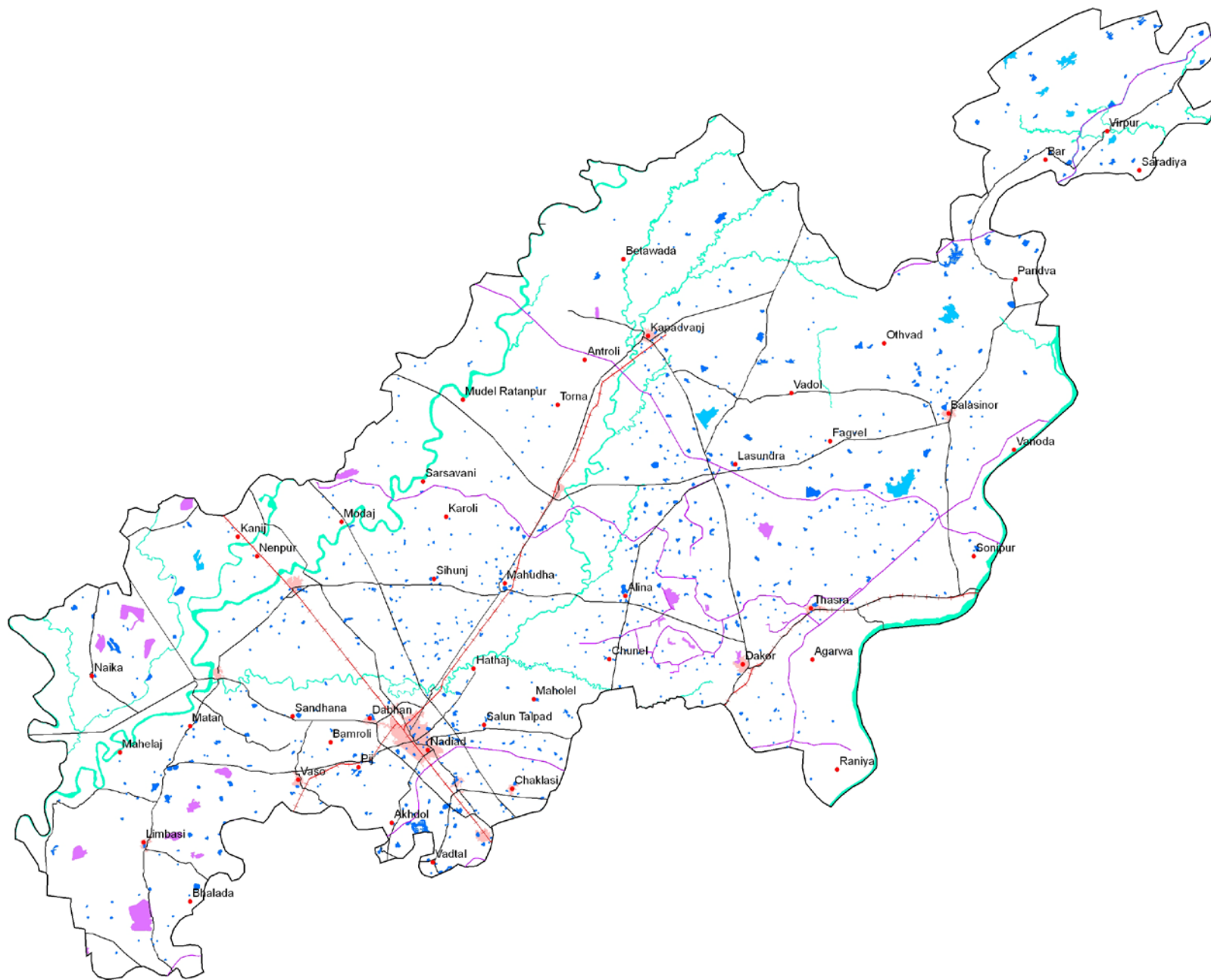
Table 21: Area estimates of wetlands in Kheda

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	260	1.80	104	34
2	1105	Waterlogged	20	1843	12.79	601	503
3	1106	River/Stream	11	7855	54.49	4348	1837
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	9	988	6.85	780	151
5	1202	Tanks/Ponds	431	3084	21.39	2243	727
		<b>Sub-Total</b>	<b>473</b>	<b>14030</b>	<b>97.33</b>	<b>8076</b>	<b>3252</b>
		Wetlands (<2.25 ha), mainly Tanks	385	385	2.67	-	-
		<b>Total</b>	<b>858</b>	<b>14415</b>	<b>100.00</b>	<b>8076</b>	<b>3252</b>

<b>Area under Aquatic Vegetation</b>	2447	3387
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<b>Area under turbidity levels</b>		
Low	5368	1728
Moderate	2332	1435
High	376	89



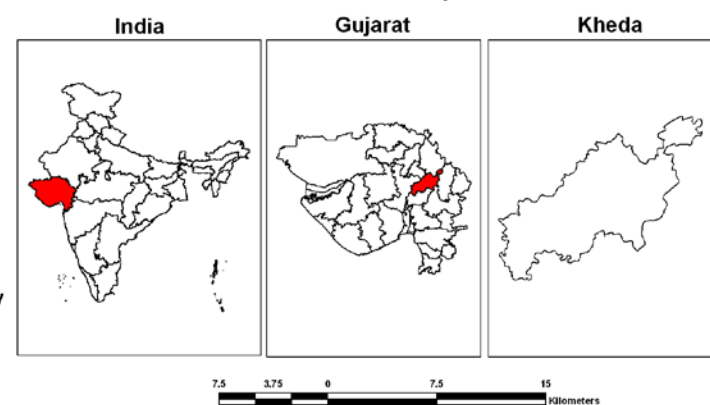


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

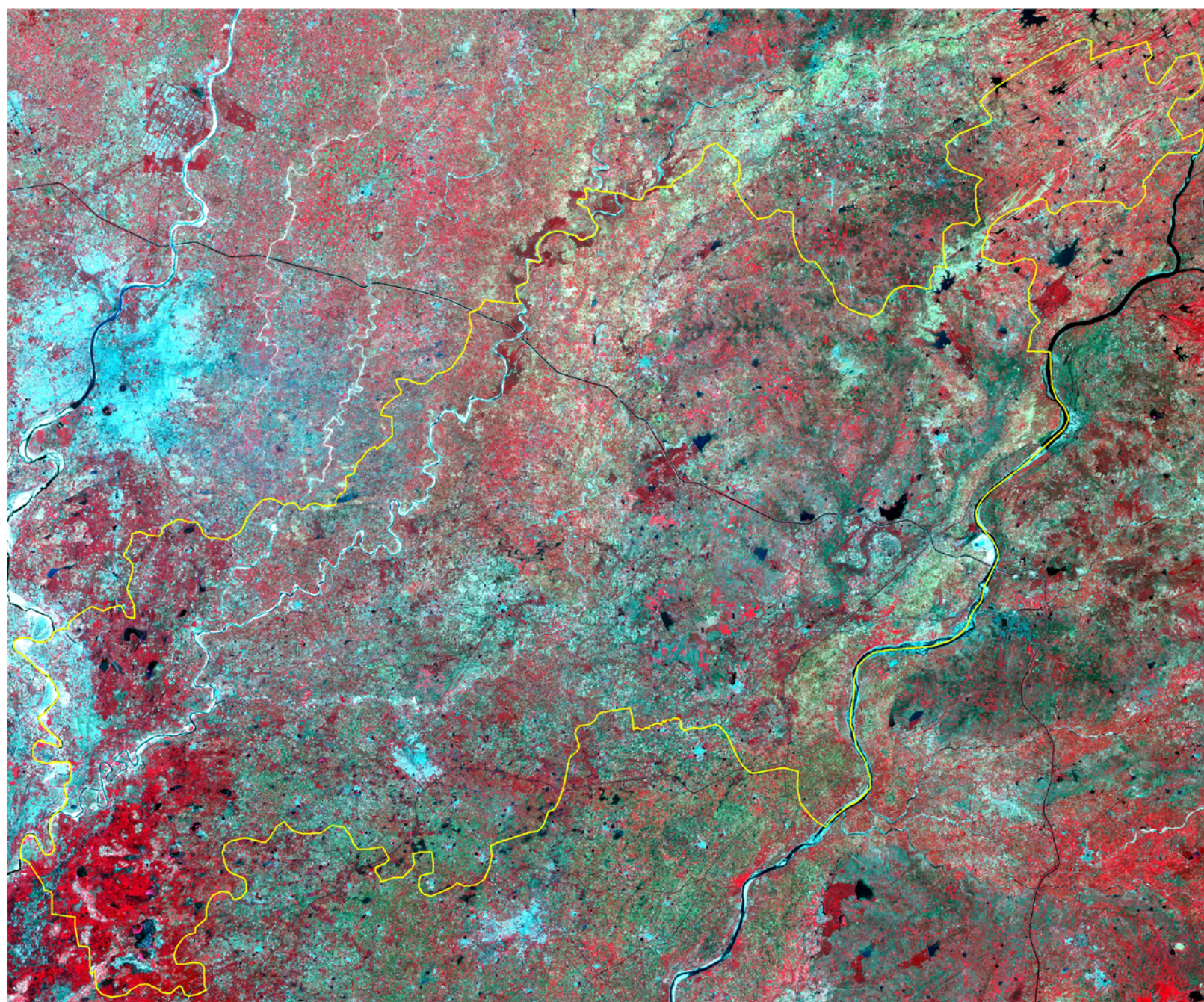
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### 7.1.17 Panchmahal

Panchmahal (or Panch Mahal) is a district of Gujarat located in the eastern part of the state. The district occupies an area of 5220 sq. km with total population of 20, 24,883. The district head quarters are located at Godhra town. Champaner, a UNESCO World Heritage site is located in this district.

Total 1081 wetlands are mapped including 332 small wetlands (< 2.25 ha) with 38049 ha area. Major wetland categories of the district are Reservoirs, Rivers/ streams and Tanks/ponds. Kadana and Panam reservoirs are important wetlands of the district. Details of area estimates of wetlands in Pandchmahal district is shown in Table-22.

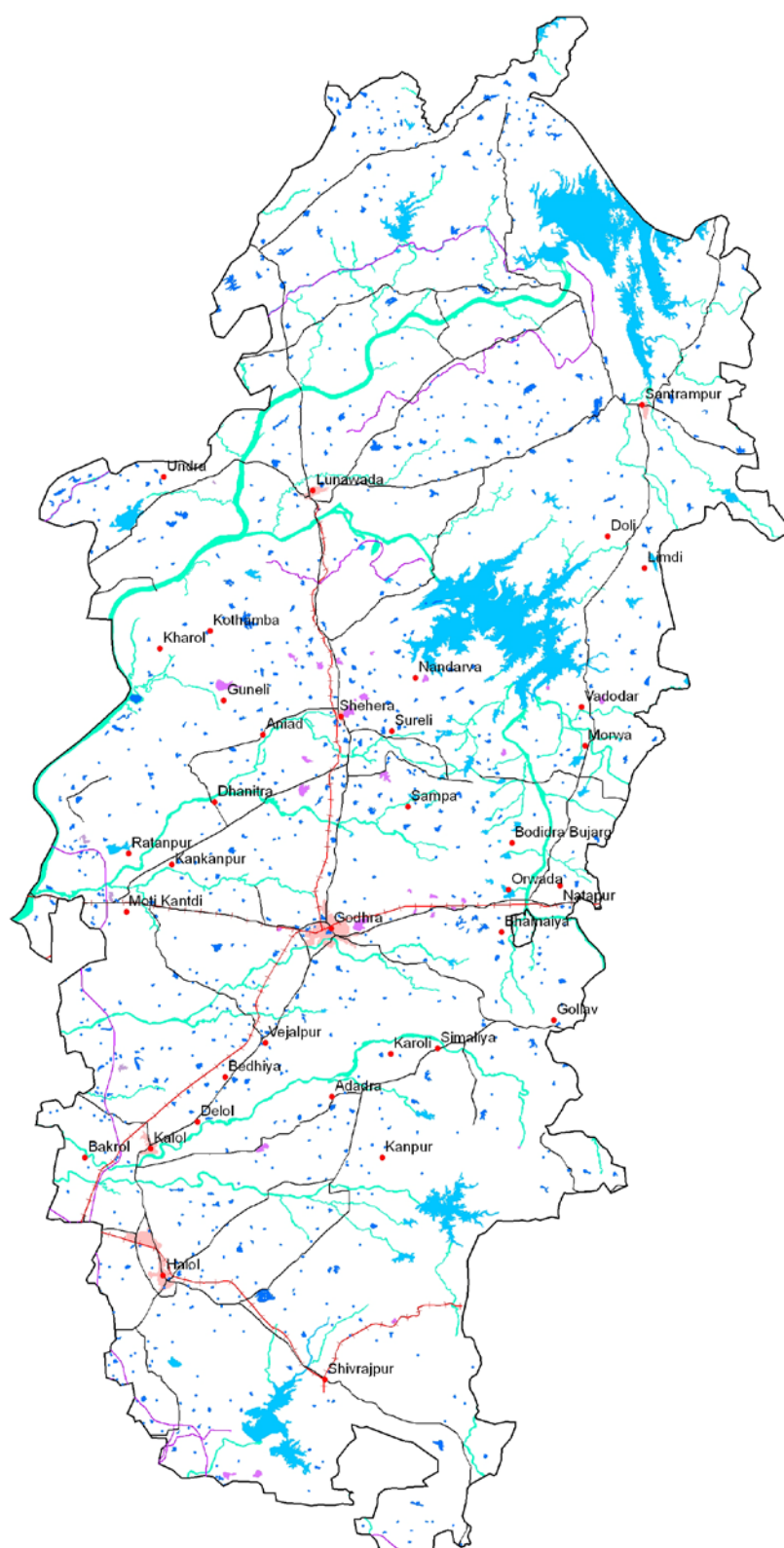
Area under aquatic vegetation in post-monsoon is about 2583 ha and high during pre monsoon (8066 ha). Open water spread of the wetlands is higher in post monsoon (27663 ha) than during pre monsoon (17834 ha). Major part of the open water area is under low turbidity during both the seasons.

Table 22: Area estimates of wetlands in Panchmahal

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	1	123	0.32	123	-
2	1105	Waterlogged	28	719	1.89	395	180
3	1106	River/Stream	45	12437	32.69	4964	3215
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	63	19561	51.41	18529	13095
5	1202	Tanks/Ponds	608	4779	12.56	3646	1314
6	1203	Waterlogged	4	98	0.26	6	30
		<b>Sub-Total</b>	<b>749</b>	<b>37717</b>	<b>99.13</b>	<b>27663</b>	<b>17834</b>
		Wetlands (<2.25 ha), mainly Tanks	332	332	0.87	-	-
		<b>Total</b>	<b>1081</b>	<b>38049</b>	<b>100.00</b>	<b>27663</b>	<b>17834</b>

<b>Area under Aquatic Vegetation</b>	2583	8066
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<b>Area under turbidity levels</b>		
Low	23612	16050
Moderate	3499	1682
High	552	102

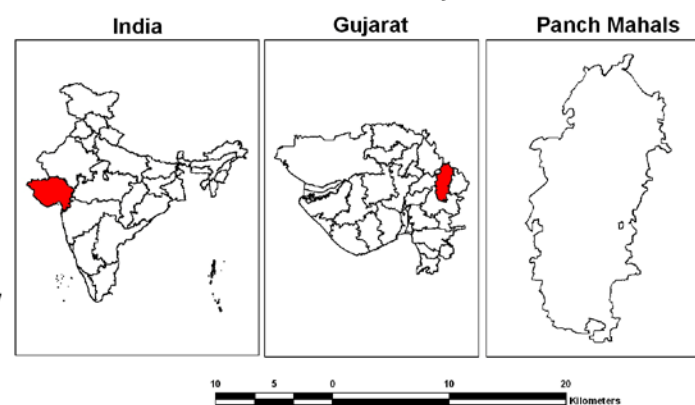


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



## Data Source :

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

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### 7.1.18 Dohad

Dahod, also known as Dohad is a district of Gujarat bounded by Panchmahal in the west, Vadodara in the south, Jhabua district of Madhya Pradesh in the east, and Banswara district of Rajasthan in the north. Dahod covers an area of 3,646 sq. km with total population 16,35,374 according to 2001 census. The population of the district is mostly rural, and majority of the residents are Adivasis, mostly Bhils. The town Dahod is the administrative head quarters.

Total 678 wetlands are mapped including 207 small wetlands (< 2.25 ha) with 15092 ha area. Major wetland categories of the district are Rivers/streams, Reservoirs and Tanks/ponds. Wetlands are more concentrated in the eastern part of the district. Details of area estimates of wetlands in Dohad district is shown in Table-23.

Area under aquatic vegetation in post-monsoon is about 222 ha and slightly high during pre-monsoon (3833 ha). Open water spread of the wetlands is higher in post-monsoon (9770 ha) than during pre-monsoon (4153 ha).

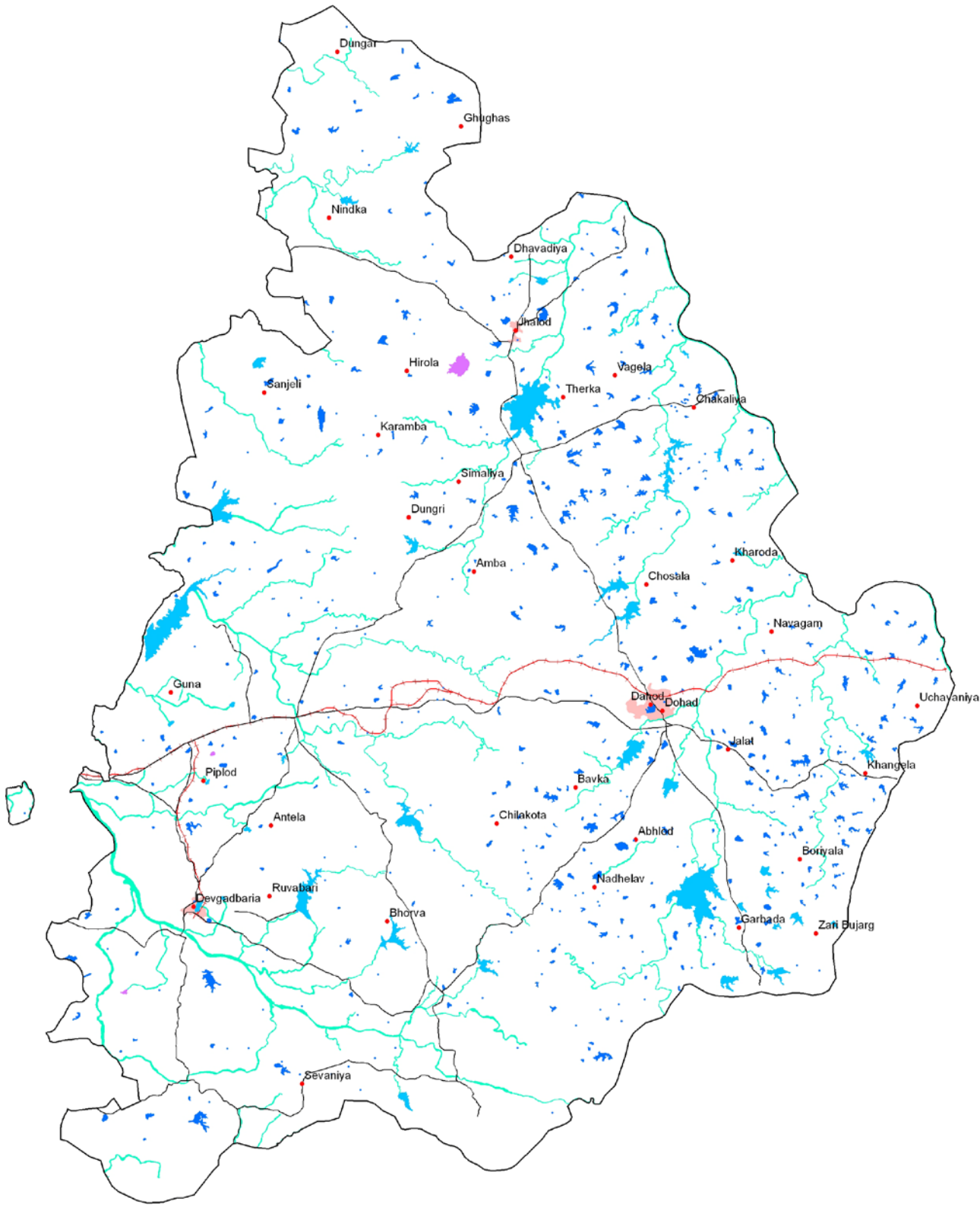
Table 23: Area estimates of wetlands in Dohad

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1105	Waterlogged	3	173	1.15	165	32
2	1106	River/Stream	42	6136	40.66	1243	488
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
3	1201	Reservoirs/Barrages	46	4787	31.72	4706	1961
4	1202	Tanks/Ponds	380	3789	25.11	3656	1672
		<b>Sub-Total</b>	<b>471</b>	<b>14885</b>	<b>98.63</b>	<b>9770</b>	<b>4153</b>
		Wetlands (<2.25 ha), mainly Tanks	207	207	1.37	-	-
		<b>Total</b>	<b>678</b>	<b>15092</b>	<b>100.00</b>	<b>9770</b>	<b>4153</b>

<b>Area under Aquatic Vegetation</b>	222	3833
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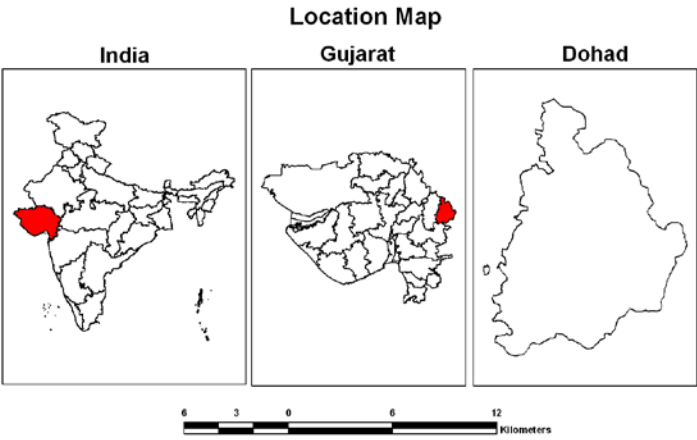
<b>Area under turbidity levels</b>		
Low	6041	2389
Moderate	3414	1645
High	315	119





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

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



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

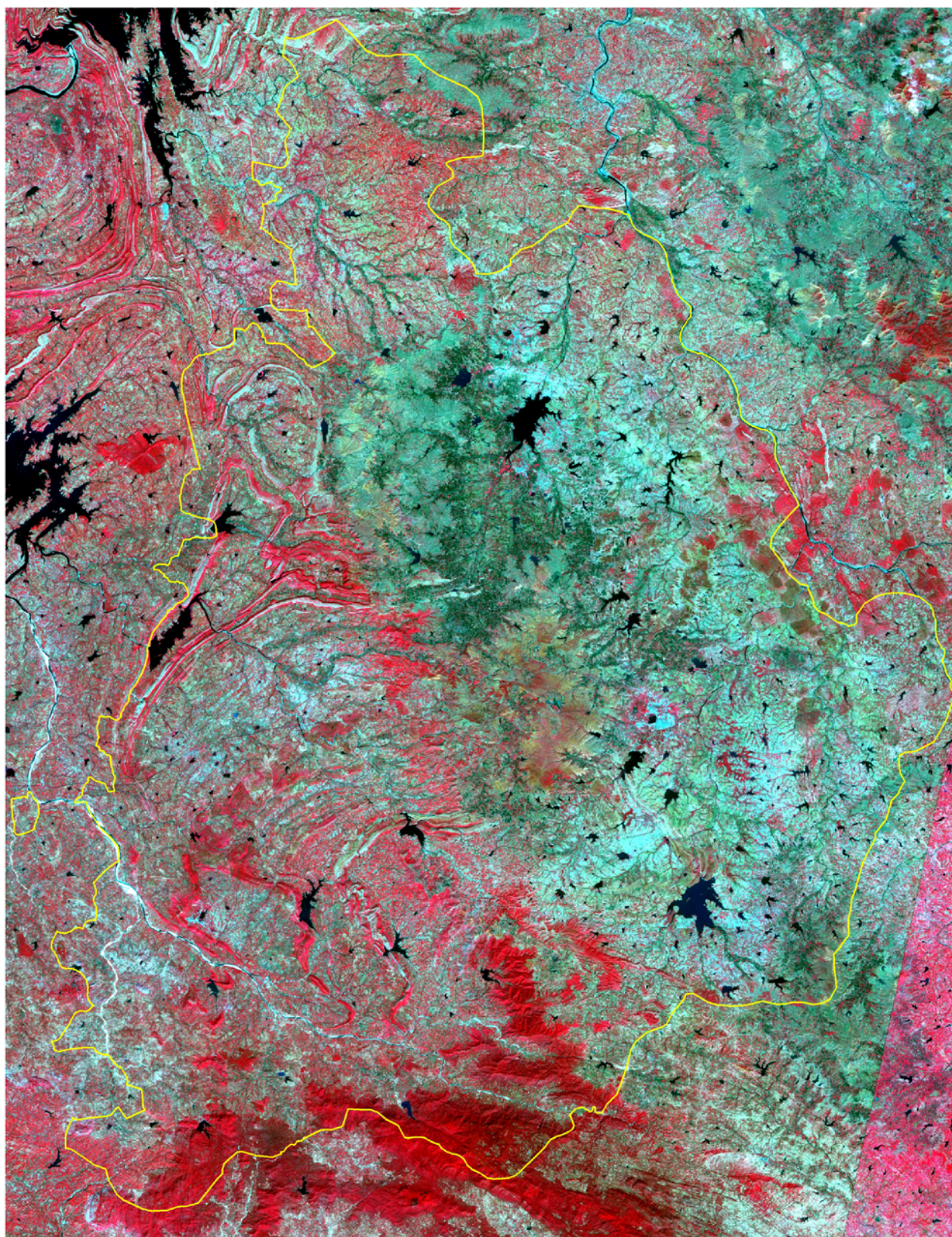
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### 7.1.19 Vadodara

Vadodara is located in the eastern part of the state with its headquarters at Vadodara city. The district covers an area of 7,549 sq. km with total population of 36,39,775 according to 2001 census. The district is bordered by Panchmahal and Dahod districts to the north, Anand and Kheda districts to the west, Bharuch and Narmada districts to the south, and the state of Madhya Pradesh to the east.

Total 1101 wetlands are mapped including 537 small wetlands (< 2.25 ha) with 35553 ha area. Inland wetlands contribute 98% of the total wetland area and coastal wetlands contribute 2% of the total wetland area. Major wetland categories of the district are Rivers/streams, Reservoirs, Tank/ponds and Lakes/ponds. Details of area estimates of wetlands in Vadodara district is shown in Table-24.

Area under aquatic vegetation in post-monsoon is about 2172 ha and higher during pre-monsoon (4968 ha). Open water spread of the wetlands is significantly high in post-monsoon (18528 ha) than during pre-monsoon (9592 ha). Major part of the open water area is under low turbidity during both the seasons.

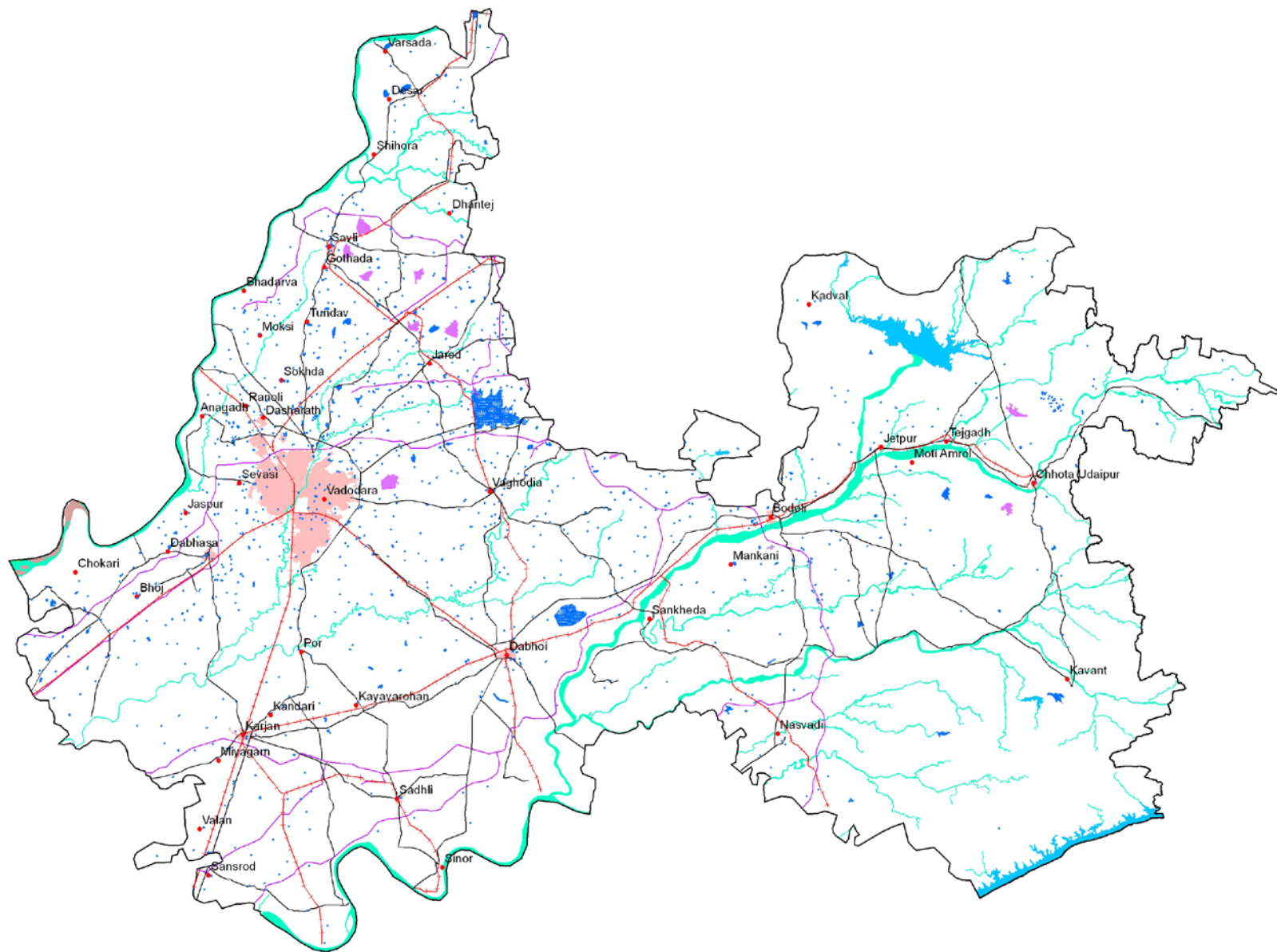
Table 24: Area estimates of wetlands in Vadodara

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	2270	6.38	1198	917
2	1105	Waterlogged	12	1320	3.71	1003	256
3	1106	River/Stream	26	22332	62.81	8683	4023
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	6	5257	14.79	5257	3549
5	1202	Tanks/Ponds	511	3129	8.80	2356	839
6	1203	Waterlogged	1	31	0.09	31	8
		<b>Total - Inland</b>	<b>558</b>	<b>34339</b>	<b>96.59</b>	<b>18528</b>	<b>9592</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
7	2104	Intertidal mud flats	5	668	1.88	-	-
8	2106	Mangroves	1	9	0.03	-	-
		<b>Total - Coastal</b>	<b>6</b>	<b>677</b>	<b>1.90</b>	<b>-</b>	<b>-</b>
		<b>Sub-Total</b>	<b>564</b>	<b>35016</b>	<b>98.49</b>	<b>18528</b>	<b>9592</b>
		Wetlands (<2.25 ha), mainly Tanks	537	537	1.51	-	-
		<b>Total</b>	<b>1101</b>	<b>35553</b>	<b>100.00</b>	<b>18528</b>	<b>9592</b>

<b>Area under Aquatic Vegetation</b>	2172	4968
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<b>Area under turbidity levels</b>		
Low	15861	8107
Moderate	1879	1291
High	788	194



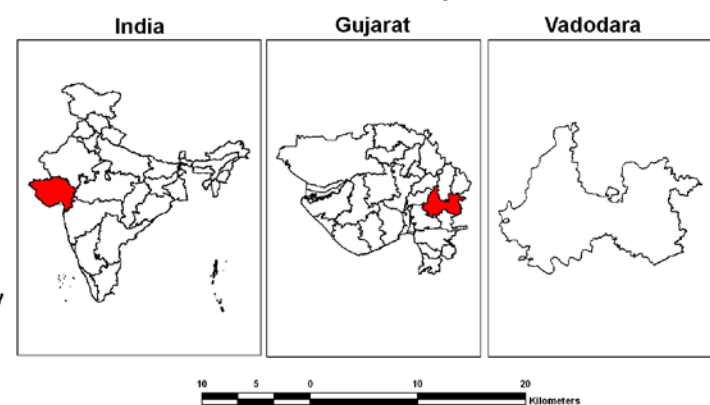


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

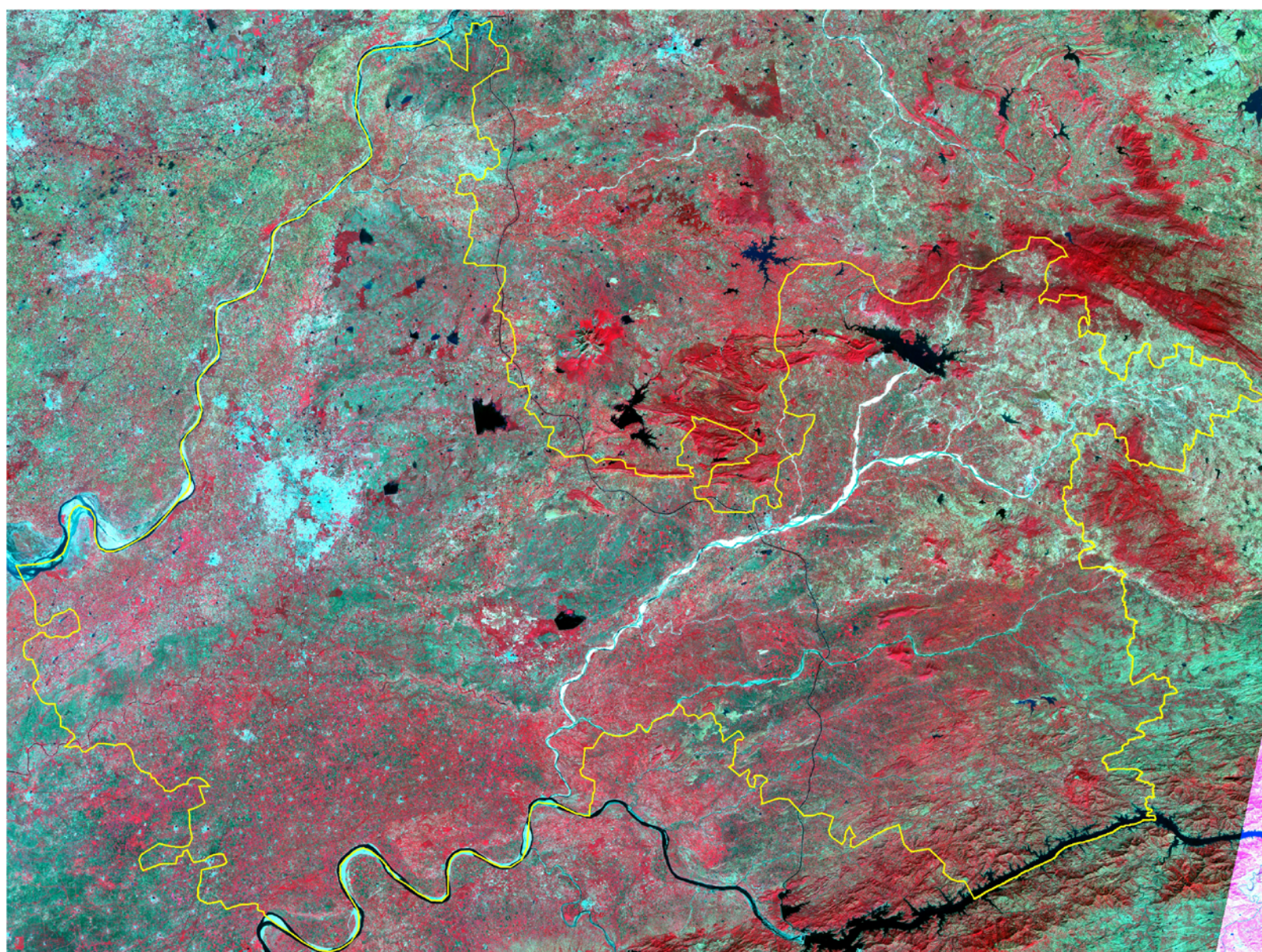
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### 7.1.20 Narmada

Narmada is one of the 25 administrative districts of Gujarat with its head quarters located at Rajpipla. The district occupies an area of 2,749 square kilometers with a population of 514,404 according to 2001 census. It is one of the backward districts in Gujarat.

Total 83 wetlands are mapped including 32 small wetlands (< 2.25 ha) with 22501 ha area. Major wetland categories of the district are Reservoirs and Rivers/streams. Sardar Sarover Dam on the river Narmada is located in the district. Details of area estimates of wetlands in Narmada district is shown in Table-25.

Area under aquatic vegetation in pre-monsoon is about 4636 ha. Open water spread of the wetlands is higher in post-monsoon (18012 ha) than during pre monsoon (11633 ha). Major part of the open water area is under low turbidity during both the seasons.

Table 25: Area estimates of wetlands in Narmada

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1106	River/Stream	28	7259	32.26	2807	1803
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
2	1201	Reservoirs/Barrages	9	15022	66.76	15022	9721
3	1202	Tanks/Ponds	14	188	0.84	183	109
		<b>Total - Inland</b>	<b>51</b>	<b>22469</b>	<b>99.86</b>	<b>18012</b>	<b>11633</b>
		<b>Sub-Total</b>	<b>51</b>	<b>22469</b>	<b>99.86</b>	<b>18012</b>	<b>11633</b>
		Wetlands (<2.25 ha), mainly Tanks	32	32	0.14	-	-
		<b>Total</b>	<b>83</b>	<b>22501</b>	<b>100.00</b>	<b>18012</b>	<b>11633</b>

<b>Area under Aquatic Vegetation</b>	5	4636
--------------------------------------	---	------

<b>Area under turbidity levels</b>		
Low	17607	11352
Moderate	378	275
High	27	6

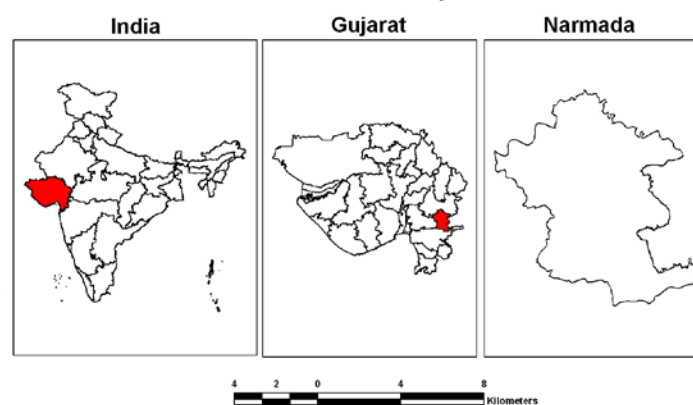


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

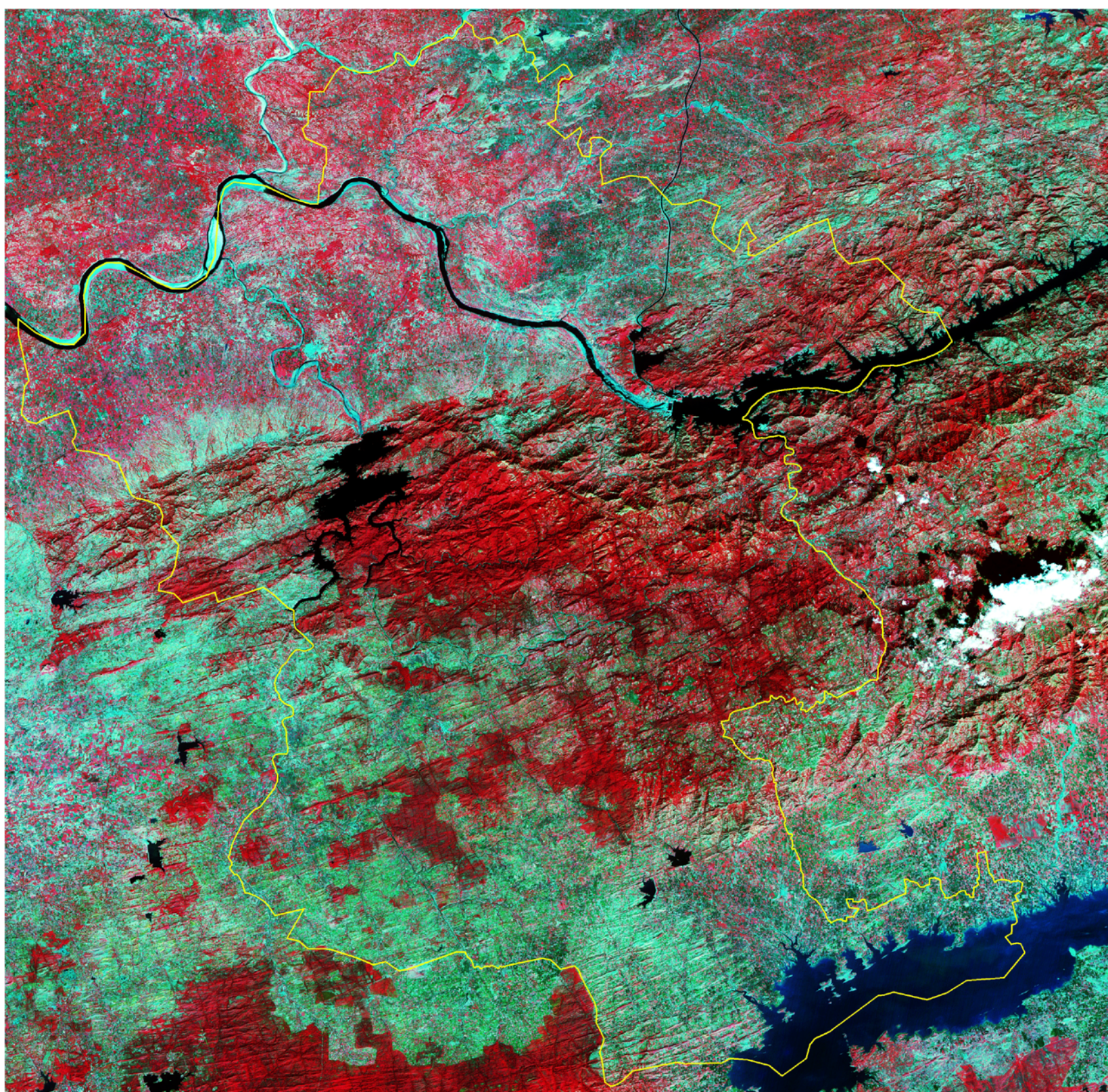
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### 7.1.21 Bharuch

Bharuch is an administrative district of Gujarat located in the southern portion of the state. There are 7 taluks in the district and the district head quarter is located at Bharuch town. The district covers an area of 6527 sq. km with total population of 13,70,104 according to 2001 census.

Total 884 wetlands are mapped including 407 small wetlands (< 2.25 ha) with 112453 ha area. Inland wetlands contribute 17.5% of the total wetland area and coastal wetlands contributes 82.5% of the total wetland area. Major wetland categories of the district are Inter-tidal mud flats, Salt marsh, Rivers/streams, Salt pans and Mangroves. Details of area estimates of wetlands in Bharuch district is shown in Table-26.

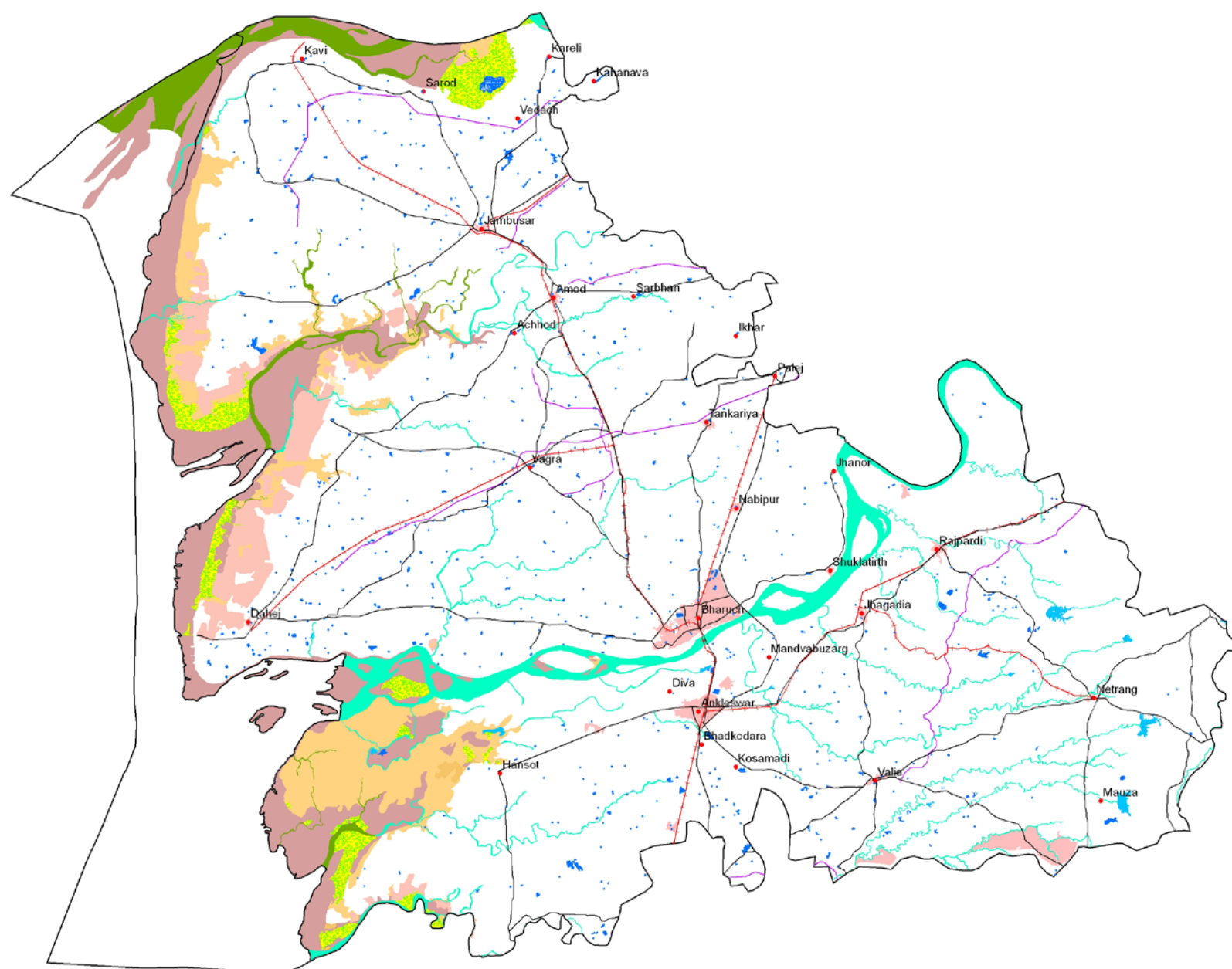
Area under aquatic vegetation in post-monsoon is about 9237 ha and slightly high during pre-monsoon (9854 ha). Open water spread of the wetlands is higher in post-monsoon (23102 ha) than during pre-monsoon (20805 ha).

Table 26: Area estimates of wetlands in Bharuch

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	1	254	0.23	254	-
2	1106	River/Stream	28	16246	14.45	7513	6340
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
3	1201	Reservoirs/Barrages	12	729	0.65	729	368
4	1202	Tanks/Ponds	291	1908	1.70	1733	714
5	1204	Salt pans	1	152	0.14	-	-
		<b>Total - Inland</b>	<b>333</b>	<b>19289</b>	<b>17.15</b>	<b>10229</b>	<b>7422</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
6	2102	Creeks	9	8604	7.65	8604	8604
7	2104	Intertidal mud flats	63	40690	36.18	-	-
8	2105	Salt Marsh	42	21982	19.55	-	-
9	2106	Mangroves	26	9073	8.07	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
10	2201	Salt pans	33	12017	10.69	4238	4755
11	2202	Aquaculture ponds	4	391	0.35	31	24
		<b>Total - Coastal</b>	<b>144</b>	<b>92757</b>	<b>82.49</b>	<b>12873</b>	<b>13383</b>
		<b>Sub-Total</b>	<b>477</b>	<b>112046</b>	<b>99.64</b>	<b>23102</b>	<b>20805</b>
		Wetlands (<2.25 ha), mainly Tanks	407	407	0.36	-	-
		<b>Total</b>	<b>884</b>	<b>112453</b>	<b>100.00</b>	<b>23102</b>	<b>20805</b>

<b>Area under Aquatic Vegetation</b>	9237	9854
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<b>Area under turbidity levels</b>		
Low	8015	6379
Moderate	6272	5753
High	8815	8673

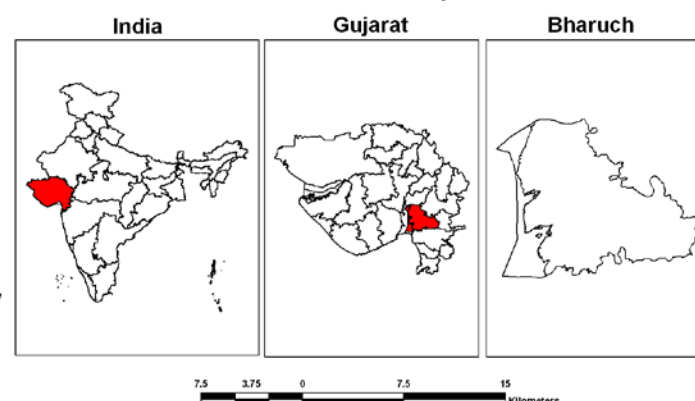


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



## Data Source :

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

## Prepared By :

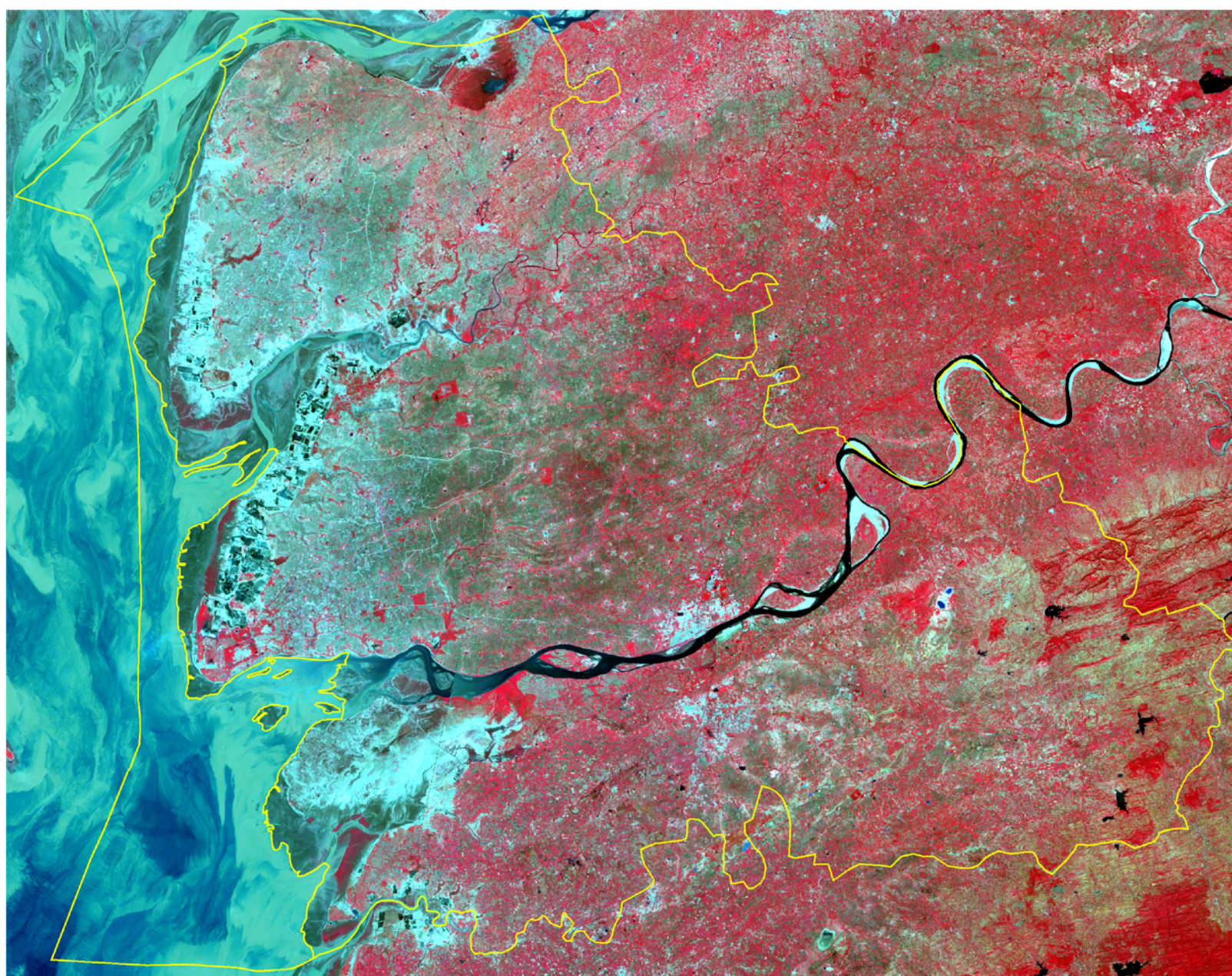
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### 7.1.22 Surat

Surat is an administrative district of Gujarat with Surat city as its head quarter town. It is the second most industrialized and advanced district of Gujarat after Ahmedabad. The district covers an area of 7,657 sq. km with total population of 49, 96,391 according to 2001 census. Surat is bordered by the districts of Bharuch and Narmada in the north, Navsari and Dang in the south and the Gulf of Khambat in the west.

Total 595 wetlands are mapped including 267 small wetlands (< 2.25 ha) with 86062 ha area. Inland wetlands contribute 70% of the total wetland area and coastal wetlands contribute 30% of the total wetland area. Major wetland categories of the district are Reservoirs, Rivers/streams, Inter-tidal mud flats, Salt marsh and mangroves. Details of area estimates of wetlands in Surat district is shown in Table-27.

Area under aquatic vegetation in post-monsoon is about 3727 ha and significantly high during pre-monsoon (15886 ha). Open water spread of the wetlands is higher in post-monsoon (58091 ha) than during pre-monsoon (37398 ha). Major part of the open water area is under low turbidity during both the seasons.

Table 27: Area estimates of wetlands in Surat

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1101	Lakes/Ponds	2	237	0.28	237	99
2	1106	River/Stream	39	16210	18.84	10953	7266
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
3	1201	Reservoirs/Barrages	7	42095	48.91	42098	25306
4	1202	Tanks/Ponds	147	1142	1.33	1070	524
		<b>Total - Inland</b>	<b>195</b>	<b>59684</b>	<b>69.35</b>	<b>54358</b>	<b>33195</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
5	2102	Creeks	7	2866	3.33	2261	2812
6	2103	Sand/Beach	1	102	0.12	-	-
7	2104	Intertidal mud flats	34	11769	13.68	-	-
8	2105	Salt Marsh	19	4923	5.72	-	-
9	2106	Mangroves	39	3655	4.25	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
10	2201	Salt pans	7	1617	1.88	364	491
11	2202	Aquaculture ponds	26	1179	1.37	1108	900
		<b>Total - Coastal</b>	<b>133</b>	<b>26111</b>	<b>30.34</b>	<b>3733</b>	<b>4203</b>
		<b>Sub-Total</b>	<b>328</b>	<b>85795</b>	<b>99.69</b>	<b>58091</b>	<b>37398</b>
		Wetlands (<2.25 ha), mainly Tanks	267	267	0.31	-	-
		<b>Total</b>	<b>595</b>	<b>86062</b>	<b>100.00</b>	<b>58091</b>	<b>37398</b>

<b>Area under Aquatic Vegetation</b>	3727	15886
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<b>Area under turbidity levels</b>		
Low	52069	31228
Moderate	3650	3316
High	2372	2854



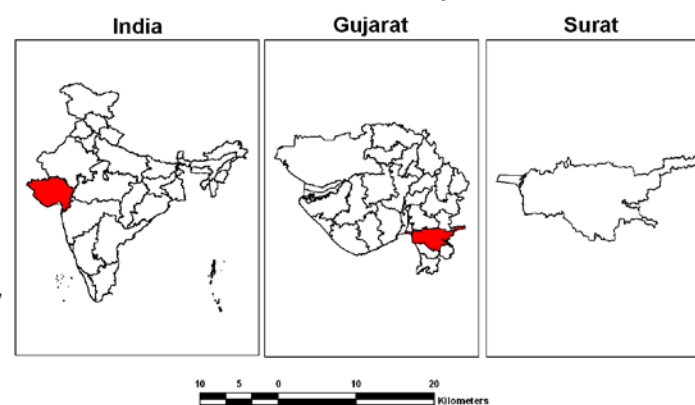


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map

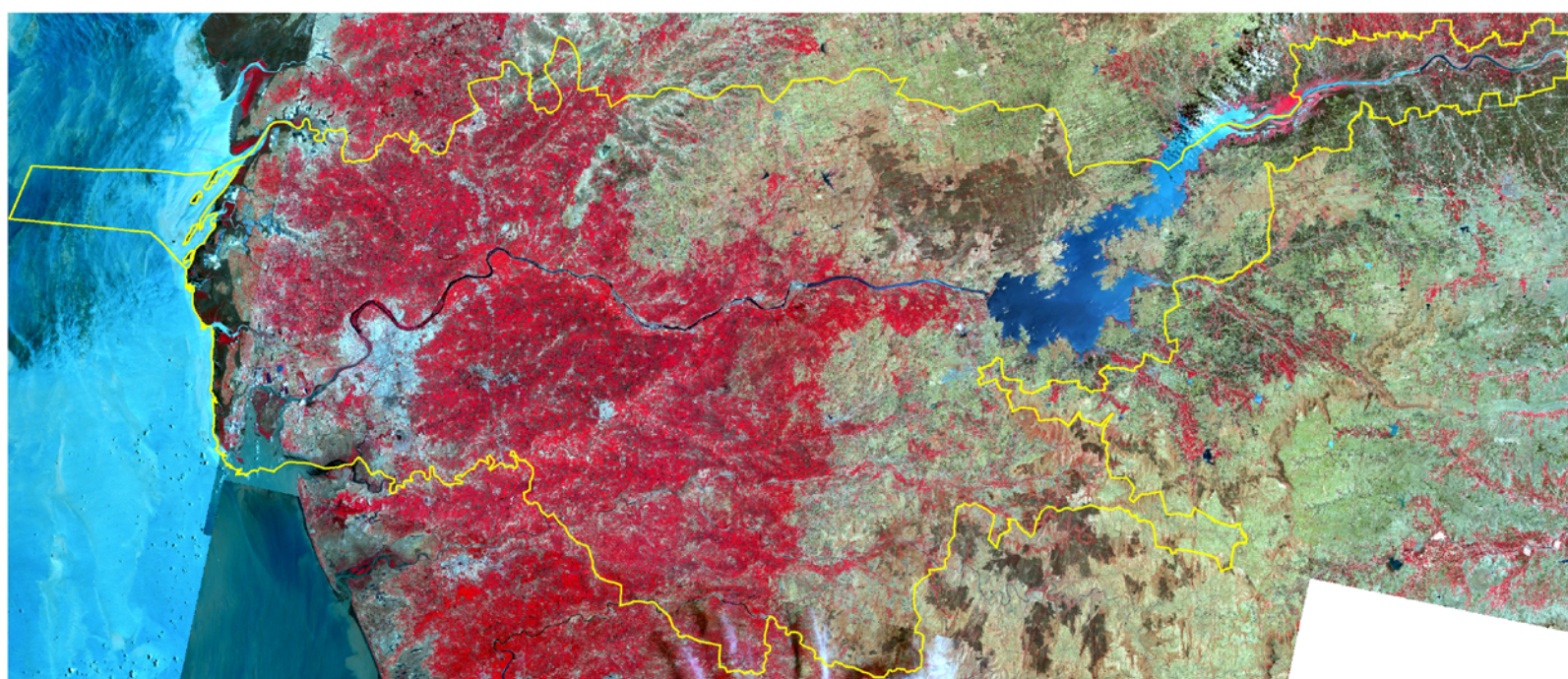


Data Source :  
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

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7.1.23 The Dangs

Dang (also known as The Dangs) is one of the 25 administrative districts of Gujarat in India. The district headquarter is located at Ahwa. The district occupies an area of 1764 square kilometres and has a population of 1,86,712 according to 2001 census. Dang is entirely a rural district.

Total 46 wetlands are mapped including 22 small wetlands (< 2.25 ha) with 4368 ha area. Major wetland category of the district is Rivers/ streams. Details of area estimates of wetlands in the district is shown in Table-28.

Table 28: Area estimates of wetlands in The Dangs

							Area in ha	
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water		
						Post-monsoon Area	Pre-monsoon Area	
	1100	Inland Wetlands - Natural						
1	1106	River/Stream	16	4305	98.56	675	968	
	1200	Inland Wetlands -Man-made						
2	1201	Reservoirs/Barrages	5	28	0.64	29	24	
3	1202	Tanks/Ponds	3	13	0.30	13	13	
		Sub-Total	24	4346	99.50	717	1005	
		Wetlands (<2.25 ha), mainly Tanks	22	22	0.50	-	-	
		Total	46	4368	100.00	717	1005	

Area under Aquatic Vegetation	-	-
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Area under turbidity levels		
Low	30	875
Moderate	681	124
High	6	6

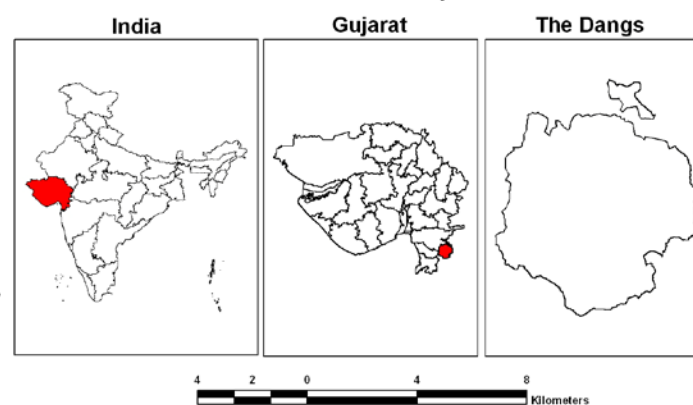


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



India

Gujarat

The Dangs



4 2 0 4 8 Kilometers

Data Source :

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

Prepared By :

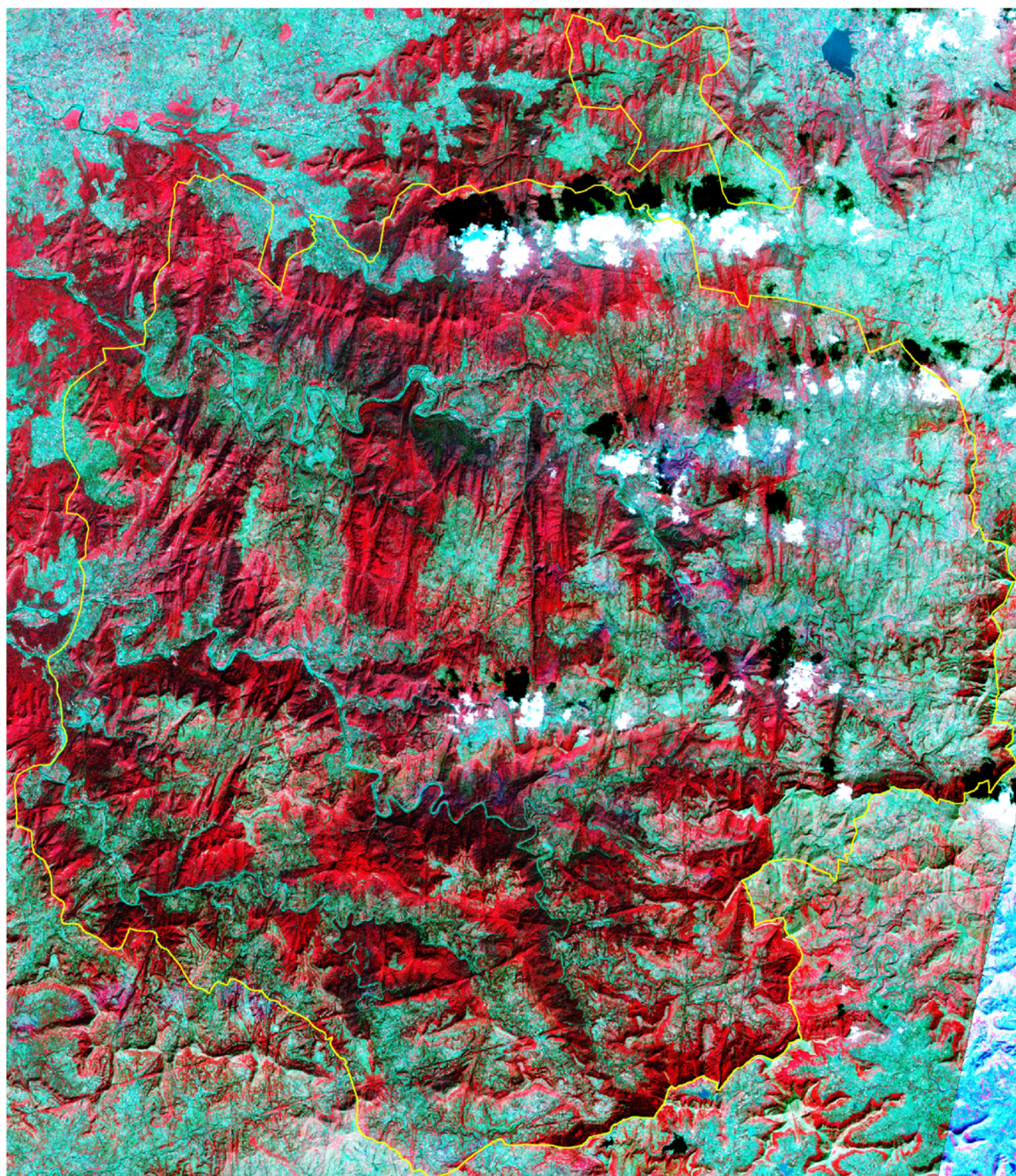
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### 7.1.24 Navsari

Navsari is located in southern part of Gujarat. Navsari city is the head quarter of the district. The district covers an area of 2,211 sq. km. Navsari is bordered by the districts of Surat in the north, Dangs in the East, Valsad district in the south and the Gulf of Khambat in the west.

Total 382 wetlands are mapped including 142 small wetlands (< 2.25 ha) with 23888 ha area. Inland wetlands contribute 25.5% of the total wetland area and coastal wetlands contribute 74.5% of the total wetland area. Major wetland categories of the district are Salt Marsh, Inter-tidal mud flats, Rivers/streams and Mangroves. Details of area estimates of wetlands in Navsari district is shown in Table-29.

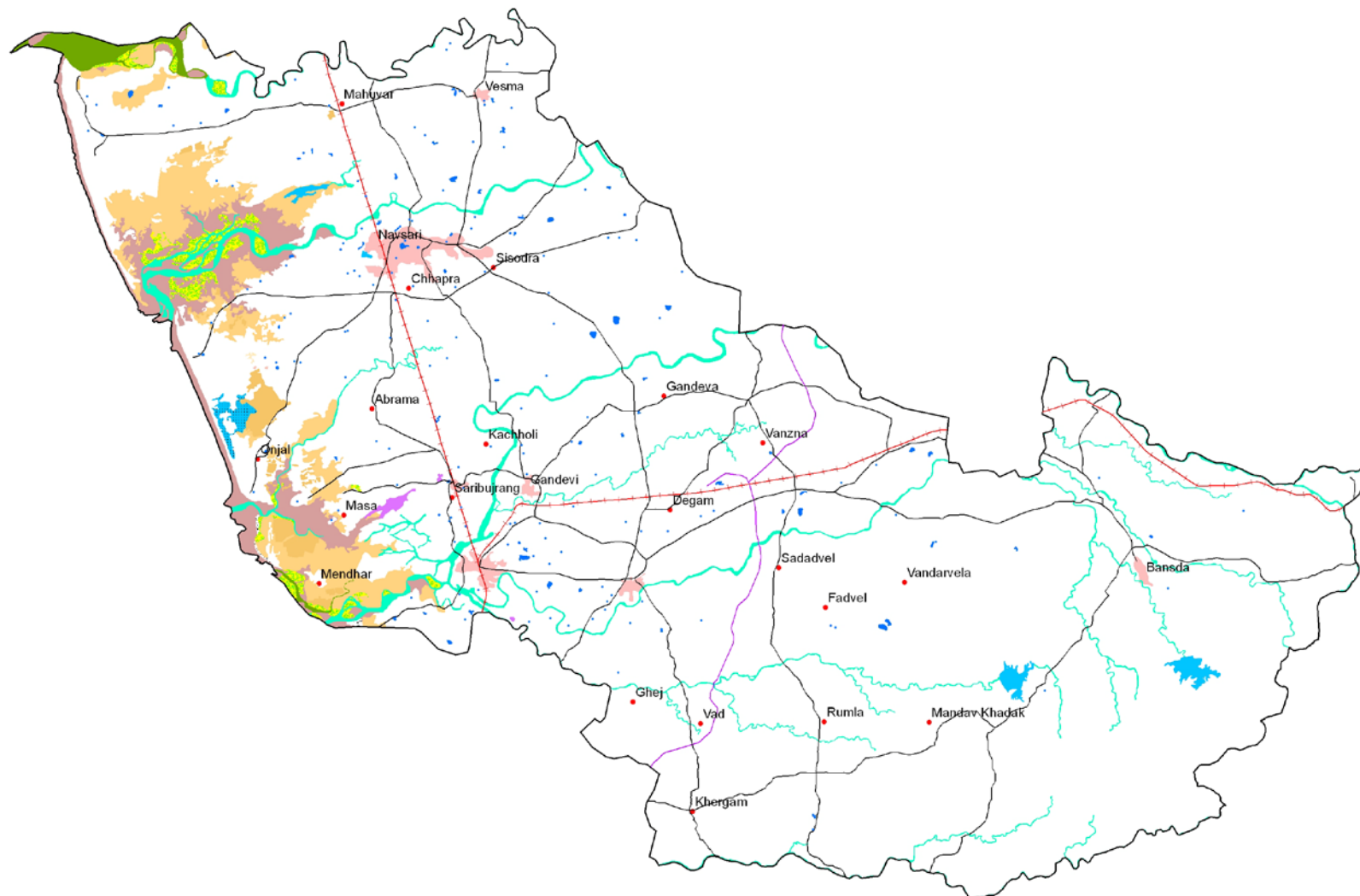
Area under aquatic vegetation in pre-monsoon is about 1725 ha. Open water spread of the wetlands is higher in post-monsoon (6439 ha) than during pre-monsoon (4848 ha).

Table 29: Area estimates of wetlands in Navsari

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1105	Waterlogged	3	155	0.65	6	-
2	1106	River/Stream	20	4854	20.32	3719	2858
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
3	1201	Reservoirs/Barrages	4	623	2.61	608	352
4	1202	Tanks/Ponds	65	306	1.28	172	88
5	1204	Salt pans	1	16	0.07	16	-
		<b>Total - Inland</b>	<b>93</b>	<b>5954</b>	<b>24.92</b>	<b>4521</b>	<b>3298</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
6	2101	Lagoons	1	348	1.46	170	-
7	2102	Creeks	4	1151	4.82	1112	1033
8	2103	Sand/Beach	3	49	0.21	-	-
9	2104	Intertidal mud flats	32	5732	24.00	-	-
10	2105	Salt Marsh	22	7562	31.66	-	-
11	2106	Mangroves	44	1574	6.59	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
12	2201	Salt pans	2	6	0.03	6	3
13	2202	Aquaculture ponds	39	1370	5.74	630	514
		<b>Total - Coastal</b>	<b>147</b>	<b>17792</b>	<b>74.48</b>	<b>1918</b>	<b>1550</b>
		<b>Sub-Total</b>	<b>240</b>	<b>23746</b>	<b>99.41</b>	<b>6439</b>	<b>4848</b>
		Wetlands (<2.25 ha), mainly Tanks	142	142	0.59	-	-
		<b>Total</b>	<b>382</b>	<b>23888</b>	<b>100.00</b>	<b>6439</b>	<b>4848</b>

<b>Area under Aquatic Vegetation</b>	1753	1725
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<b>Area under turbidity levels</b>		
Low	3868	2527
Moderate	1390	1262
High	1181	1059

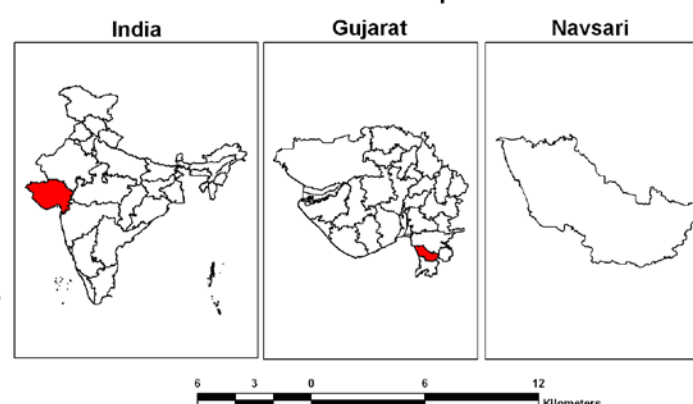


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

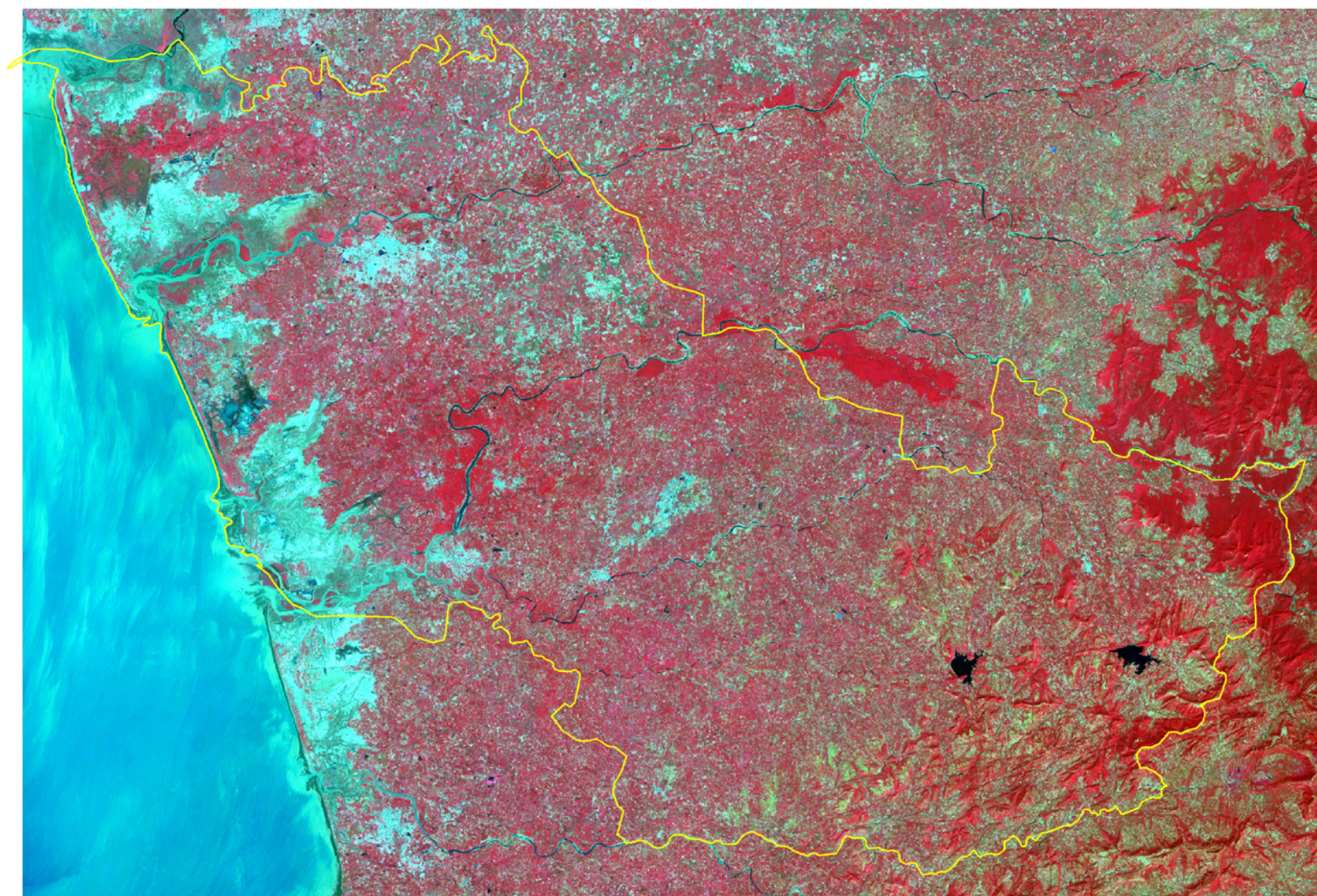
Space Applications Centre (ISRO), Ahmedabad  
and  
Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar

Sponsored By :

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Government of India







### 7.1.25 Valsad

Valsad is the southernmost district of Gujarat with its head quarters located at Valsad town. The district is surrounded by Navsari district in north, Dang in the east, Maharashtra state in south and Arabian Sea on the west coast. Valsad district covers an area of 3,035 sq. km with total population of 14,10,680 according to 2001 census. There are five taluks in Valsad district – Valsad, Pardi, Umargam, Kaparada and Dharampur.

Total 294 wetlands are mapped including 120 small wetlands (< 2.25 ha) with 23116 ha area. Inland wetlands contributes 59.25% of the total wetland area and coastal wetlands contributes 40.25% of the total wetland area. Major wetland categories of the district are Rivers/ streams, Reservoirs, Inter-tidal mud flats, and Salt marsh. Details of area estimates of wetlands in Valsad district is shown in Table-30.

Area under aquatic vegetation in pre-monsoon is about 3552 ha. Open water spread of the wetlands is higher in post monsoon (9670 ha) than during pre monsoon (2736 ha).

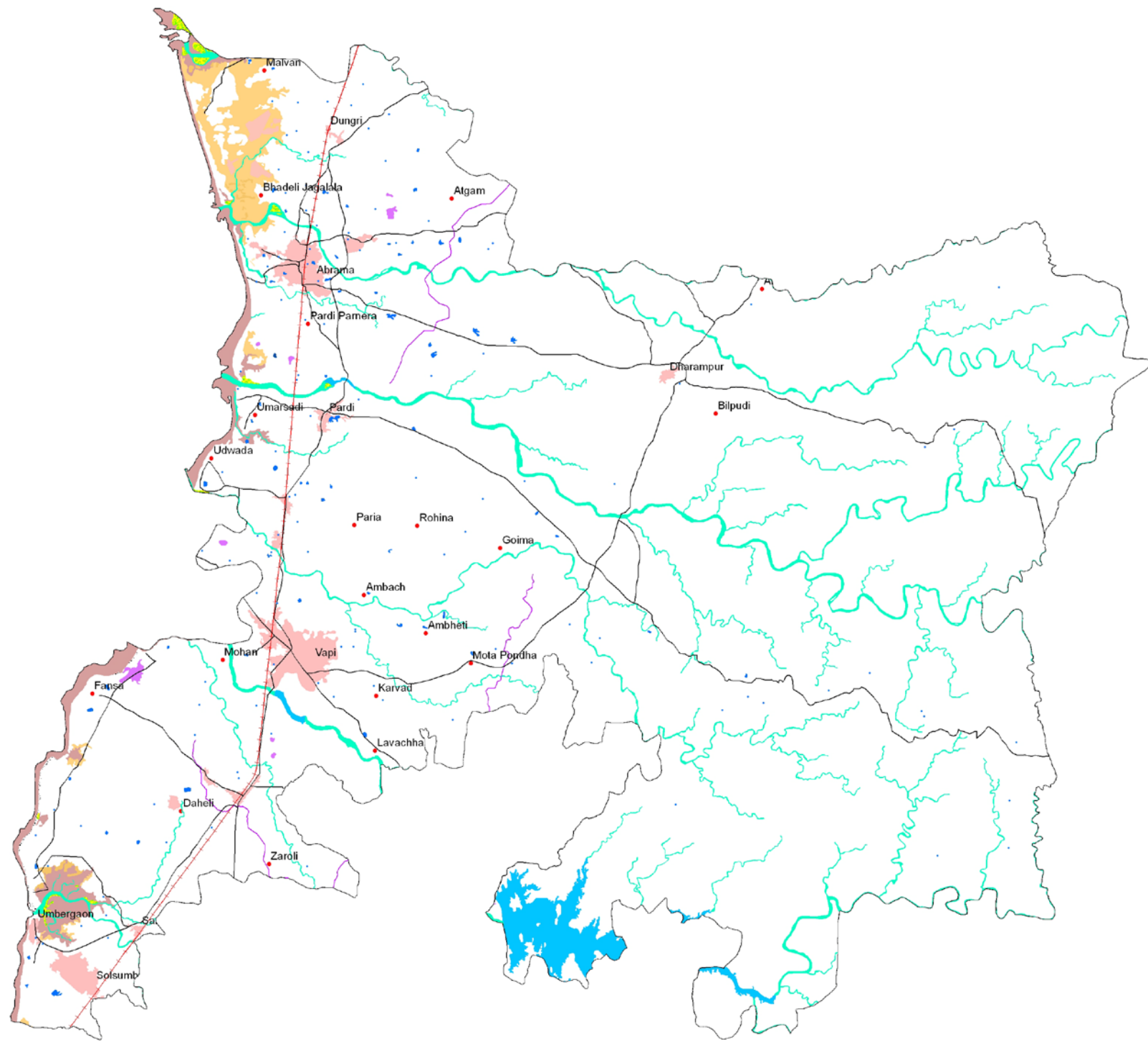
Table 30: Area estimates of wetlands in Valsad

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Area in ha	
						Open Water	
						Post-monsoon Area	Pre-monsoon Area
	<b>1100</b>	<b>Inland Wetlands - Natural</b>					
1	1102	Ox-bow lakes/ Cut-off meanders	1	6	0.03	6	-
2	1105	Waterlogged	8	209	0.90	117	88
3	1106	River/Stream	19	7319	31.66	3747	1684
	<b>1200</b>	<b>Inland Wetlands -Man-made</b>					
4	1201	Reservoirs/Barrages	10	5754	24.89	5626	862
5	1202	Tanks/Ponds	63	282	1.22	151	49
6	1204	Salt pans	2	7	0.03	7	7
		<b>Total - Inland</b>	<b>103</b>	<b>13577</b>	<b>58.73</b>	<b>9654</b>	<b>2690</b>
	<b>2100</b>	<b>Coastal Wetlands - Natural</b>					
7	2102	Creeks	1	4	0.02	2	4
8	2103	Sand/Beach	3	115	0.50	-	-
9	2104	Intertidal mud flats	17	4762	20.60	-	-
10	2105	Salt Marsh	10	3563	15.41	-	-
11	2106	Mangroves	16	346	1.50	-	-
	<b>2200</b>	<b>Coastal Wetlands - Man-made</b>					
12	2201	Salt pans	4	384	1.66	-	-
13	2202	Aquaculture ponds	20	245	1.06	14	42
		<b>Total - Coastal</b>	<b>71</b>	<b>9419</b>	<b>40.75</b>	<b>16</b>	<b>46</b>
		<b>Sub-Total</b>	<b>174</b>	<b>22996</b>	<b>99.48</b>	<b>9670</b>	<b>2736</b>
		Wetlands (<2.25 ha), mainly Tanks	120	120	0.52	-	-
		<b>Total</b>	<b>294</b>	<b>23116</b>	<b>100.00</b>	<b>9670</b>	<b>2736</b>

<b>Area under Aquatic Vegetation</b>	565	3552
--------------------------------------	-----	------

<b>Area under turbidity levels</b>		
Low	8096	1195
Moderate	1496	1523
High	78	18



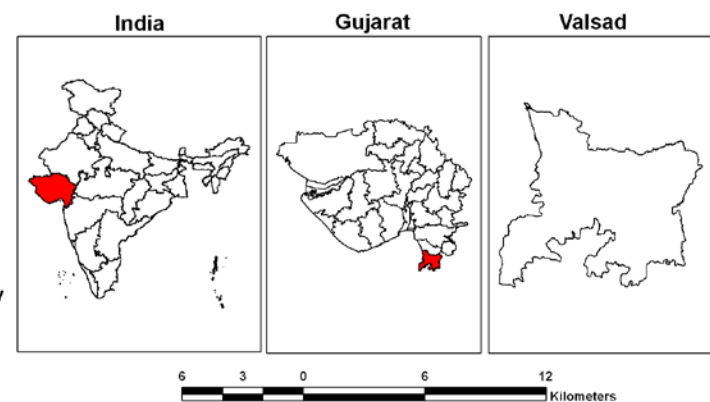


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

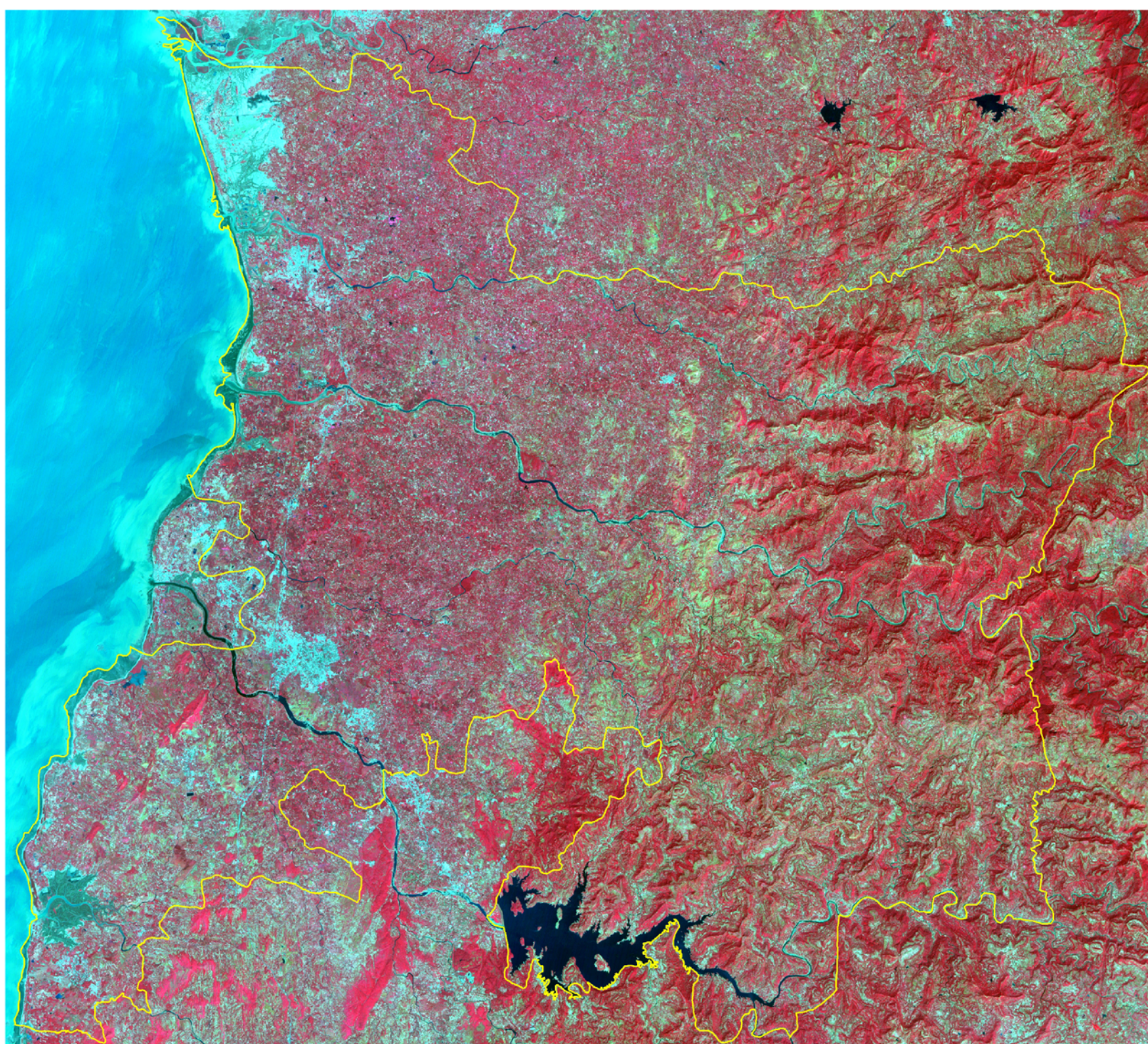
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## **MAJOR WETLAND TYPES**





## 8.0 MAJOR WETLAND TYPES OF GUJARAT

Major wetland types observed in the state are Salt Marsh, Mangroves, River/Stream, Intertidal Mudflats, Creeks, Salt pans, Lakes/Ponds, Natural Waterlogged area, Tanks/Ponds, Coral reefs, Lagoons and Reservoirs. Details are given in Plates 1a-1d. Ground truth data was collected for selected wetland sites. The standard proforma was used to record the field data. Field photographs are also taken to record the water quality (subjective), status of aquatic vegetation and water spread. The location of the features was recorded using GPS. Field photographs of different wetland types are shown in Plates 2a-2c.

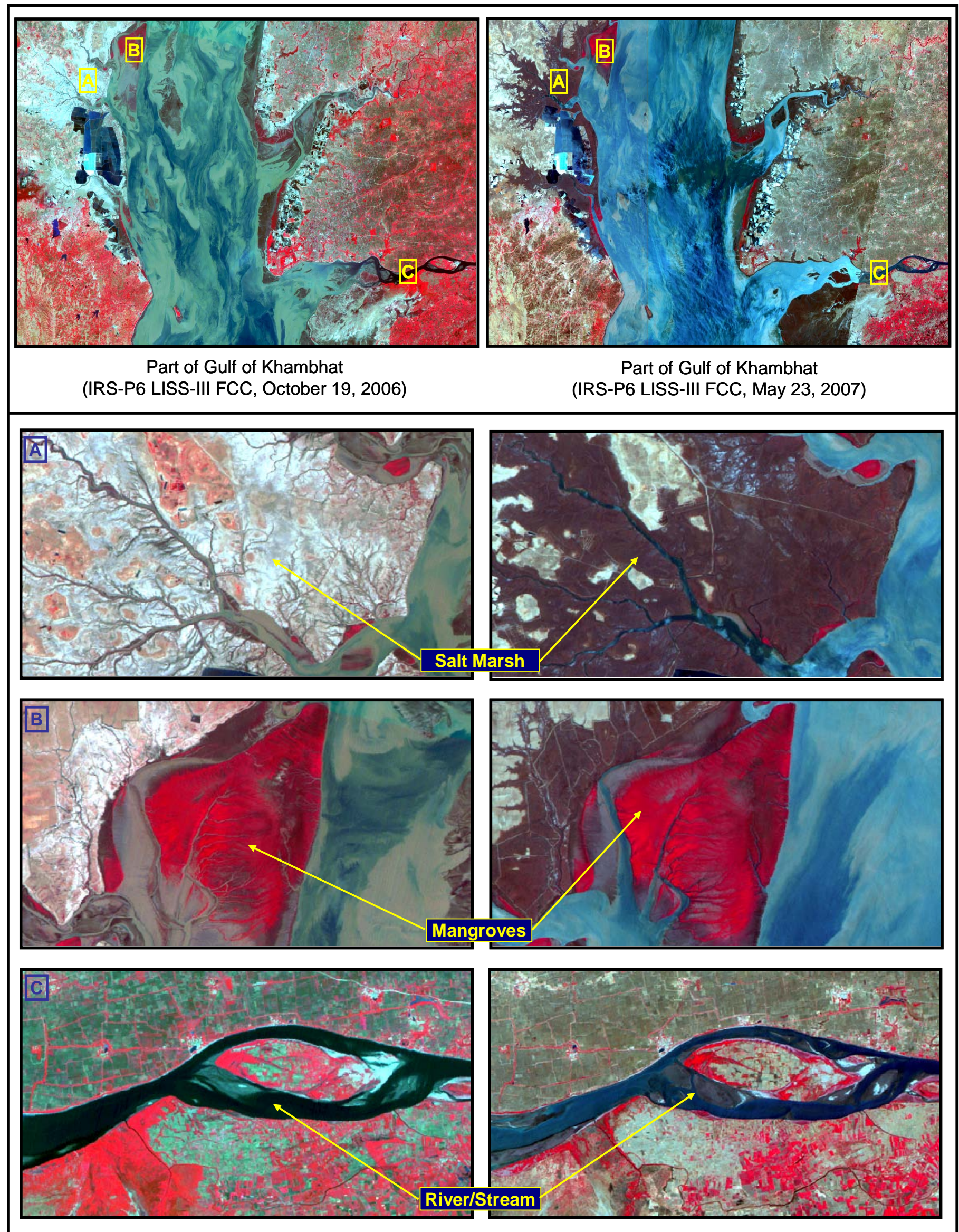


Plate – 1a: Major wetland types of Gujarat





Coastal part of Kutch and Jamnagar districts  
(IRS-P6 LISS-III FCC, November 26, 2006)



Coastal part of Kutch and Jamnagar districts  
(IRS-P6 LISS-III FCC, May 13, 2007)

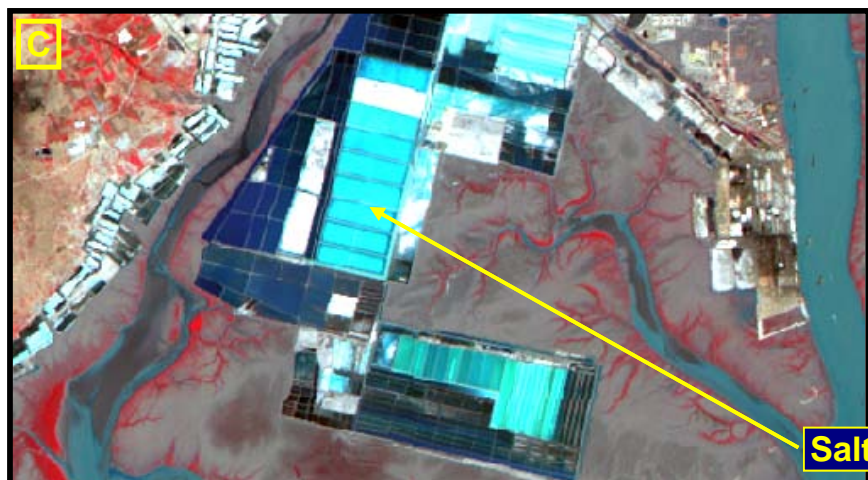
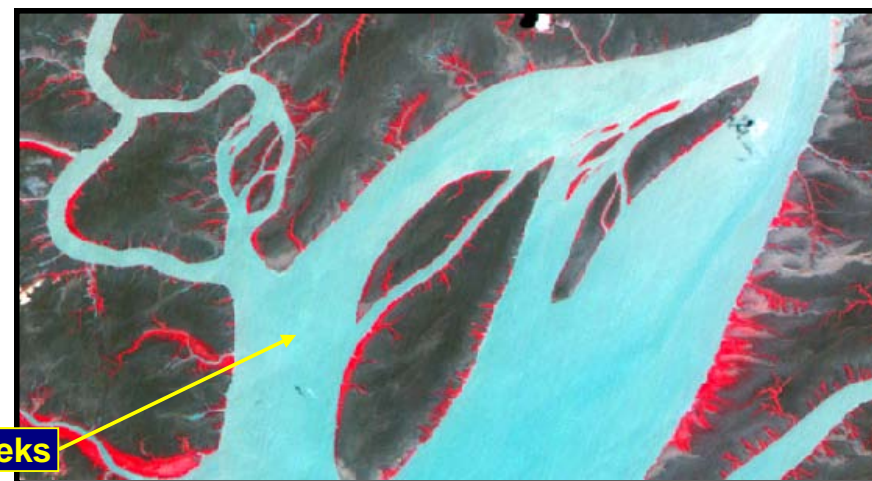
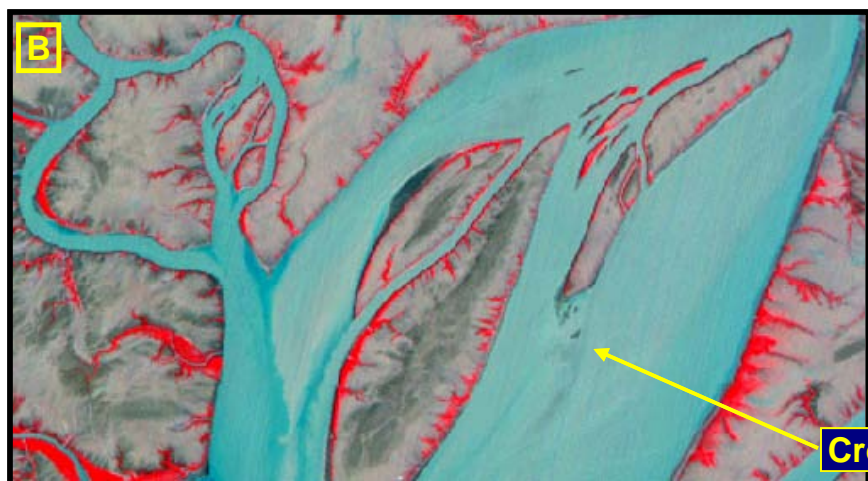
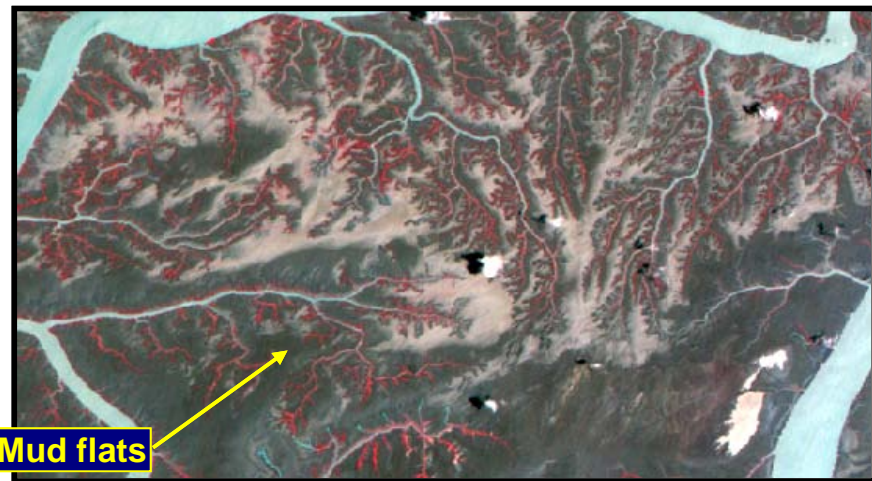
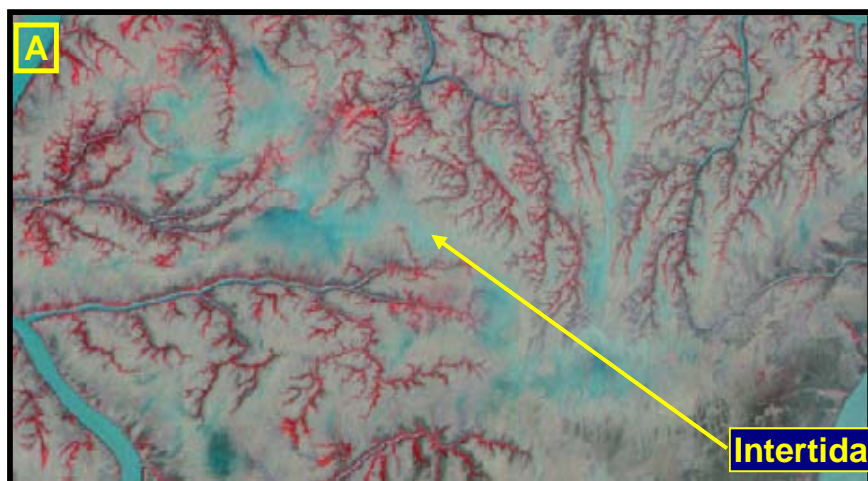
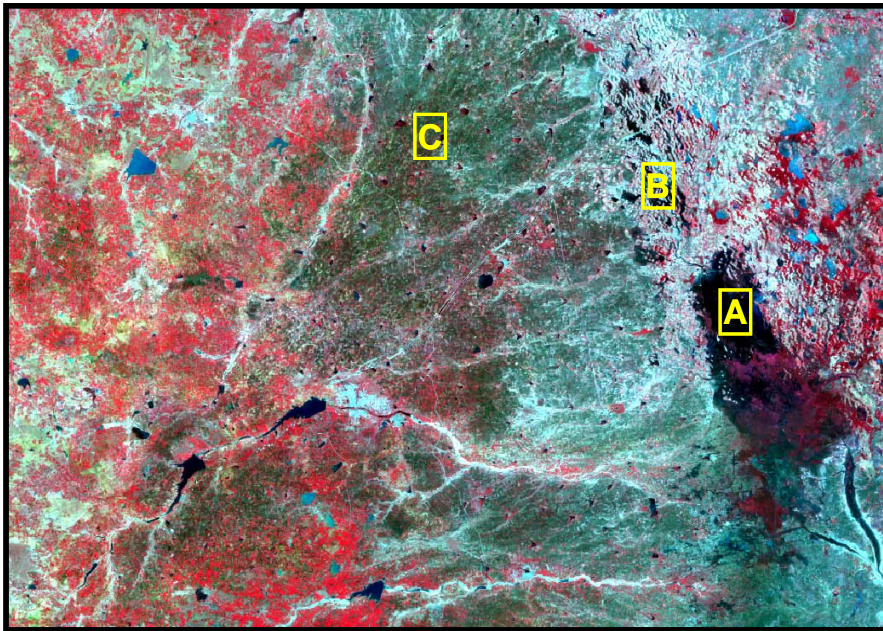
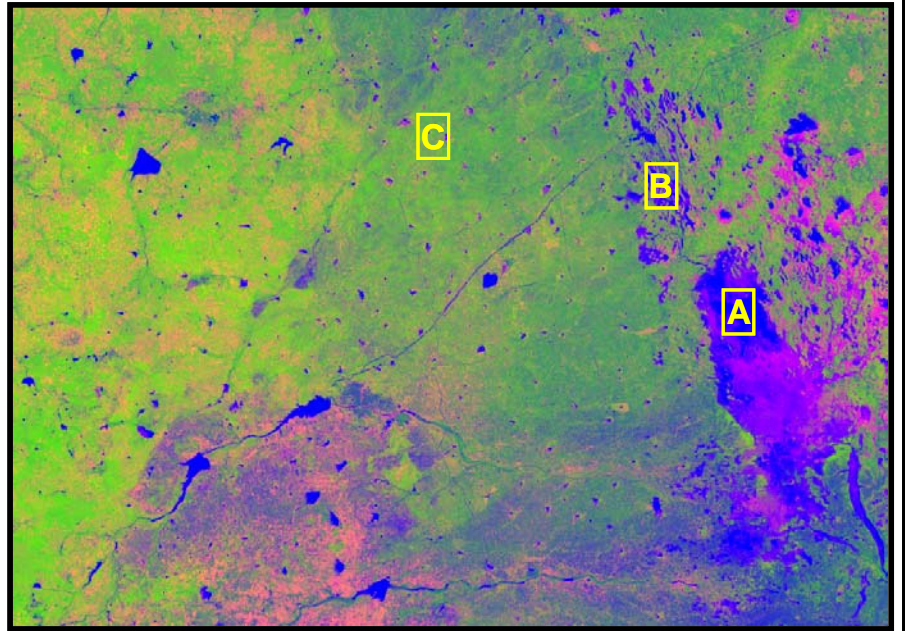


Plate – 1b: Major wetland types of Gujarat





Nal Sarovar and surrounding area  
(IRS-P6 LISS-III FCC, November 26, 2006)



Nal Sarovar and surrounding area  
(MNDWI NDPI NDVI from LISS-III data)

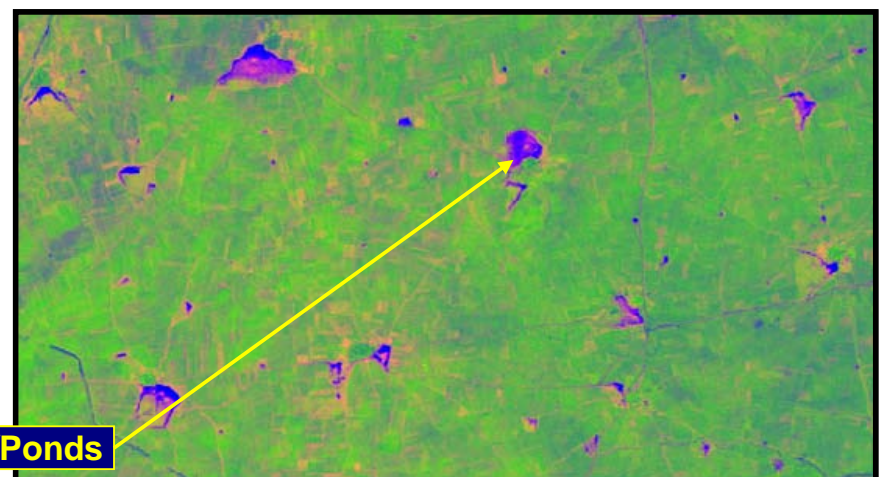
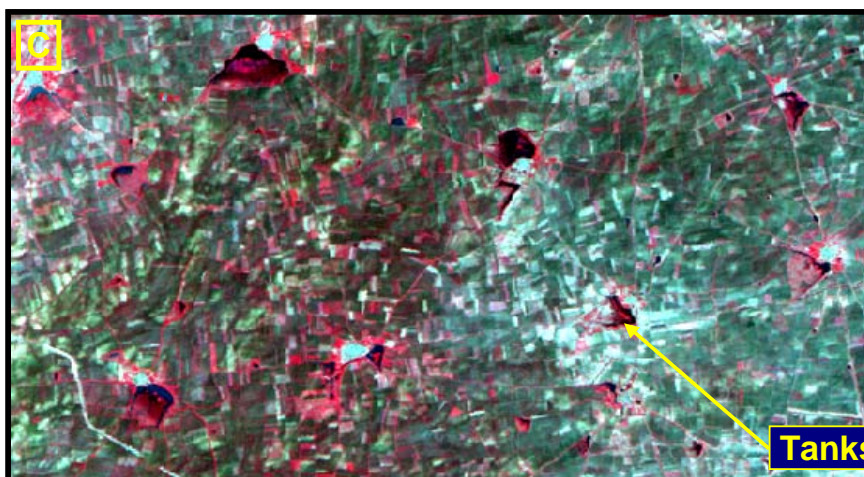
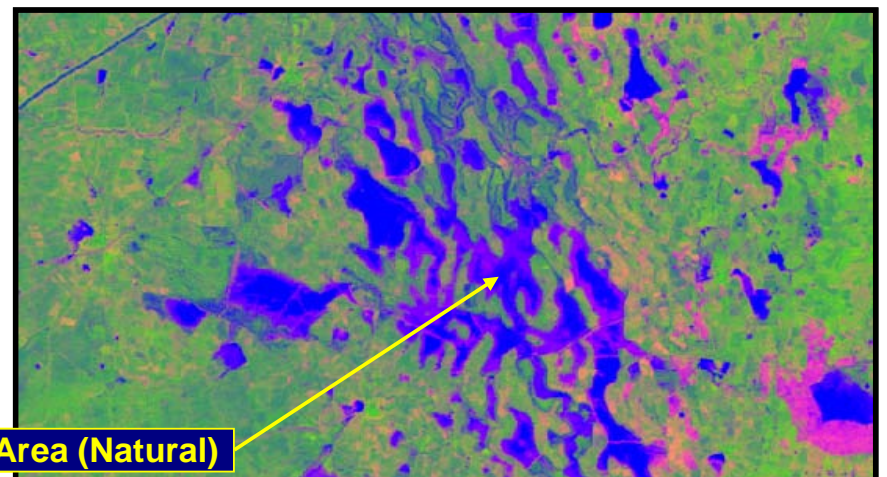
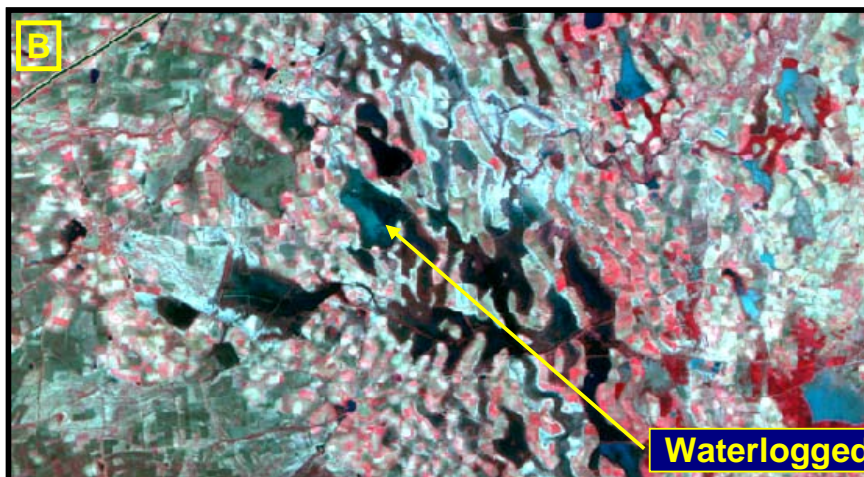
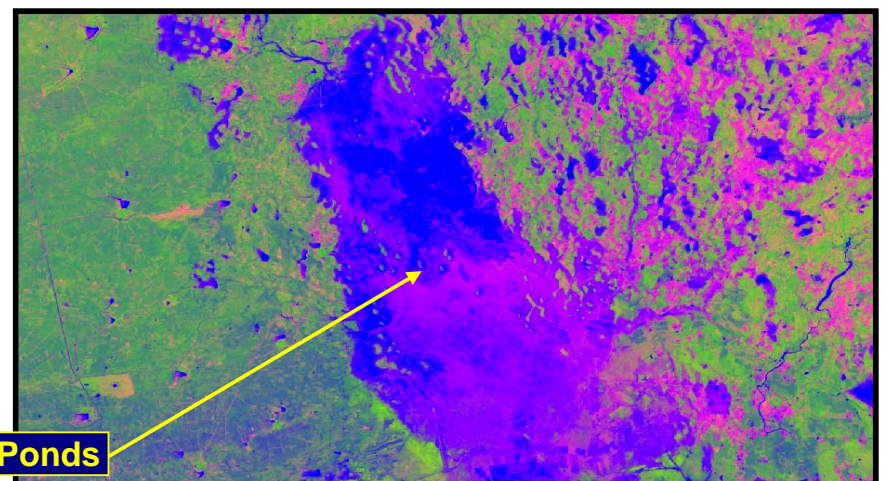
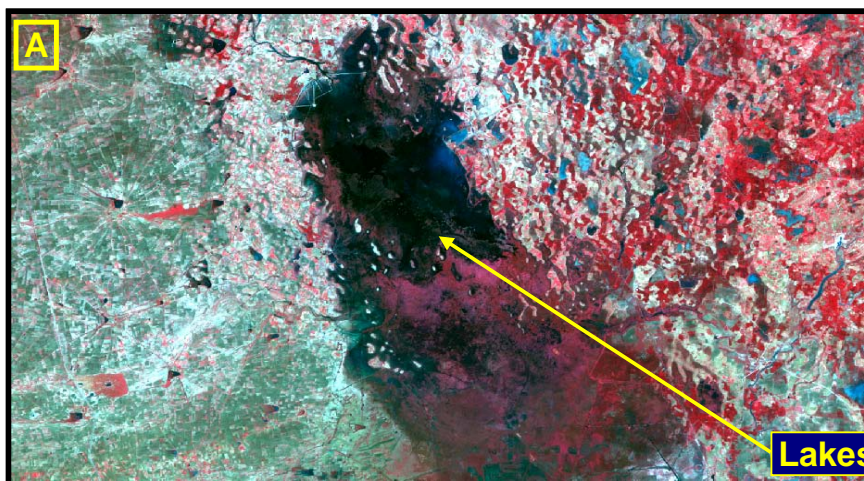
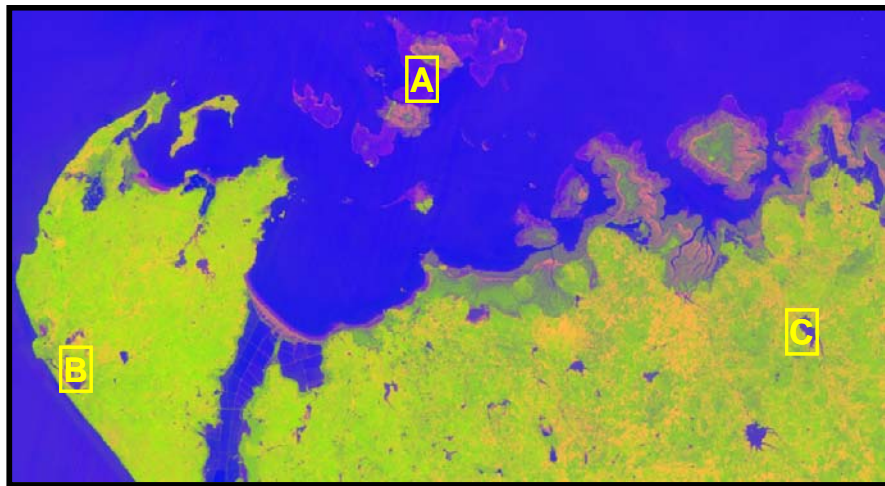


Plate – 1c: Major wetland types of Gujarat





Coastal part of Jamnagar district  
(IRS-P6 LISS-III FCC, October 28, 2006)



Coastal part of Jamnagar district  
(MNDWI NDPI NDVI from LISS-III data)

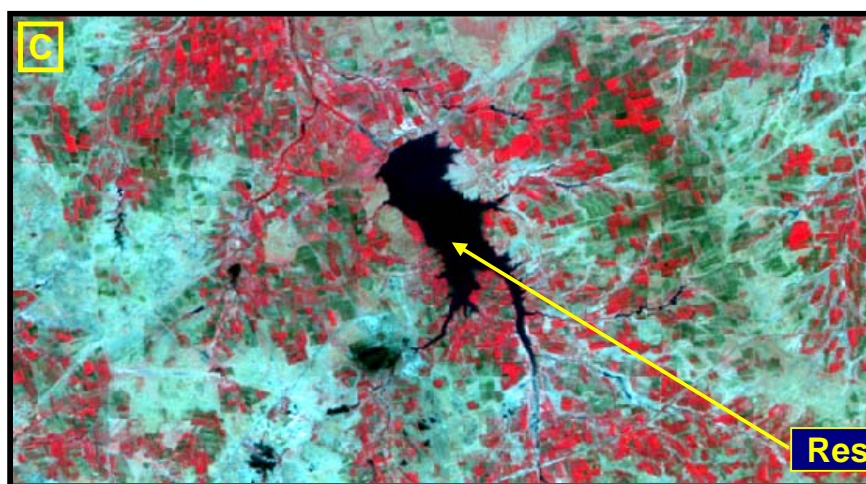
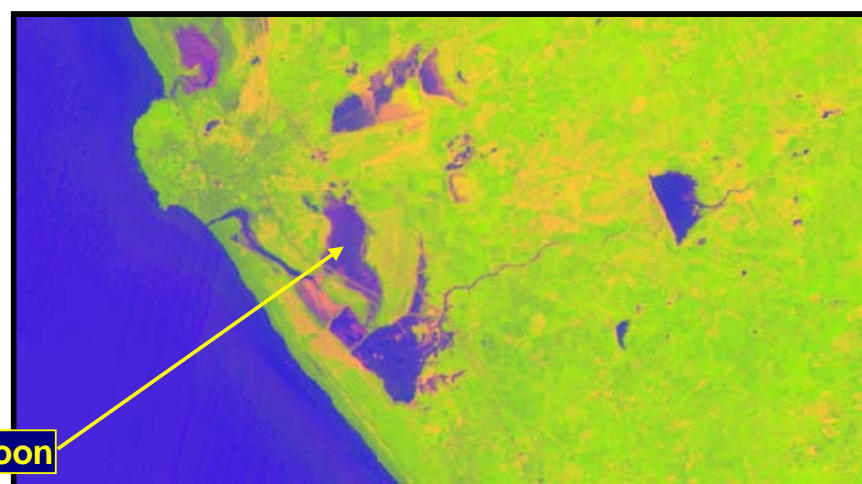
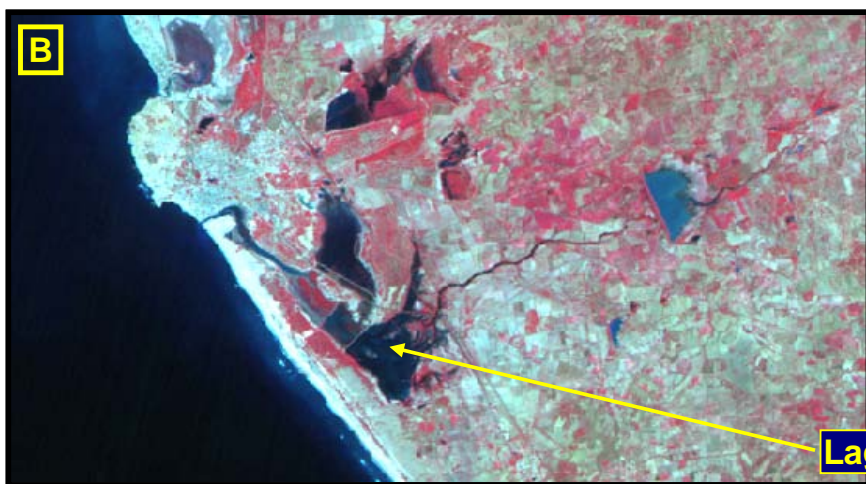
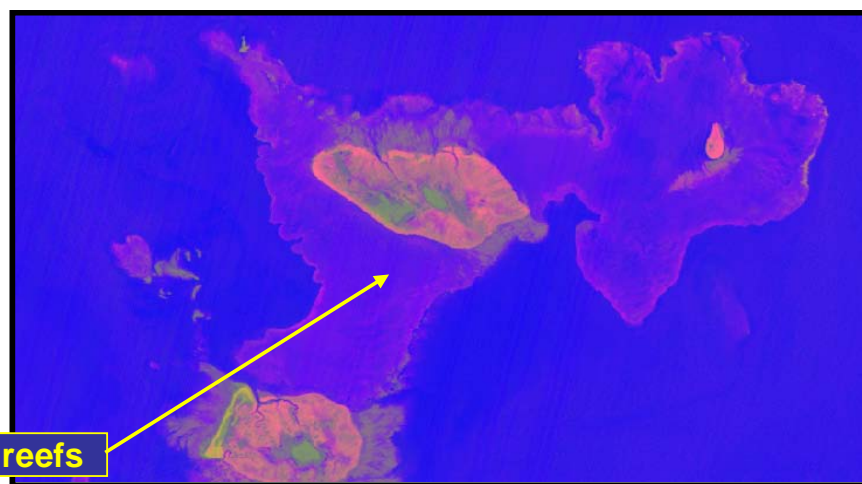
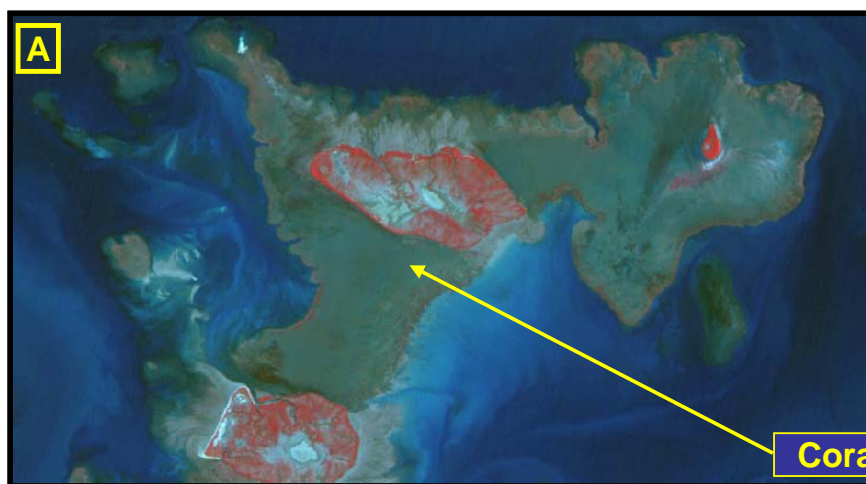


Plate – 1d: Major wetland types of Gujarat







Sr. No	Description	Field Photograph
1	<p><b>Wetland Type:</b> Lakes/Ponds (Thol Lake)</p> <p><b>Location:</b> Latitude : 23° 08' 17" N Longitude : 72° 23' 36" E</p> <p><b>Aquatic vegetation:</b> Present (Emergent)</p> <p><b>Turbidity:</b> Low</p>	
2	<p><b>Wetland Type:</b> Tanks/Ponds</p> <p><b>Location:</b> Latitude : 23° 35' 01" N Longitude : 72° 08' 10" E</p> <p><b>Aquatic vegetation:</b> Present</p> <p><b>Turbidity:</b> Low</p>	
3	<p><b>Wetland Type:</b> Reservoir/Barrages (Willington Dam)</p> <p><b>Location:</b> Latitude : 21° 33' 58" N Longitude : 70° 30' 59" E</p> <p><b>Aquatic vegetation:</b> Not Present</p> <p><b>Turbidity:</b> Low</p>	
4	<p><b>Wetland Type:</b> Lakes/Ponds (Khijadiya Bird Sanctuary)</p> <p><b>Location:</b> Latitude : 22° 30' 59" N Longitude : 70° 10' 18" E</p> <p><b>Turbidity:</b> Low</p>	

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





Sr. No	Description	Field Photograph
5	<p><b>Wetland Type:</b> Salt pans</p> <p><b>Location:</b>  Latitude : 20° 38' 12" N  Longitude : 72° 53' 45" E</p> <p><b>Aquatic vegetation:</b> NA</p> <p><b>Turbidity:</b> Moderate</p>	
6	<p><b>Wetland Type:</b> Salt Marsh</p> <p><b>Location:</b>  Latitude : 22° 06' 47" N  Longitude : 72° 15' 08" E</p> <p><b>Aquatic vegetation:</b> Absent</p> <p><b>Turbidity:</b> NA</p>	
7	<p><b>Wetland Type:</b> Intertidal Mud flat</p> <p><b>Location:</b>  Latitude : 21° 37' 06" N  Longitude : 72° 44' 14" E</p> <p><b>Aquatic vegetation:</b> Absent</p> <p><b>Turbidity:</b> NA</p>	
8	<p><b>Wetland Type:</b> Sand/Beach (Madhavpur Beach)</p> <p><b>Location:</b>  Latitude : 21° 14' 41" N  Longitude : 69° 57' 56" E</p> <p><b>Aquatic vegetation:</b> Absent</p> <p><b>Turbidity:</b> NA</p>	

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







Sr. No	Description	Field Photograph
9	<p><b>Wetland Type:</b> Mangroves</p> <p><b>Location:</b>  Latitude : 21° 40' 11" N  Longitude : 72° 17' 04" E</p> <p><b>Turbidity:</b> NA</p>	
10	<p><b>Wetland Type:</b> Creek</p> <p><b>Location:</b>  Latitude : 21° 39' 01" N  Longitude : 69° 36' 25" E</p> <p><b>Turbidity:</b> Moderate</p>	
11	<p><b>Wetland Type:</b> Aquaculture Pond</p> <p><b>Location:</b>  Latitude : 20° 46' 29" N  Longitude : 72° 51' 51" E</p> <p><b>Aquatic vegetation:</b> Absent</p> <p><b>Turbidity:</b> Moderate</p>	
12	<p><b>Wetland Type:</b> Reservoir</p> <p><b>Location:</b>  Latitude : 21° 49' 59" N  Longitude : 73° 45' 01" E</p> <p><b>Aquatic vegetation:</b> Nil</p> <p><b>Turbidity:</b> Low</p>	

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



## **IMPORTANT WETLANDS OF GUJARAT**





## 9.0 IMPORTANT WETLANDS OF GUJARAT

Various types of sanctuaries and parks like bird, wildlife, marine, and education have been notified in Gujarat state. The four national parks occupy 479.67 sq.km. and twenty two sanctuaries occupy 16440.91 sq. km. Reservoirs/dams, rivers/streams, tanks/ponds, water logged areas and lowlands like Bhal area are typical inland wetlands. Different types of inland wetlands exist in the state include freshwater lake (locally called 'Sarovar'), village pond/tank ('Gam Talav'), reservoirs, marshes, and rivers/streams. There are also some small wetlands like abandoned quarries and cooling ponds.

Of the various wetland types mentioned above, Tanks/ponds dominate the rural landscape of Gujarat. The rural Gujarat is dotted with numerous natural, semi-natural and man-made ponds of varied shapes, size and depth. Though many of them are seasonal, they play an important role of providing habitat to numerous resident and migratory waterfowl. The growth of trees at several inland wetlands provides roosting and/or nesting site to the resident waterfowl like egrets, herons, cormorants, storks, ibises and spoonbills. Several ponds in rural and sub-urban areas provide breeding site for the endangered Indian Sarus Crane. Many tanks/ponds are rich in social-economically important aquatic plants like *Typha*, *Nymphaea*, *Nelumbo* and *Traphy*.

Apart from the ponds, the state harbours a large number of reservoirs, which are primarily meant for irrigation purpose. There are several reservoirs in Saurashtra and Kachchh. Some of them are: Lalpari, Nyari, Aji, Veri, Sardhan, Alangsagar, Hargovind, Ramdhan, Muli, and Bhadar in saurashtra; and Hamirsar, Bhimasar, Sinnari, Dewisar, Rudramata, Ningher, Topansar, and Vijaysagar. Dantiwada, Sipu, Kadana, Panam, Dharoi, Sardar Sarovar, Ukai, Vasma barrage and Ajwa reservoir in Gujarat mainland region are some of the important reservoirs. These reservoirs are considered to be the prime sources of water for irrigation and drinking across the state.

There are 2751 coastal wetlands occupying a total area of 28093 sq. Km. area. There are 302 man-made coastal wetlands (mainly salt pans) covering an area of 997 sq. Km. This is bound to increase with the expansion of the salt industry. There are few natural lakes in the state having the total area of 23550 ha. Nal Sarovar, one of the largest lakes of the country in Surendranagar and Ahmedabad district is supporting large number of waterfowl and aquatic plants. The lake is the life-supporting system for a large number of local people. Thol Lake in Mehsana district is well known for their high diversity and population of the wintering waterfowl.

Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of each wetland sites. Details of the wetlands and wetland maps of 5 km buffer area are shown in plates 4 to 29.

9.1 Nal Sarover

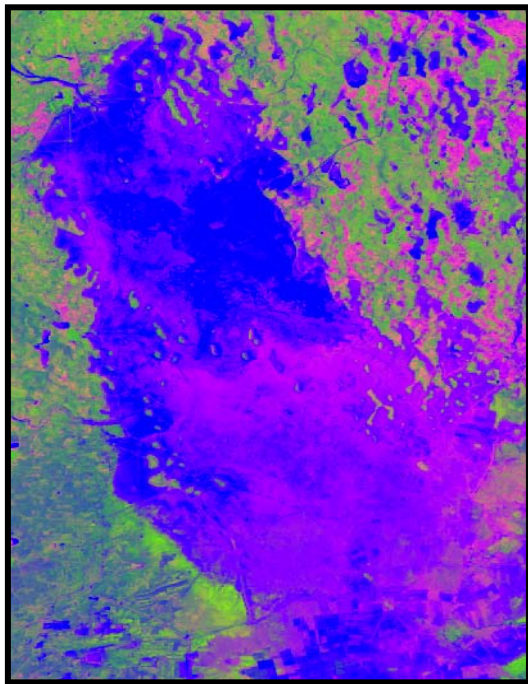
Name	Nal Sarover
Location	22° 40' 21" to 22° 52' 00" N Latitude and 71° 58' 55" to 72° 06' 43" E Longitude
Area	14673 ha
Wetland Type	Lake/Pond
Climate	Dry, tropical monsoon climate, with rainfall from the southwest monsoon concentrated in July, August and September. Average annual rainfall is about 400 mm
Description	Nal Sarovar represents a typical wetland, an ideal bird sanctuary, and also a notified wetland declared by the Ministry of Environment and Forests, Govt. of India. The lake is a shallow, natural lake. Geologically it is a shallow basin which was once a part of the sea during the Miocene period of the Quaternary era. The soil is medium black. The average depth is 3 meters in the monsoon while in pre-monsoon it becomes very shallow (< 100 cm). A large part of the lake dry up during summer. The water spread changes seasonally depending on rainfall and the consequent climatic conditions. The larger part of the lake has other vegetation on fringes which provides shelter for migratory birds.
Vegetation	Hydrophytes include species of <i>Chara</i> , <i>Potamogeton</i> , <i>Najas</i> , <i>Vallisneria</i> , <i>Nymphaea</i> , <i>Limnanthemum</i> , <i>Lemna</i> , <i>Wolffia</i> , and <i>Hydrilla</i> . Major part of the lake is characterised by a rich growth of <i>Xanthium strumarium</i> , <i>Solanum surattense</i> , and <i>Tephrosia purpurea</i> . The semi-aquatic and marsh-land zones hold <i>Ammania bacciferu</i> , <i>A. multiflora</i> , <i>Bergia sp.</i> , <i>Alternanthera sessilis</i> , <i>Cyperus sp</i> , <i>Scirpus sp.</i> , <i>Polygonum plebeium</i> , and <i>Marsilea aegyptiaca</i> . Surrounding agricultural land supports crops of cotton, cereals, pulses and groundnuts. The few trees in the region include <i>Prosopis juliflora</i> , <i>P.spicigera</i> , <i>Salvadora persica</i> , <i>S. oleoides</i> , and <i>Acacia nilotica</i> among others.
Fauna	Nal Sarovar is an important winter habitat for thousands of migratory birds like Flamingos, Pelicans, cranes, ducks, spoonbill, herons etc., from Siberia, Central Asia and Europe.
Turbidity	Low



Post monsoon data (2006)



Pre monsoon data (2007)

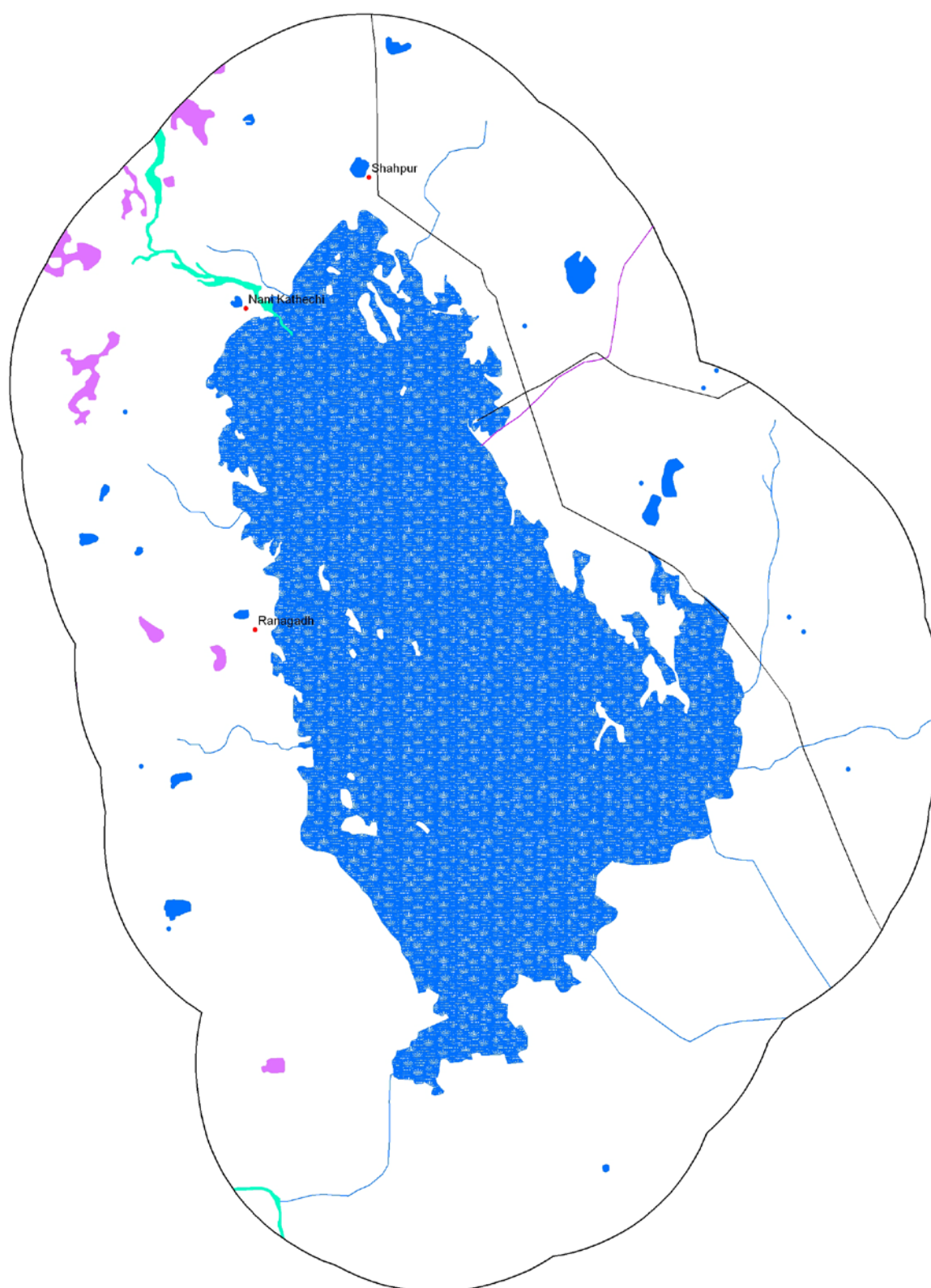


Indices (MNDWI NDPI NDVI)  
Post monsoon data (2006)



Plate 3: Nal Sarover



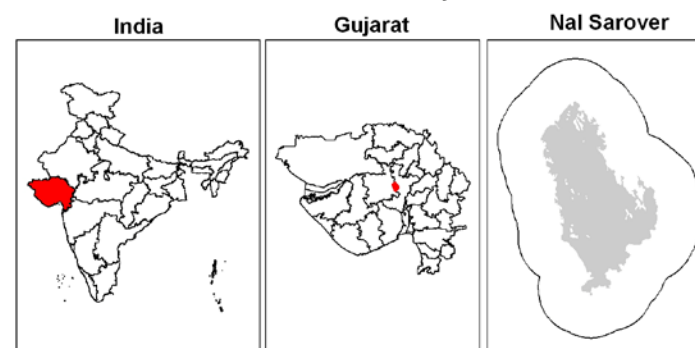


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



1 0.5 0 1 2  
Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad  
and  
Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar

Sponsored By :

Ministry of Environment and Forests  
Government of India

Plate 4: Wetland map - 5 km buffer area of Nal Sarover





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

Plate 5: IRS LISS III FCC - 5 km buffer area of Nal Sarover

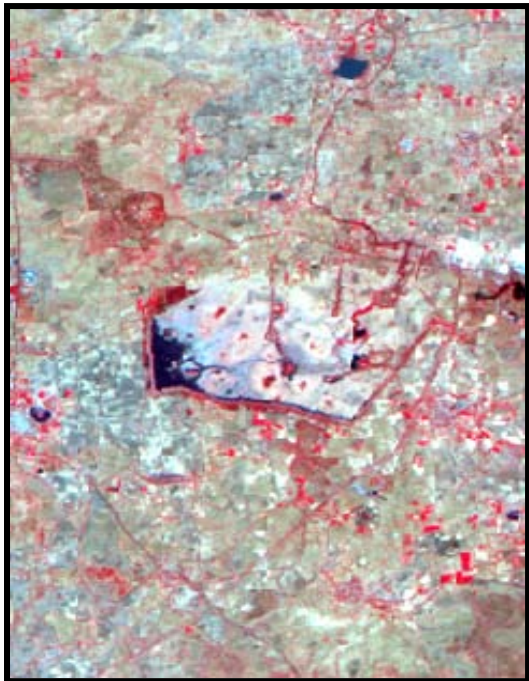


9.2 Thol Lake

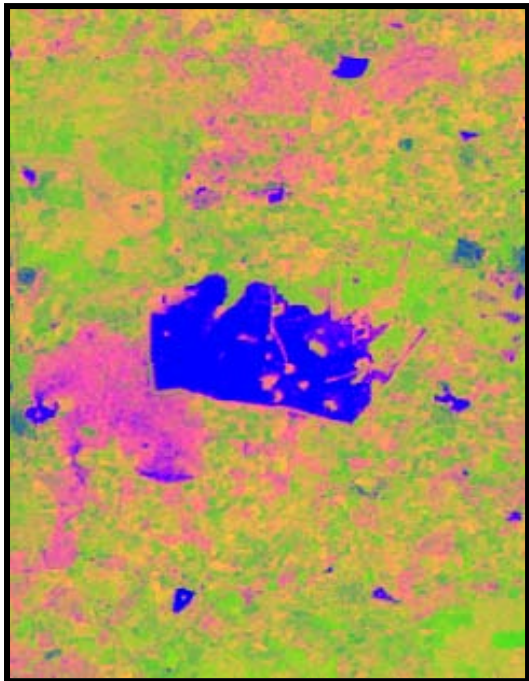
Name	Thol Lake
Location	23° 07' 55" to 23° 08' 51" N Latitude and 72° 23' 35" to 72° 25' 19" E Longitude
Area	379 ha
Wetland Type	Lake/Pond
Climate	Average annual rainfall : 250 mm Average annual temperature range from a maximum of 44° C and a minimum of 6° C.
Description	Thol sanctuary is located 40 kms northwest of Ahmedabad, in Mehsana district. Major part of the lake is under open water. There are small marshes at the edges and some scrub forest on the side of the embarkments. The sanctuary is covered with lush green trees making it extremely peaceful. There are Thol Lake,
Fauna	Thol Lake is well known for wintering Great White Pelicans, Famingos, a variety of waterfowl including Mallards and good numbers of Greylag Geese, Sarus Cranes, the odd Spotted Flycatcher and waders which include Eurasian Curlews.
Turbidity	Low-Moderate



Post monsoon data (2006)



Pre monsoon data (2007)



Indices image  
Post monsoon data (2006)



Plate 6: Thol Lake

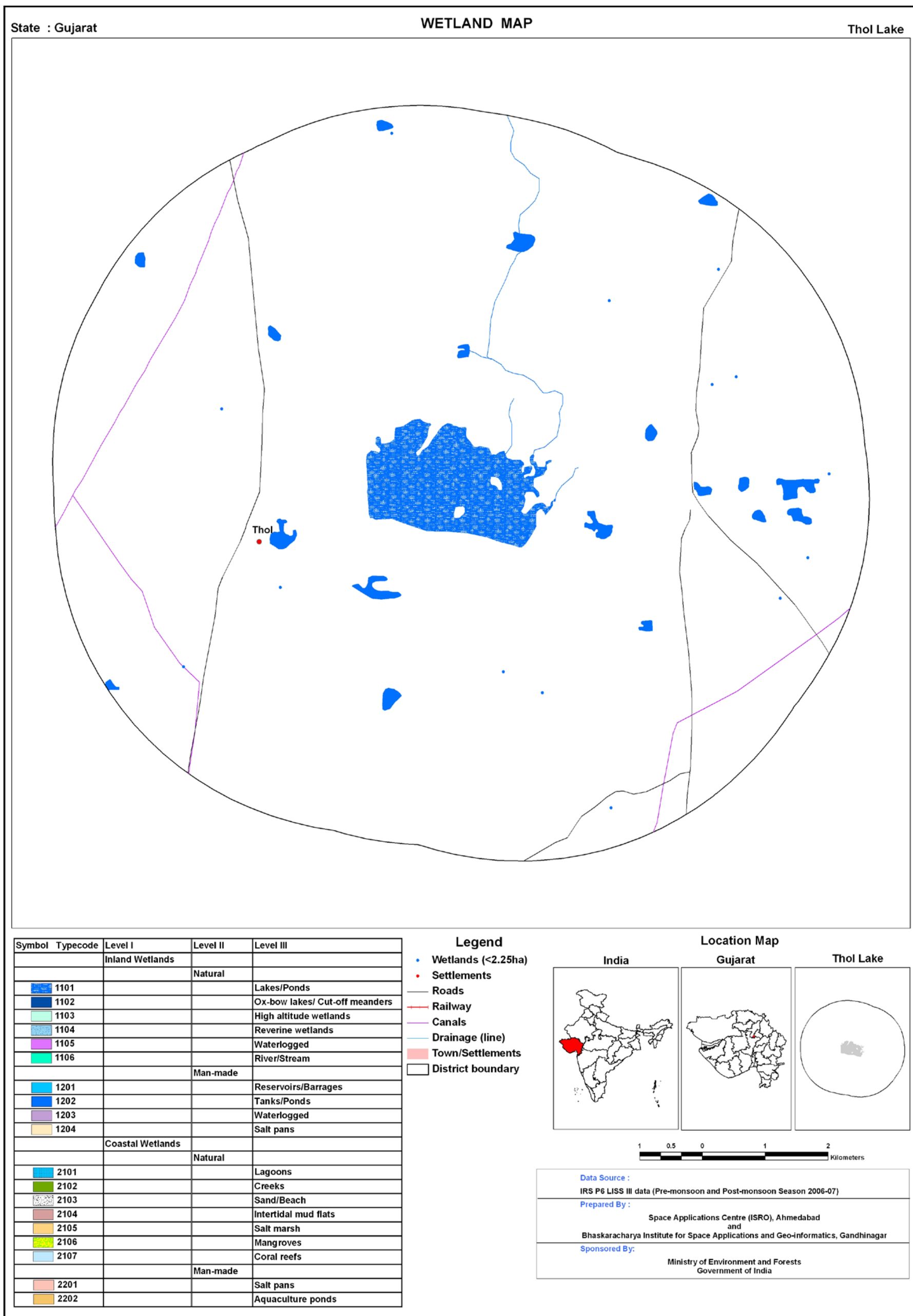
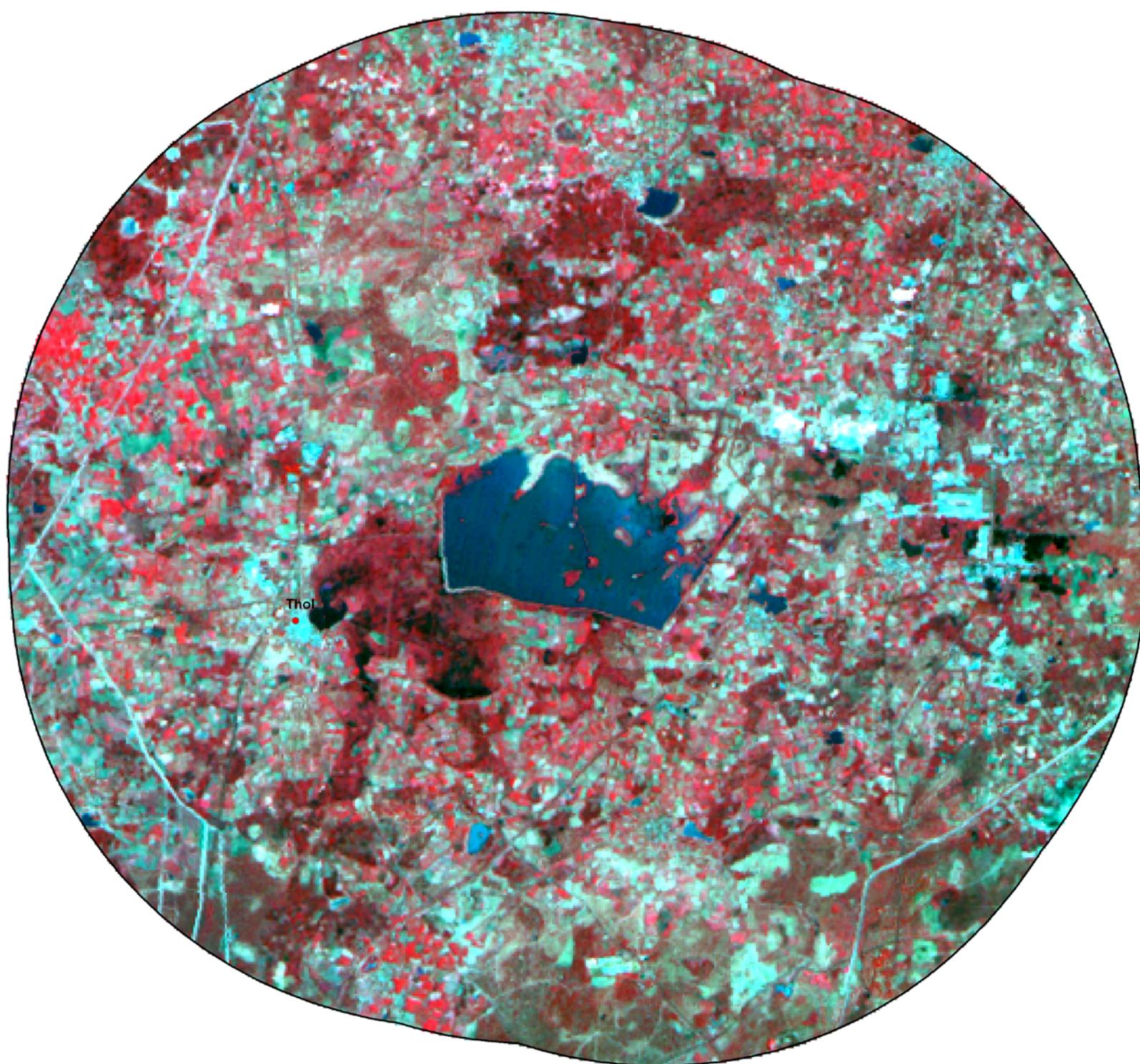


Plate 7: Wetland map - 5 km buffer area of Thol Lake








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

Plate 8: IRS LISS III FCC - 5 km buffer area of Thol Lake




9.3 Southern Gulf of Kachchh


Name	Southern Gulf of Kachchh
Location	22° 17' 23" to 22° 42' 15" N Latitude and 69° 00' 11" to 70° 12' 40" E Longitude
Area	Wetland area : 99535 ha
Wetland Type	Intertidal mud flats, mangroves, creeks, coral reefs, salt marsh and salt pans etc.,
Climate	Average annual rainfall of about 300 mm concentrated in July and August. The mean maximum temperature is 40° c, and the minimum 7° c.
Description	The Gulf of Kutch is a large inlet of the Arabian Sea about 60 km wide at its widest and tapering northeastwards for 170 km. The Marine National Park and Marine Sanctuary are situated along the southern shore of the Gulf from Okha eastwards to the vicinity of Khijadia. The National Park and Marine Sanctuary include 42 islands and a complex of fringing reefs backed by mud and sand flats, coastal salt marsh and mangrove forest. The towns of Okha, Salaya, Vadinar, Sikka and Jamnagar have developed along the southern edge of the Gulf and exert considerable influence over these wetlands. The major islands (from west to east) are Beyt, Chusnas, Bhaidar, Nora, Ajad, Chauk, Dhanibet, Karumbhar, Goos Reef, Moouada, Pirotan, Jindra and Chhad. The Gulf is famous for its coral formations and mangrove forest.
Fauna	Large numbers of hard (Scleractinavian) and soft (Alcyonarian) corals have been recorded, along with more than 100 species of fishes and prawn have been recorded. Major species are Sponges, Corals, Jelly fish, Sea horse, Octopus, Oyster, Pearl oyster, Starfish, Lobster, Dolphin, Dugon, and Waterfowls.




Post monsoon data (2006)



Pre monsoon data (2007)






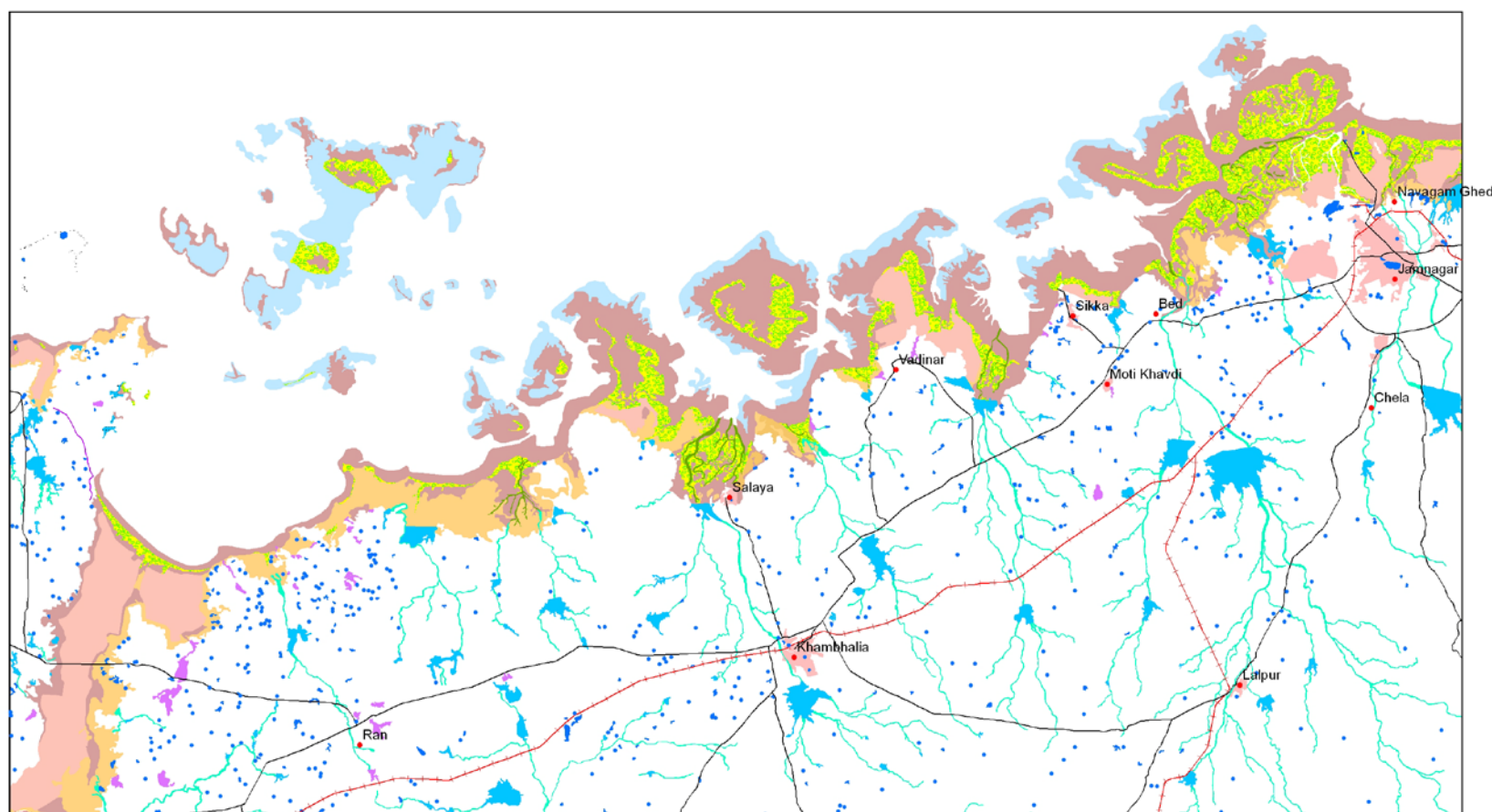


Plate 9: Southern Gulf of Kachchh

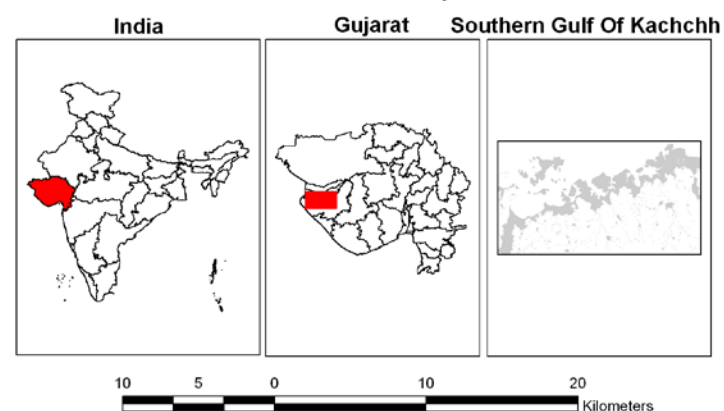


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



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

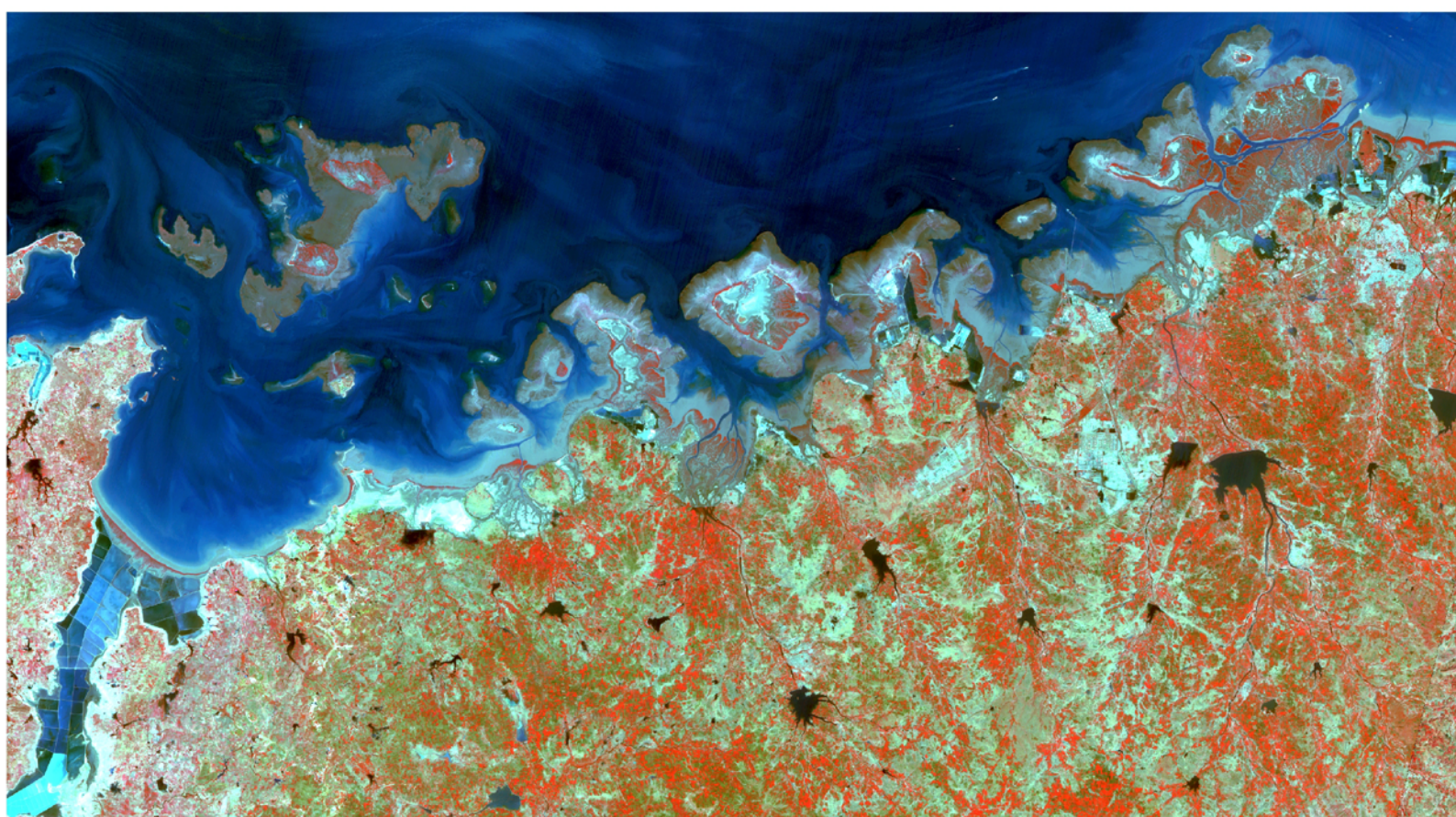
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Government of India

Plate 10: Wetland map - 5 km buffer area of Southern Gulf of Kachchh







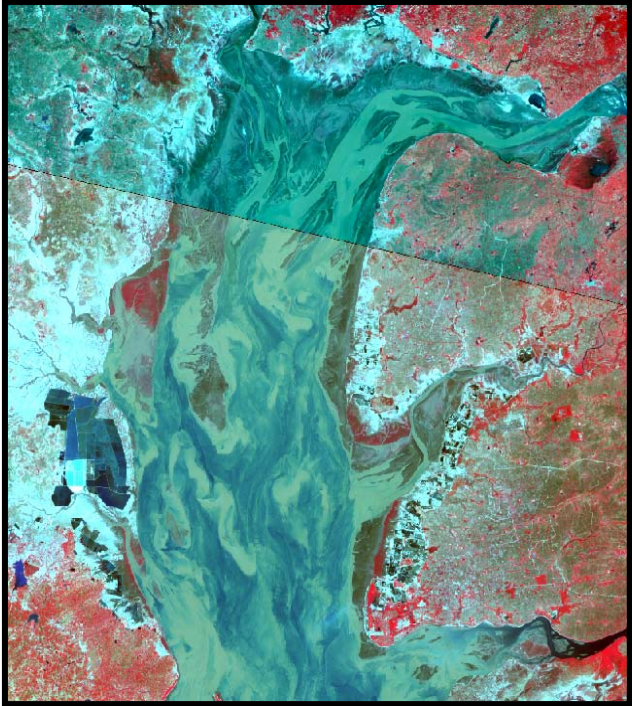
IRS P6 LISS-III Post-monsoon data(2006)

Plate 11: IRS LISS III FCC - 5 km buffer area of Southern Gulf of Kachchh




9.4 Gulf of Khambhat

Name	Gulf of Khambhat
Location	21° 38' 31" to 22° 22' 02" N Latitude and 72° 10' 57" to 72° 41' 17" E Longitude
Area	Wetland area : 185365 ha
Wetland Type	Intertidal mud flats, mangroves, creeks, Salt marsh and salt pans etc.
Climate	Average annual rainfall of about 800 mm.
Description	An extensive area of estuarine habitats around the periphery of the Gulf of Khambhat. The wetland area is located from the region of Talaja on the west coast to the head of the Gulf at Khambhat, and south on the east coast for about 200 km to Valsad, The Tapi, Narmada, Mahi, Sabarmati and several other rivers have deposited alluvium over large areas as the marine recession has united Saurashtra with the mainland of Gujarat. The area supports large numbers and types of mangrove vegetation.
Fauna	The coastal marshes and mudflats provide feeding areas for large numbers of herons, egrets, storks, and ibises which breed in groves of trees. The New Port of Bhavnagar harbors one of the largest colonies of Egretta gularis in the world. Other common breeding species include Nycticorax nycticorax, Ardeola grayii, Bubulcus ibis, Egretta garzetta, E. alba, Mycteria leucocephala, Threskiornis melanocephalus, Pseudibis papillosa, and Platalea leucorodia.



Post monsoon data (2006)



Pre monsoon data (2007)




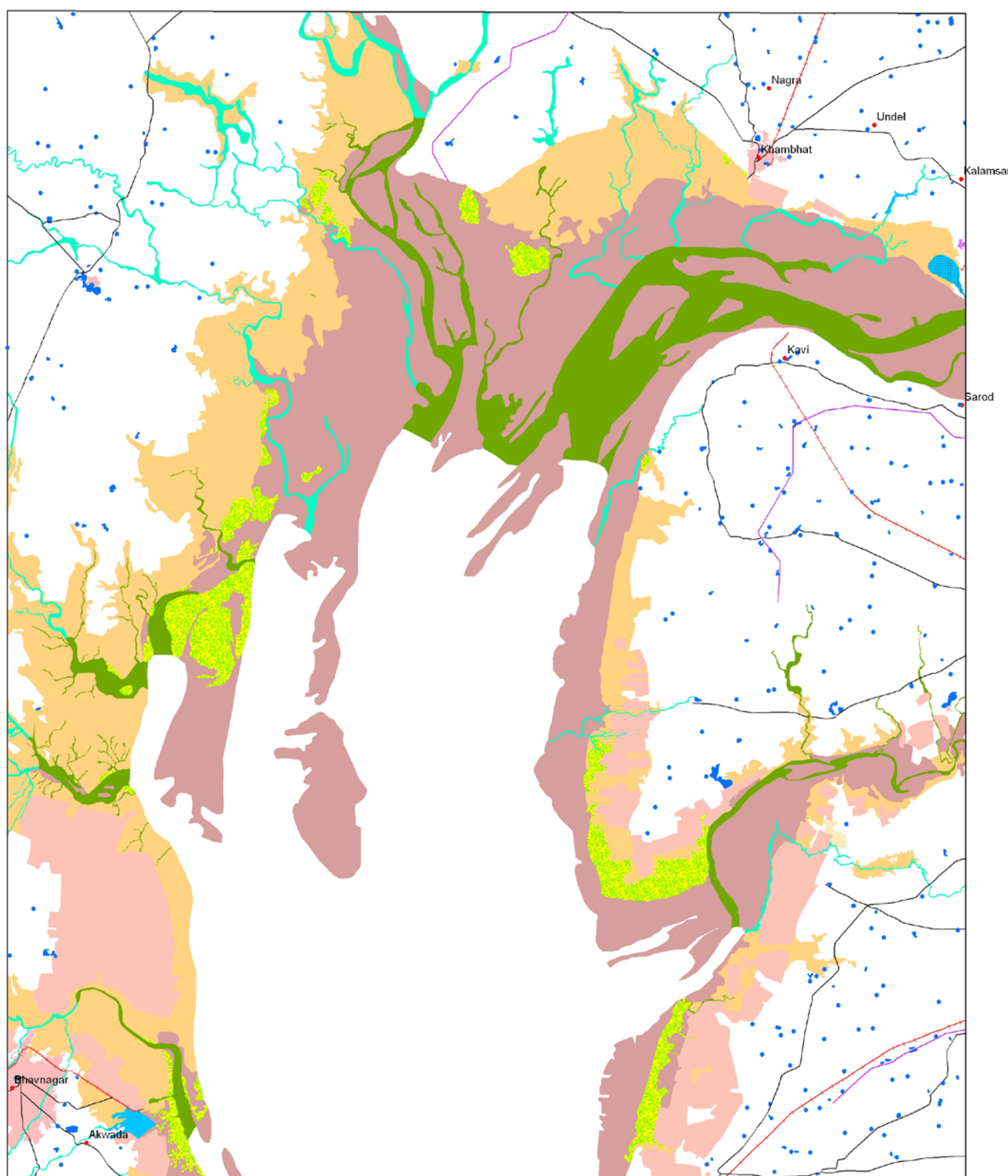


Plate 12: Gulf of Khambhat



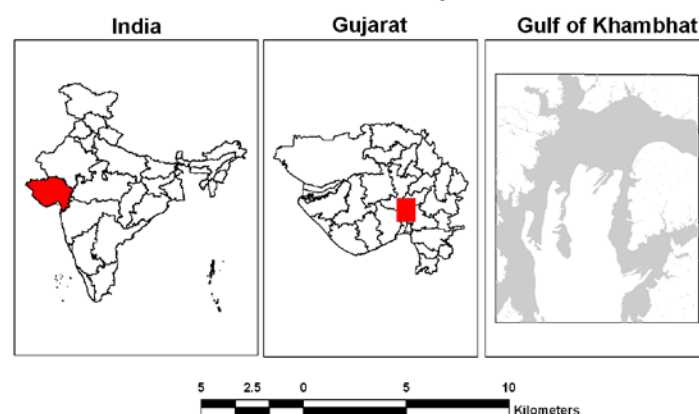


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

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and  
Bhaskaracharya Institute for Space Applications and Geo-informatics, Gandhinagar

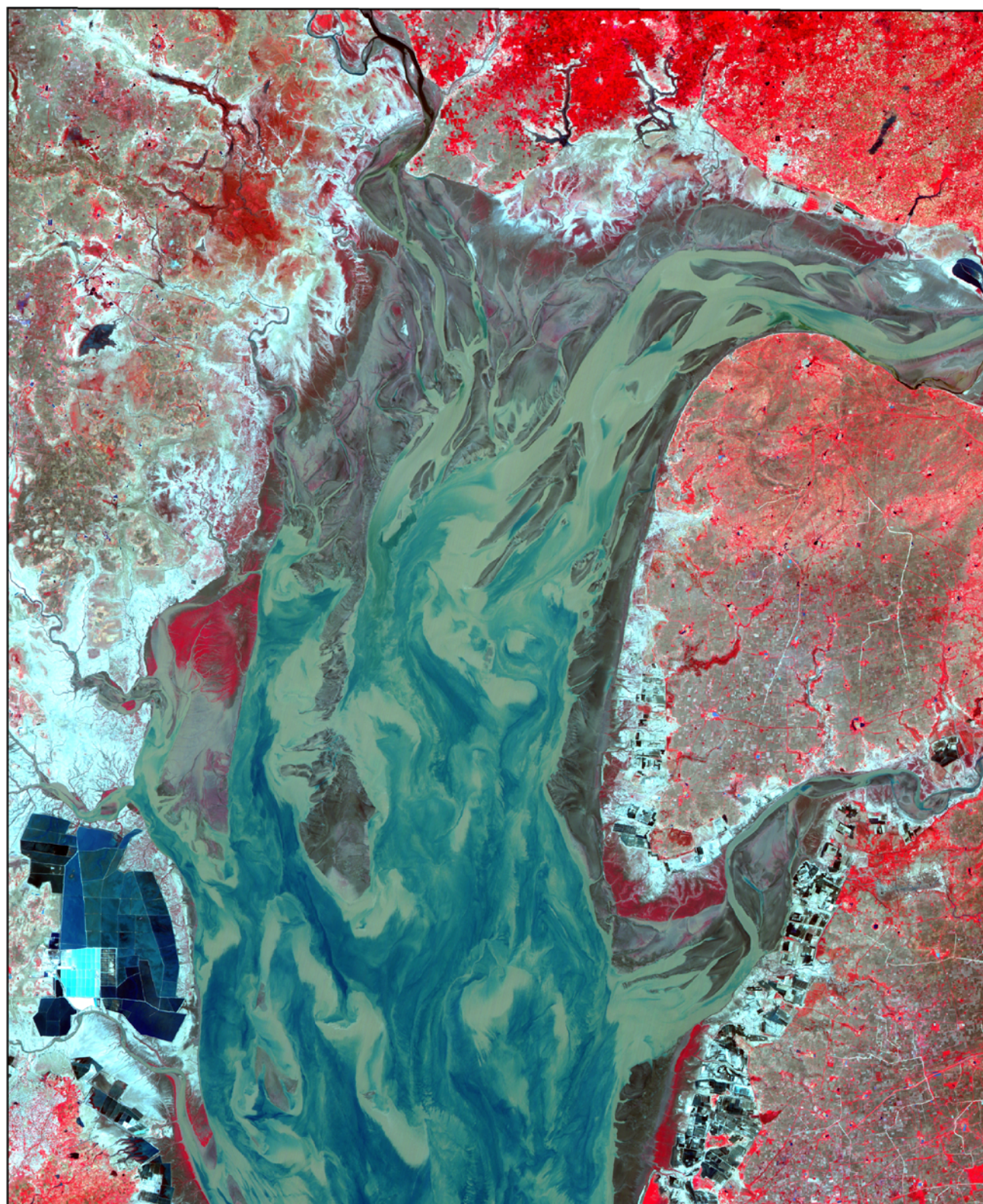
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Plate 13: Wetland map - 5 km buffer area of Gulf of Khambhat







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

Plate 14: IRS LISS III FCC - 5 km buffer area of Gulf of Khambhat



9.5 Jamnagar Mangroves

Name	Jamnagar Mangroves
Location	22° 28' 42" to 22° 37' 12" N Latitude and 69° 49' 40" to 70° 02' 46" E Longitude
Area	Mangrove area : 6415 ha (total wetland area : 19918 ha)
Wetland Type	Mangroves, coral reefs, inter-tidal mudflats and salt marsh
Climate	Average annual rainfall : 300 mm The mean maximum temperature is 40° C, and the minimum of 7° C.
Description	This is cluster of four islands and a complex of fringing reefs backed by mud flats, mangrove forest and coastal salt marsh. Site is located at North-West from Jamnagar city. This area contains some of the best mangrove forests on the west coast of India. The principal species are <i>avicennia alba</i> , <i>Rhizophora mucronata</i> and <i>Ceriops tagal</i> .
Fauna	This wetland site supports large number of birds, fishes, reptiles and mammals.



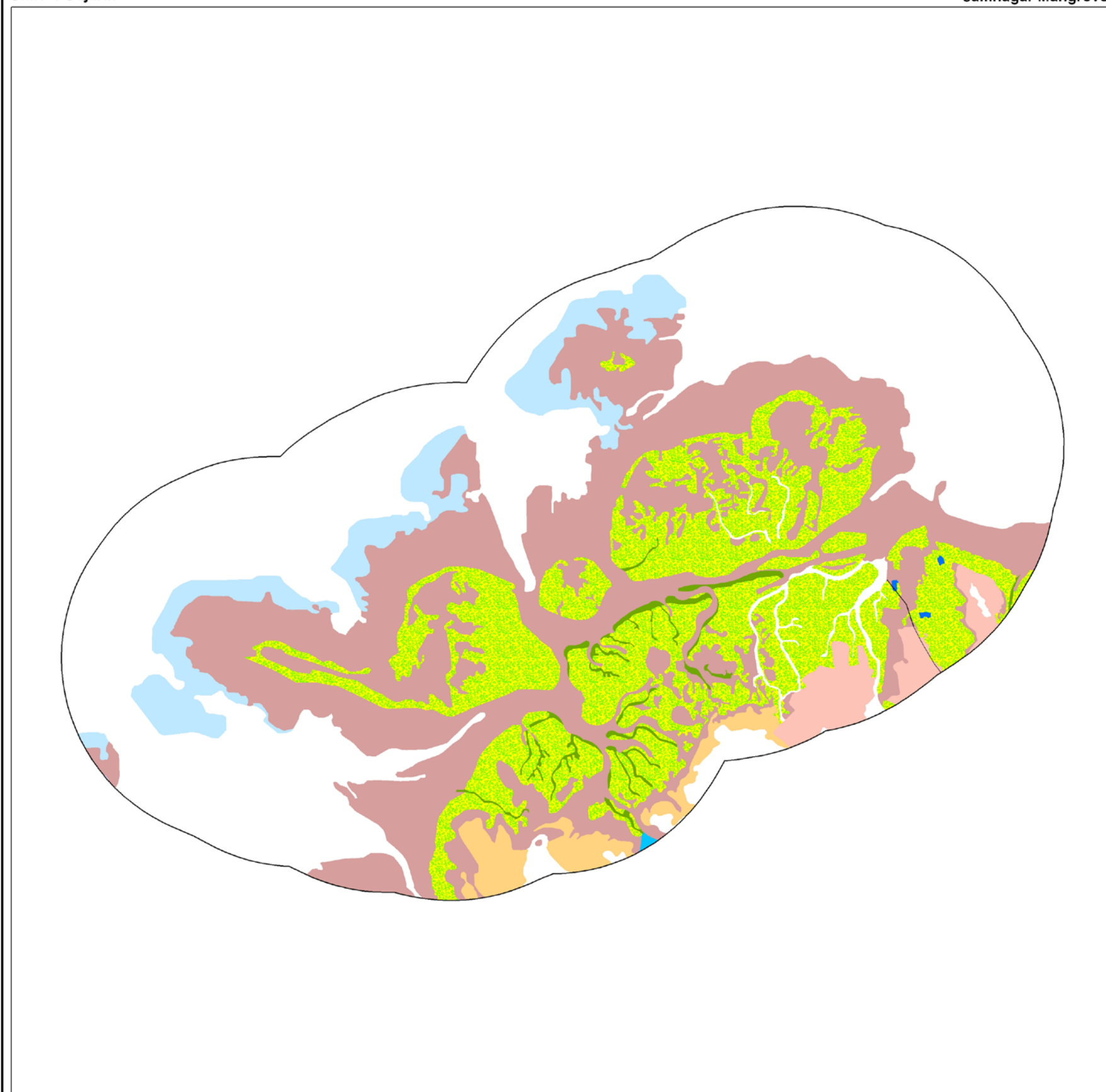
Post monsoon data (2006)



Pre monsoon data (2007)



Plate 15: Jamnagar Mangroves

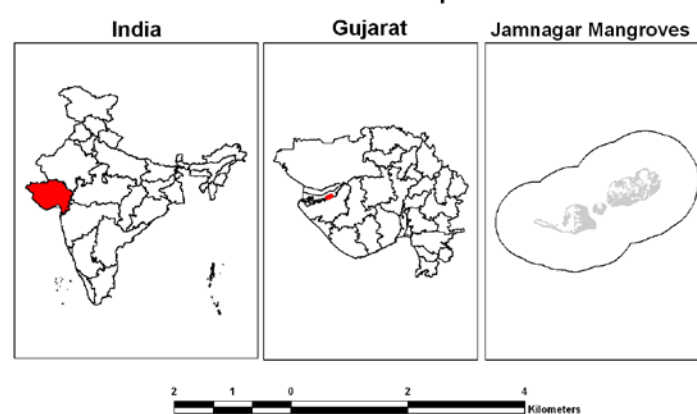


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



Data Source :

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

Prepared By :

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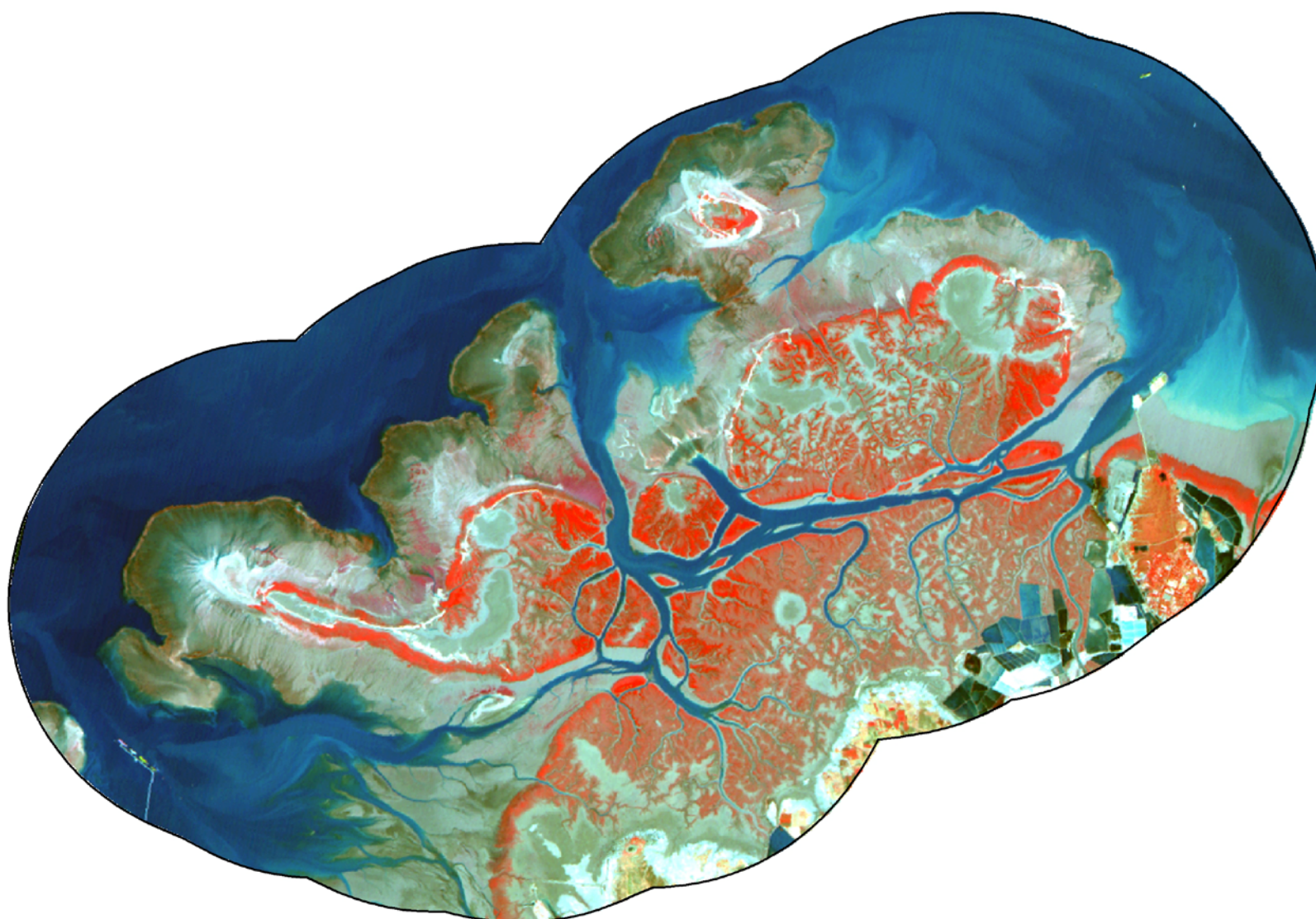
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Plate 16: Wetland map - 5 km buffer area of Jamnagar Mangroves







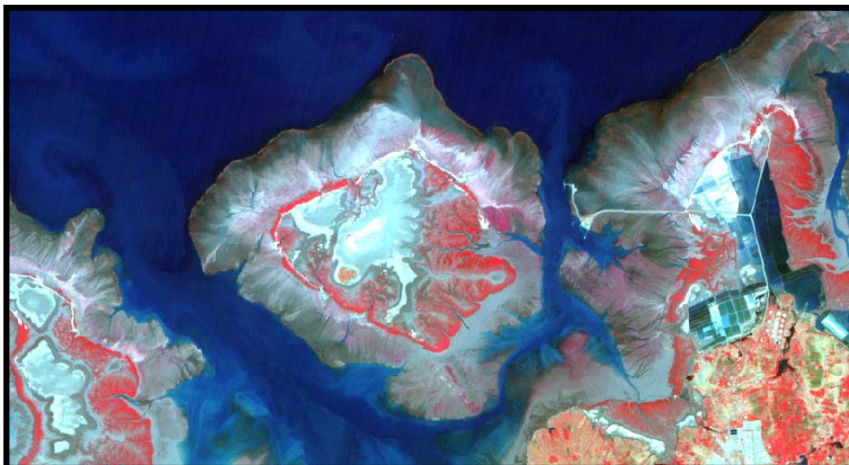
IRS P6 LISS-III Post-monsoon data (2006)

Plate 17: IRS LISS III FCC - 5 km buffer area of Jamnagar Mangroves




9.6 Coral Reefs of Gulf of Kachchh


Name	Coral Reefs of Gulf of Kachchh
Location	22° 22' 14" to 22° 29' 53" N Latitude and 69° 32' 34" to 69° 43' 52" E Longitude
Area	Wetland area 14495 ha (coral reefs : 2698 ha)
Wetland Type	Coral Reefs, Inter-tidal mudflats, mangroves etc.
Climate	Average annual rainfall : 300 mm The mean maximum temperature is 40° C, and the minimum of 7° C.
Description	Wetland site is located in southern part of Gulf of Kachchh at Karumbhar and surrounding Islands.. This site is famous for its coral formations which are now the only living reefs between the Arabian Gulf and Laccadives. The reefs are generally restricted to areas exposed to strong tidal currents, and living reefs are confined to the northern and western sides of the islands where the currents are strongest.

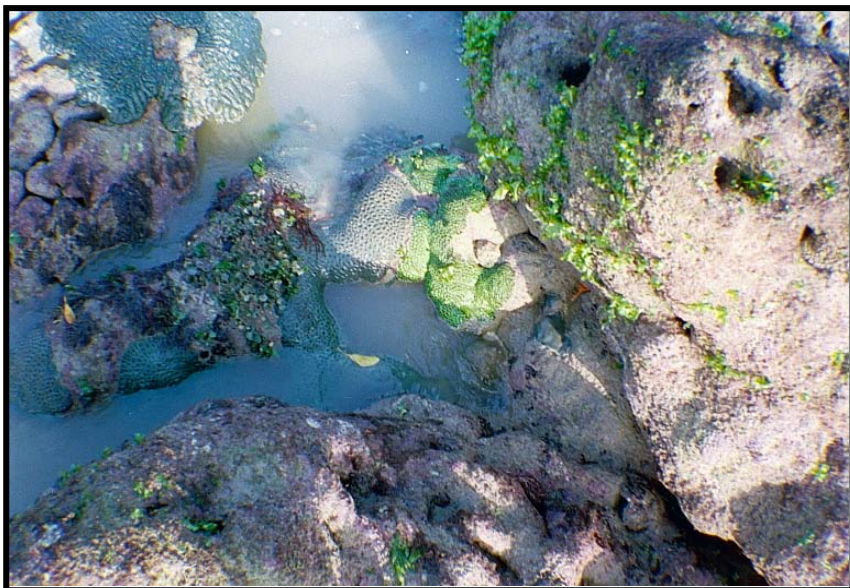


Post-monsoon data (2006)



Pre-monsoon data (2007)






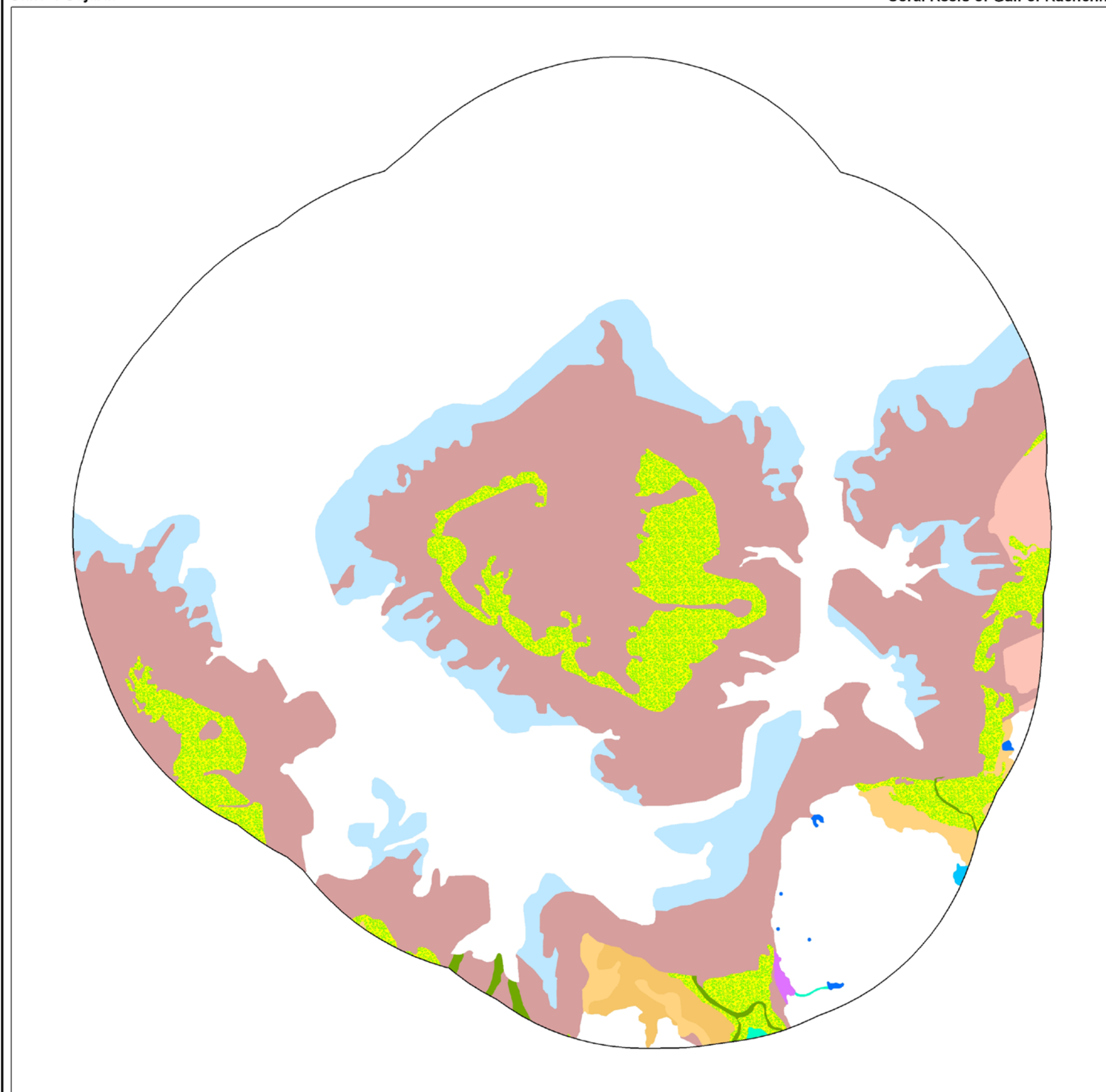


Plate 18: Coral Reefs of Gulf of Kachchh





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

## Legend

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

## Location Map

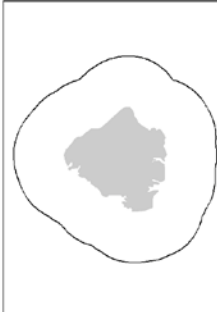
India



Gujarat



Coral Reefs of Gulf of Kachchh



1 0.5 0 1 2  
Kilometers

## Data Source :

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

## Prepared By :

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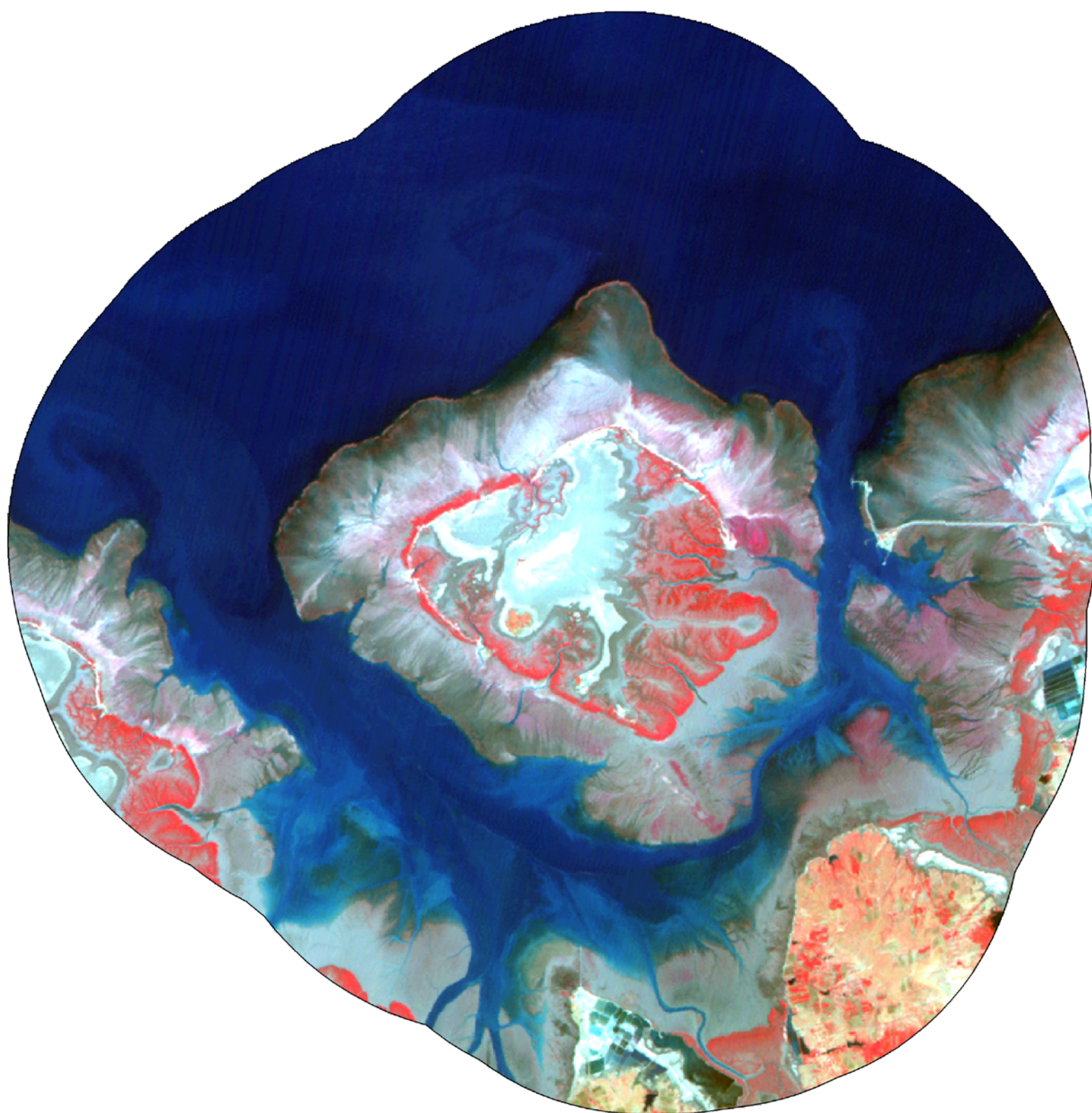
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Plate 19: Wetland map - 5 km buffer area of Coral Reefs of Gulf of Kachchh







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

Plate 20: IRS LISS III FCC - 5 km buffer area of Coral Reefs of Gulf of Kachchh

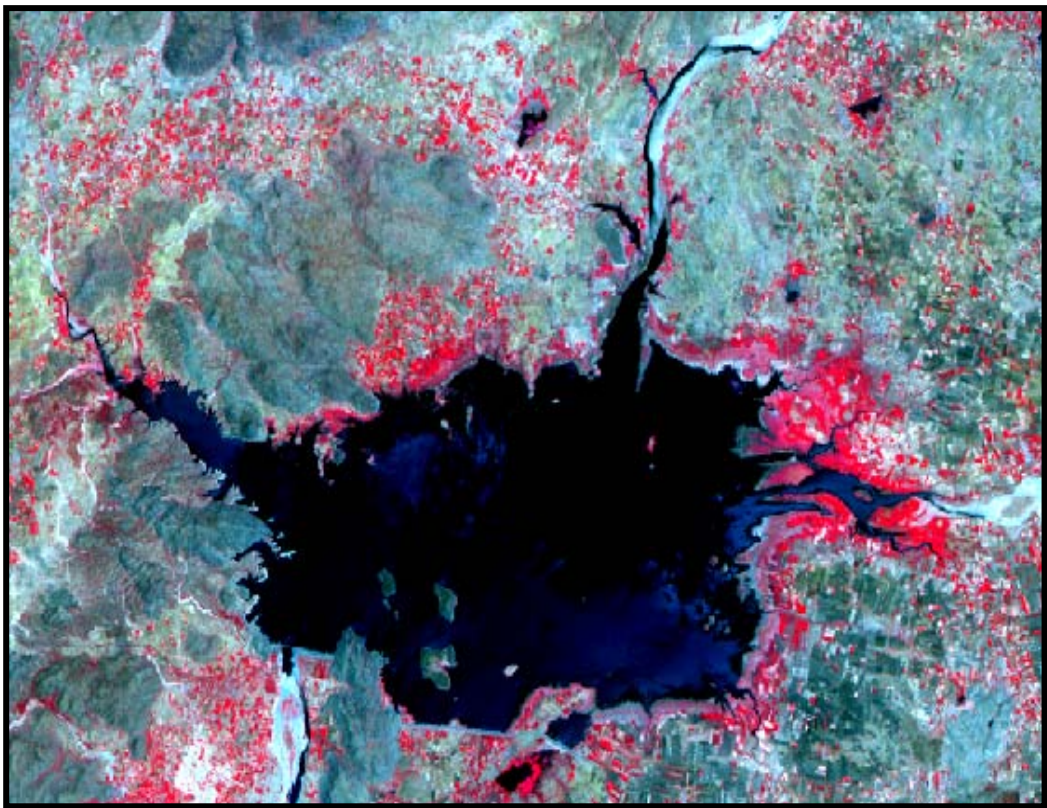


9.7 Dharoi Reservoir

Name	Dharoi Reservoir
Location	23° 59' 08" to 24° 04' 39" N Latitude and 72° 48' 43" to 72° 59' 55" E Longitude
Area	10053 ha
Wetland Type	Reservoir
Climate	Semi-arid climate with average annual rainfall of 300 mm Mean maximum temperature is 40° c, and the minimum 7° c.
Description	Located at Dharoi in Sabarkantha district. The Dharoi Dam was built for supplying drinking water to urban area such as Ahmedabad that is located 85 km away. The Dam was constructed across the Sabarmati River in 1973. The Dam is also one of the tourist spots in the state.
Turbidity	Low to Moderate



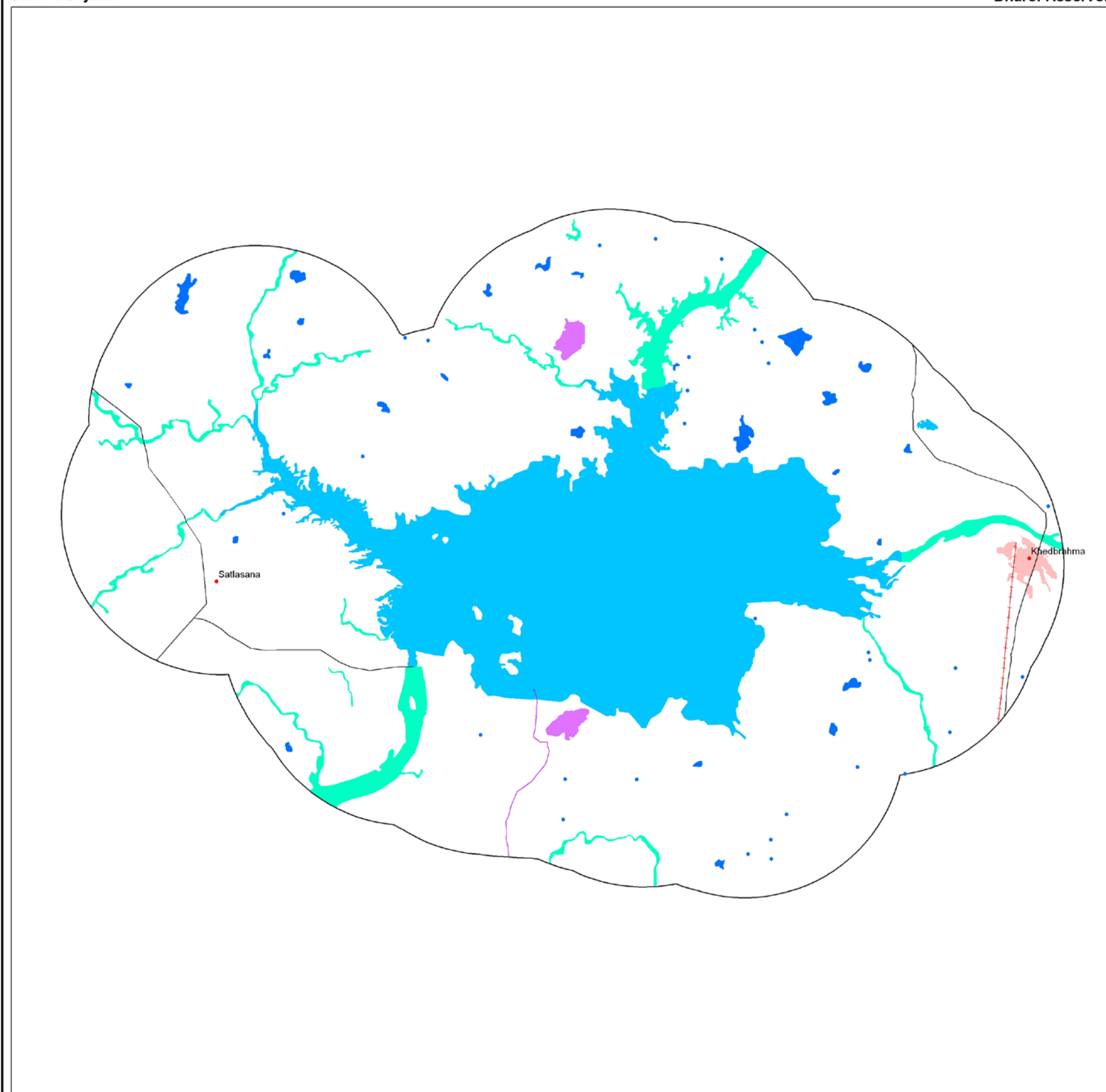
Post monsoon data (2006)



Pre monsoon data (2007)

Plate 21: Dharoi Reservoir



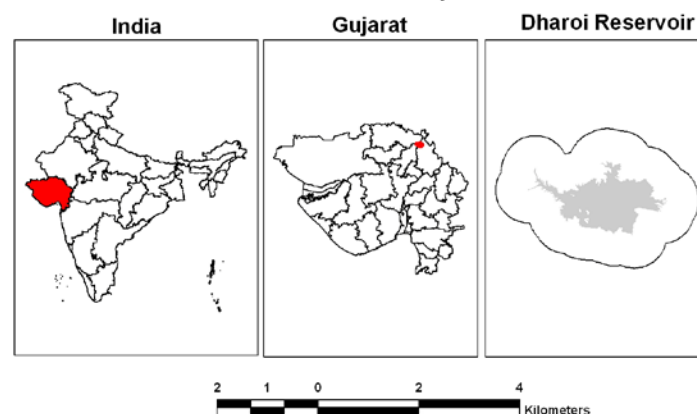


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



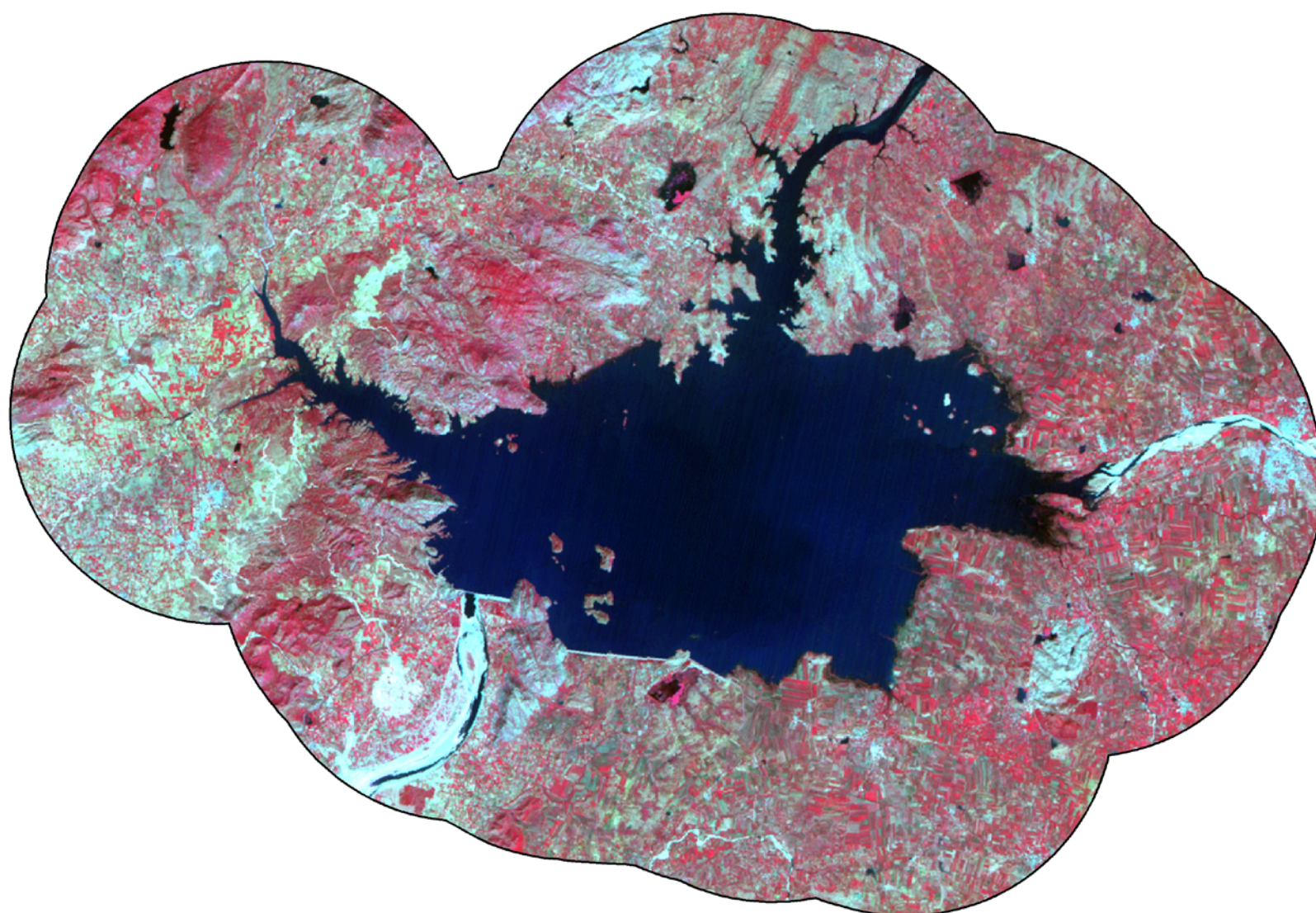
Data Source :  
IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :  
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Plate 22: Wetland map - 5 km buffer area of Dharoi Reservoir





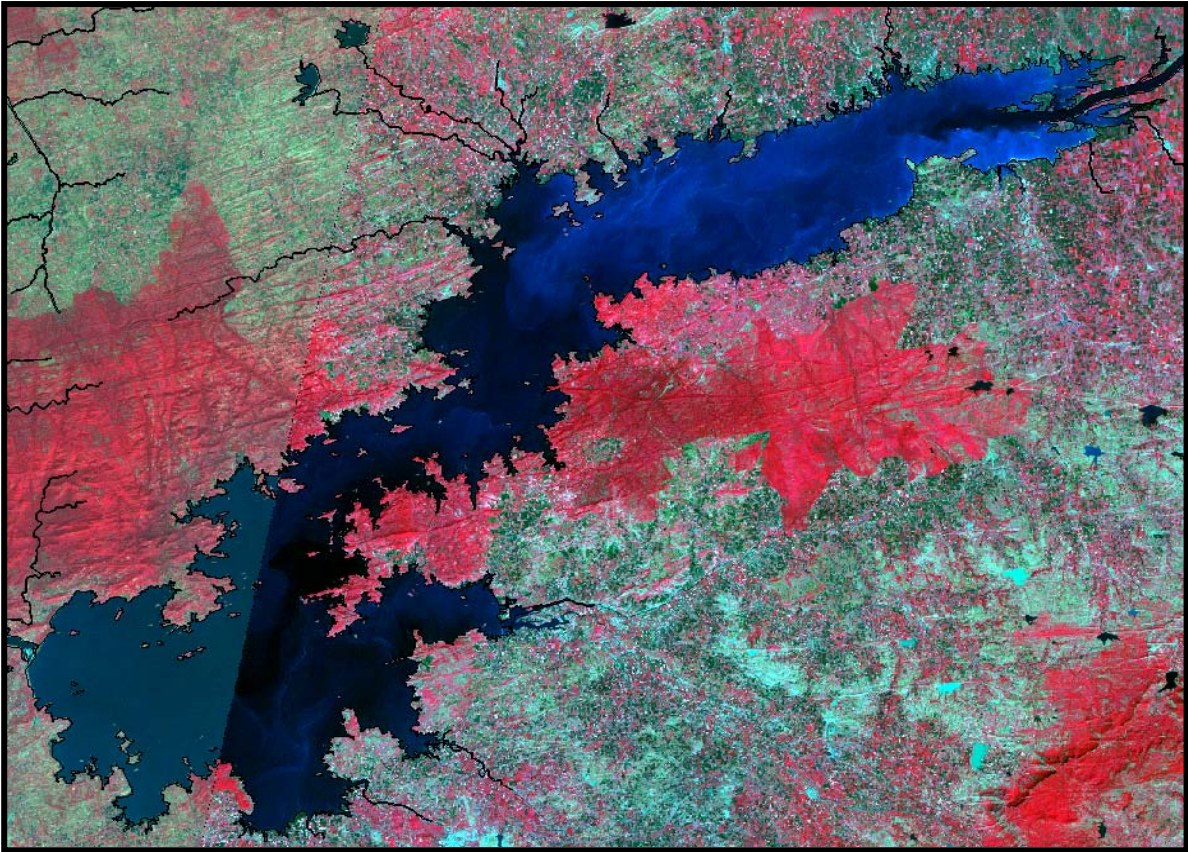
IRS P6 LISS-III Post-monsoon data (2006)

Plate 23: IRS LISS III FCC - 5 km buffer area of Dharoi Reservoir

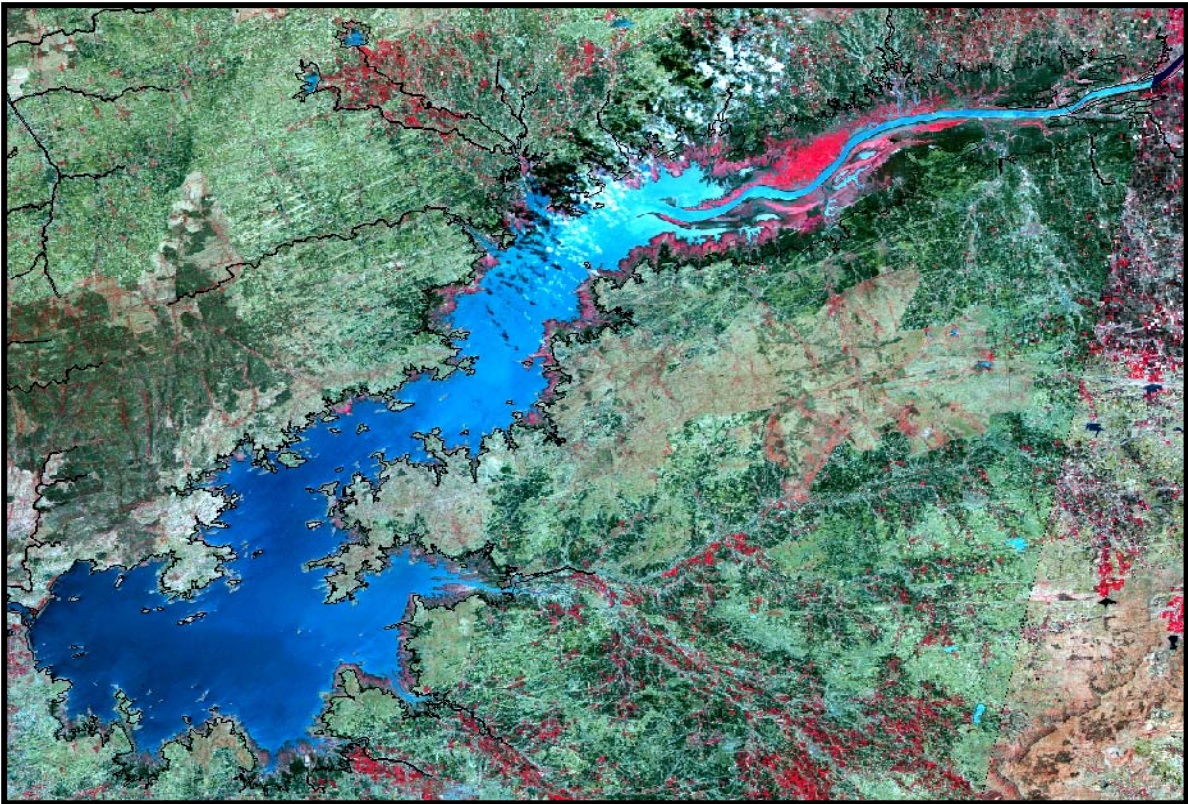


9.8 Ukai Reservoir

Name	Ukai Reservoir
Location	21° 10' 06" to 21° 31' 53" N Latitude and 73° 35' 15" to 74° 08' 41" E Longitude
Area	49401 ha
Wetland Type	Reservoir
Climate	Average annual rainfall of about 900 mm concentrated in July and August. The mean maximum temperature is 40° c, and the minimum 10° c.
Description	Ukai Dam near Surat is known as a mega project in the state. Ukai is constructed on the river Tapi. It is major irrigation scheme of South Gujarat. The reservoir is also providing water for domestic and industrial usage in Surat and surrounding area.
Turbidity	Low



Post monsoon data (2006)



Pre monsoon data (2007)

Plate 24: Ukai Reservoir



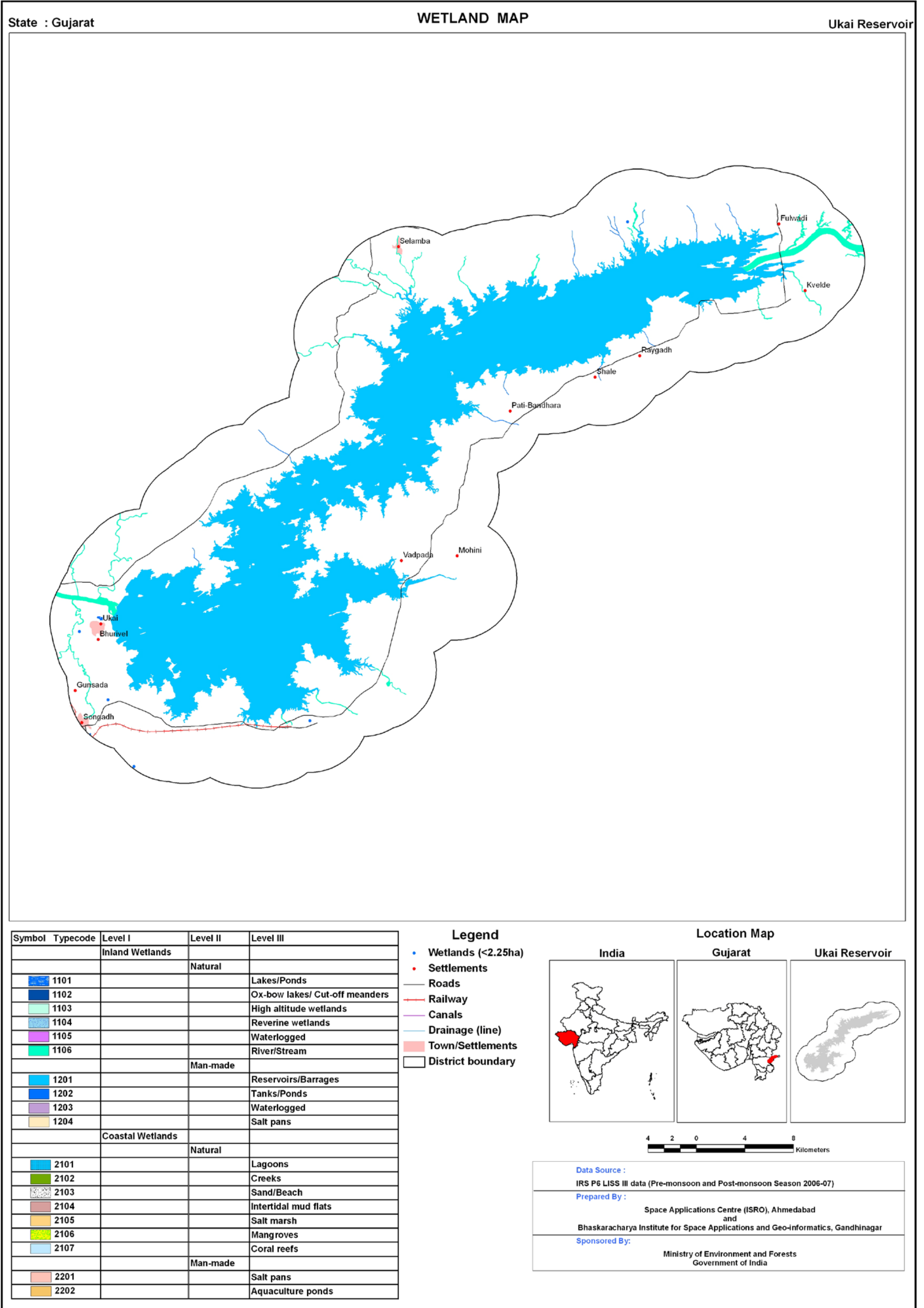
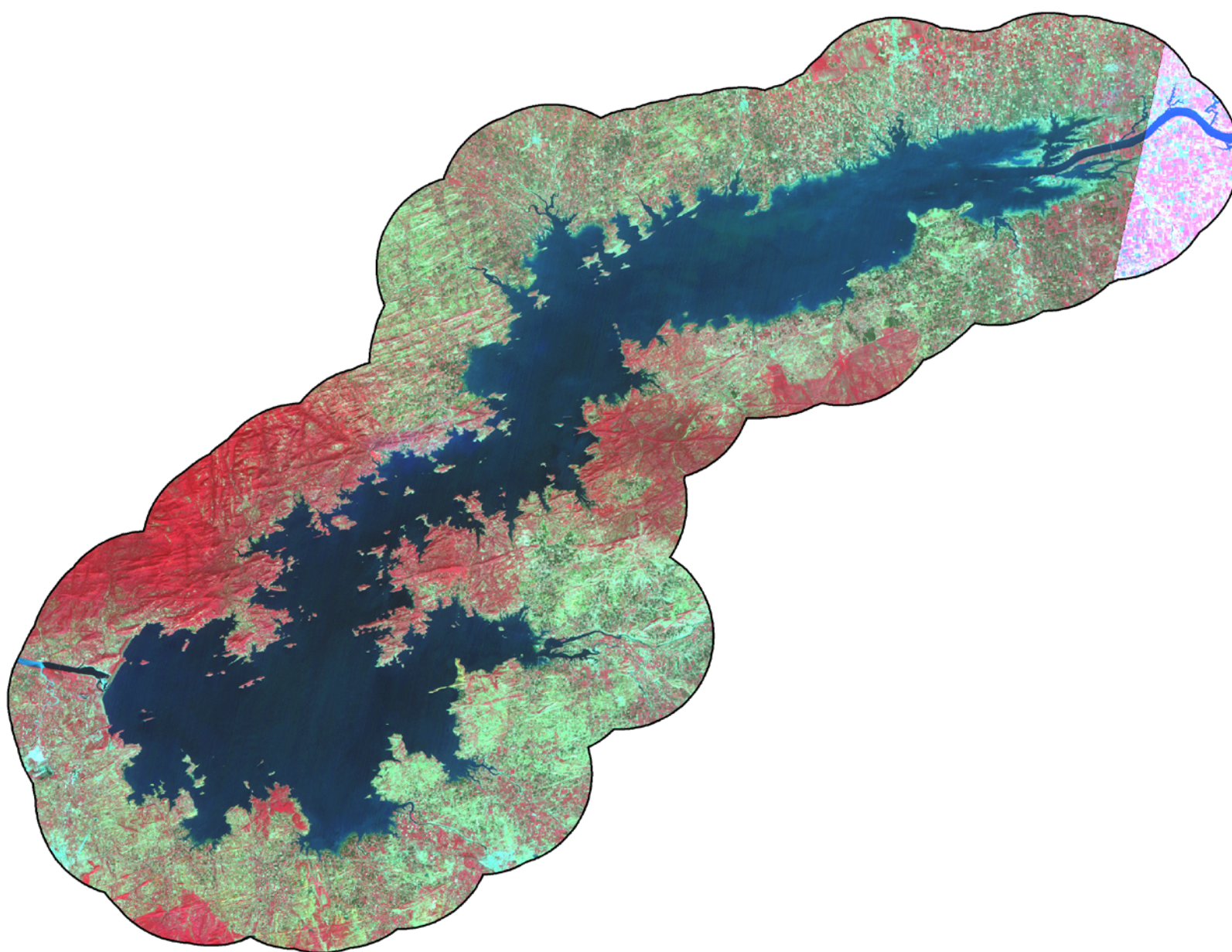


Plate 25: Wetland map - 5 km buffer area of Ukai Reservoir







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

Plate 26: IRS LISS III FCC - 5 km buffer area of Ukai Reservoir



9.9 Kerly Lagoon

Name	Kerly Lagoon
Location	21° 31' 56" to 21° 41' 37" N Latitude and 69° 32' 25" to 69° 50' 39" E Longitude Located at South-East part of Porbandar city
Area	9670 ha
Wetland Type	Lagoon
Climate	Average annual rainfall of about 400 mm concentrated in July - September. The mean maximum temperature is 39° c, and the minimum 12° c.
Description	This lagoon is located at south-east of Porbander city is basically a mudflat inundated during monsoon season. It is a very shallow in nature and the extent of water spread is governed by the high tides. The saline water enters through western part of the lagoon and the connectivity is segmented during pre-monsoon season due to extraction of salt through saltpans. Fresh water enters through river/streams in the north-eastern part of the lagoon and species composition is mainly fresh water type. It attract large number of migratory birds mainly flamingoes due to rich phytoplankton population.
Turbidity	Moderate to High

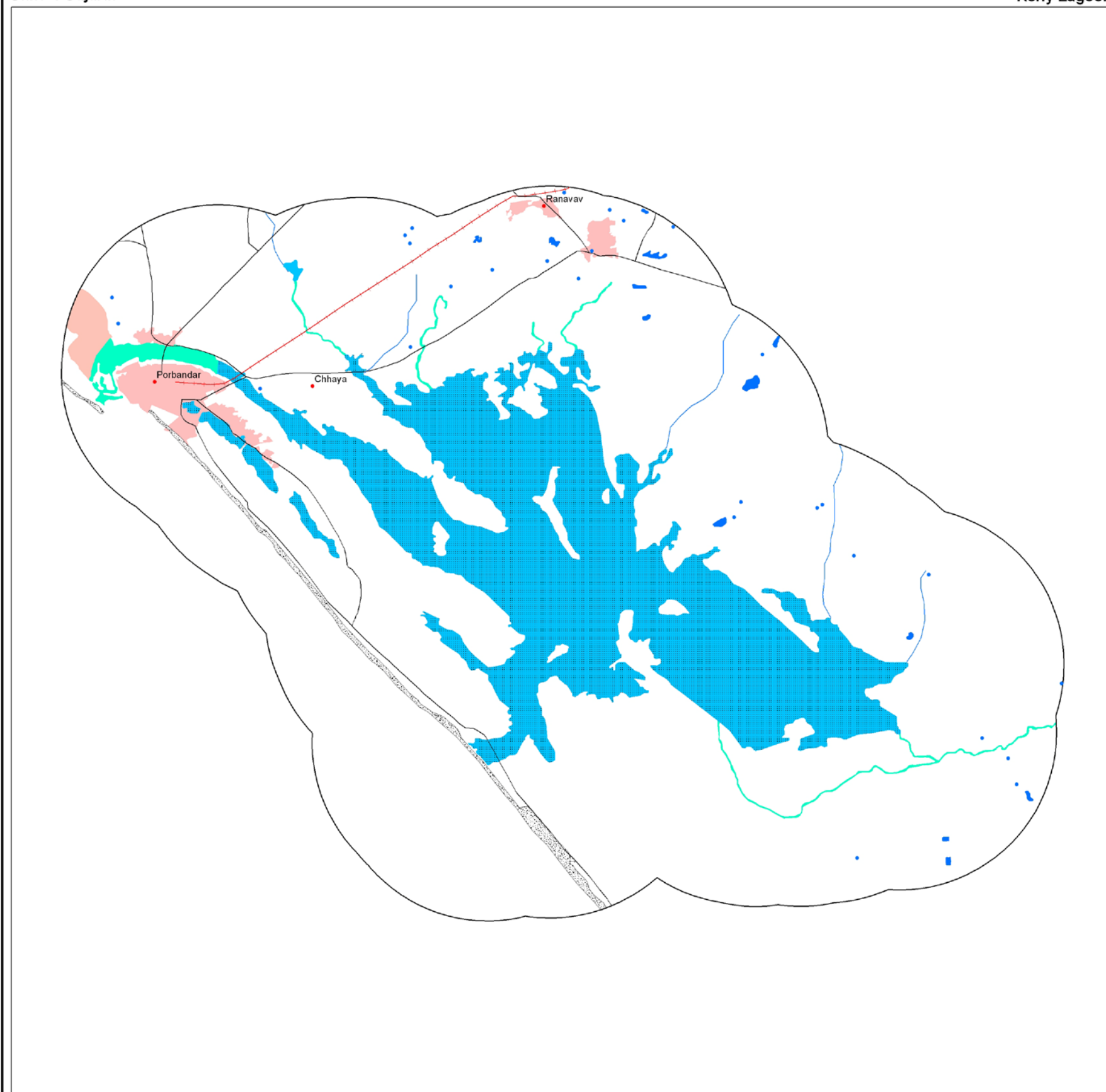


Post monsoon data (2006)



Pre monsoon data (2007)

Plate 27: Kerly Lagoon

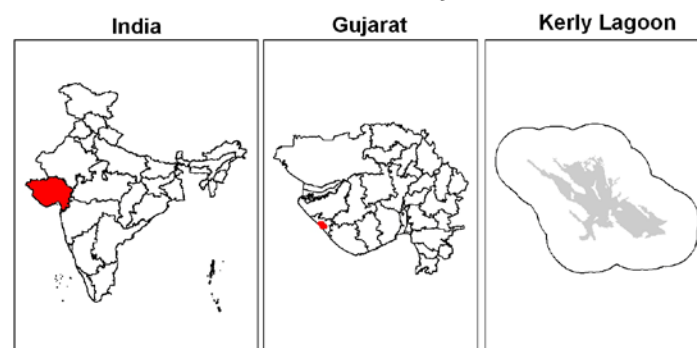


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
1101				Lakes/Ponds
1102				Ox-bow lakes/ Cut-off meanders
1103				High altitude wetlands
1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
			Man-made	
1201				Reservoirs/Barrages
1202				Tanks/Ponds
1203			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

## Legend

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

## Location Map



2 1 0 2 4 Kilometers

Data Source :

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

Prepared By :

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Plate 28: Wetland map - 5 km buffer area of Kerly Lagoon







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

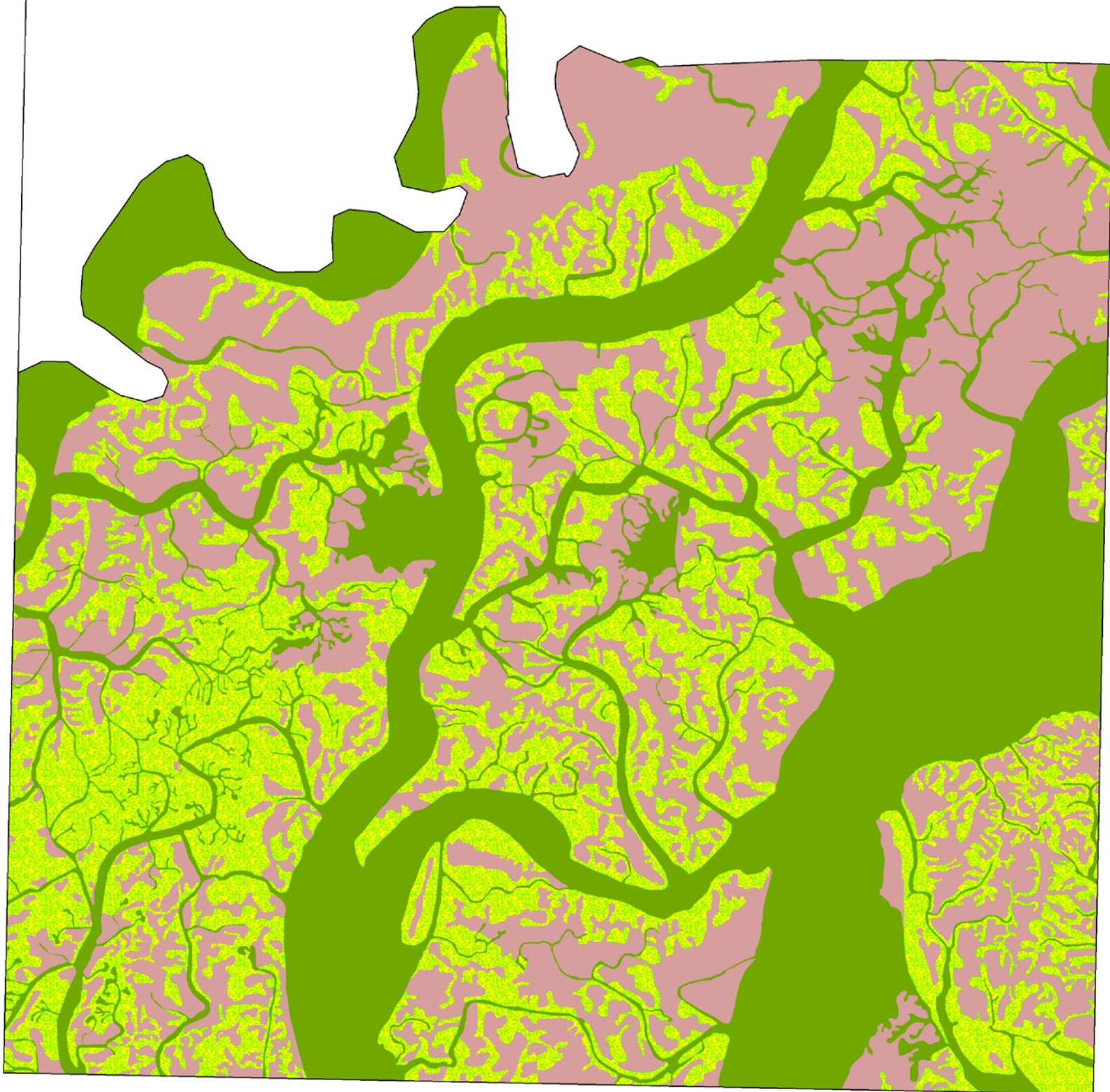
Plate 29: IRS LISS III FCC - 5 km buffer area of Kerly Lagoon





## **SOI MAP SHEET-WISE WETLAND MAPS (Selected)**



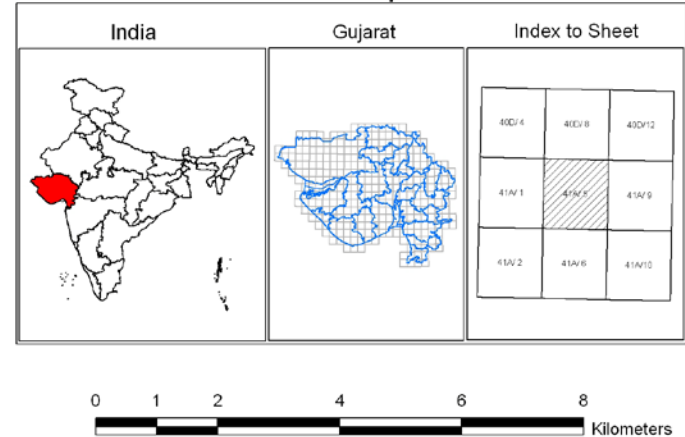


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

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

## Location Map



Data Source :

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

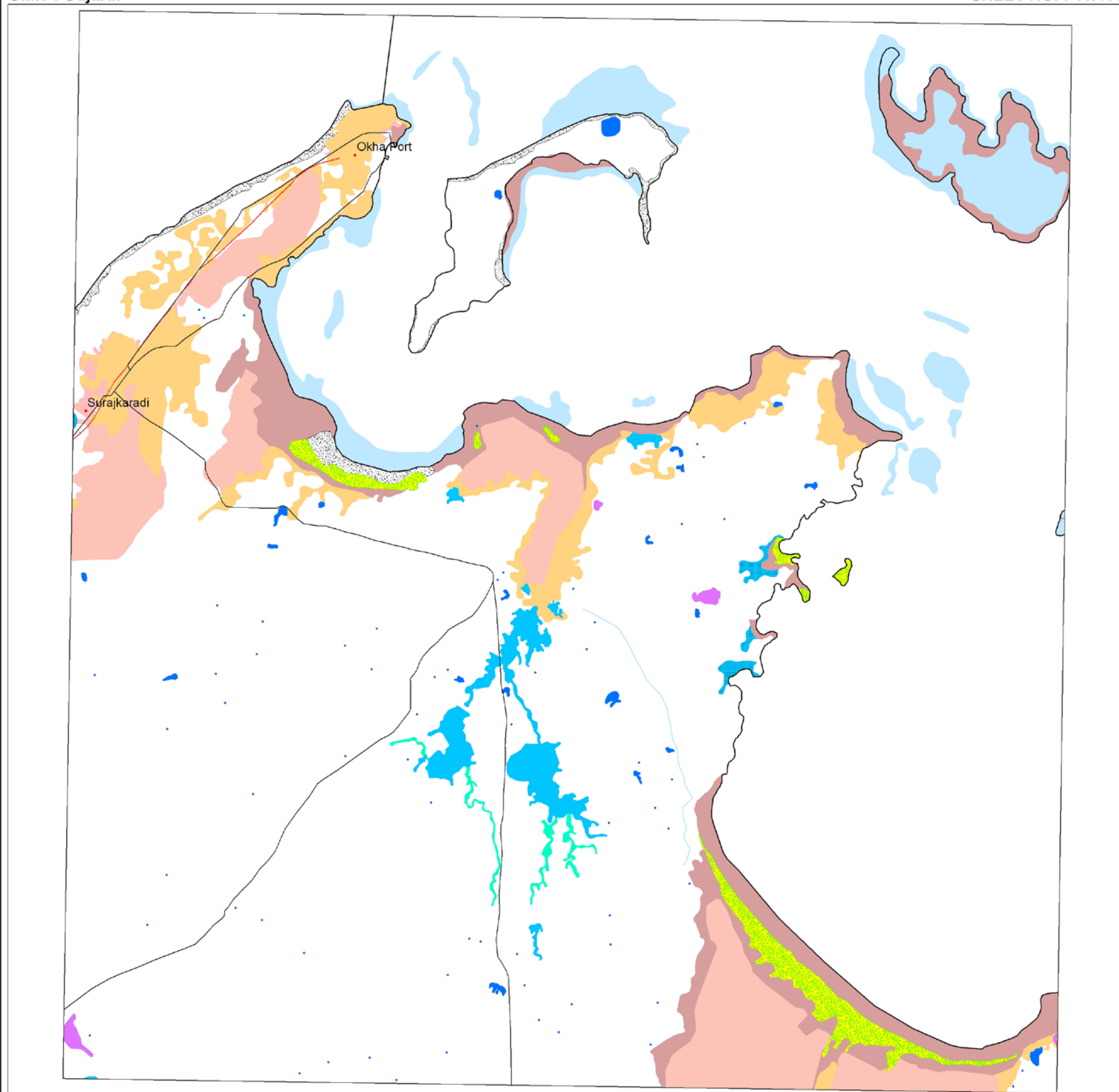
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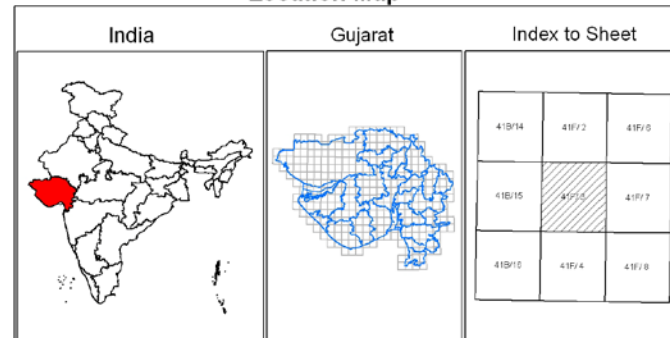


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

## Legend

- Wetlands (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
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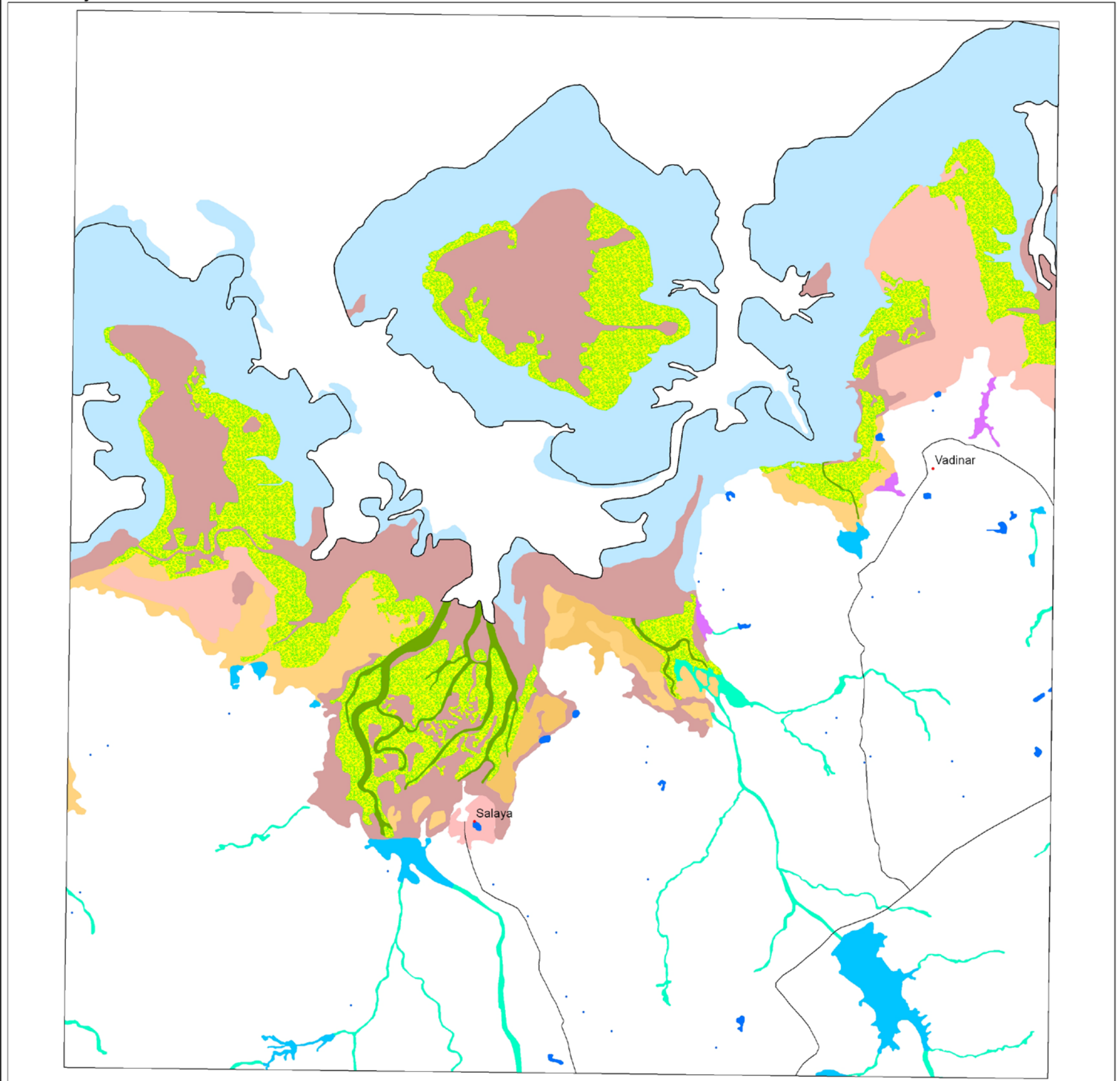
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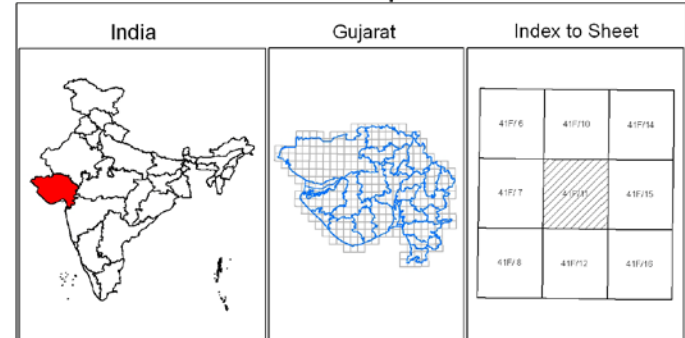


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		Inland Wetlands		
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1101				Lakes/Ponds
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1104				Reverine wetlands
1105				Waterlogged
1106				River/Stream
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1202				Tanks/Ponds
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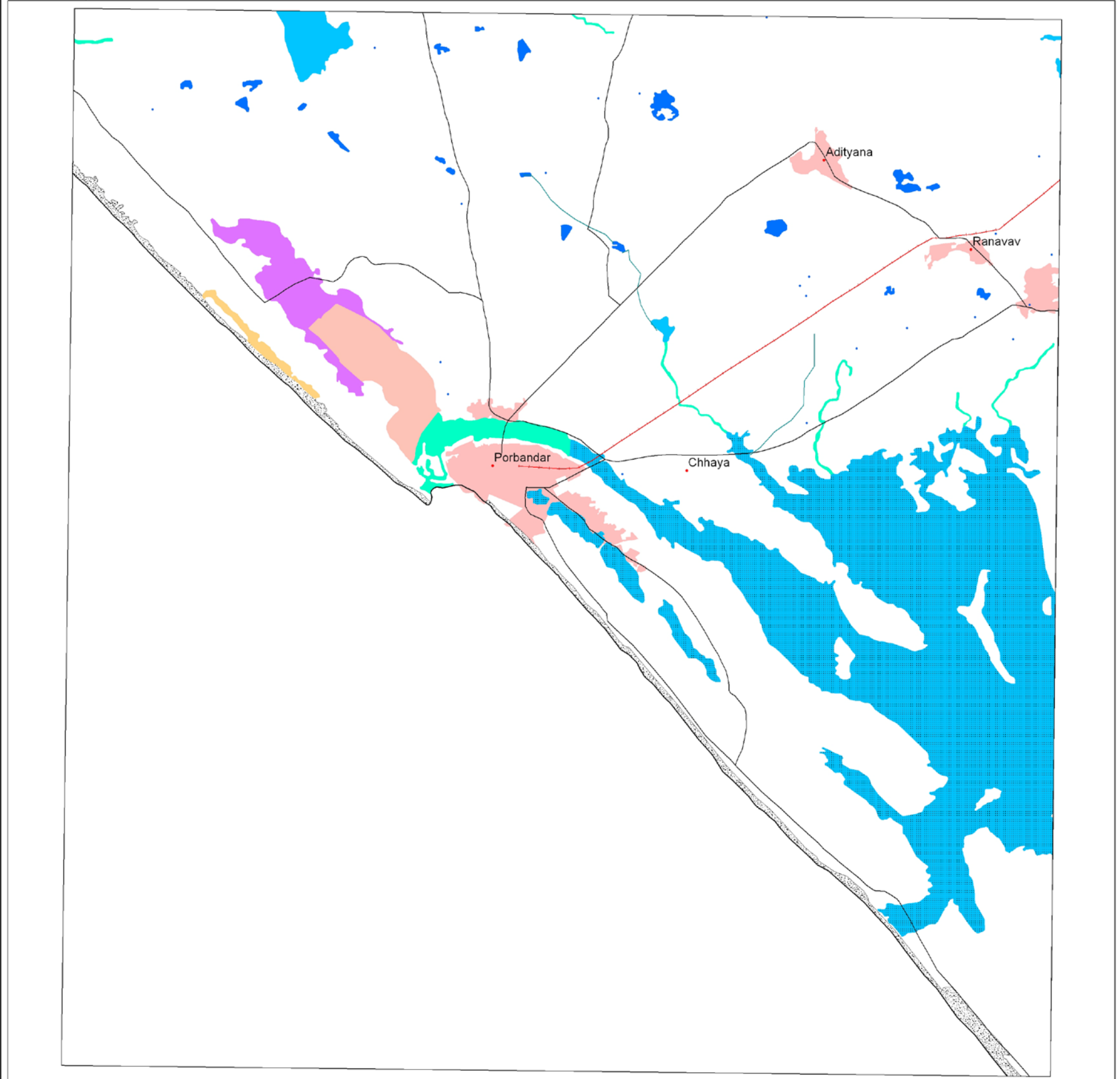
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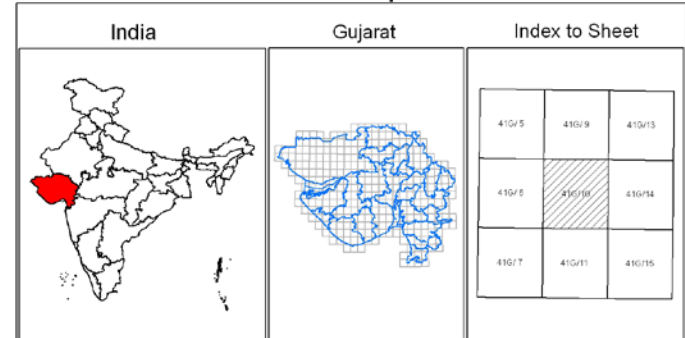


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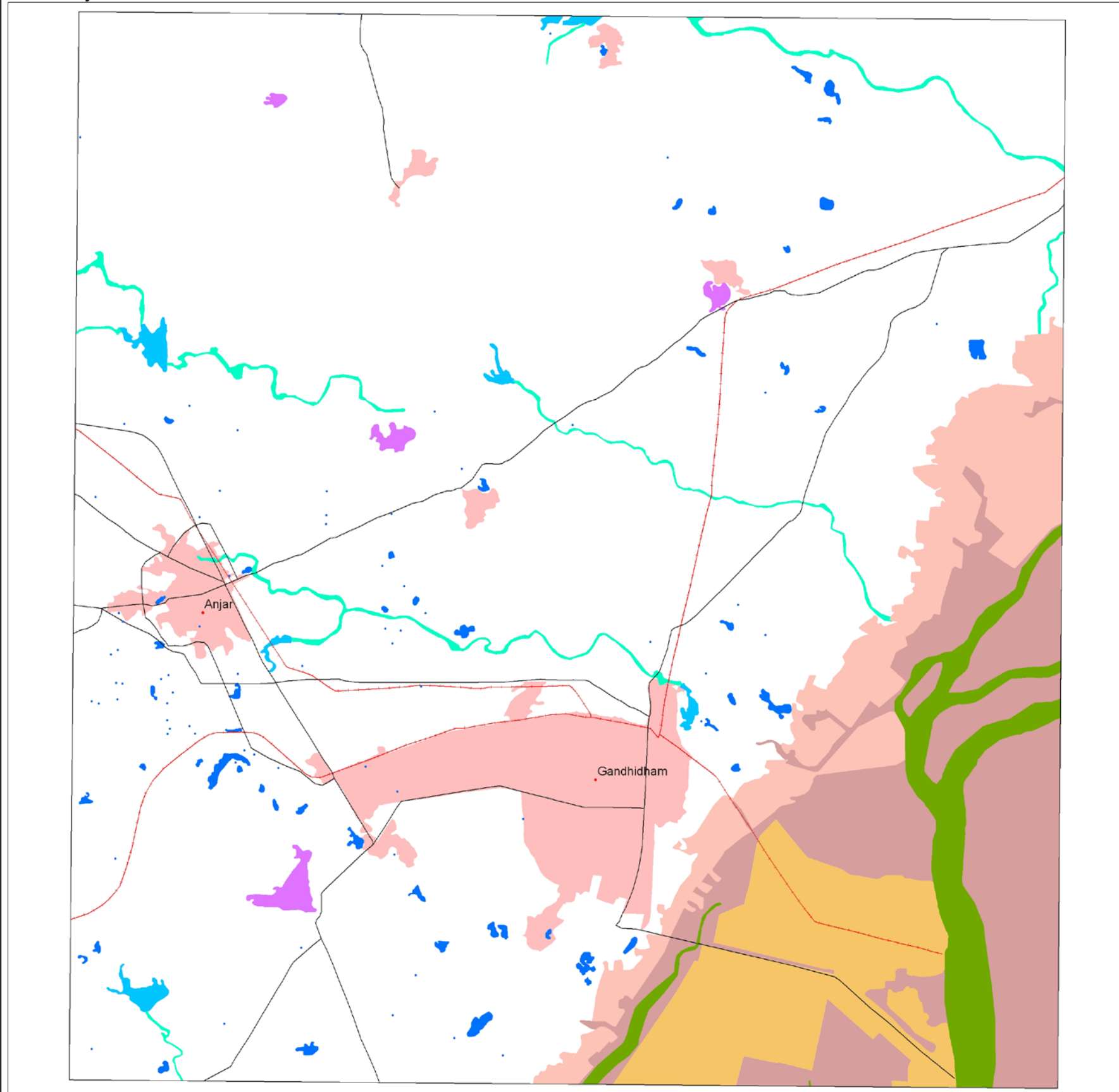
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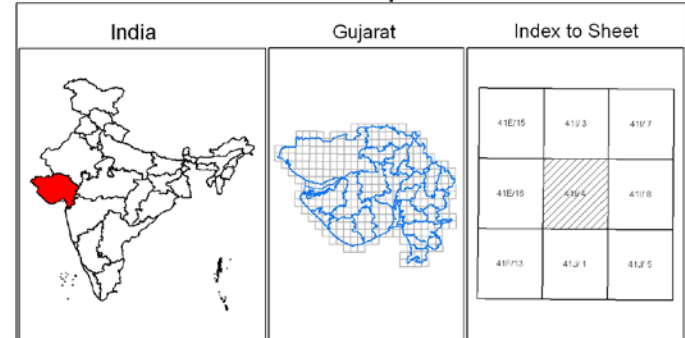


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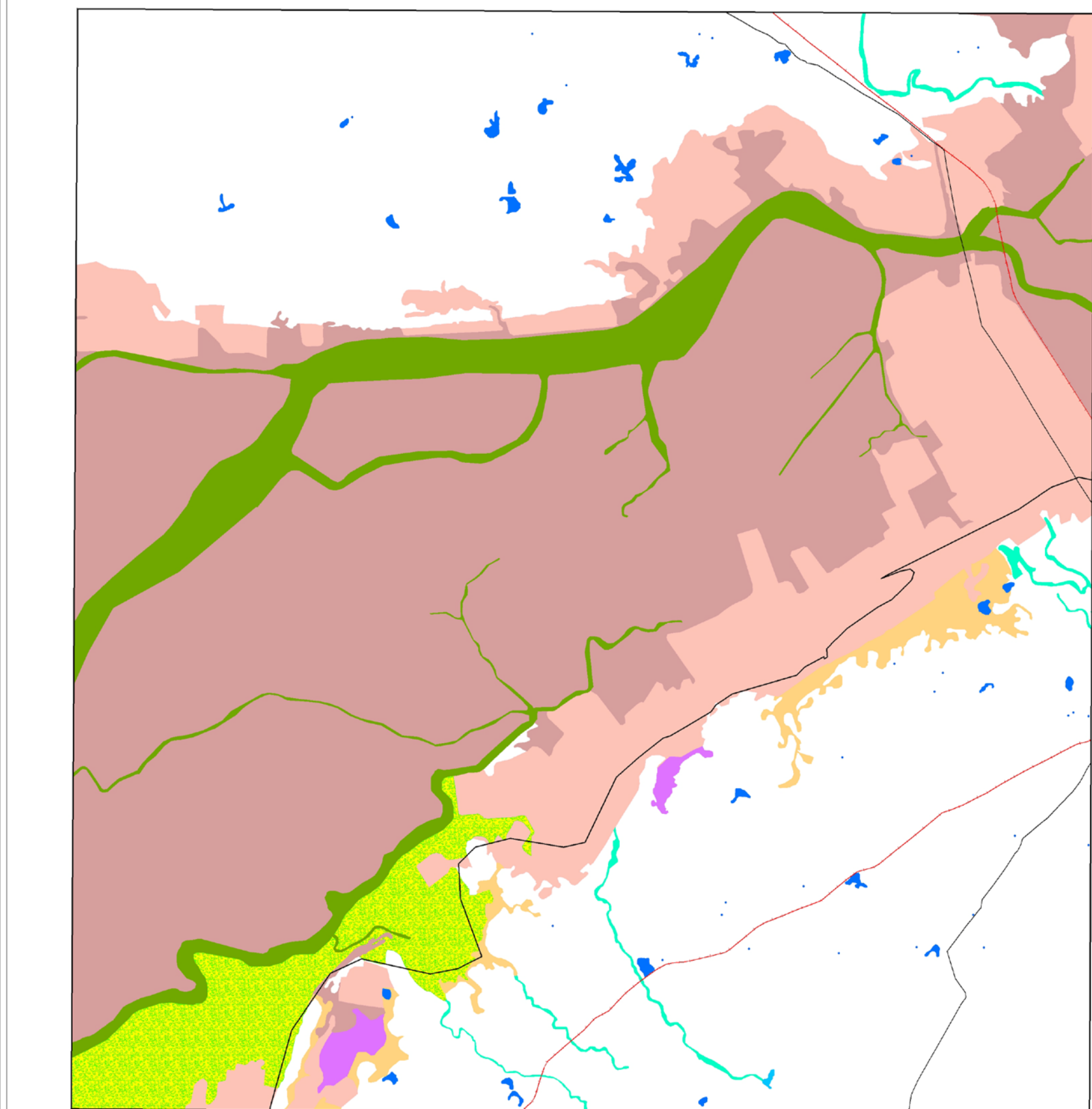
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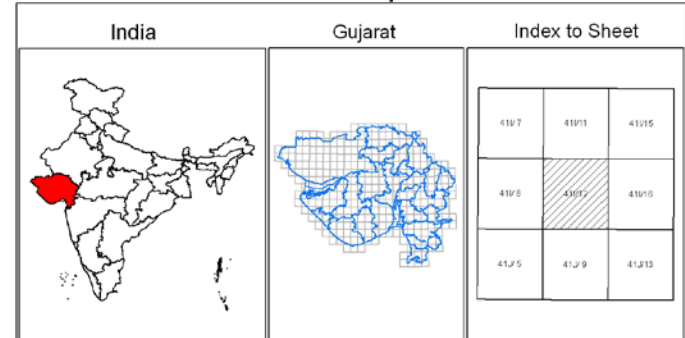


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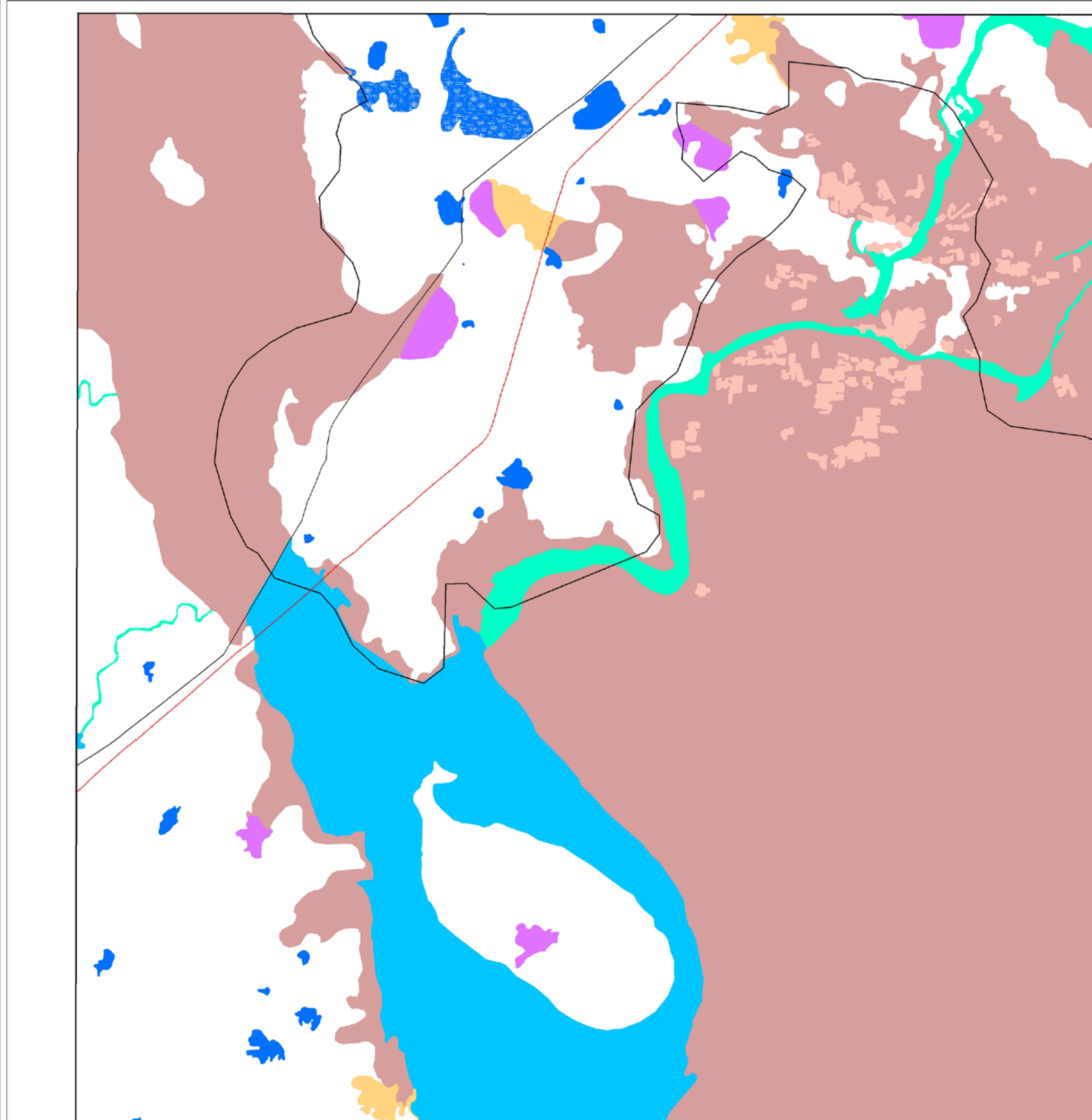
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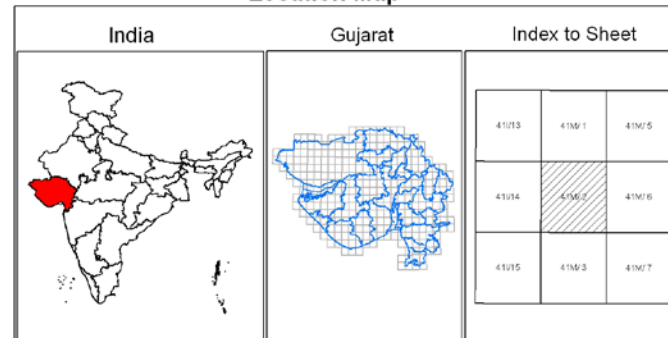


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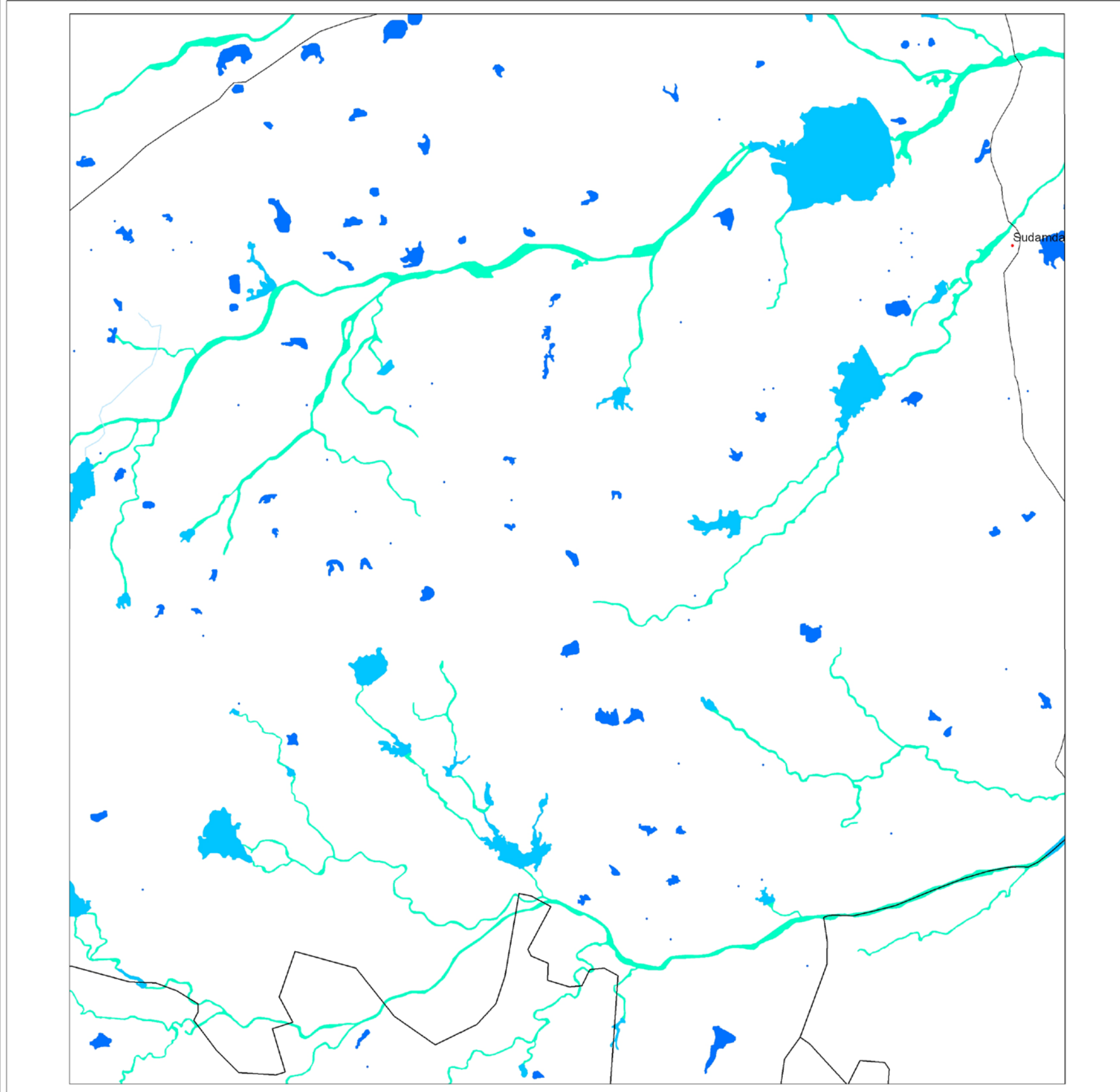
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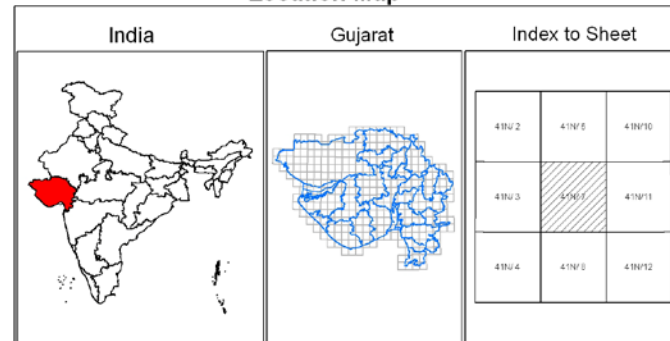


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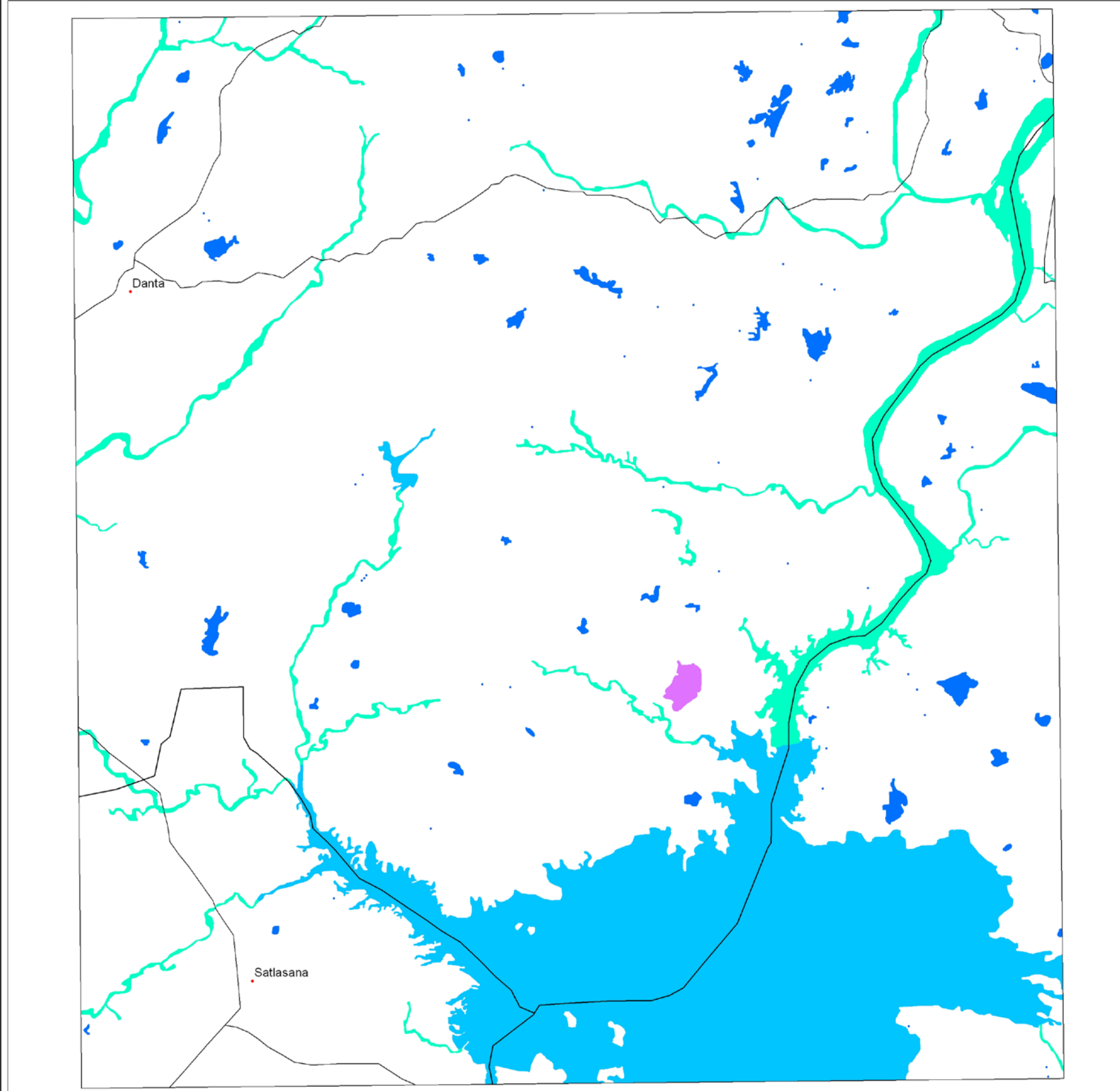
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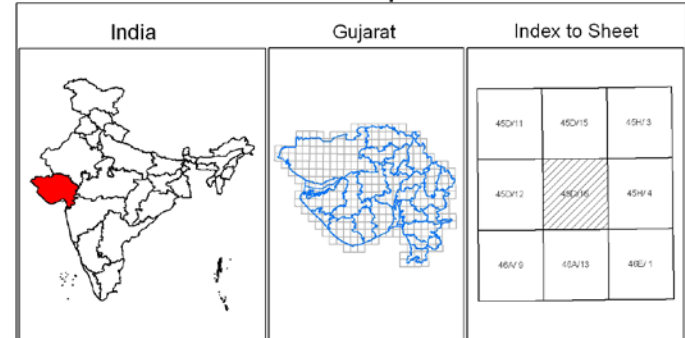


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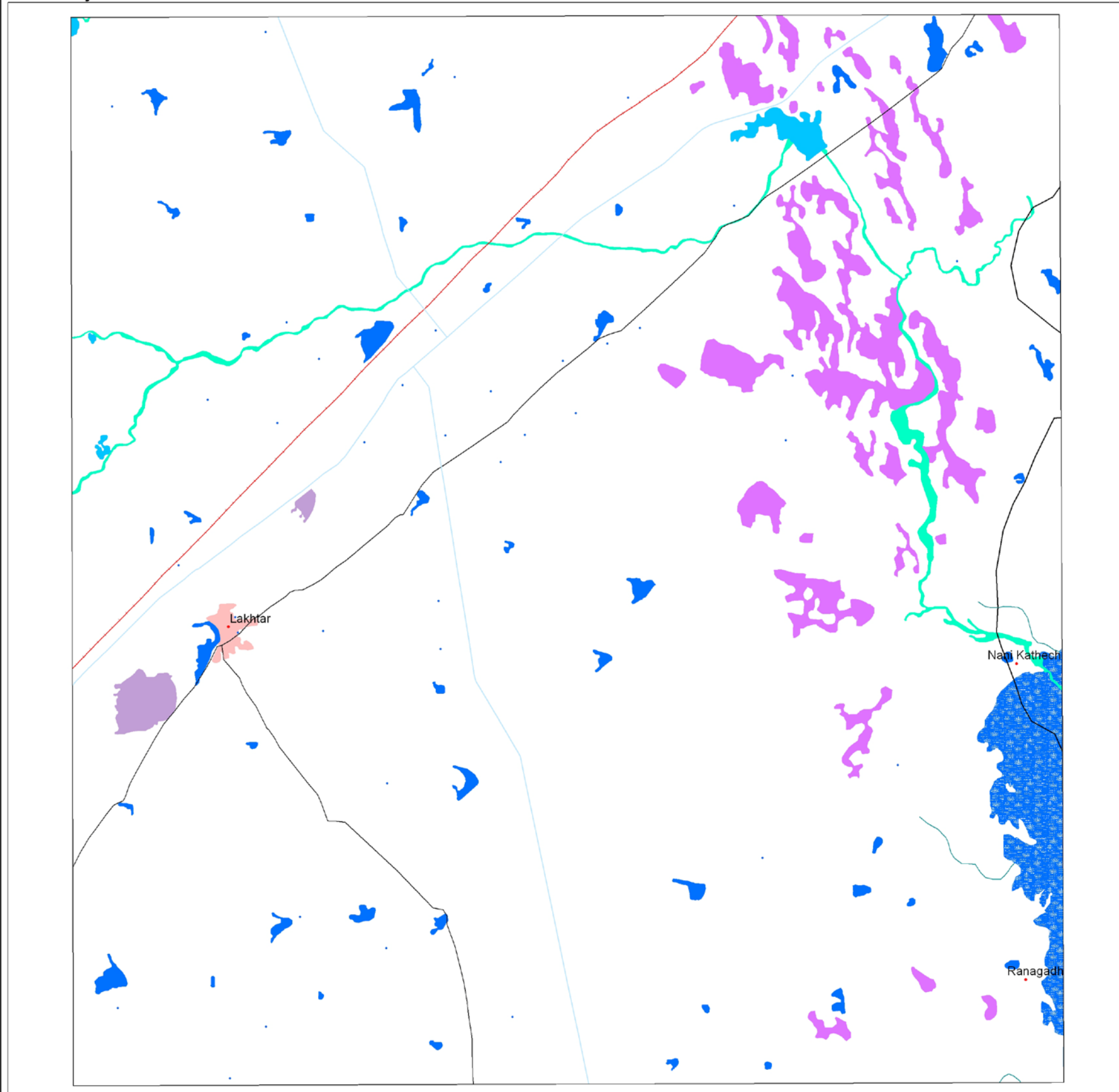
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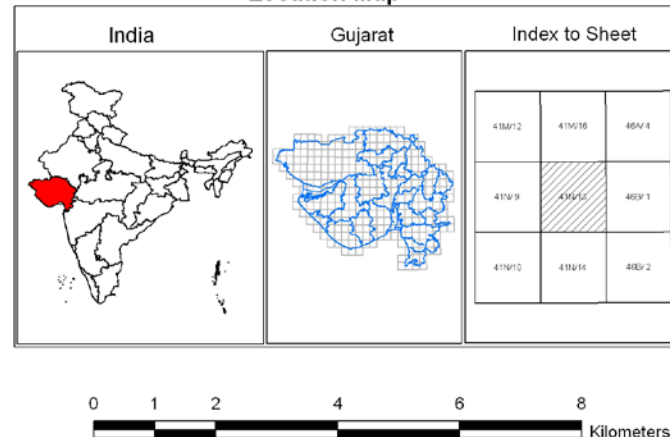


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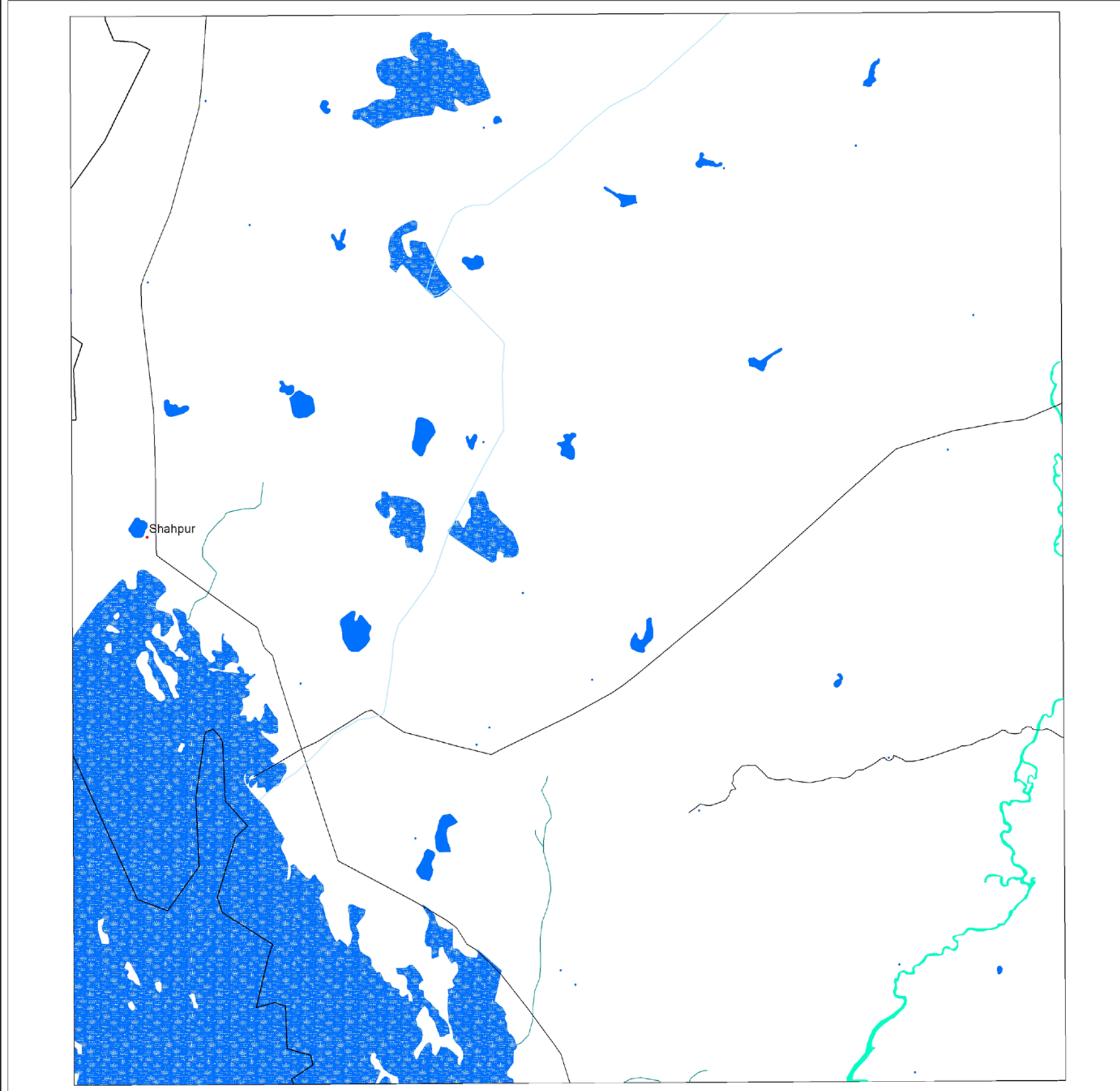
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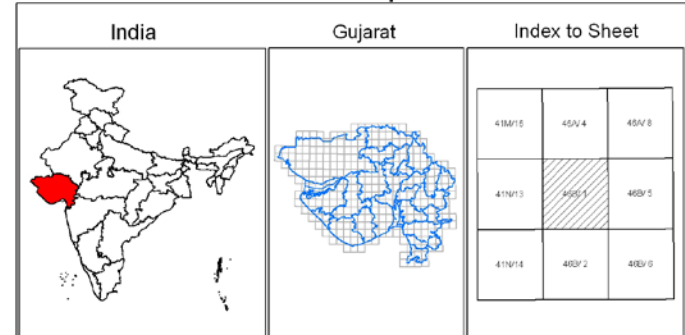


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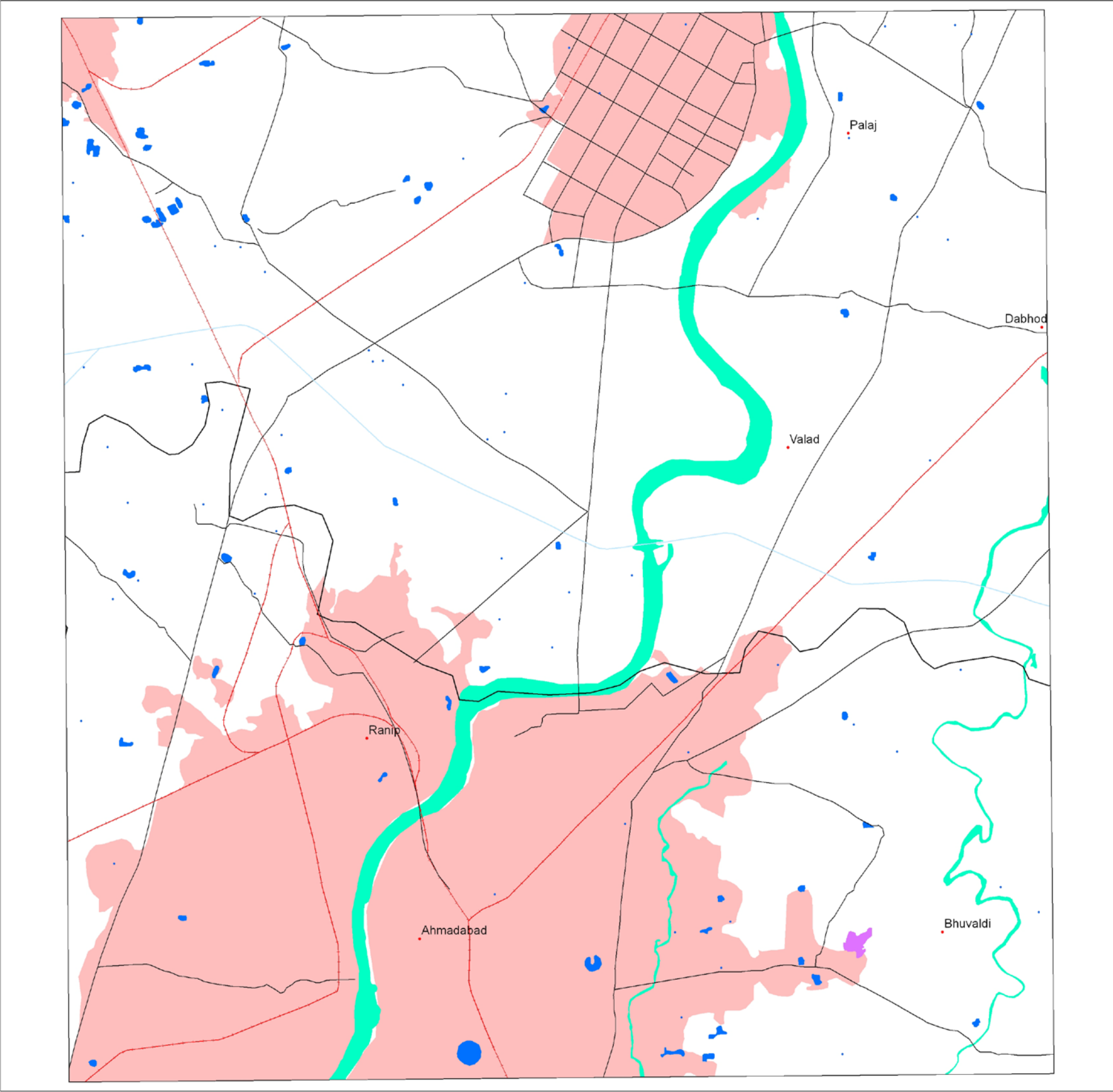
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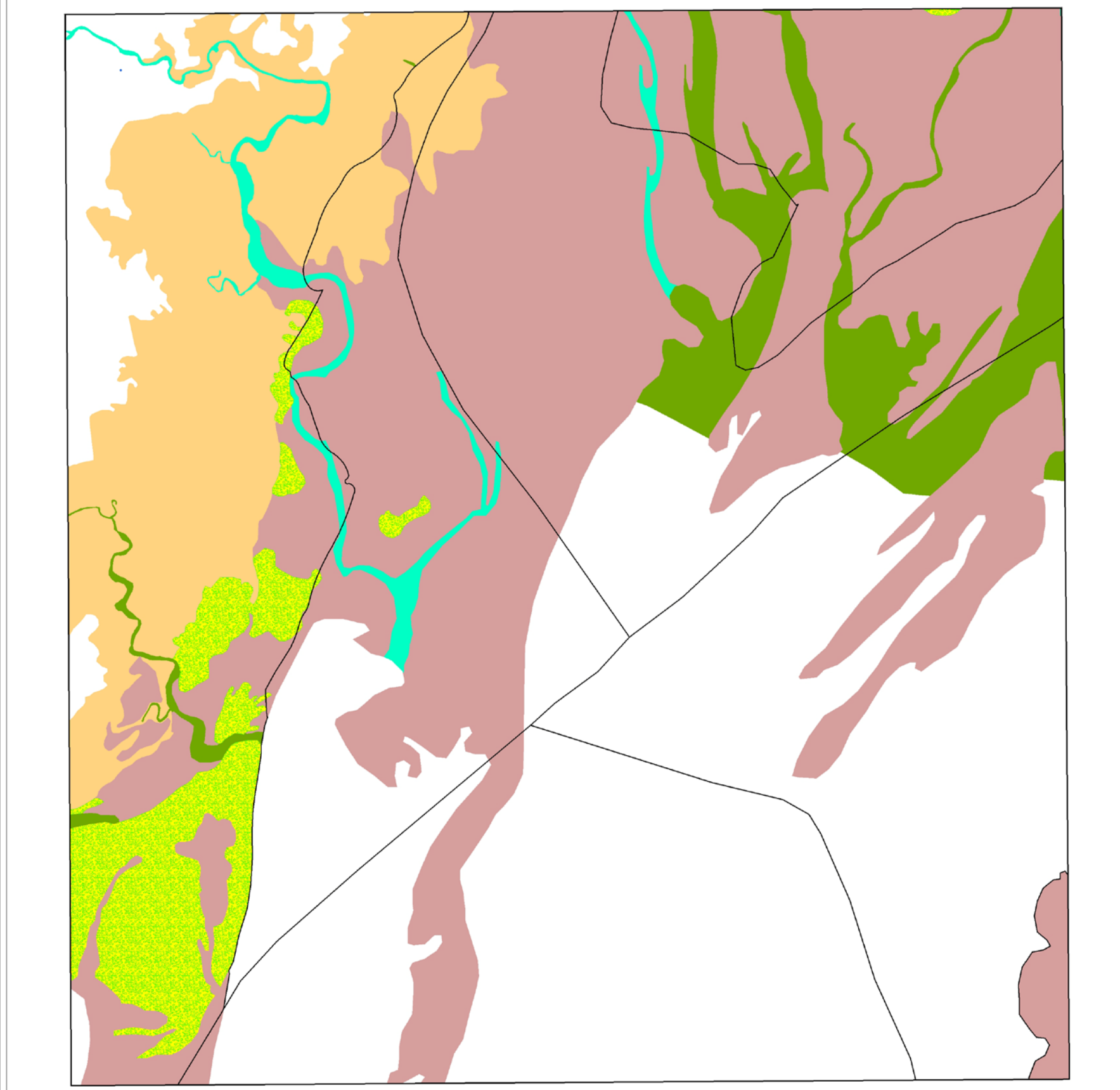
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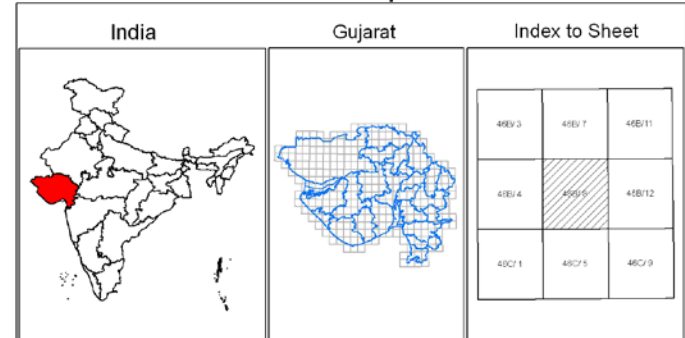


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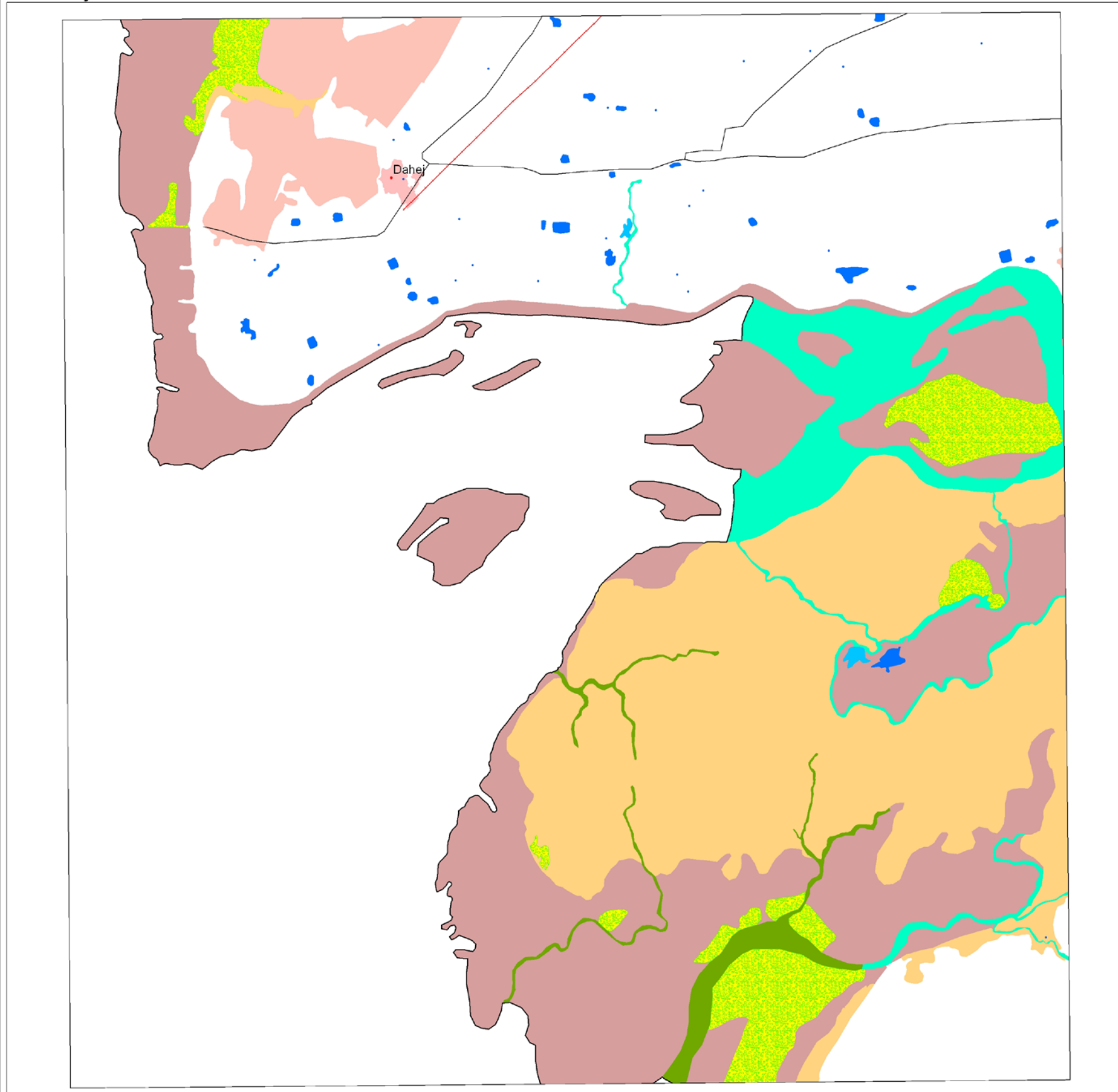
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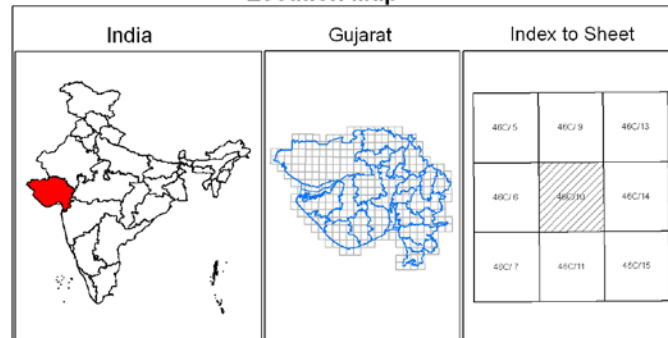


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## REFERENCES

1. Anon. 2005, NNRMS Standards. A National Standards for EO images, thematic & cartographic maps, GIS databases and spatial outputs. ISRO:NNRMS: TR:112:2005. A Committee Report: National Natural Resources Management System, Bangalore
2. Anon. 1993. Directory of Indian Wetlands, 1993. WWF India, New Delhi and AWB Kuala Lumpur, xvi+264pp., 32 maps.
3. Clark, John R. (1977). *Coastal Ecosystem Management*, A Wiley Interscience Publication, John Wiley & Sons, New York,.
4. Cowardin, L.M., Carter, V., Golet, E.C. and La Roe (1979). *Classification of wetlands and deep water habitats*. USFWS/085-79/31, Office of the Biological Services, U.S. Fish and Wildlife Service, Washington, D.C.
5. *Encyclopaedic Directory of Environment* (1988). (Ed. By G.R. Chatwal, D.K. Pandey, and K.K. Nanda). Vol. I-IV, Anmol Publications, New Delhi.
6. Garg, J.K., Singh, T.S. and Murthy, T.V.R. (1998). *Wetlands of India*. Project Report: RSAM/sac/resa/pr/01/98, June 1998, 240 p. Space Applications Centre, Ahmedabad,
7. Garg J.K. and Patel J. G., 2007. National Wetland Inventory and Assessment, Technical Guidelines and Procedure Manual, Technical Report, SAC/EOAM/AFEG/NWIA/TR/01/2007, June 2007, Space Applications Centre, Ahmedabad,
8. *Glossary of Geology* (1974). (Ed. By Margarate G., Robbert, M. Jr. and Wolf, C.L), American Geological Institute, Washington, D.C..
9. Jensen, J.R. (1986). *Introductory Digital Image Processing: A Remote Sensing Perspective*, Prentice Hall, Englewoods Cliff, NJ.
10. Lacaux, J.P., Tourre, Y.M., Vignolles, C., Ndione, J.A. and Lafaye, M. 2007. Classification of ponds from high-spatial resolution remote sensing: Application to Rift valley fever epidemics in Senegal. *Remote Sensing of Environment*, 106, pp. 66-74
11. Lillesand, T.M. and Keifer, R.W. 1987. Remote Sensing and Image Interpretation. John Wiley and Sons, New York.
12. *Manorama Yearbook 2007*
13. *McGraw - Hill Encyclopaedia of Environmental Science* (1974). (Ed. Sybil P. Parkar), McGraw-Hill Book Company, New York.
14. McFeeters, S.K. 1996. The use of Normalised Difference Water Index (NDWI) in the delineation of open water features. *International Journal of remote Sensing*, 7, pp. 1425-1432.
15. Millennium Ecosystem Assessment. 2005, Ecosystems and Human Well-being: A Framework for Assessment, <http://www.MAweb.org>
16. Mitsch, William J. and Gosselink, James G. (1986). *Wetlands*, Van Nostrand Reinhold Company, New York.
17. Navalgund, R.R., Nayak, S.R., Sudarshana, R., Nagaraja, R. and Ravindran, S. 2002. Proceedings of the ISPRS Commission VII. Symposium on Resource and Environmental Monitoring, IAPRS & SIS, Vol.35, Part-7, NRSA, Hyderabad.
18. Patel J.G., Singh T.S., Garg J.K. et al, Wetland Information System, West Bengal, SAC/RSAM/RESA/FLPG/WIS/01/2003, A Technical report: Space Applications Centre, Ahmedabad
19. Ramsar Convention (2007). [www.ramsar.org](http://www.ramsar.org)
20. Reid, George K and Wood, Richard D. (1976). *Ecology of Inland Waters and Estuaries*. D. Van Nostrand Company, New York.
21. SACON, 2004, Inland Wetlands of India : Conservation Atlas. Coimbatore, Salim Ali Centre for Ornithology and Natural History, 2004, ISBN 81-902136-1-X. ,Vedams eBooks (P) Ltd. Vardhaman Charve Plaza IV, Building # 9, K.P Block, Pitampura,
22. Singh T.S., Patel J.G., Garg J.K. et al. Loktak Lake Resources Information System (LRIS), SAC/RSAM/RESIPA/FLPG/WIS/02/2003, A Technical report: Space Applications Centre, Ahmedabad
23. Townshend, J.R., and Justice, C.O. 1986. Analysis of dynamics of African vegetation using the Normalised difference Vegetation Index. *International Journal of Remote Sensing*, 7, pp. 1435-1445.
24. Tucker, C.J. and Sellers, P.J. 1986. Satellite remote sensing of primary productivity. *International Journal of Remote Sensing*, 7, pp. 1395-1416.
25. Xu Hanqiu, 2006. Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. *International Journal of Remote Sensing*, 7, pp. 3025-3033.





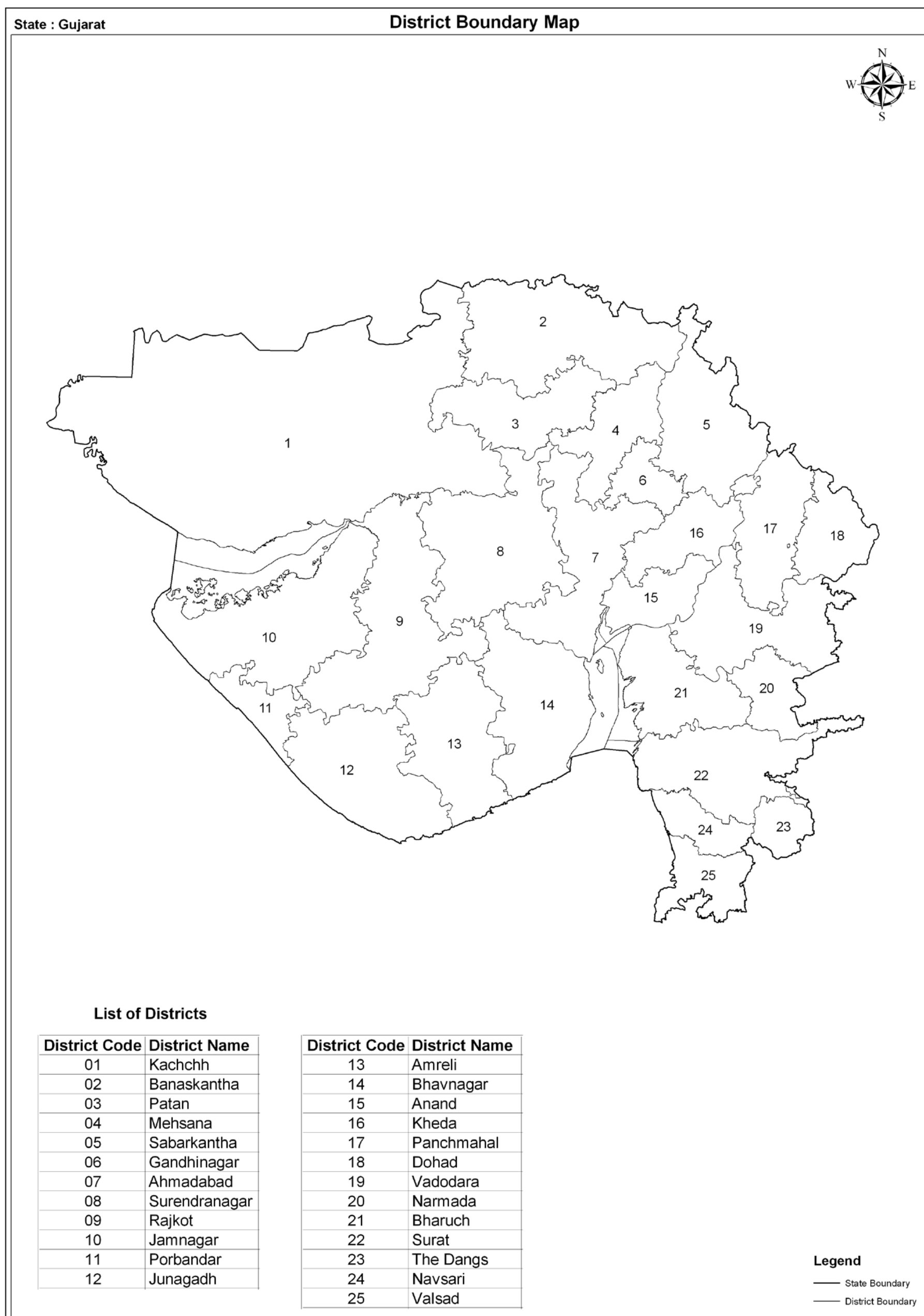
**Annexure I**  
**Definitions of wetland categories used in the project**

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

<b>Wetland type code</b>	<b>Definition and description</b>
1000	<b>Inland Wetlands</b>
1100	<b>Natural</b>
1101	<b>Lakes:</b> Larger bodies of standing water occupying distinct basins (Reid <i>et al</i> , 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different hues of blue interspersed with pink (aquatic vegetation), islands (white if unvegetated, red in case of terrestrial vegetation). Vegetation if scattered make texture rough.
1102	<b>Ox-bow lakes/ Cut off meanders:</b> 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 <i>et al</i> , 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	<b>High Altitude lakes:</b> 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	<p><b>Riverine Wetlands:</b> Along the major rivers, especially in plains water accumulates leading to formation of marshes and swamp. <b>Swamps</b> 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 <i>Sphagnum</i>) could be called a swamp. In some areas reed grass - dominated wetlands are also called swamps). (Mitsch and Gosselink, 1986).</p> <p><b>Marsh:</b> 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.</p> <p><b>Comment:</b> Using satellite data it is difficult to differentiate between swamp and marsh. Hence, both have been clubbed together.</p>
1105	<b>Waterlogged:</b> Said of an area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die (Margarate <i>et al</i> , 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	<b>River/stream:</b> 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 Caverry river is a bird sanctuary etc.). Wherever, rivers are wide and features like sand bars etc. are visible, they will be mapped.
1200	<b>Man-made</b>
1201	<p><b>Reservoir:</b> A pond or lake built for the storage of water, usually by the construction of a dam across a river (Margarate <i>et al</i>, 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.</p> <p><b>Barrage:</b> 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.</p>

1202	<p><b>Tanks/Ponds:</b> A term used in Ceylon and the drier parts of Peninsular India for an artificial pond, pool or lake formed by building a mud wall across the valley of a small stream to retain the monsoon (Margarate <i>et al</i>, 1974). <b>Ponds</b> 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 <i>et al</i>, 1976). Tanks appear in light blue colour showing bottom reflectance.</p> <p>In this category <b>Industrial ponds/mining pools mainly comprising Abandoned Quarries are also included</b> (Quarry is defined as "An open or surface working or excavation for the extraction of stone, ore, coal, gravel or minerals." In such pits water accumulate (McGraw Hill Encyclopaedia of Environmental Sciences, 1974), <b>Ash pond/Cooling pond</b> (The water body created for discharging effluents in industry, especially in thermal power plants (Encyclopaedic Directory of Environment, 1988) and <b>Cooling pond:</b> An artificial lake used for the natural cooling of condenser-cooling water serving a conventional power station (Encyclopaedic Directory of Environment, 1988). These ponds can be of any shape and size. Texture is rough and tonal appearance light (quarry) to blue shade (cooling pond).</p>
1203	<p><b>Waterlogged :</b> Man-made activities like canals cause waterlogging in adjacent areas due to seepage especially when canals are unlined. Such areas can be identified on the images along canal network. Tonal appearance is in various hues of blue. Sometimes, such waterlogged areas dry up and leave white scars on the land. Texture is smooth.</p>
1204	<p><b>Salt pans:</b> 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.</p>
2000	<b>Coastal Wetlands</b>
2100	<b>Natural</b>
2101	<p><b>Lagoons/Backwaters:</b> 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 <i>et al</i>, 1976). <b>Backwater:</b> A creek, arm of the sea or series of connected lagoons, usually parallel to the coast, separated from the sea by a narrow strip of land but communicating with it through barred outlets (Margarate <i>et al</i>, 1974).</p>
2102	<p><b>Creek:</b> 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.</p>
2103	<p><b>Sand/Beach:</b> Beach is an unvegetated part of the shoreline formed of loose material, usually sand that extends from the upper berm (a ridge or ridges on the backshore of the beach, formed by the deposit of material by wave action, that marks the upper limit of ordinary high tides and wave wash to low water mark(Clark,1977).Beach comprising rocky material is called rocky beach.</p>
2104	<p><b>Intertidal mudflats:</b> Most unvegetated areas that are alternately exposed and inundated by the falling and rising of the tide. They may be mudflats or sand flats depending on the coarseness of the material of which they are made (Clark, 1977).</p>
2105	<p><b>Salt Marsh:</b> 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.</p>
2106	<p><b>Mangroves:</b> 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.</p>
2107	<p><b>Coral reefs:</b> Consolidated living colonies of microscopic organisms found in warm tropical waters. The term coral reef, or organic reef is applied to the rock- like reefs built-up of living things, principally corals. They consist of accumulations of calcareous deposits of corals and corraline algae with the intervening space connected with sand, which consists largely of shells of foraminefera. Present reefs are living associations growing on this accumulation of past (Clark, 1977). Reefs appear in light blue shade.</p>
2200	<b>Man-made</b>
2201	<p><b>Salt pans:</b> An undrained usually small and shallow rectangular, man-made depression or hollow in which saline water accumulates and evaporates leaving a salt deposit (Margarate <i>et al</i>, 1974). Salt pans are square or rectangular in shape. When water is there appearance is blue while salt is formed tone is white.</p>
2202	<p><b>Aquaculture ponds:</b> Aquaculture is defined as "The breeding and rearing of fresh-water or marine fish in captivity. Fish farming or ranching". The water bodies used for the above are called aquaculture ponds (Encyclopaedic Directory of Environment, 1988). Aquaculture ponds are geometrical in shape usually square or rectangular. Tone is blue.</p>

**Annexure – II**  
**Details of District information followed in the atlas**



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





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