NATIONAL WETLAND ATLAS:

PUNJAB

Sponsored by

Ministry of Environment and Forests

Government of India

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015

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

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

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

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

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

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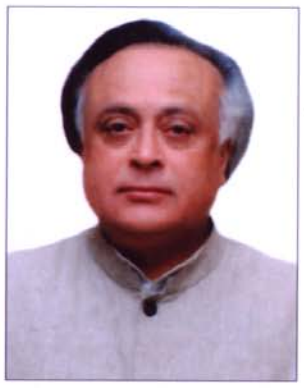
जयराम रमेश
JAIRAM RAMESH



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MESSAGE

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

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

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

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

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

(Jairam Ramesh)

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सत्यमेव जयते

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FOREWORD

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

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

January 25, 2010

(Ranganath R. Navalgund)

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

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

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(Sushma Panigrahy)

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1.0 INTRODUCTION

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

1.1 Wetlands

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

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

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

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

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

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

1.2 Mapping and Geospatial Technique

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

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

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

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.

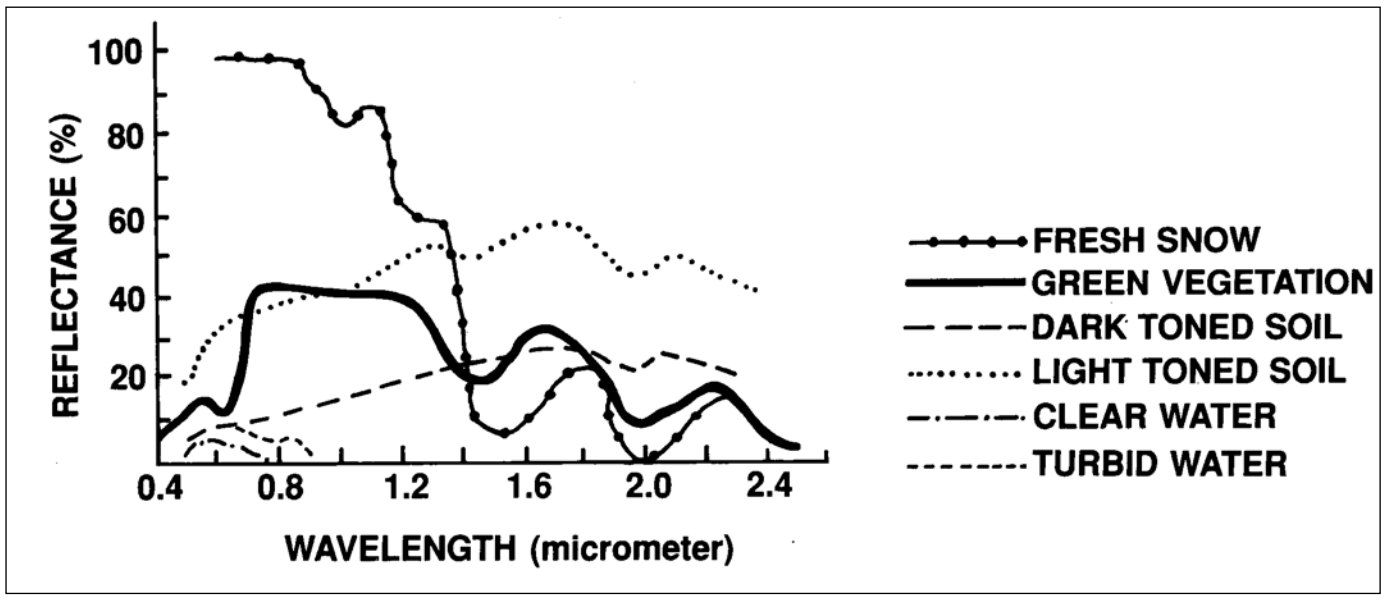
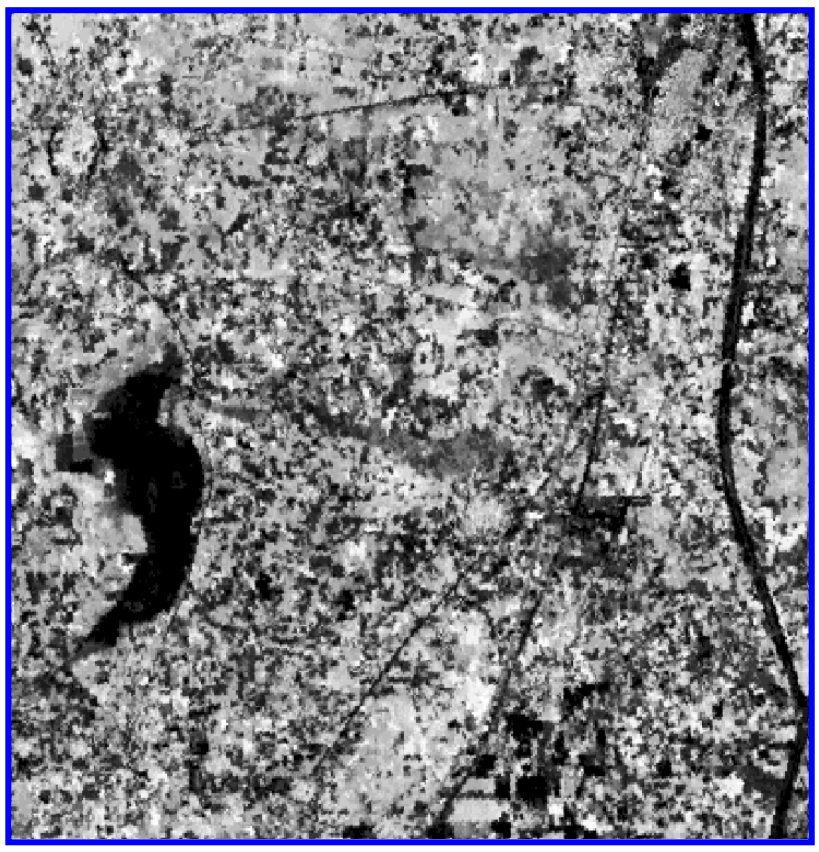
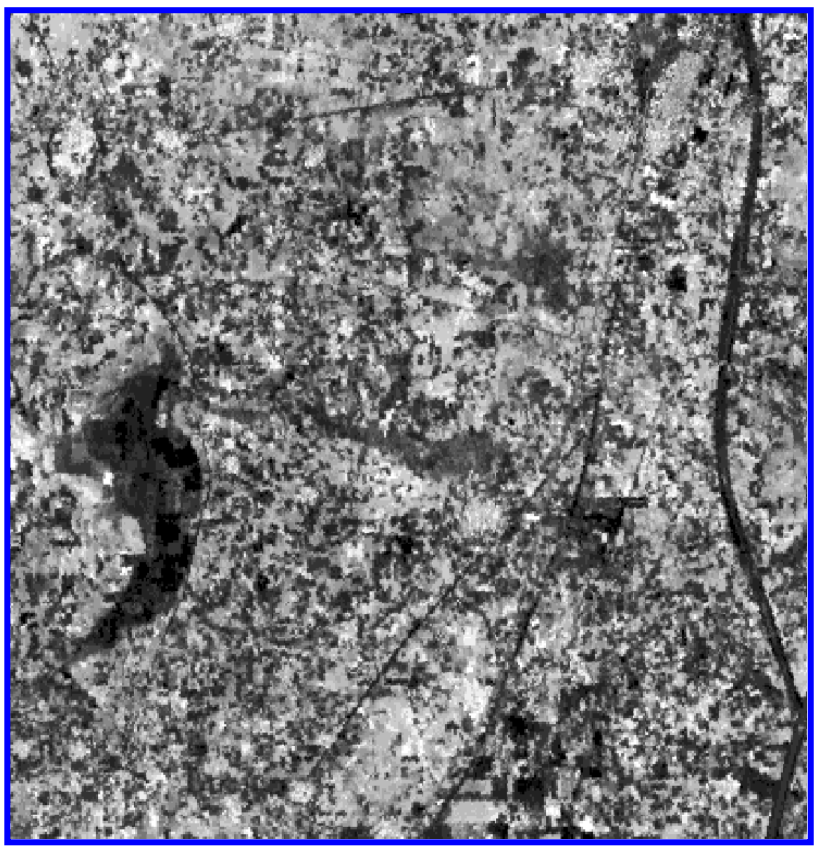


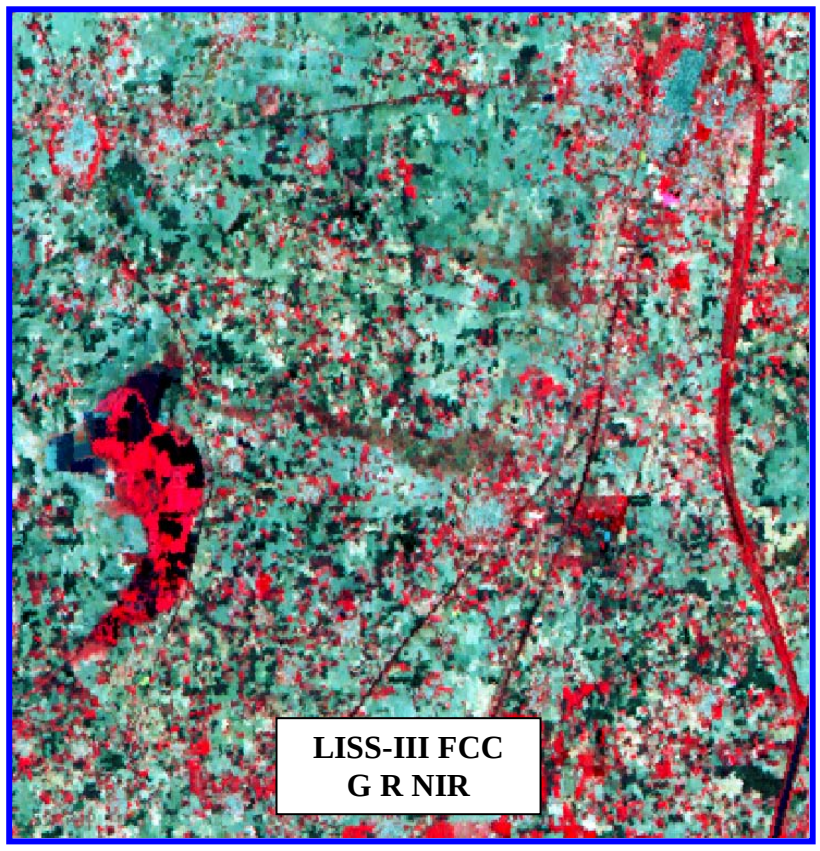
Figure 1: Spectral Signature of various targets



Red

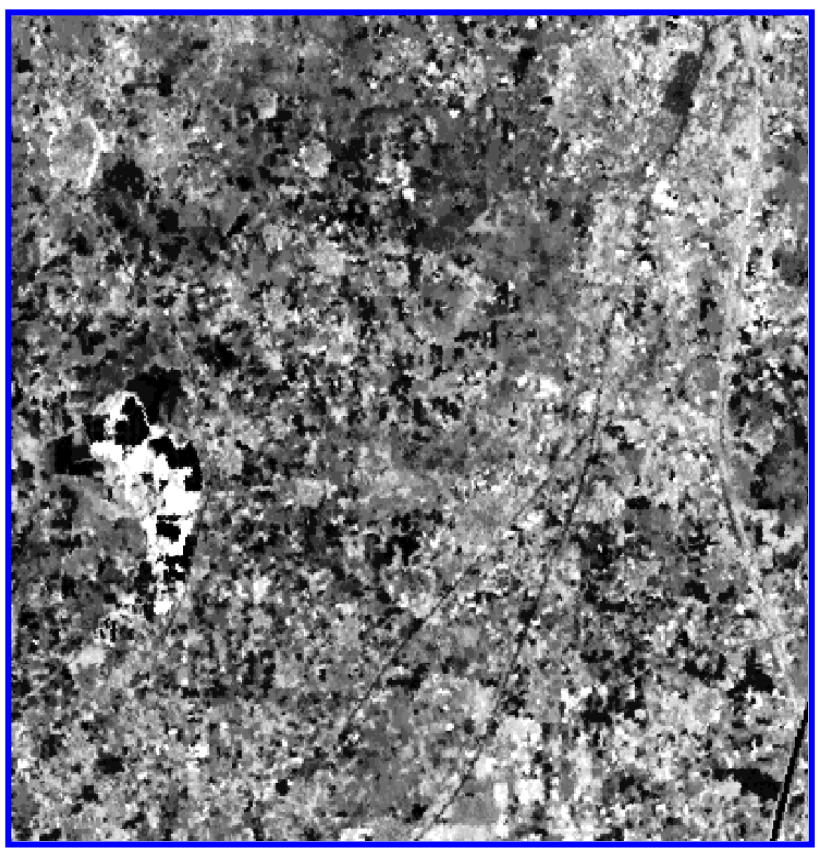


Green



NIR

SWIR



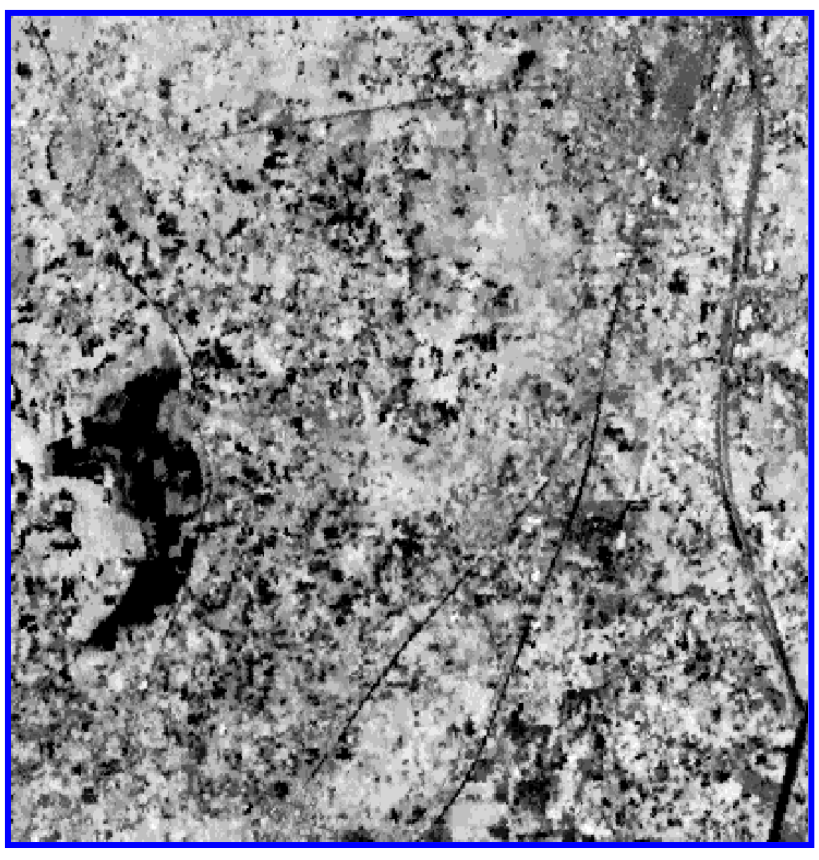


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC

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). Ramsar convention entered into force in 1975. Under the text of the Convention (Article 1.1) wetlands are defined as:

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

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

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

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

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

2.0 NATIONAL WETLAND INVENTORY AND ASSESSMENT (NWIA) PROJECT

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

The main objectives of the project are:

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

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

2.1 Wetland Classification System

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

2.2 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

Punjab lies between latitudes of 29^0 30' to 32^0 32' North and longitudes of 73^0 55' to 76^0 50' East. Geographic area of the state is 50362 sq km. The western Himalayas be in its north and the Thar Desert in its Southwest. It is bounded by Pakistan in the west, State of Jammu & Kashmir in the North, Himachal Pradesh in the northeast, Haryana in the south and Rajasthan in the southwest. Chandigadh is a union territory and technically, it is not a part of Punjab state however, it is the capital of Punjab. Location map is shown in Figure-3.

Punjab, an Indo-Iranian word, is a combination of 'Punj' meaning five and 'Aab' meaning water, i.e. it is the land of five rivers. The Ravi, the Beas, the Satluj, the Indus, and Ghaggar River drain Punjab. The rivers of Punjab have played an active role in the geography of Punjab. Among all rivers the sutluj is being considered the most important river of the Punjab. Some of the important towns are exist on the banks of the rivers are Rampur, Bilaspur, Ropar, Ludhiana, Harika, and Ferozpur. The Harapan culture was linked to these great rivers.

Punjab falls into six physiographic regions such as Hills (siwaliks),Piedmont plains (slopping), Plains (nearly level), sand dunes (tibbas), Flood plains (bet areas) and old palaeo channels. However, the major physiographic regions are two; the Siwalik hills and the plains. Siwalik hills consists of conglomerates, clays and silt, all having the characteristics of fluvial deposits of rivers and streams. The Punjab plain is a part of the great Indo-Gangetic plain that is a synclinal basin formed by the elevation of the Himalayas. It covers two-third of the total geographical area of the state.

The climate varies from extremely hot and dry during the summer season to fairly cold and dry during the winter season. The minimum temperature rarely drops to below 0^0 C, the maximum frequently exceeds 45^0 C in May and June. The amount of rainfall in the Punjab ranges between 250 mm and 1000 mm the maximum falling near the Siwalik Hills.

Some of the important wetlands are Harike Reservoir, Kanjli Wetland, Ropar Wetland, Dholbaha Reservoir, Januari Reservoir and Ranjit Sagar Reservoir. Bakra Nangal complex, Harike, Ropar, Kanjali and. The Bakhra Nangal project is the most prestigious hydro electric project of India, which harnesses the water of river Sutluj. The Bhakra Nangal project not only provides electric power to Punjab but also to Haryana, Rajasthan, Himachal Pradesh, Delhi, and Jammu & Kashmir. Harike, Ropar, Kanjali are notified wetlands by Ministry of Environment and Forests, Govt. of India. The ecological characteristics of there wetlands is at risk of particularly due to siltation, weed infestation, pollution and encroachment. This has not only inflicted damage to the associated biological diversity but also is adversely affecting the sustainability of ecosystem.

Punjab is covered in one hundred six 1:50,000 scale Survey of India topographical maps that form the spatial frame work for mapping (Figure 4).

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

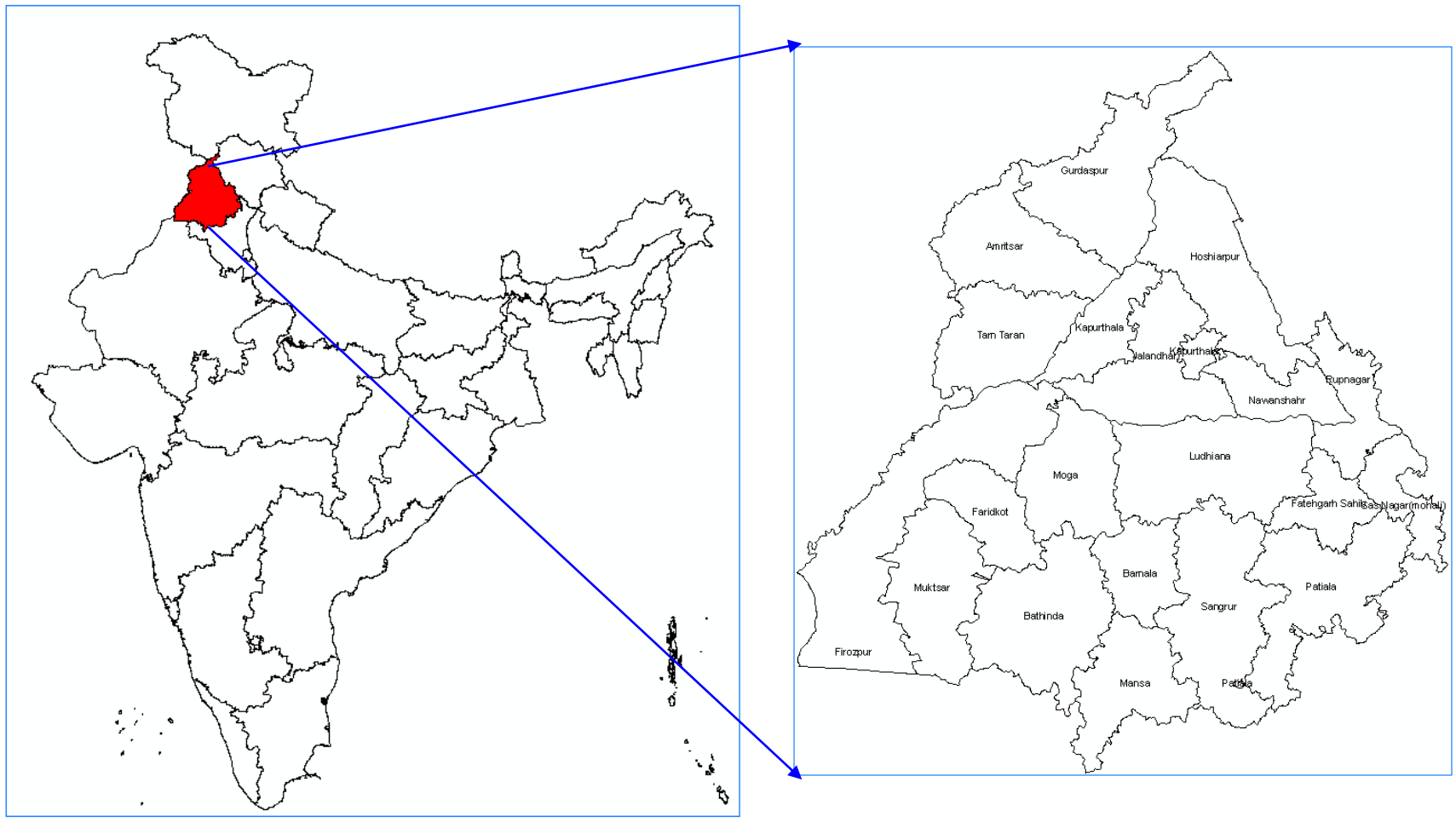


Figure 3: Location map

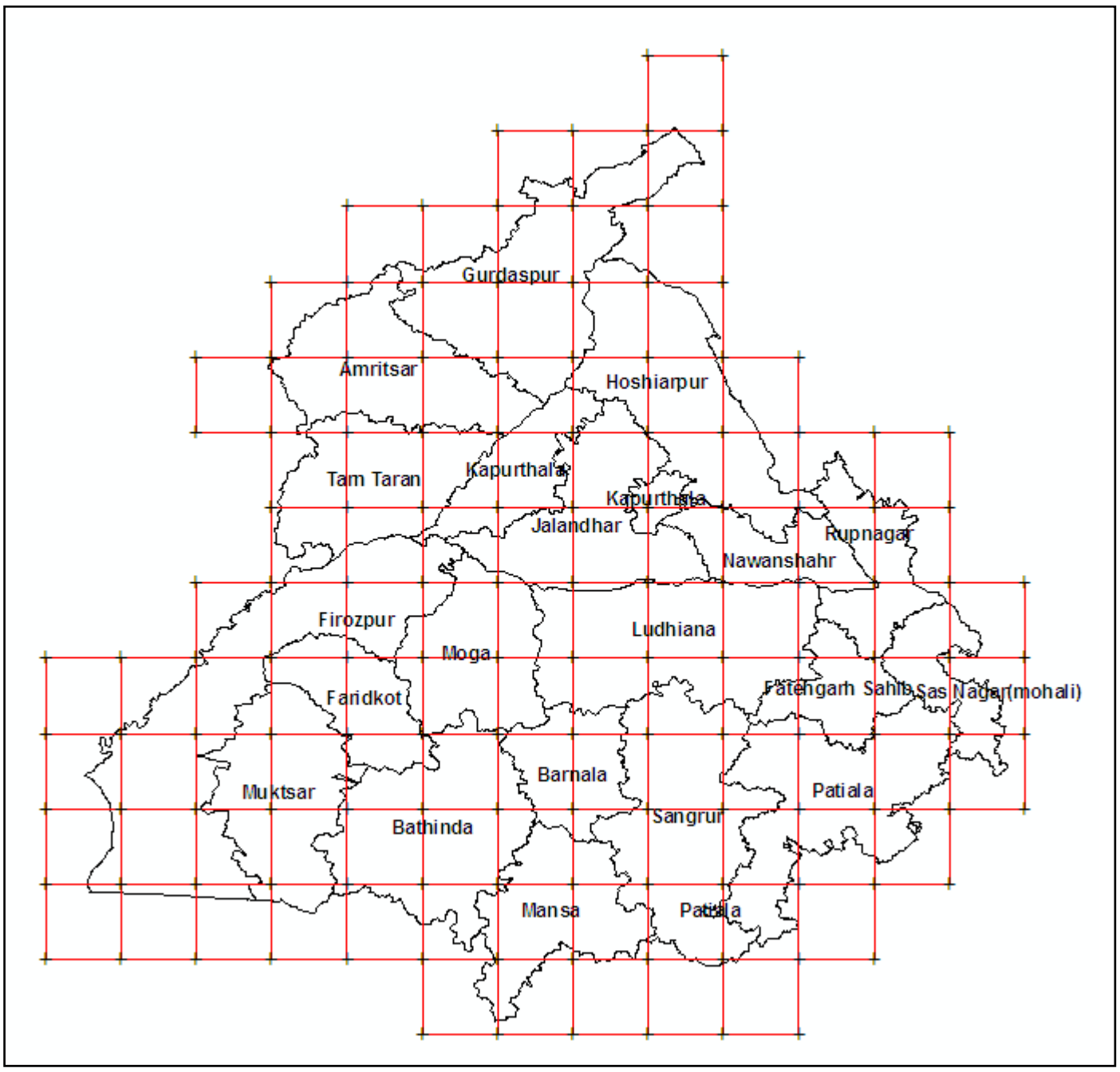


Figure 4: Spatial framework of Punjab

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 Punjab is covered in 8 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 Punjab as seen in the LISS III FCC of post-monsoon pre-monsoon data respectively.

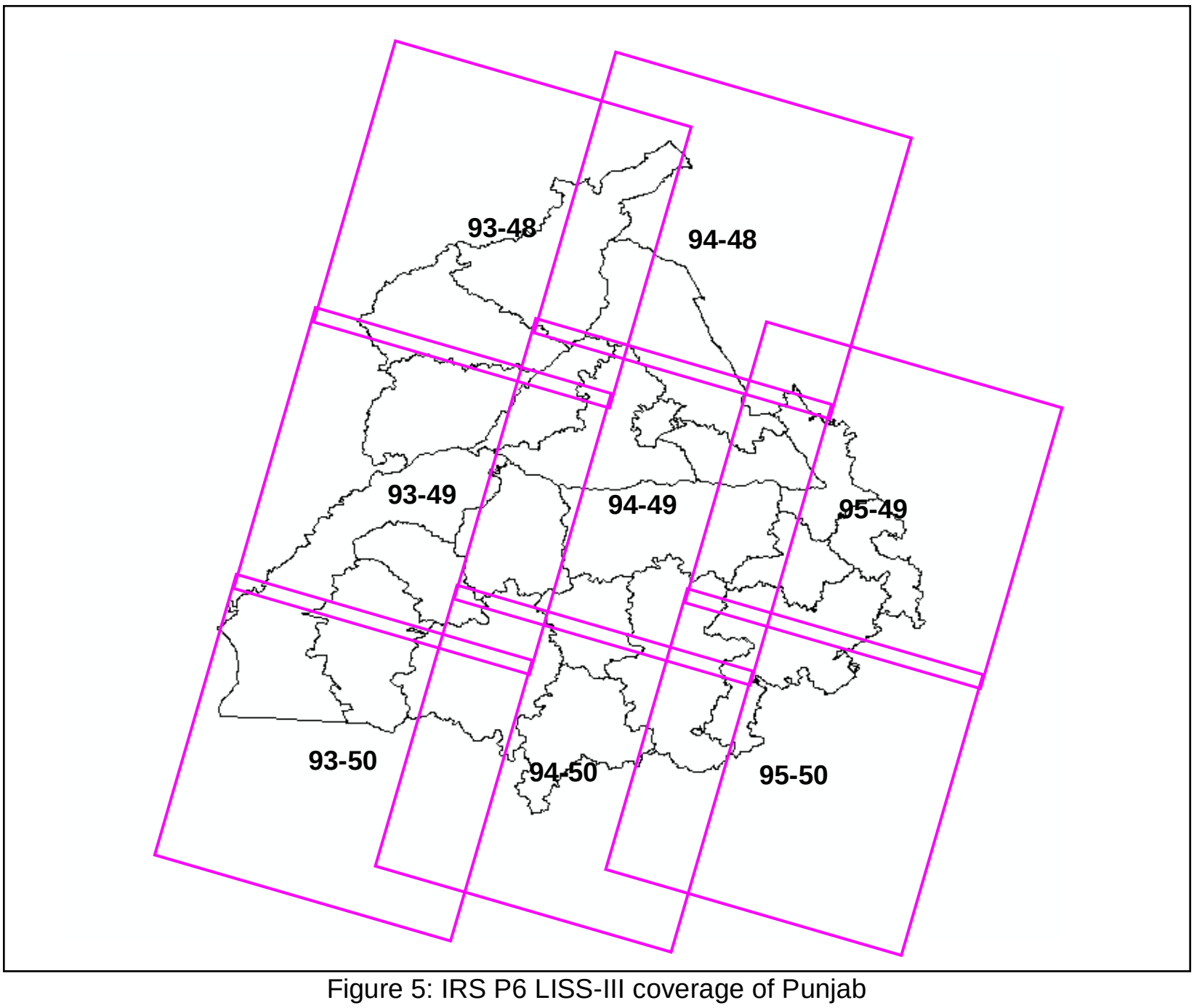


Figure 5: IRS P6 LISS-III coverage of Punjab

Table-2: Satellite data used

Sl. No.	IRS P6 LISS-III Path Row	Date of acquisition	
		Post-Monsoon (2006)	Pre-Monsoon (2007)
1	93-48	Oct 19, 2006	May 23, 2007
2	93-49	Oct 19, 2006	May 23, 2007
3	93-50	Oct 19, 2006	May 23, 2007
4	94-49	Oct 24, 2006	Apr 10, 2007
5	94-50	Oct 24, 2006	Apr 10, 2007
6	95-50	Oct 5, 2006	May 9, 2007
7	94-48	Oct 24, 2006	Apr 10, 2007
8	95-49	Oct 5, 2006	May 9, 2007

4.2 Ground truth data

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

4.3 Other data

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

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 software.

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 Punjab 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.

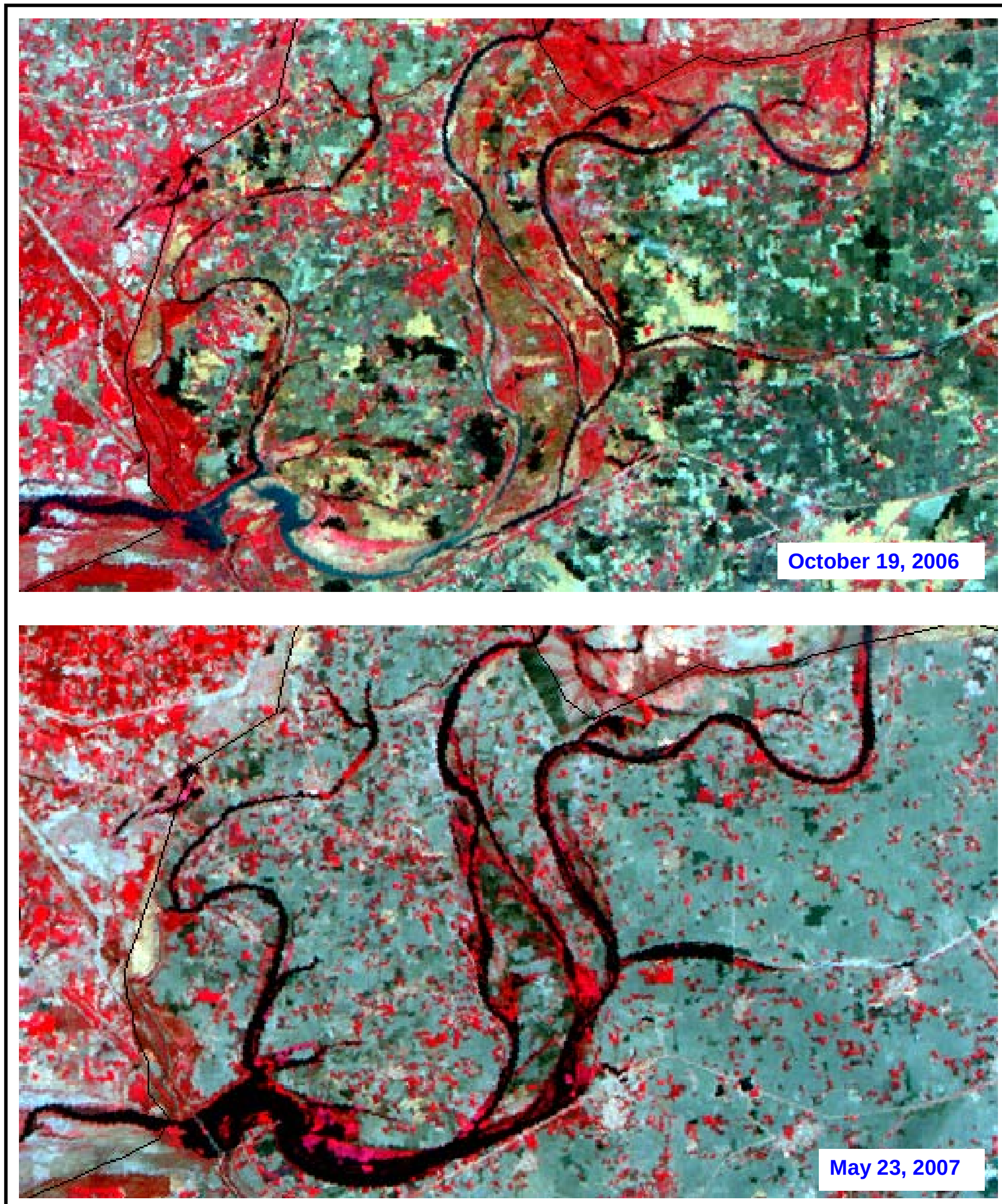


Figure 6: IRS LISS-III FCC (Post-monsoon and Pre-monsoon), Part of Punjab state

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

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

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

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

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

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

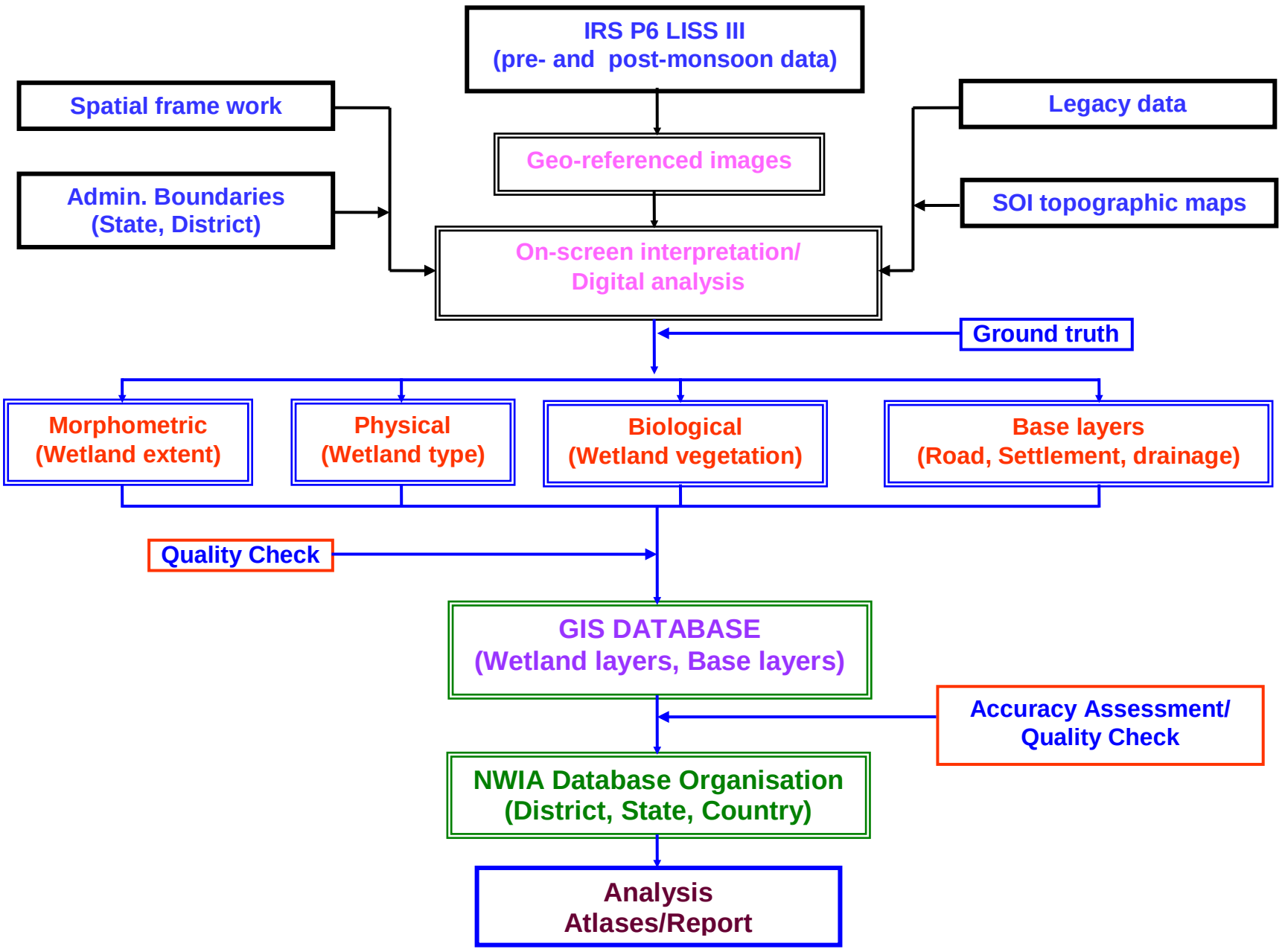


Figure 7: Flow chart of the methodology used

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

- Extraction of wetland extent :
  MNDWI, NDPI and NDVI image was used to extract the wetland boundary through suitable hierarchical thresholds.

- Extraction of open water :
  MNDWI was used with in the wetland mask to delineate the water and no-water areas.

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

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

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

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

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

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

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

  f) Assign turbidity classes as per the table 3.

Table 3: Qualitative turbidity based on Mean and Standard deviation observed in the MNDWI image

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

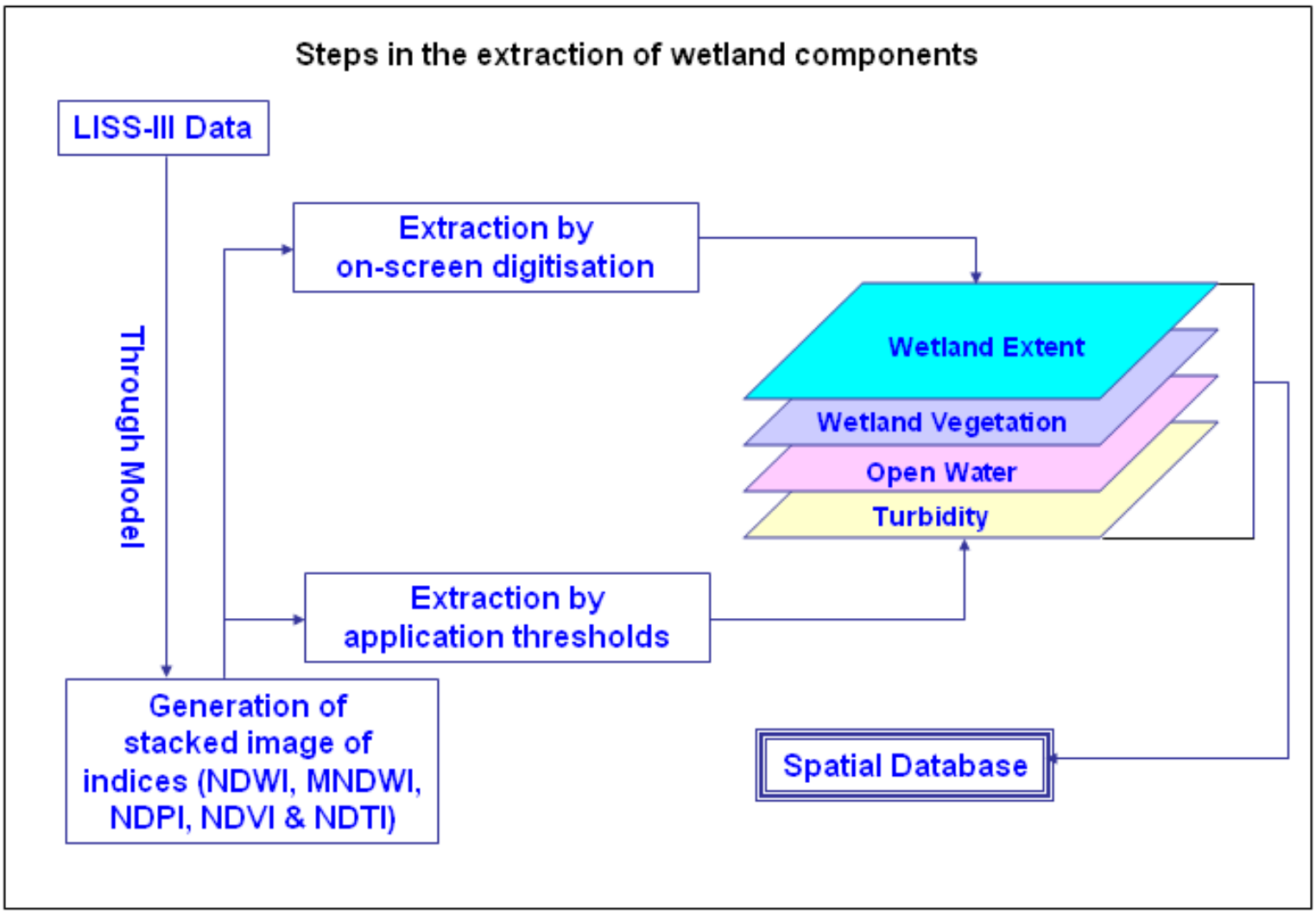


Figure 8: Steps in the extraction of wetland components

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.

6.0 ACCURACY ASSESSMENT

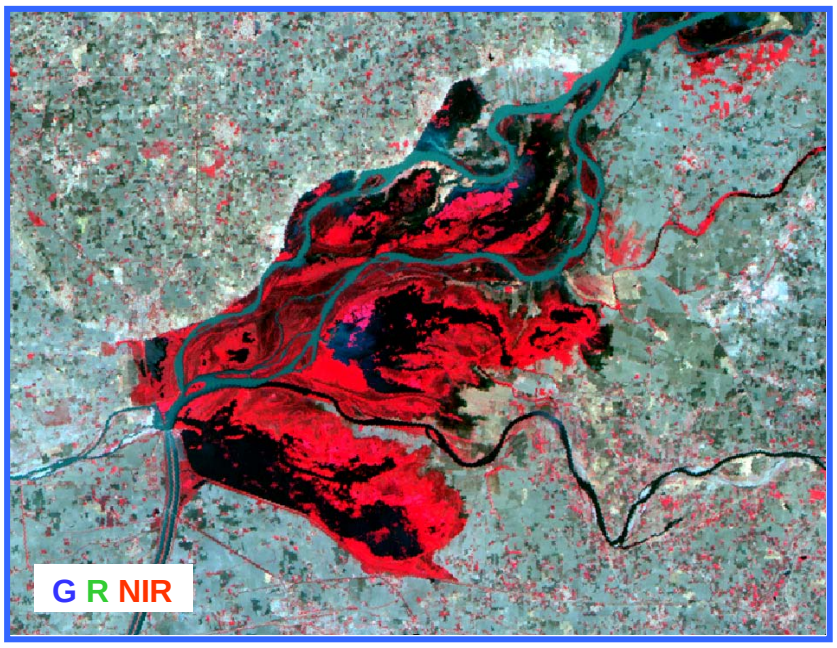
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as location accuracy. In addition, GIS database(s) contents have been also evaluated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

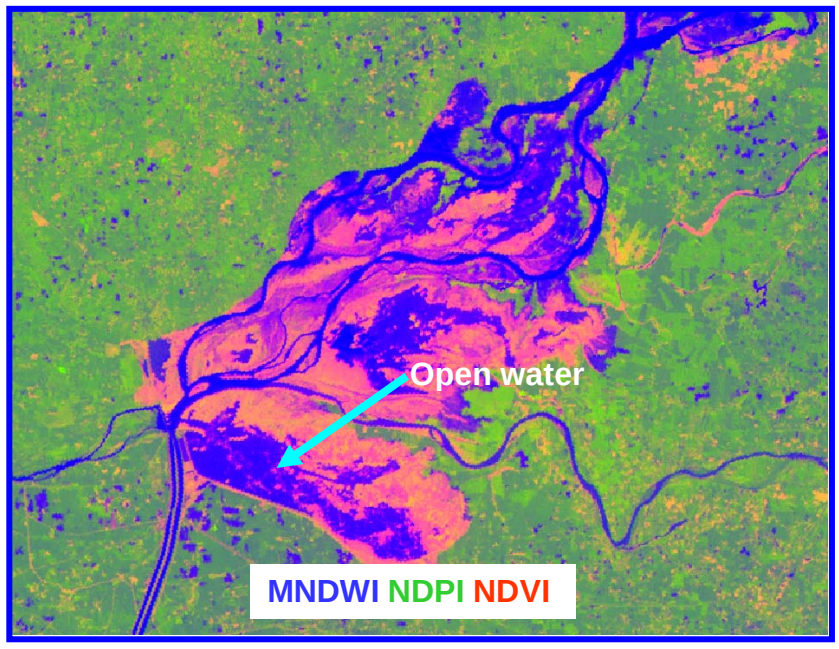
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imagery was reviewed by technical expert team for accuracy and code. The reviewing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

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

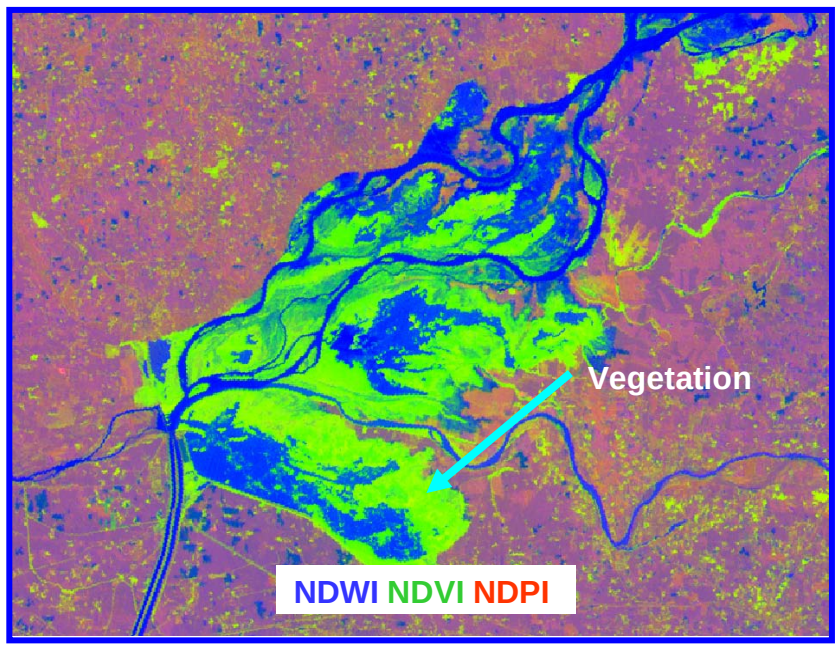
6.1 Data verification and quality assurance of output digital data files

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

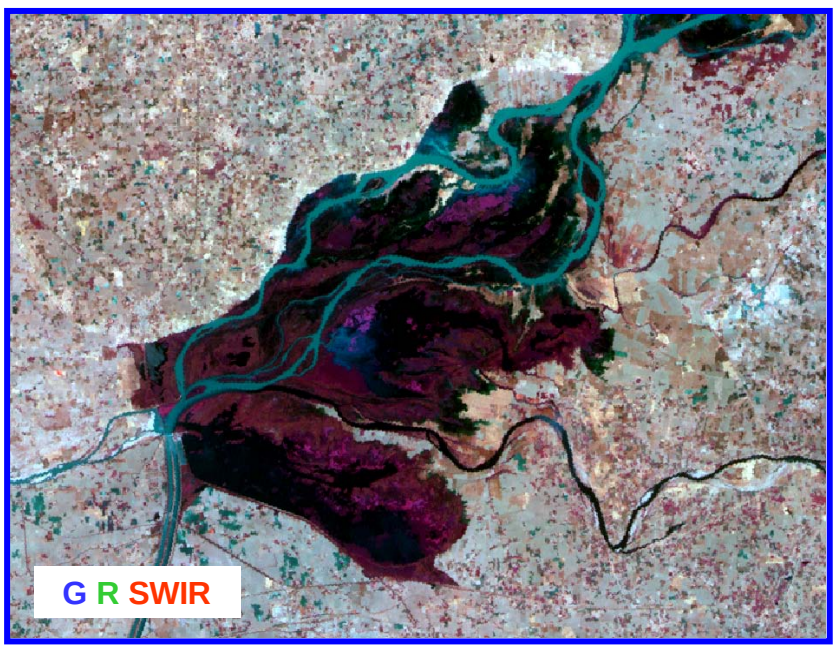




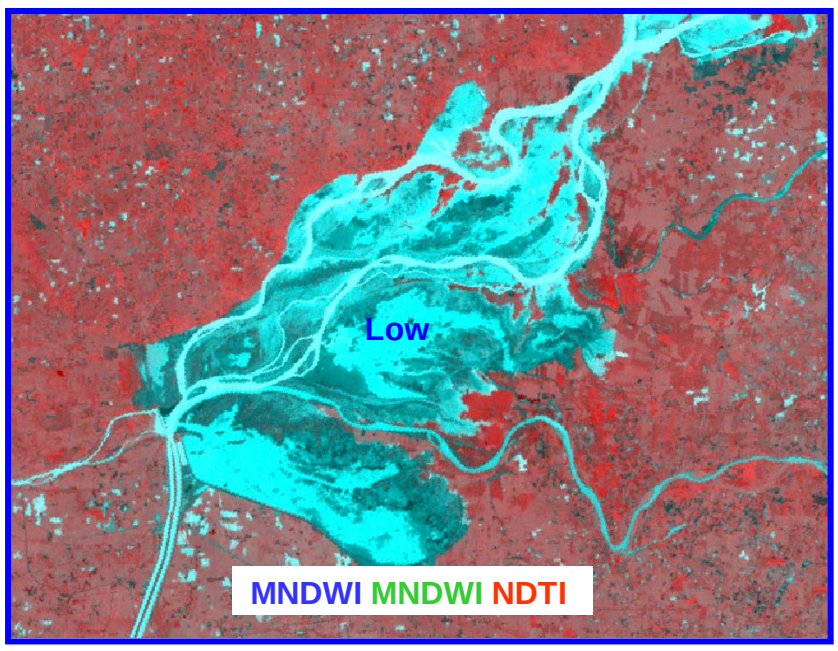
Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features



Part of Harike Wetland,
IRS LISS III data, 23 May, 2007



Useful for qualitative turbidity delineation

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

MAPS AND STATISTICS

7.0 WETLANDS OF PUNJAB: MAPS AND STATISTICS

Area estimates of various wetland categories for Punjab have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total 1381 wetlands have been mapped at 1:50,000 scale in the state. In addition, 5049 small wetlands (< 2.25 ha) have also been identified. Total wetland area estimated is 86283 ha accounting for about 1.71 per cent of the geographic area of state The river/stream is the major type, accounting for 69.38 per cent of the wetlands (59864 ha),Reservoirs/Barrages ranked second with 13.74 % share (11858 ha area). The other wetland types observed are: Tanks/ponds (3526 ha), Waterlogged, Lake/pond, Ox-bow lake and Riverine wetlands. Details of state level wetland statistics are shown in Table-4. Graphical distribution of wetland type is shown in Figure 10.

Aquatic vegetation is observed in Lake/pond, Riverine wetlands, Tank/pond and Reservoir/barrages. The vegetation spread in wetlands is more during pre monsoon (17160 ha) compared to post monsoon (15920 ha). The open water spread of wetlands is more during post monsoon (36344 ha) that during pre monsoon (24386 ha). The qualitative turbidity of water in wetlands is in general low in both the seasons.

Table 4: Area estimates of wetlands in Punjab

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	200	1934	2.24	1052	778
2	1102	Ox-bow lakes/ Cut-off meanders	11	373	0.43	152	105
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	9	306	0.35	13	13
5	1105	Waterlogged	43	2032	2.36	151	35
6	1106	River/Stream	151	59864	69.38	25748	15955
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	31	11858	13.74	6220	5488
8	1202	Tanks/Ponds	878	3526	4.09	2196	1937
9	1203	Waterlogged	58	1341	1.55	812	75
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**1381**	**81234**	**94.15**	**36344**	**24386**
		Wetlands (<2.25 ha), mainly Tanks	5049	5049	5.85	-	-
		Total	**6430**	**86283**	**100.00**	**36344**	**24386**

Area under Aquatic Vegetation	15920	17160

Area under turbidity levels		
Low	30906	20504
Moderate	5117	3573
High	321	309

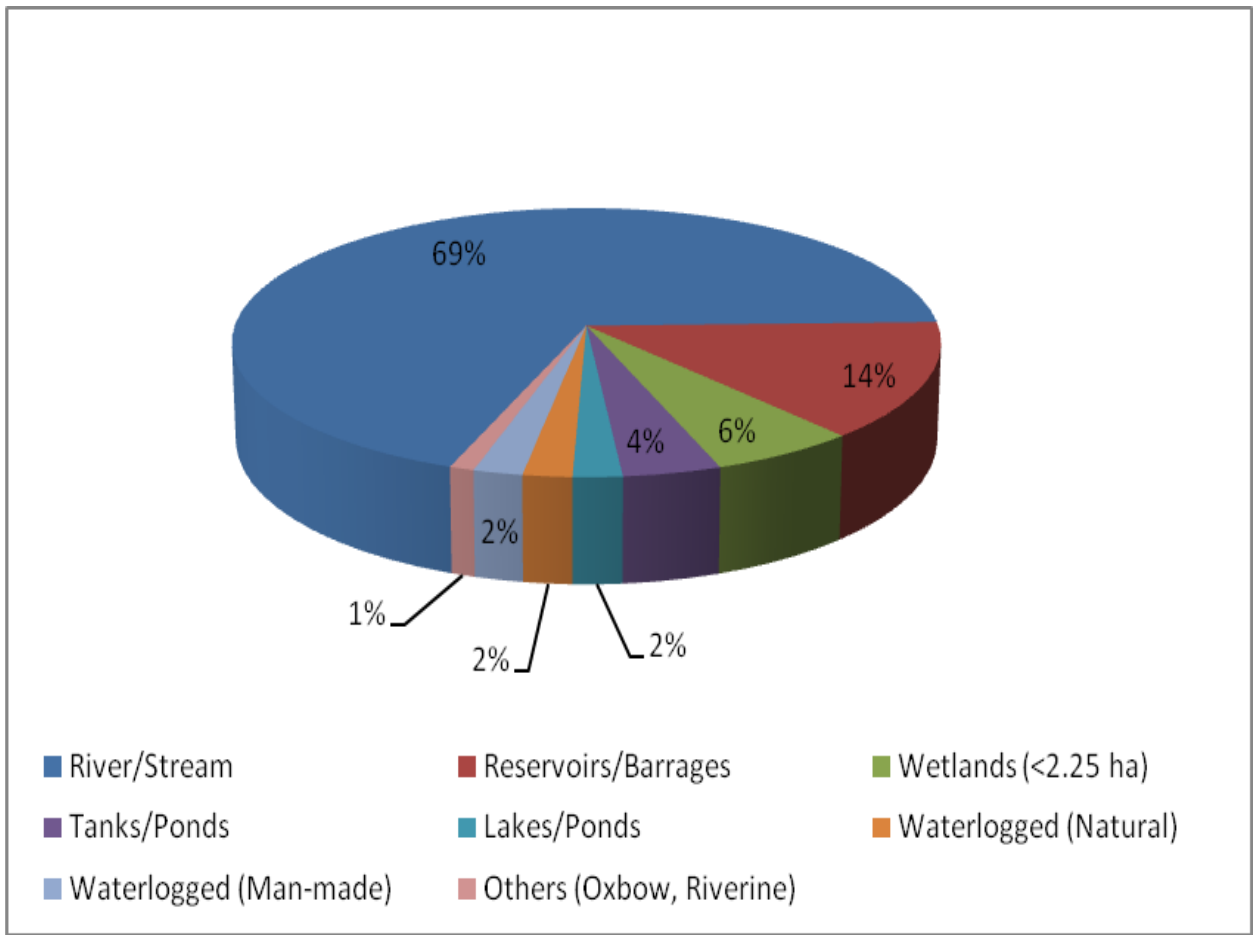


Figure 10: Type-wise wetland distribution in Punjab

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has twenty districts. The wetland area as a percent of geographic area of the districts varied from 0.23% (Fatehgarh Sahib) to 8.75% (Rupnagar). The wetland area of the districts as a per cent of total wetland area of the state varied from 0.68% (Barnala and Faridkot) to 19.19% (Gurdaspur). Gurdaspur, Kapurthala, Rupnagar and Firozpur are the districts each having more than 10.0% share of wetland area (Table-5, Fig.11). Gurdaspur ranks first in terms of area under River/stream (11969 ha), and Lake/pond (388 ha), Waterlogged-natural (1108 ha). Kapurthala leads in terms of area under Reservoir/barrage (3252 ha). Tarn-Taran leads in terms of small wetland (>2.25 ha) which are mainly Tanks; 430 such wetlands are identified. Riverine wetland are observed in Gurdaspur, Amritsar, Kapurthala, Hoshiarpur and Sas Nagar districts; Hoshiarpur having the highest area (128 ha).

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 (sq. km)	Wetland Area (ha)	% of total wetland area	% of district geographic area
1	Gurdaspur	3570	16557	19.19	4.64
2	Amritsar	2656	5661	6.56	2.13
3	Kapurthala	1646	8765	10.16	5.33
4	Jalandhar	2658	3140	3.64	1.18
5	Hoshiarpur	3310	6209	7.20	1.88
6	Nawansahar	1258	2103	2.44	1.67
7	Rupnagar	1023	8950	10.37	8.75
8	Fatehgarh Sahib	1180	267	0.31	0.23
9	ludhiana	3744	4740	5.49	1.27
10	Moga	1672	1823	2.11	1.09
11	Firozpur	5865	8647	10.02	1.47
12	Muktsar	2596	1812	2.10	0.70
13	Faridkot	1472	585	0.68	0.40
14	Bhatinda	3377	1597	1.85	0.47
15	Mansa	2174	1258	1.46	0.58
16	Sangrur	3608	1810	2.10	0.50
17	Patiala	3627	2924	3.39	0.81
18	Barnala	1414	590	0.68	0.42
19	Sas nagar	1093	2198	2.55	2.01
20	Tarn taran	2419	6647	7.70	2.75
	Total	**50362**	**86283**	**100.00**	**1.71**

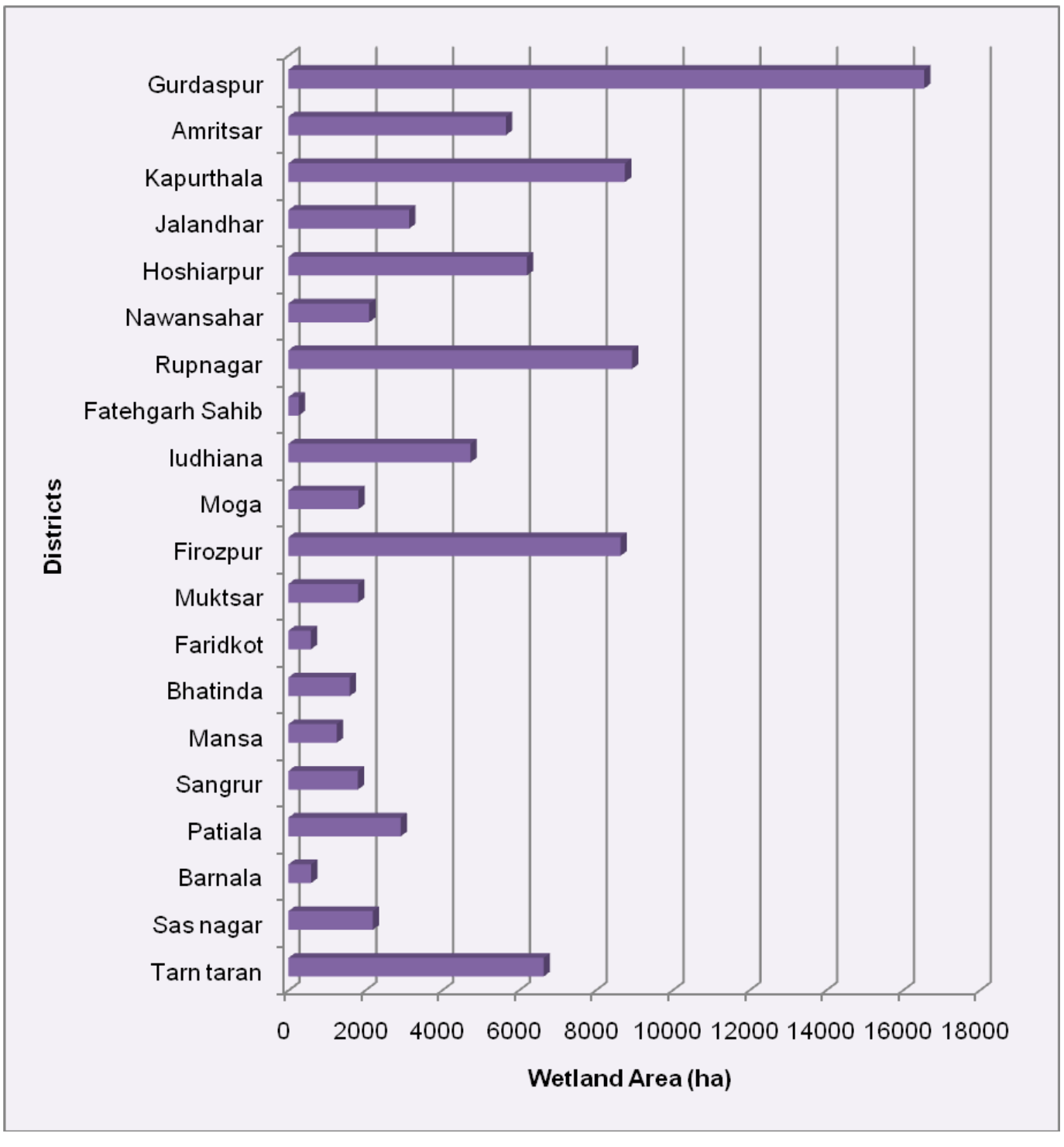
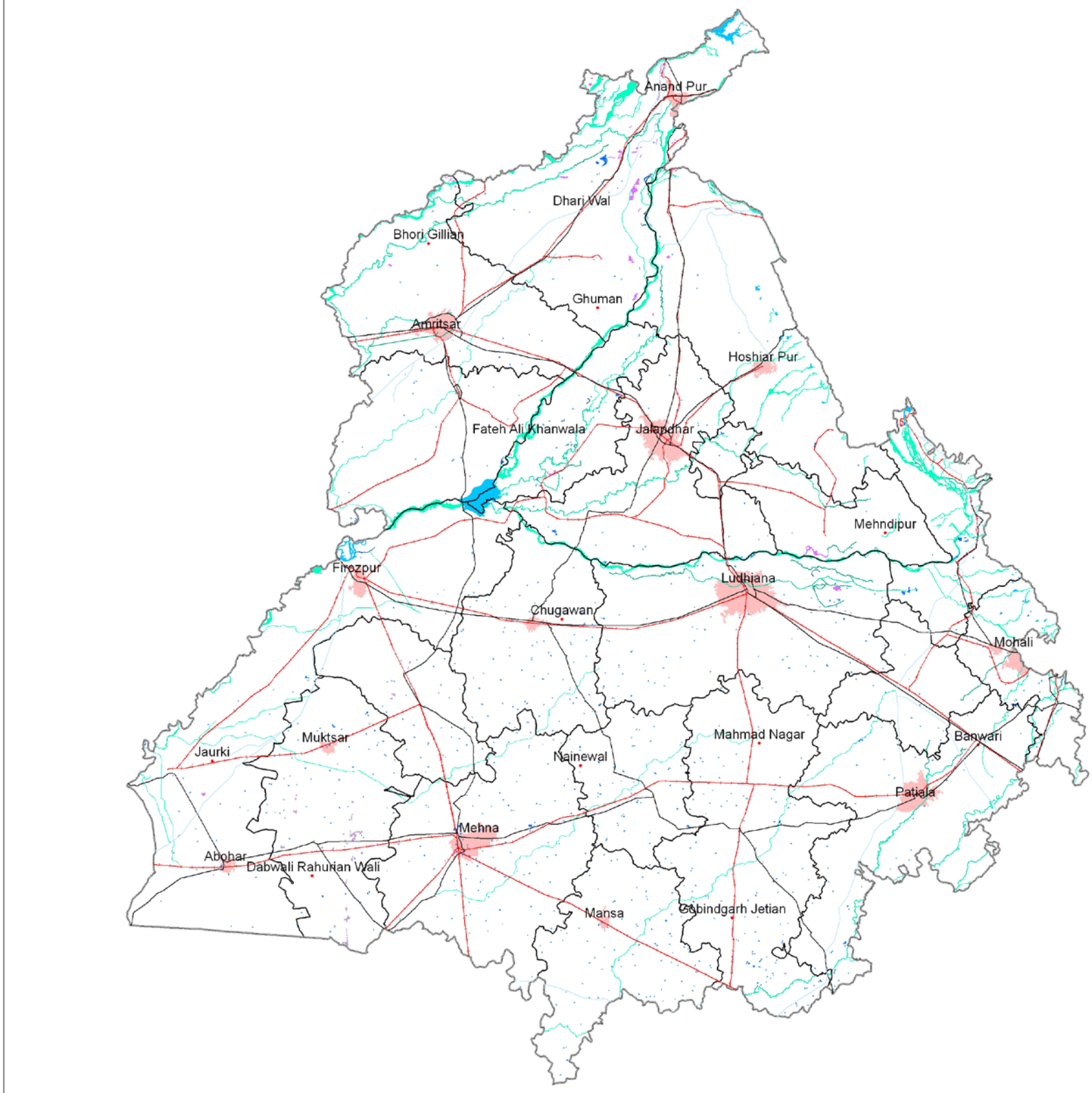


Figure 11: District-wise graphical distribution of wetlands

State : Punjab

WETLAND MAP

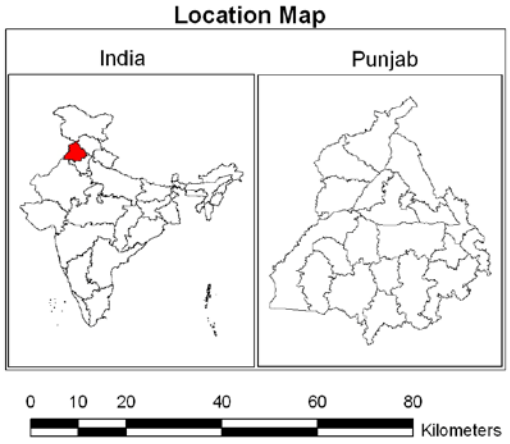


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

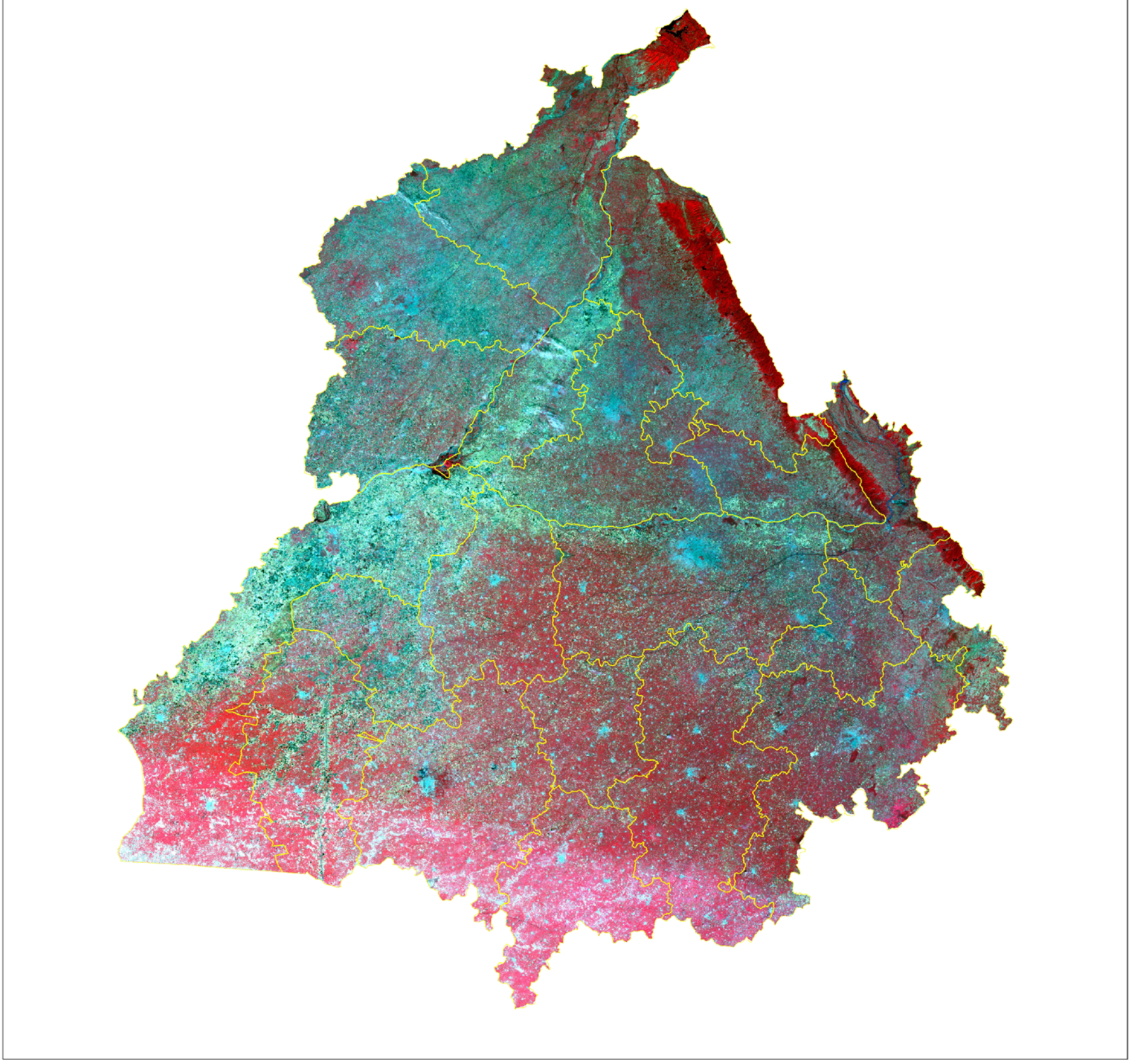
Prepared By :

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

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab



IRS-P6 AWiFS post-monsoon data (2005)

7.1.1 Gurdaspur

Gurdaspur district lying in the north-east of Punjab forms a part of the Kandi belt of the state. The district lies between the latitudes of 31^{O} 36' 13" to 32^{O} 30' 24" north and longitudes of 74^{O} 53' 30" to 75^{O} 56' 11" east. It covers an area of 3570 sq. km. It is bounded by Hoshiarpur district of Punjab and Himachal Pradesh in the east, Jammu and Kashmir in the north, Pakistan in the north-western side, Amritsar and Kapurthala districts of Punjab in the south. From administrative point of view, district Gurdaspur is divided into five tehsils. Gurdaspur district has been divided into three major landforms viz. Shiwalik hills, piedmont and alluvial plain. The soils are sandy skeletal to coarse loamy in texture, calcareous in nature and mostly well drained. The district is drained by choes into the Ravi and Beas Rivers. Landuse statistics suggest that about 82 per cent of the total geographical area of the district is under agricultural use. Forest occupies more than 10 per cent TGA of the district. Annual rainfall is very high compared to other districts of Punjab, however, due to its hilly terrains in the northeast with a natural rolling topography in the southern direction, water retention is very less.

Total wetland area in the district is 16557 ha that includes 138 small wetlands (<2.25 ha). River/stream occupies 72.29% of wetlands. Reservoir/Barrage is the second large wetland type in the district. There is one large reservoir with 2333 ha area (14.09%). The other major wetland types are Waterlogged - natural (6.69%), Lake/pond (2.34%), Waterlogged -man made (1.94%)) and Ox-bow lakes (1.03%). Details of wetland statistics is given in Table-6.

Aquatic vegetation is observed in Lake/pond, waterlogged wetland types. The area under aquatic vegetation is slightly more during pre monsoon (4348 ha) than in post monsoon (3289 ha). The open water spread of wetlands is significantly more in post monsoon (6885 ha) than in pre monsoon (4208 ha). The qualitative turbidity of water is low in both the seasons.

Table 6: Area estimates of wetlands in Gurdaspur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	6	388	2.34	124	106
2	1102	Ox-bow lakes/ Cut-off meanders	6	171	1.03	61	54
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	1	47	0.28	-	-
5	1105	Waterlogged	25	1108	6.69	50	10
6	1106	River/Stream	30	11969	72.29	4357	2197
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	2333	14.09	2248	1813
8	1202	Tanks/Ponds	24	81	0.49	39	24
9	1203	Waterlogged	10	322	1.94	6	4
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**103**	**16419**	**99.17**	**6885**	**4208**
		Wetlands (<2.25 ha), mainly Tanks	138	138	0.83	-	-
		Total	**241**	**16557**	**100.00**	**6885**	**4208**

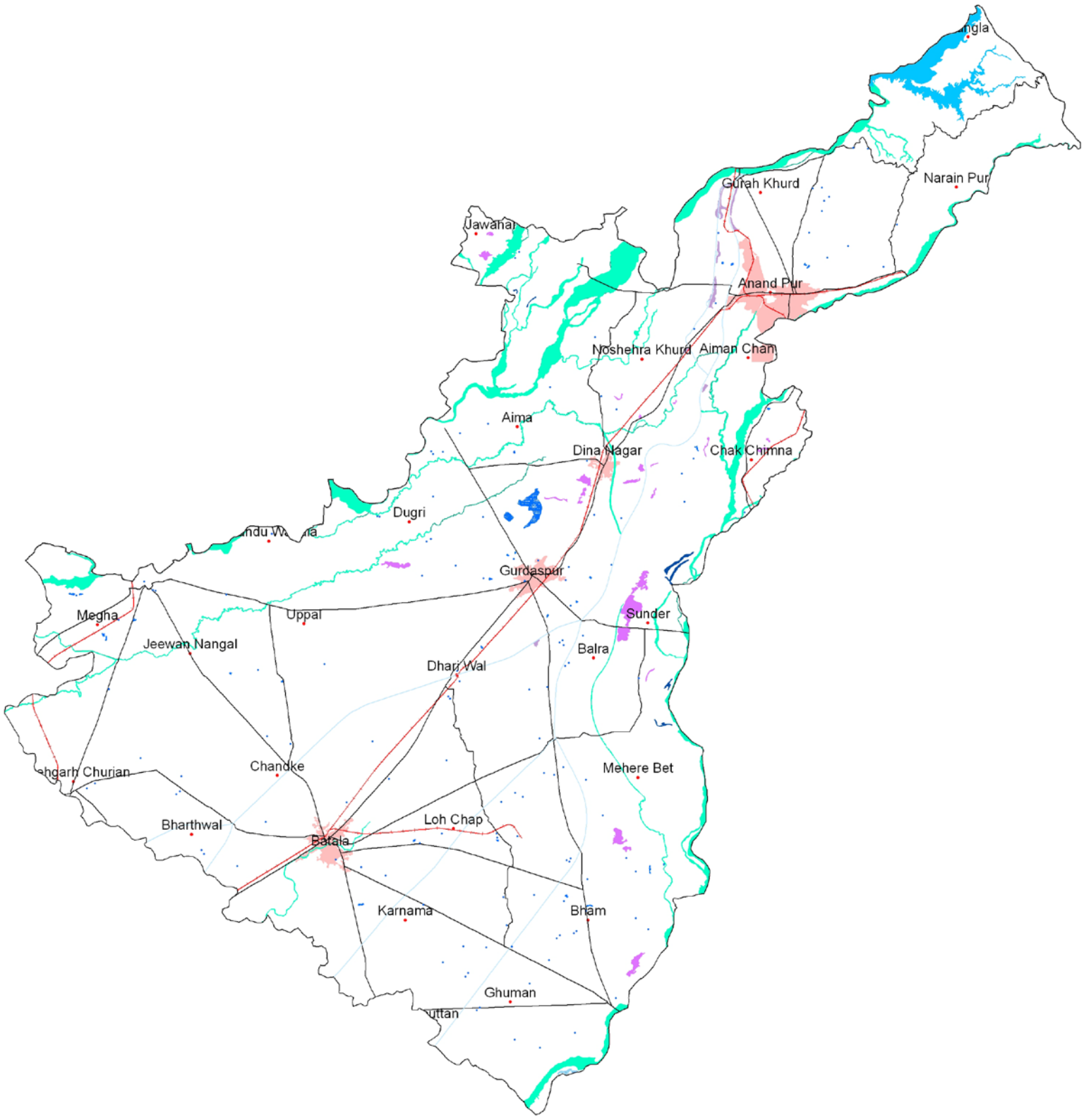
Area under Aquatic Vegetation	3289	4348

Area under turbidity levels		
Low	6523	3643
Moderate	362	565
High	-	-

State : Punjab

WETLAND MAP

District : Gurdaspur

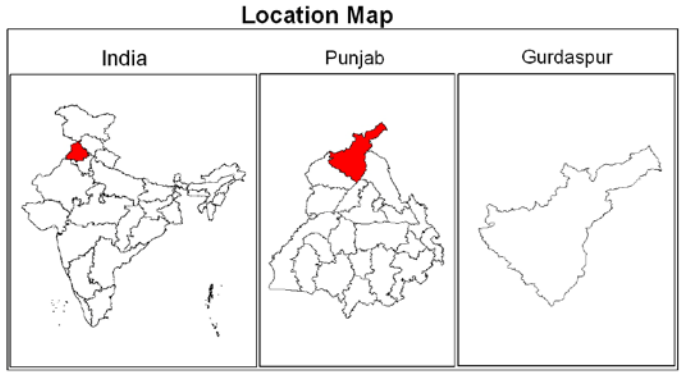


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

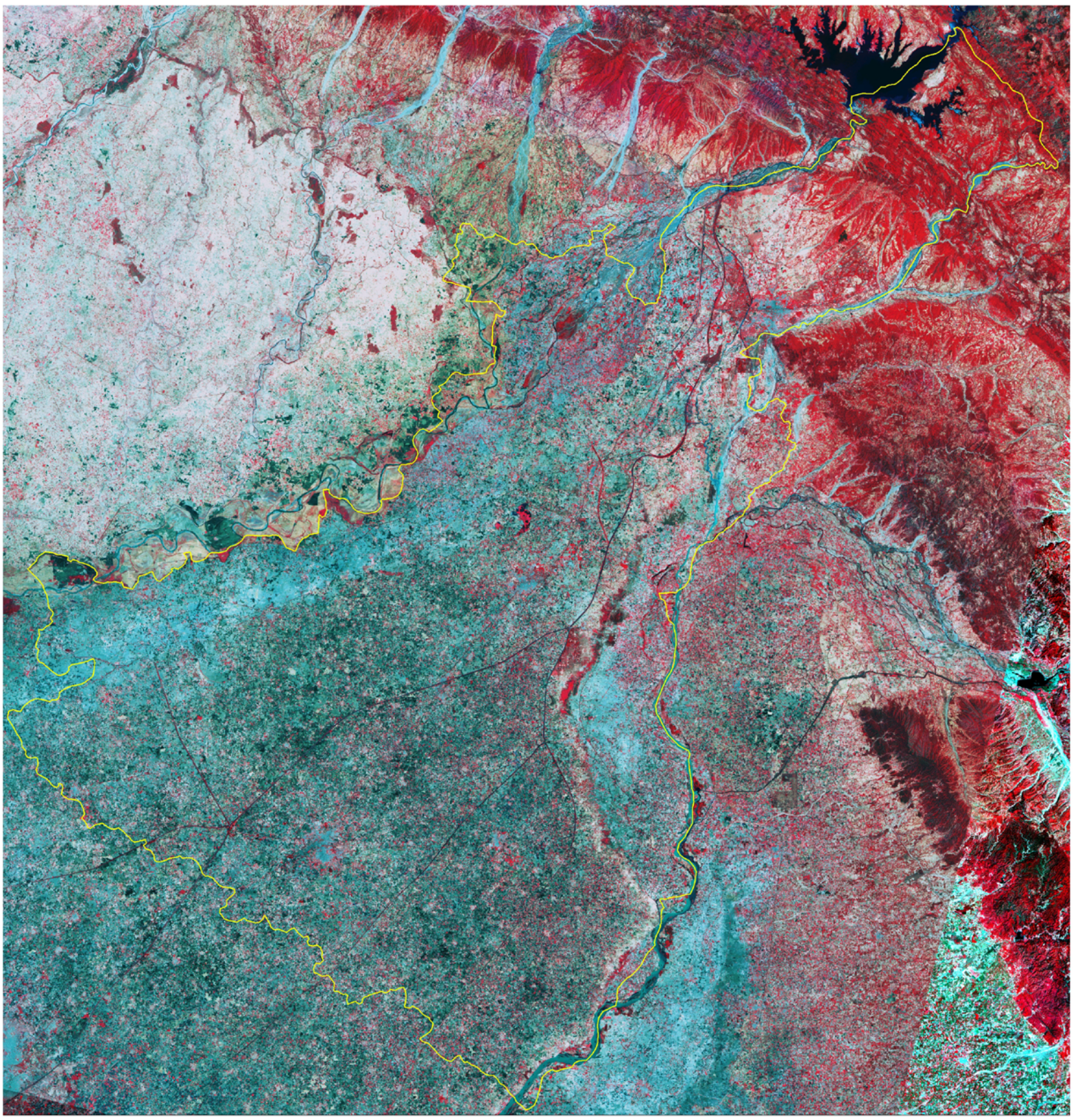
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Gurdaspur



IRS P6 LISS-III post monsoon data (2006)

7.1.2 Amritsar

Amritsar district forming a part of Indo-Gangetic alluvial plain is located in the north-western part of Punjab. The total geographical area of the district is 2656 sq. km. The district lies between the latitudes of 31^{O} 28' 49" to 32^{O} 03' 26" N and longitudes of 74^{O} 29' 06" to 75^{O} 24' 24" E. It is bounded on east by Kapurthala, on the north-east by Gurdaspur and on the south by Tarn Taran districts of Punjab and on north and west by Pakistan. The Amritsar district consists of 4 tehsils. The major towns are: Amritsar, Amritsar Cantt, Jandiala, Ajnala, Majitha, Rayya, Rajasansi and Ramdas. The district has been divided into two major landform units viz. alluvial plain and sand bars. Alluvial plain constitute the major part of the district. This unit is formed by the alluvial deposits brought by Ravi and Beas rivers. The sand bars are the other landform in the district. The low to high ridges of sand occur along the old courses of the river. The soils in the district are coarse to fine loamy in texture, calcareous and well drained. The area is drained into Satluj and Beas rivers through network of drains. Due to the higher landscape of the Amritsar district, there is stream bank erosion and formation of gullies/ravines along the Beas River. Around 84.5 per cent of the total geographical area (TGA) of the Amritsar district is under cultivation The Amritsar district is irrigated by a network of canals and tube wells.

Total wetland area in the district is 5661 ha that includes 142 small wetlands (<2.25 ha). River/stream occupies 92.56% of wetlands. The other major wetland types are waterlogged - natural (1.85%), Riverine wetland (1.73%), Tank/pond (1.11%). Details of wetland statistics is given in Table-7.

Aquatic vegetation is observed in Riverine wetlands and waterlogged area. The area under aquatic vegetation is slightly more during pre monsoon (1934 ha) than in post monsoon (1852 ha). The open water spread of wetlands is significantly more in post monsoon (2323 ha) than in pre monsoon (1157 ha). The qualitative turbidity of water is low in both the seasons.

Table 7: Area estimates of wetlands in Amritsar

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	2	13	0.23	9	9
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	5	98	1.73	-	-
5	1105	Waterlogged	5	105	1.85	59	-
6	1106	River/Stream	12	5240	92.56	2223	1121
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	19	63	1.11	32	27
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**43**	**5519**	**97.49**	**2323**	**1157**
		Wetlands (<2.25 ha), mainly Tanks	142	142	2.51	-	-
		Total	**185**	**5661**	**100.00**	**2323**	**1157**

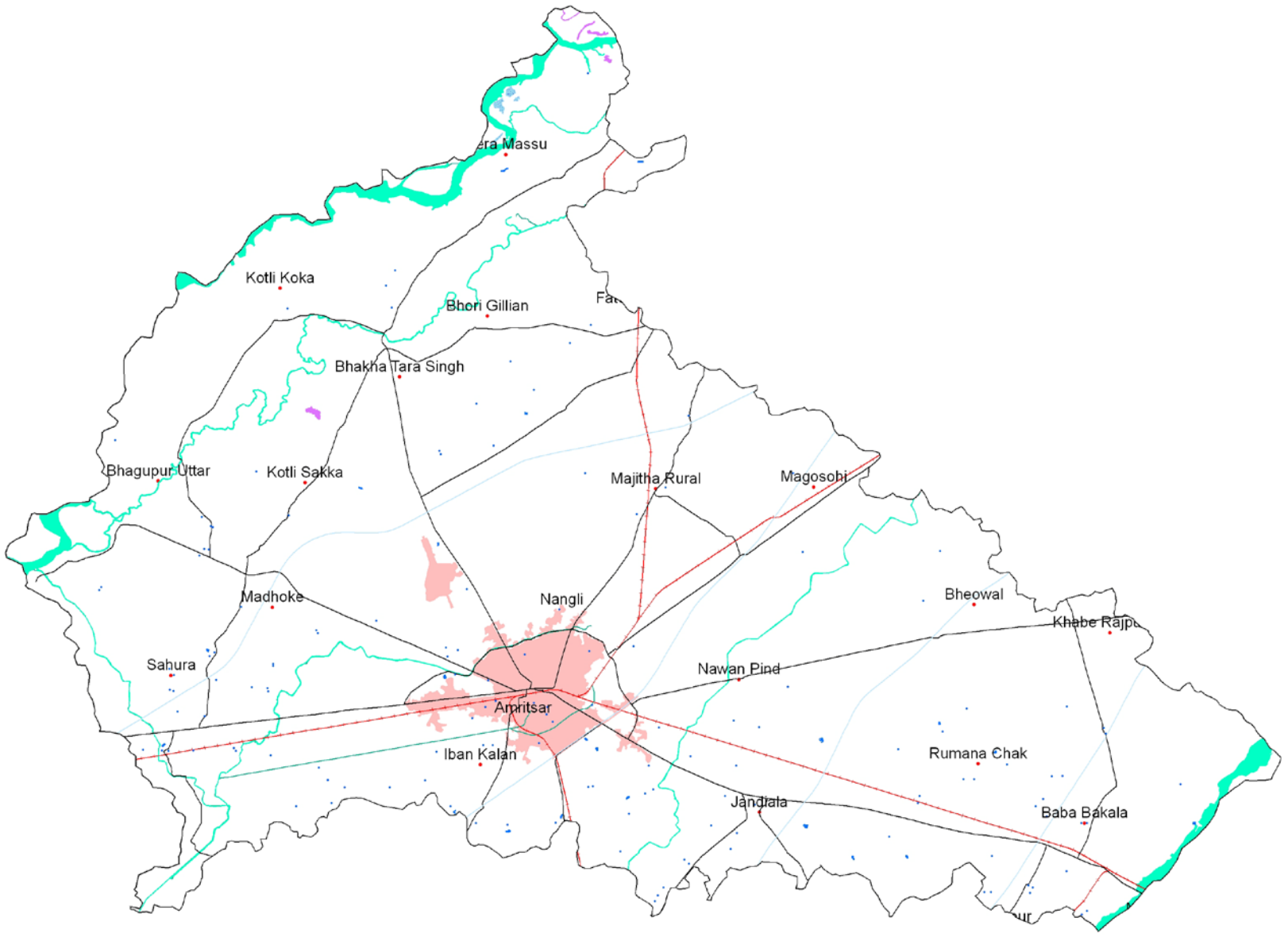
Area under Aquatic Vegetation	1851	1934

Area under turbidity levels		
Low	2136	886
Moderate	187	271
High	-	-

State : Punjab

WETLAND MAP

District : Amritsar

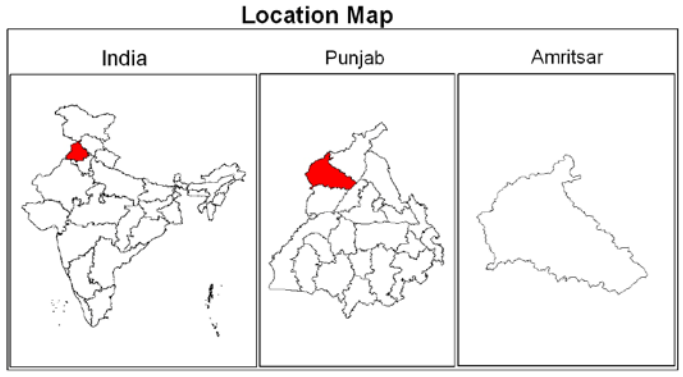


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

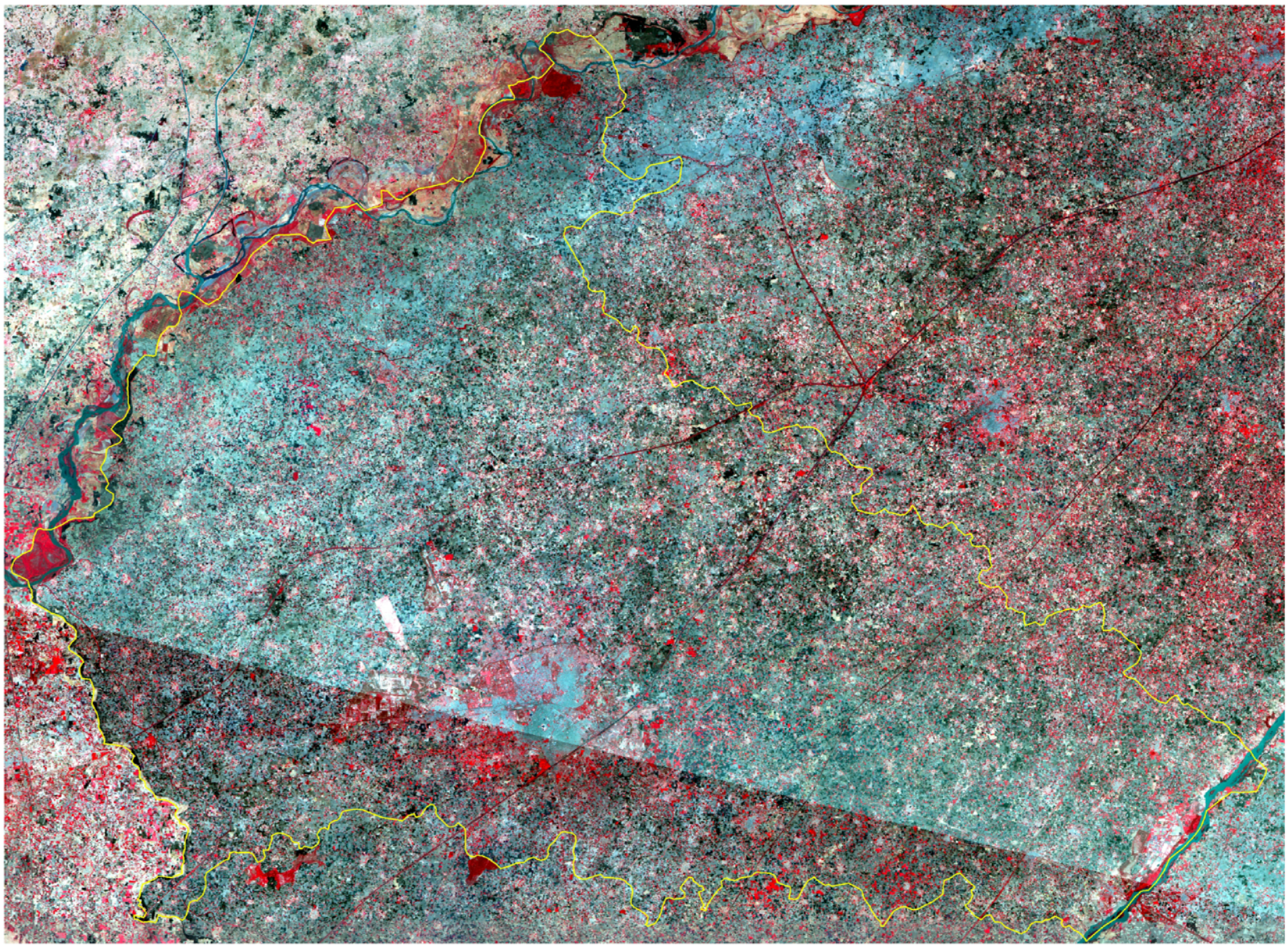
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Amritsar



IRS P6 LISS-III pre monsoon data (2007)

7.1.3 Kapurthala

Kapurthala district covers an area of 1646 sq. km and is situated in north-central part of the Punjab state, forms a part of the Bist Doab in Central Punjab. It lies between the latitude of 31^{O} 07' 30" to 31^{O} 39' 30" north and the longitude of 74^{O} 58' 30" to 75^{O} 55' 00" east. The localized depressions and the areas around the East and West Beas and their tributaries are salt-affected. The recent flood-plain area along Beas River is separated from the upper terrace by a steep and eroded escarpment in the northwest and a flood protection embankment in the east. It is bounded by Beas River in the north-west adjoining Amritsar, part of Hoshiarpur and Jalandhar districts in north-east, Hoshiarpur and Nawan Shahar in the east, Jalandhar and Firozepur districts of Punjab in the south and south-west. From administrative point of view, the district has been divided into four tehsils. Kapurthala district is more or less a flat terrain. The various landforms in the Kapurthala district are alluvial plain (upper / lower), sand dunes, flood plains, and paleo channels. Alluvial plain constitutes the major portion of the district. It is gently sloping from north-east to south-west. Part of the alluvial plain is subjected to local flooding and thus has sufficient soil moisture content.

Total wetland area in the district is 8765 ha that includes 78 small wetlands (<2.25 ha). River/stream occupies 57.57% of wetlands. Reservoir/Barrage is the second large wetland type in the district. There are two large reservoirs with 3252 ha area (37.10%). The other major wetland types are Tank/pond (1.63%), Waterlogged - natural (1.44%) and Lake/pond (1.02%). Details of wetland statistics is given in Table-8.

Aquatic vegetation is observed in Lake/pond, waterlogged and Reservoir/Barrage wetland types. The area under aquatic vegetation is slightly more during post monsoon (4004 ha) than in pre monsoon (3681 ha). The open water spread of wetlands is more or less same in post monsoon (3476 ha) and pre monsoon (3761 ha). The qualitative turbidity of water is low in both the seasons.

Table 8: Area estimates of wetlands in Kspurthala

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	14	89	1.02	48	41
2	1102	Ox-bow lakes/ Cut-off meanders	1	22	0.25	3	1
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	1	9	0.10	-	-
5	1105	Waterlogged	4	126	1.44	9	0
6	1106	River/Stream	33	5046	57.57	2520	2748
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	3252	37.10	786	888
8	1202	Tanks/Ponds	24	143	1.63	110	83
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**79**	**8687**	**99.11**	**3476**	**3761**
		Wetlands (<2.25 ha), mainly Tanks	78	78	0.89	-	-
		Total	**157**	**8765**	**100.00**	**3476**	**3761**

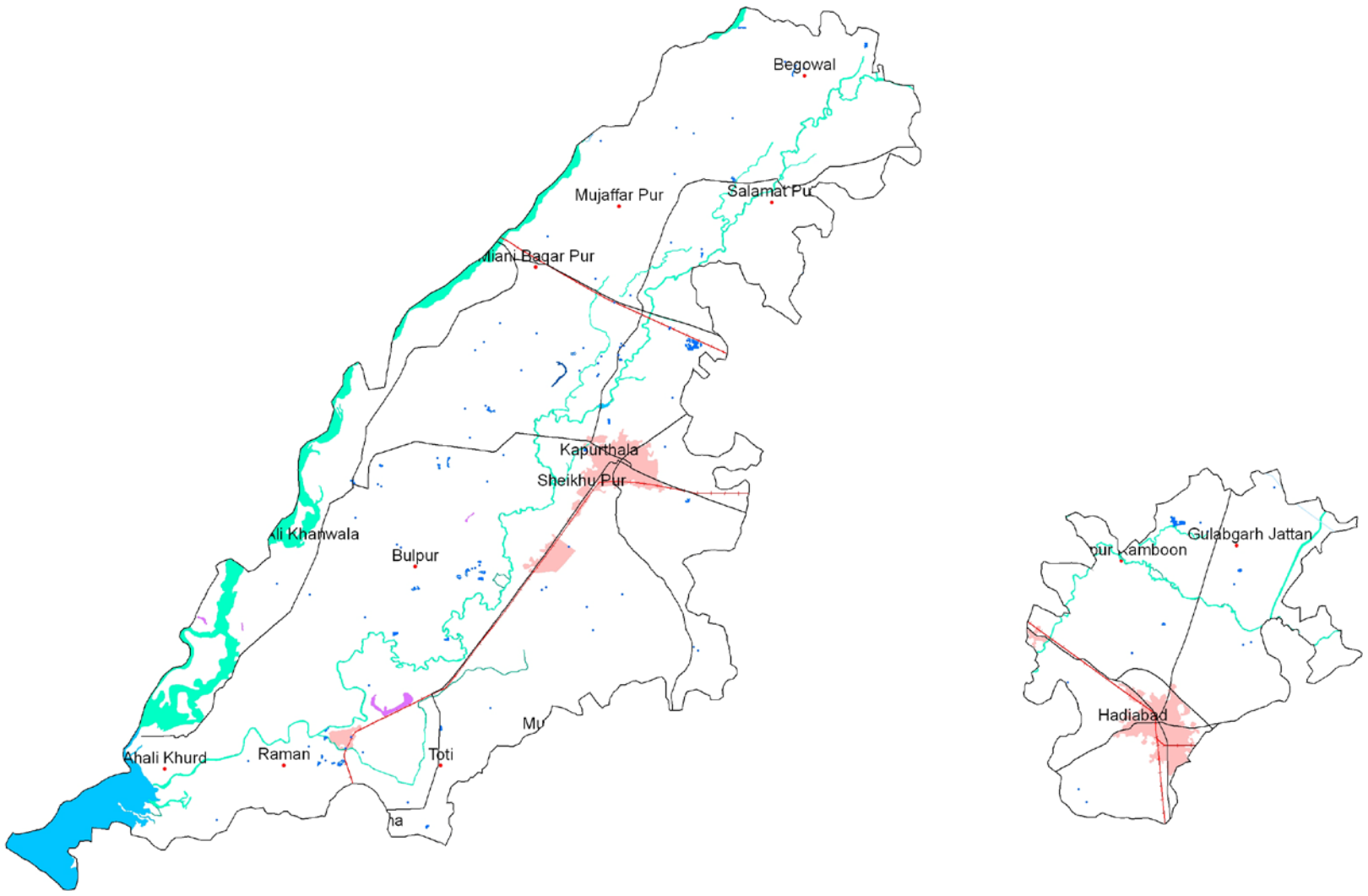
Area under Aquatic Vegetation	4004	3681

Area under turbidity levels		
Low	3207	3605
Moderate	212	111
High	57	45

State : Punjab

WETLAND MAP

District : Kapurthala

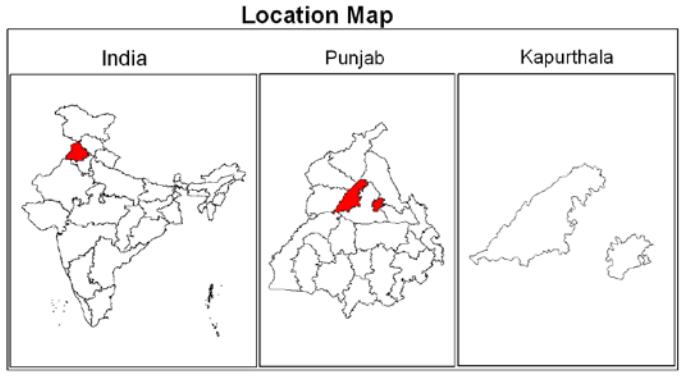


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

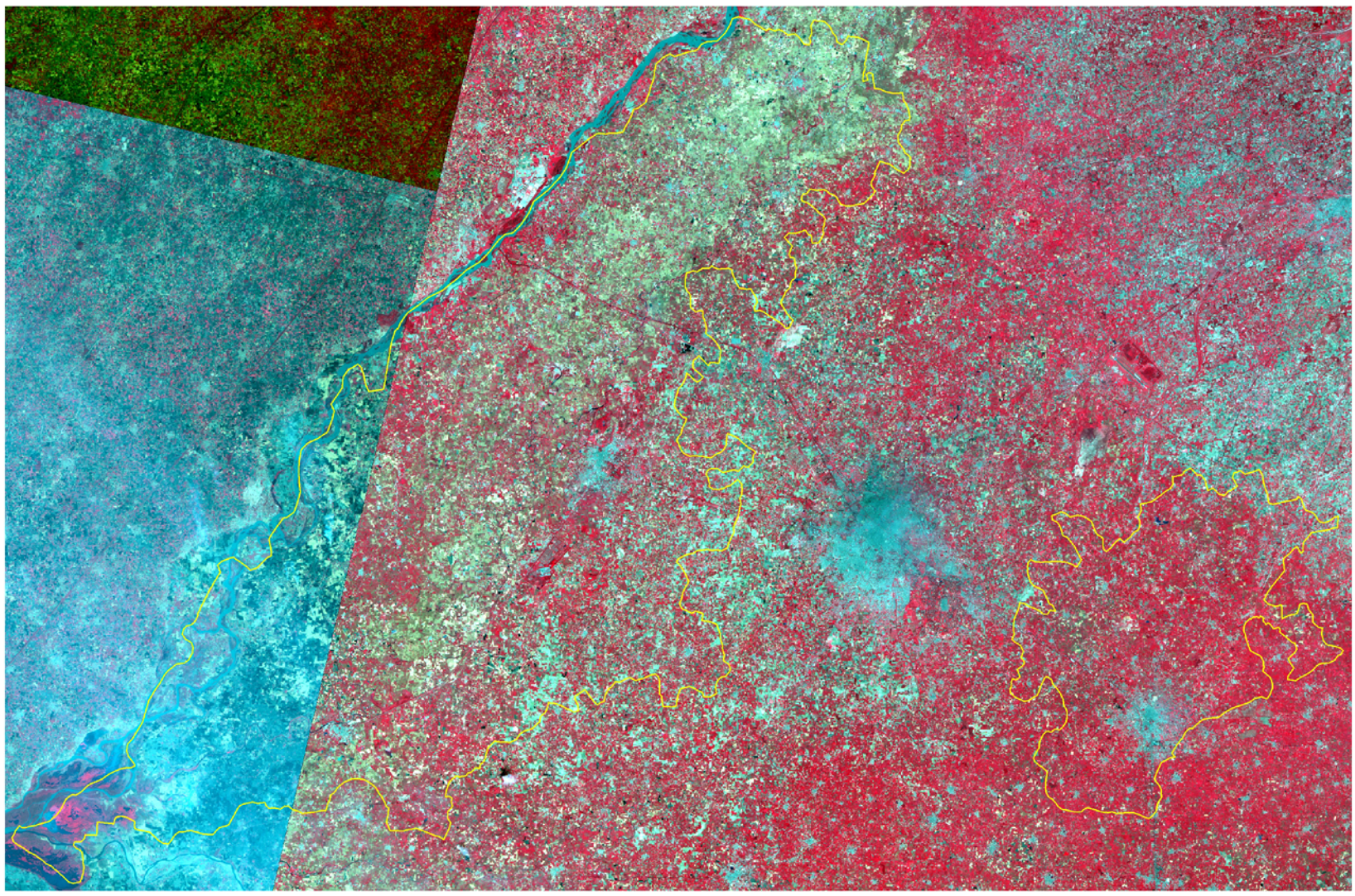
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Kapurthala



IRS P6 LISS-III post monsoon data (2006)

7.1.4 Jalandhar

Jalandhar district covers an area of 2658 sq. km and is situated in north-central part of the Punjab state. It lies between 30^{O} 58' 00" to 31^{O} 37' 00" N latitude and 75^{O} 04' 09" to 75^{O} 58' 00" E longitude. It is bounded by Hoshiarpur and Nawan Shahar district in the northeastern side, Ludhiana and Moga in the south and in the west by Firozpur & Kapurthala districts of Punjab. Jalandhar district is sub divided into 5 tehsils. The district is more or less a flat terrain. The various landforms in the Jalandhar district are alluvial plain (upper/lower), flood plains, and paleo channels. Alluvial plain constitutes the major portion of the district. It is gently sloping from north-east to south-west. Part of the alluvial plain is subjected to local flooding and thus has sufficient soil moisture content. River Sutluj is flowing along the southern side of the district. The average annual rainfall is 400 mm, out of which more than 60 per cent is received during the monsoon months of July, August and September. Nearly 90 per cent of total geographical area (TGA) is under agricultural land use.

Total wetland area in the district is 3140 ha that includes 157 small wetlands (<2.25 ha). River/stream occupies 88.15% of wetlands. The other wetland types are Lake/pond (4.43%) and Tank/pond (2.42%), There are 12 Lake/pond with 139 ha area and 22 Tank/pond with 76 ha area. Details of wetland statistics is given in Table-9.

Aquatic vegetation is very less. The area under aquatic vegetation is slightly more during pre monsoon (261 ha) than in post monsoon (127 ha). The open water spread of wetlands is significantly more in post monsoon (1705 ha) than in pre monsoon (637 ha). The qualitative turbidity of water is low in both the seasons.

Table 9: Area estimates of wetlands in Jalandhar

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	12	139	4.43	83	29
2	1102	Ox-Bow Lakes/Cutt-Off Meanders	-	-	-	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Riverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	23	2768	88.15	1568	576
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	22	76	2.42	54	32
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**57**	**2983**	**95.00**	**1705**	**637**
		Wetlands (<2.25 ha), mainly Tanks	157	157	5.00	-	-
		Total	**214**	**3140**	**100.00**	**1705**	**637**

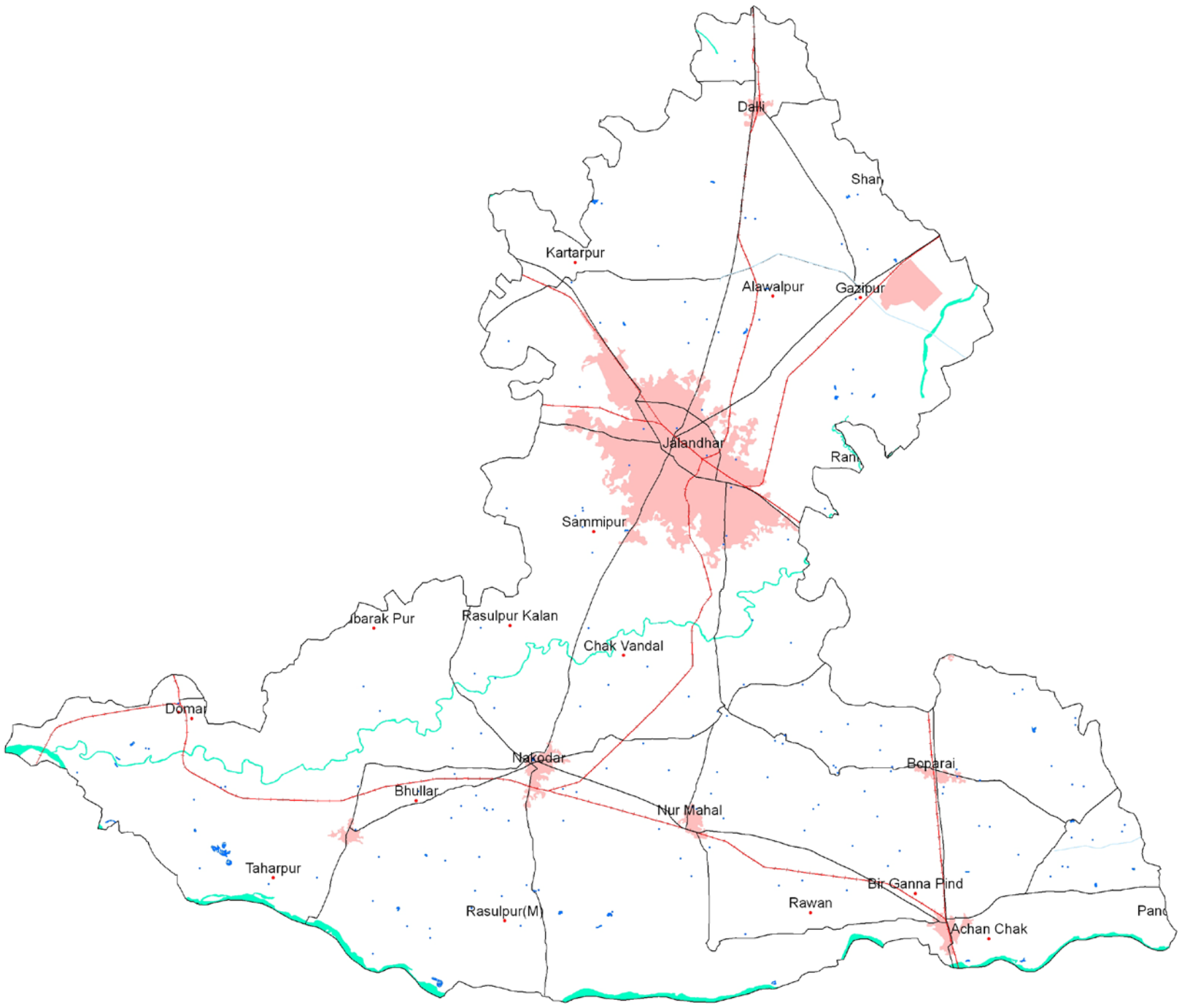
Area under Aquatic Vegetation	127	261

Area under turbidity levels		
Low	1566	576
Moderate	139	61
High	-	-

State : Punjab

WETLAND MAP

District : Jalandhar

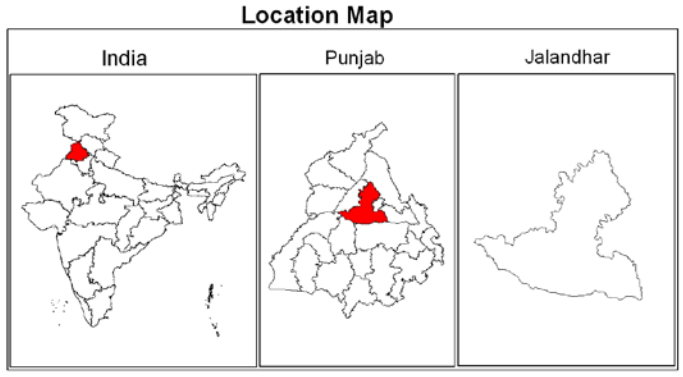


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

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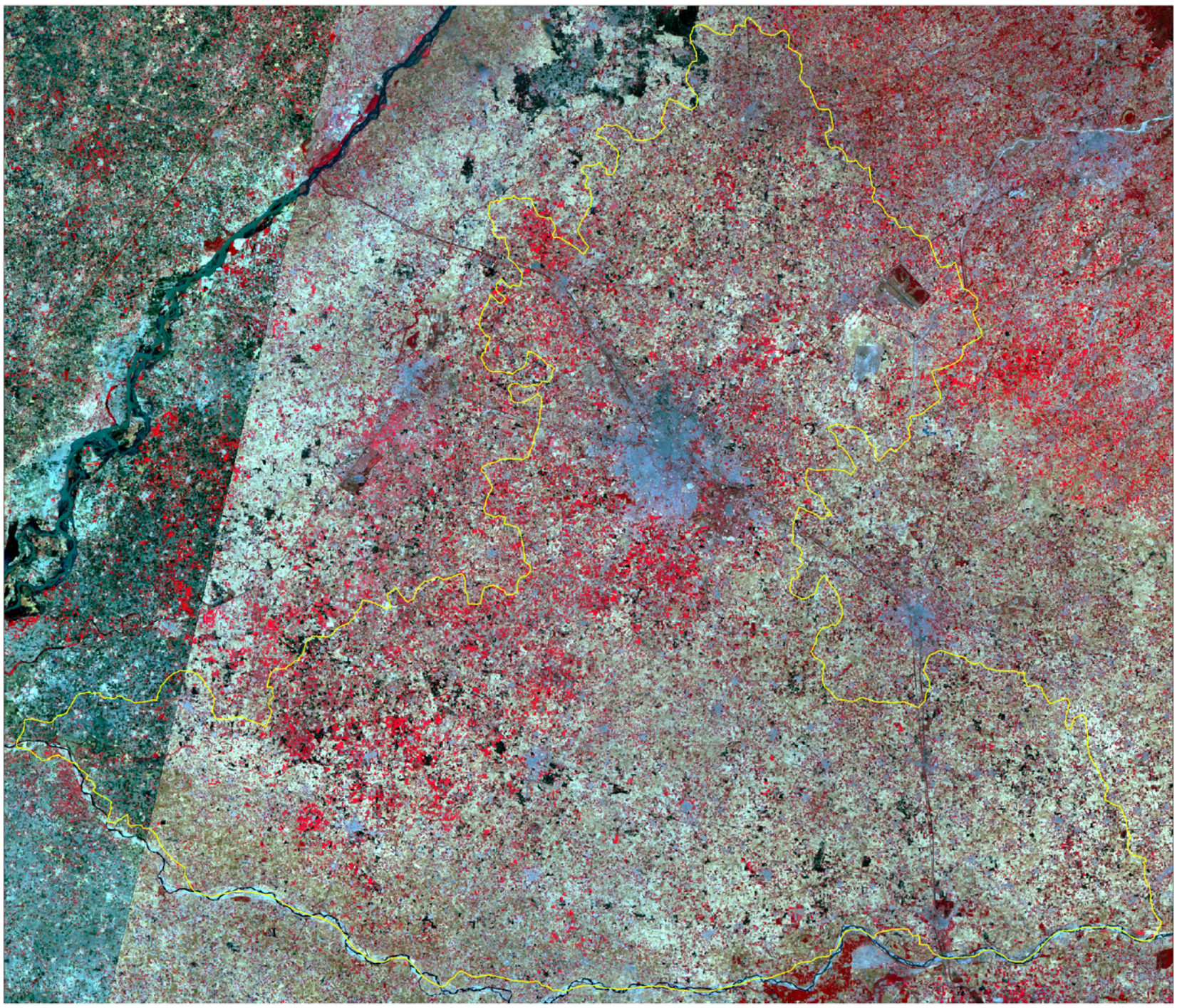
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Jalandhar



IRS P6 LISS-III pre monsoon data (2007)

7.1.5 Hoshiarpur

Hoshiarpur district lying in the north-east of Punjab forms a part of the Kandi belt of the state. The district lies between the latitudes of 31^{O} 07' 58" to 32^{O} 05' 13" north and longitudes of 75^{O} 28' 25" to 76^{O} 20' 58" east. It covers an area of 3310 sq. km. It is bounded by Gurdaspur in the north and north-west, Kapurthala and Jalandhar in the west, Nawan Shahar districts of the Punjab state in the south and Himachal Pradesh in the east and north-eastern side. From administrative point of view, Hoshiarpur district is divided into four tehsil. Hoshiarpur district has been divided into three major landforms viz. Shiwalik Hills, piedmont plain and alluvial plain. The soils are sandy skeletal to coarse fine loamy in texture, and mostly, well drained. Nearly 19 per cent area of the district is occupied by Shiwalik hills and piedmont plain. The district is drained by a number of hilly torrents locally called choes and is surrounded by the Beas River on the northwestern side. Landuse statistics reflected that among all the districts of Punjab, Hoshiarpur has the highest area under forest cover (31.7% of TGA), which is almost at par as per the recommendation of National Forest Policy of 33 per cent.

Total wetland area in the district is 6209 ha that includes 84 small wetlands (<2.25 ha). River/stream occupies 87.03% of wetlands. Reservoir/Barrage is the second large wetland type in the district. There are 8 in this type with 379 ha area (6.10%). The other major wetland types are Riverine (2.066%) and Waterlogged - natural (1.53%). There are 4 Lake/pond with 55 ha area (0.89%). Details of wetland statistics is given in Table-10.

Aquatic vegetation is observed in Lake/pond, Riverine and waterlogged wetland types. The area under aquatic vegetation is slightly more or less same during pre monsoon (737 ha) and post monsoon (747 ha). The open water spread of wetlands is significantly more in post monsoon (2675 ha) than in pre monsoon (1541 ha). The qualitative turbidity of water is low in both the seasons.

Table 10: Area estimates of wetlands in Hoshiarpur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	4	55	0.89	26	34
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	2	128	2.06	-	-
5	1105	Waterlogged	3	95	1.53	16	18
6	1106	River/Stream	34	5404	87.03	2280	1259
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	8	379	6.10	344	224
8	1202	Tanks/Ponds	4	13	0.21	5	2
9	1203	Waterlogged	5	51	0.82	4	4
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**60**	**6125**	**97.83**	**2675**	**1541**
		Wetlands (<2.25 ha), mainly Tanks	84	84	1.35	-	-
		Total	**144**	**6209**	**99.18**	**2675**	**1541**

Area under Aquatic Vegetation	747	737

Area under turbidity levels		
Low	2484	1458
Moderate	191	83
High	-	-

State : Punjab

WETLAND MAP

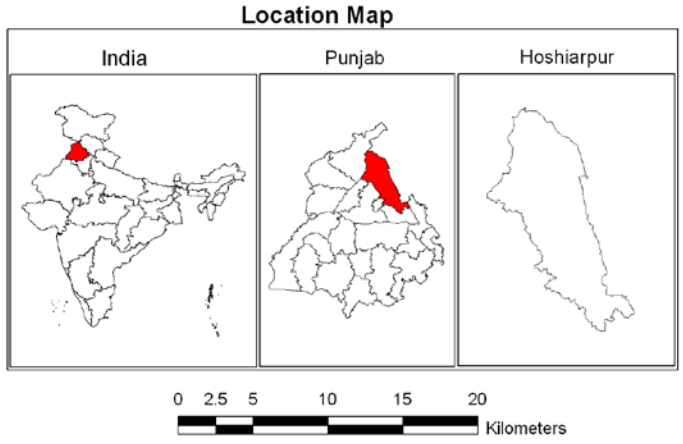
District : Hoshiarpur

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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

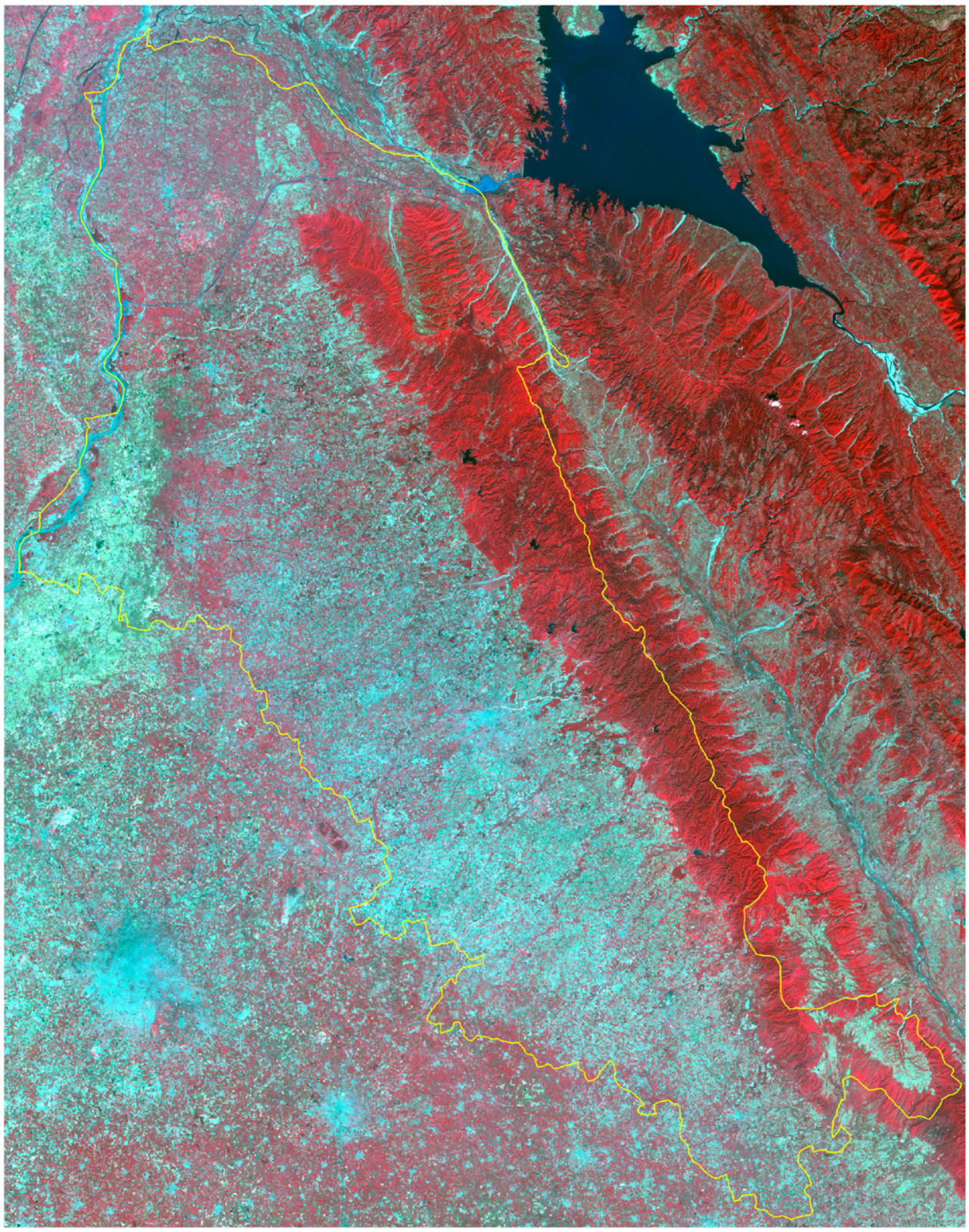
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Hoshiarpur



IRS P6 LISS-III post monsoon data (2006)

7.1.6 Nawansahar

Nawan Shahar district lying in the northeast of Punjab forms a part of the Kandi belt of the state. The district lies between the latitudes of 30^{O} 58' 00" to 31^{O} 14' 00" north and longitudes of 75^{O} 47' 00" to 76^{O} 31' 00" east. It covers an area of 1258 sq. km. It is bounded by Hoshiarpur in the north, Jalandhar and Kapurthala in west, Rupnagar in the east and south east side and in the south, Ludhiana district of Punjab. From administrative point of view, district Nawan Shahar is divided into two tehsils. The district Nawan shahar constitutes Shiwalik Hills, piedmont plain, alluvial plain and flood plain. The low-lying areas, which have been recognized as filled up channels are filled by the finer sediments brought down by the run off waters from the uplands. River Satluj is the main drainage channel which transverse the district Nawan Shahar along its southern boundary. The area is also drained by a number of choes. For most parts of the year these seasonal streams do not carry any water. Bist Doab canal passes through the district. Around 76.4 per cent total geographical area (TGA) of the district is under agricultural use.

Total wetland area in the district is 2106 ha that includes 86 small wetlands (<2.25 ha). River/stream occupies 79.22% of wetlands. Waterlogged - natural is the second large wetland type in the district with 325 ha area (15.45%). The other wetland types are Lake/pond (0.57%), and Tank/pond (o.67%). Details of wetland statistics is given in Table-11.

Aquatic vegetation is observed in Lake/pond, waterlogged wetland types. The area under aquatic vegetation is more or less same in pre monsoon (367 ha) and post monsoon (351 ha). The open water spread of wetlands is significantly more in post monsoon (793 ha) than in pre monsoon (412 ha). The qualitative turbidity of water is low in both the seasons.

Table 11: Area estimates of wetlands in Nawansahar

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes	2	12	0.57	7	3
2	1102	Ox-Bow Lakes/ Cut-Off Meanders	-	-	-	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Riverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	1	325	15.45	-	5
6	1106	River/Stream	7	1666	79.22	779	401
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/ Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	5	14	0.67	7	3
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**15**	**2017**	**95.91**	**793**	**412**
		Wetlands (<2.25 ha), mainly Tanks	86	86	4.09	-	-
		Total	**101**	**2103**	**100.00**	**793**	**412**

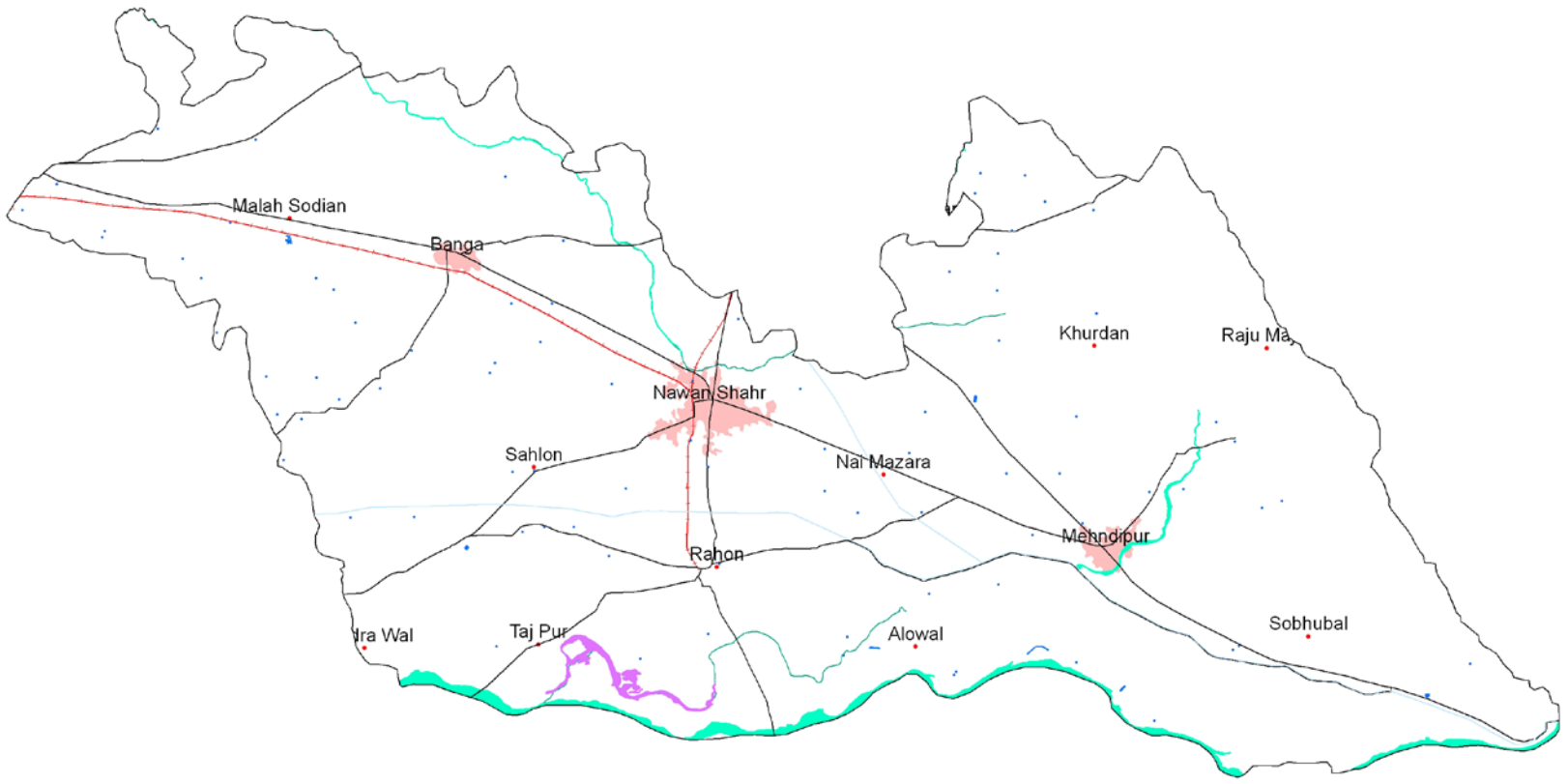
Area under Aquatic Vegetation	351	367

Area under turbidity levels		
Low	779	406
Moderate	14	6
High	-	-

State : Punjab

WETLAND MAP

District : Nawanshahar

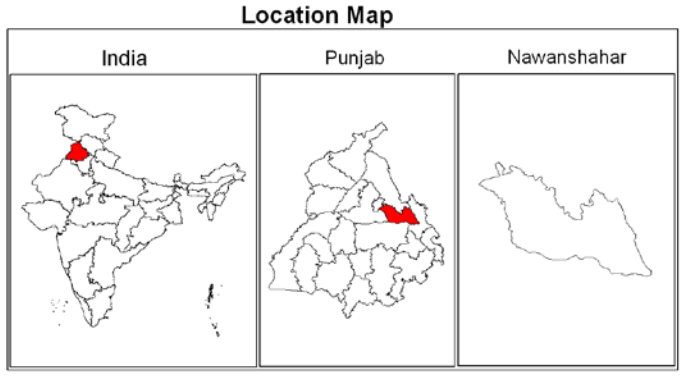


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

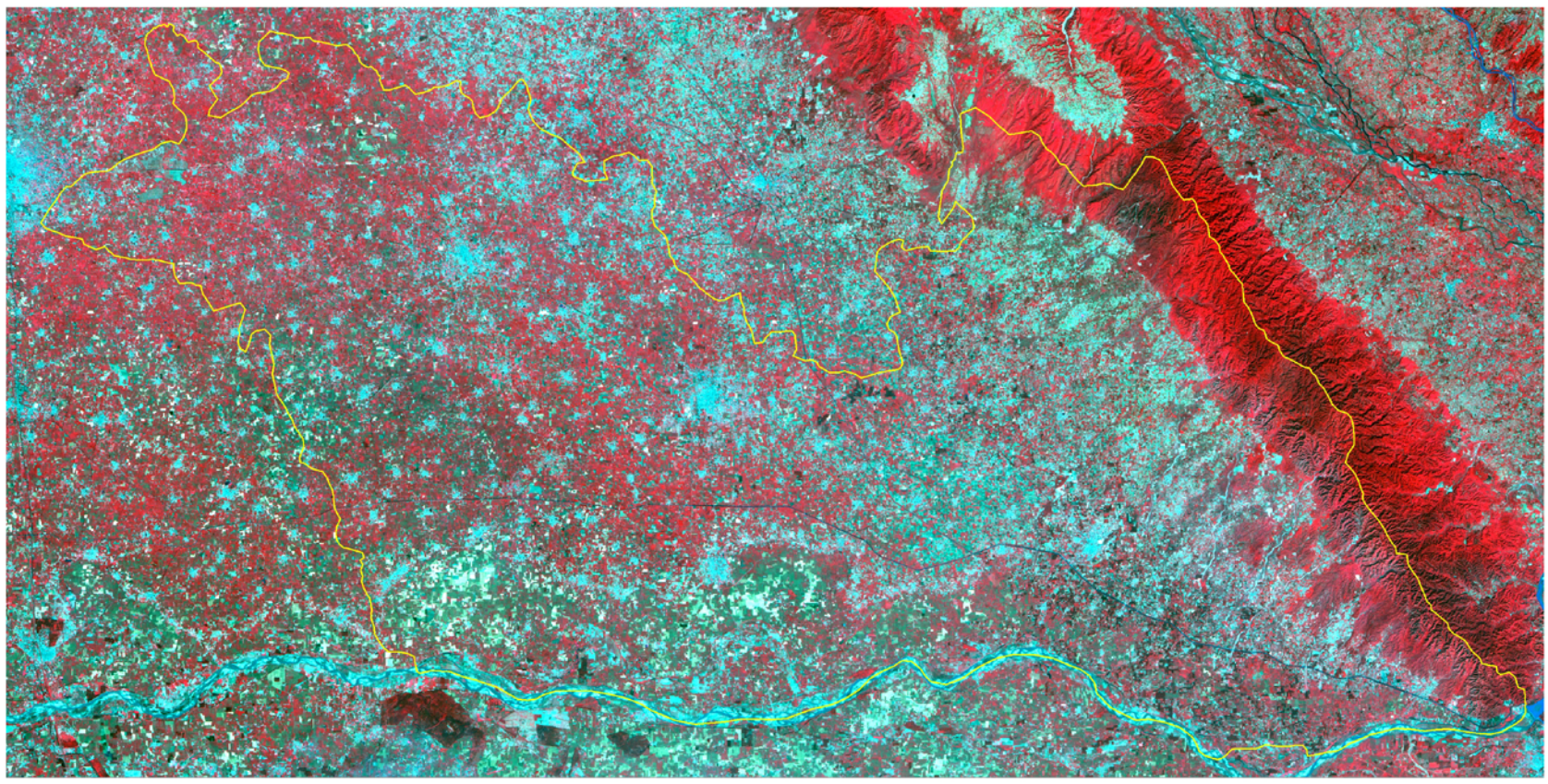
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Nawanshahar



IRS P6 LISS-III post monsoon data (2006)

7.1.7 Rupnagar

Rupnagar district lying in the central-east of Punjab forms a part of the Kandi belt of the state. Recently, a new district Mohali has been curved out from the erstwhile Rupnagar and Patiala districts. The district lies between the latitudes of 30^{O} 44' 37" to 31^{O} 26' 19" north and longitudes of 76^{O} 17' 16" to 76^{O} 44' 24" east. It is bounded by Mohali in the southeast, Fatehgarh Sahib in the south, Nawan Shahar and Ludhiana in the west, Hoshiarpur districts of Punjab in the northwest and Himachal Pradesh in the north and east. From administrative point of view, district Rupnagar is divided into two tehsils. Rupnagar district has been divided into three major landforms viz. Shiwalik Hills, piedmont plain and alluvial plain. The district is drained by a number of hill torrents locally called choes and is surrounded by the Beas River on the northwestern side. Nearly 57.5 per cent of total geographical area (TGA) is under agricultural use.

Total wetland area in the district is 8950 ha that includes 115 small wetlands (<2.25 ha). River/stream occupies 89.35% of wetlands. Reservoir/barrage is the second large wetland type in the district. There are 5 in this category with 502 ha area (5.61%). The other wetland types are Tank/pond (3.52%), and Lake/pond (0.23%). Details of wetland statistics is given in Table-12.

Aquatic vegetation is observed in Lake/pond, waterlogged wetland types. The area under aquatic vegetation is more or less same in pre monsoon (101 ha) and post monsoon (75 ha). The open water spread of wetlands is slightly more in post monsoon (3633 ha) than in pre monsoon (2590 ha). The qualitative turbidity of water is low in both the seasons.

Table 12: Area estimates of wetlands in Rupnagar

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	3	21	0.23	13	9
2	1102	Ox-Bow Lakes/ Cut-Off Meanders	-	-	-	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Riverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	22	7997	89.35	2977	1933
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	5	502	5.61	445	427
8	1202	Tanks/Ponds	23	315	3.52	198	221
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**53**	**8835**	**99**	**3633**	**2590**
		Wetlands (<2.25 ha), mainly Tanks	115	115	1.28	-	-
		Total	**168**	**8950**	**100**	**3633**	**2590**

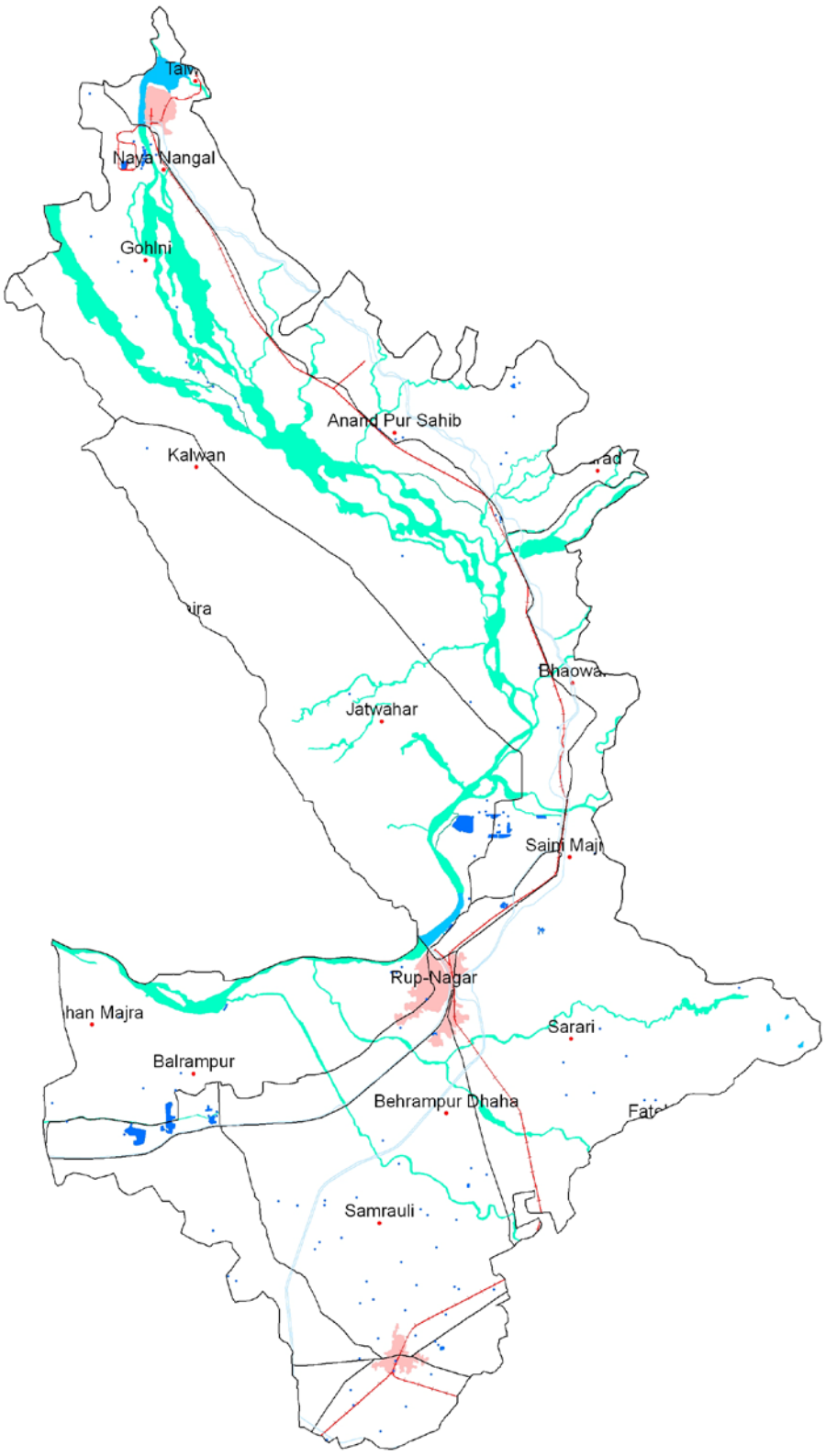
Area under Aquatic Vegetation	75	101

Area under turbidity levels		
Low	3191	2239
Moderate	318	238
High	124	113

State : Punjab

WETLAND MAP

District : Rupnagar

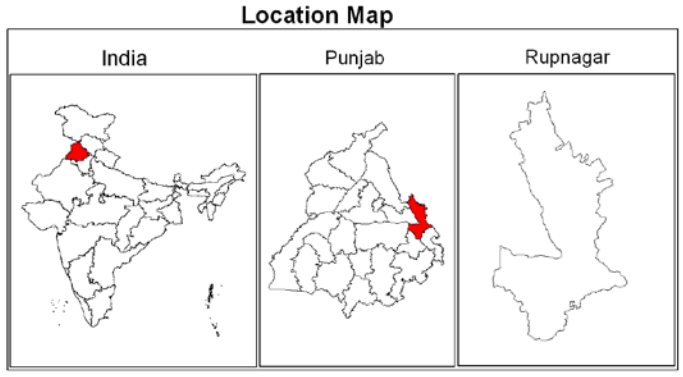


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

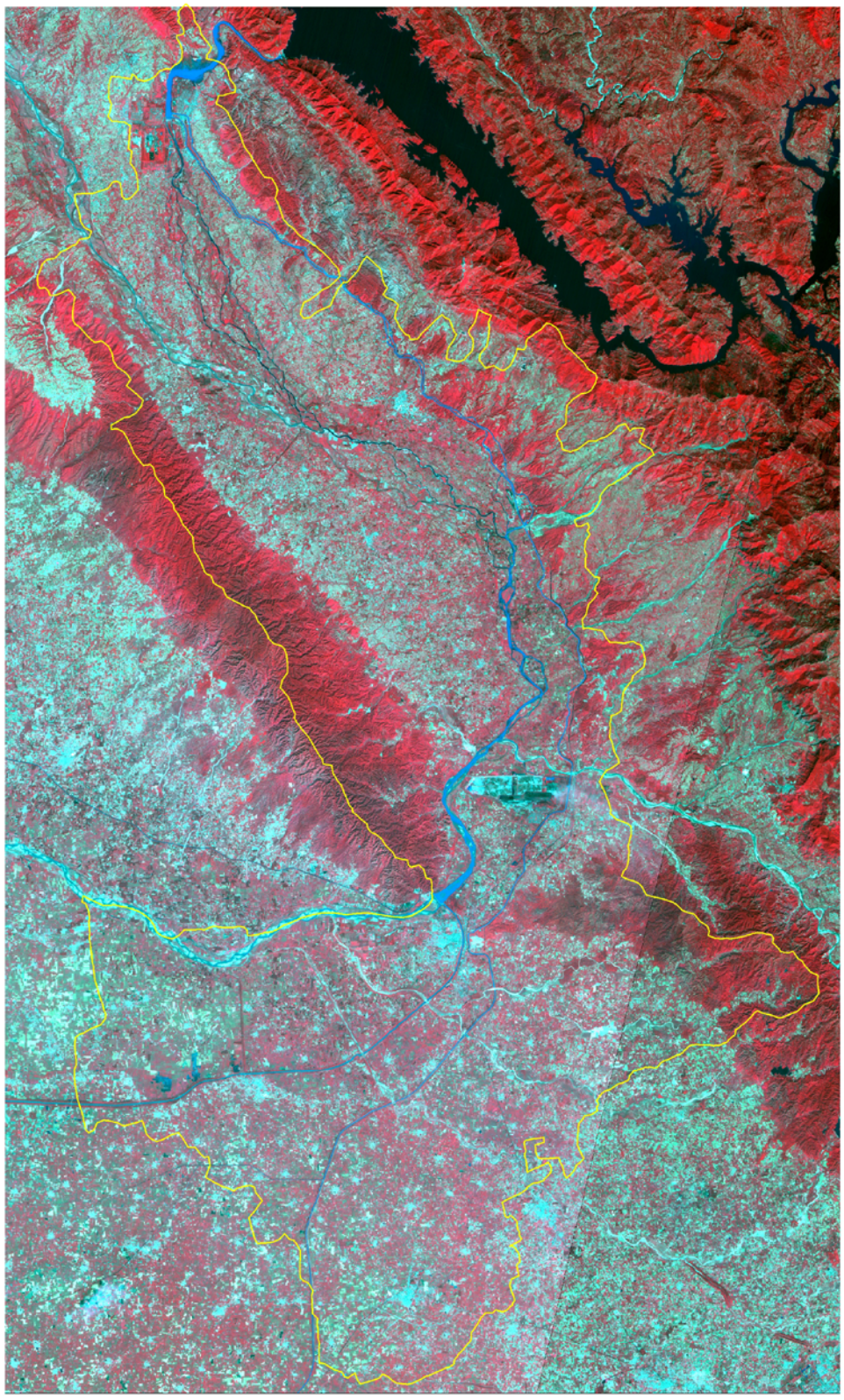
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Rupnagar



IRS P6 LISS-III post monsoon data (2006)

7.1.8 Fatehgarh Sahib

Fatehgarh sahib district lies in the central-eastern part of Punjab and is bounded by the latitudes of 30^{O} 25' 00" to 30^{O} 53' 00" north and longitudes of 76^{O} 05' 00" to 76^{O} 36' 00" east. Geographically, it is the second smallest district of Punjab, covers an area of 1180 sq. km. It is bounded by Rupnagar in the north east, Mohali in the east, Ludhiana district in the northwest and west, Sangrur district in the south-west and Patiala districts of Punjab in the south. From administrative point of view, district Fatehgarh sahib is divided into four tehsils The soil of the district are mainly alluvial type with soil texture varying from coarse to fine loamy even clayey in localized areas. Most of the soils are calcareous in nature. The climate of the district is extreme hot in summer and cold in winter. The temperature varies from 45^{0}C (in May / June) to 4^{0}C in December / January. It has a sub-tropical continental monsoon climate with an average annual rainfall varies from 400 to 500 mm. The district has more than 88 per cent of the total geographical area (TGA) under cultivation.

This district has the smallest share of total wetland area of the state. Total wetland area in the district is 267 ha that includes 138 small wetlands (<2.25 ha). In fact, the small wetlands which are mainly Tank/pond type account for 51.69% of total wetland area. River/stream occupies 24.72% followed by Tank/pond (20.97%). There is only one Lake/pond with 7 ha area (2.62%). Details of wetland statistics is given in Table-13.

The area under aquatic vegetation is slightly more in pre monsoon (76 ha) than in post monsoon (21 ha). The open water spread of Tank/pond and Lake/pond is more or less same in post monsoon (39 ha) and pre monsoon (35 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 13: Area estimates of wetlands in Fatehgarh Sahib

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	7	2.62	5	5
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	1	66	24.72	-	-
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	14	56	20.97	34	30
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**16**	**129**	**48.31**	**39**	**35**
		Wetlands (<2.25 ha), mainly Tanks	138	138	51.69	-	-
		Total	**154**	**267**	**100.00**	**39**	**35**

Area under Aquatic Vegetation	21	76

Area under turbidity levels		
Low	-	-
Moderate	39	35
High	-	-

State : Punjab

WETLAND MAP

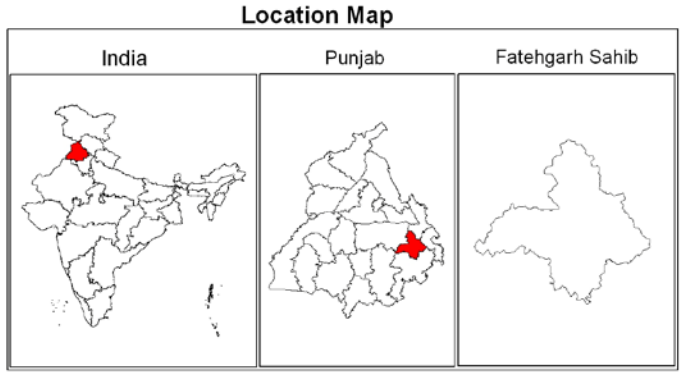
District : Fatehgarh Sahib

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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

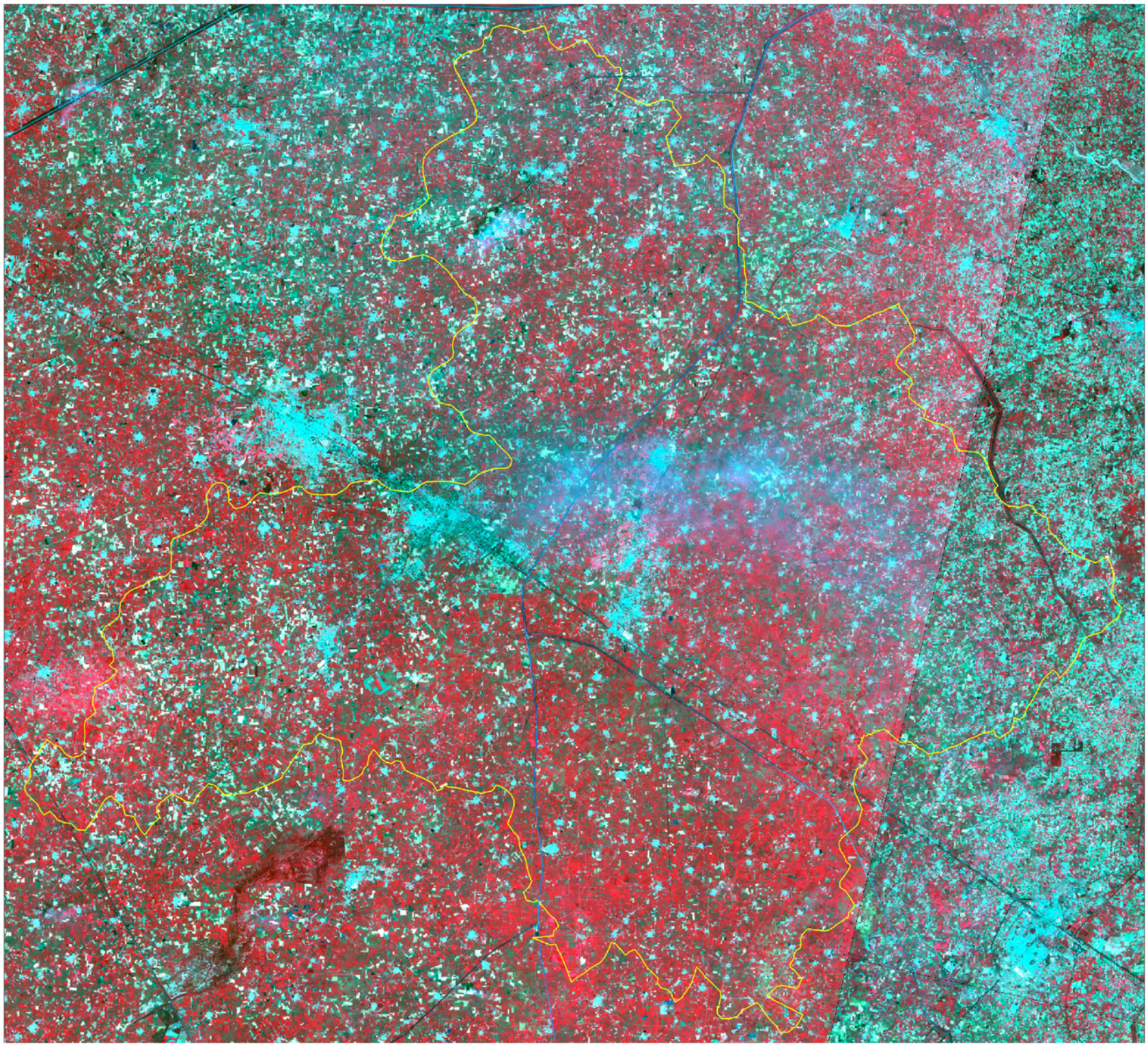
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Fatehgarh Sahib



IRS P6 LISS-III post monsoon data (2006)

7.1.9 Ludhiana

Ludhiana is one of the centrally located districts of Punjab covering a geographical area of 3744 Sq Km. The district lies between the latitudes of $30^{O}33^{'}$ to $31^{O}01^{'}$ N and longitudes of $75^{O}21^{'}$ to $76^{O}19^{'}$ E. It is bounded by the river Satluj in the north, in the east by Rupnagar and Fatehgarh Sahib, in the west by Moga and in the southern side, Sangrur and Barnala districts of Punjab. From administrative point of view, district Ludhiana is divided into seven Tehsils Physiographically, Ludhiana district is a flat terrain consisting of three units viz. flood plain, alluvial plain and sand bars/dunes. The district is drained by the river Satluj in addition well distributed drainage system which includes the Buddha Nallah (tributary of Satluj River), Bassian drain, Jasowal drain, Lissara Nallah and Phida drain. The district has an extensive network of canals like Abohar, Bathinda, Sirhind and Sidhwan branch. Around 83.2 per cent of the total geographical area (TGA) of the Ludhiana district is under cultivation.

Total wetland area in the district is 4740 ha that includes 475 small wetlands (<2.25 ha). River/stream occupies 75.68% of wetlands. There are 87 Tank/pond with 308 ha area (6.50%). There are 15 Lake/pond with 133 ha area (2.81%). Waterlogged - natural account for 4.2% area. Details of wetland statistics is given in Table-14.

Aquatic vegetation is observed in Lake/pond, Tank/pond wetland types. The area under aquatic vegetation is more or less same in pre monsoon (582 ha) and post monsoon (486 ha). The open water spread of wetlands is significantly more in post monsoon (2299 ha) than in pre monsoon (1197 ha). The qualitative turbidity of water is low in both the seasons.

Table 14: Area estimates of wetlands in Kudhiana

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	15	133	2.81	82	60
2	1102	Ox-Bow Lakes/ Cut-Off Meanders	1	38	0.80	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Riverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	1	199	4.20	14	-
6	1106	River/Stream	3	3587	75.68	2009	962
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	87	308	6.50	194	167
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**107**	**4265**	**89.98**	**2299**	**1197**
		Wetlands (<2.25 ha), mainly Tanks	475	475	10.02	-	-
		Total	**582**	**4740**	**100.00**	**2299**	**1197**

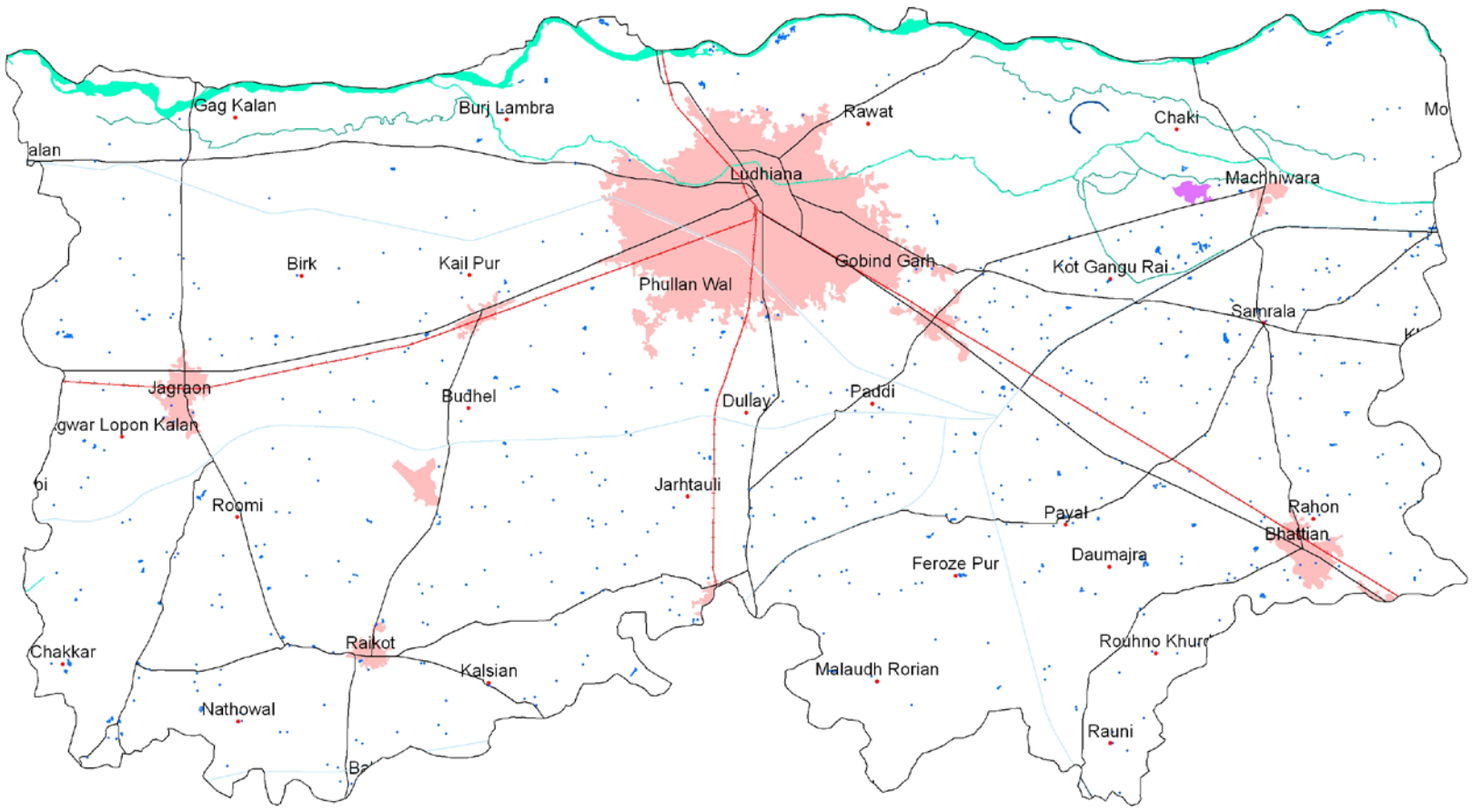
Area under Aquatic Vegetation	486	582

Area under turbidity levels		
Low	2022	961
Moderate	277	236
High	-	-

State : Punjab

WETLAND MAP

District : Ludhiana

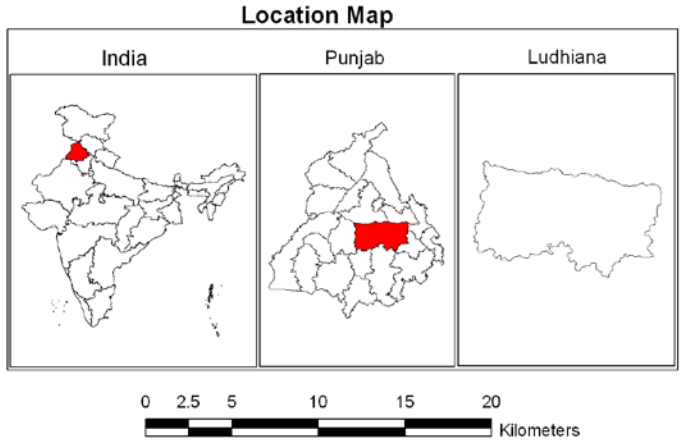


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

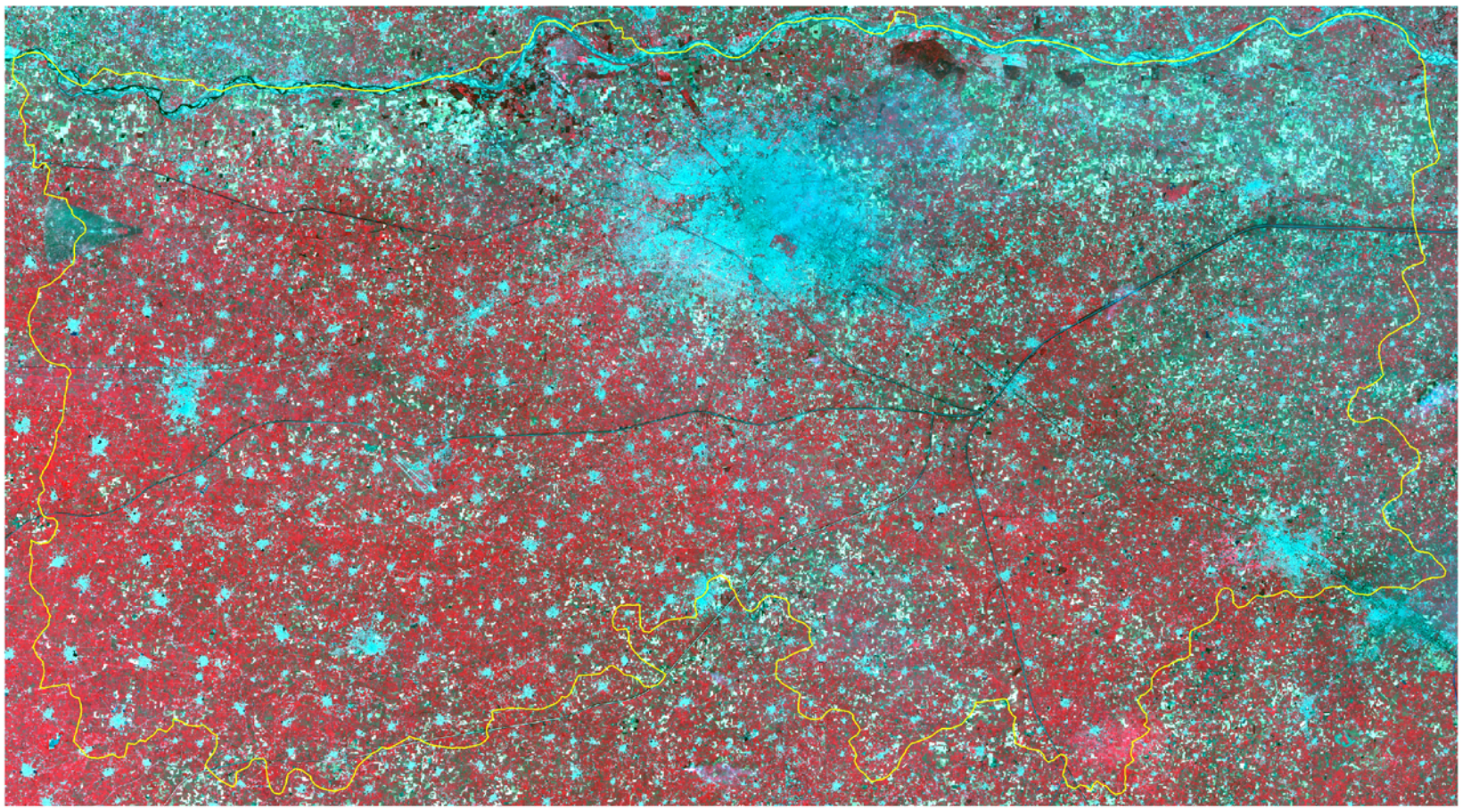
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Ludhiana



IRS P6 LISS-III post monsoon data (2006)

7.1.10 Moga

Moga is one of the centrally located districts of the Punjab, which is surrounded by Ludhiana in east, Bathinda and newly formed Barnala districts in the south, Faridkot and Firozpur in the west and in the north, Jalandhar districts of Punjab. The district lies between the latitudes of 30^0 29' 06" to 31^0 06' 12" north and a longitude ranging from 74^0 54' 13" to 75^0 25' 08" east. Geographically, the district is medium in size compared to other surrounding districts covering an area of 1672 sq. km.. The district has been divided into five blocks. The area can be divided into three geomorphic units viz. alluvial plain, flood plain and sand dune complexes. Alluvial plain constitute the major part of study area and formed by the alluvial deposits brought by Satluj river. The soils are coarse loamy to fine loamy, calcareous and well drained. The district has a well-developed canal network. Satluj river flowing along the northern border of the district, Phidda drain traversing through central part of the district, Chandbhan and Samadh Bhai drains flowing across the southern parts of the district are part of the effective drainage network of the district. Apart from these drains, Daodhar drain, Longiana drain, Dagru drain, Daulatpur drain, Chachrari drain, Singhanwala drain, Bassian Outfall drain and Sukar Nala are also part of the drainage system in the district.

Total wetland area in the district is 1823 ha that includes 276 small wetlands (<2.25 ha). River/stream occupies 64.56% of wetlands. There are 68 Tank/pond with 237 ha area (13.7%). Total 13 Lake/pond are mapped with 133 ha area (7.3%). Small wetlands which are mainly Tank/pond account for about 15.14% share. No other wetland types are observed. Details of wetland statistics is given in Table-15.

Aquatic vegetation is observed in Lake/pond and Tank/pond types. The area under aquatic vegetation is more or less same in pre monsoon (196 ha) and post monsoon (149 ha). The open water spread of wetlands is significantly more in post monsoon (804 ha) than in pre monsoon (343 ha). The qualitative turbidity of water is low to moderate in both the seasons.

Table 15: Area estimates of wetlands in Moga

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	18	133	7.30	83	40
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	3	1177	64.56	584	209
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	68	237	13.00	137	94
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**89**	**1547**	**84.86**	**804**	**343**
		Wetlands (<2.25 ha), mainly Tanks	276	276	15.14	-	-
		Total	**365**	**1823**	**100.00**	**804**	**343**

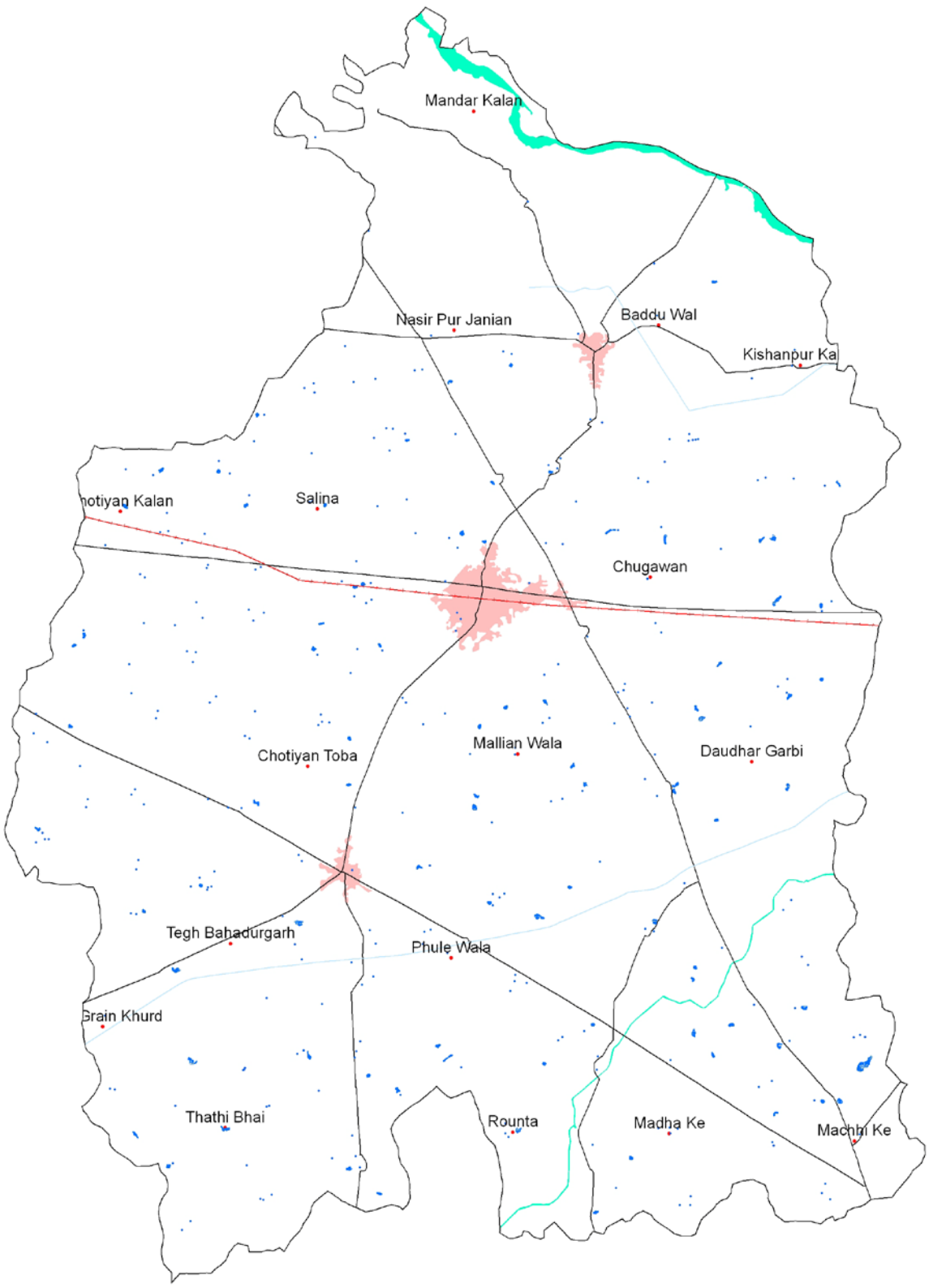
Area under Aquatic Vegetation	149	196

Area under turbidity levels		
Low	584	210
Moderate	220	133
High	-	-

State : Punjab

WETLAND MAP

District : Moga

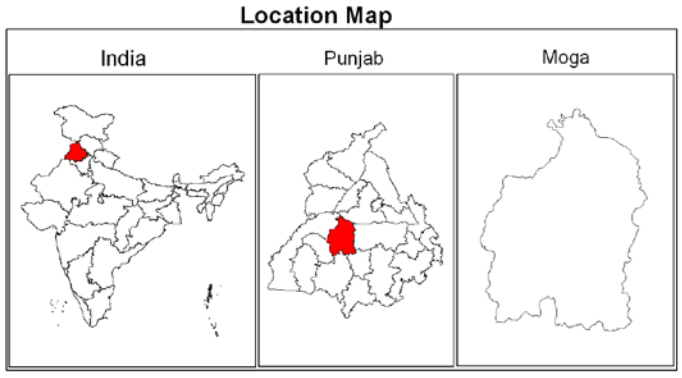


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20

Kilometers

Data Source :

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

Prepared By :

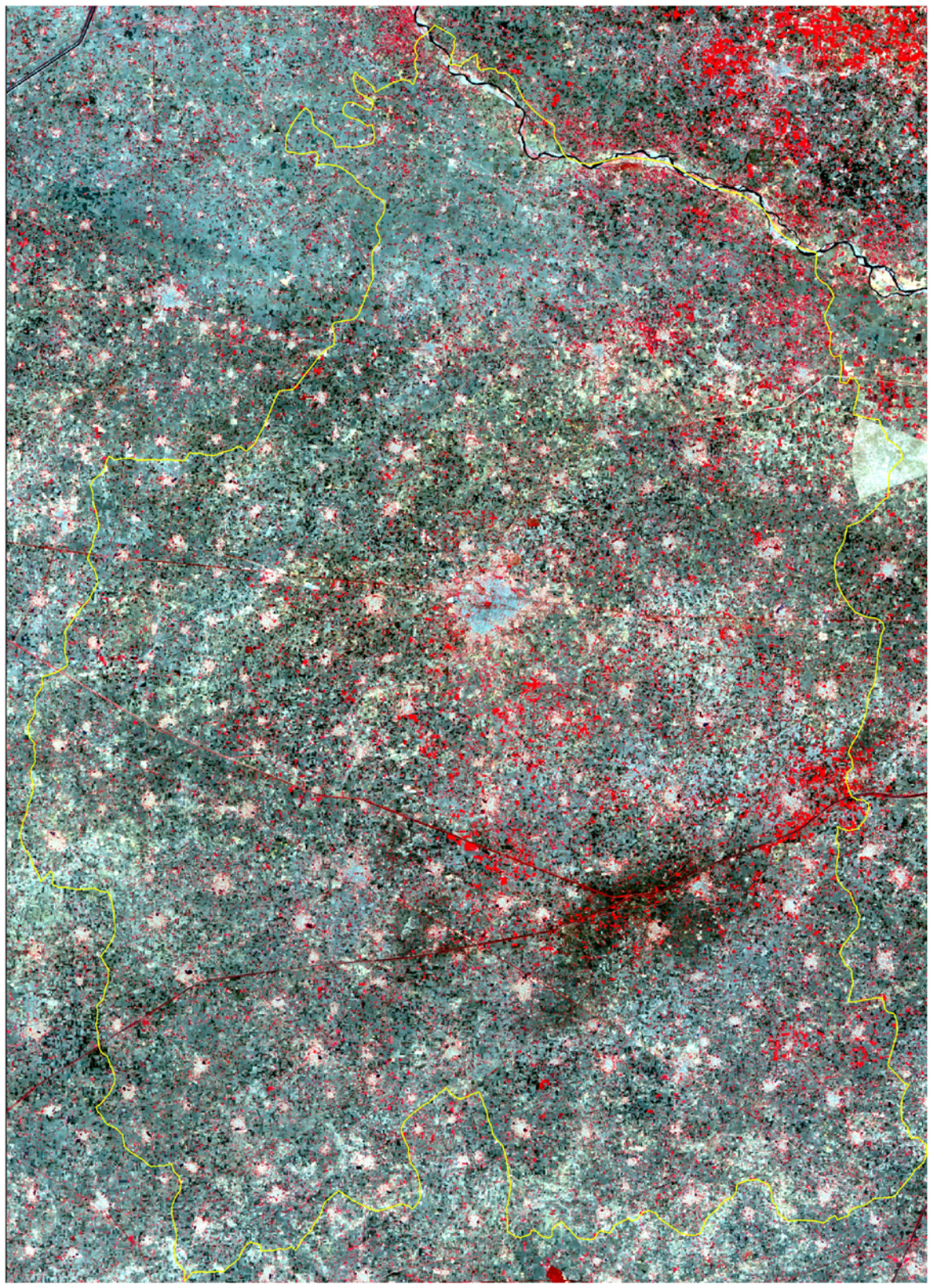
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Moga



IRS P6 LISS-III pre monsoon data (2007)

7.1.11 Firozpur

The Firozpur district is located in the southwestern part in the Malwa region of Punjab. It covers an area of 5865 sq. km. Geographically, it is the biggest district of Punjab. It is bounded by the State of Rajasthan in the south, by Tarn Taran district in the north, Kapurthala and Jalandhar in the northeast; Moga, Faridkot and Muktsar districts of Punjab in the east and Pakistan in the west. The district lies between the latitudes of 29^{O} 55' 36" to 31^{O} 10' 58" N and longitudes of 73^{O} 52' 33" to 75^{O} 09' 19" E with mean elevation of 204.33 meters above mean sea level. It has extreme climate, with the summers being very hot and the winters very cold. The river Sutlej runs along the western boundary of the district and discends to Pakisatan. From administrative point of view, the district is divided into five tehsils. Physio-graphically, Firozpur district has been divided into three landform units' viz. alluvial plain, flood plain and sand dune complexes. The sand dunes complexes constitute nearly 14 per cent geographical area of the district. The district experiences flooding / or water logging problems in some localised pockets in the years of above normal rainfall. The Bikaner canal originating from Hussaniwala passes through the district and there is a network of distributaries covering the whole area except sand dunes. More than 90 per cent of the total geographical area (TGA) of the district is under agricultural use.

Total wetland area in the district is 8647 ha that includes 498 small wetlands (<2.25 ha). River/stream occupies 61.21% of wetlands. Reservoir/Barrage is the second largest wetland type. Total 3 of this type is mapped with 2425 ha area (28.04%). The other wetland types are Lake/pond (0.43%), Ox-bow lakes (1.01%), Tank/pond (2.64%) and waterlogged. Details of wetland statistics is given in Table.16.

The area under aquatic vegetation is slightly more in post monsoon (1512 ha) than in pre monsoon (1222 ha). The open water spread of wetlands is more in post monsoon (2881 ha) than in pre monsoon (1037 ha). The qualitative turbidity of water is low in both the seasons.

Table 16: Area estimates of wetlands in Firozpur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	5	37	0.43	12	9
2	1102	Ox-bow lakes/ Cut-off meanders	2	87	1.01	46	42
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	57	0.66	3	2
6	1106	River/Stream	19	5293	61.21	1612	865
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	3	2425	28.04	1094	985
8	1202	Tanks/Ponds	61	228	2.64	114	134
9	1203	Waterlogged	1	22	0.25	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**0**	**8149**	**0.00**	**2881**	**2037**
		Wetlands (<2.25 ha), mainly Tanks	498	498	5.76	-	-
		Total	**498**	**8647**	**5.76**	**2881**	**2037**

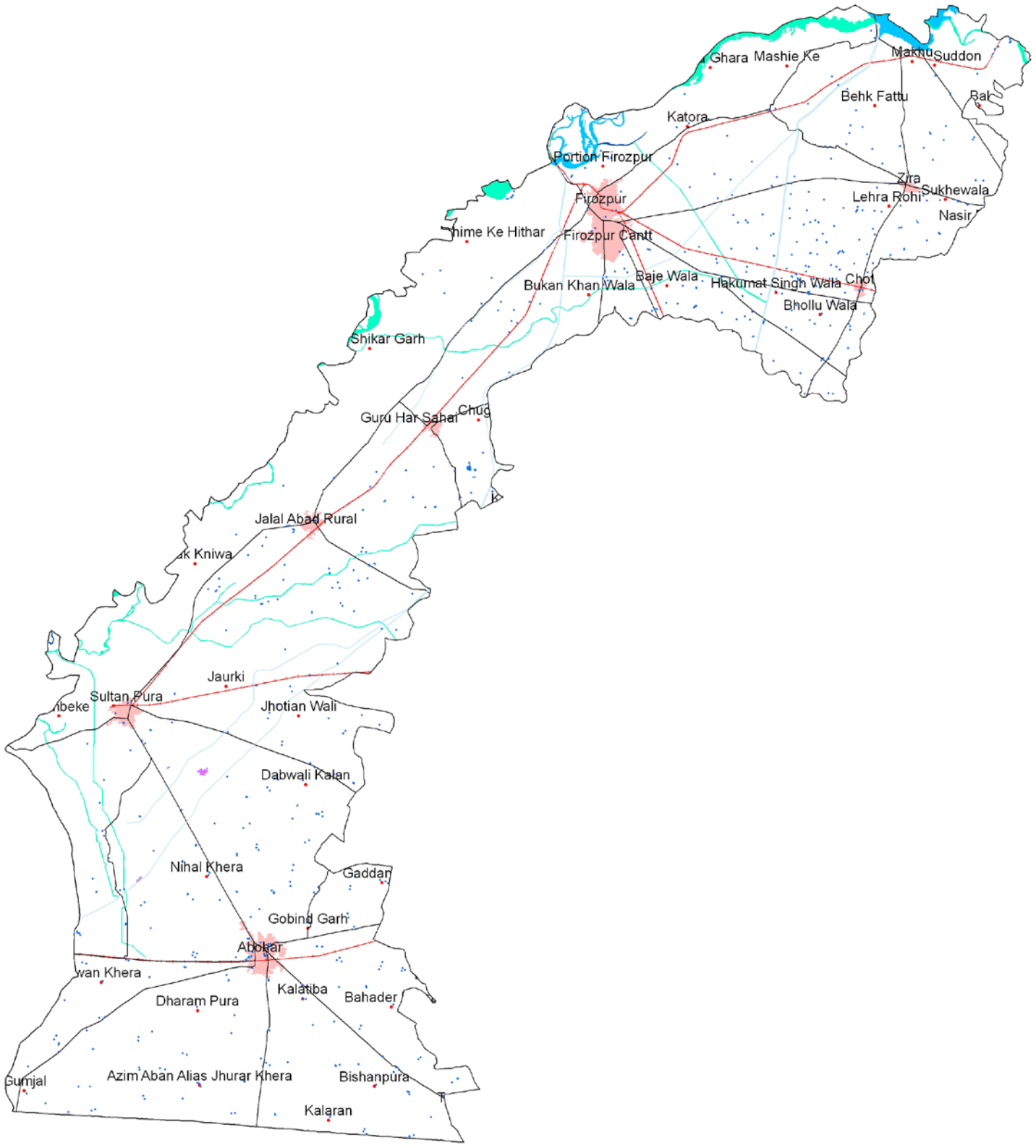
Area under Aquatic Vegetation	1512	1222

Area under turbidity levels		
Low	2600	1755
Moderate	268	260
High	13	22

State : Punjab

WETLAND MAP

District : Firozpur

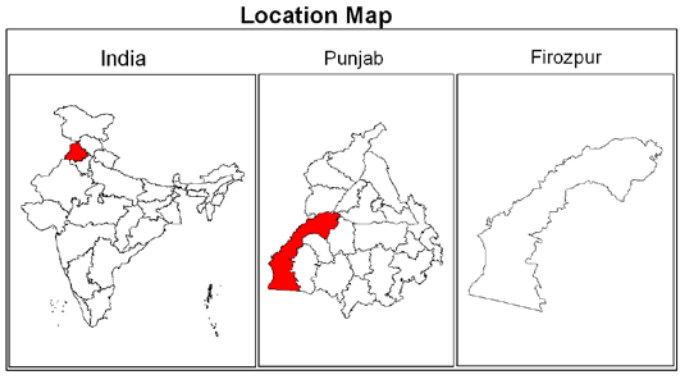


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 5 10 20 30 40 Kilometers

Data Source :

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

Prepared By :

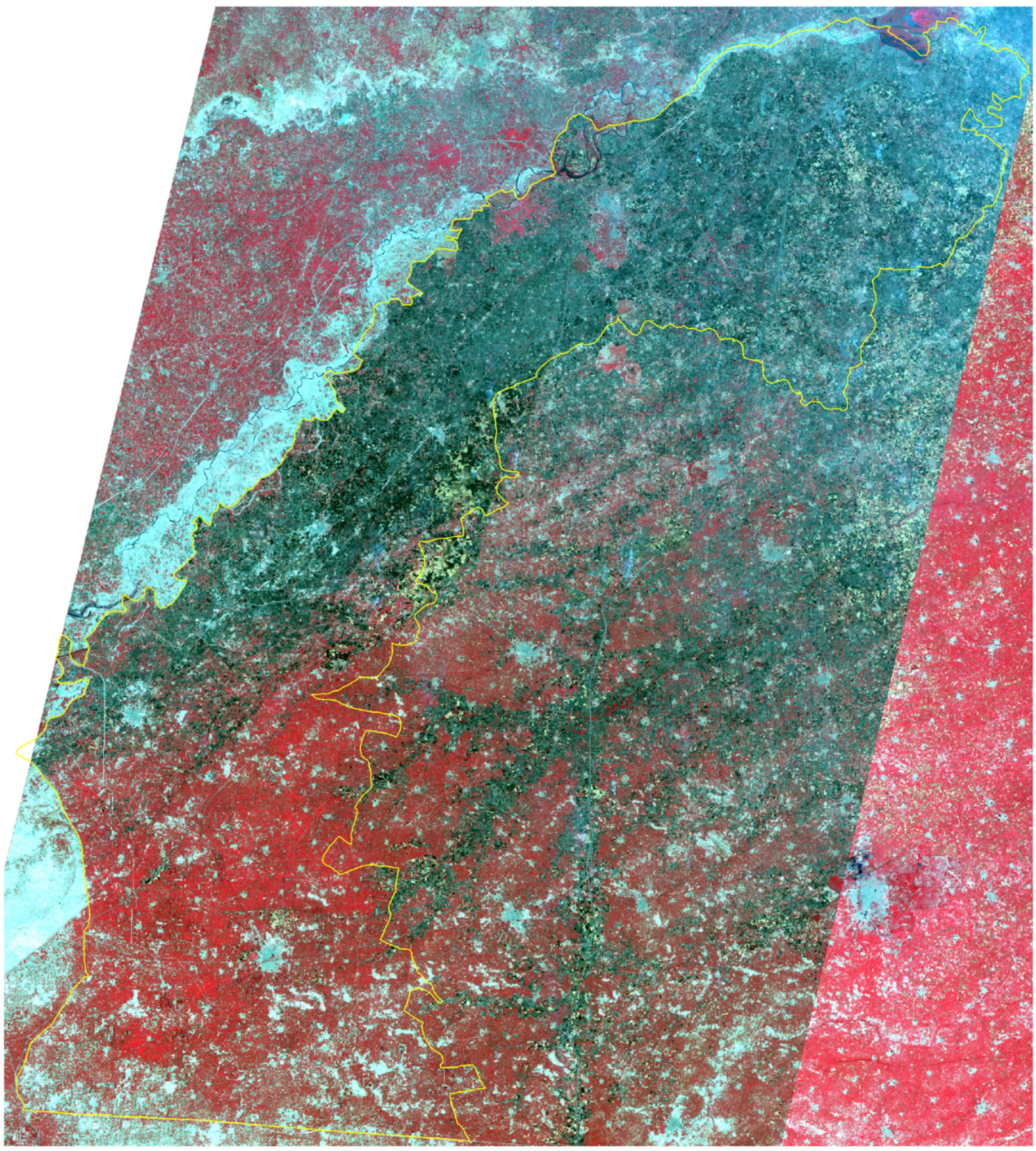
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Firozpur



IRS P6 LISS-III post monsoon data (2006)

7.1.12 Muktsar

This district was carved out of Faridkot district on November 7, 1995 with it's headquarter at Muktsar. It covers an area of 2596 sq km which is 5.23 per cent area of Punjab state. The district is located in the southern part of Punjab. It is bounded by the State of Haryana in the south, in the north by Faridkot, in the west by Firozpur and in the east by Bathinda districts of Punjab. The district lies between the latitudes of 29^{O} 53' 31" to 30^{O} 40' 43" N and longitudes of 74^{O} 15' 03" to 74^{O} 49' 32" E. From administrative point of view, district Muktsar is divided into three thesis. Physiographically, the area can be divided into two major geomorphic units' viz. Alluvial plain and Palaeochannels /Sand dune complexes. Later constitutes nearly 14 per cent geographical area of the district. The district experiences occasional drainage problems in some localised pockets. In the years of above normal rainfall, the runoff water accumulates in low-lying areas resulting in flooding and subsequent water logging. The twin canals i.e., Rajasthan and Sirhind Feeders pass through the district and there is a network of distributaries covering the whole area except sand dunes. The soils are coarser in texture and have poor structure. These soils are highly permeable with very low water and nutrient holding capacity. The seepage from canals and paddy fields in surrounding upland districts has further compounded the problem of water logging. Around 91.3 per cent of the total geographical area (TGA) of the Muktsar district is under cultivation.

Total wetland area in the district is 1812 ha that includes 359 small wetlands (<2.25 ha). Waterlogged-manmade is the major wetland type in the district. Total 35 sites of this wetland type with 845 ha is mapped which account for 46.53 % of total wetland area of the district. River/stream occupies 13.47% of wetlands. There are 69 Tank/pond mapped with 239 ha area (13.19%). There are 14 Lake/pond with 125 ha area (6.90%). Details of wetland statistics is given in Table.17.

Aquatic vegetation is observed in Lake/pond, Tank/pond and waterlogged wetland types. The area under aquatic vegetation is significantly more in pre monsoon (664 ha) than in post monsoon (221 ha). The open water spread of wetlands is significantly more in post monsoon (1174 ha) than in pre monsoon (350 ha). The qualitative turbidity of water is mainly moderate in post monsoon and low to moderate in pre monsoon.

Table 17: Area estimates of wetlands in Muktsar

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	14	125	6.90	70	61
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	4	244	13.47	192	105
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	69	239	13.19	110	117
9	1203	Waterlogged	35	845	46.63	802	67
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**122**	**1453**	**80.19**	**1174**	**350**
		Wetlands (<2.25 ha), mainly Tanks	359	359	19.81	-	-
		Total	**481**	**1812**	**100.00**	**1174**	**350**

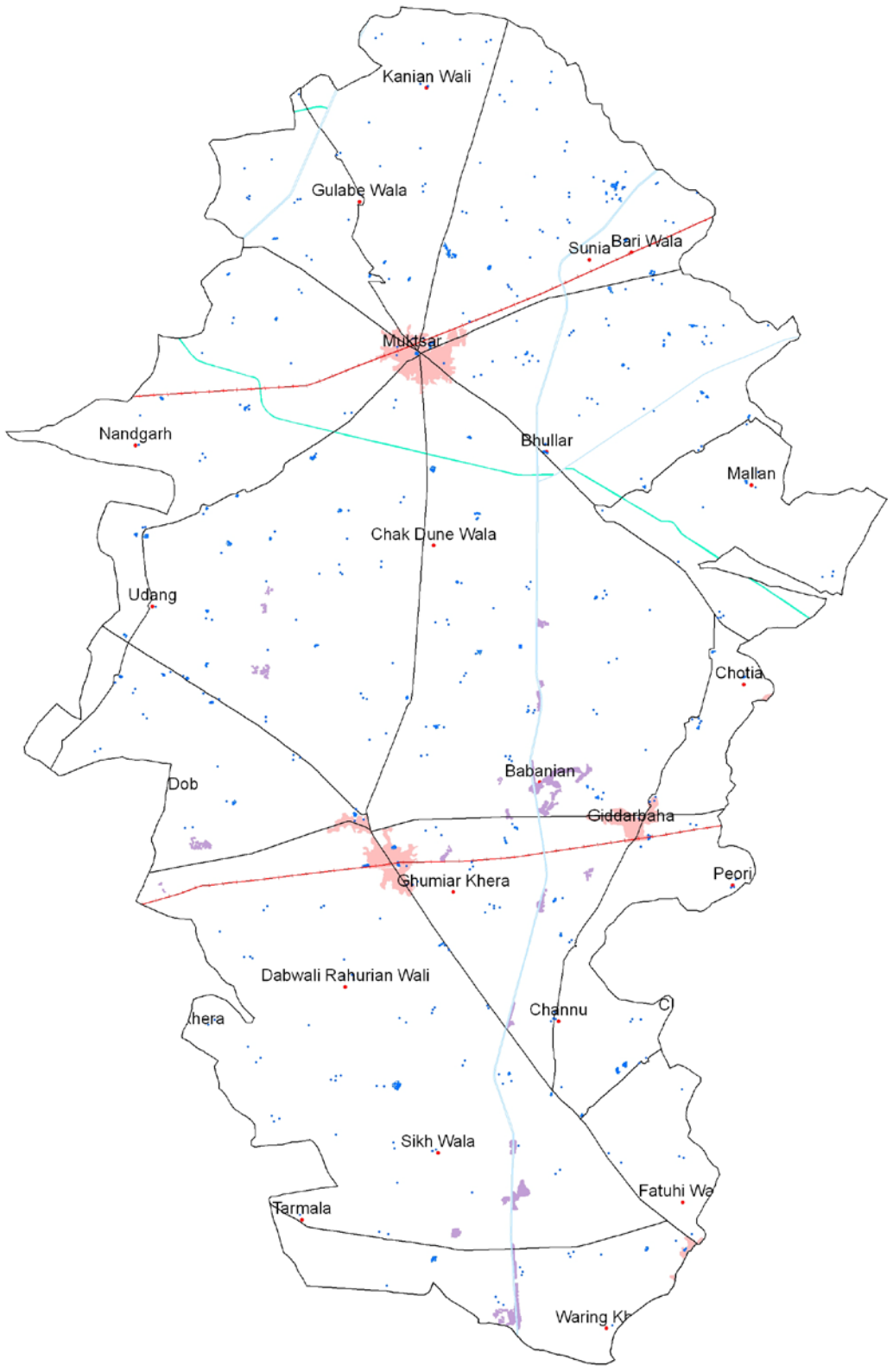
Area under Aquatic Vegetation	221	664

Area under turbidity levels		
Low	192	105
Moderate	982	245
High	-	-

State : Punjab

WETLAND MAP

District : Muktsar

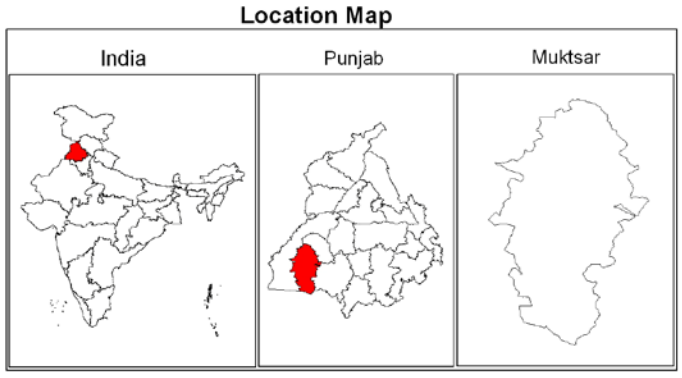


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

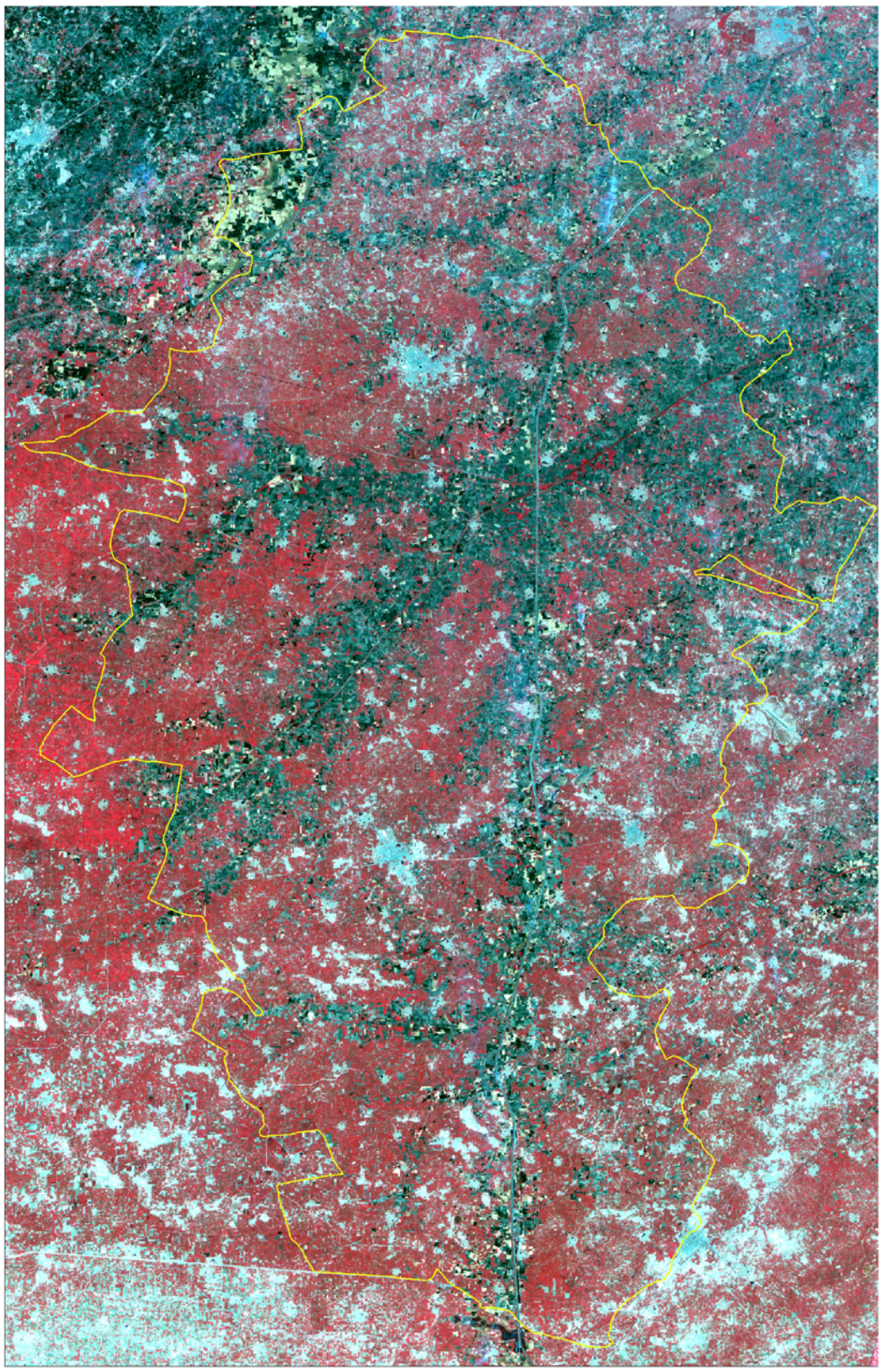
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Muktsar



IRS P6 LISS-III post monsoon data (2006)

7.1.13 Faridkot

Faridkot district is located in the southwestern part of Punjab state. It lies between 30° 21' 30'' to 30° 50' 49'' north latitude and 74° 28' 15'' to 75° 03' 20'' east longitude and forms part of Malwa plain. It shares common boundaries with Moga and Bhatinda district in the east, Firozpur district in the north & west and Muktsar district in the south. The average elevation is 204.3 metres above mean sea level. The district covers an area of 1472 sq. km. and is sub divided into two tehsils. The district is situated in the relatively semi-arid region of the state. The climate is extremely hot and dry in the summer and cold in the winter. The area receives relatively less rainfall (around 400 mm). Faridkot district is more or less a flat terrain. The various landforms in the Faridkot district are alluvial plain (upper/lower), sand dunes, flood plains, and Palaeochannels. Alluvial plain constitutes the major portion of the district. It is gently sloping from northeast to southwest. Part of the alluvial plain is subjected to local flooding. No river flows through this district but there is a vast network of canals emanating from Sirhind Canal System and Sirhind feeder. Nearly 87 per cent of the total geographical area (TGA) of the district is under agricultural use

Total wetland area in the district is 585 ha that includes 257 small wetlands (<2.25 ha). River/stream account only 19.49 % of total wetland area. Total 37 Tank/pond are mapped with 120 ha area (20.51%). Waterlogged-manmade is a major wetland type (15.04%). Thus, the small wetlands which are mainly Tank/pond type which account for around 44.0 per cent has special significance for the district. Details of wetland statistics is given in Table.18.

Aquatic vegetation is observed in Tank/pond, waterlogged wetland types. The area under aquatic vegetation is more in post monsoon (152 ha) than in pre monsoon (48 ha). The open water spread of wetlands is more or less same in post monsoon (53 ha) and pre monsoon (65 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 18: Area estimates of wetlands in Faridkot

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	6	1.03	2	5
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	3	114	19.49	-	-
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	37	120	20.51	51	60
9	1203	Waterlogged	5	88	15.04	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**46**	**328**	**56.07**	**53**	**65**
		Wetlands (<2.25 ha), mainly Tanks	257	257	43.93	-	-
		Total	**303**	**585**	**100.00**	**53**	**65**

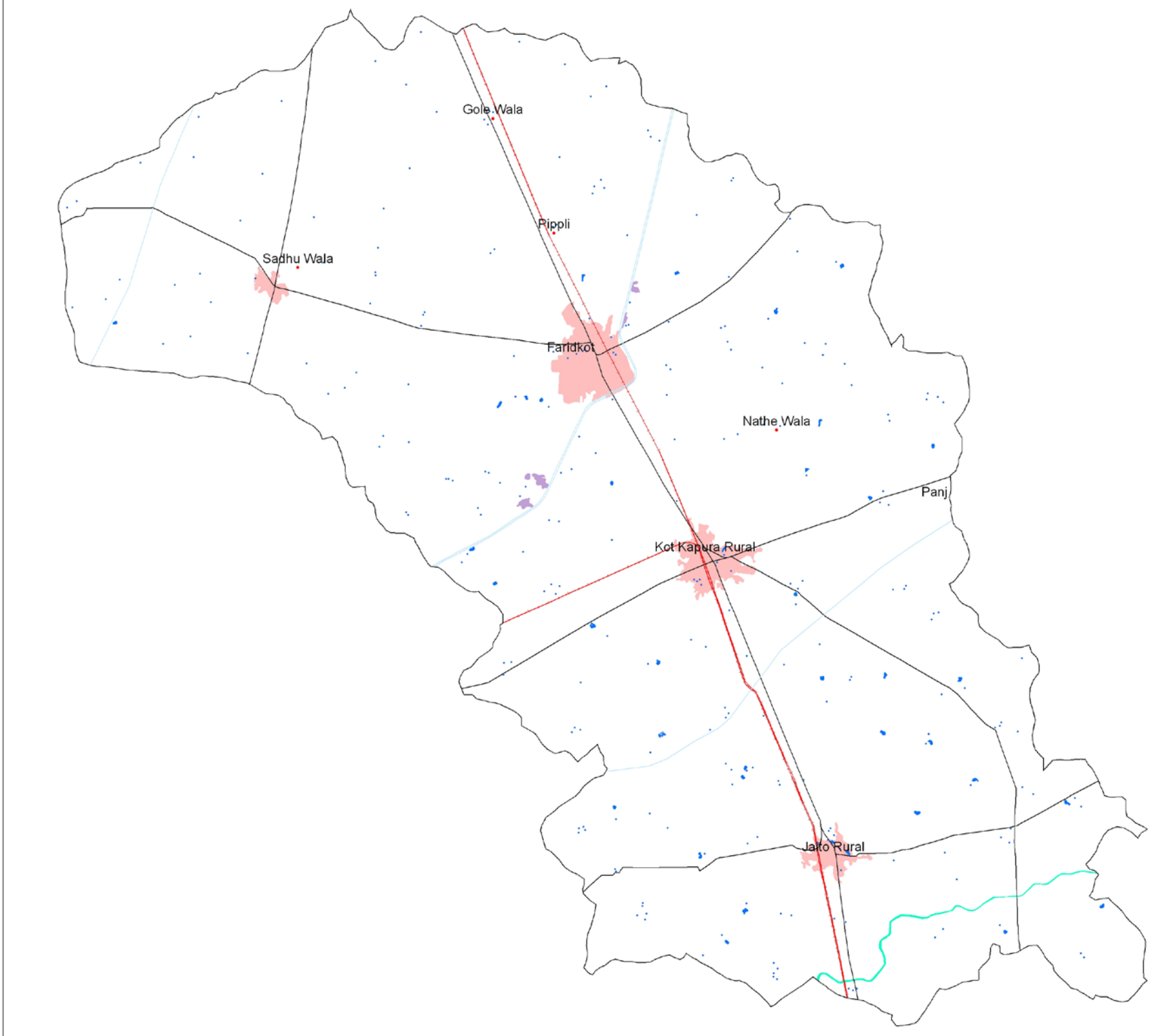
Area under Aquatic Vegetation	152	48

Area under turbidity levels		
Low	-	-
Moderate	53	65
High	-	-

State : Punjab

WETLAND MAP

District : Faridkot

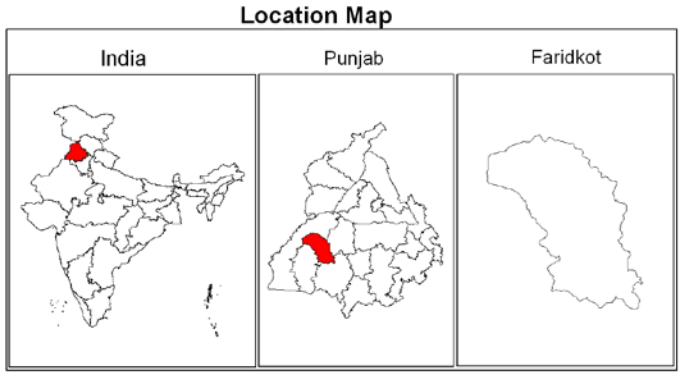


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

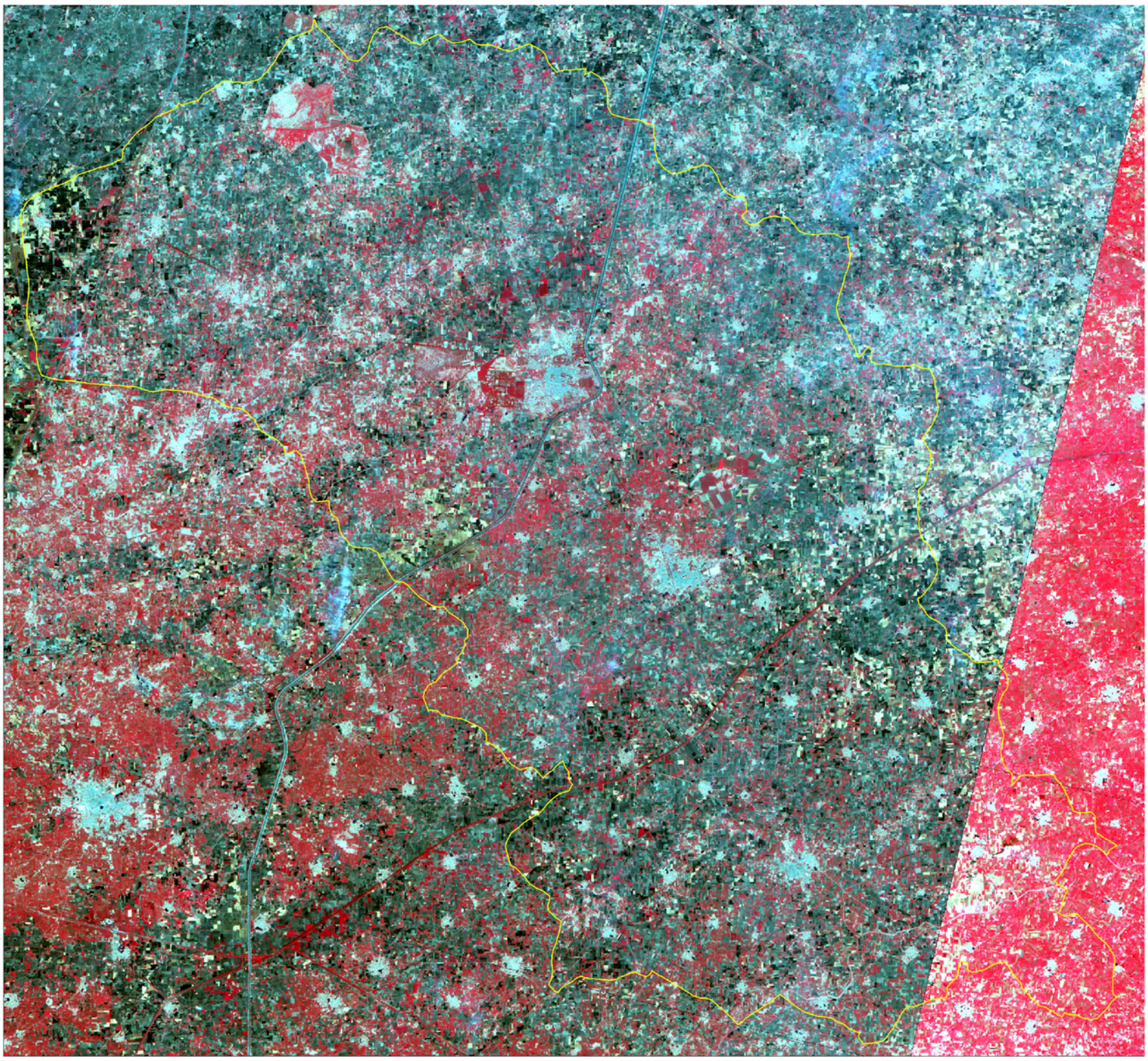
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Faridkot



IRS P6 LISS-III post monsoon data (2006)

7.1.14 Bhatinda

Bathinda is one of the southern districts of the Punjab State. It lies between the latitude of 29^{O} 46' 11" to 30^{O} 35' 08" north and longitude of 74^{O} 37' 49" to 75^{O} 22' 54" east, covering a geographical area of 3377 sq. km. It is bounded by the districts of Faridkot in the west, Moga in the north, newly created Barnala district in the east and Hisar & Sirsa districts of Haryana state in the south. From Administrative point of view, Bathinda district is divided into three tehsils. The climate of the district is semi-arid with an average annual rainfall of around 300 mm of which nearly 70 per cent is received during the monsoon months from July to September. The soils in the district are mostly light to medium in texture with very low water holding capacity in the light textured soils. On the basis of physiography, the area has been divided into alluvial plain, sand dunes and basins. The general gradient of the terrain is from northeast to southwest. The district doesn't have any river flowing through its area. Around 88.1 per cent of the total geographical area (TGA) of the district is under cultivation

Total wetland area in the district is 1597 ha that includes 409 small wetlands (<2.25 ha). River/stream occupies 33.38% of wetlands. Tank/pond is the second large wetland type in the district with 504 ha area (31.56%). There are 25 Lake/pond mapped with 151 ha area (9.46%). No other wetland type is observed. The small wetlands which are mainly Tank/pond account for 25.6% and has thus of importance. Details of wetland statistics is given in Table.19.

Aquatic vegetation is observed in Tank/pond and Lake/pond wetland types. The area under aquatic vegetation is more or less same in pre monsoon (183 ha) and post monsoon (154 ha). The open water spread of wetlands is more in post monsoon (715 ha) than in pre monsoon (407 ha). The qualitative turbidity of water is low in both the seasons.

Table 19: Area estimates of wetlands in Bhatinda

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	25	151	9.46	101	80
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	5	533	33.38	240	-
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	103	504	31.56	374	327
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**133**	**1188**	**74.39**	**715**	**407**
		Wetlands (<2.25 ha), mainly Tanks	409	409	25.61	-	-
		Total	**542**	**1597**	**100.00**	**715**	**407**

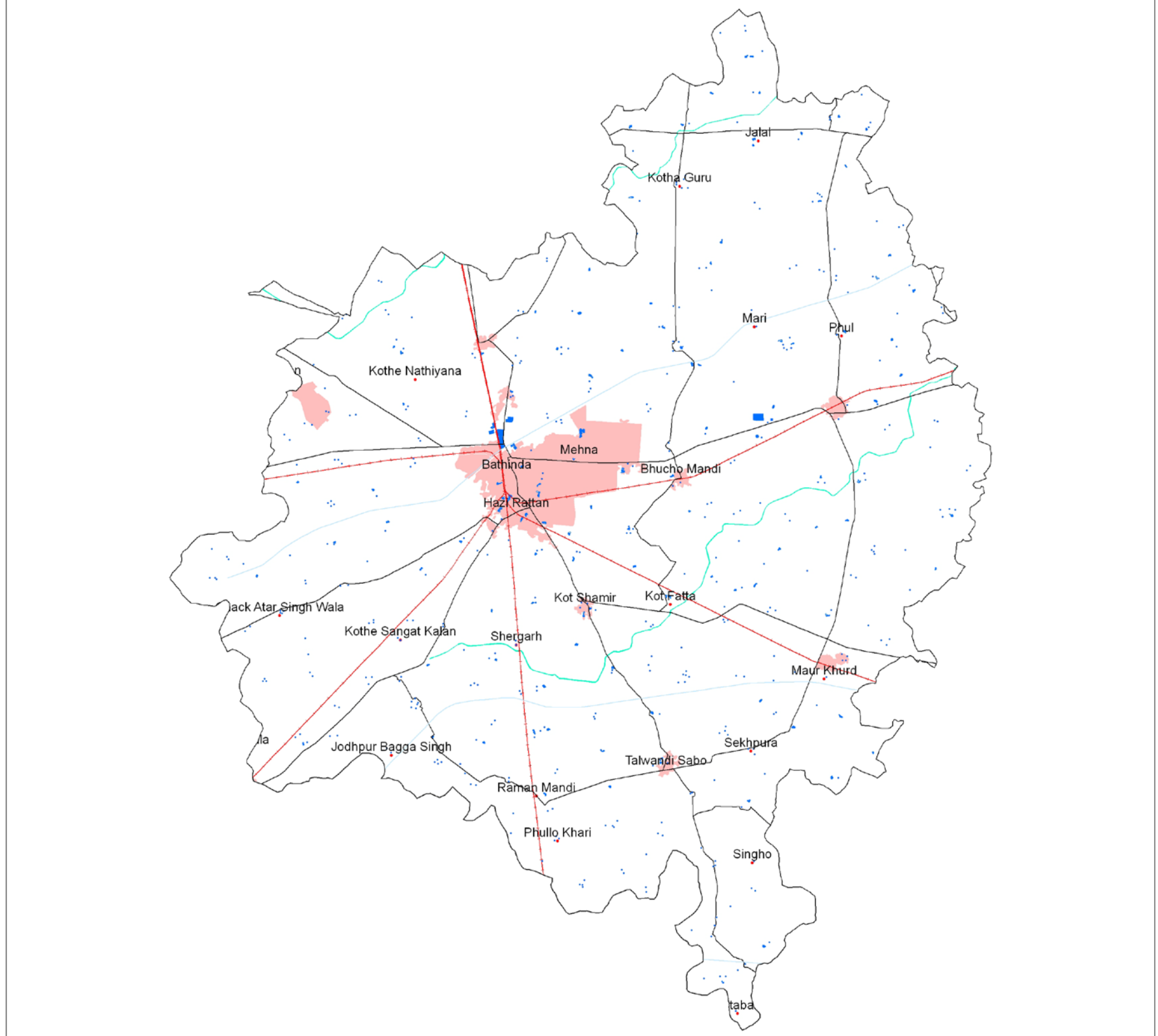
Area under Aquatic Vegetation	154	183

Area under turbidity levels		
Low	240	-
Moderate	371	303
High	104	104

State : Punjab

WETLAND MAP

District : Bhathinda

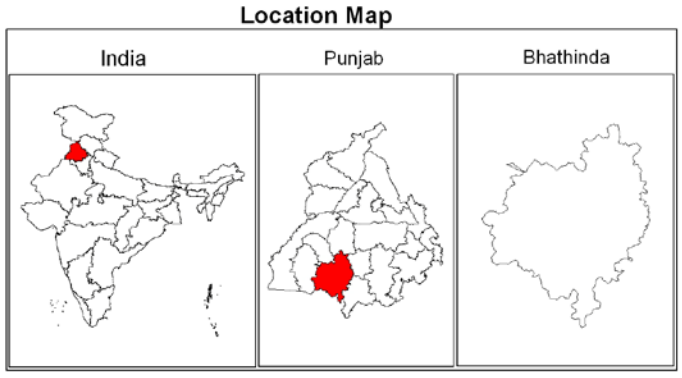


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

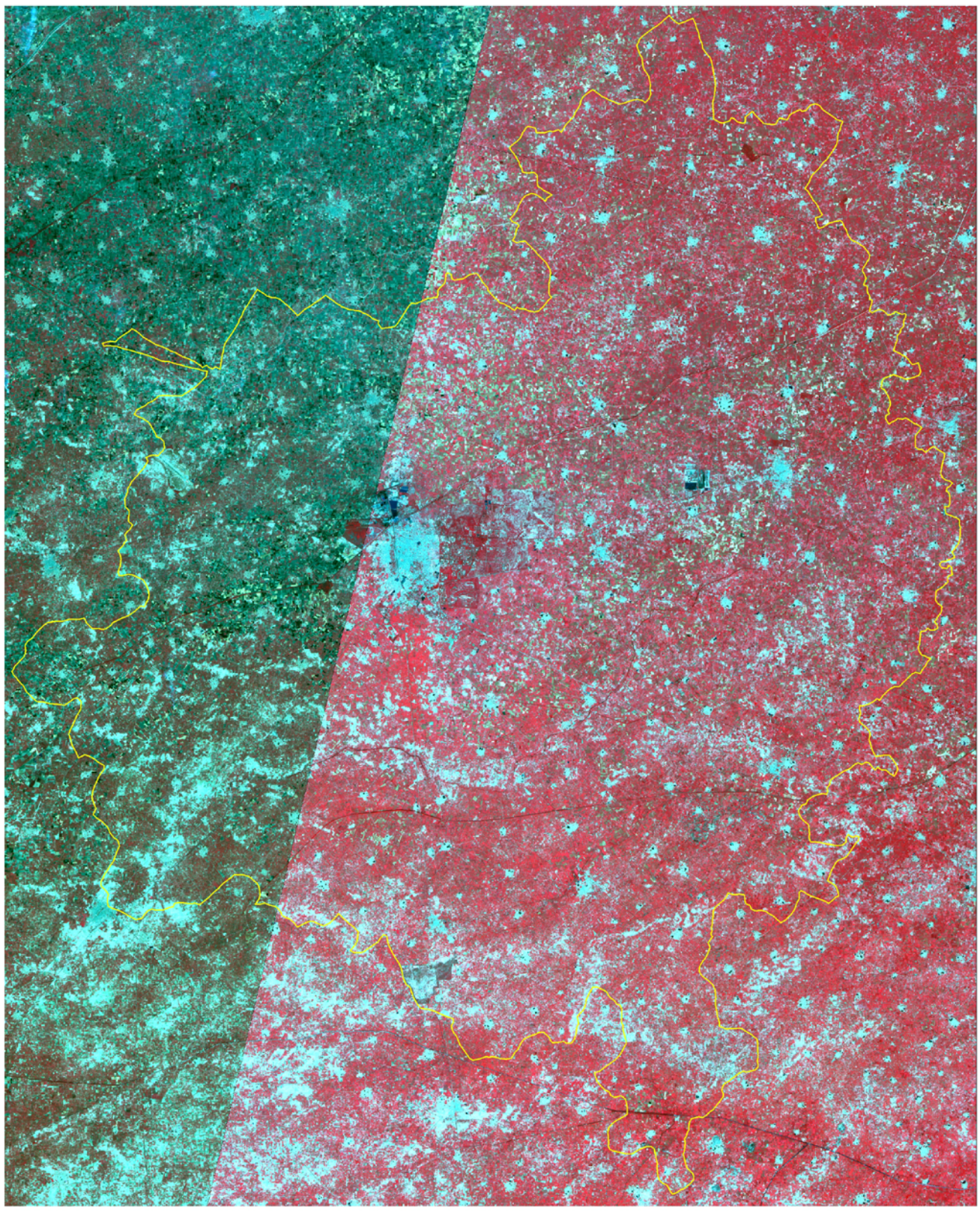
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Bhathinda



IRS P6 LISS-III post monsoon data (2006)

7.1.15 Mansa

Mansa district was formed on 13th April 1992 from the erstwhile Bathinda District. It lies between the latitude of 29^{O} 32' 19" to 30^{O} 13' 00" north and longitude of 75^{O} 09' 49" to 75^{O} 47' 00" east, and is spread over 2,174 sq. km. The total population of the district is 6, 88,630 as per 2001 census amounting to 2.9% of the total population of Punjab. The district is roughly triangular in shape, and is bounded on the northwest by Bathinda, on the northeast by Sangrur, on the north by Barnala districts of Punjab and on the south by Haryana state. The district is divided into three tehsils. The climate of the district is more or less typical of Punjab plains. It is extremely hot and dry in summer. Hot winds & dust storms are prevalent during summer season. The soils of Mansa district are coarse loamy in texture, calcareous in nature and well drained with very low water holding capacity. The land is predominately plain except few sand dunes. The general gradient of the terrain is from northeast to southwest. In Mansa district, river Ghaggar enters on southern end and flows through for a distance of 15 Km. The Sirhind drain run across the entire district and has its out-fall in river Ghaghar. The area has an extensive canal system except in sand dune area. The Bhakra Main line passes through the district and there is network of distributaries of Kotla branch and Ghaggar branch, covering the whole area. 92 per cent of the total geographical area (TGA) of the Mansa district is under cultivation.

Total wetland area in the district is 1258 ha that includes 303 small wetlands (<2.25 ha). River/stream occupies 46.98% of total wetland area. Tank/pond is the second large wetland type in the district with 266 ha area (21.14%). The other wetland type is Lake/pond. There are 13 such wetland types occupies an area of 98 ha (7.79%). Small wetlands which are mainly Tank/pond type account 24.0% and thus have of particular significance. Details of wetland statistics is given in Table.20.

Aquatic vegetation is observed in Tank/pond and Lake/pond wetland types. The area under aquatic vegetation is slightly more in post monsoon (100 ha) than in pre monsoon (77 ha). The open water spread of wetlands is significantly more in post monsoon (676 ha) than in pre monsoon (477 ha). The qualitative turbidity of water is low to moderate in both the seasons.

Table 20: Area estimates of wetlands in Mansa

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	13	98	7.79	64	58
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	2	591	46.98	431	258
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	79	266	21.14	181	161
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**94**	**955**	**75.91**	**676**	**477**
		Wetlands (<2.25 ha), mainly Tanks	303	303	24.09	-	-
		Total	**397**	**1258**	**100.00**	**676**	**477**

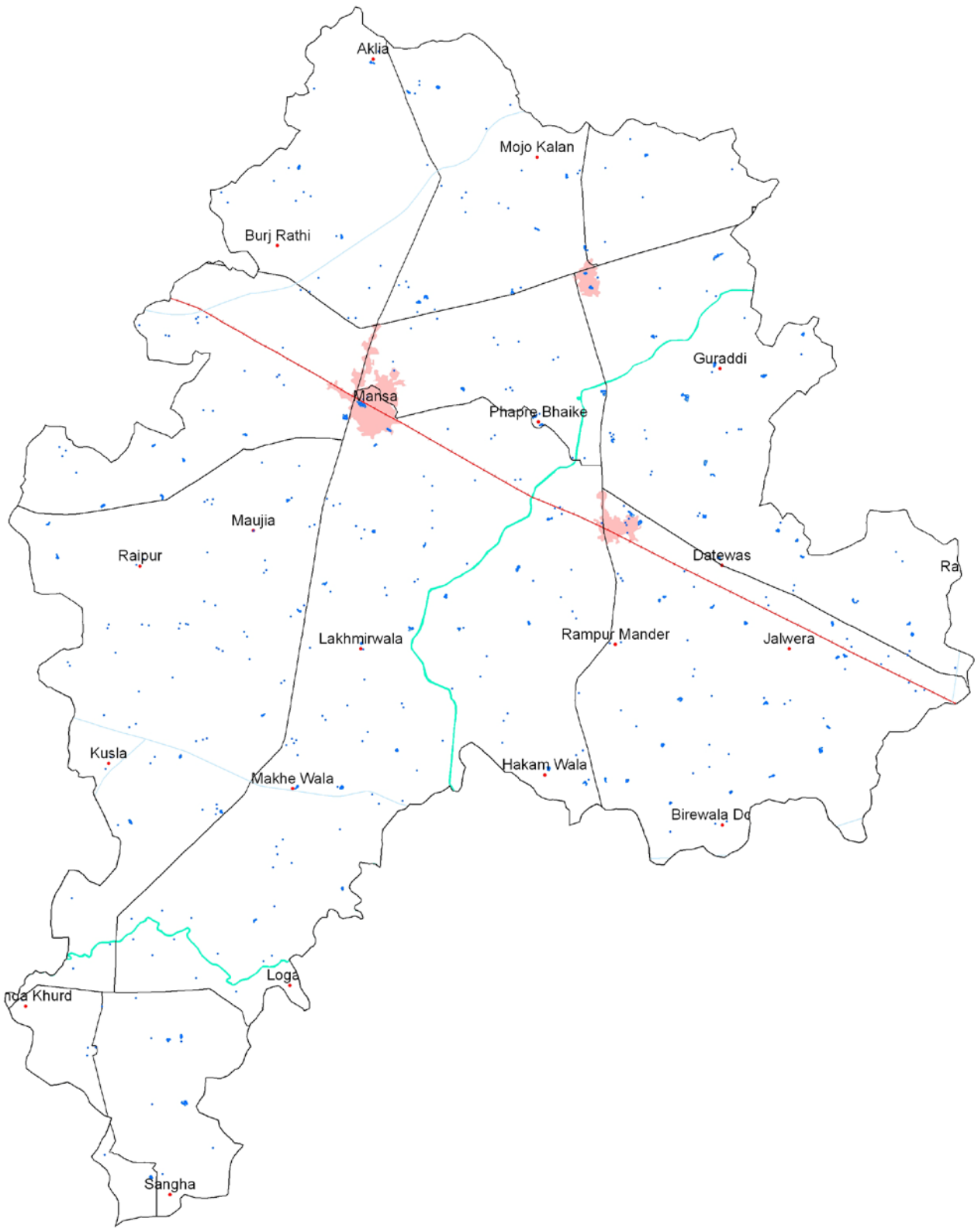
Area under Aquatic Vegetation	100	77

Area under turbidity levels		
Low	430	259
Moderate	246	218
High	-	-

State : Punjab

WETLAND MAP

District : Mansa

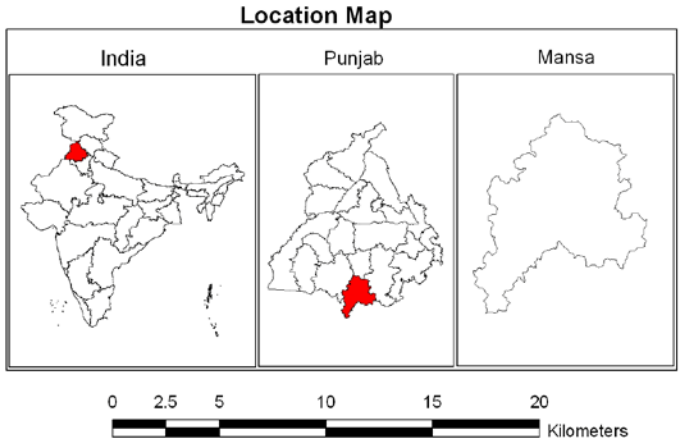


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

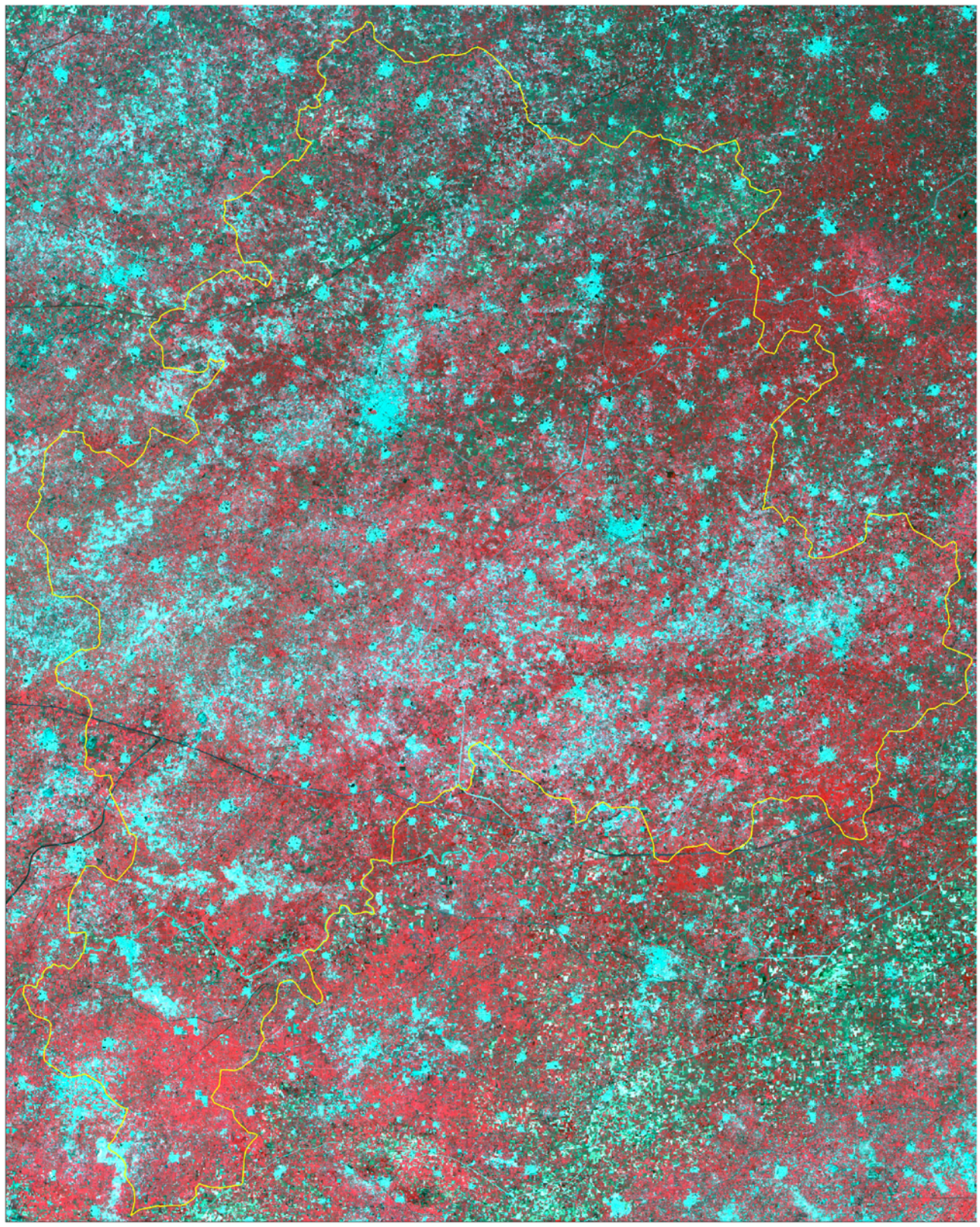
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Mansa



IRS P6 LISS-III post monsoon data (2006)

7.1.16 Sangrur

The district in general is a rural region in the southern part of the Punjab state. The geographical area is 3608 km^2. It is bounded in the north by Ludhiana, Patiala in east, Barnala in west, Mansa district in southwest and in south, Jind district of Haryana State. The district lies between the latitude of 29^o 43' 25" to 30^o 41' 41" North and a longitude of 75^0 33' 09" to 76^o 12' 40" East with an average elevation of 232 meters from the mean sea level. The general gradient of the terrain is from northeast to southwest. From Administrative point of view, the district is divided into four tehsils. The district gets very dry and hot in summers lasting from early March to July. The soils of the district are mostly coarse loamy to fine loamy, calcareous and moderate to well drained and has the problems of water logging, salinity and/or alkalinity and flooding in some pockets. No major stream or river crosses the Sangrur district except the Ghaggar, which passes through the southern part of the district from east to almost west. The northern part of the district is drained by the Lehra drain flowing in a south western direction. The district has extensive canal network. Around 87.8 per cent of the total geographical area (TGA) of the Sangrur district is under cultivation.

Total wetland area in the district is 1810 ha that includes 397 small wetlands (<2.25 ha). River/stream occupies 45.75% of total wetland area. Tank/pond is the second large wetland type in the district with 384 ha area (21.22%). The other major wetland type is Lake/pond. There is 25 such wetland types with 186 ha area (10.28%). Small wetlands which are mainly Tank/pond type account 22.0% and thus have of particular significance. Details of wetland statistics is given in Table.21.

Aquatic vegetation is observed in Tank/pond and Lake/pond wetland types. The area under aquatic vegetation is slightly more in pre monsoon (195 ha) than in post monsoon (169 ha). The open water spread of wetlands is significantly more in post monsoon (934 ha) than in pre monsoon (604 ha). The qualitative turbidity of water is low to moderate in both the seasons.

Table 21: Area estimates of wetlands in Sangrur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	25	186	10.28	128	94
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	2	12	0.66	-	-
6	1106	River/Stream	4	828	45.75	549	287
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	109	384	21.22	257	223
9	1203	Waterlogged	1	3	0.17	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**141**	**1413**	**78.07**	**934**	**604**
		Wetlands (<2.25 ha), mainly Tanks	397	397	21.93	-	-
		Total	**538**	**1810**	**100.00**	**934**	**604**

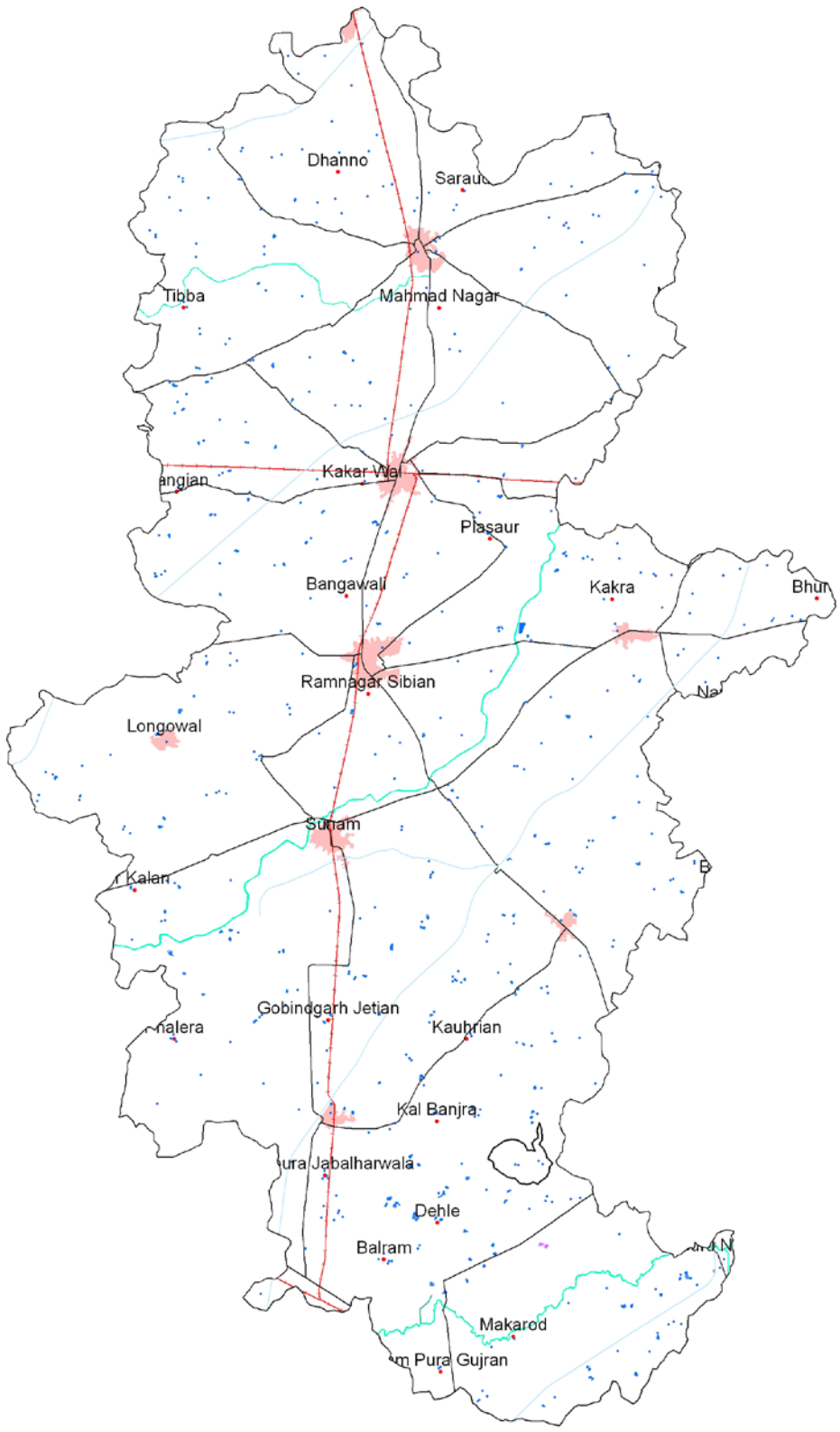
Area under Aquatic Vegetation	169	195

Area under turbidity levels		
Low	537	287
Moderate	374	292
High	23	25

State : Punjab

WETLAND MAP

District : Sangrur

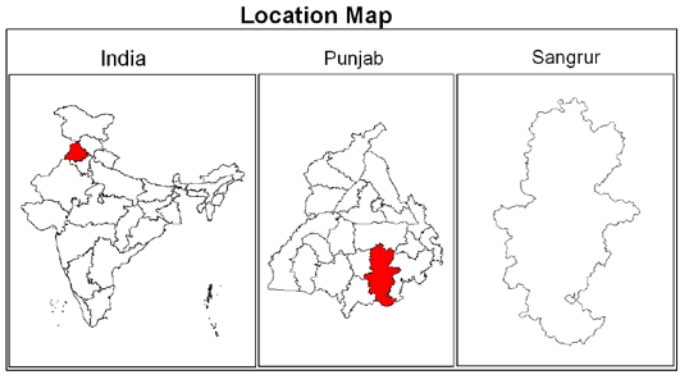


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

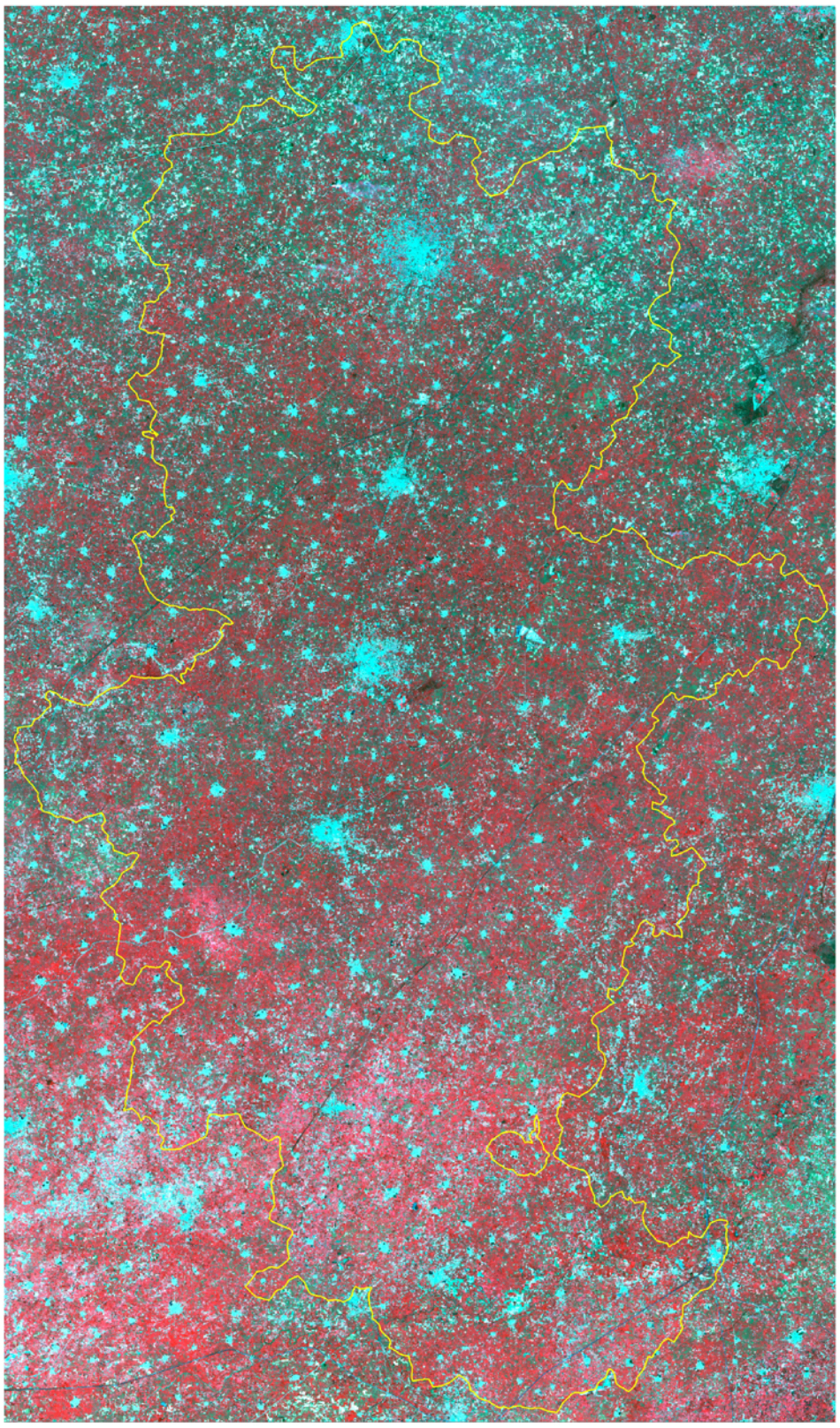
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Sangrur



IRS P6 LISS-III post monsoon data (2006)

7.1.17 Patiala

Patiala district covers an area of 3627 sq. km and is situated in southeastern part of the Punjab state. It lies between the latitude of 29^{O} 47' 16" to 30^{O} 37' 58" north and longitude of 75^{O} 55' 50" to 76^{O} 48' 02" east. It is bounded by Fatehgarh Sahib and newly formed Mohali districts in the north, Sangrur district in the west and Ambala district of Haryana state in the south and southeast. Patiala district is sub divided into 5 tehsils. Patiala district is more or less a flat terrain. The various landforms in the Patiala district are alluvial plain (upper/lower), sand dunes, flood Texture of the soils varies from coarse to fine loamy with some patches of sandy or fine silty, calcareous in nature and mostly well drained plains, and paleo channels. Alluvial plain constitutes the major portion of the district. Part of the alluvial plain is subjected to local flooding. The river Ghaggar is the major natural drainage channels which transverse the area. It rises in the Sirmur hills in Himachal Pradesh and passes through Morni Hills. The Dangri and Patiala Nadi are its main tributaries. Nearly 84 per cent of the total geographical area (TGA) of the district is under agricultural use.

Total wetland area in the district is 2924 ha that includes 421 small wetlands (<2.25 ha). River/stream occupies 75.21% of total wetland area. The other major wetland types are Tank/pond (5.13%) and Lake/pond (4.92%). Total 16 Lake/pond and 41 Tank/pond are mapped with 144 ha and 150 ha respectively. Small wetlands which are mainly Tank/pond type account 14.0% and thus have of particular significance. Details of wetland statistics is given in Table.22.

Aquatic vegetation is observed in Tank/pond and Lake/pond wetland types. The area under aquatic vegetation is slightly more in pre monsoon (419 ha) than in post monsoon (271 ha). The open water spread of wetlands is more in post monsoon (1597 ha) than in pre monsoon (1353 ha). The qualitative turbidity of water is low to moderate in both the seasons.

Table 22: Area estimates of wetlands in Patiala

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	16	144	4.92	81	56
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	25	2199	75.21	1415	1217
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	41	150	5.13	101	80
9	1203	Waterlogged	1	10	0.34	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**83**	**2503**	**85.60**	**1597**	**1353**
		Wetlands (<2.25 ha), mainly Tanks	421	421	14.40	-	-
		Total	**504**	**2924**	**100.00**	**1597**	**1353**

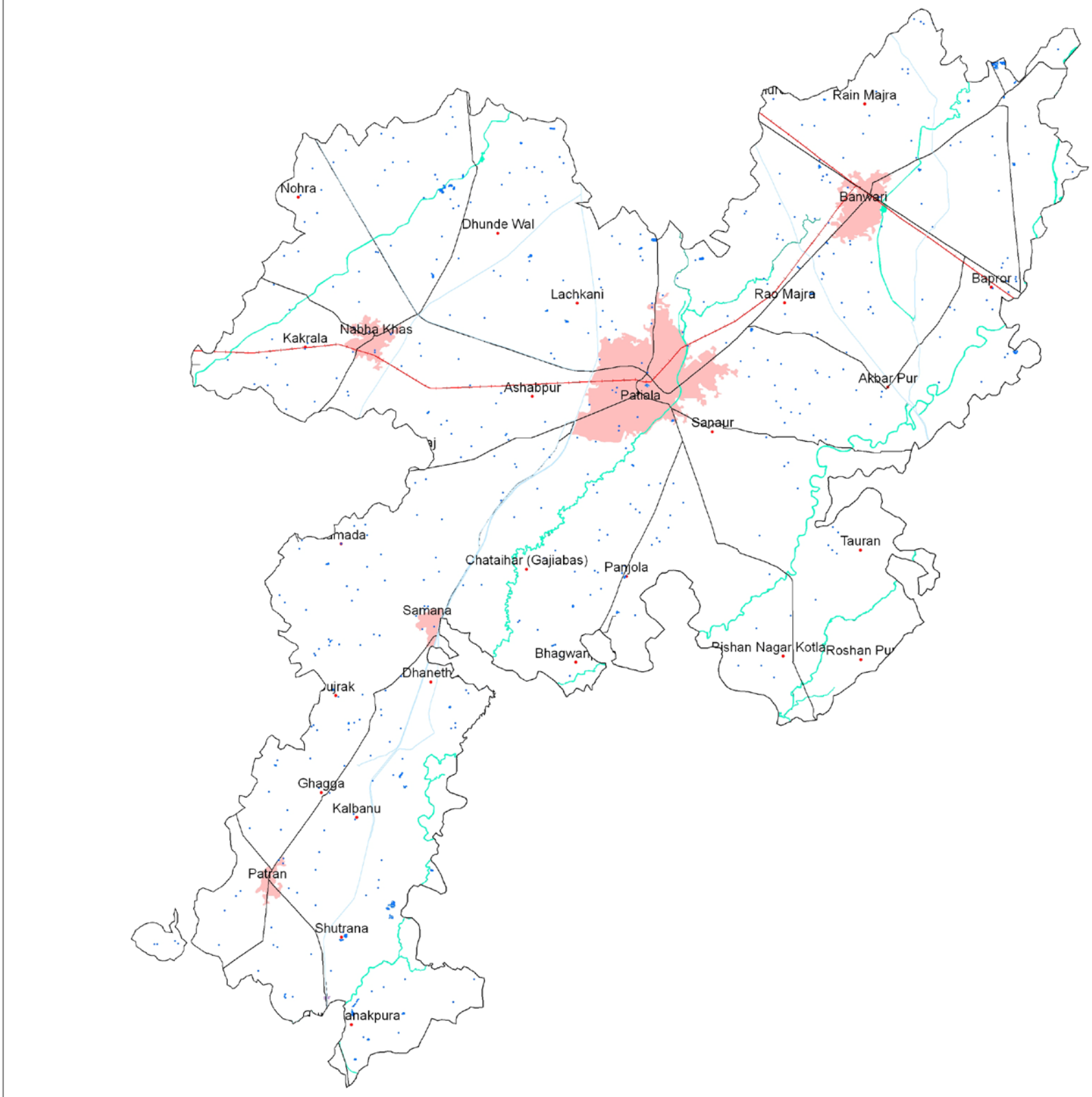
Area under Aquatic Vegetation	271	419

Area under turbidity levels		
Low	1283	1210
Moderate	314	143
High	-	-

State : Punjab

WETLAND MAP

District : Patiala

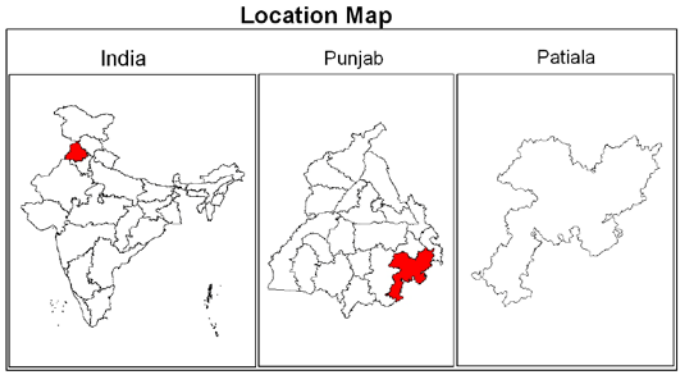


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20

Kilometers

Data Source :

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

Prepared By :

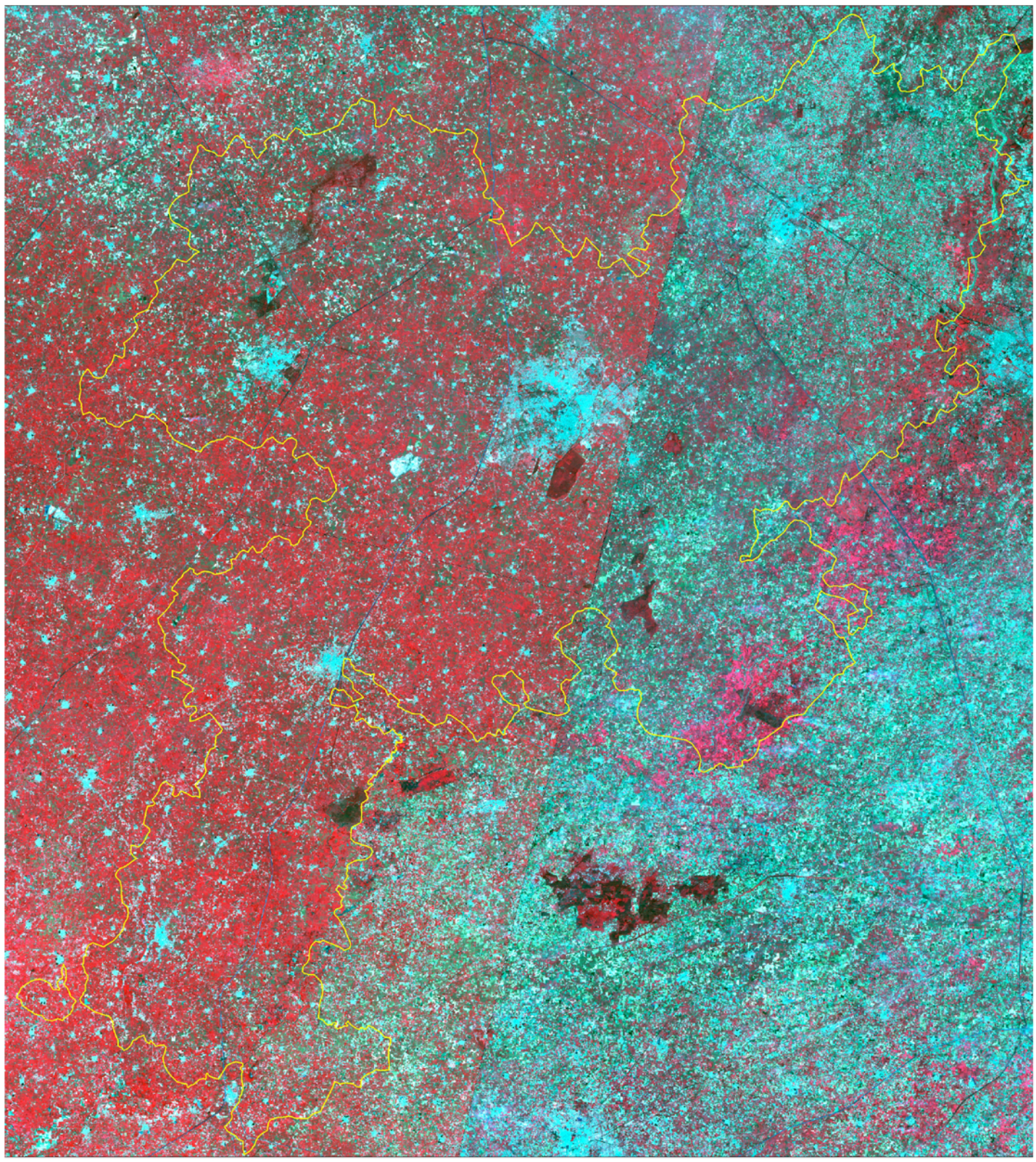
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Patiala



IRS P6 LISS-III post monsoon data (2006)

7.1.18 Barnala

The district is situated in the southern part of Punjab state. It is bounded by Ludhiana in north, Sangrur in east, Moga in northwest, Bathinda in west and Mansa in the south. It lies between the latitude of 30^{o} 08' 17" to 30^{o} 36' 28" north and longitude of 75^{o} 15' 13" to 75^{o} 43' 56" east. Barnala district has an area of 1414 $km^{2.}$ The districts have been further subdivided into 3 developmental blocks. The area is nearly level, with imperceptible slopes, except for the areas in and around the sand dunes. The general gradient of the terrain is from northeast to southwest. The soil type of the district is mostly coarse loamy to fine loamy, calcareous and moderate to well drained and has the problems of water logging, salinity and / or alkalinity and flooding in some pocketsThe district gets very dry and hot in summers lasting from early March to July. It becomes quite cold in December - January. No Major stream or river crosses the Barnala district. The district has extensive canal networks. Around 87.9 per cent of the total geographical area of the Barnala district is under cultivation.

Total wetland area in the district is 590 ha that includes 134 small wetlands (<2.25 ha). River/stream occupies 29.83% of total wetland area. Tank/pond is the second large wetland type in the district with 165 ha area (27.97%). The other major wetland type is Lake/pond. There is 16 such wetland types with 110 ha area (18.64%). Small wetlands which are mainly Tank/pond type account 22.7.0% and thus has of particular significance. Details of wetland statistics is given in Table.23.

Aquatic vegetation is observed in Tank/pond and Lake/pond wetland types. The area under aquatic vegetation is slightly more in pre monsoon (114 ha) than in post monsoon (97 ha). The open water spread of wetlands is slightly more in post monsoon (194 ha) than in pre monsoon (139 ha). The dominant qualitative turbidity of water is moderate in both the seasons.

Table 23: Area estimates of wetlands in Barnala

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	16	110	18.64	73	60
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	5	0.85	-	-
6	1106	River/Stream	2	176	29.83	16	-
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	45	165	27.97	105	79
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**64**	**456**	**77.29**	**194**	**139**
		Wetlands (<2.25 ha), mainly Tanks	134	134	22.71	-	-
		Total	**198**	**590**	**100.00**	**194**	**139**

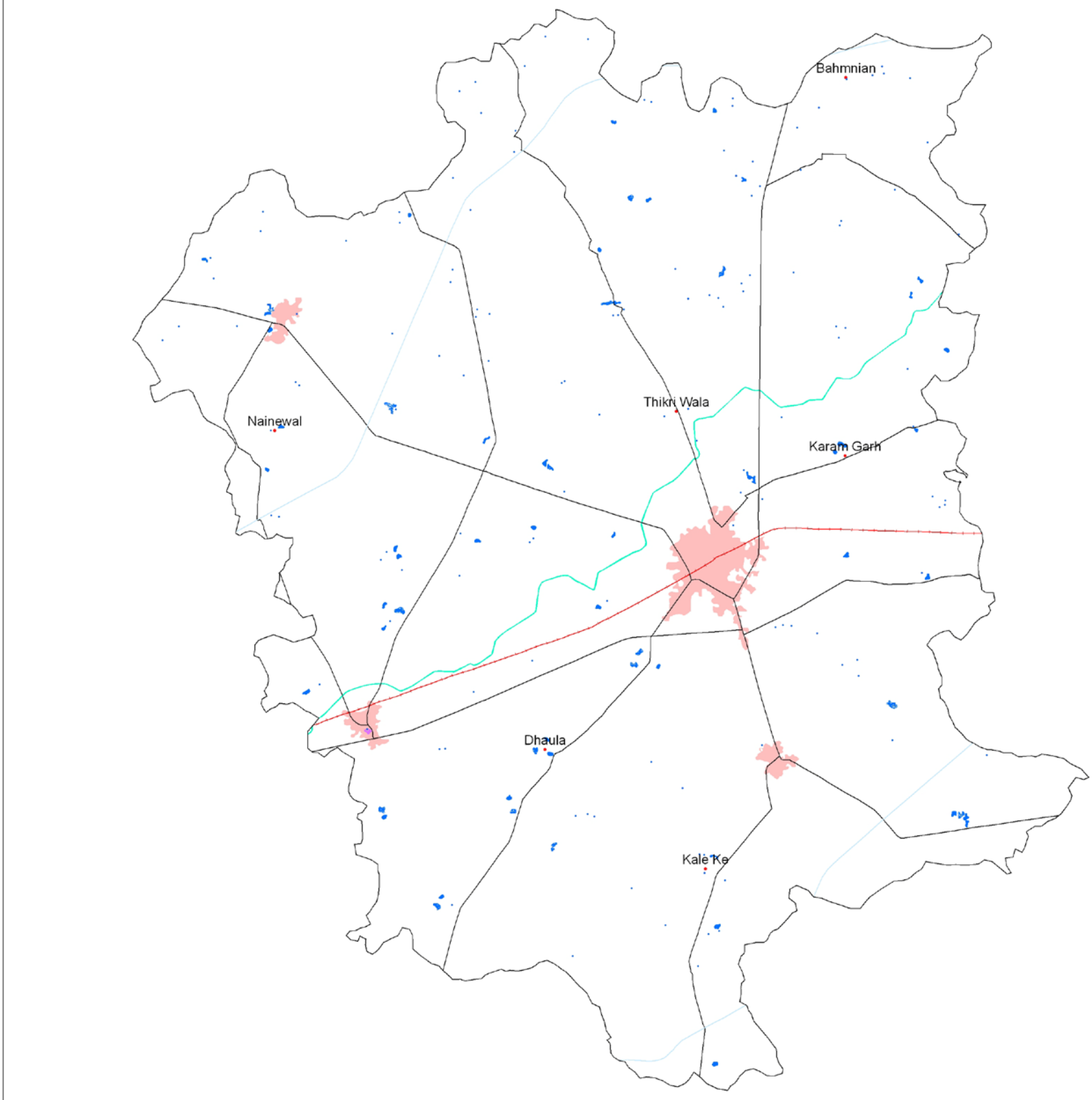
Area under Aquatic Vegetation	97	114

Area under turbidity levels		
Low	16	-
Moderate	178	139
High	-	-

State : Punjab

WETLAND MAP

District : Barnala

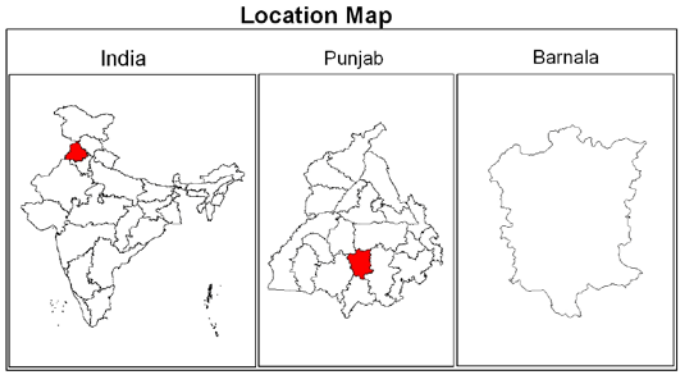


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

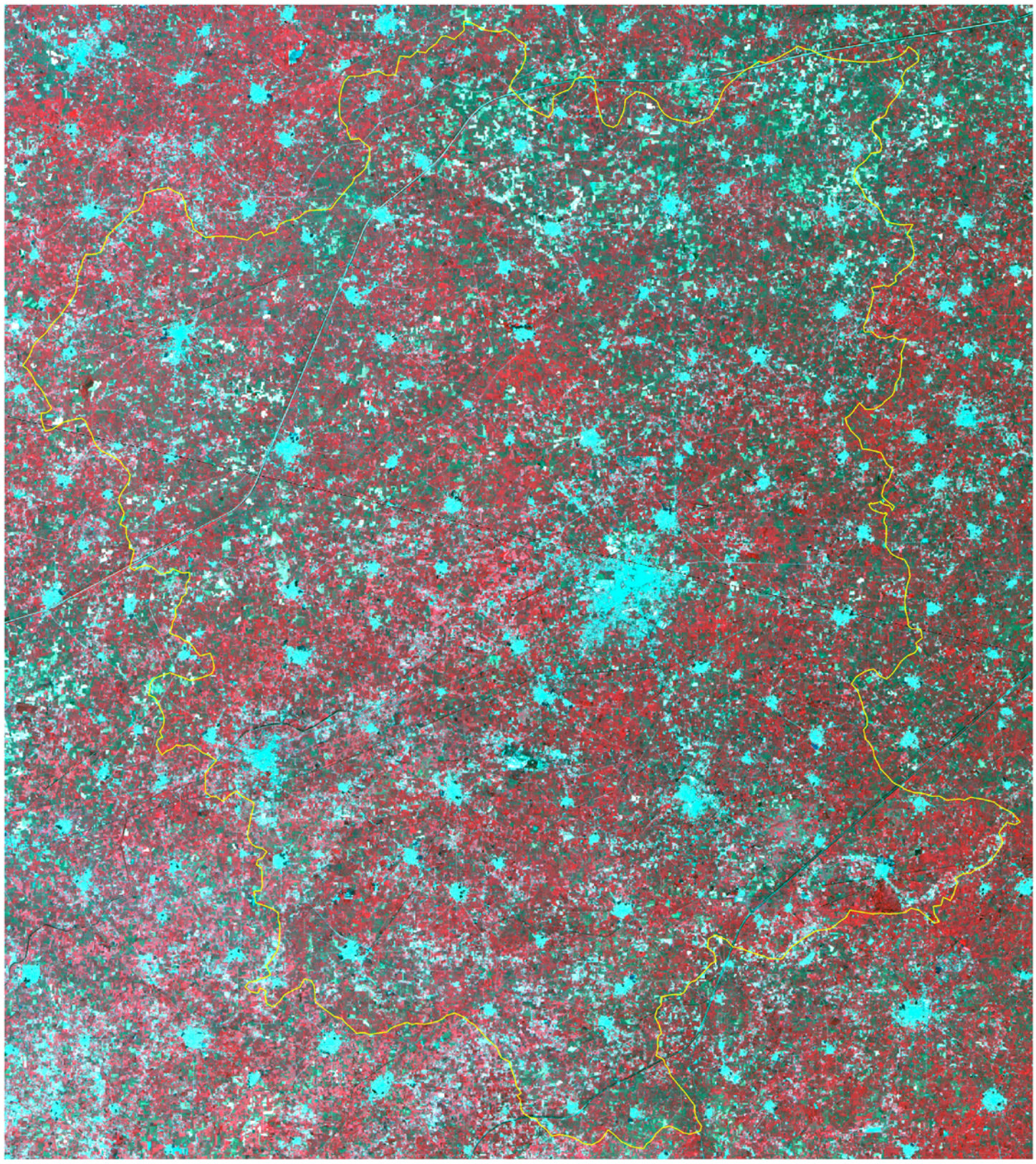
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Barnala



IRS P6 LISS-III post monsoon data (2006)

7.1.19 Sas Nagar

It was earlier a city under undivided erstwhile Rupnagar district of Punjab adjacent to Chandigarh has now become the 18th district of Punjab and is officially named Sahibzada Ajit Singh Nagar (SAS Nagar) after the eldest son of Guru Gobind Singh. It along with Chandigarh and Panchkula of Haryana form a part of the Chandigarh Tricity. It is also known as Mohali district. The district lies between the latitudes of 30O 21' 35" to 30O 56' 28" north and longitudes of 76O 31' 16" to 76O 56' 39" east. It covers an area of 1093 sq. km with an elevation of 316 km from the mean sea level. It is bounded by Himachal Pradesh in the northeast, union territory of Chandigarh in the east, Rupnagar in the north and northwest, Fatehgarh Sahib in the southwest and Patiala district of Punjab in the south. From administrative point of view, district Mohali is divided into two tehsils. Mohali district has been divided into three major landforms viz. Shiwalik Hills, piedmont and alluvial plains. The district is drained by a number of hilly torrents locally called choes.

Total wetland area in the district is 2198 ha that includes 152 small wetlands (<2.25 ha). River/stream occupies 76.52% of total wetland area. Reservoir/barrage is the second large wetland type in the district. Total 14 are mapped under this type with 210 ha area (9.55%). The other major wetland types are Tank/pond (3.0%), Lake/pond (2.91%) and Riverine (1.09%). Details of wetland statistics is given in Table.24.

Aquatic vegetation is observed in Tank/pond and Lake/pond wetland types. The area under aquatic vegetation is slightly more in pre monsoon (114 ha) than in post monsoon (97 ha). The open water spread of wetlands is slightly more in post monsoon (194 ha) than in pre monsoon (139 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 24: Area estimates of wetlands in Sas Nagar

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	9	64	2.91	32	14
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	1	24	1.09	13	13
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	21	1682	76.52	653	435
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	14	210	9.55	197	94
8	1202	Tanks/Ponds	18	66	3.00	43	24
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**63**	**2046**	**93.08**	**938**	**580**
		Wetlands (<2.25 ha), mainly Tanks	152	152	6.92	-	-
		Total	**215**	**2198**	**100.00**	**938**	**580**

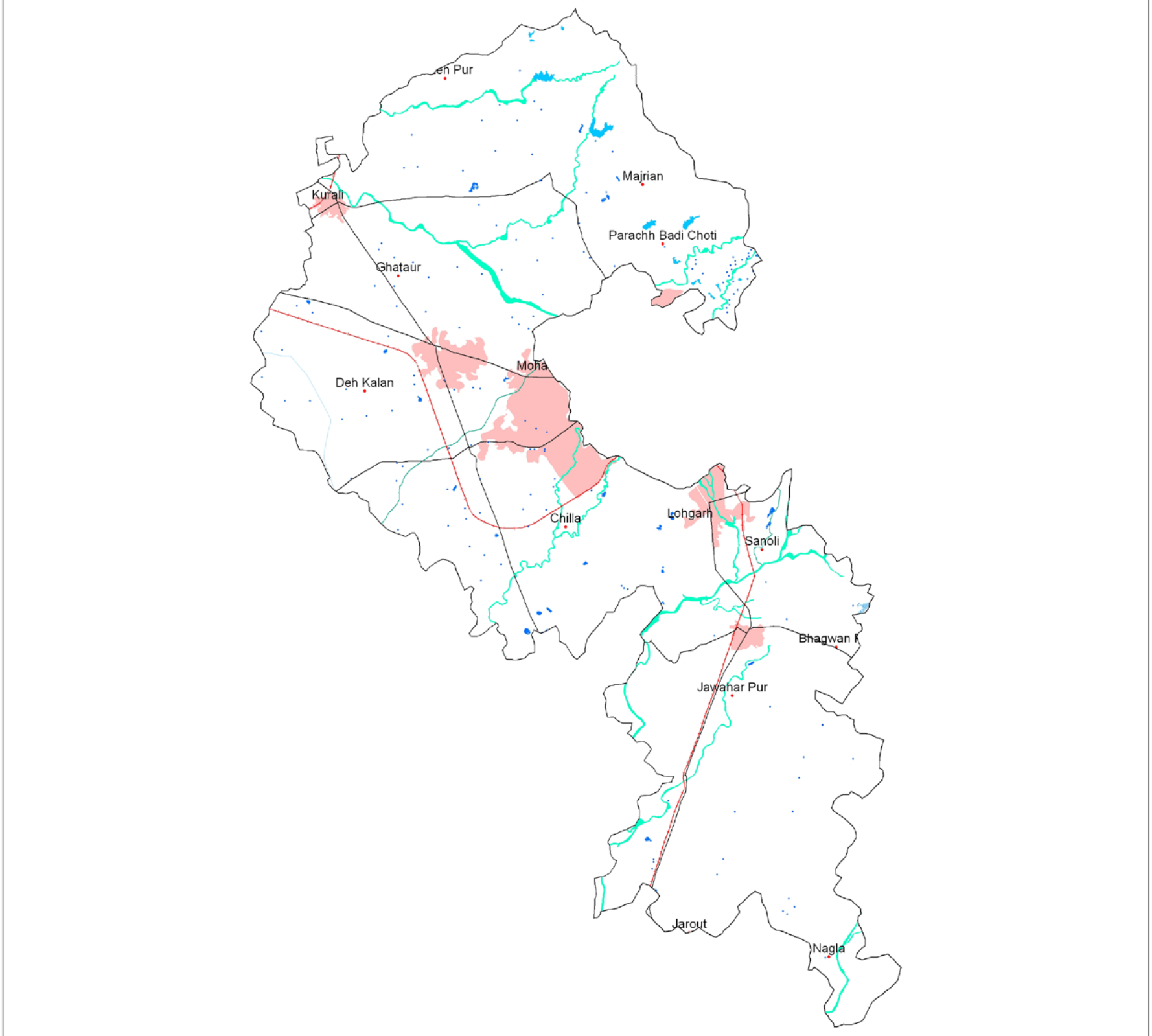
Area under Aquatic Vegetation	61	80

Area under turbidity levels		
Low	675	466
Moderate	263	114
High	-	-

State : Punjab

WETLAND MAP

District : Sas Nagar (Mohali)

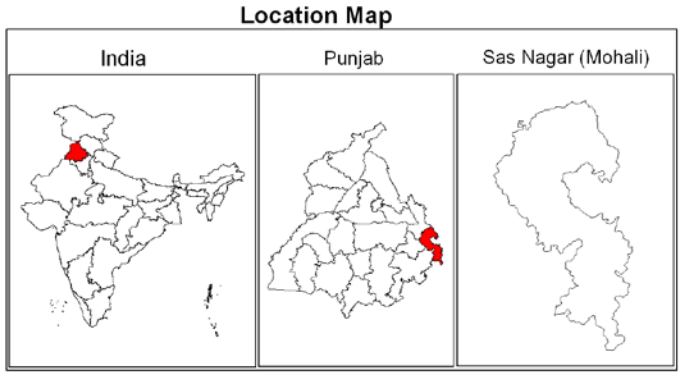


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

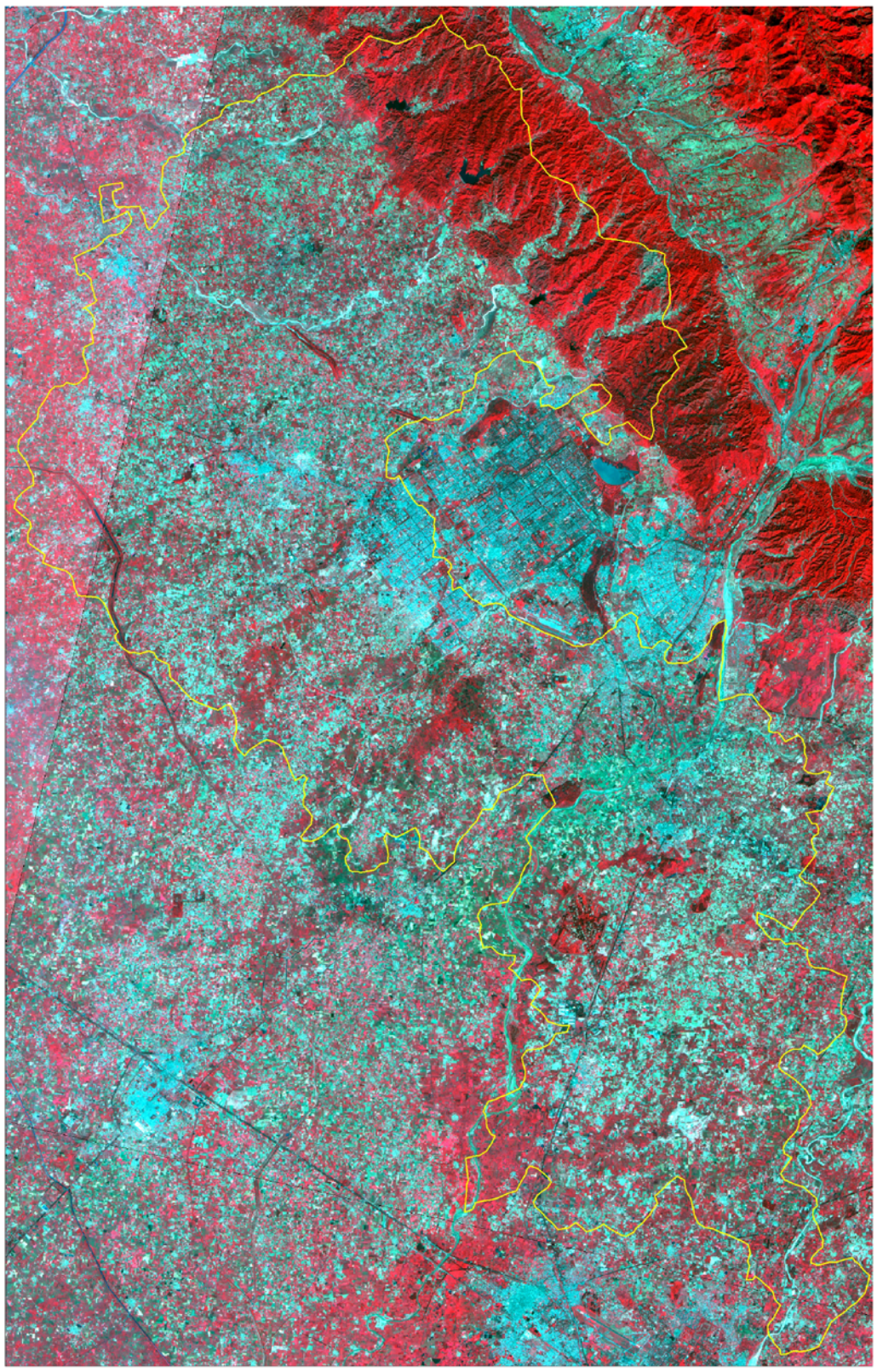
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Sas Nagar (Mohali)



IRS P6 LISS-III post monsoon data (2006)

7.1.20 Tarn Taran

Tarn Taran district was formed on June 16th, 2006 by combining Khadur Sahib and Patti tehsils of erstwhile Amritsar district. Tarn Taran district, a part of Indo-Gangetic alluvial plain with conspicuously flat terrain is located in the north-western part of the Punjab. It lies between latitude of 31^0 04' 01" N to 31^0 34' 46" N and longitudes of 74^0 30' 38.14" E to 75^0 16' 53" E covering an area of 2419 Km^2. It is bound in north by district Amritsar, in west by Pakistan, in the east by district Kapurthala and in the south by district Firozpur. The administratively Tarn Taran district comprises of three tehsils**.** Tarn Taran district has three major landform units viz. alluvial plain, flood plain and sand dunes. Alluvial plain constitute the major part of the district. This unit is formed by the alluvial deposits brought by rivers of Indus system. The Beas River forms the eastern and south eastern boundary of the district. The area is drained into Satluj and Beas rivers through a network of drains. Around 90.5 per cent of the total geographical area (TGA) of the Tarn Taran district is under cultivation.

Total wetland area in the district is 6647 ha that includes 430 small wetlands (<2.25 ha). River/stream occupies 49.41% of total wetland area. Reservoir/barrage is the second large wetland type in the district. Only one Reservoir is mapped with 2757 ha area (41.48%). The other wetland types are Tank/pond (1.47%), Ox-bow lake (0.83%) and Lake/pond (0.35%). Details of wetland statistics is given in Table.25.

Aquatic vegetation is observed in Reservoir and Lake/pond wetland types. The area under aquatic vegetation is slightly more in post monsoon (2083ha) than in pre monsoon (1875 ha). The open water spread of wetlands is slightly more in post monsoon (2550 ha) than in pre monsoon (2493 ha). The qualitative turbidity of water is low in both the seasons.

Table 25: Area estimates of wetlands in Tarn Taran

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetland	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	2	23	0.35	9	5
2	1102	Ox-bow lakes/ Cut-off meanders	1	55	0.83	42	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	9	3284	49.41	1343	1382
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	2757	41.48	1106	1057
8	1202	Tanks/Ponds	27	98	1.47	50	49
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**40**	**6217**	**93.53**	**2550**	**2493**
		Wetlands (<2.25 ha), mainly Tanks	430	430	6.47	-	-
		Total	**470**	**6647**	**100.00**	**2550**	**2493**

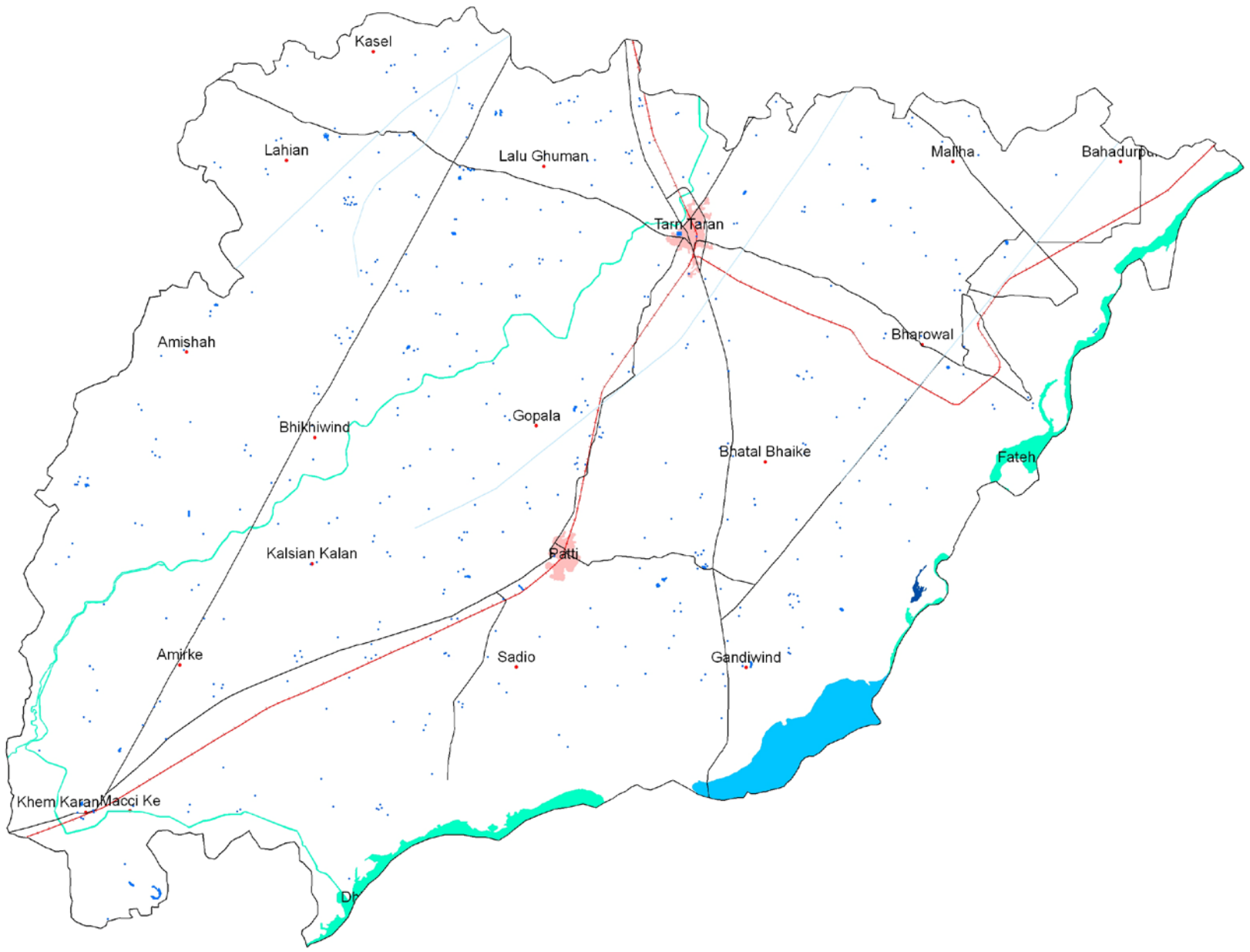
Area under Aquatic Vegetation	2083	1875

Area under turbidity levels		
Low	2441	2438
Moderate	109	55
High	-	-

State : Punjab

WETLAND MAP

District : Tarn Taran

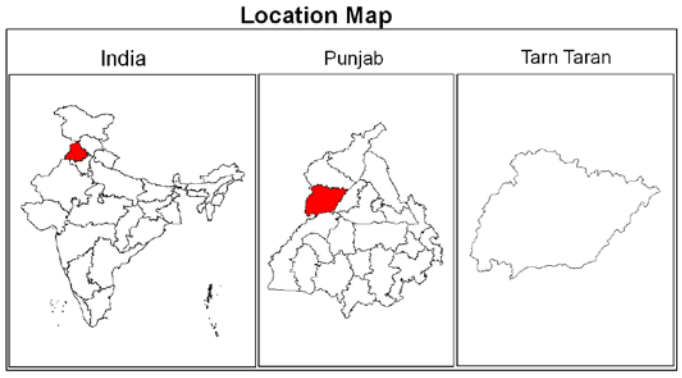


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

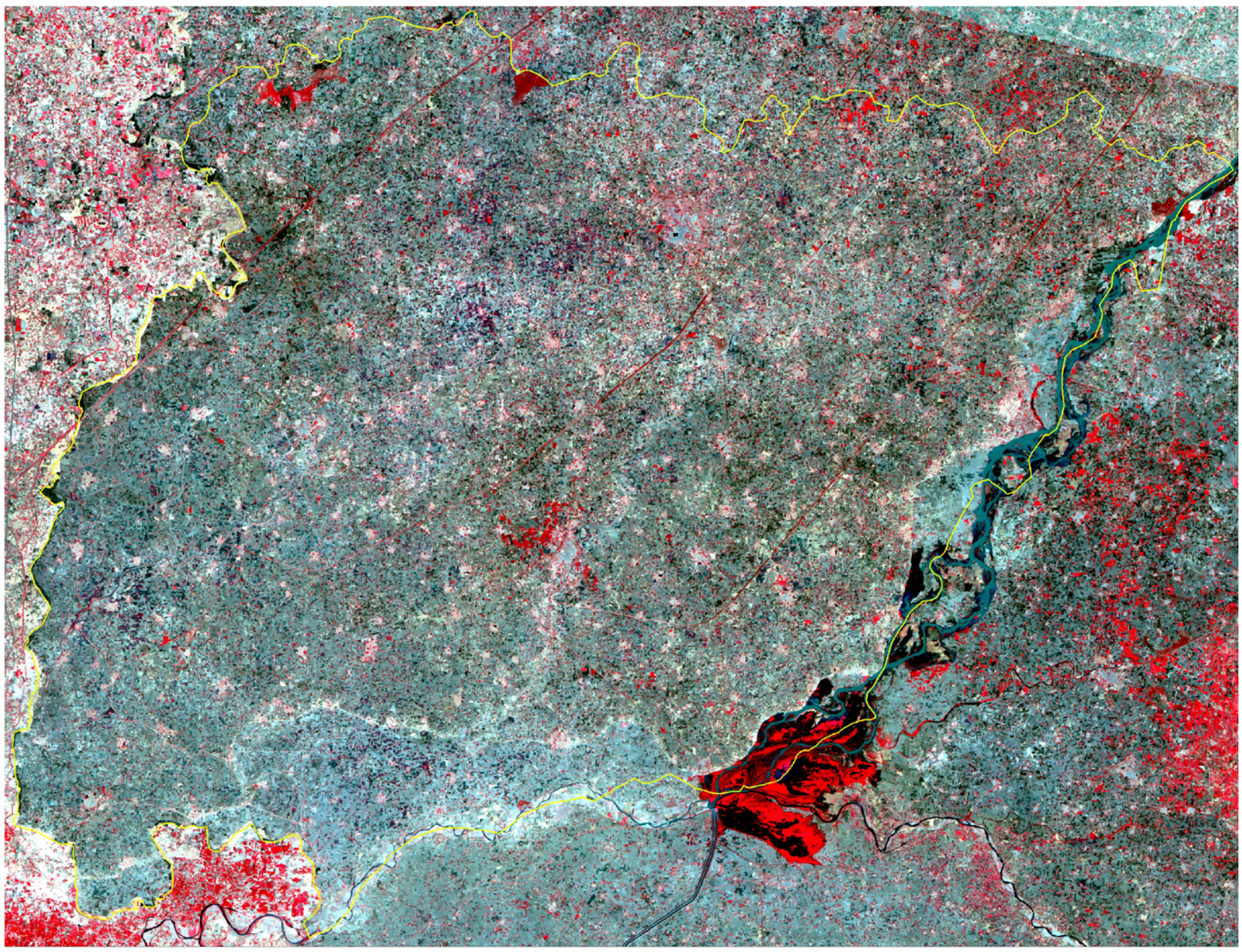
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

District : Tarn Taran



IRS P6 LISS-III pre monsoon data (2007)

MAJOR WETLAND TYPES

9.0 MAJOR WETLAND TYPES OF PUNJAB

River/stream is the most dominant wetland type in Punjab. Three mighty rivers Ravi, Beas and Satluj draining the central Punjab along with their tributaries give a wide variation of hydrological regime. Reservoir/ barrage is the second major wetland type and most dominant man made type in the state. The other major wetland types are Tanks/pond and Lake/pond. Plate-1 shows representative major wetland types of Punjab as manifested in LISS III FCC. Field photographs of different wetland types are shown in Plate 2.

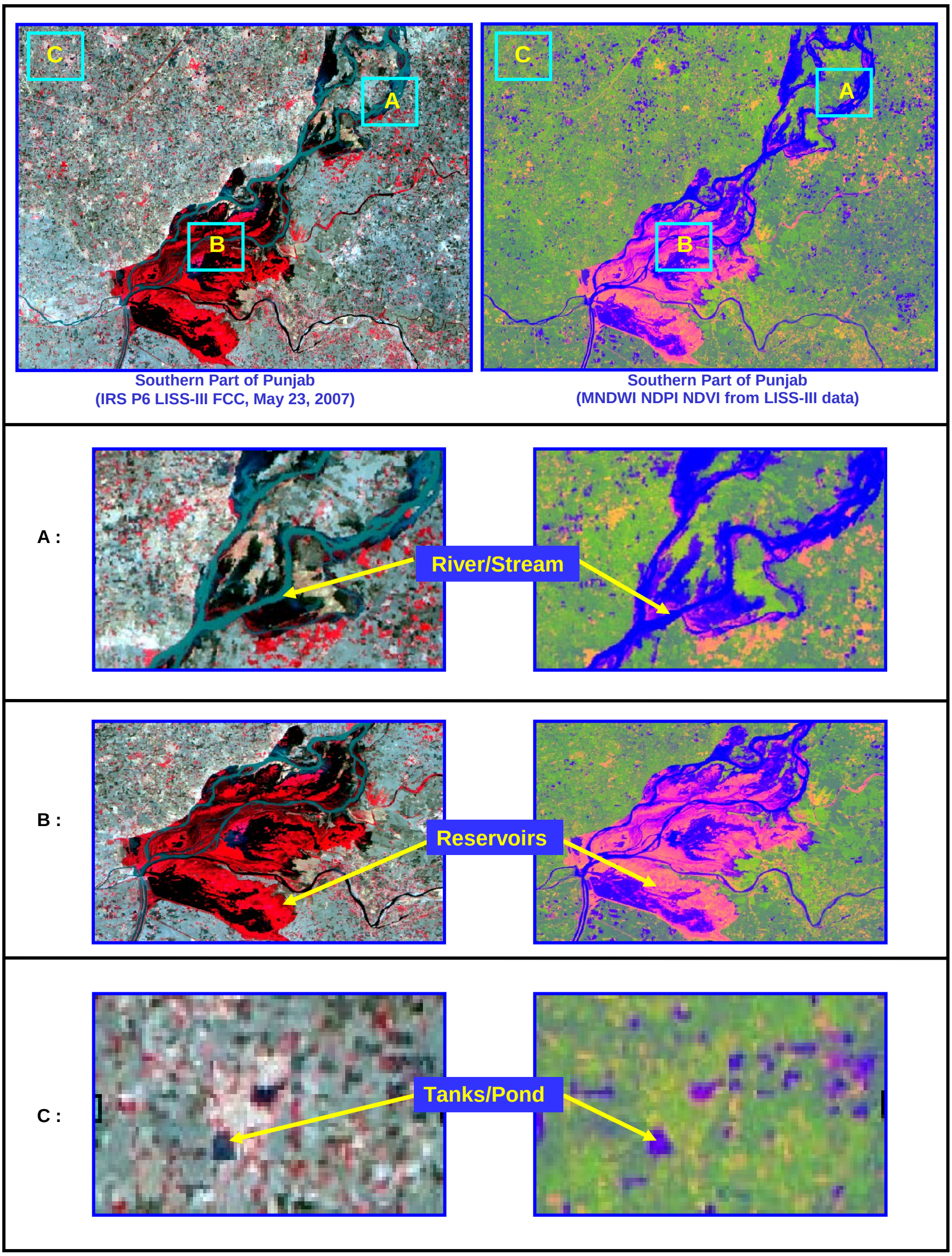


Plate 1: Major wetland types of Punjab

Sr. No.	Description	Field photograph
1	Wetland Type : Lake/Pond Location : longitude: 75^0 12’ 25” E latitude : 31 ^{0}13’ 42” N Turbidity : Moderate Aquatic Vegetation : No	
2	Wetland Type : River/Stream Location : longitude: 75° 23′ 02″ E latitude : 31° 24′ 51″ N Turbidity : Moderate Aquatic Vegetation : Yes	
3	Wetland Type : Waterlogged Location : longitude: 75^0 03’ 03” E latitude : 31^0 09’ 47” N Turbidity : Low Aquatic Vegetation : No	
4	Wetland Type : Reservoir/Barrage Location : longitude: 76^0 31’ 58” E latitude : 30^0 59’ 58” N Turbidity : Low Aquatic Vegetation : Yes	

Plate-2: Field photographs and ground truth data

IMPORTANT WETLANDS OF PUNJAB

9.0 IMPORTANT WETLANDS OF PUNJAB

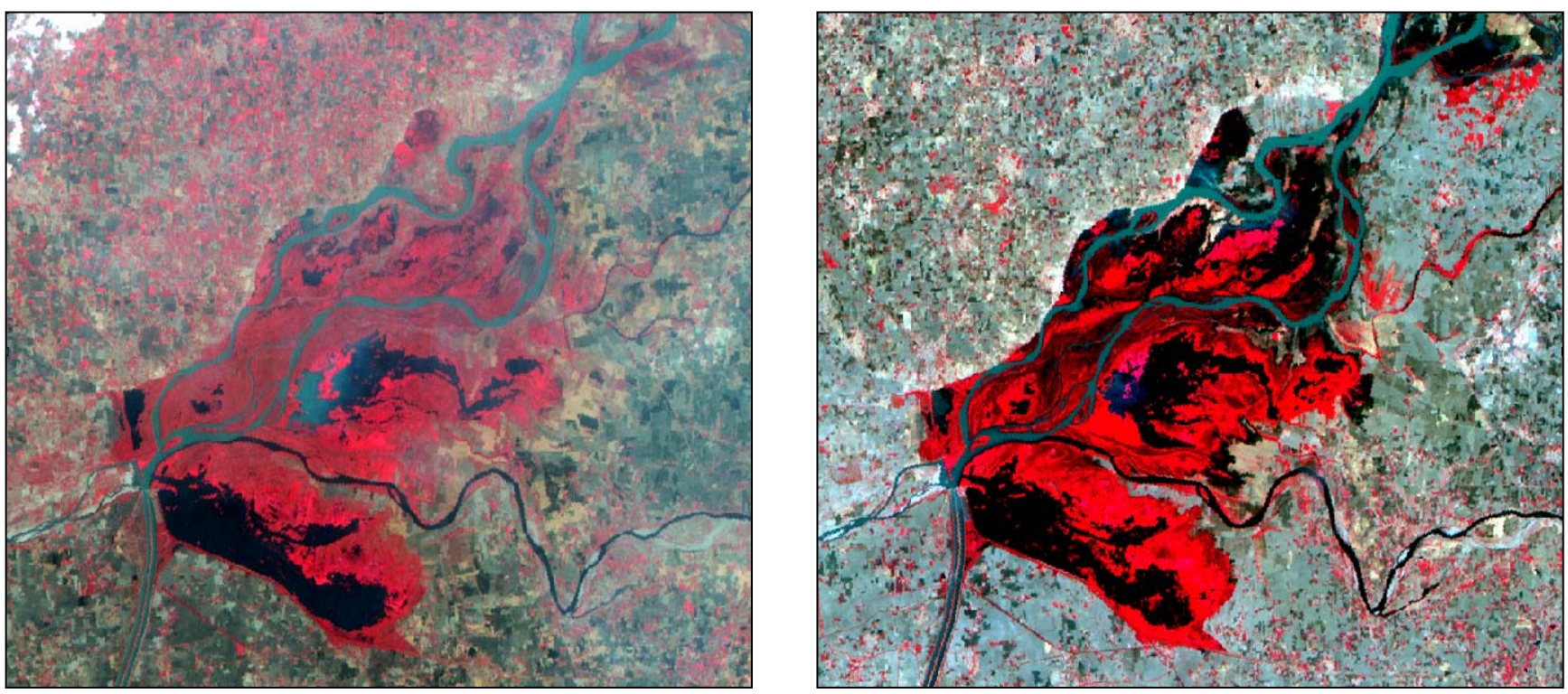
Most of the wetlands of Punjab are located on major rivers and they are mainly reservoirs and barrages. These wetlands are main source of water for irrigation and hydropower generation. Waterlogged areas are associated with canal systems and attract large number of migratory birds. These areas are well sported by emergent vegetation mainly typha grass and kalinga sp. etc. There are natural and man-made wetlands distributed though out the state. There are around 16 man-made wetlands which are used for irrigation and power generation these wetlands include Harike Lake, Kanjali, Nangal lake, Ranjit Sagar, Ropar wetland etc. Waterlogged areas mainly associated with canals. Most of the waterlogged areas are infested by phragmatis grass which is used in cottage industry and making roofs in villages. Some of these wetlands have been recognized as wetland of National Importance by the Ministry of Environment & Forests, Govt. of India (MoEF, GOI), the Punjab State Council for Science & Technology has initiated efforts to take up conservation programmes involving the state executing departments.

These wetlands have tremendous ecological values and these aquatic ecosystems are threatened on many counts, which include excessive siltation as a result of the erosion from the adjoining nude hills. Major restoration programmes includes survey and mapping, afforestation and soil conservation, fencing and wildlife development, monitoring water quality and research studies including hydrology and productivity and socio-economic values and ecotourism.

Field verification was carried out for important wetland sites to understand the trophic conditions and distribution of structural components. Wetland maps have been prepared for 5km buffer area of each wetland sites. Details of each wetland and wetland map of 5 km buffer area are shown in plates 3 to 17.

9.1 Harike Lake

Name	Harike Lake
Location	Between 31^0 09' 41" N and 31^0 13' 11" N latitudes and 74^0 56' 01" E and 75^0 16' 01" E longitudes
Area	Wetland area demarcated using satellite data 7406 ha where as water spread is around 4100ha.
Climate	North Indian monsoon climate, typical of the Punjab.
Salient features	This wetland falls in three districts encompassing Amritsar, Kapurthala, and Ferozepur. It is constructed at the confluence of Beas-Sutlej river and it has biggest watershed. Siltation is the main natural and anthropogenic problems are associated with this wetland. It receives large amount of nutrients from the catchment and support luxurious growth water hyacinth. Manual removal of water hyacinth is a regular phenomenon in this wetland.
Turbidity	High -Low
Vegetation	Species of Eichhornia crassipes covers around 75 per cent of the lake surface, *Typha sp*. is also reported from this wetland.
Fauna	The main fish fauna in the lake is Hilsa. It is as important breeding area for several species of waterfowl, notably *Anas acutta, A.clypeata, A. reecca, A.falcatta, A. Penelope, Grus grus, Netta rufina,* etc. This wetland can support around 200 000 waterfowl every year. The secondary productivity is very poor due to invasion of aquatic weeds and phytoplankton studies are also limited.



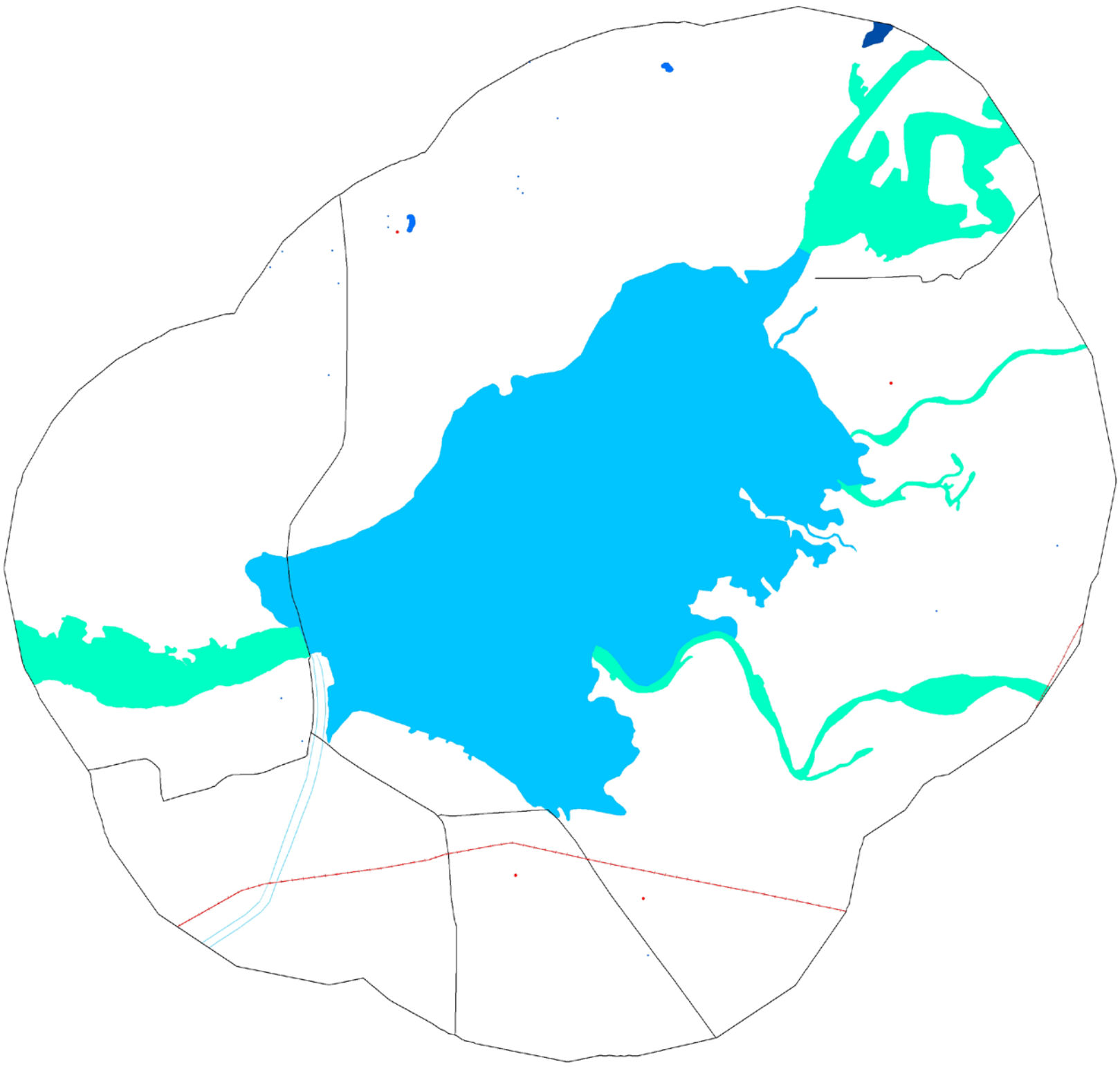
Post-Monsoon 2006 Pre-Monsoon 2007

Plate 3: Harike Lake

State : Punjab

WETLAND MAP

Harike Lake

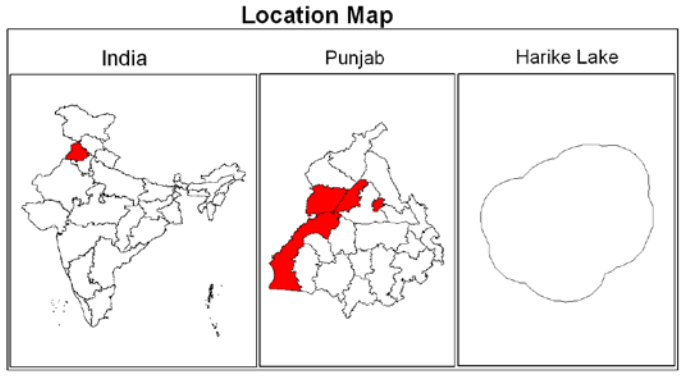


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.5 1 2 3 4 Kilometers

Data Source :

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

Prepared By :

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

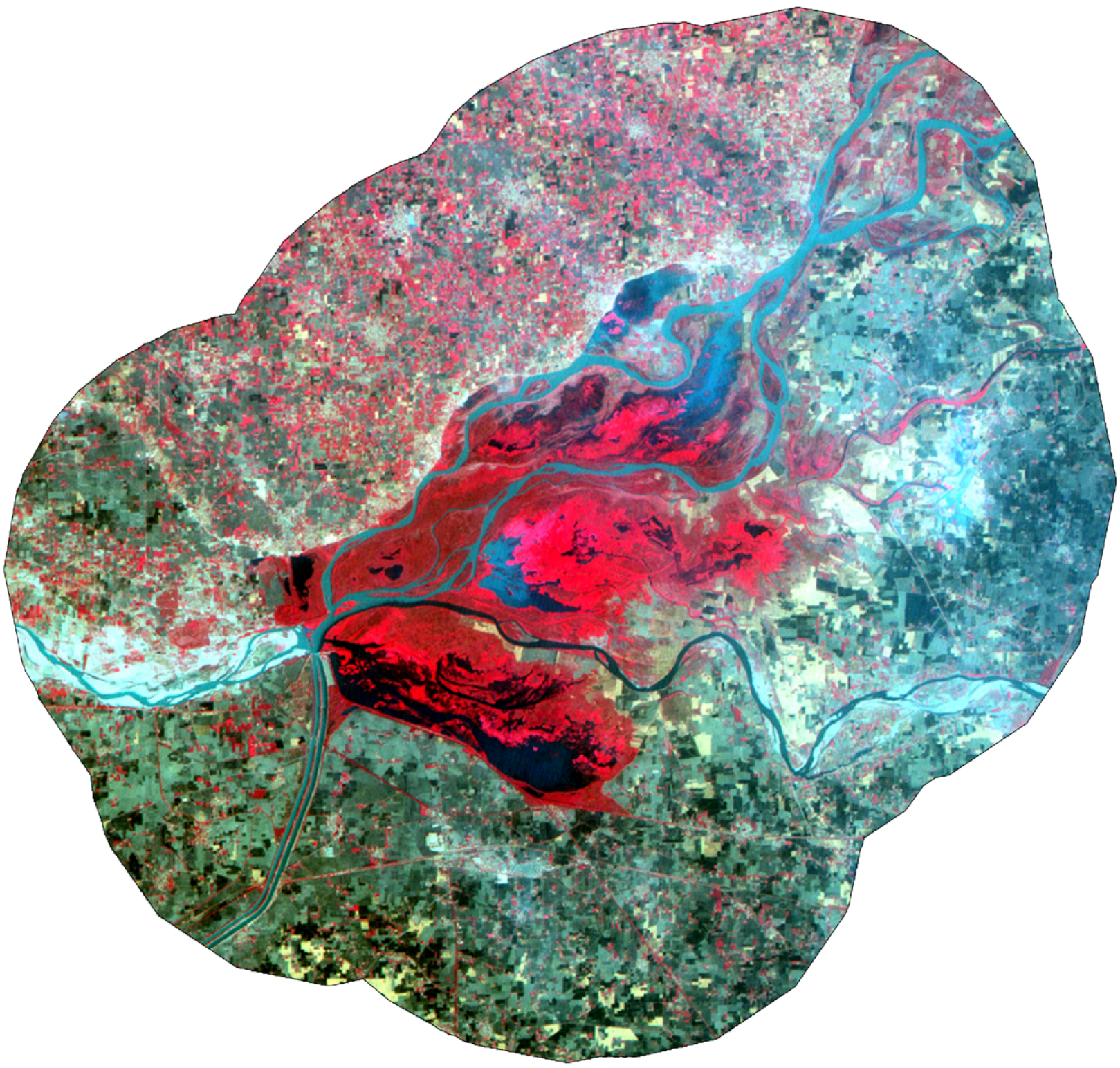
Sponsored By:

Ministry of Environment and Forests
Government of India

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

State : Punjab

Harike Lake

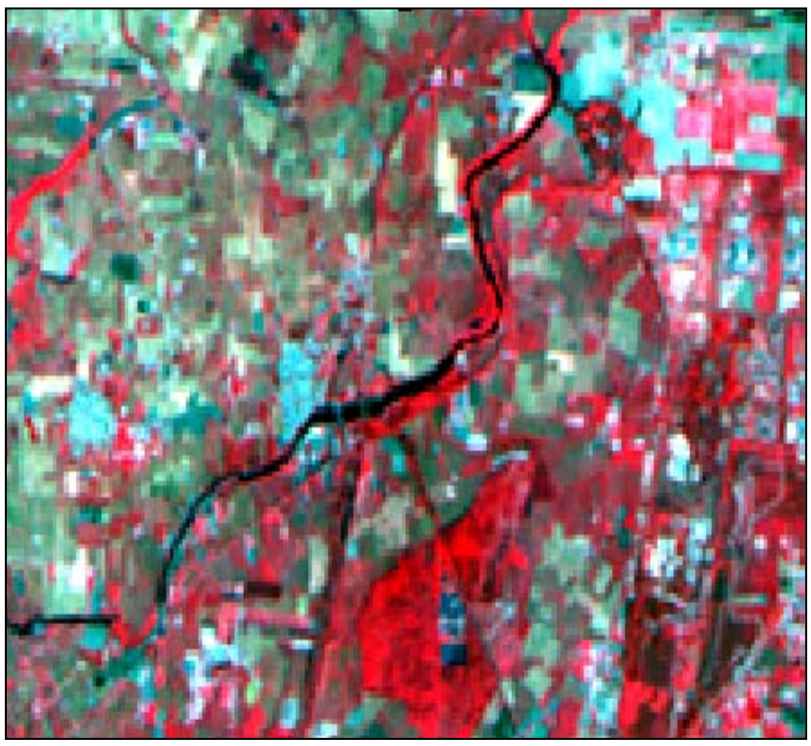


IRS P6 LISS-III post monsoon data (2006)

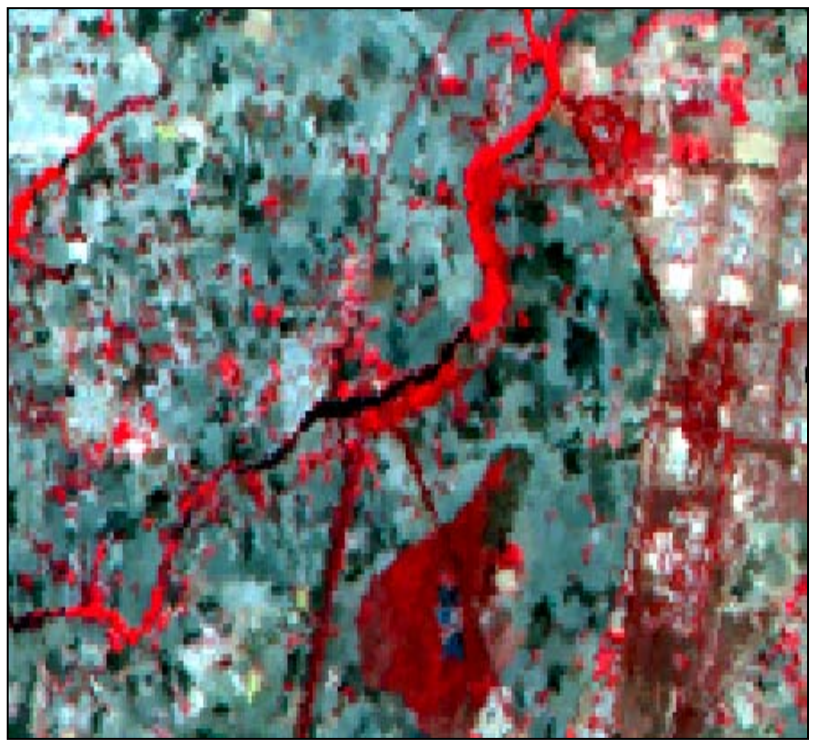
Plate 5: IRS LISS-III FCC - 5 km buffer area of Harike Lake

9.2 Kanjli Wetland

Name	**Kanjli Wetland**
Location	Between 31^0 06'41" N and 31^0 13'11" N latitudes and 75^0 22'33" E and 75^0 23'02" E longitudes
Area	The wetland area is as .low as 16 ha during pre-monsoon season and reaches up to 180 ha during good monsoon season.
Climate	Average annual rainfall : 700 mm Temperature: 6^o to 45^o C.
Salient features	The kanjli wetland is situated about 20 kms North-East of Harika town ship. Kanjli wetland came into formation in 1870 with the construction of Head regulator near village kanjli on the Kali Bein rivulet in Kapurthala district. It supports diversity of aquatic meso-phytic and terrestrial flora and fauna including important species of plants and animals.
Turbidity	Low
Vegetation	Number of tree species were recorded. These are *Acacia Arabica, Albizzia lebbeck, Dalbergia sissoo, Eucalyptus hybrid, Ficus bengalensis, Mangifera indica, Melia azedarach, Prosopis juliflora, Syzygium cumini and Ziziphus mauritiana.* Shrubs and Herbs included *Chara sp., Cyperus sp., Eichhornia crassipes, Hydrilla sp., Nelumbo sp., Hymphea sp., Potamogeton sp., Trapa sp., Typha angustata, Vallesnaria sp*., etc. respectively.
Fauna	Aquatic fauna comprised of fishes dominated by *Catla catla, Channa marulius, C. striatus, Cirrhinus mrigala, Labeo calbus, L.rohita.* Some of the common resident birds are *Little cormorant, Parakeets, Sparrow-hawk, Pigeon, Ring dove, Peafowl Common coot, Lapwing, Shikra, Blue rock, Turtle dove, Spotted Dove, Common quail, Grey partridge, Purple moorhen, Koel, Sparrow vulfure, Weaver bird, Indian robbin, Field king fisher, Black-winged kite*. Migratory birds mainly includes various spices of *Goose, Wigeon, White eyed pochard* and *Tufted pochard*.



Post-Monsoon 2006



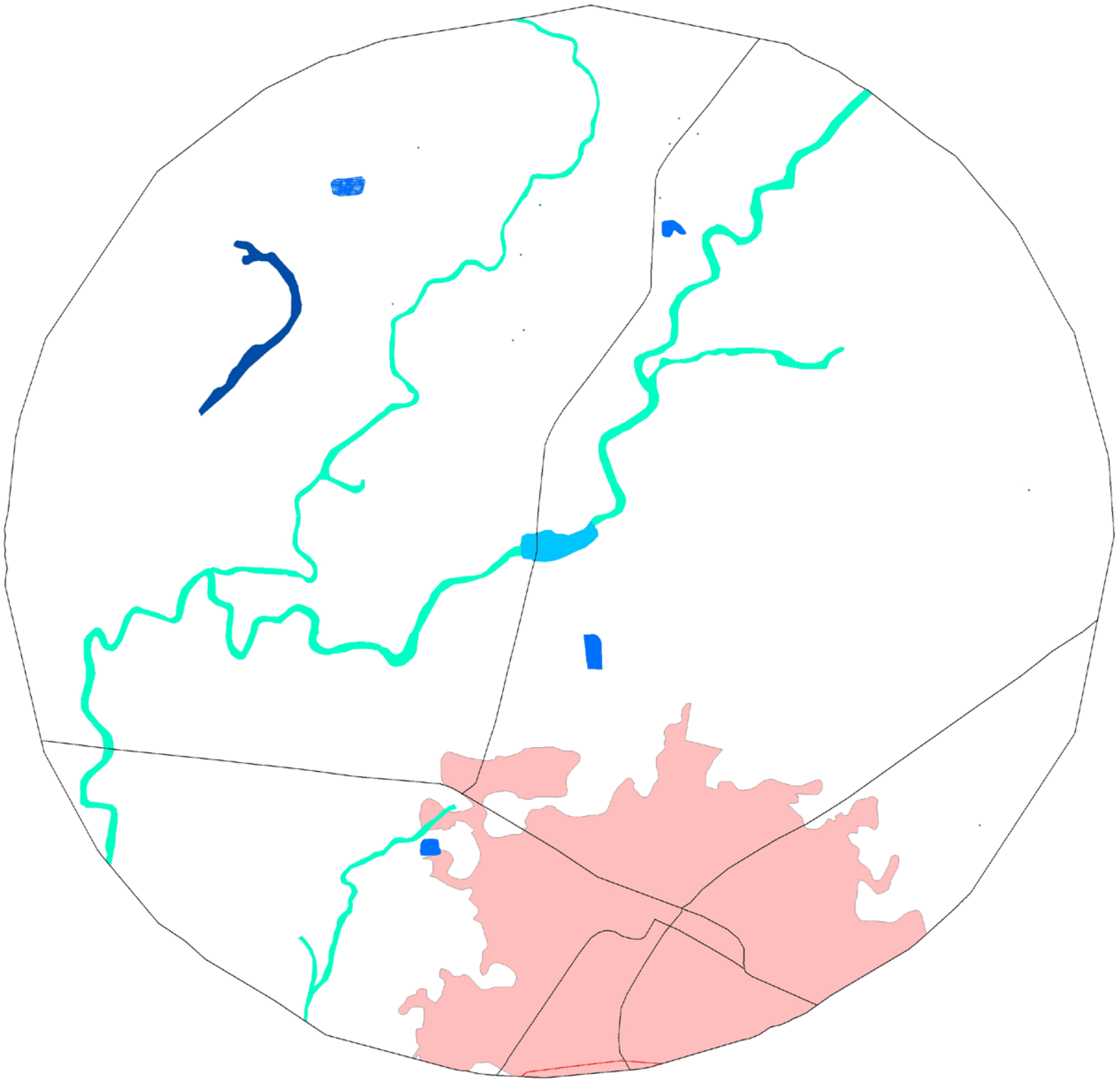
Pre-Monsoon 2007

Plate 6: Kanjli Wetland

State : Punjab

WETLAND MAP

Kanjli Wetland



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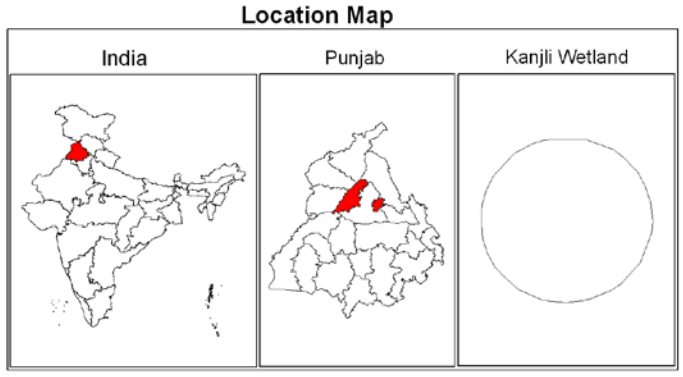
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged
1204			Salt pans
	Coastal Wetlands		
		Natural	
2101			Lagoons
2102			Creeks
2103			Sand/Beach
2104			Intertidal mud flats
2105			Salt marsh
2106			Mangroves
2107			Coral reefs
		Man-made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

Legend

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

Location Map



0 0.25 0.5 1 1.5 2 Kilometers

Data Source :

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

Prepared By :

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

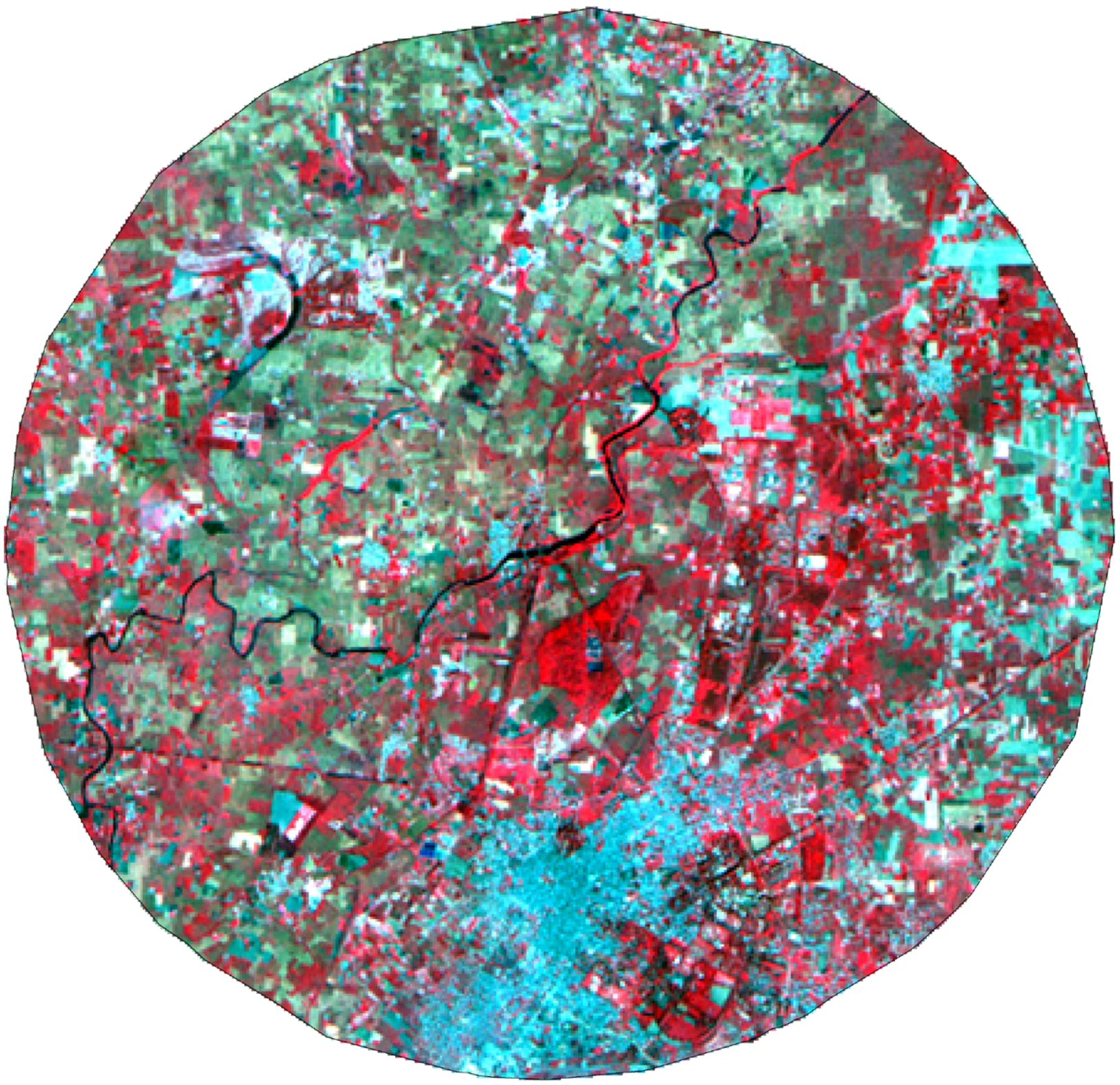
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 7: Wetland map - 5 km buffer area of Kanjli Wetland

State : Punjab

Kanjli Wetland

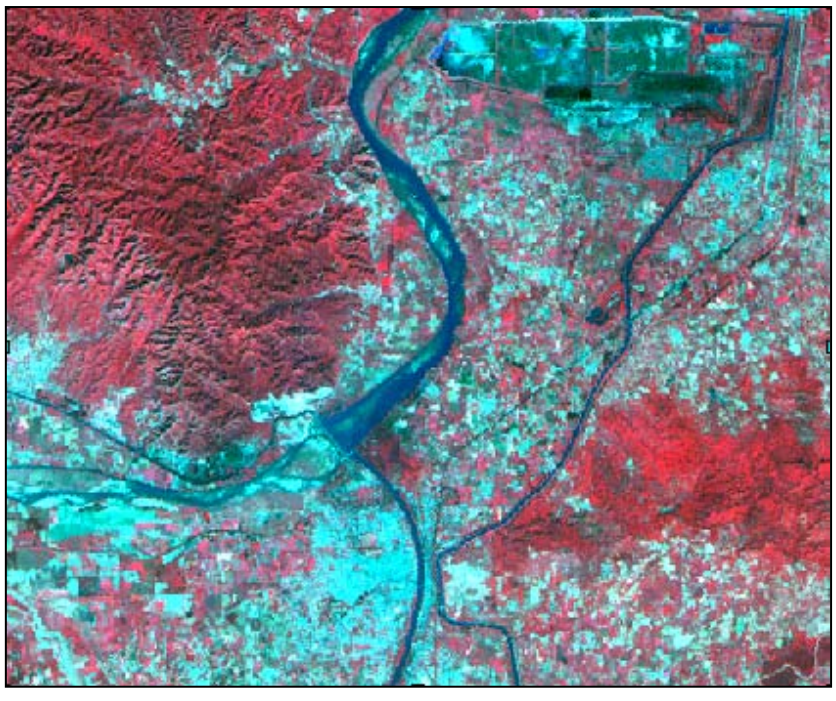


IRS P6 LISS-III post monsoon data (2006)

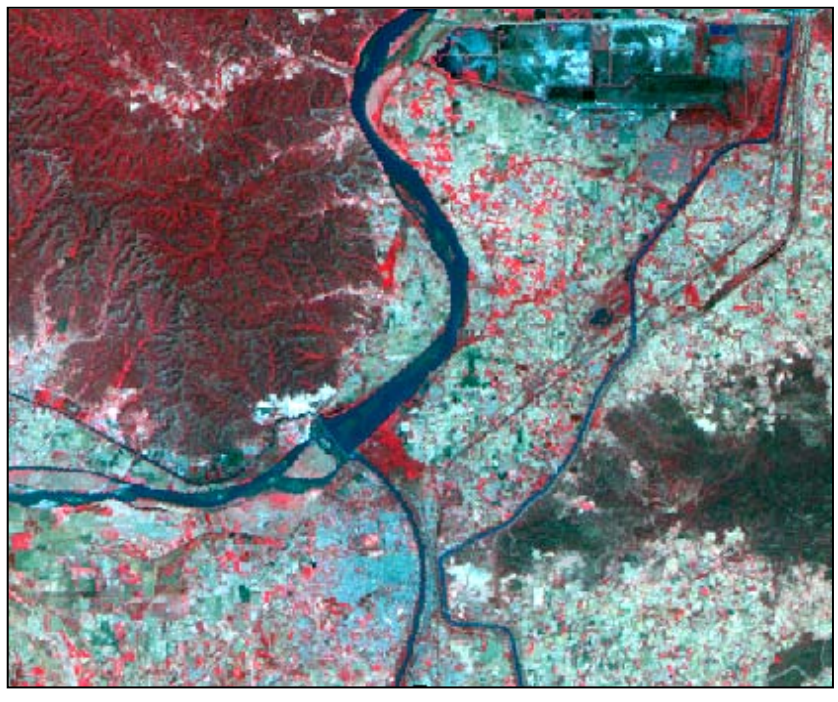
Plate 8: IRS LISS-III FCC - 5 km buffer area of Kanjli Wetland

9.3 Ropar Reservoir

Name	**Ropar Reservoir**
Location	Between 31^0 06'41" N and 31^0 13'11" N latitudes and 75^0 22'33" E and 75^0 23'02" E longitudes
Area	143 ha (reduce water level is 874 ft above see level)
Climate	Average annual rainfall : 1518 mm
Salient features	It is situated near Ropar city, 45 Km north west of Chandigarh city. It is constructed in 1952 on the right side of Sutlej river to supply to Sirhind canal. The average depth is 4 meters and the maximum depth is recorder is around 6 meters. It is recreational sight and there are are many watch towers constructed around the wetland to watch flora and fauna and also act as monitoring stations to guard poaching. There many sampling stations are fixed to collect water quality parameters and this will enable the authorities to monitor the silt load and primary and secondary productivity in the wetland.
Turbidity	Low – Moderate
Vegetation	The catchment of the reservoir comprised of various trees species and dominated by Acacia sps. It also support large number of species of bushes and grasses in the periphery of the reservoir Ropar wetland facing various threats due to siltation and invasion of weeds such as *Parthenium sp*. and *Lantana sp*. These weeds do not allow the other plants to grow. There are reports of poaching of endanger birds and also fish fauna in the wetlands.
Fauna	Aquatic fauna comprised of more than 20 species of fishes dominated by *Ambasis nama, Catla catla, Channa punctatus, Cyprinus sps, Labeo roita., labeo sps.*, etc. Migratory birds mainly includes *Anas acta, Anas sps., Circus aeruginosus, Hydrophasianus sps., Netta rufina and rare birds are Dinopium benghalense, Megalaima haemacephala, M.zeylanica*



Post-Monsoon 2006



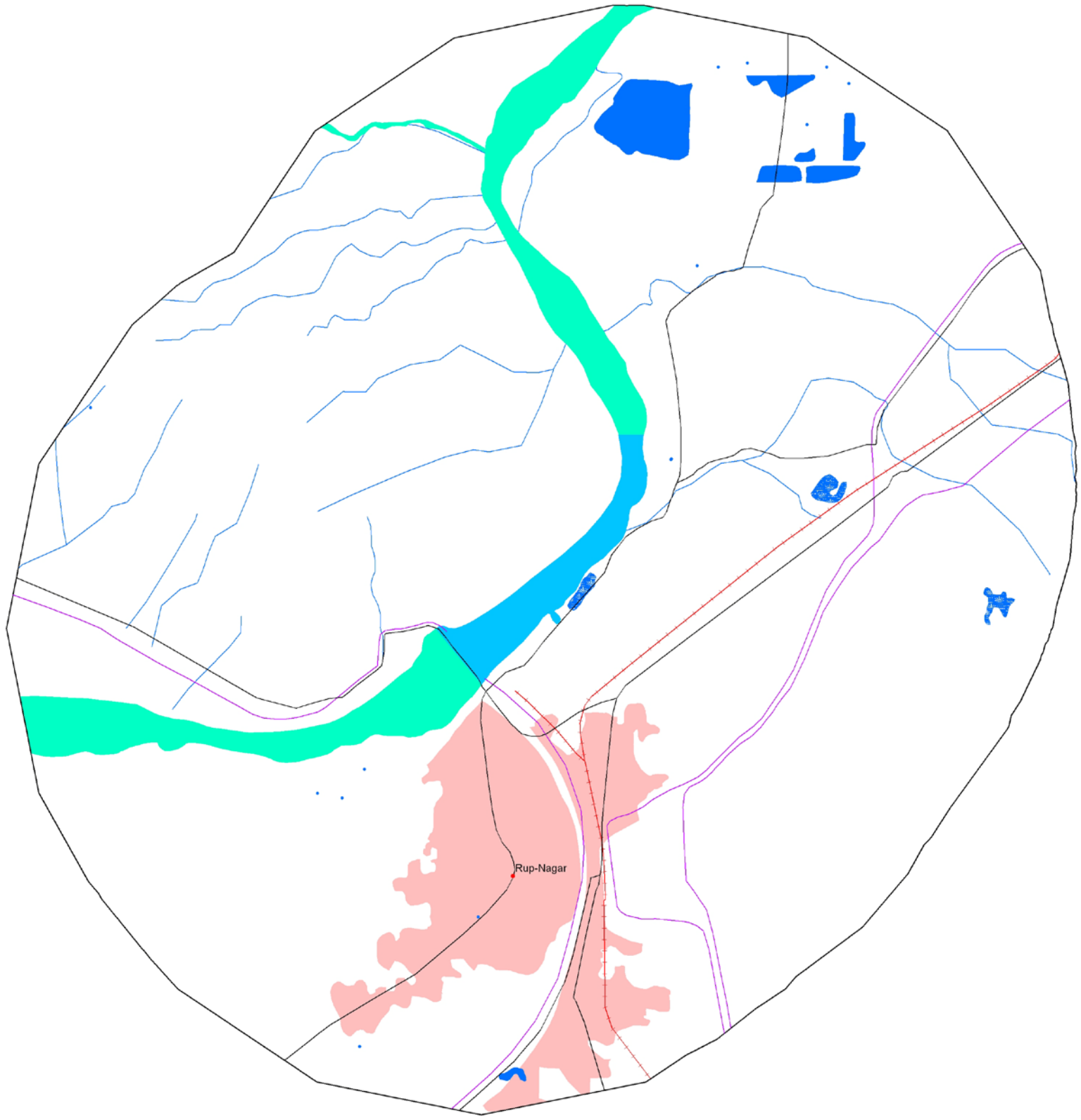
Pre-Monsoon 2007

Plate 9: Ropar Reservoir

State : Punjab

WETLAND MAP

Ropar Reservoir

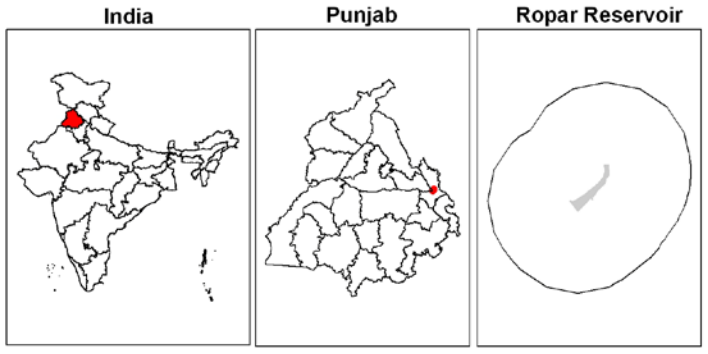


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



Data Source :

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

Prepared By :

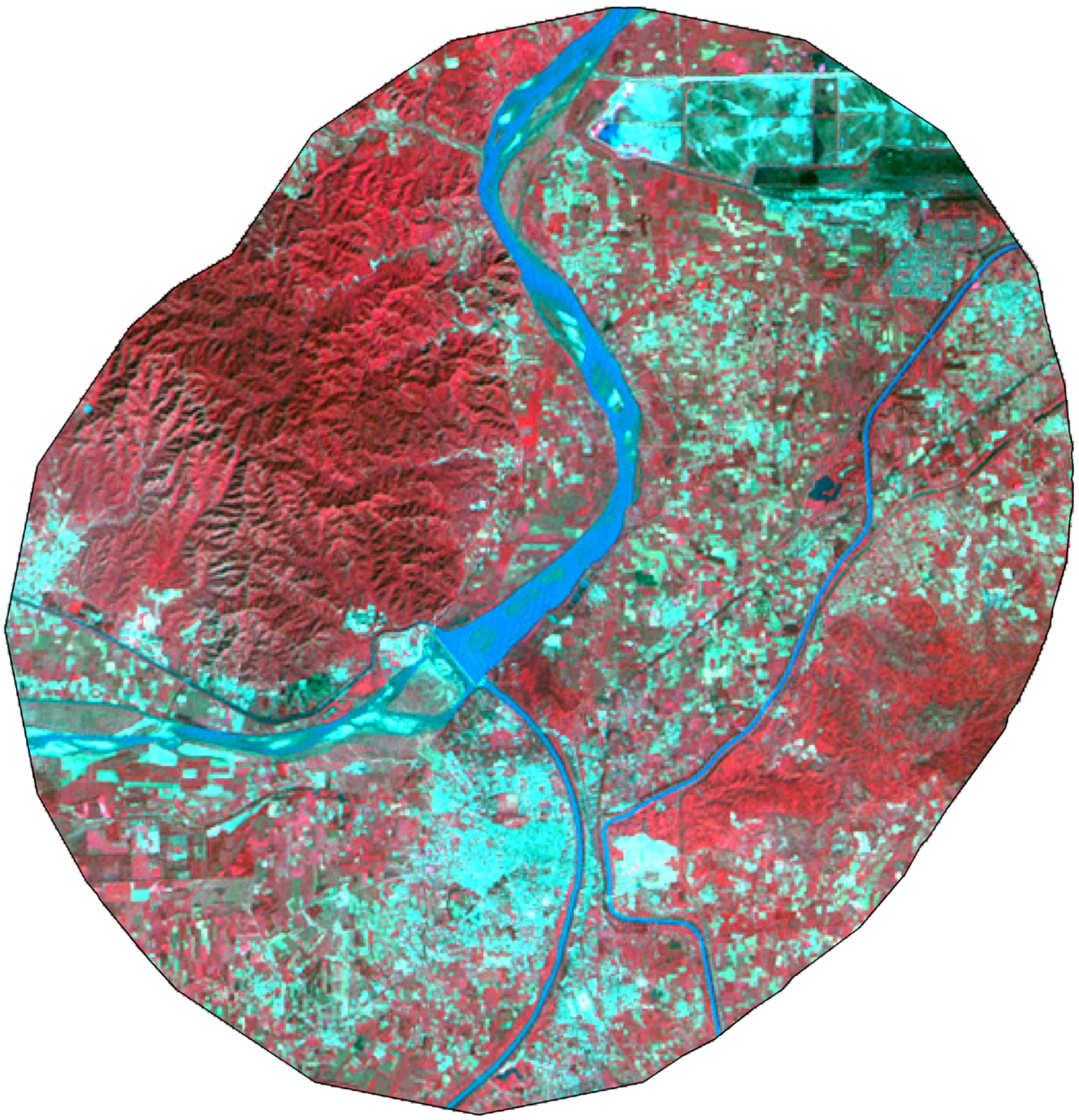
Space Applications Centre (ISRO), Ahmedabad
and
Punjab Remote Sensing Applications Centre, Ludhiana

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

Roapar Reservoir

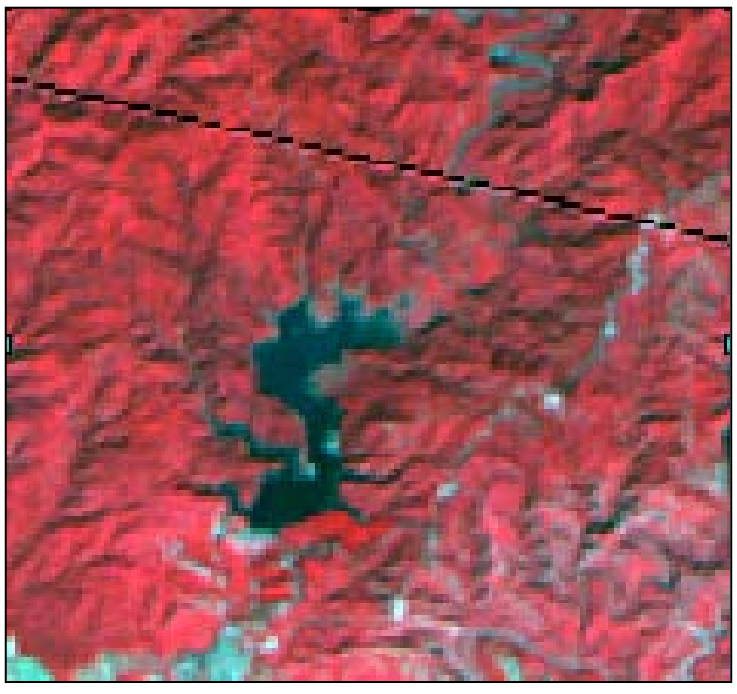


IRS P6 LISS-III Post-monsoon data (2006)

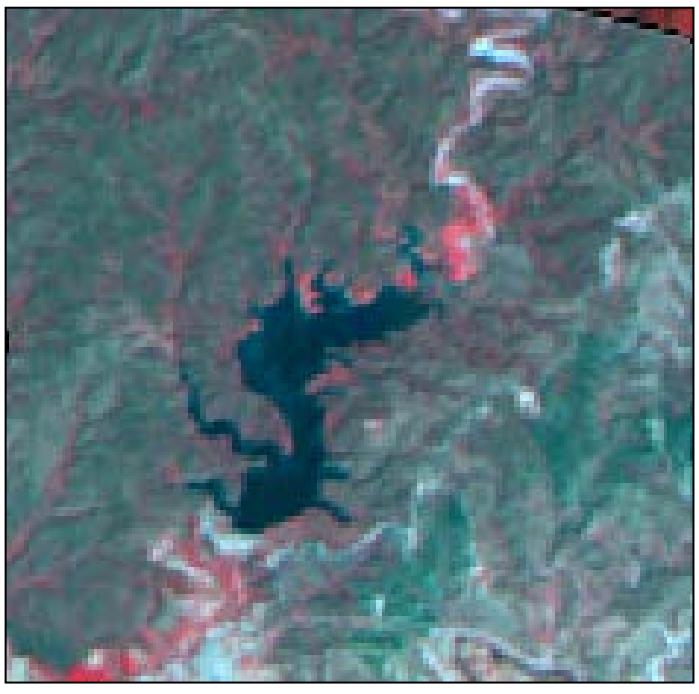
Plate 11: IRS LISS-III FCC - 5 km buffer area of Ropar Reservoir

9.4 Dholbaha Reservoir

Name	**Dholbaha Reservoir**
Location	31^0 05' N latitude and 77^0 00' E longitude
Area	46 ha
Climate	Average annual rainfall : NA Temperature: 13^o to 30^o C.
Salient features	The Dholbaha Reservoir is situated about 30 kms Hoshiarpur town. The dam is located downstream of confluence of Kukanet and Buhera khads. Dholbaha dam is an earth fill dam consisting of a central impervious core, protected by previous shell zones on its upstream.
Turbidity	Low
Vegetation	A total of 23 species of phytoplankton were recorded. These are *Amphora sp., Calonies sp., Characium sp., Coconies sp., Cymbella sp., Cystodinium sp., Diatoma sp., Eunotica sp., Fragilara sp., Gyrosigma sp., Mastoglioa sp., Melosira sp., Naviculla sp., Neidium sp., Nizshia sp., Nitzshia sp., Nostoc sp., Oscillatora sp., Planktosphaeria sp., Pediastrum sp., Synedra sp., Tabellaria sp., Troschia sp., Rhizoclonium sp.*
Fauna	Aquatic fauna comprised of *Cyprinus carpio, Labeo rohita, Ctenopharyngodon idella* and *Cirrhinus mrigala.*



Post-Monsoon 2006



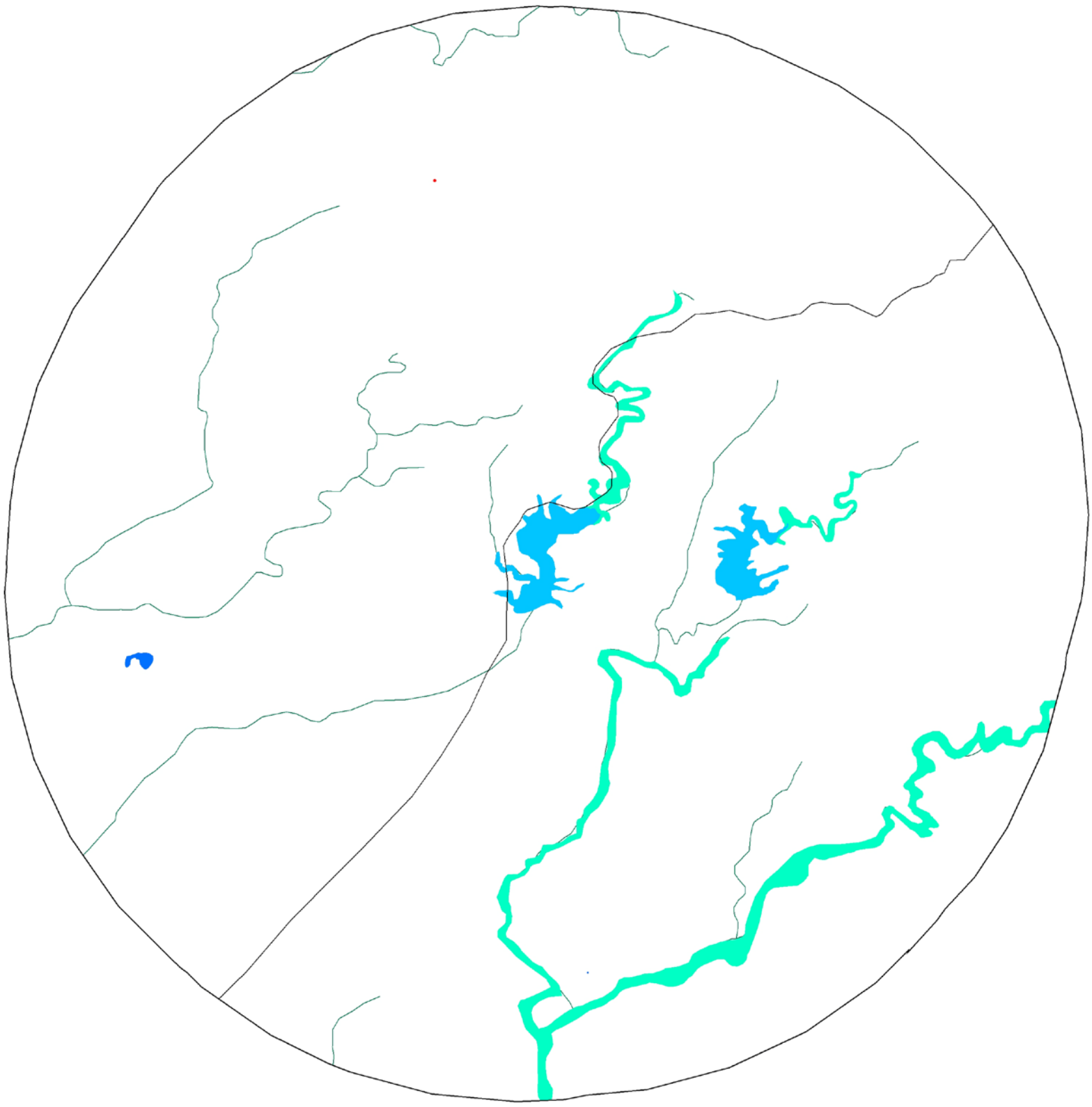
Pre-Monsoon 2007

Plate 12: Dholbaha Reservoir

State : Punjab

WETLAND MAP

Dholbaha Reservoir

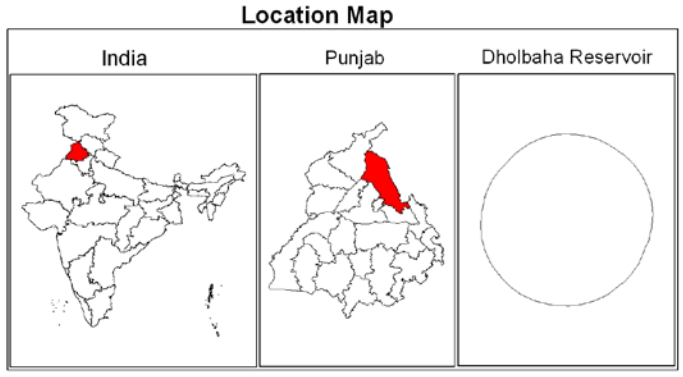


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.25 0.5 1 1.5 2 Kilometers

Data Source :

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

Prepared By :

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

Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 13: Wetland map - 5 km buffer area of Dholbaha Reservoir

State : Punjab

Dholbaha Reservoir

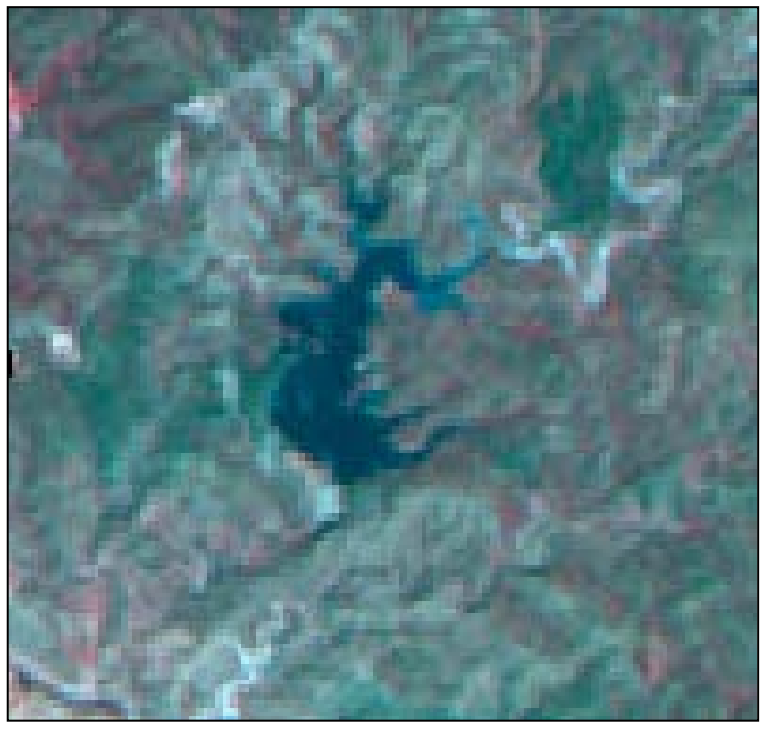
IRS P6 LISS-III post monsoon data (2006)

Plate 14: IRS LISS-III FCC - 5 km buffer area of Dholbaha Reservoir

9.5 Januari Reservoir

Name	**Januari Reservoir**
Location	31^0 05' N latitude and 77^0 00' E longitude
Area	33 ha
Climate	Average annual rainfall : NA Temperature: 13^o to 30^o C.
Salient features	The Dholbaha Reservoir is situated about 27 kms Hoshiarpur town. The dam is located sownstream of confluence of Kukanet and Buhera khads. The dam is an earth fill dam consisting of a central impervious core, protected by previous shell zones on its upstream.
Turbidity	Low
Vegetation	A total of 25 species of phytoplankton were recorded. These are *Amphora sp., Calonies sp., Characium sp., Coconies sp., Cymbella sp., Cystodinium sp., Diatoma sp., Eunotica sp., Fragilara sp., Gyrosigma sp., Gomphonema sp., Mastoglioa sp., Melosira sp., Naviculla sp., Neidium sp., Nizshia sp., Nostoc sp., Oscillatora sp., Planktosphaeria sp., Pediastrum sp., Psdiastrum sp., Rhizoclonium sp., Synedra sp., Tabellaria sp., Troschia sp.*
Fauna	Aquatic fauna comprised of *Cyprinus carpio, Labeo rohita, Ctenopharyngodon idella* and *Cirrhinus mrigala.*

Post-Monsoon 2006



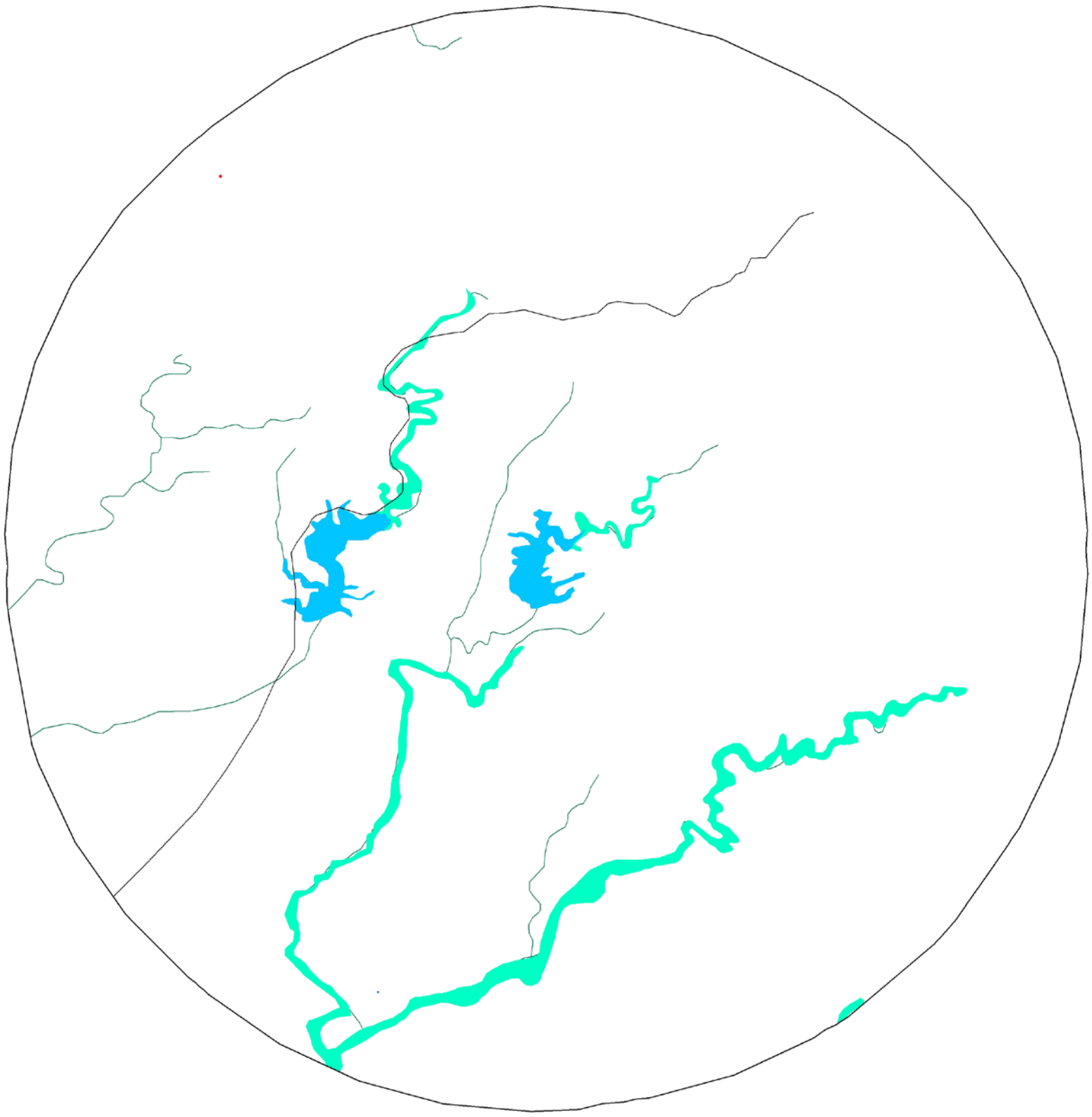
Pre-Monsoon 2007

Plate 15: Januari Reservoir

State : Punjab

WETLAND MAP

Januari Reservoir

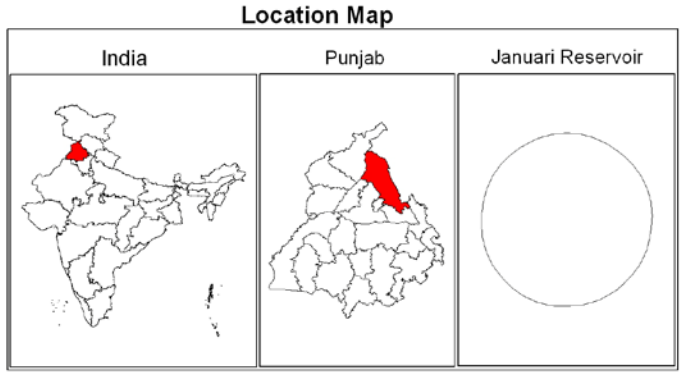


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 0.25 0.5 1 1.5 2 Kilometers

Data Source :

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

Prepared By :

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

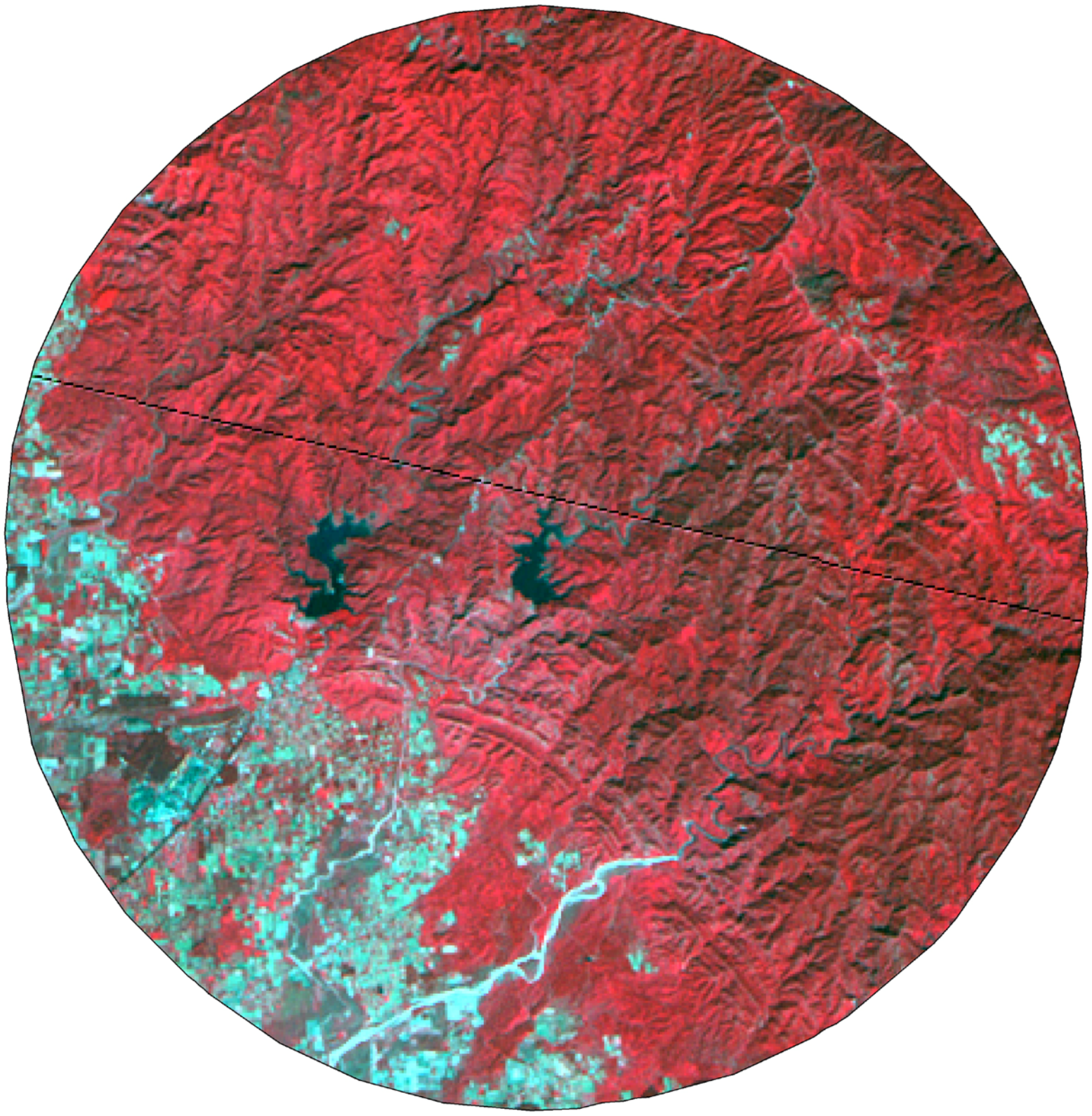
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 16: Wetland map - 5 km buffer area of Januari Reservoir

State : Punjab

Januari Reservoir



IRS P6 LISS-III post monsoon data (2006)

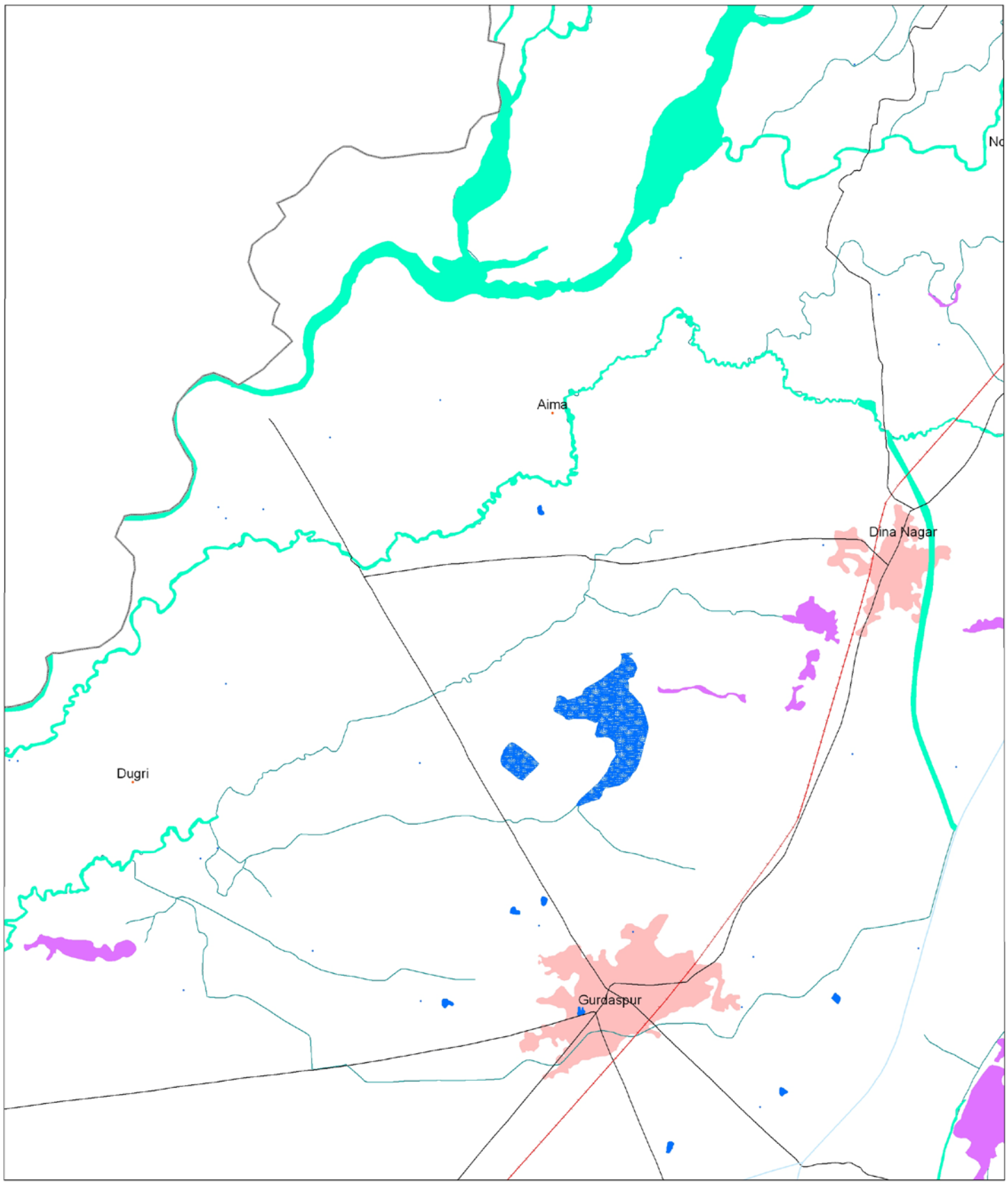
Plate 17: IRS LISS-III FCC - 5 km buffer area of Januari Reservoir

SOI MAP SHEET-WISE WETLAND MAPS (SELECTED)

State : Punjab

WETLAND MAP

SHEET NO. : 43P/08

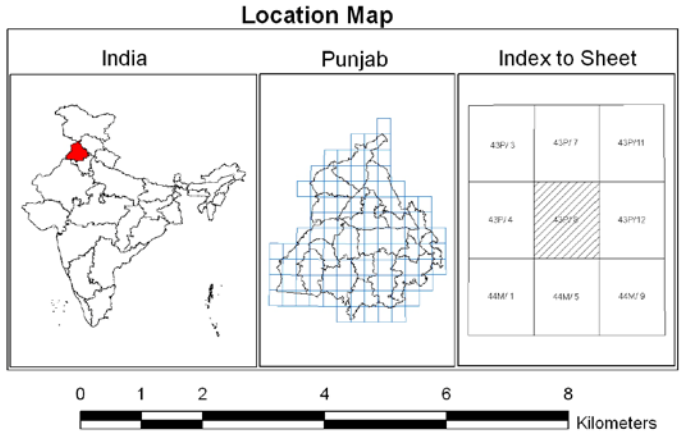


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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

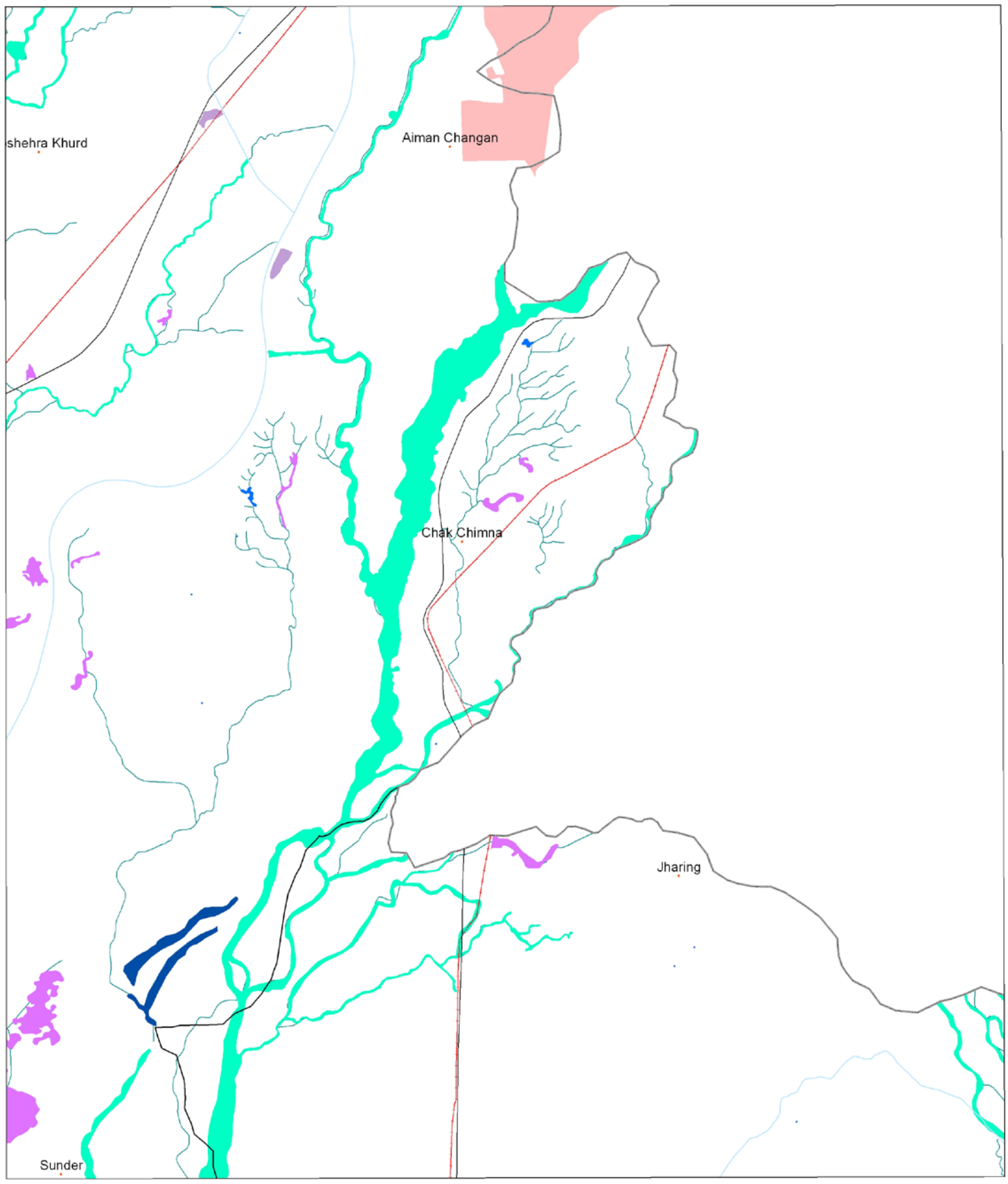
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 43P/12

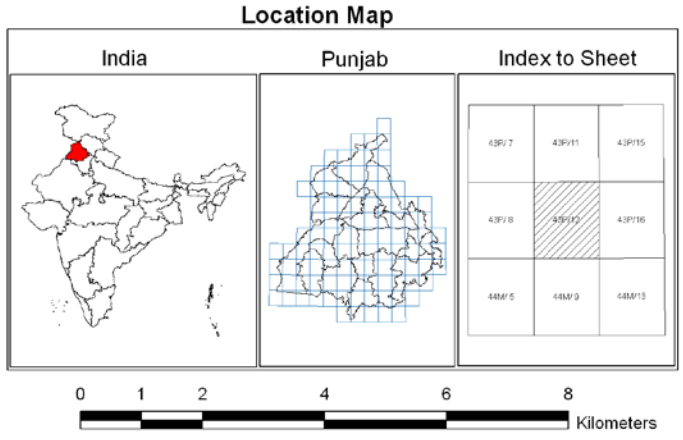


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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

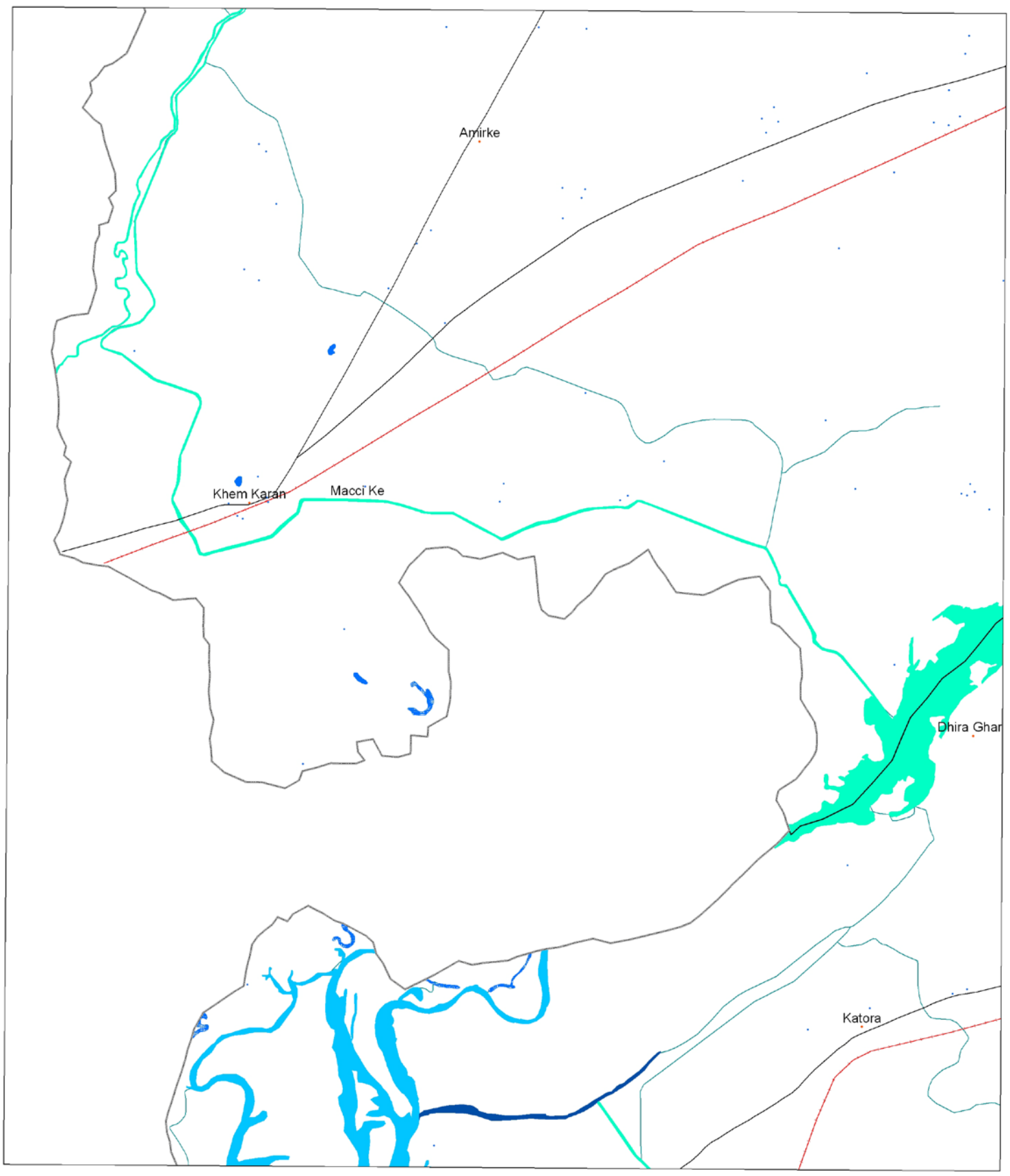
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 44I/12

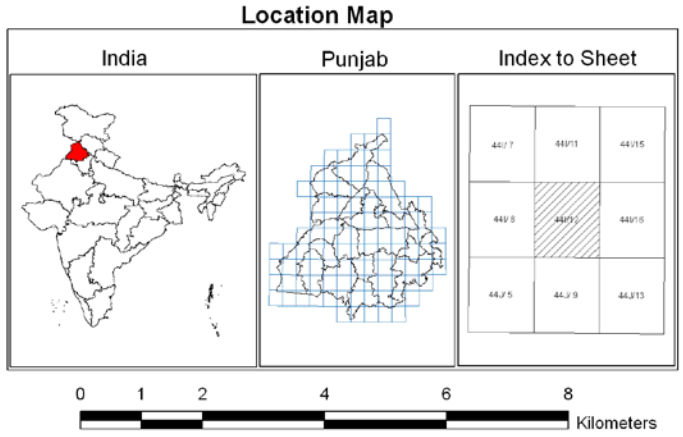


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

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

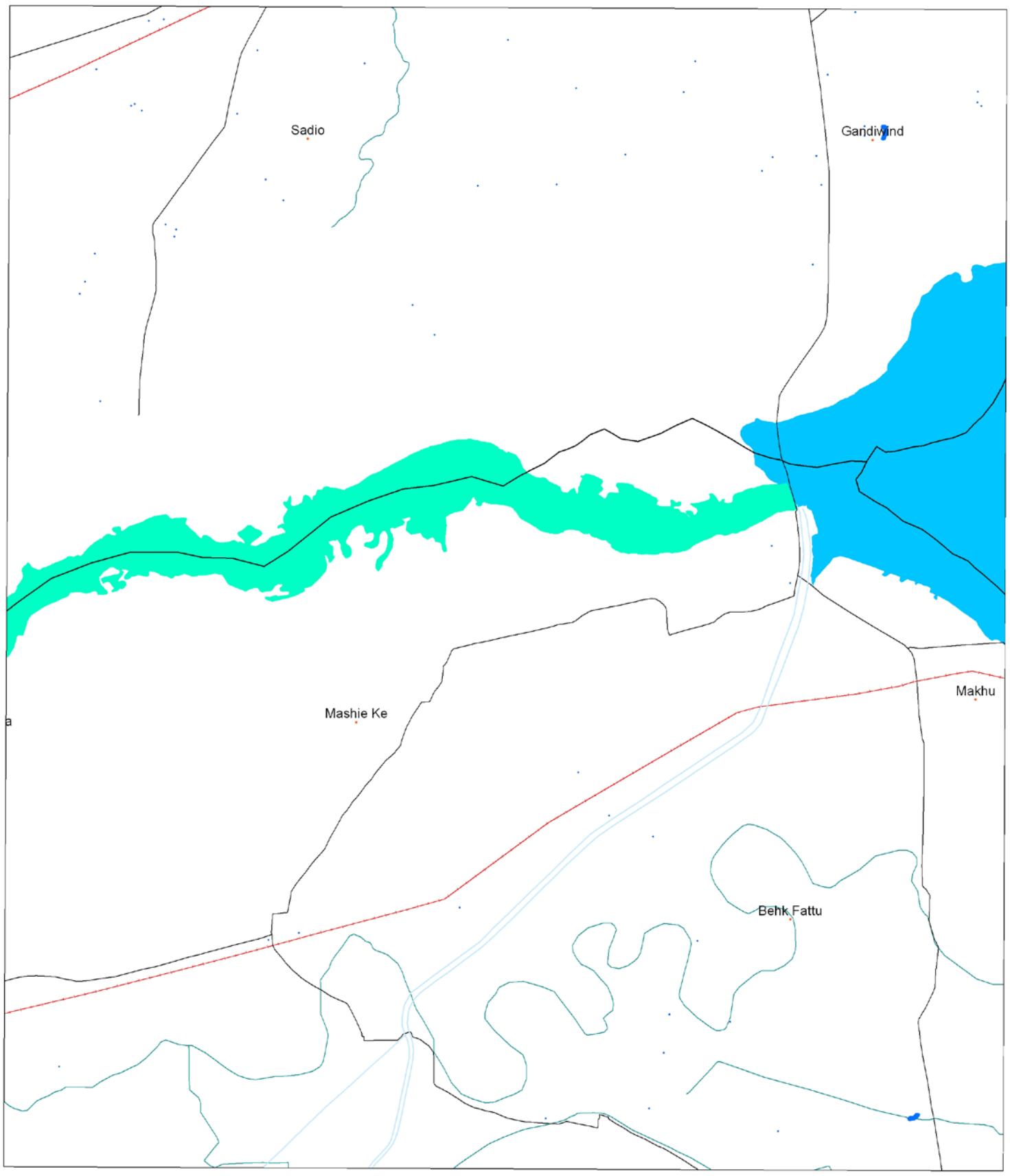
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 44I/16

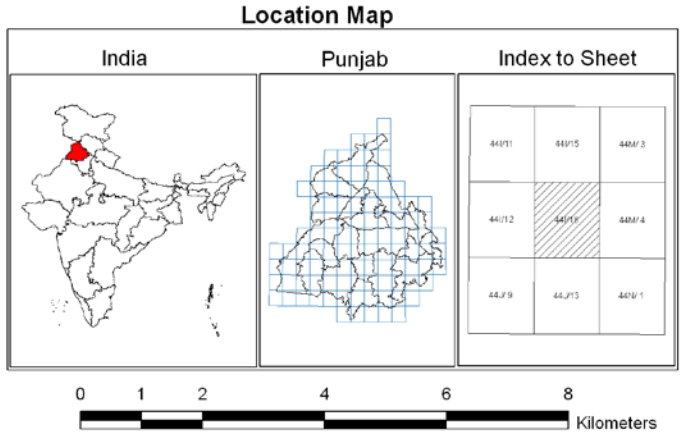


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 (<2.25 ha)
- Settlements
- Drainage (line)
- Canal
- Roads
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map



Data Source :

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

Prepared By :

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

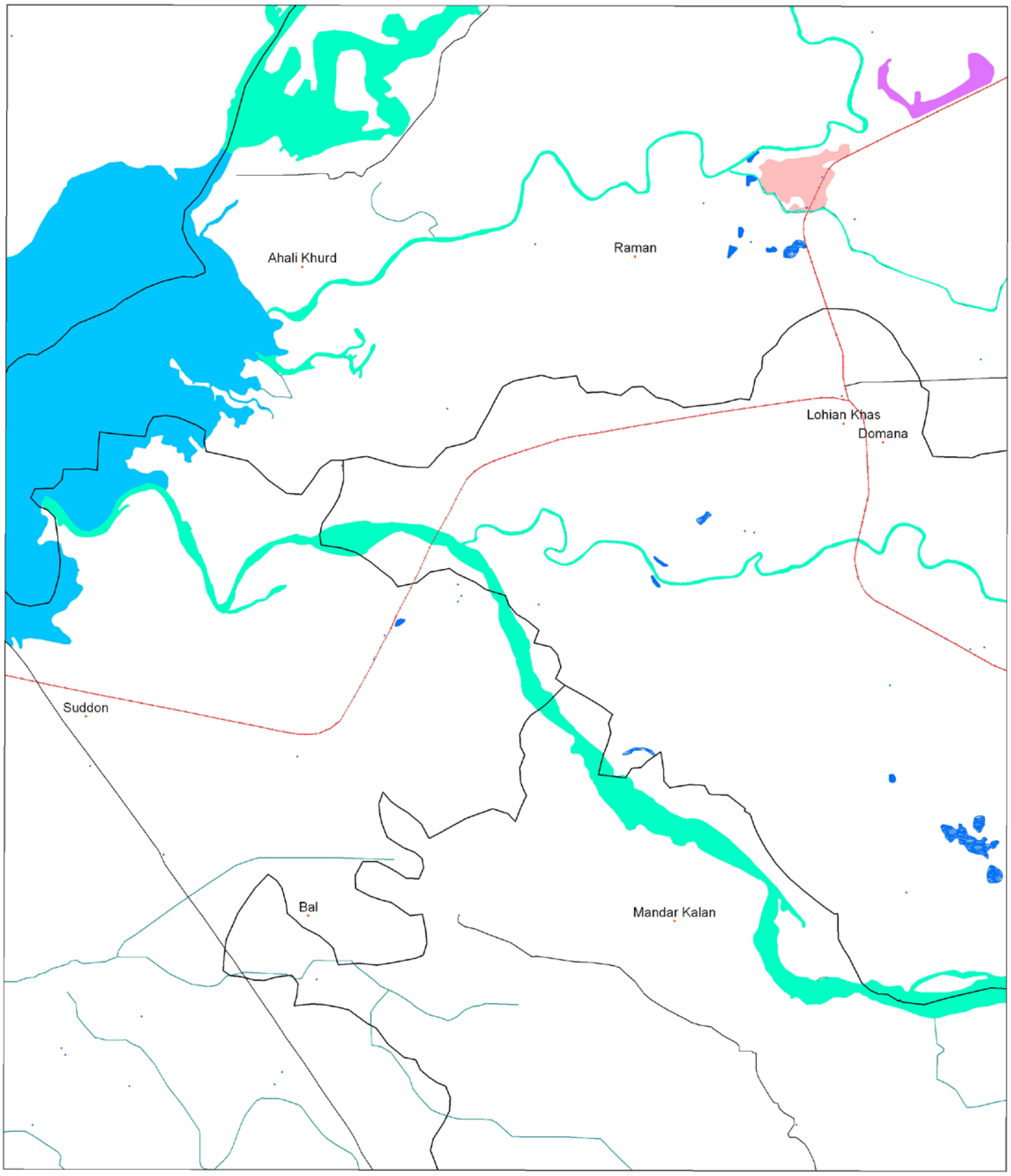
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 44M/04

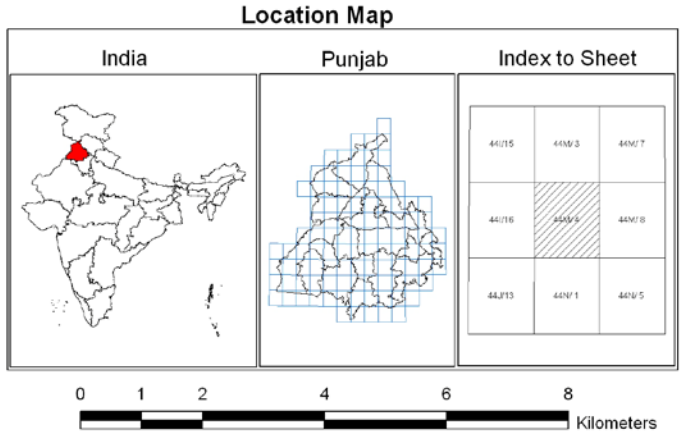


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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

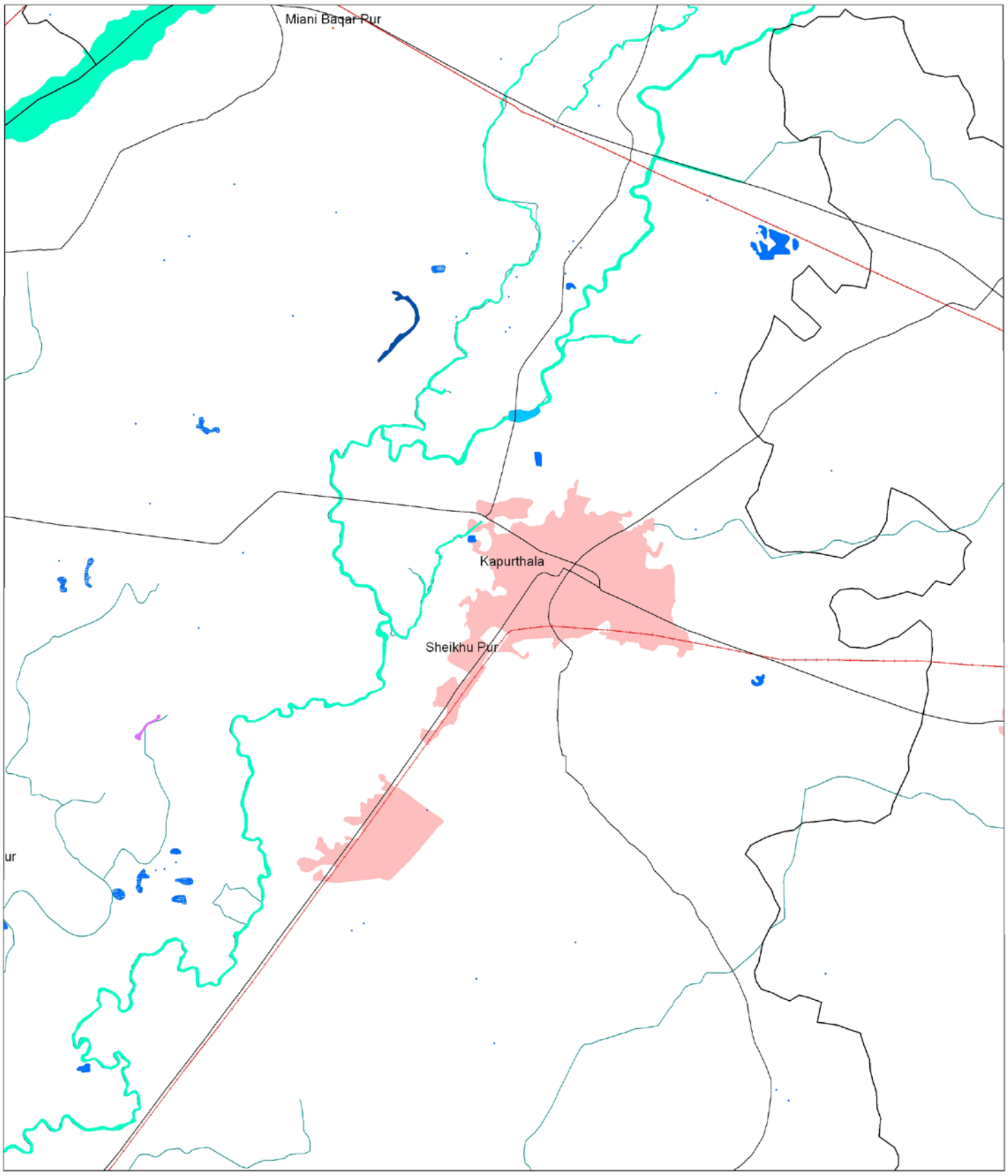
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 44M/07

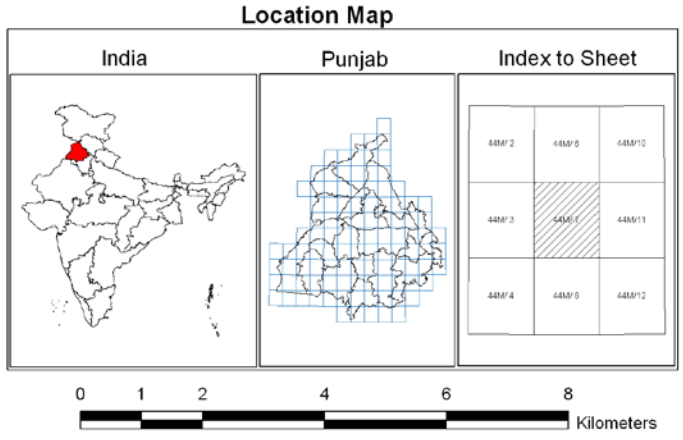


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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

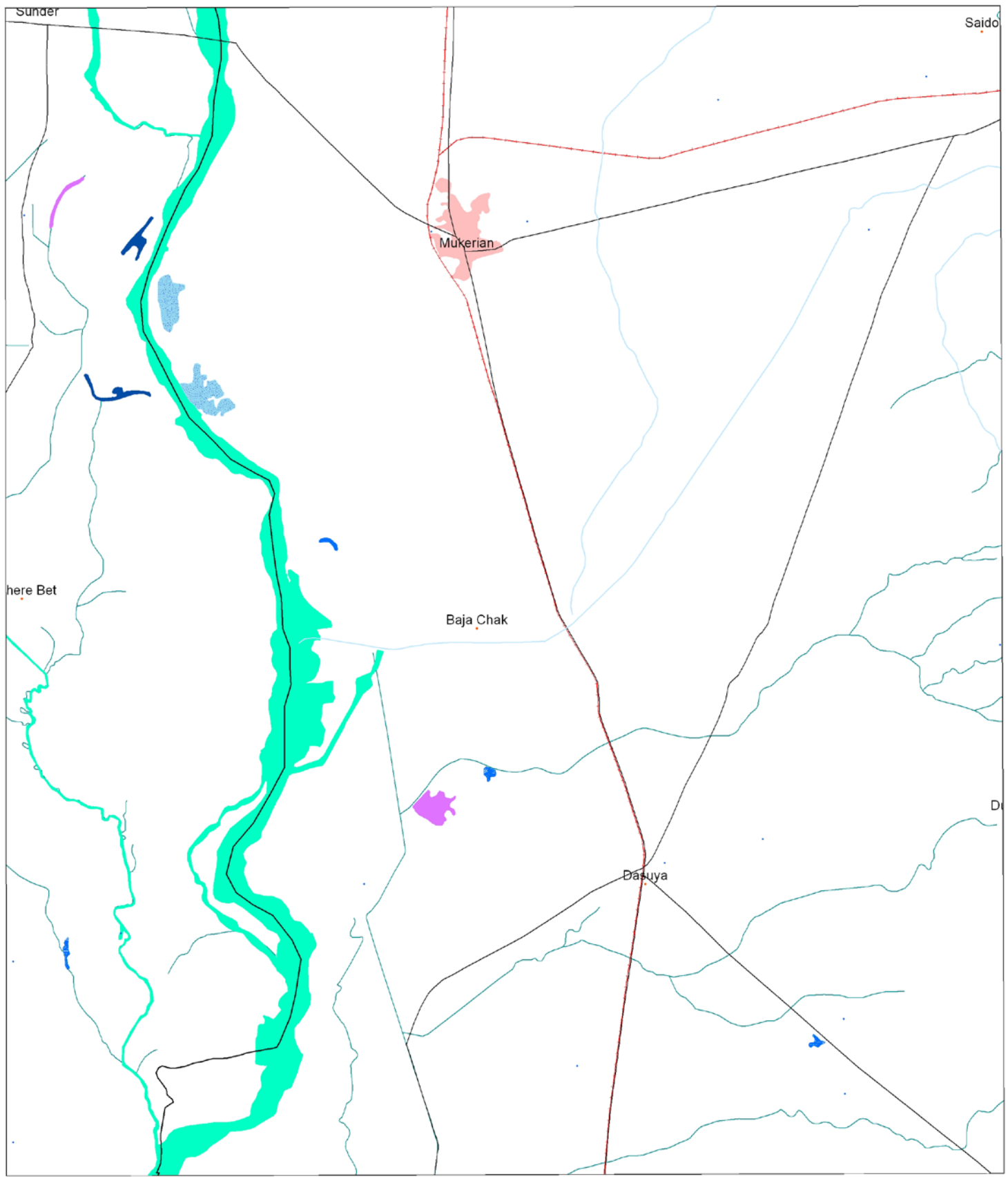
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 44M/09



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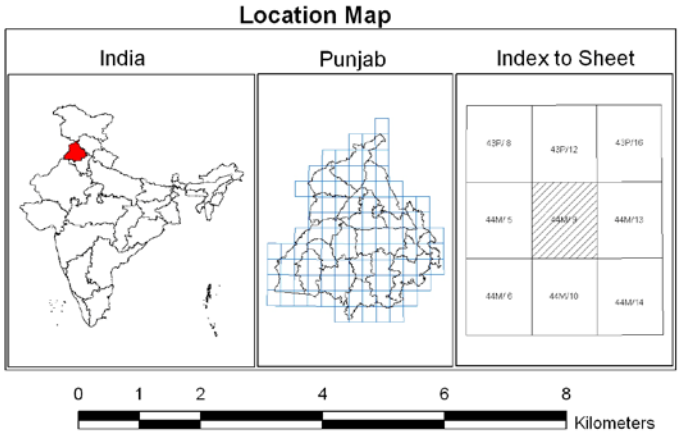


Data Source :

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

Prepared By :

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

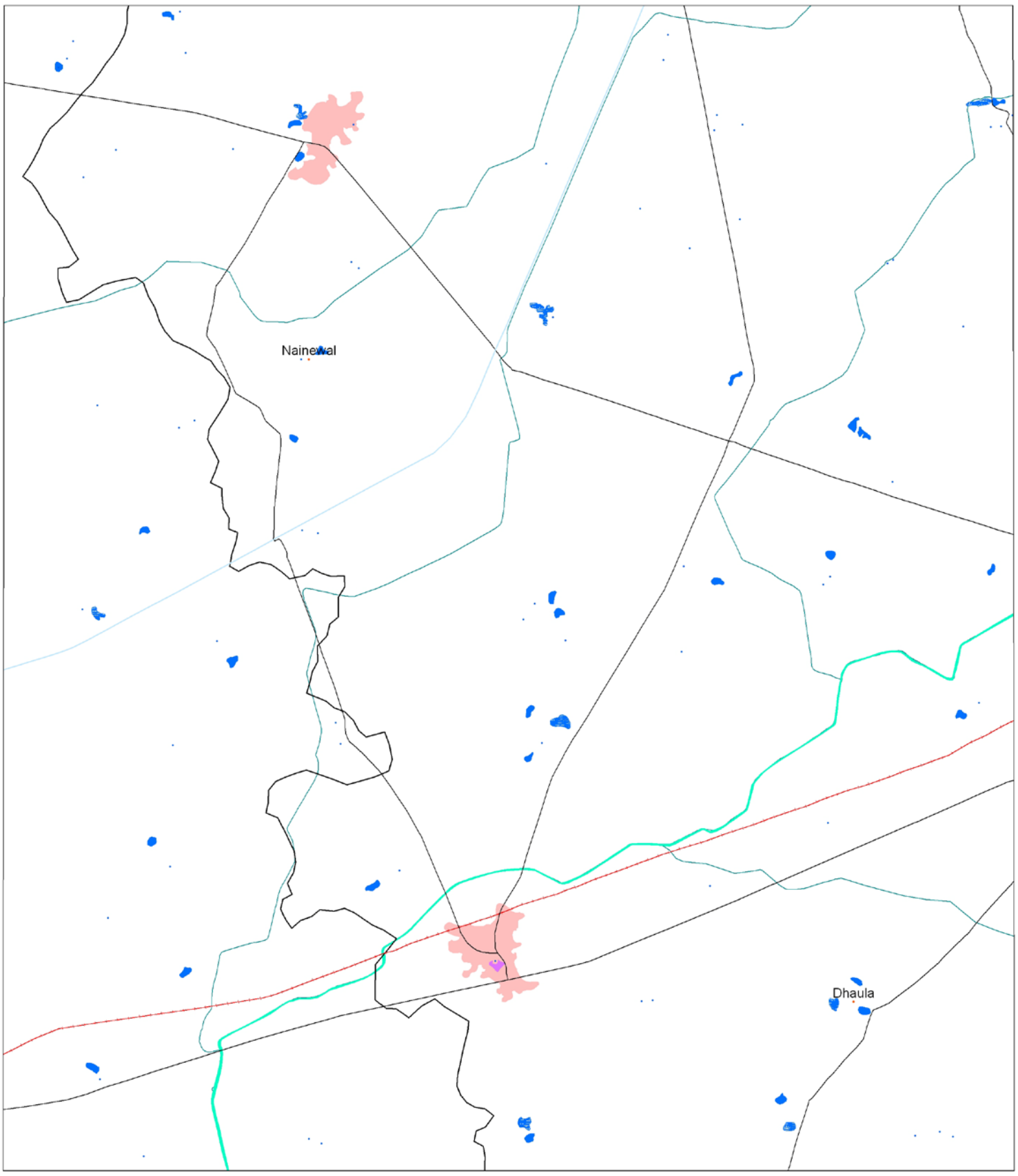
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 44N/07



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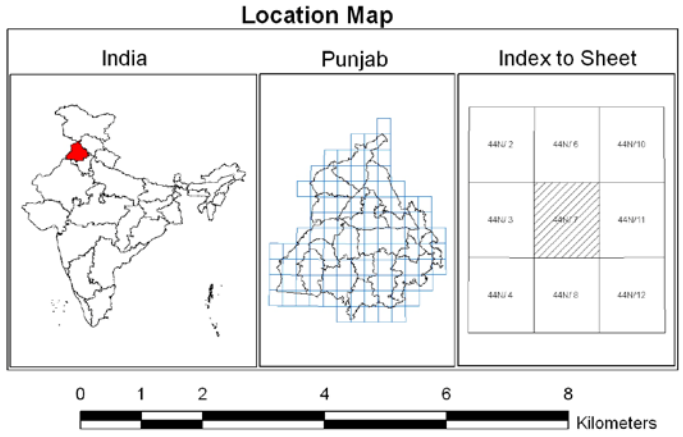

Data Source :

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

Prepared By :

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

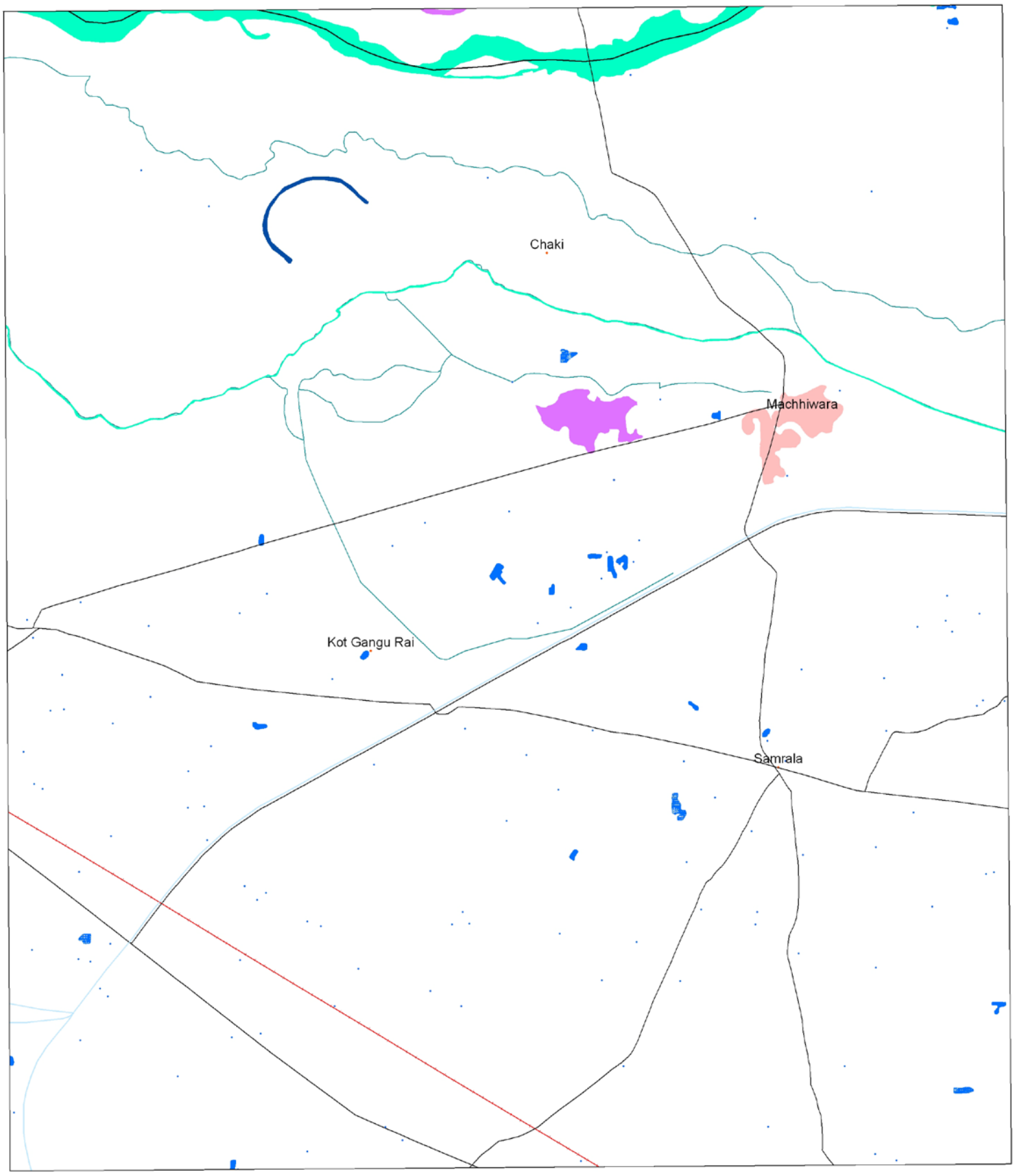
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 53B/01



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
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1201			Reservoirs/Barrages
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- District Boundary
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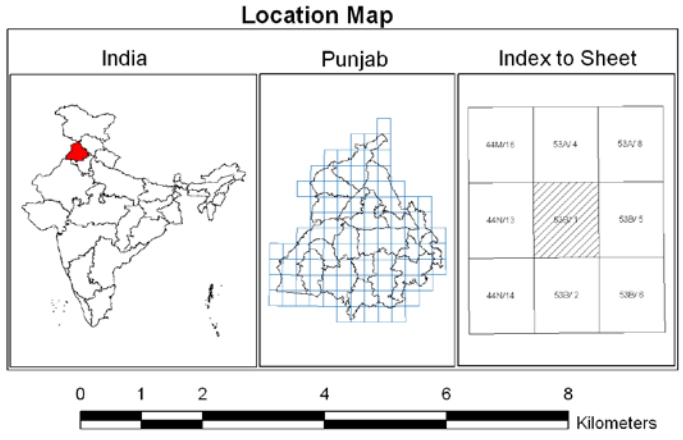
- International Boundary

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
Punjab Remote Sensing Applications Centre, Ludhiana

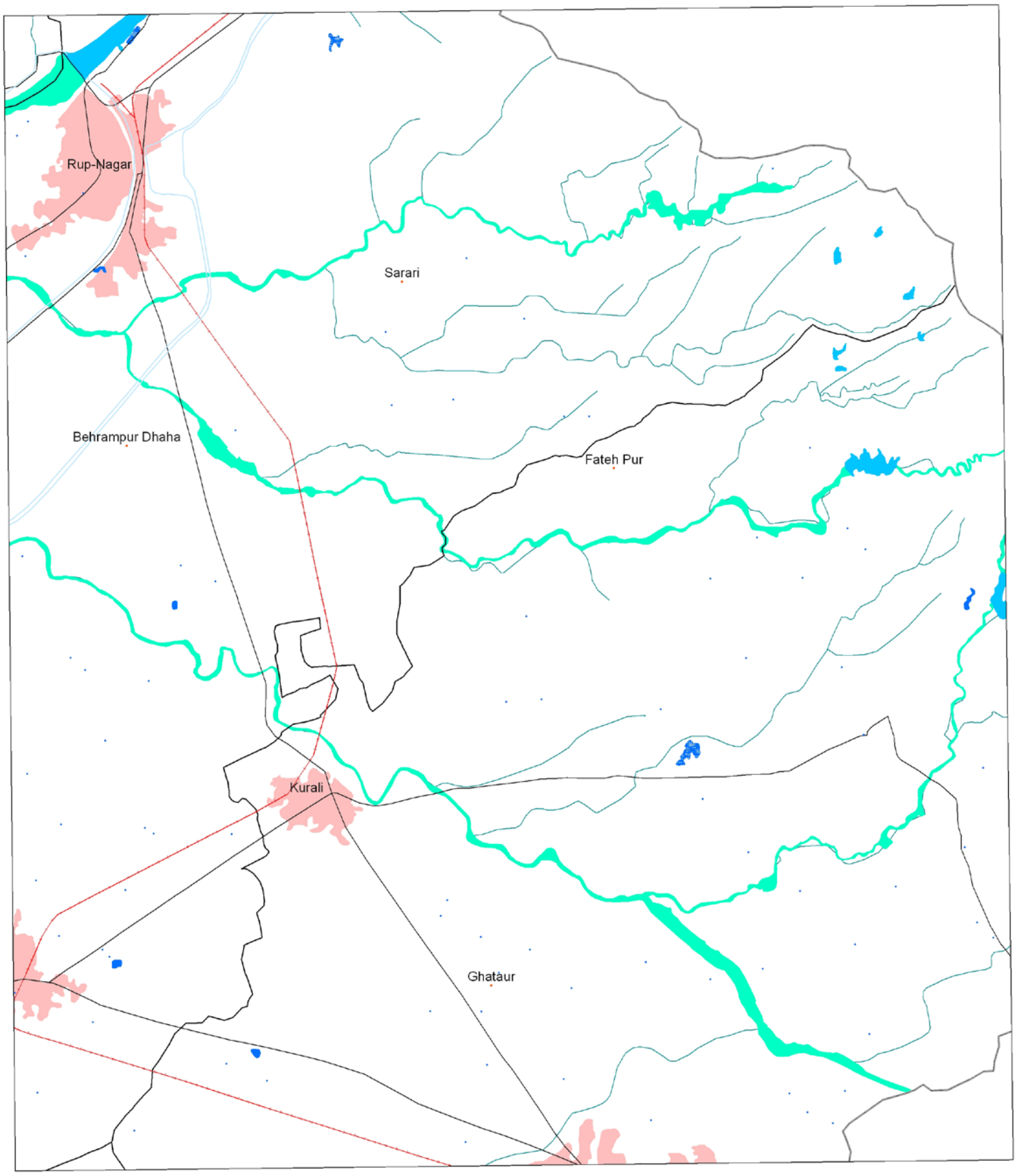
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Punjab

WETLAND MAP

SHEET NO. : 53B/09



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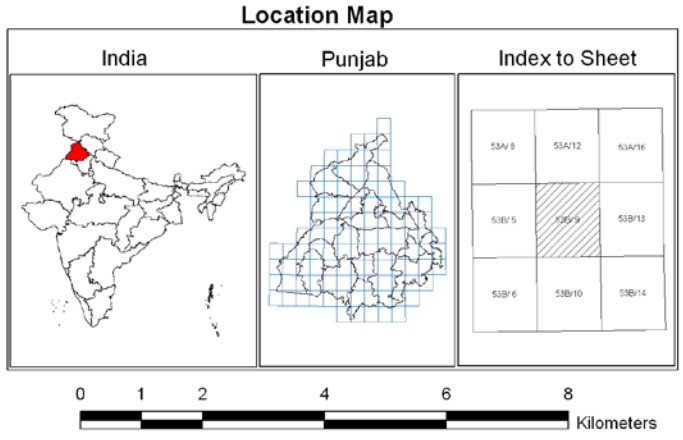

Data Source :

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

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Sponsored By:

Ministry of Environment and Forests
Government of India

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Annexure I
Definitions of wetland categories used in the project

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

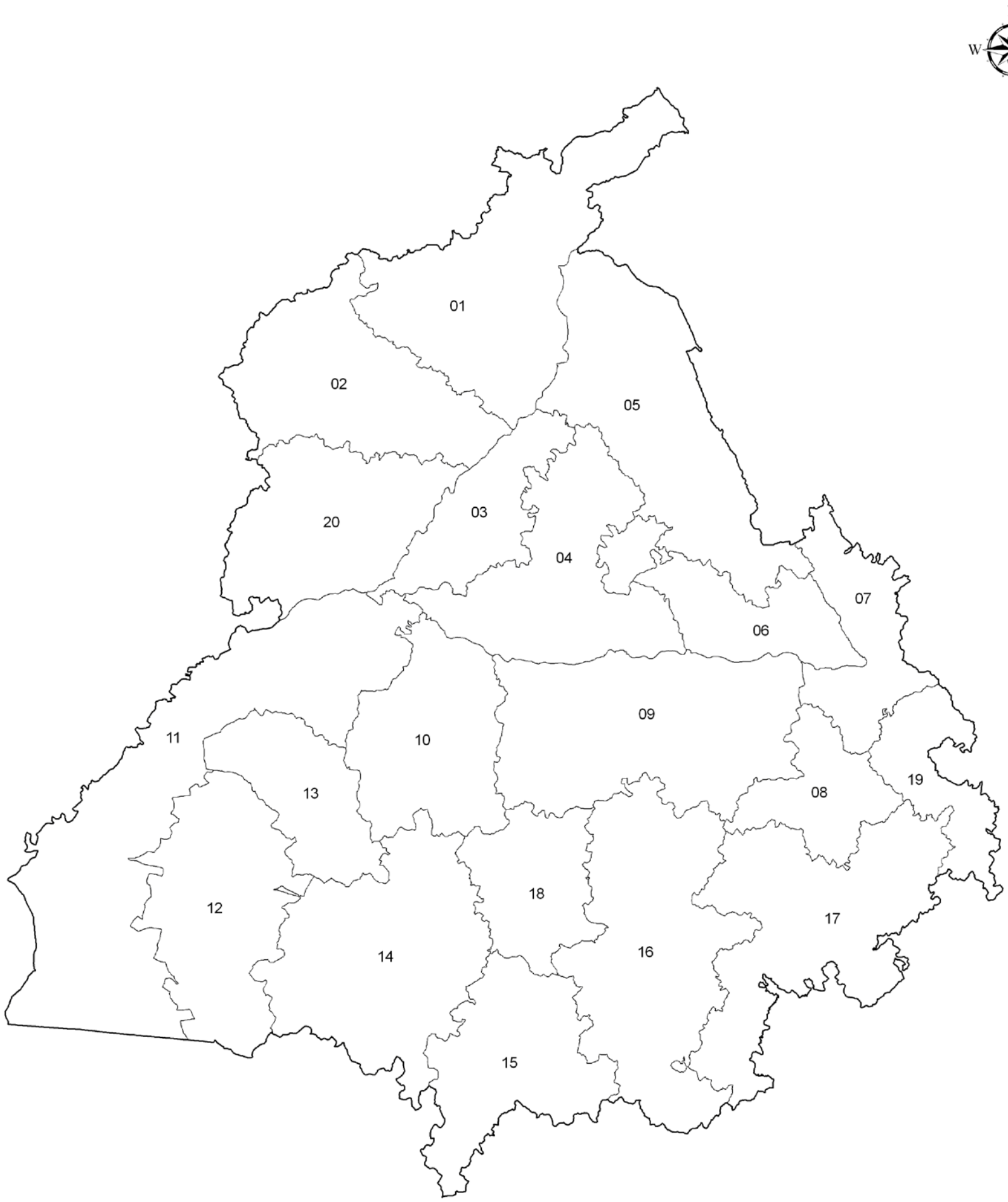
Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different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

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

Annexure – II
Details of District information followed in the atlas

State : Punjab

District Boundary Map



List of Districts

District code	District Name
1	Gurdaspur
2	Amritsar
3	Kapurthala
4	Jalandhar
5	Hoshiarpur
6	Nawanshahr
7	Rupnagar
8	Fatehgarh Sahib
9	Ludhiana
10	Moga

District code	District Name
11	Firozpur
12	Muktsar
13	Faridkot
14	Bathinda
15	Mansa
16	Sangrur
17	Patiala
18	Barnala
19	Sas Nagar(mohali)
20	Tarn Taran

Legend

State Boundary

District Boundary

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

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

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

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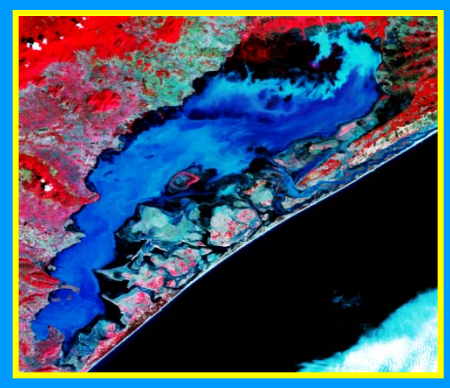

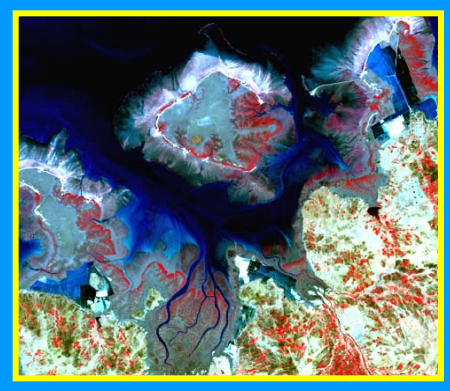

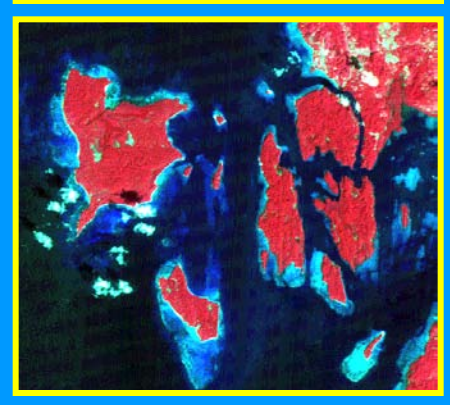

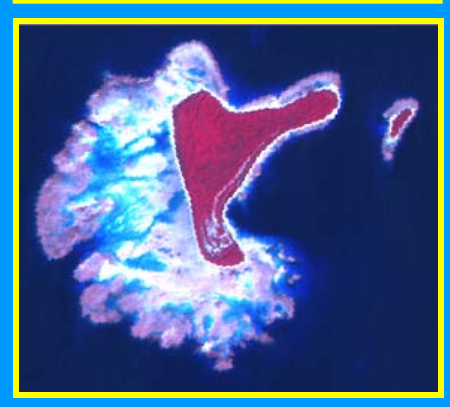

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