NATIONAL WETLAND ATLAS:

HIMACHAL PRADESH

Sponsored by

Ministry of Environment and Forests

Government of India

Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015

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

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

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

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

Space Applications Centre (ISRO), Ahmedabad

and

HP Remote Sensing Cell

State Council for Science, Technology & Environment, Shimla

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MESSAGE

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

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

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

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

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

(Jairam Ramesh)

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FOREWORD

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

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

January 25, 2010

(Ranganath R. Navalgund)

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This project has benefited from the wisdom of many people**.** It is a pleasure to acknowledge the contributions made by the wetland experts especially to Prof. C.K. Varshney, Former Dean, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, Prof. A.R. Yousuf, The University of Kashmir, Srinagar, Prof. Pradeeep Shrivastava, Head, Wetland Research Centre, Barakatullah University, Bhopal, Dr. Prikshit Gautam, Director, WWF-India, Dr. S. Narendra Prasad, Salim Ali Centre for Ornithology and Nature, 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 Himachal Pradesh, which is part of the National Wetland Atlas of India, is an attempt in this direction.

1.1 Wetlands

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

Provisioning services:	The resources or products provided by ecosystems, such as food, raw materials (wood), genetic resources, medicinal resources, ornamental resources (skin, shells, flowers).
Regulating services:	Ecosystems maintain the essential ecological processes and life support systems, like gas and climate regulation, water supply and regulation, waste treatment, pollination, etc.
Cultural and Amenity services:	Ecosystems are a source of inspiration to human culture and education throughout recreation, cultural, artistic, spiritual and historic information, Science and education.
Supporting services:	Ecosystems provide habitat for flora and fauna in order to maintain biological and genetic diversity.

Despite these benefits, wetlands are the first target of human interference and are among the most threatened of all natural resources. Around 50% of the earth's 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 include 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.

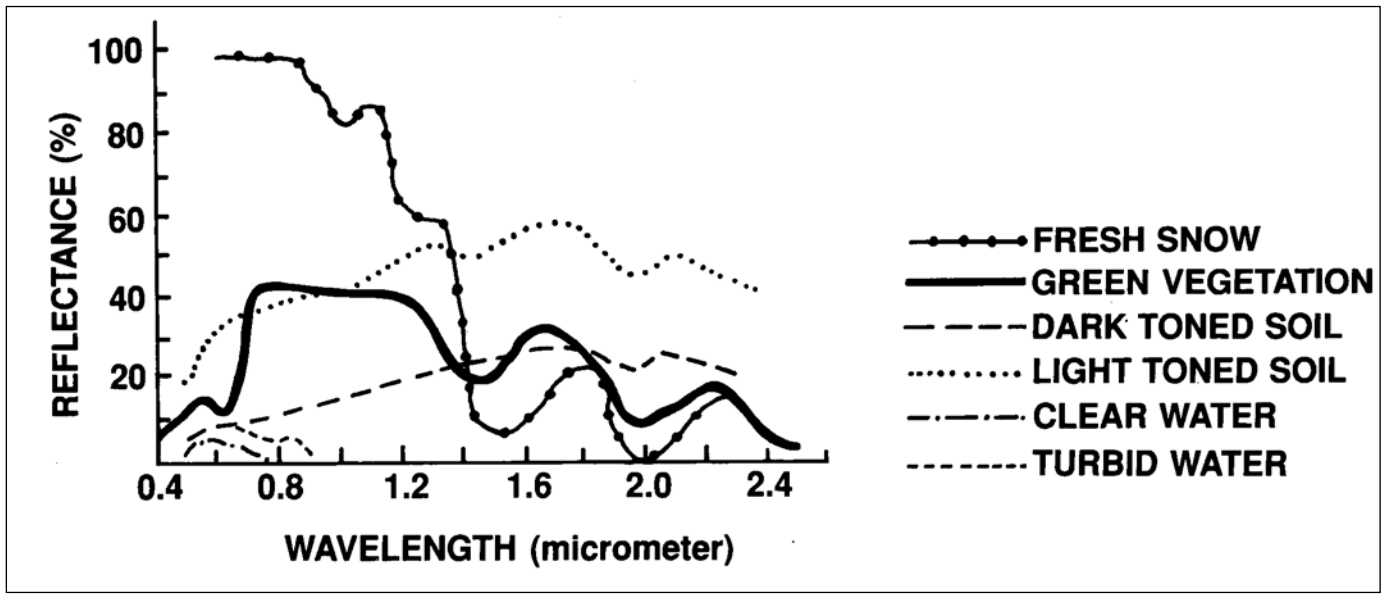
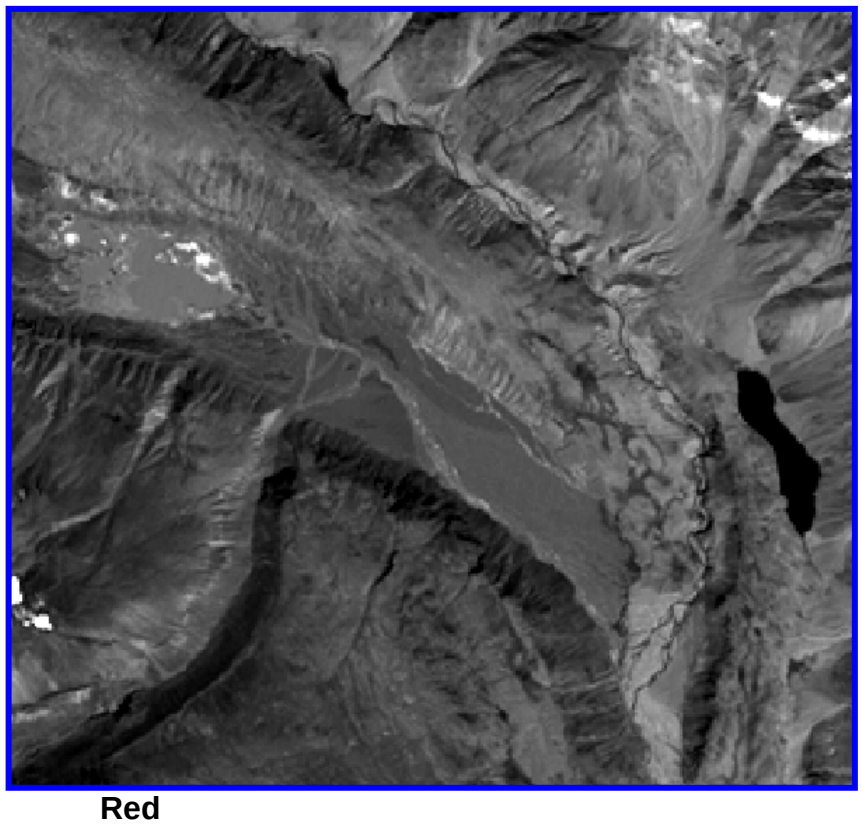
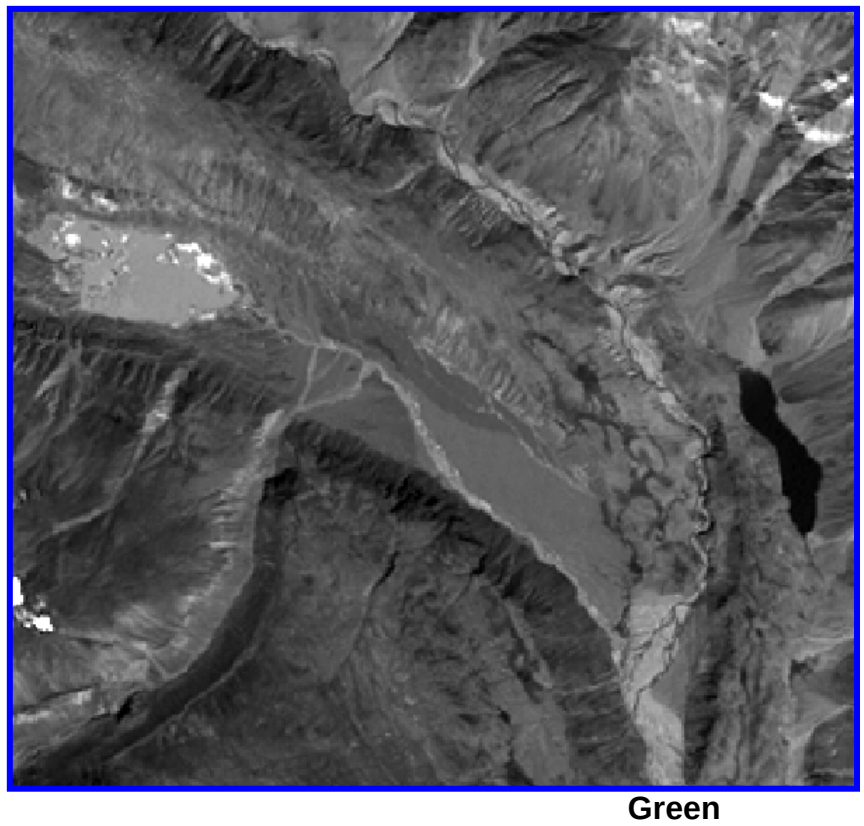


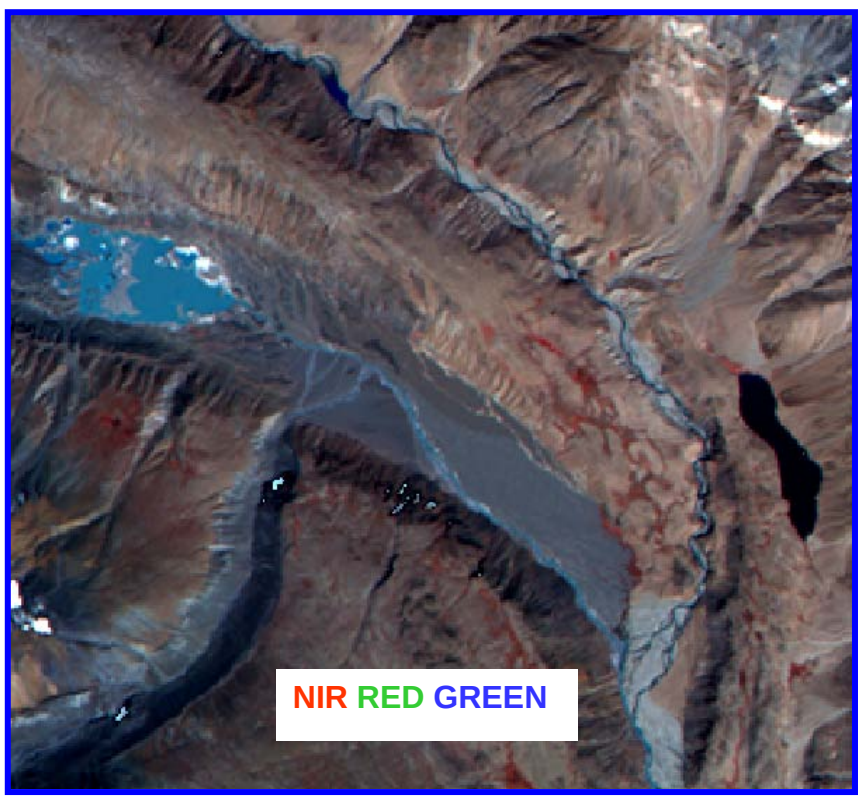
Figure 1: Spectral Signature of various targets

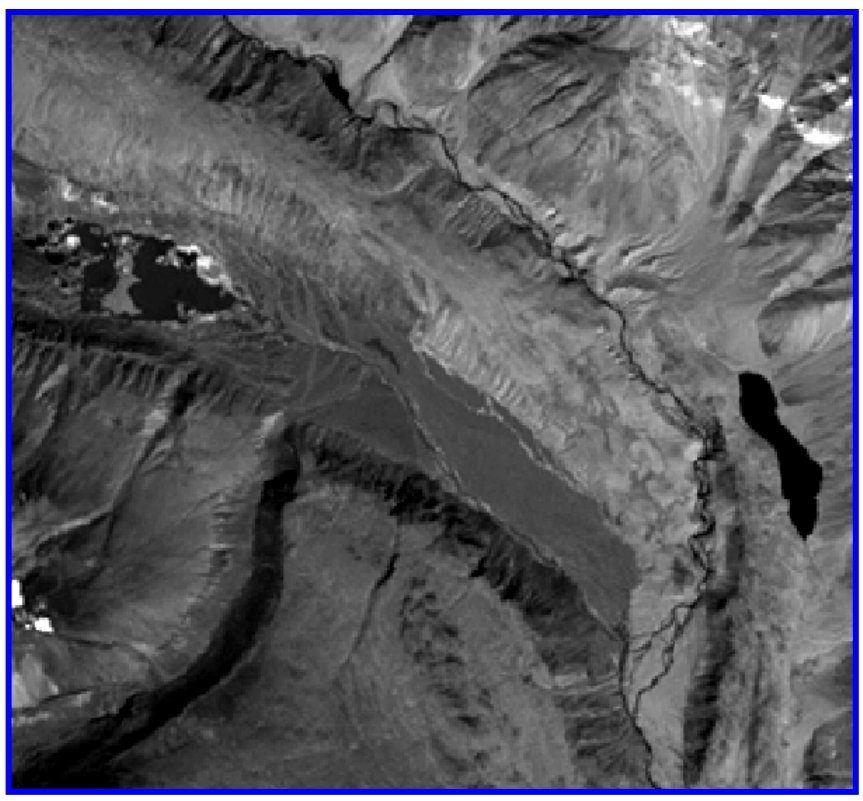


Red

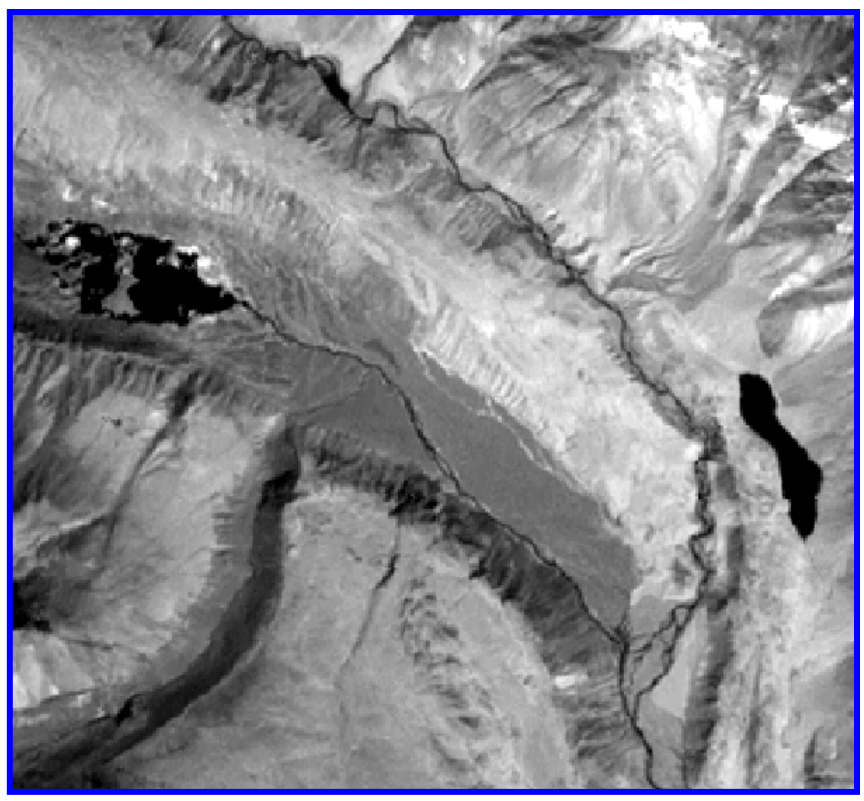


Green





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 database and deals with the state of Himachal Pradesh.

2.1 Wetland Classification System

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

2.2 Spatial Framework and GIS Database

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

Following wetland layers are generated for each inland wetland:

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

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

- Aquatic vegetation spread: The presence of vegetation in wetlands provides information about its trophic condition. As is known, aquatic vegetation is of four types, viz. benthic, submerged, floating and emergent. It is possible to delineate last two types of vegetation using optical remote sensing data.

A qualitative layer pertaining to presence of vegetation is generated for each season (as manifested on pre-monsoon and post-monsoon imagery).

- Turbidity of open water: A layer pertaining to a qualitative turbidity rating is generated. Three qualitative turbidity ratings (low, medium and high) is followed for pre- and post-monsoon turbidity of lakes, reservoirs, barrages and other large wetlands.

- Small wetlands (smaller than minimum mappable unit: < 2.25 ha) are mapped as point features.

- Base layers like major road network, railway, settlements, and surface drainage are created (either from the current image or taken from other project data base).

Table 1: Wetland Classification System and coding

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

* Wetland type code

3.0 STUDY AREA

The state of Himachal Pradesh has an area of 55,673 km². Its borders touch Uttar Pradesh, Haryana, Punjab, Jammu & Kashmir, and Tibet. It is a mountainous region known for its pristine natural beauty that includes gurgling streams, conifer-clad slopes and snowbound peaks that seem to reach up to the skies. The state of Himachal Pradesh is divided into the following 12 administrative districts Bilaspur, Chamba, Hamirpur, Kangra, Kinnaur, Kullu, Lahul & Spiti, Mandi, Shimla, Sirmaur, Solan and Una . The state capital is at Shimla. The location map of Himachal Pradesh is shown in Figure 3.

Himachal Pradesh has the distinction of being the home of some great rivers, which flow down to other states and some even go to Pakistan. The five rivers Sutlej, Ravi, Chenab, Jhelum, and Bias may only give Punjab its name, the land of the five waters but they all originate in Himachal Pradesh.

The state is mountainous in nature and the perennial white snowline on the Himalayas is a prominent physiographic feature of the state. It has many cool and beautiful places, rivers and rivulets, lakes, parks, meadows, pasturelands and terraces, often clinging precariously to the mountainsides.

There is general increase in elevation from west to east and from south to north. The state may be divided into four major physiographic divisions (from south to north), 1. Outer Himalaya, 2. Lower or Lesser Himalaya, 3. Main or Central Himalaya and 4. Trans-Himalaya. The average elevation is 600 mts with southern slopes that usually gently dip into longitudinal valleys known as the duns. Dunes are longitudinal valleys occurs in Siwaliks and lower Himalayan ranges. This physiographic division occupies the central part of Himachal Pradesh and it consists of important ridges such as Mussoori, Shimla, Pir Panjal, and Dhauladhar ridge.

Some of the principal minerals, which occur in the state, are barite, limestone, gypsum, rock salt and some minor minerals. Limestone is available in abundance in many districts and it is the basic source for cement industry. Himachal Pradesh is the only state where rock salt is mined.

Himachal Pradesh has diverse climatic conditions due to altitudinal variations. These variations range from 400 mts in the southern tract to over 6400 mts in the main Himalaya. The two main climatic characteristics of the region are the seasonal system of weather and the vertical zoning. The climatic conditions vary from hot and sub-humid tropical in the southern low tracts to temperate, cold alpine and glacial in the northern and eastern high mountains.

The distribution of vegetation varies based on altitudinal variations and it is broadly divided into four classes viz. Alpine (over 4100 mts), Sub-alpine (3600-4100), Temperate (1650 mts) and Tropical and sub-tropical (up to 1650 mts).

The spatial framework of Himachal Pradesh was prepared using 15’ x 15’ grid. The state is covered by 116 Survey of India topographic maps on 1:50,000 scale that form the spatial frame work for mapping (Figure 4).

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

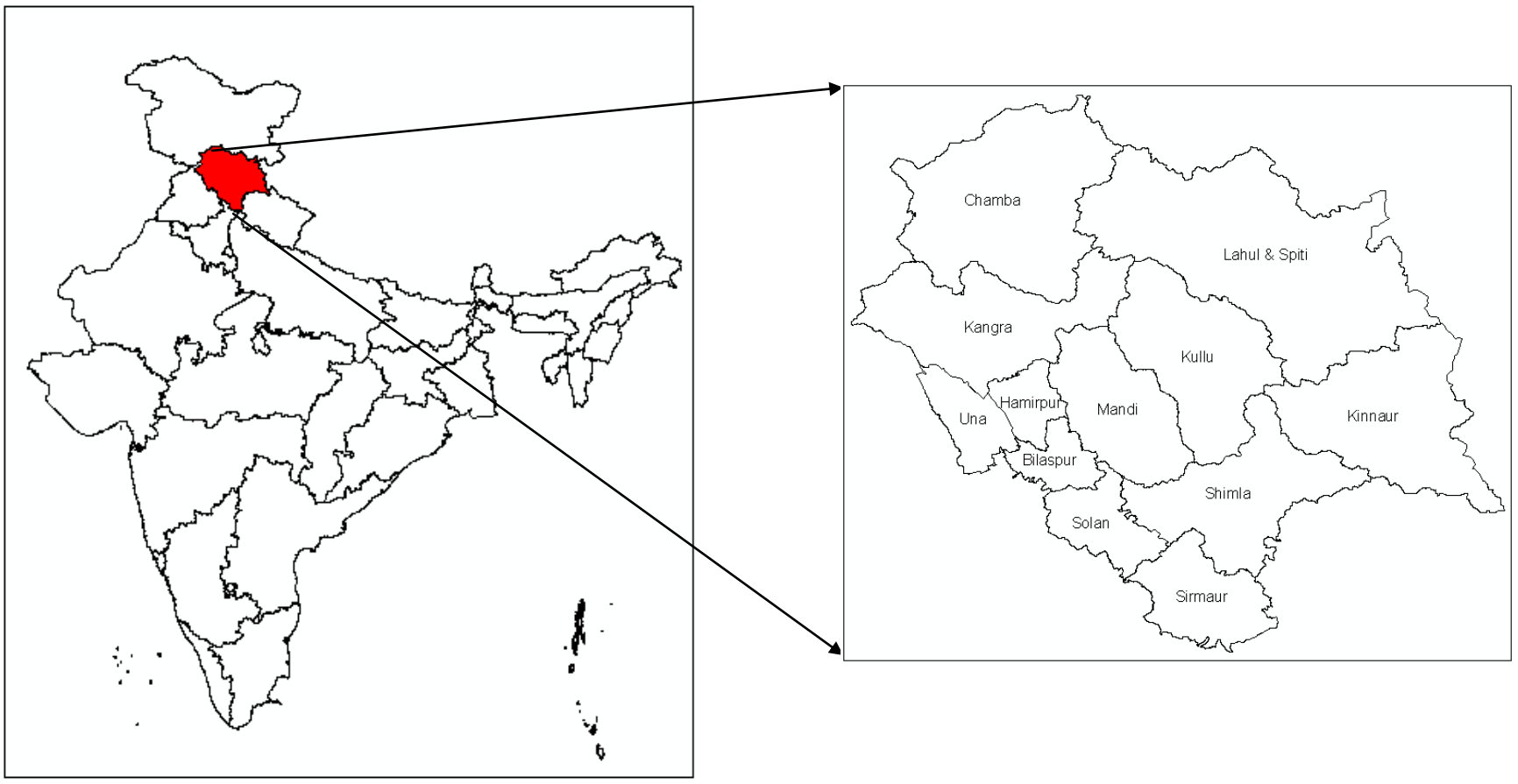


Figure 3: Location Map

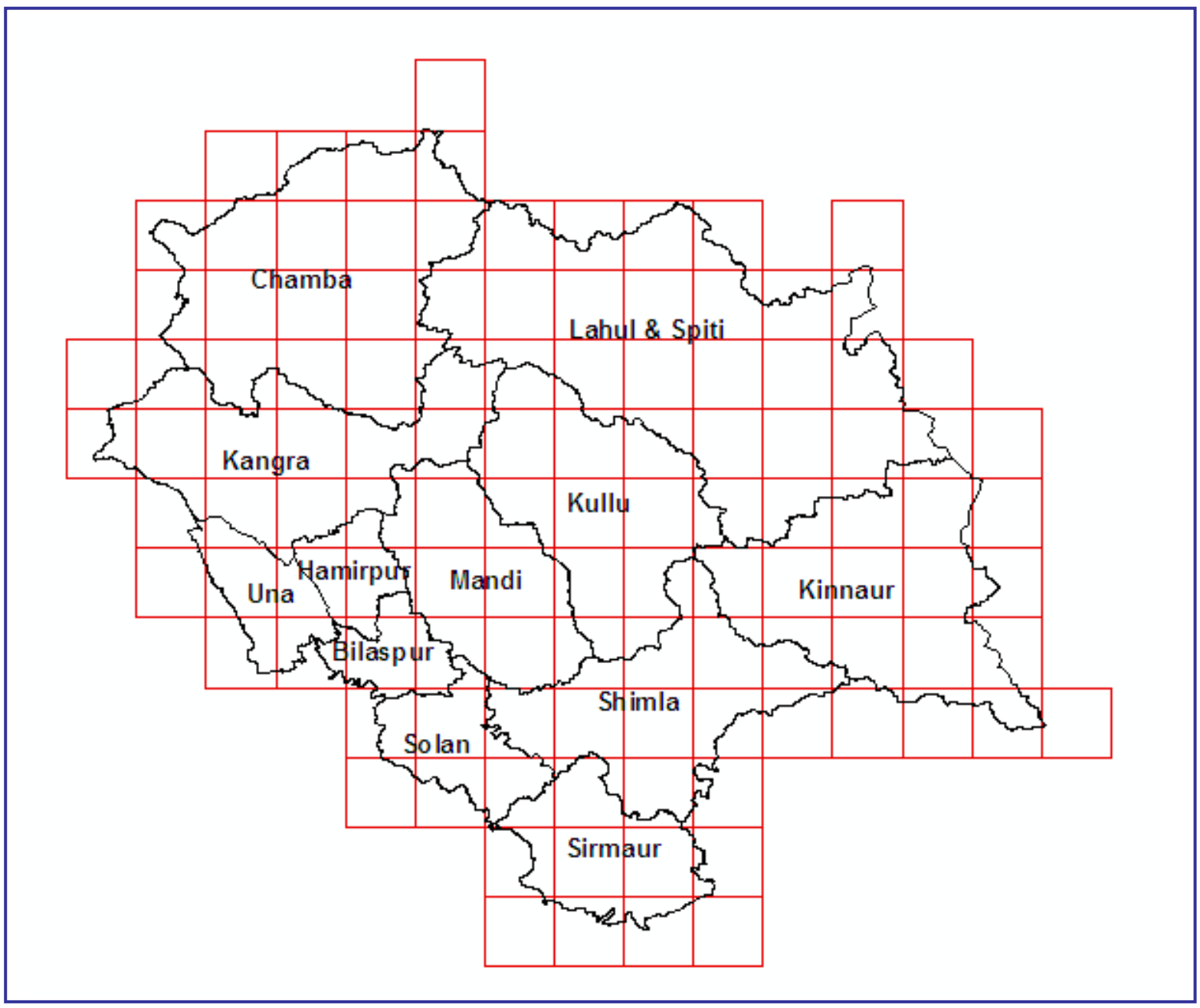


Figure 4: Spatial Framework of Himachal Pradesh

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 Himachal Pradesh is covered in 11 IRS-LISS-III scenes (Figure 5).

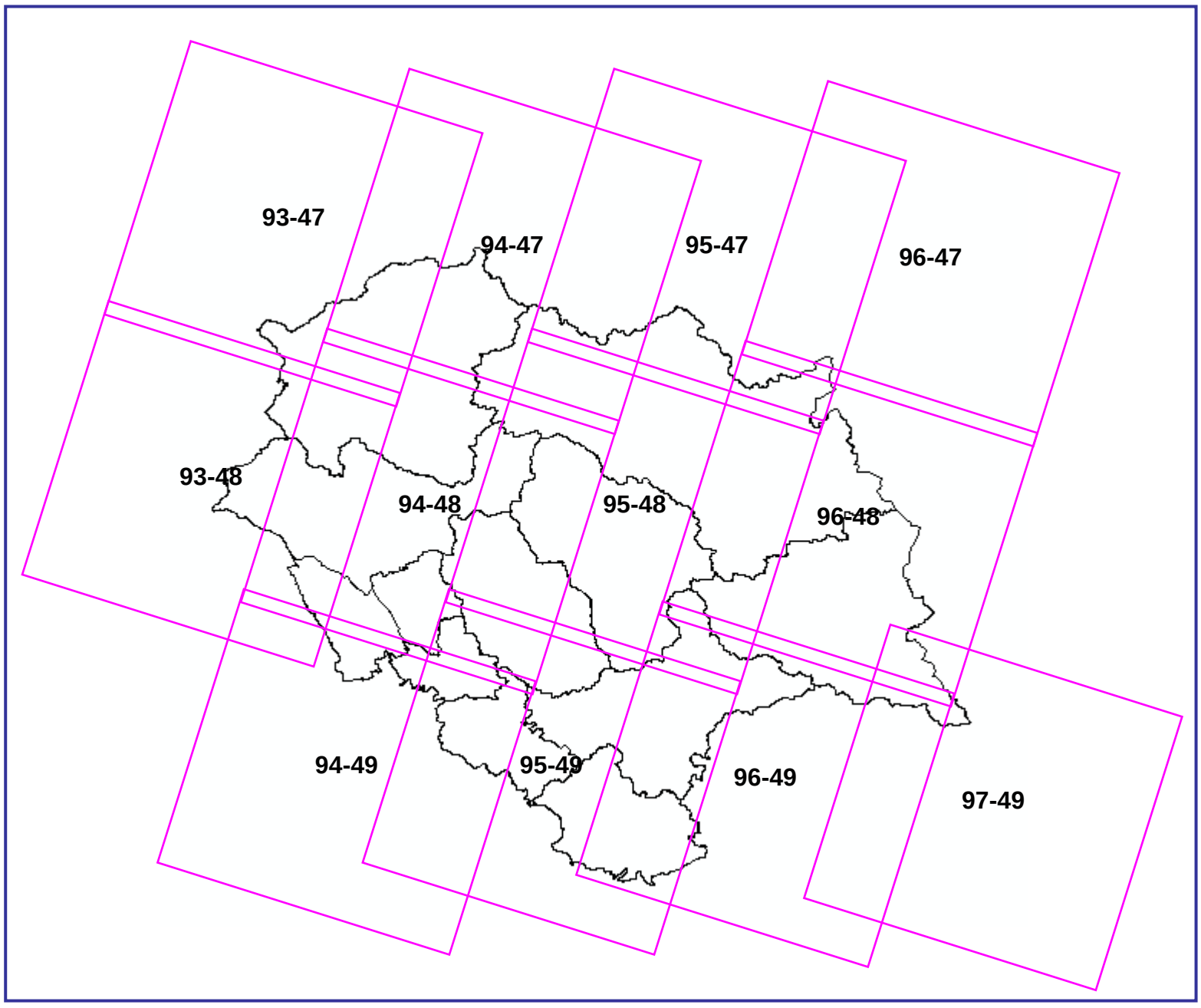


Figure 5: IRS P6 LISS-III coverage (path-row) of Himachal Pradesh

Two date data, one acquired during April-May and another during Oct-Dec 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 Himachal Pradesh as seen in the LISS III FCC of post-monsoon pre-monsoon data respectively.

Table-2: Satellite data used

Sr. No.	Path-Raw	Date of Acquisition	
		Post-monsoon	Pre-monsoon
1	93-47	Dec 30, 2006	Apr 29, 2007
2	93-48	Oct 19, 2007	May 23, 2007
3	94-47	Oct 24, 2006	Apr 10, 2007
4	94-48	Oct 24, 2006	Apr 10, 2006
5	94-49	Oct 5, 2006	May 9, 2007
6	95-47	Oct 24, 2006	Apr 10, 2007
7	95-48	Oct 5, 2006	May 9, 2007
8	95-49	Oct 5, 2006	May 9, 2007
9	96-48	Nov 03, 2006	June 7, 2007
10	96-49	Oct 5, 2006	May 9, 2007
11	97-49	Oct 15, 2006	Apr 1, 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

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

5.0 METHODOLOGY

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

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

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

5.1 Creation of Spatial Framework

This is the most important task as the state forms a part of the national frame work and 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 Himachal Pradesh state is shown in Figure 4.

5.2 Geo-referencing of Satellite Data

In this step the raw satellite images were converted to specific map projection using geometric correction. This is done using 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.

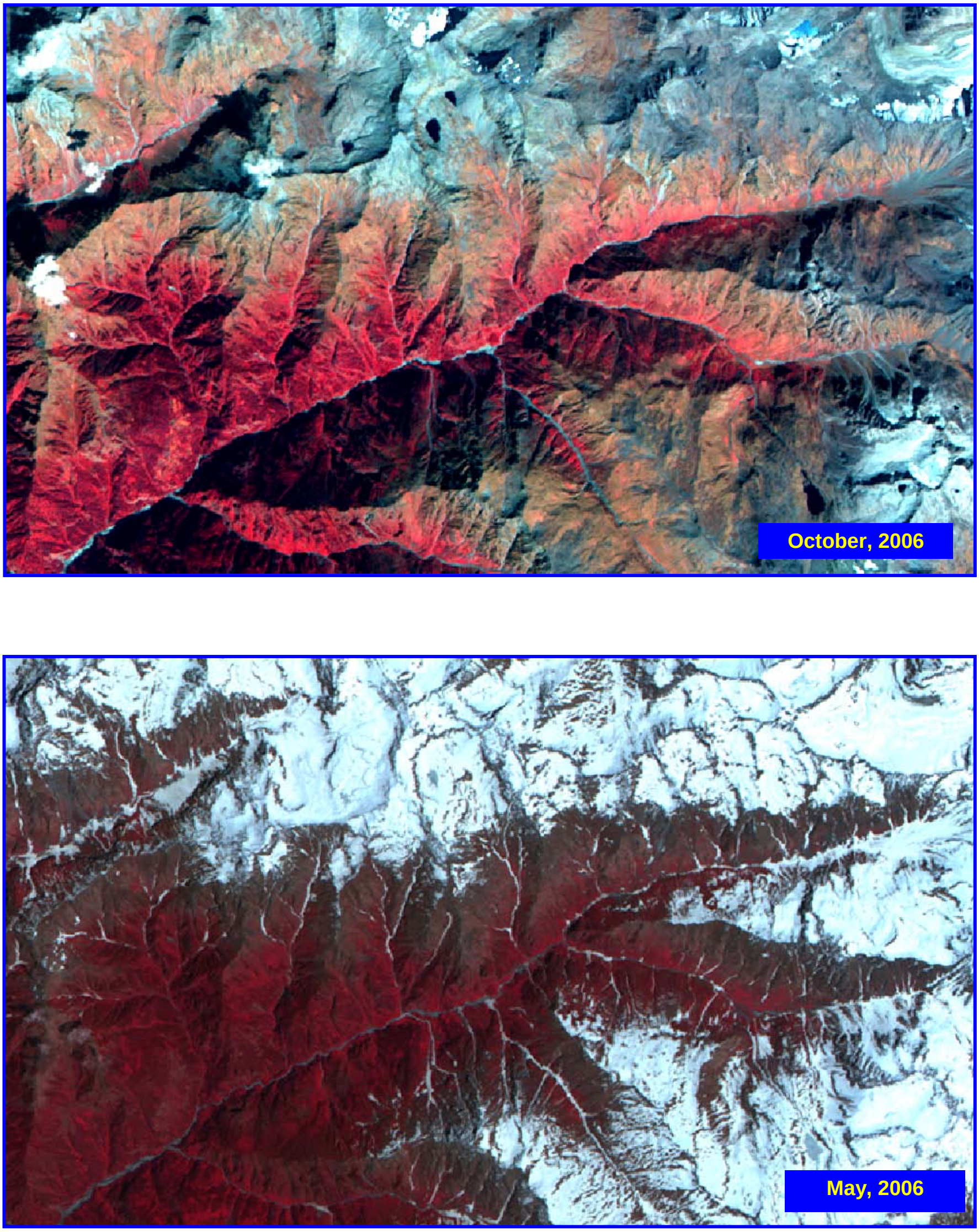


Figure 6: IRS LISS-III FCC (Post-monsoon and Pre-monsoon): Part of Himachal Pradesh state

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)

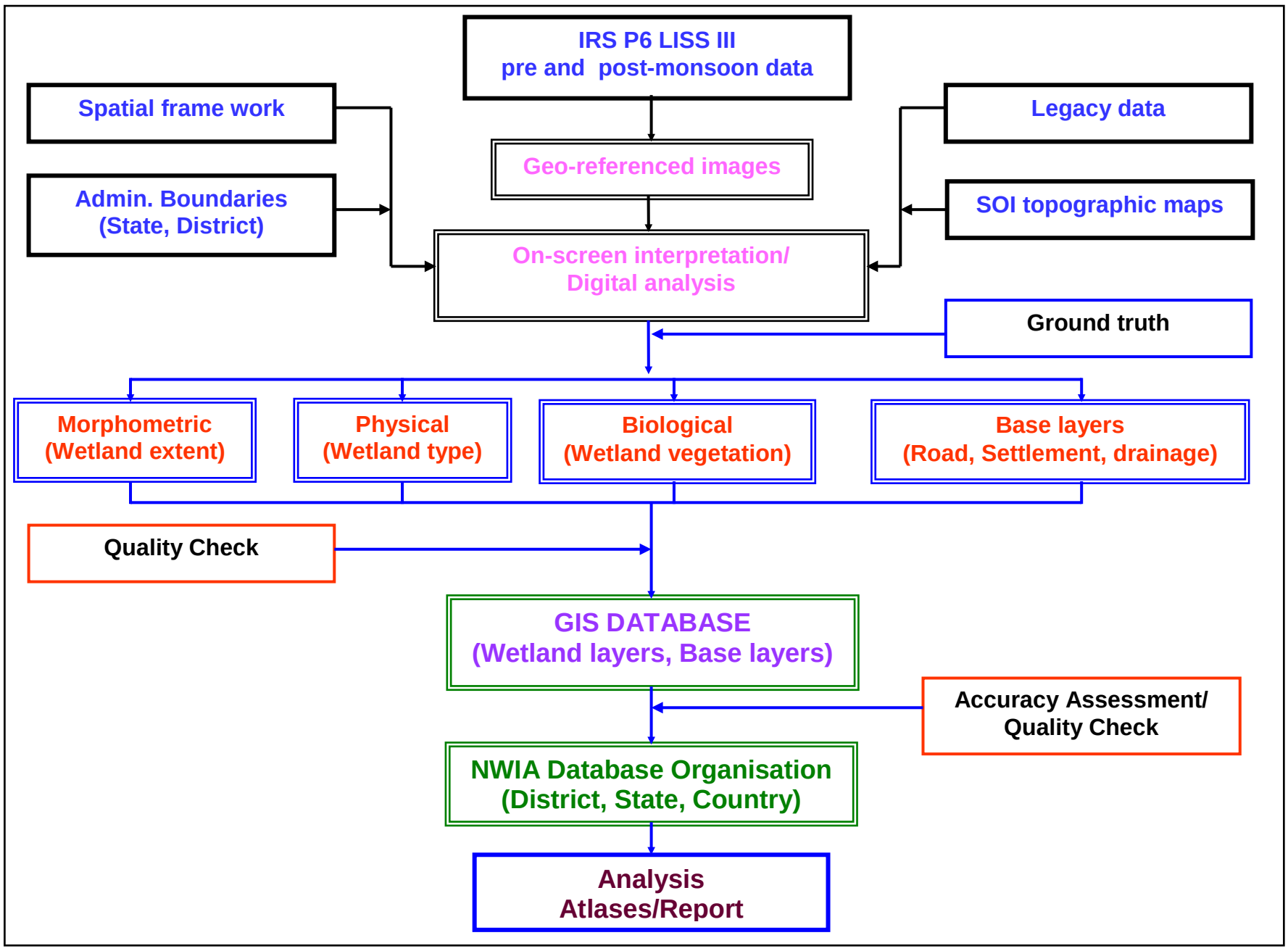


Figure 7: Flow chart of the methodology used

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

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

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

Table 3: Qualitative turbidity ratings

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

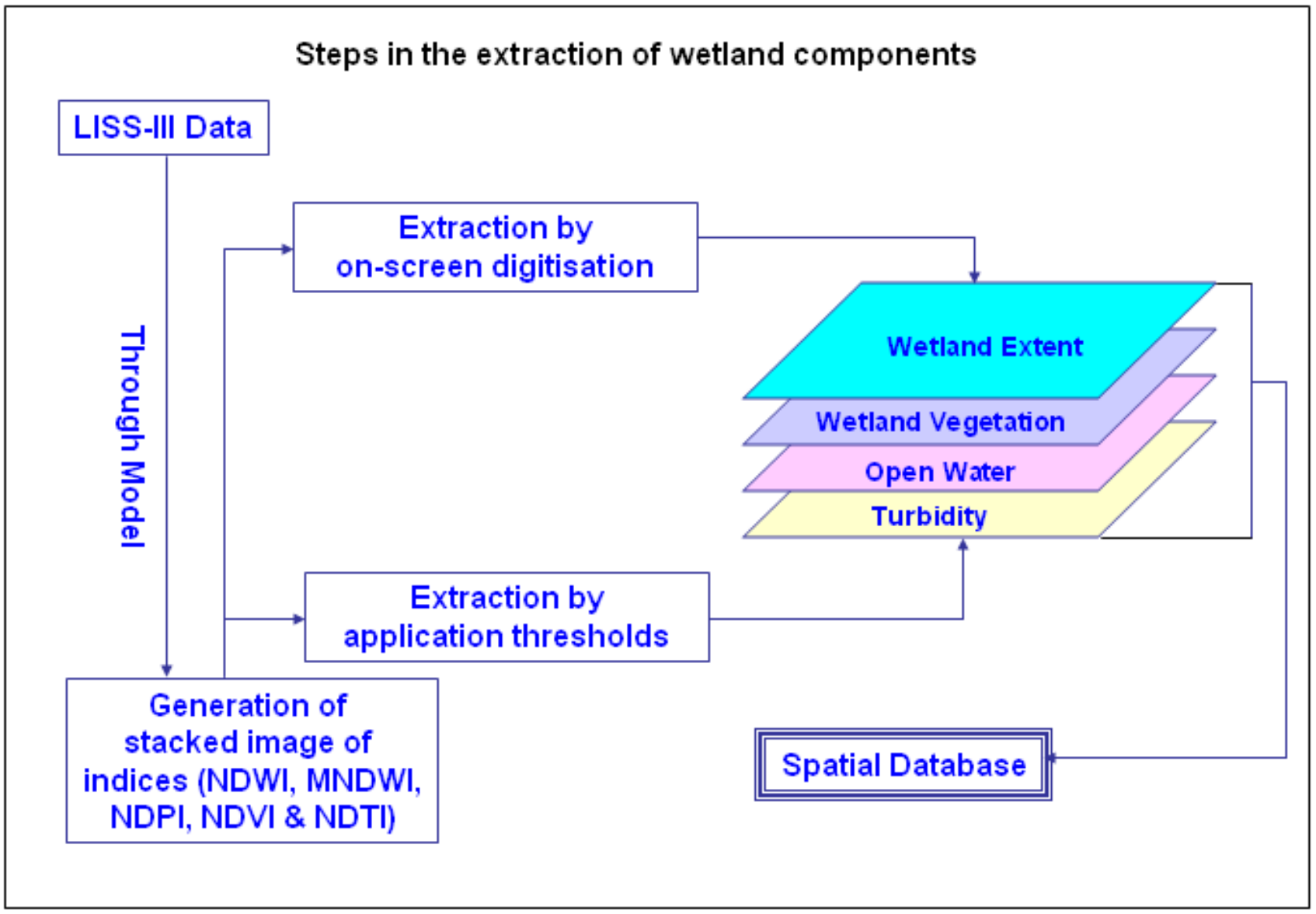


Figure 8: Steps in the extraction of wetland components

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 region 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

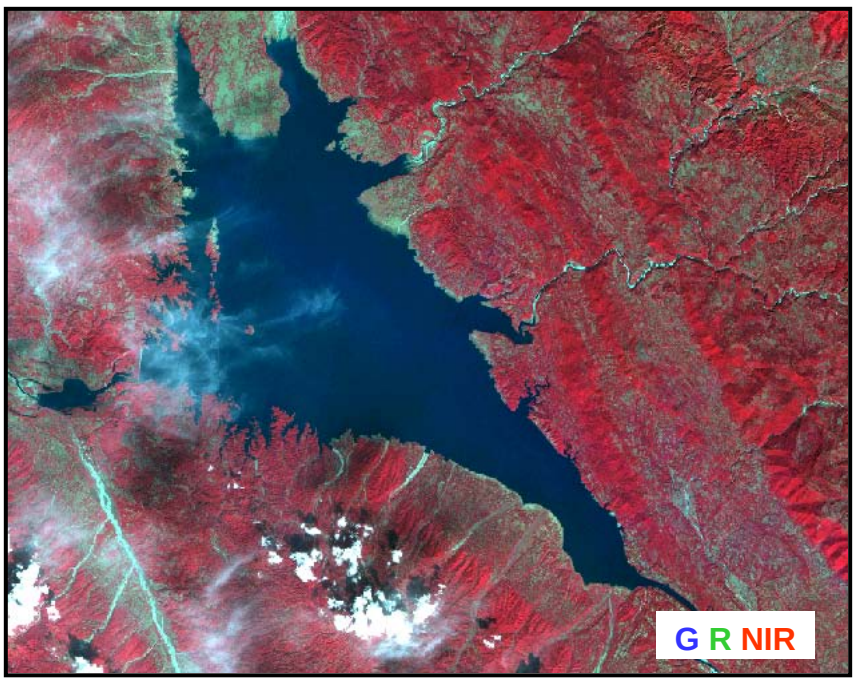
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as location accuracy. In addition, GIS database(s) contents have been also evaluated 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.

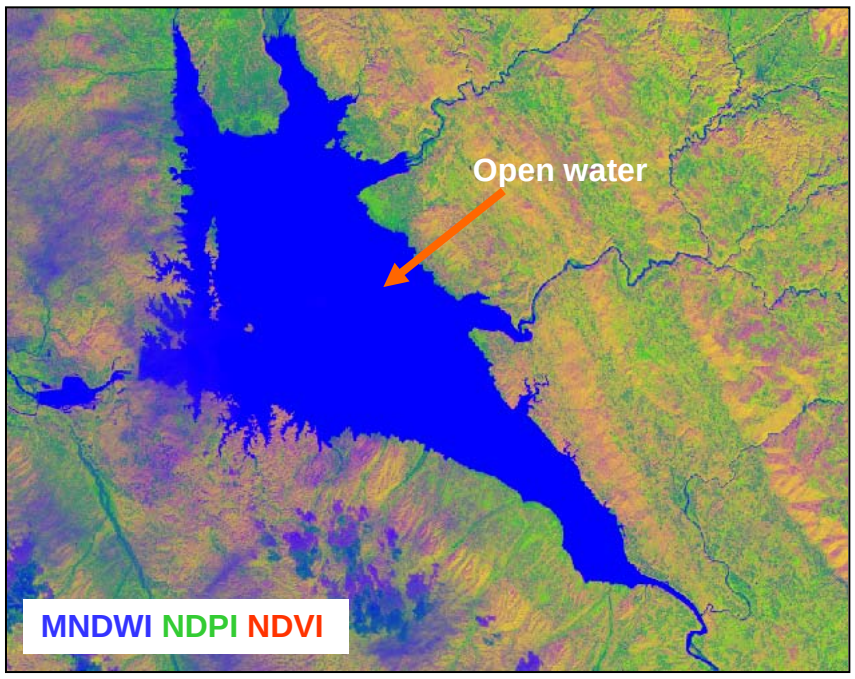
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imagery was reviewed by technical expert team for accuracy and code. The reviewing 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.

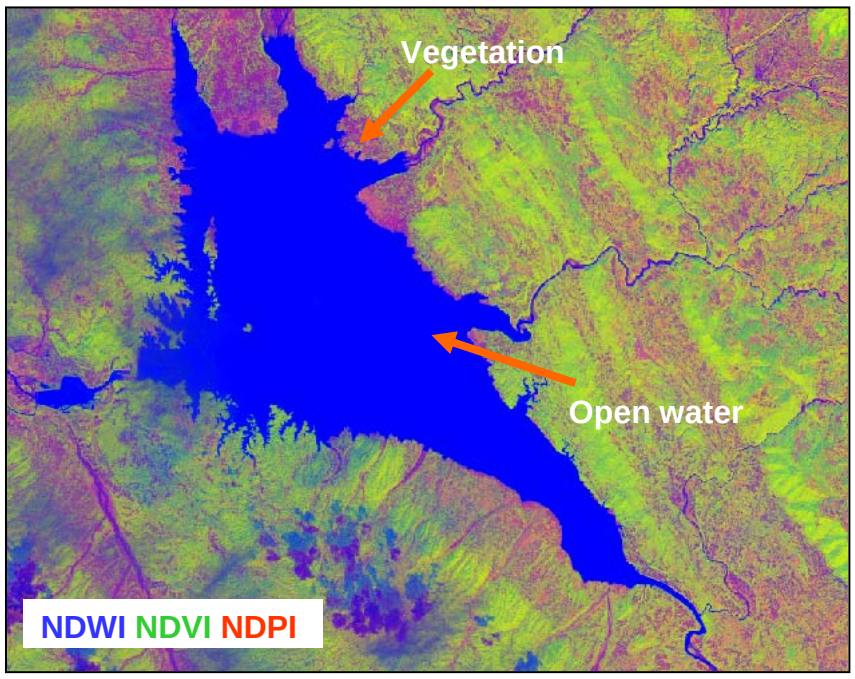
6.1 Data verification and quality assurance of output digital data files

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.

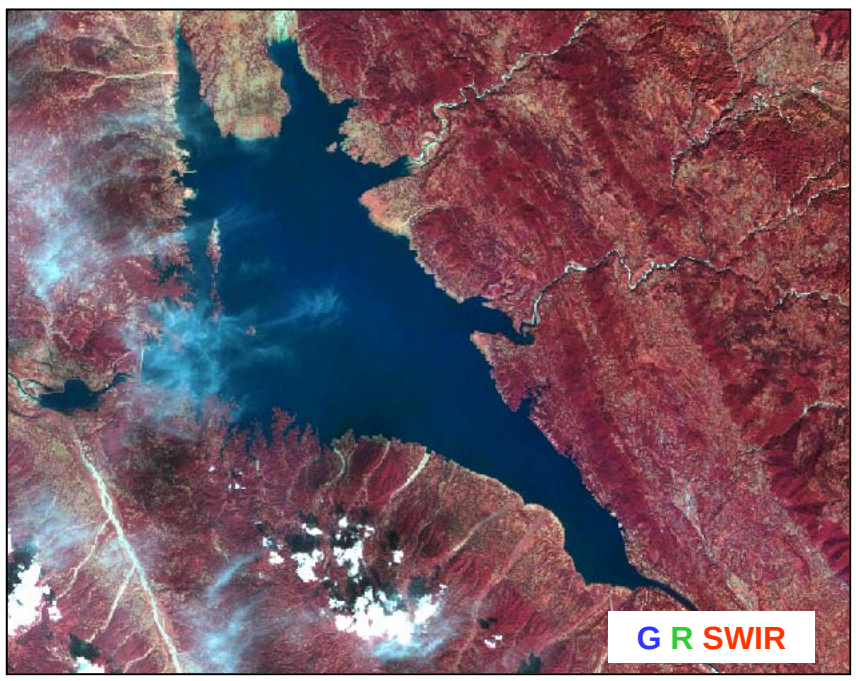


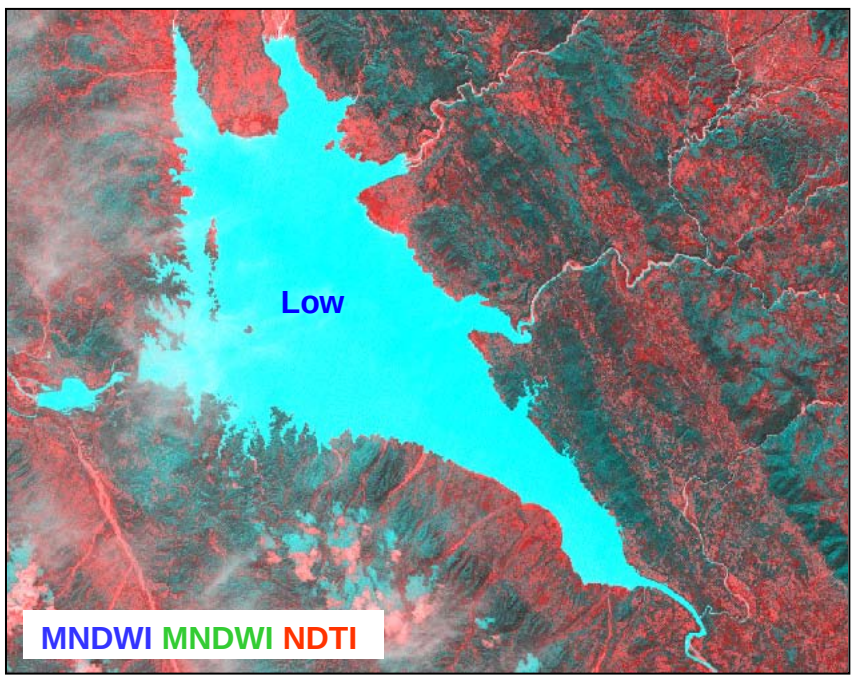


Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features





Useful for qualitative turbidity delineation

Part of Pong Dam Lake,
IRS LISS III data, October 2006

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

MAPS AND STATISTICS

7.0 WETLANDS OF HIMACHAL PRADESH: MAPS AND STATISTICS

Area estimates of various wetland categories for Himachal Pradesh have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total 170 wetlands have been mapped at 1:50,000 scale in the state. In addition, 471 small wetlands (< 2.25 ha) have also been identified. Total wetland area estimated is 98496 ha that is around 1.77 per cent of the geographic area (Table 4). The major wetland types are River/Stream (55558 ha). The major rivers are Sutlej, Ravi, Chenab, Jhelum and Bias.

There are 13 Reservoirs/Barrages with 41817 ha area. Total 42 high altitude lakes are mapped with 387 ha area. However, among the 471 small wetlands mapped as point feature, many are high altitude lakes. Chandratal is a famous high altitude lake of the state which is a popular tourist destination. The other wetlands are Tanks/ponds, Waterlogged and Lakes/ponds. Graphical distribution of wetland type is shown in Figure 10.

Aquatic vegetation is observed in Reservoirs/Barrages and Tanks/Ponds. The aquatic vegetation in wetlands was observed only during pre monsoon (5294 ha). The open water spread area is significantly lower during pre monsoon (49245 ha) compared to post monsoon (69107 ha). The qualitative turbidity of water is mainly low to moderate in both the seasons.

Table 4: Area estimates of wetlands in Himachal Pradesh

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	8	52	0.05	49	26
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	42	387	0.39	285	128
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	10	47	0.05	39	19
6	1106	River/Stream	67	55558	56.41	27153	17063
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	13	41817	42.46	41445	31966
8	1202	Tanks/Ponds	27	134	0.14	106	29
9	1203	Waterlogged	3	30	0.03	30	14
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**170**	**98025**	**99.52**	**69107**	**49245**
		Wetlands (<2.25 ha)	471	471	0.48	-	-
		Total	**641**	**98496**	**100.00**	**69107**	**49245**

Area under Aquatic Vegetation	-	5294

Area under turbidity levels		
Low	46870	33949
Moderate	22236	15296
High	-	-

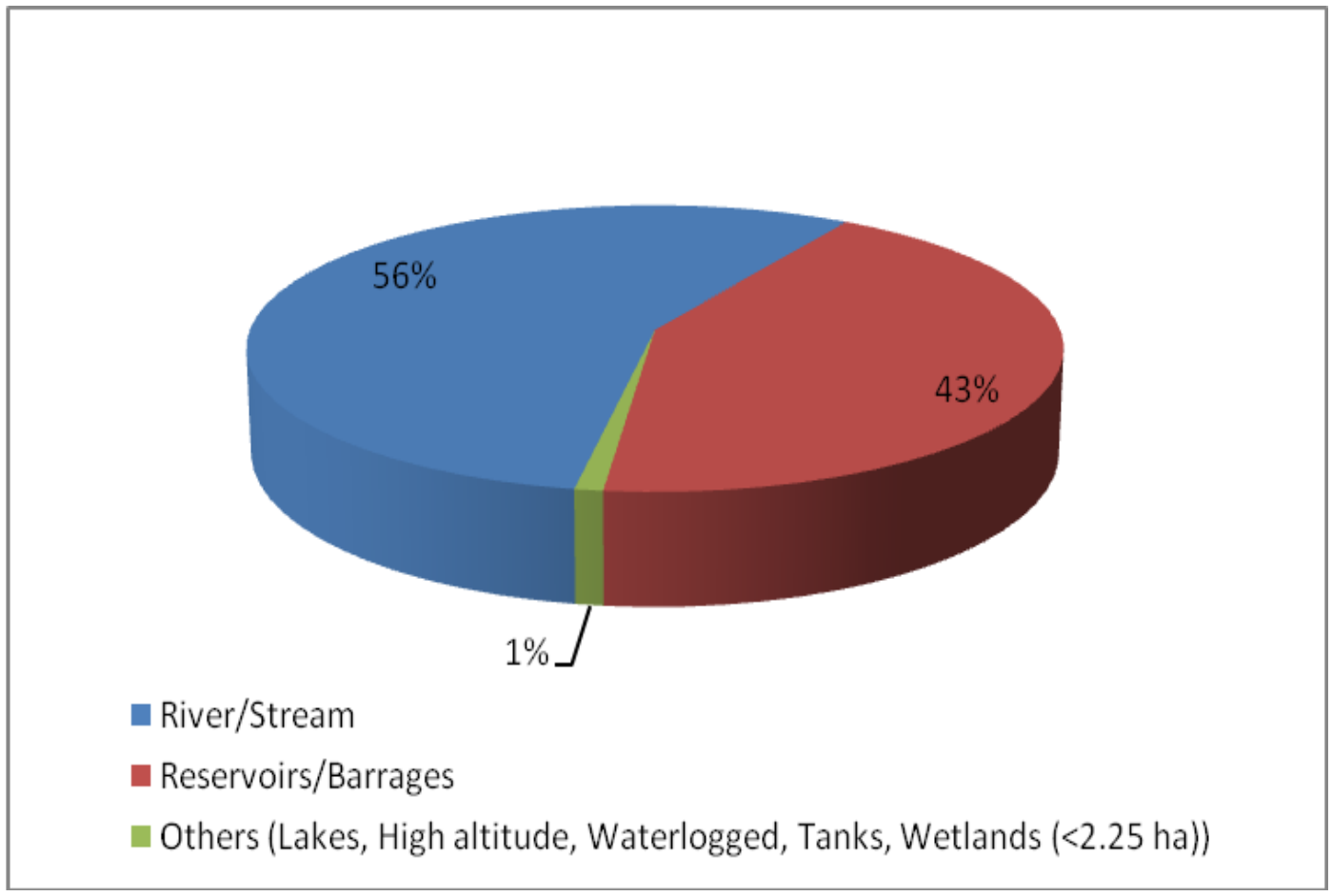


Figure 10: Type-wise wetland distribution in Himachal Pradesh

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

There are 12 districts in the state. The geographic area of the districts varies from 1118 sq.km (Hamirpur) to 13835 sq.km (Lahul and Spiti). The wetlands occupy as high as 10.63% of geographic area (Bilaspur district), and as low as 0.46% (Shimla). In terms of total wetland area (% wetland area), Kangra is the leading district (34605 ha, 35.13%) and Hamirpur is the least (2182 ha, 2.22 %). District-wise wetland area estimates is given in Table 5 and graphical distribution of wetlands is shown in Figure - 11. River/Stream and Reservoirs/Barrages are the dominate wetland types in almost all districts.

The following section gives the details of district wise wetland statistics and maps. The districts are arranged as per census serial number. 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	Bilaspur	1167	12407	12.60	10.63
2	Chamba	6528	4667	4.74	0.71
3	Hamirpur	1118	2182	2.22	1.95
4	Kangra	5739	34605	35.13	6.03
5	Kinnaur	6401	4990	5.07	0.78
6	Kullu	5503	2894	2.94	0.53
7	Lahul & Spiti	13835	10766	10.93	0.78
8	Mandi	3950	3704	3.76	0.94
9	Shimla	5131	2368	2.40	0.46
10	Sirmaur	2825	9990	10.14	3.54
11	Solan	1936	2720	2.76	1.40
12	Una	1540	7203	7.31	4.68
	Total	**55673**	**98496**	**100**	1.77

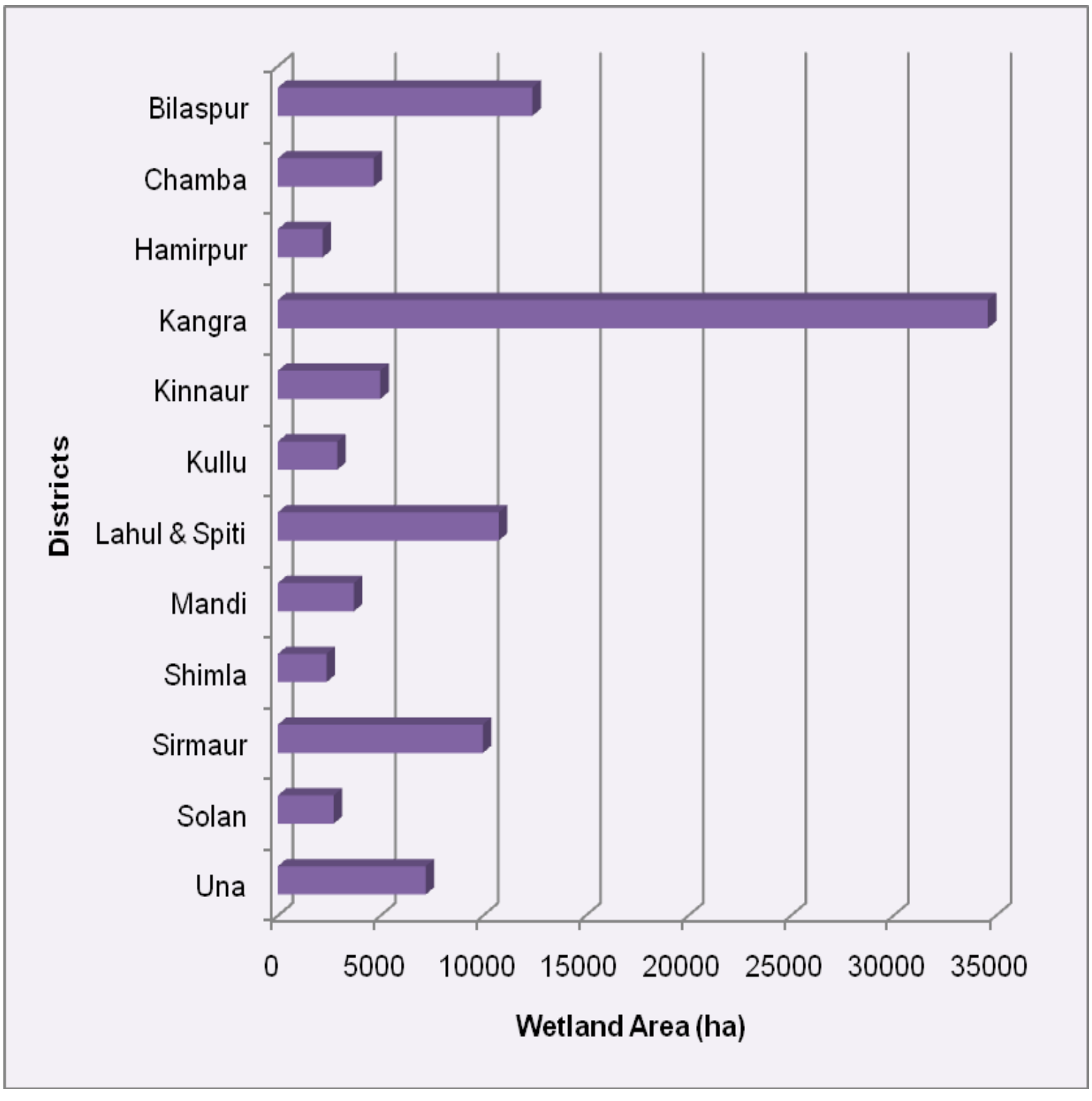
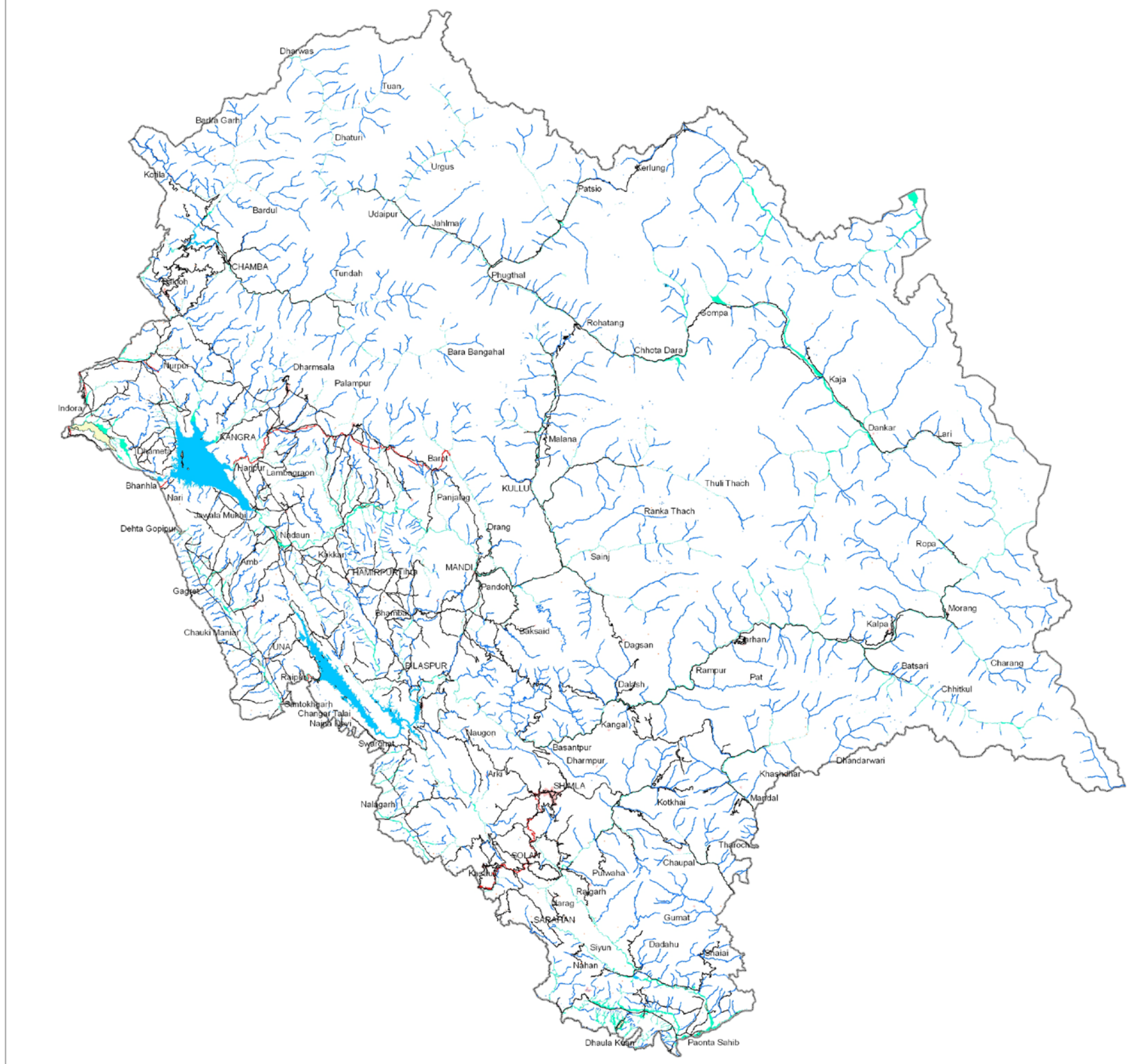


Figure 11: District-wise wetland distribution

State : Himachal Pradesh

WETLAND MAP

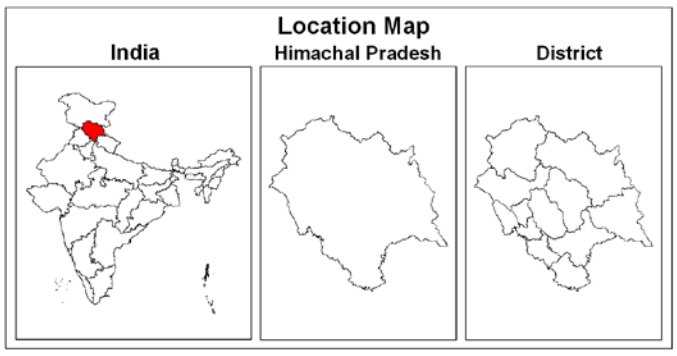


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



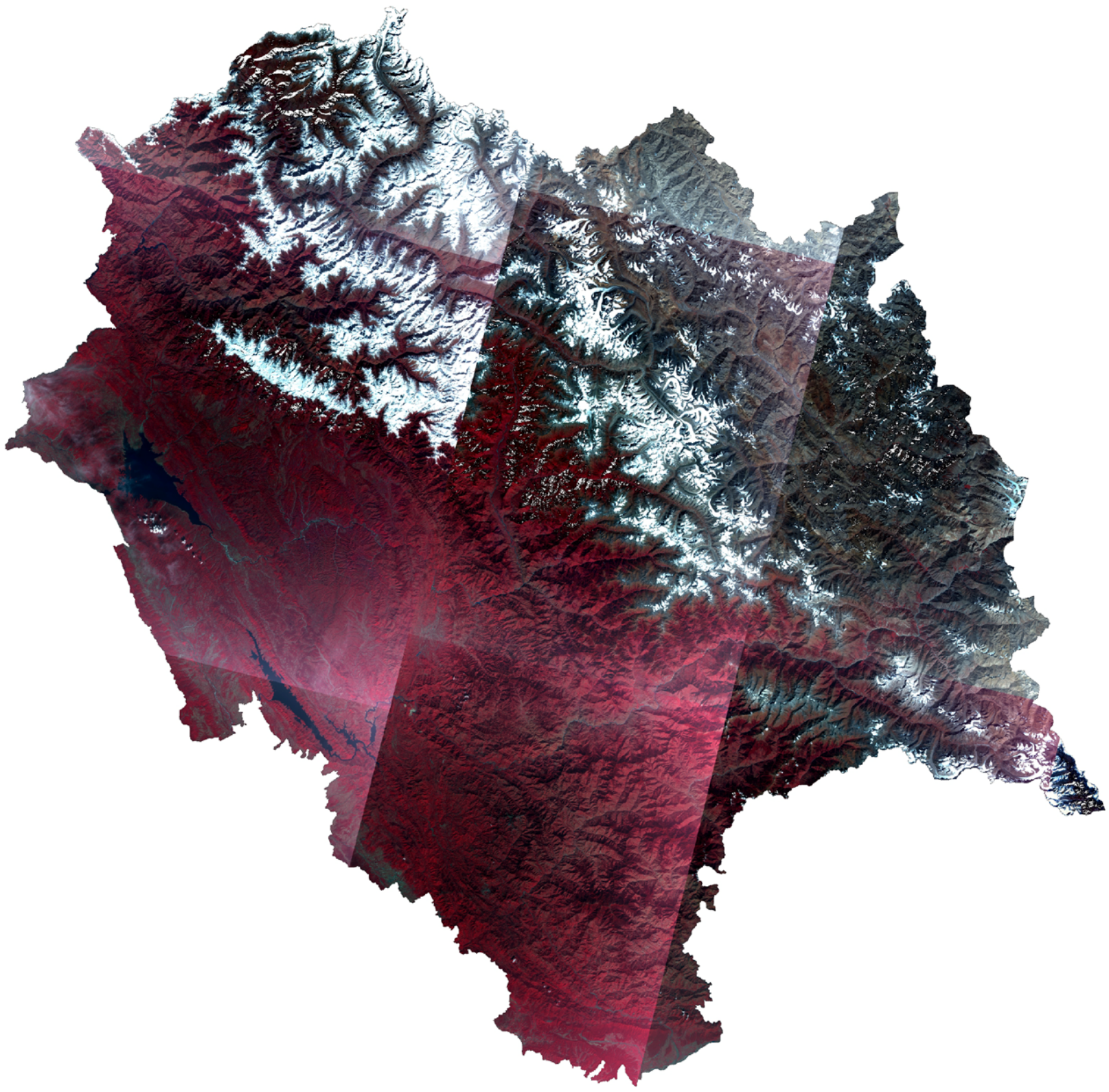
40 20 0 40 Kilometers

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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.1 Bilaspur

The Bilaspur district is predominantly situated in the Sutluj River basin. It lies between 31^0 12' 30'' and 31^0 35' 30'' North latitude and between 76^0 23' 45'' and 76^0 55' 40''East longitude. The area of the district is 1167 sq. km. It is located at an altitude of 610 meters above from mean sea level. Its boundaries touch Una, Hamirpur, Mandi and Solan districts. The temperature fluctuates from maximum 37^0 C to minimum 05^0 C. The principal river that passes through the district is the Sutlej River, which divides the district almost into two equal halves. Bhakra Dam is an important wetland of this district, which is the highest straight gravity dam of the world at the height of 740 fts.

Total wetland area in the district is 12407 ha that includes 33 small wetlands (<2.25 ha). Reservoir/Barrage occupies 89.39% of wetlands. River/Stream is the second large wetland type in the district accounted for 9.89%. Details of wetland statistics is given in Table 6.

The area under aquatic vegetation is 396 ha in pre monsoon. The open water spread of wetlands is significantly more in Post-monsoon (12257 ha) than in Pre-monsoon (8527 ha). The qualitative turbidity of water is low in both the seasons.

Table 6: Area estimates of wetlands in Bilaspur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	1	42	0.34	41	18
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	5	0.04	5	4
6	1106	River/Stream	9	1227	9.89	1112	901
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	4	11090	89.39	11089	7604
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	1	10	0.08	10	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**16**	**12374**	**99.73**	**12257**	**8527**
		Wetlands (<2.25 ha)	33	33	0.27	-	-
		Total	**49**	**12407**	**100.00**	**12257**	**8527**

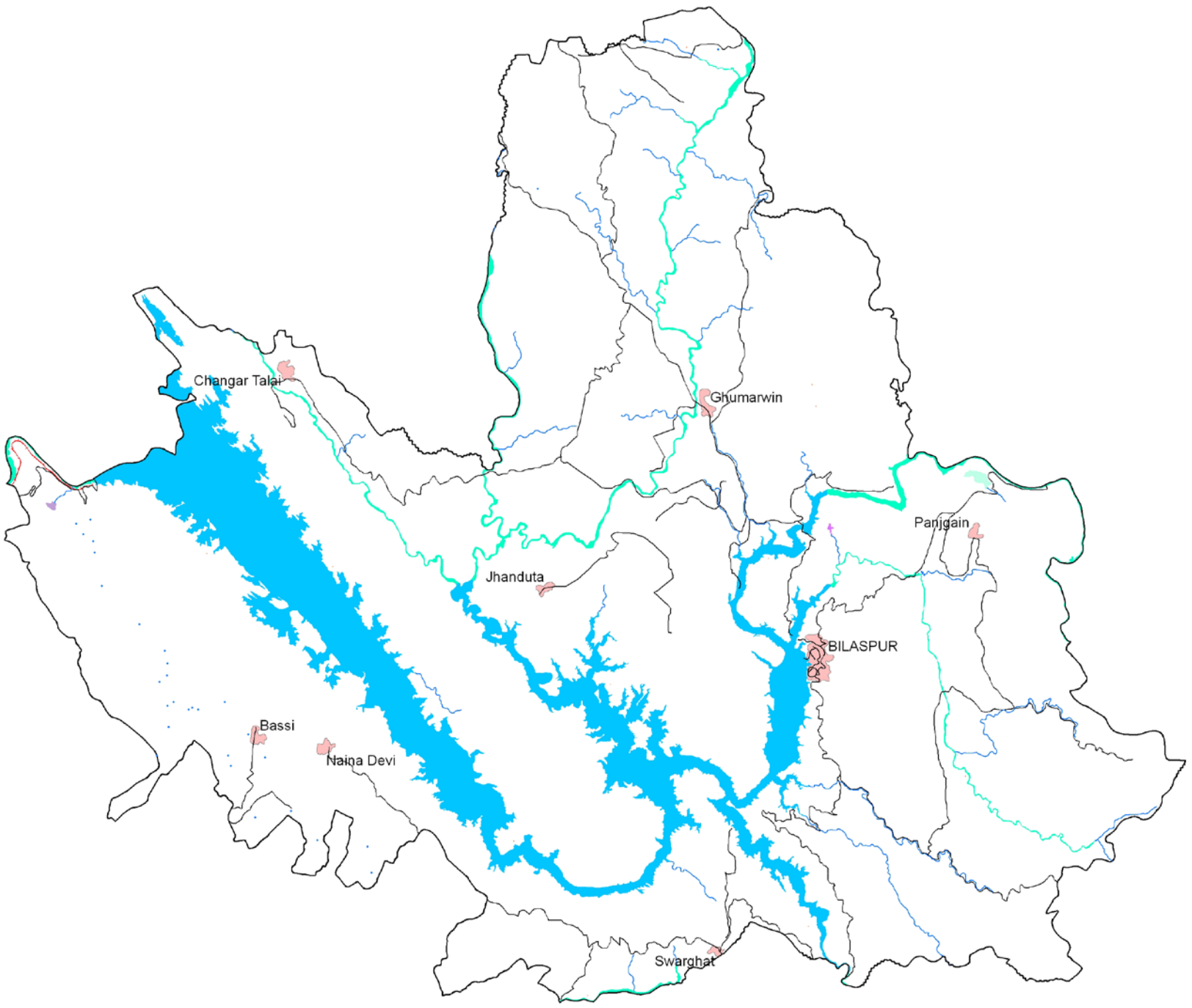
Area under Aquatic Vegetation	-	396

Area under turbidity levels		
Low	11306	7866
Moderate	951	661
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Bilaspur

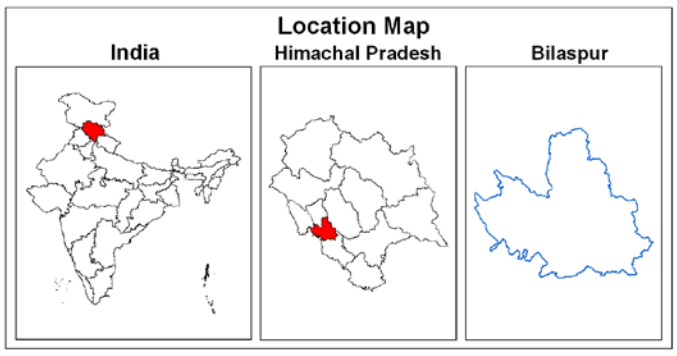


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



6 3 0 6 Kilometers

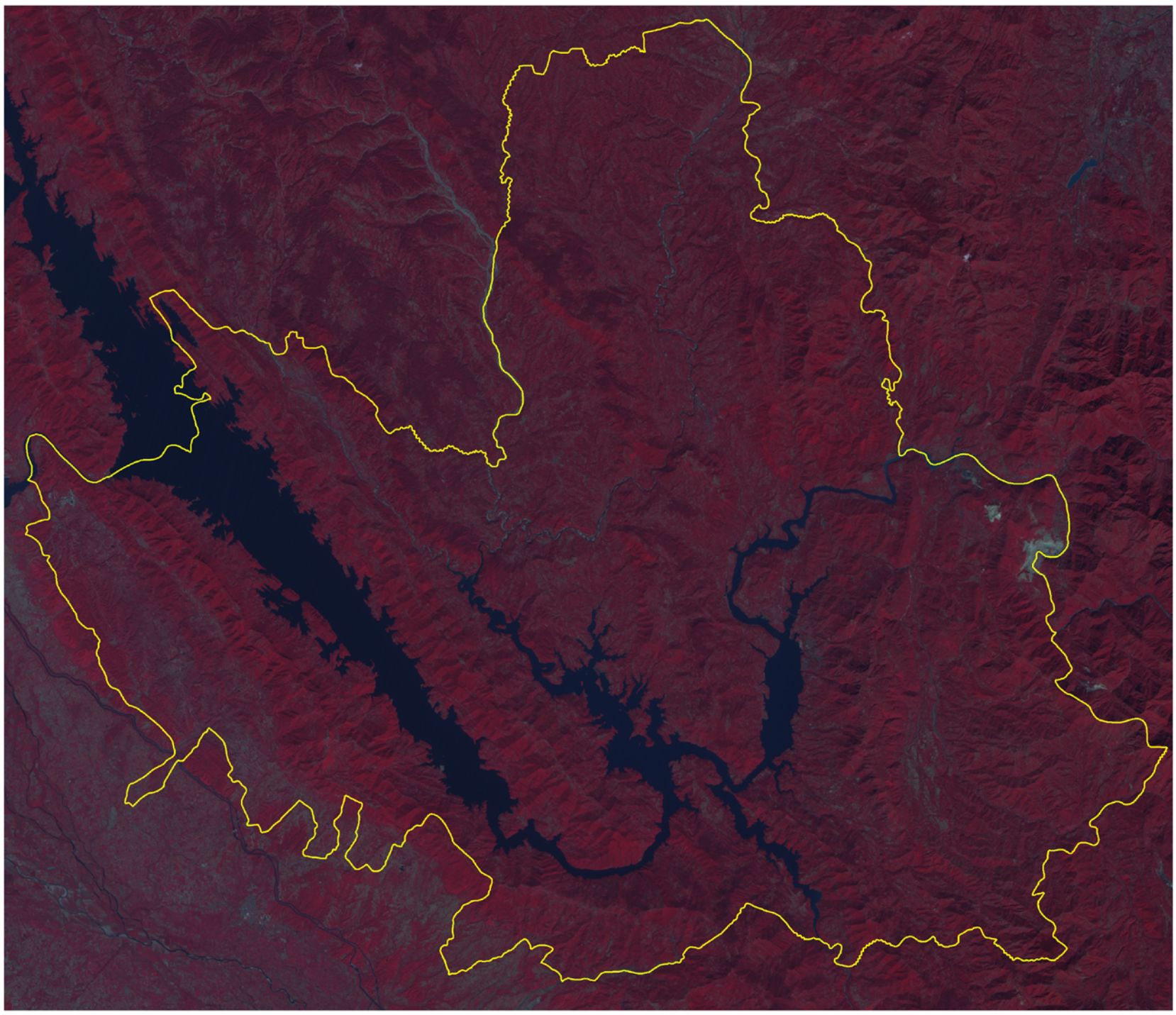
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Bilaspur



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.2 Chamba

Chamba is the north-western district of Himachal Pradesh, with its headquarters in Chamba town. The disrict is surrounded on the north-east and east by Ladakh area of Jammu and Kashmir state, Lahaul and Bara Bangahlaa area of Himachal Pradesh, on the south-east and south by the districts of Kangra of Himachal Pradesh and Gurudaspur of Punjab state. The Ravi river flows through this district. Chamba lies between 32^0 11' 30'' and 33^0 13' 06'' North latitude and between 75^0 49' 00'' and 77^0 49' 30'' East longitude. The area of the district is 6528 sq. km. The territory is wholly mountainous with altitude ranging from 610 meters to about 6400 meters above mean sea level. There are four major wild life sanctuaries in the district i.e. Kalatop Khhiar, Sechu, Kugti, and Tundah. These Sanctuaries are mainly distributed in the northern part of the district.

Total wetland area in the district is 4667 ha that includes 13 small wetlands (<2.25 ha). River/stream occupies 77.80% of wetlands. Reservoir/Barrage is the second large wetland type in the district accounting for 21.23%. The other major wetland types are High altitude lakes (0.64%). Details of wetland statistics is given in Table 7.

The area under aquatic vegetation very low (2 ha) and observed during pre monsoon. The open water spread of wetlands is more in Post-monsoon (3568 ha) than in Pre-monsoon (2307 ha). The qualitative turbidity of water is low to moderate in both the seasons.

Table 7: Area estimates of wetlands in Chamba

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	2	0.04	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	4	30	0.64	27	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	10	3631	77.80	2657	1453
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	991	21.23	884	854
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**17**	**4654**	**99.72**	**3568**	**2307**
		Wetlands (<2.25 ha)	13	13	0.28	-	-
		Total	**30**	**4667**	**100.00**	**3568**	**2307**

Area under Aquatic Vegetation	-	2

Area under turbidity levels		
Low	3310	1130
Moderate	258	1177
High	-	-

State : Himachal Pradesh

WETLAND MAP

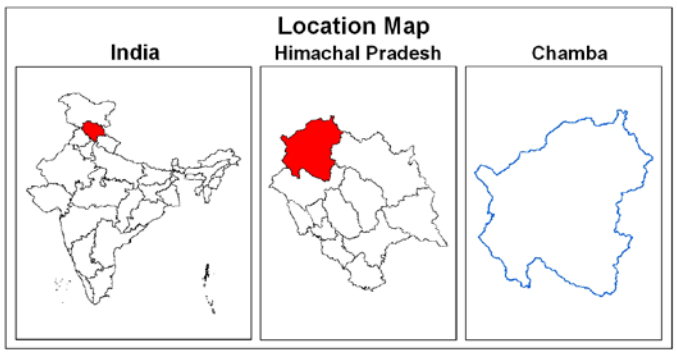
District : Chamba

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



10 5 0 10 Kilometers

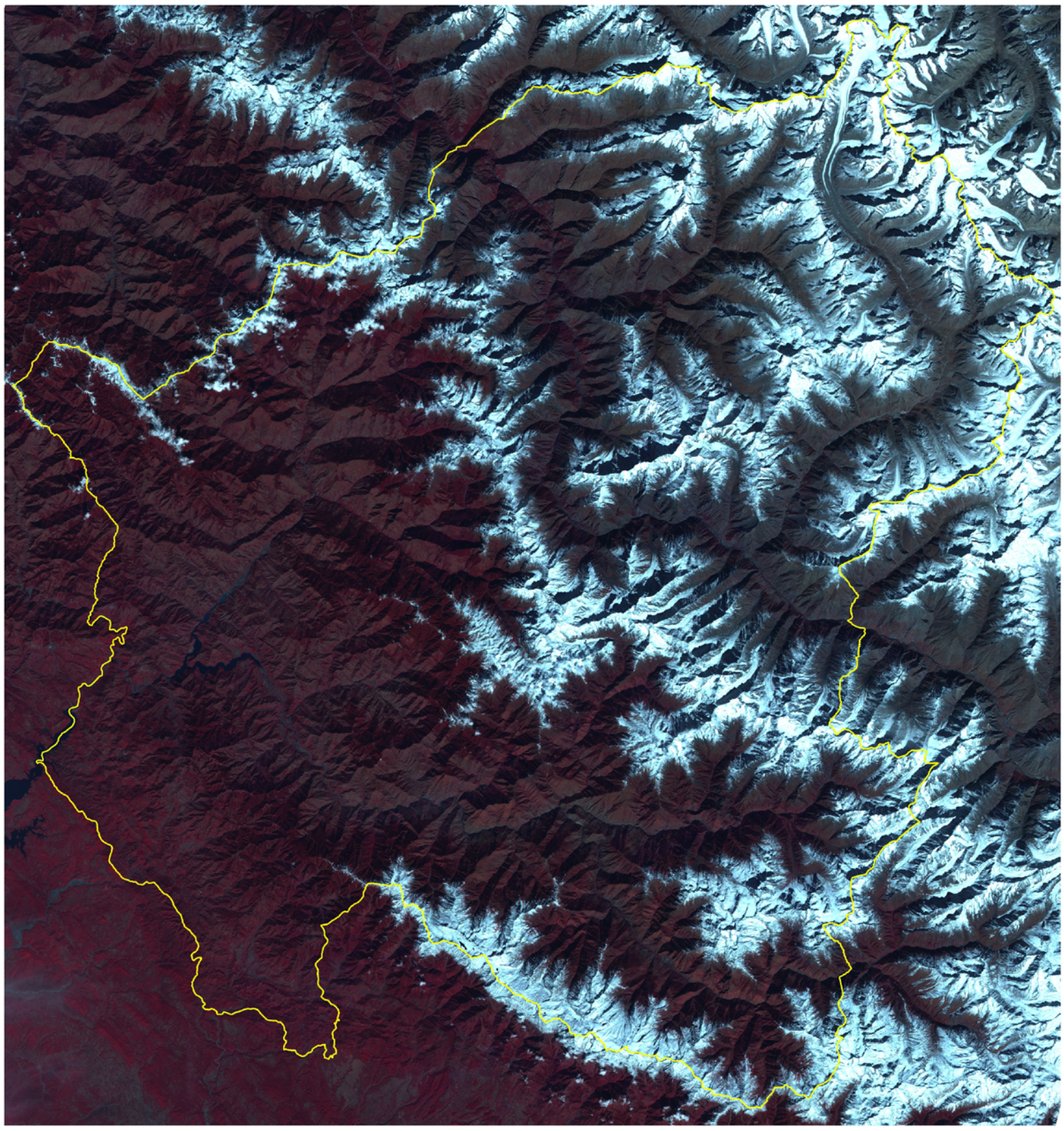
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Chamba



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.3 Hamirpur

The Hamirpur district is predominantly drained by the river Beas. It is the smallest district of the state and lies between 31^0 24' 48'' and 31^0 53' 35'' North latitude and between 76^0 17' 50'' and 76^0 43' 42''East longitude. Its boundaries touch Una in the west and in the south Bilaspur district of Himachal Pradesh. In the west the district shares the boundary with Mandi district and on south with Kangra district of the Himachal Pradesh. Hamirpur is located in a relatively warmer region with a lower altitude as compared to the other districts of the state. The average elevation is 738 metres and it ranges from 400 meters to 1232 meters. The maximum temeprature of the districts ranges from 37^0 C to 39^0 C and the minimum from 03 ^{0}C to 05^0 C. The area of the district is 1118 sq. km.

Total wetland area in the district is 2182 ha that includes 8 small wetlands (<2.25 ha). River/stream occupies 99.63% of wetlands. The open water spread of wetlands is more in Post-monsoon (875 ha) than in Pre-monsoon (643 ha). The qualitative turbidity of water is moderate in both the seasons. Details of wetland statistics is given in Table 8.

Table 8: Area estimates of wetlands in Hamirpur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	6	2174	99.63	875	643
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**6**	**2174**	**99.63**	**875**	**643**
		Wetlands (<2.25 ha)	8	8	0.37	-	-
		Total	**14**	**2182**	**100.00**	**875**	**643**

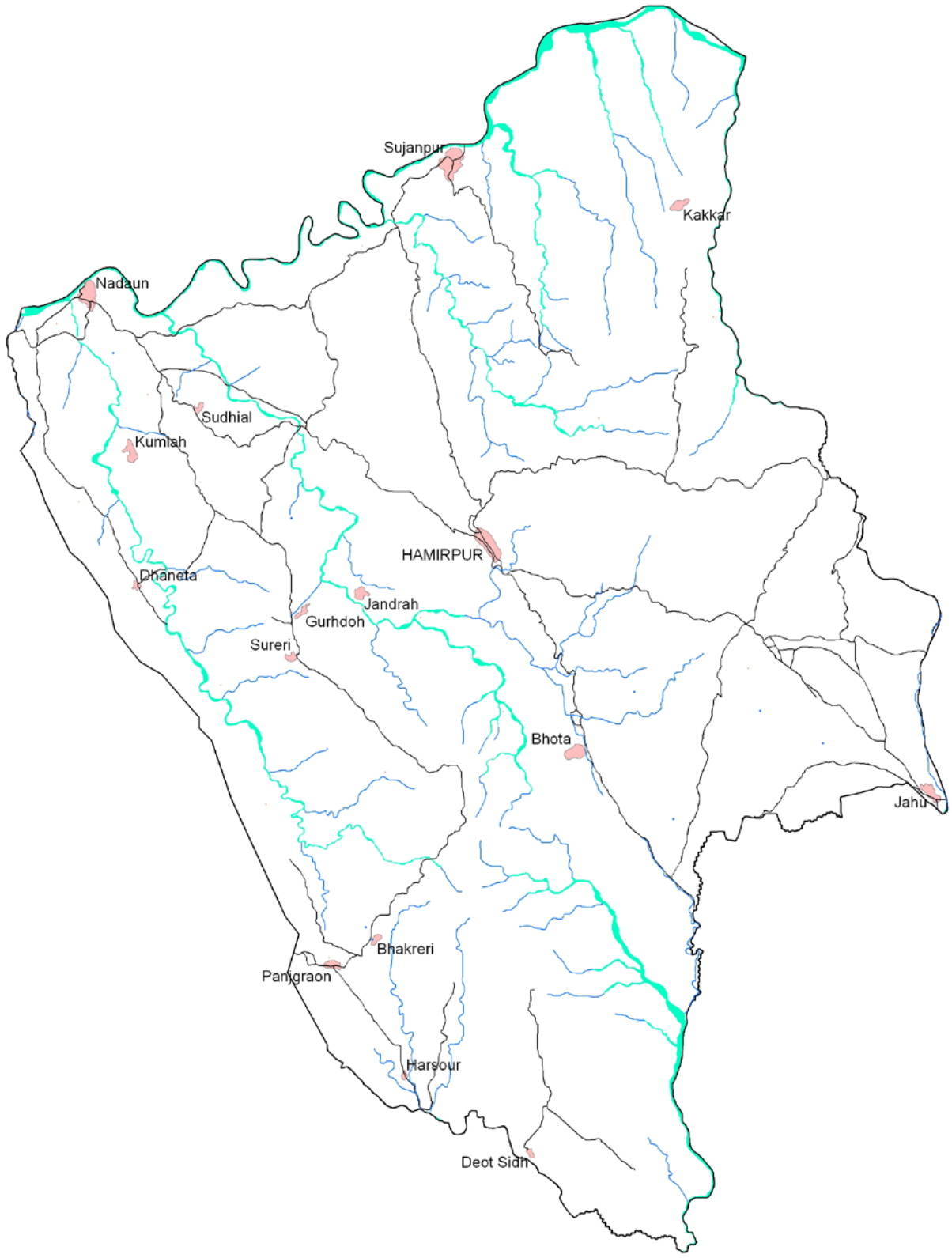
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	-	44
Moderate	875	599
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Hamirpur



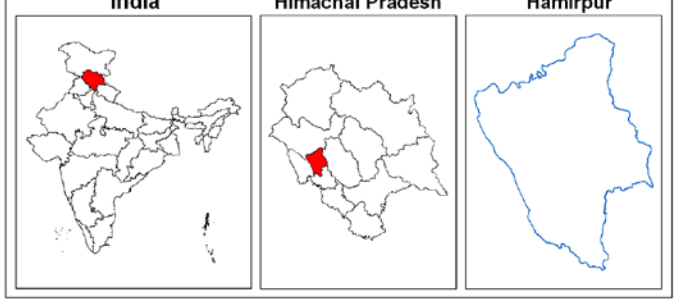
Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

India | Himachal Pradesh | Hamirpur



6 3 0 6 Kilometers

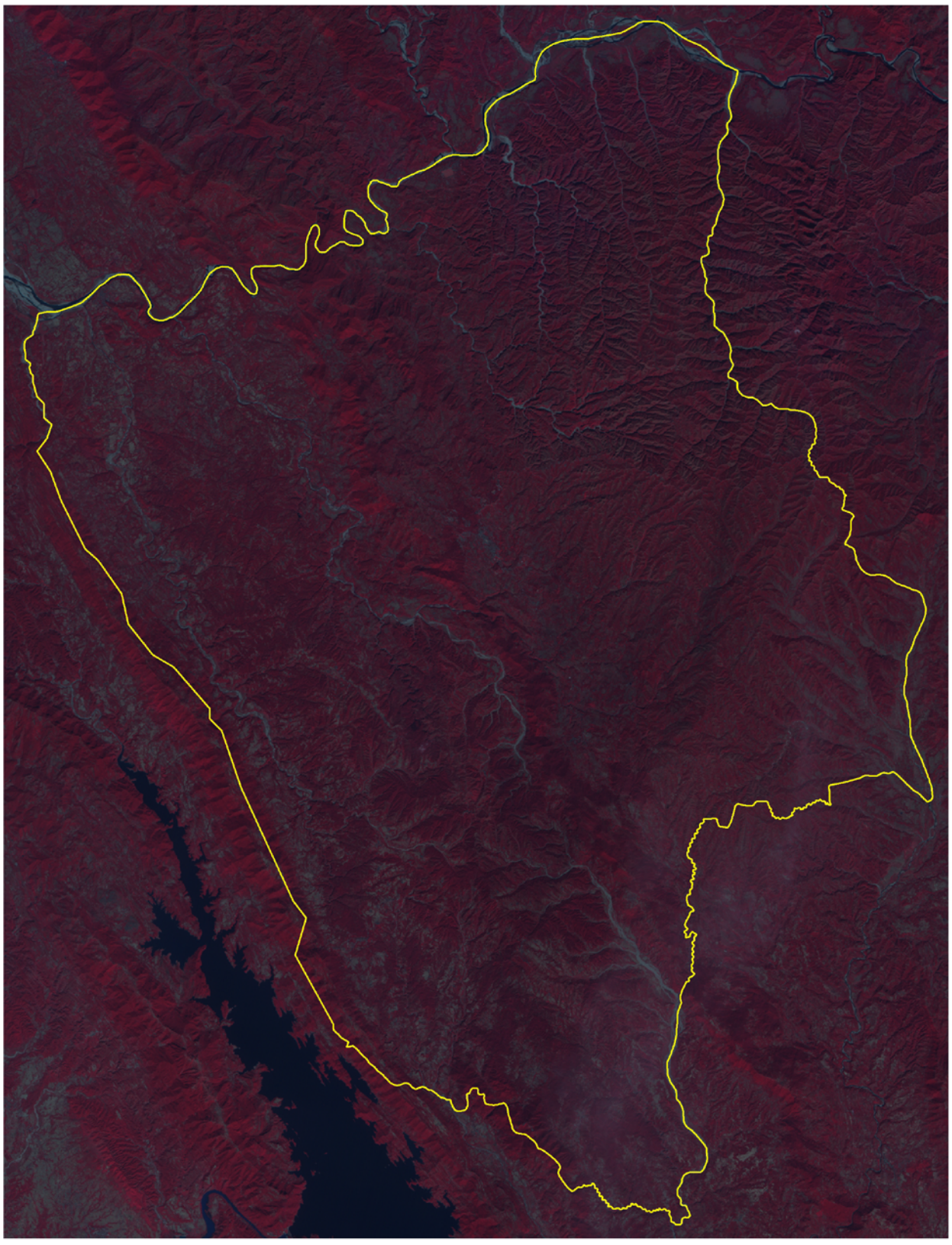
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Hamirpur



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.4 Kangra

Kangra district lies between 31^0 40' 00'' and 32^0 25' 00'' North latitude and between 75^0 35' 00'' and 77^0 05' 00'' East longitude. The area of the district is 5739 sq. km and it's criss-crossed by mountain ranges and enclosed valleys. It is bounded on the southwest by Una district on the northwest by District Gurdaspur of Punjab, on the north by Lahaul & Spiti and Chamba districts of Himachal Pradesh. In the east by Kullu and Mandi districts while on the south it touches Hamirpur district. The Beas is the principal rive which receives almost the entire drainage of the district. The territory is wholly mountainous with altitude ranging from 500 meters to about 5500 meters from the mean sea level.

Total wetland area in the district is 34537 ha that includes 68 small wetlands (<2.25 ha). Reservoir/Stream occupies 71.06% of wetlands. River/Stream is the second large wetland type in the district accounted for 28.63%. Details of wetland statistics is given in Table 9.

The area under aquatic vegetation is 3731 ha in pre monsoon. The open water spread of wetlands is more in Post-monsoon (28375 ha) than in Pre-monsoon (22265 ha). The qualitative turbidity of water is low in both the seasons.

Table 9: Area estimates of wetlands in Kangra

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	6	0.02	-	3
6	1106	River/Stream	35	9908	28.63	3834	1941
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	24589	71.06	24508	20307
8	1202	Tanks/Ponds	2	14	0.04	13	-
9	1203	Waterlogged	2	20	0.06	20	14
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**42**	**34537**	**99.80**	**28375**	**22265**
		Wetlands (<2.25 ha)	68	68	0.20	-	-
		Total	**110**	**34605**	**100.00**	**28375**	**22265**

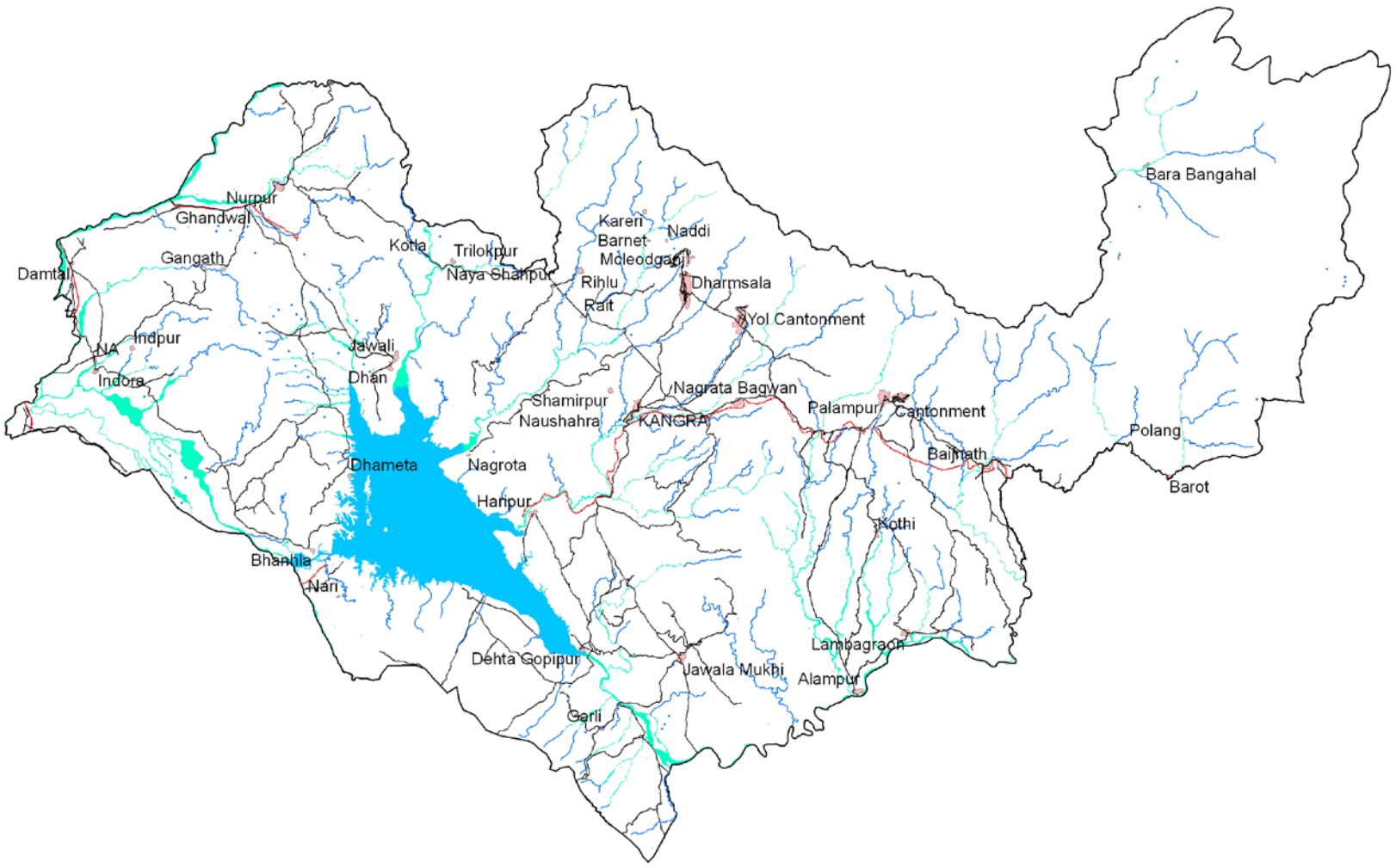
Area under Aquatic Vegetation	-	3731

Area under turbidity levels		
Low	24648	20342
Moderate	3727	1923
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Kangra

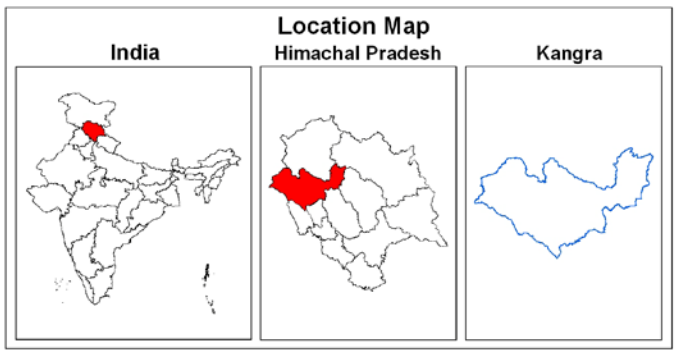


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



10 5 0 10 Kilometers

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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
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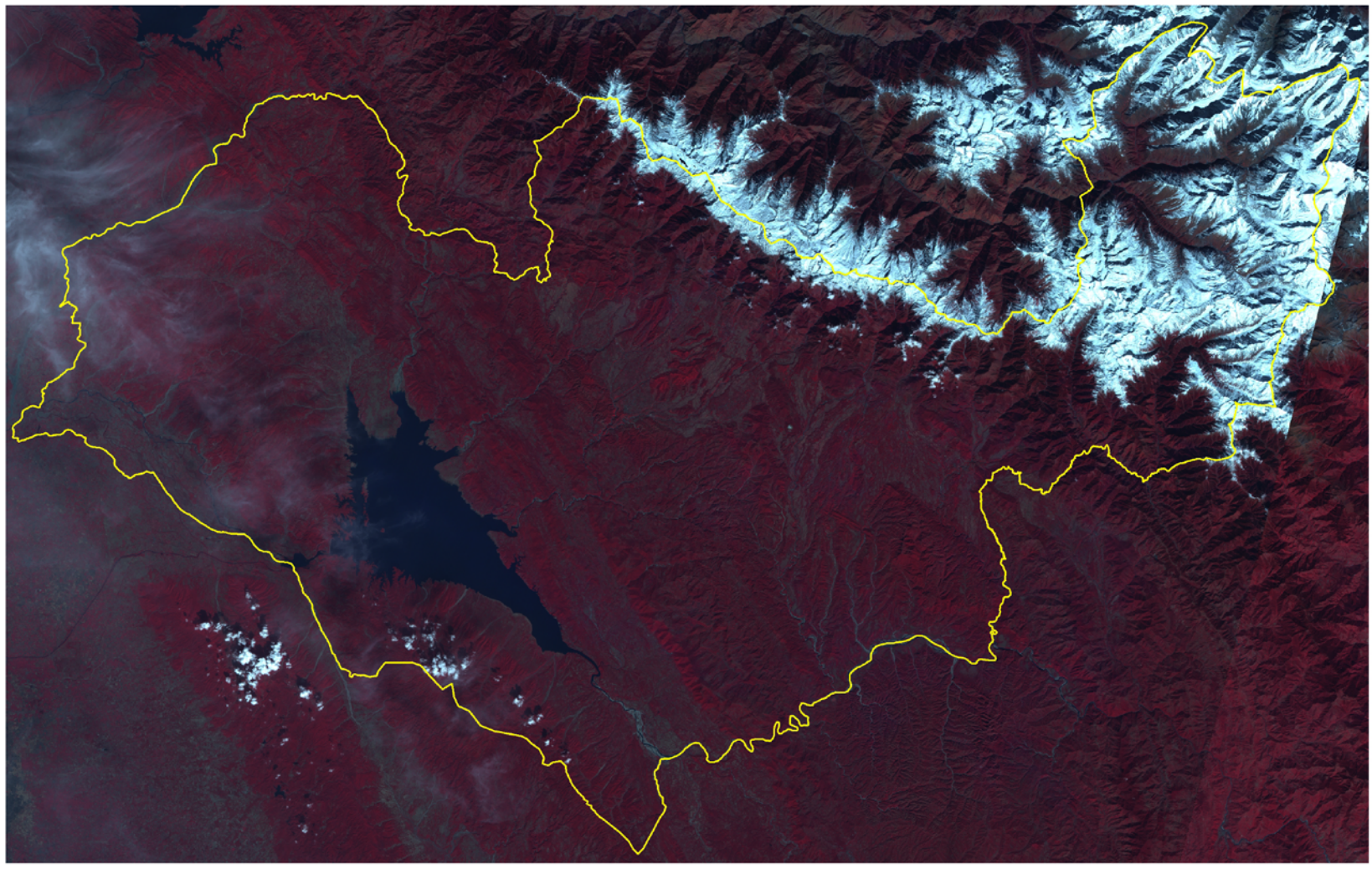
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Kangra



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.5 Kinnaur

The Kinnaur district has an area of 6401 sq. km. The district coordinates are ranges from 31^0 05' 55'' to 32^0 05' 20'' North latitude and 77^0 45' 00'' and 79^0 00' 50'' East longitude. Lahaul and Spiti district of Himachal Pradesh bound Kinnaur on the north on the east by Tibetan territory, on the south by Shimla district and Uttarkashi district of Uttarakhand and on the west by Shimla district. Sutlej, the principal river of the district arises in the Himalayas and has plenty water through out the year, as it is the only perennial river of the district.

Total wetland area in the district is 4990 ha that includes 43 small wetlands (<2.25 ha). River/stream occupies 97.37% of wetlands. The open water spread of wetlands is more in Post-monsoon (1426 ha) than in Pre-monsoon (1312 ha). The qualitative turbidity of water is moderate in both the seasons. Details of wetland statistics is given in Table 10.

Table 10: Area estimates of wetlands in Kinnaur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	7	47	0.94	15	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	8	0.16	8	-
6	1106	River/Stream	1	4859	97.37	1378	1302
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	5	0.10	-	-
8	1202	Tanks/Ponds	5	28	0.56	25	10
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**16**	**4947**	**99.14**	**1426**	**1312**
		Wetlands (<2.25 ha)	43	43	0.86	-	-
		Total	**59**	**4990**	**100.00**	**1426**	**1312**

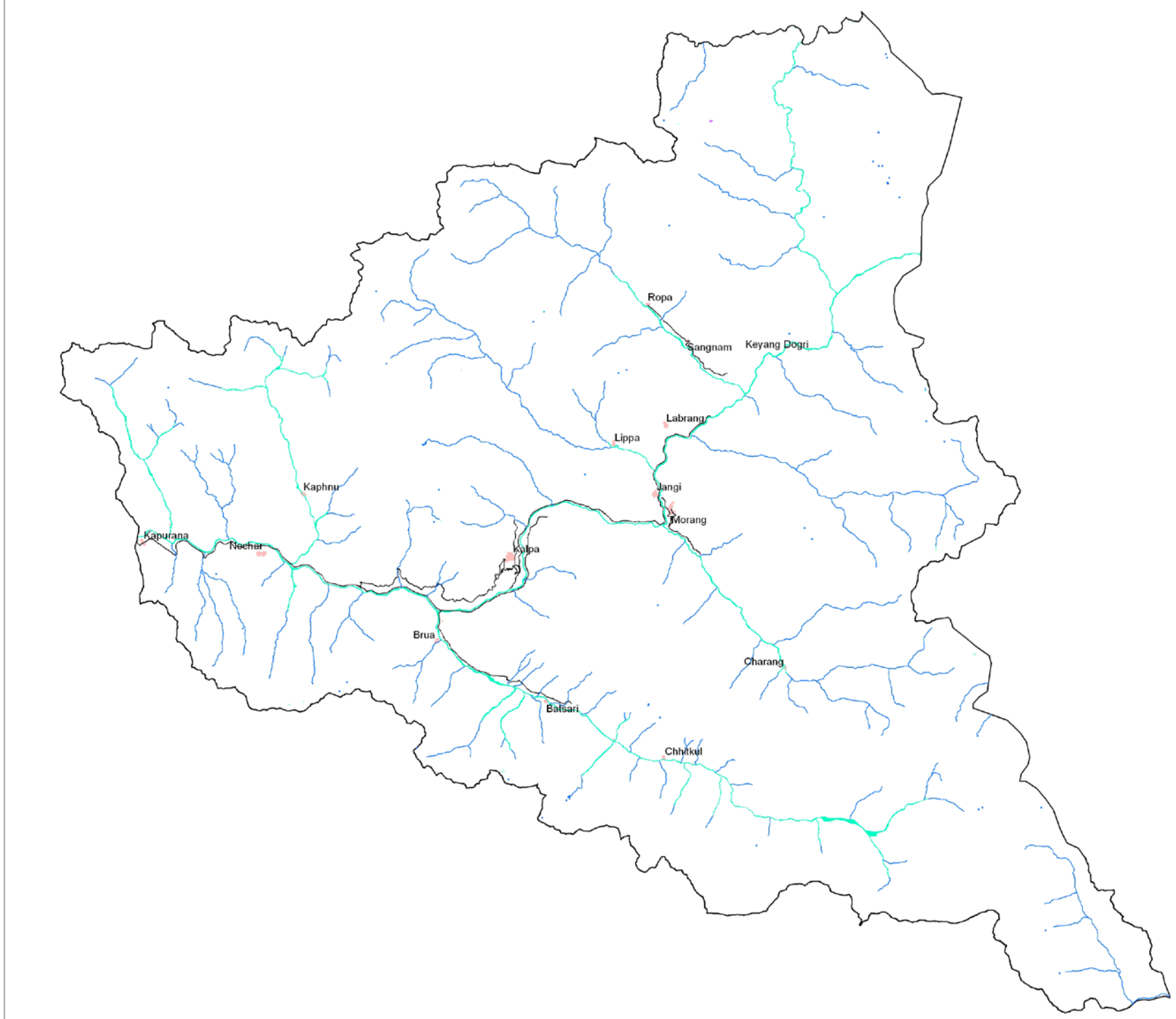
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	40	12
Moderate	1386	1300
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Kinnaur

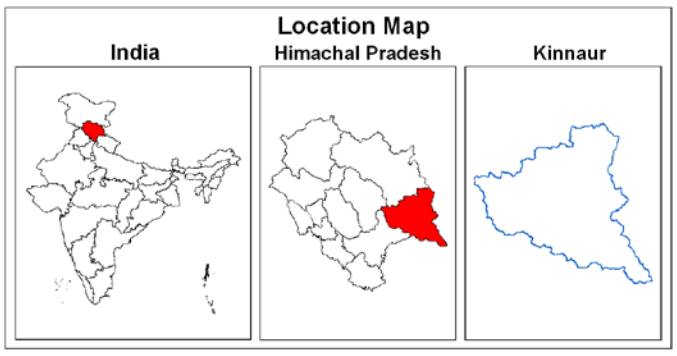


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



10 5 0 10 Kilometers

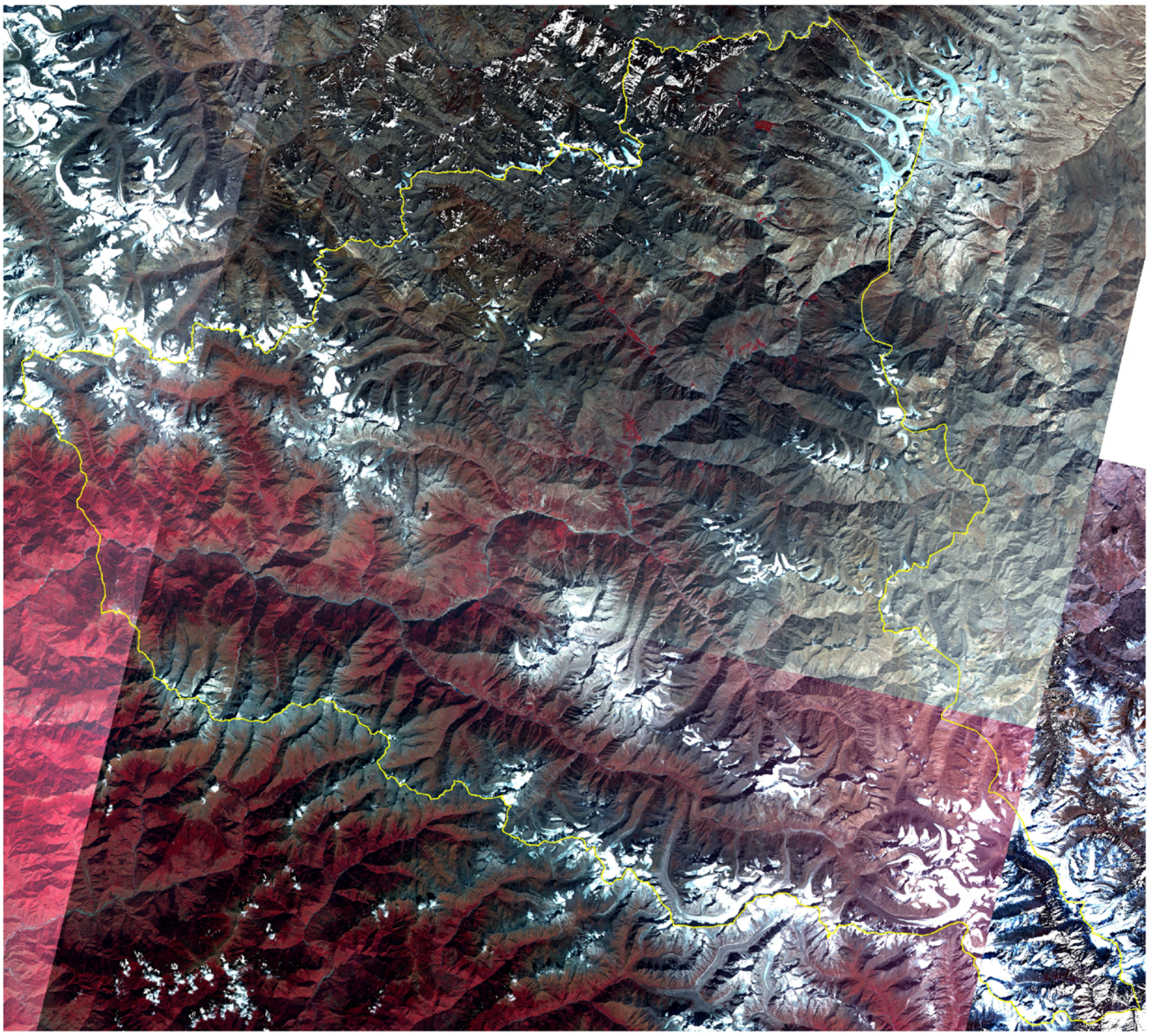
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Kinnaur



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

7.1.6 Kullu

The district of Kullu forms a transitional zone between the lesser and greater Himalayas and presents a typical rugged mountainous terrain with moderate to high relief. The altitude varies from 1300 meters to over 6000 meters from the mean sea level. The central coordinates of Kullu district are 31^0 58' 00'' North latitude and 77^0 06' 04'' East longitude. The area of the district is 5503 sq. km. On the North and Northeast it is bounded by Lahaul & Spiti and Kangra districts, on the east and southeast by Kinnaur, and Shimla district, in the Southwest by Mandi District. The Sutluj and the Beas are the principal rivers of the district and these two rivers receive the entire drainage of the district.

Total wetland area in the district is 2894 ha that includes 65 small wetlands (<2.25 ha). River/stream occupies 94.96% of wetlands. Tanks/Ponds are the second large wetland type in the district accounted for 1.87%. The other major wetland types are High altitude lakes. There are 7 large ones that were mapped with 27 ha area (0.93%). Details of wetland statistics is given in Table 11.

The open water spread of wetlands is more in Pre-monsoon (2015 ha) than in Post-monsoon (1907 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 11: Area estimates of wetlands in Kullu

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	7	27	0.93	11	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	2	2748	94.96	1855	2013
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	12	54	1.87	41	2
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**21**	**2829**	**97.75**	**1907**	**2015**
		Wetlands (<2.25 ha)	65	65	2.25	-	-
		Total	**86**	**2894**	**100.00**	**1907**	**2015**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	52	2
Moderate	1855	2013
High	-	-

State : Himachal Pradesh

WETLAND MAP

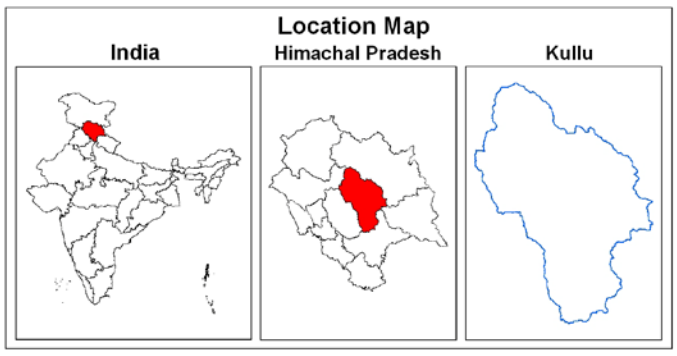
District : Kullu

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



10 5 0 10 Kilometers

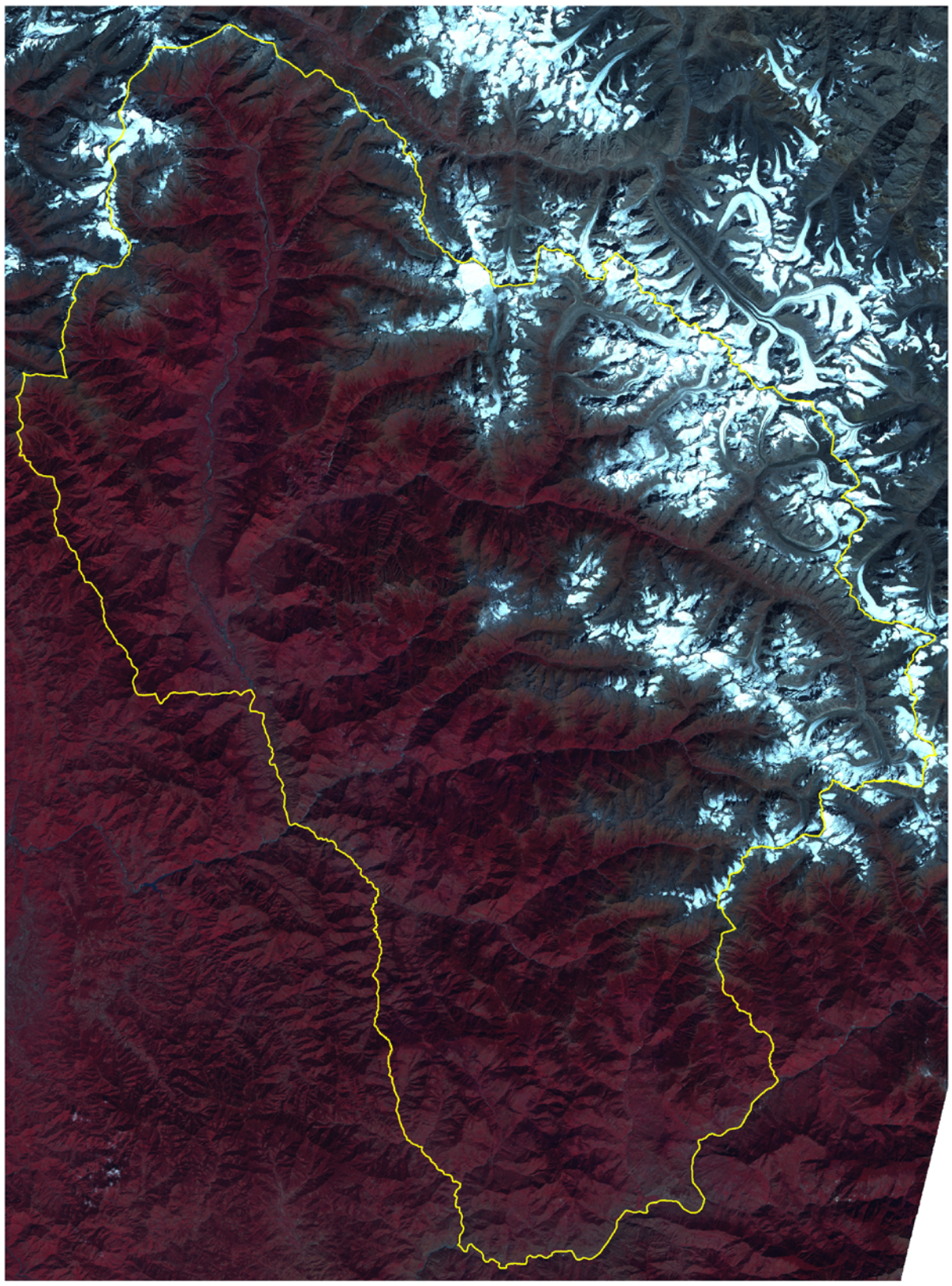
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Kullu



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.7 Lahul and Spiti

The location of the district is between north latitude 31^0 04' 47'' to 32^0 59' 57'' and east longitude 76^0 46' 29'' and 78^0 41' 34''. The geographic area of the district is 13835 sq. km. Lahaul and Spiti is bounded between Thirot Nallah in the west to Samdu, in the east Baralacha pass and its Parallel ranges in the north to Bhaha Parvati Hamta, Rothang and Kuji and the Sach pass in the south, It touches Tibet on its eastern border and north to it lies Ladakh, on the western and southern side. It borders with Champa and Kullu districts, on the south-eastern side is the Kinnaur district.

The wetlands are associated with the main river of Lahul valley, Chandra river which originate from Chandra Tal near Baralacha, the other river is the Bhaga river which originate from Suraj Tal opposite Baralacha and meets Chandra river at Tandi and finally joins with Chenab river.

Total wetland area in the district is 10766 ha that includes 87 small wetlands (<2.25 ha). River/stream occupies 96.30% of wetlands. High altitude lakes are the second large wetland type in the district. This district has maximum number of large high altitude lakes (16) accounting for 1.71%. Chandratal is the most famous high altitude lake in the district. The other major wetland types are Tanks/Ponds (0.07%). Details of wetland statistics is given in Table 12.

The open water spread of wetlands is significantly more in Post-monsoon (4406 ha) than in Pre-monsoon (2376 ha). The qualitative turbidity of water is low to moderate in both the seasons.

Table 12: Area estimates of wetlands in Lahul and Spiti

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	16	184	1.71	160	95
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	2	8	0.07	7	-
6	1106	River/Stream	4	10368	96.30	4128	2213
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	111	1.03	111	68
8	1202	Tanks/Ponds	2	8	0.07	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**25**	**10679**	**99.19**	**4406**	**2376**
		Wetlands (<2.25 ha)	87	87	0.81	-	-
		Total	**112**	**10766**	**100.00**	**4406**	**2376**

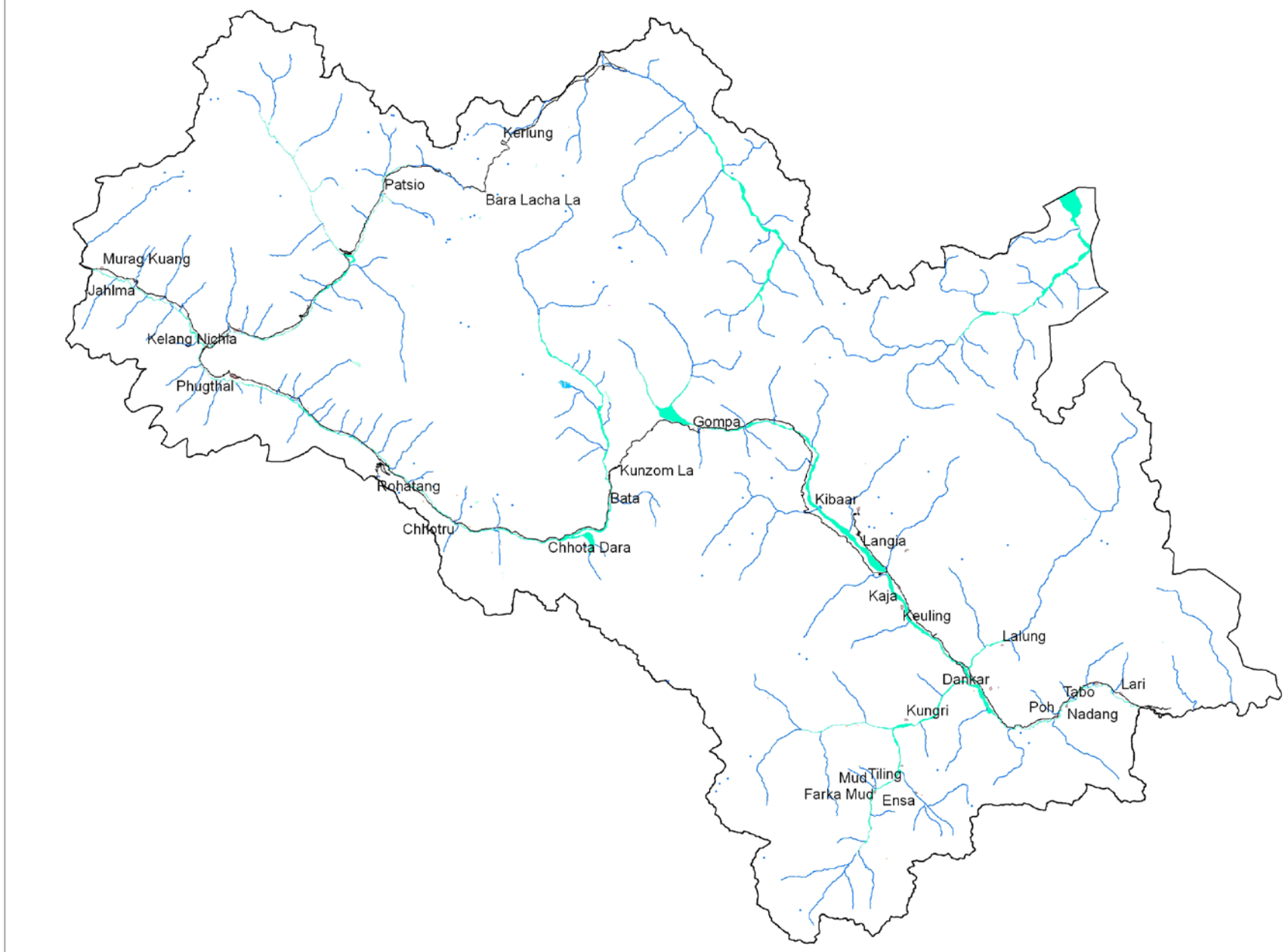
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2315	163
Moderate	2091	2213
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Lahun & Spiti

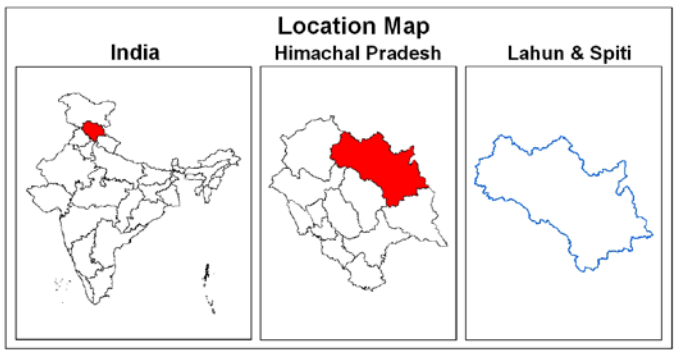


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



20 10 0 20 Kilometers

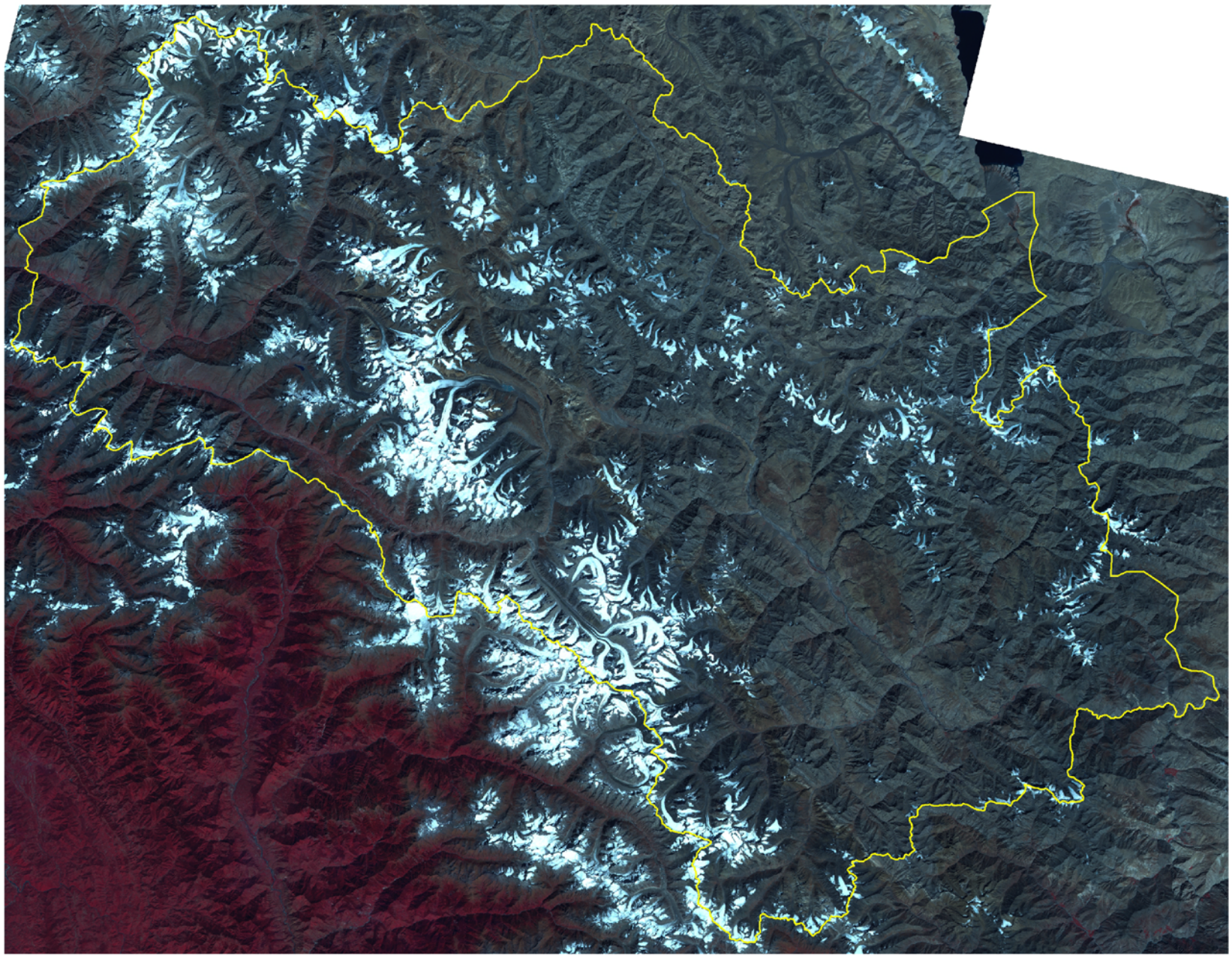
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Lahun & Spiti



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.8 Mandi

The location of the district is between north latitude 31^0 13' 50'' to 32^0 04' 30'' and east longitude 76^0 37' 20'' and 77^0 23' 15''. The geographic area of the district is 3950 sq. km. Kangra bound the district on the northwest, Hamirpur and Bilaspur district in the west, Solan district in the south, Shimla district on south – west and Kullu district in the east. Beas and Sutlej are the main rivers, which pass through the district. There are three lakes in the district that are popular from religious and tourist point of view. The Rewalsar Lake is situated at southwest of Mandi Township at the height of 1300 meters from the mean sea level. It is a very deep and oligotrophic in nature. Parashar Lake is small in size and located about 36 km. away from Mandi Township in the northeast direction. The Kamrunag Lake is located at an altitude of 3150 meters from the mean sea level.

Total wetland area in the district is 3704 ha that includes 4 small wetlands (<2.25 ha). River/stream occupies 93.90% of wetlands. Reservoir/Barrage is the second large wetland type in the district accounted for 5.21%. Details of wetland statistics is given in Table 13.

The open water spread of wetlands is more in Pre-monsoon (2139 ha) than in Post-monsoon (2300 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 13: Area estimates of wetlands in Mandi

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	1	4	0.11	3	2
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	2	7	0.19	7	6
6	1106	River/Stream	8	3478	93.90	2100	1985
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	193	5.21	172	137
8	1202	Tanks/Ponds	4	18	0.49	18	9
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**17**	**3700**	**99.89**	**2300**	**2139**
		Wetlands (<2.25 ha)	4	4	0.11	-	-
		Total	**21**	**3704**	**100.00**	**2300**	**2139**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	198	254
Moderate	2103	1885
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Mandi

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

India | Himachal Pradesh | Mandi

10 5 0 10 Kilometers

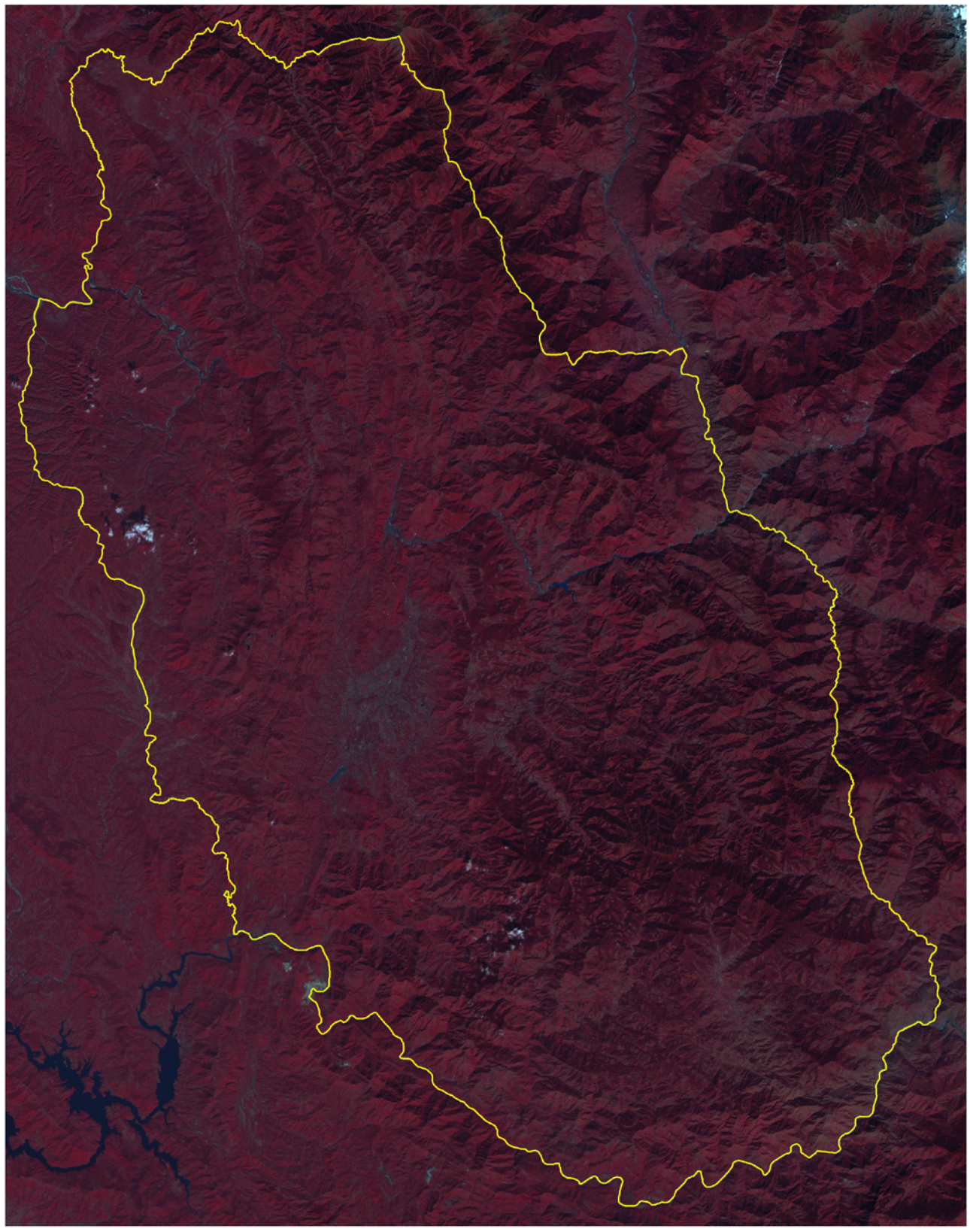
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Mandi



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.9 Shimla

Shimla is a hill station and lies in between north latitude 30^0 45' 00'' to 31^0 44' 00'' and east longitude 77^0 00' 00'' and 78^0 19' 00''. The geographic area of the district is 5131 sq. km. It is bounded by Mandi and Kullu district of Himachal Pradesh in the north, Kinnaur in the east, and by Solan district in the west. Shimla district is covered by the catchment area of the rivers Sutlej, Pabbar and Giri. The Sutlej is the principal rivers of the district rises from Man sarover Lake in the eastern peaks of Himalayas.

Total wetland area in the district is 2368 ha that includes 13 small wetlands (<2.25 ha). River/stream occupies 97.04% of wetlands. High Altitude Lakes is the second large wetland type in the district. Seven such lakes awere mapped accounting for 2.41%. Details of wetland statistics is given in Table 14.

The open water spread of wetlands is more in Post-monsoon (1517 ha) than in Pre-monsoon (1440 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 14: Area estimates of wetlands in Shimla

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	7	57	2.41	31	15
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	4	2298	97.04	1486	1425
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**11**	**2355**	**99.45**	**1517**	**1440**
		Wetlands (<2.25 ha)	13	13	0.55	-	-
		Total	**24**	**2368**	**100.00**	**1517**	**1440**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	31	277
Moderate	1486	1163
High	-	-

State : Himachal Pradesh

WETLAND MAP

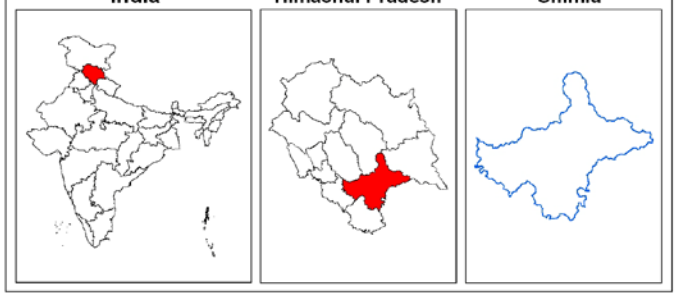
District : Shimla

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



10 5 0 10 Kilometers

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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
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Sponsored by:
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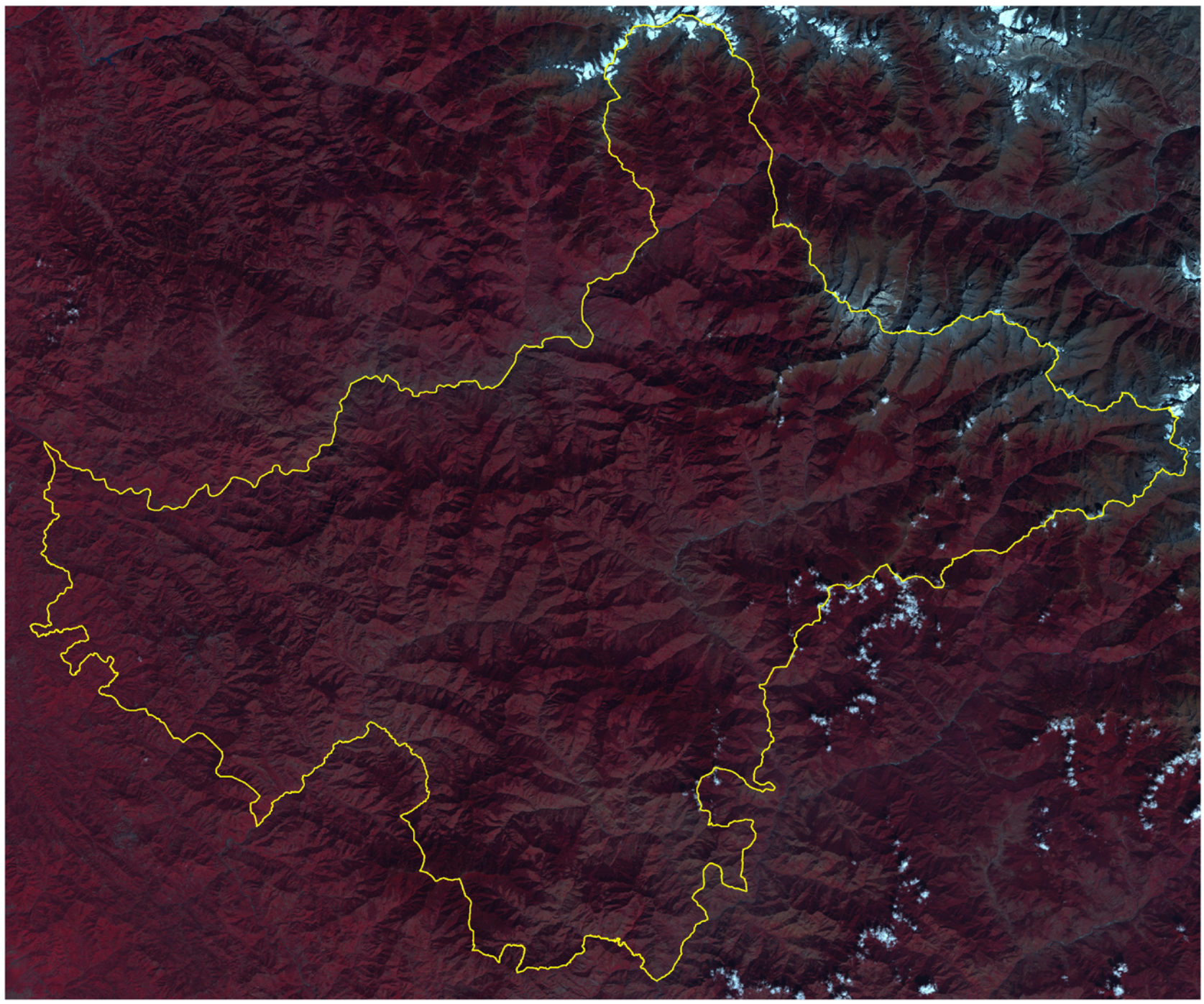
State : Himachal Pradesh

District : Shimla



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.10 Sirmaur

The district lies in the outer Himalayan range, commonly called as shivaliks. The district coordinates are extended from north latitude 30^0 22' 30'' to 31^0 01' 20'' and east longitude 77^0 10' 12'' and 77^0 49' 40''. The area of the district is 2825 sq. km. Sirmaur is bounded by Shimla district in the north, the river Tons and Yamuna in the east, district Ambala of Haryana in the south and west and northwest by Solan district of Himachal Pradesh. The river Giri is the major river in the district.

Total wetland area in the district is 9990 ha that includes 30 small wetlands (<2.25 ha). River/stream occupies 97.33% of wetlands. Reservoir/Barrage is the second large wetland type in the district accounted for 1.89%. Details of wetland statistics is given in Table 15.

The area under aquatic vegetation is 7 ha in pre monsoon. The open water spread of wetlands is significantly more in Post-monsoon (5795 ha) than in Pre-monsoon (1750 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 15: Area estimates of wetlands in Sirmaur

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	4	40	0.40	40	20
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	8	0.08	7	3
6	1106	River/Stream	14	9723	97.33	5716	1691
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	3	189	1.89	32	36
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**22**	**9960**	**99.70**	**5795**	**1750**
		Wetlands (<2.25 ha)	30	30	0.30	-	-
		Total	**52**	**9990**	**100.00**	**5795**	**1750**

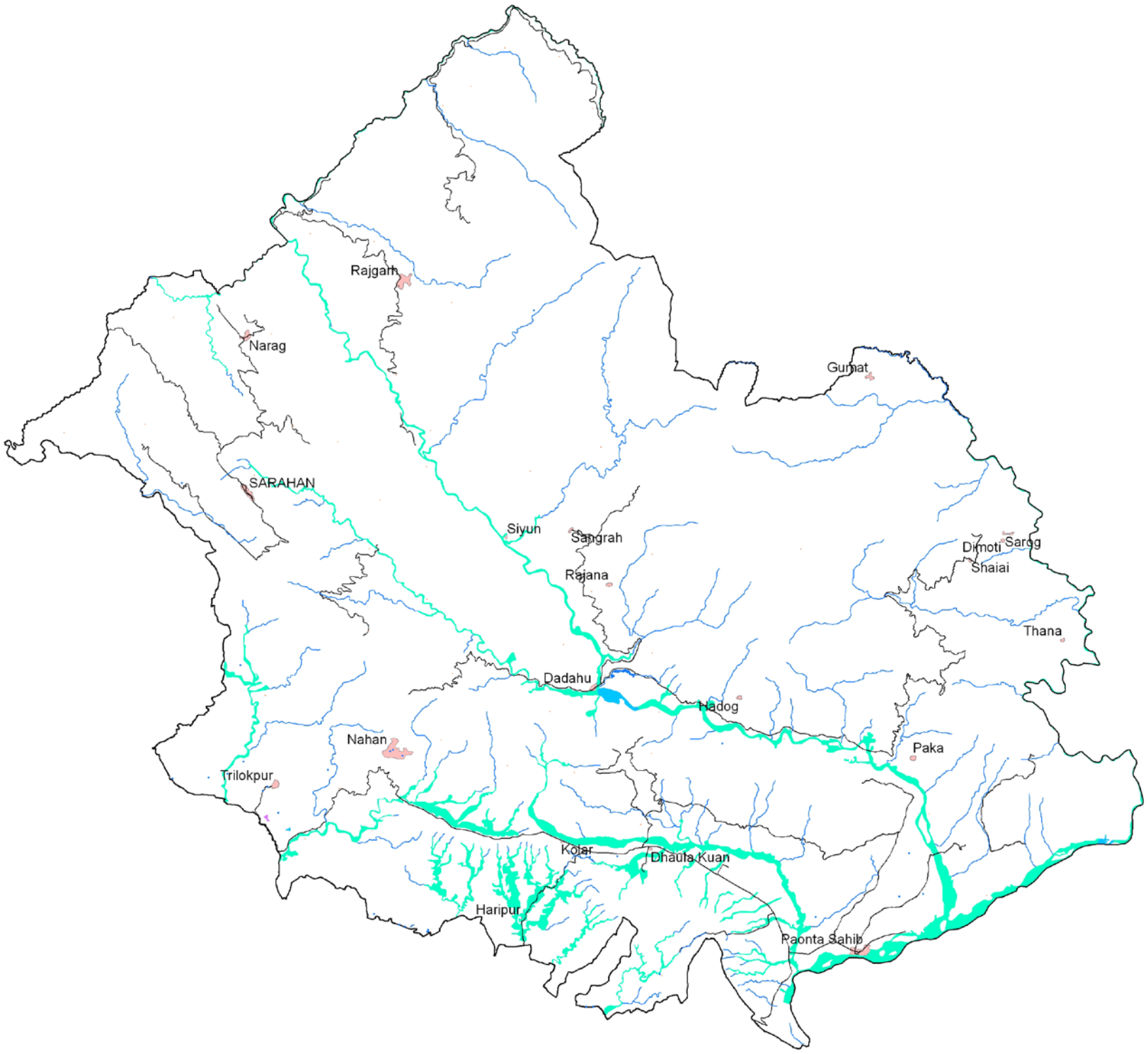
Area under Aquatic Vegetation	-	7

Area under turbidity levels		
Low	78	711
Moderate	5716	1039
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Sirmaur



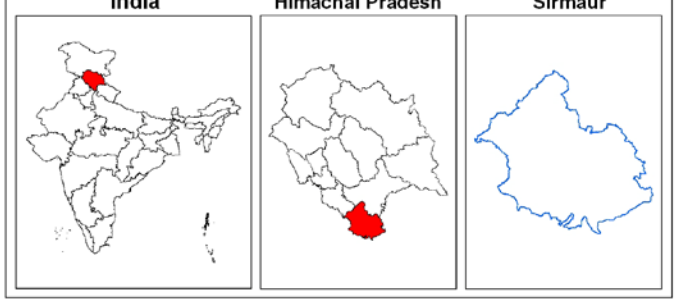
Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

India | Himachal Pradesh | Sirmaur



9 4.5 0 9 Kilometers

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

Prepared by:
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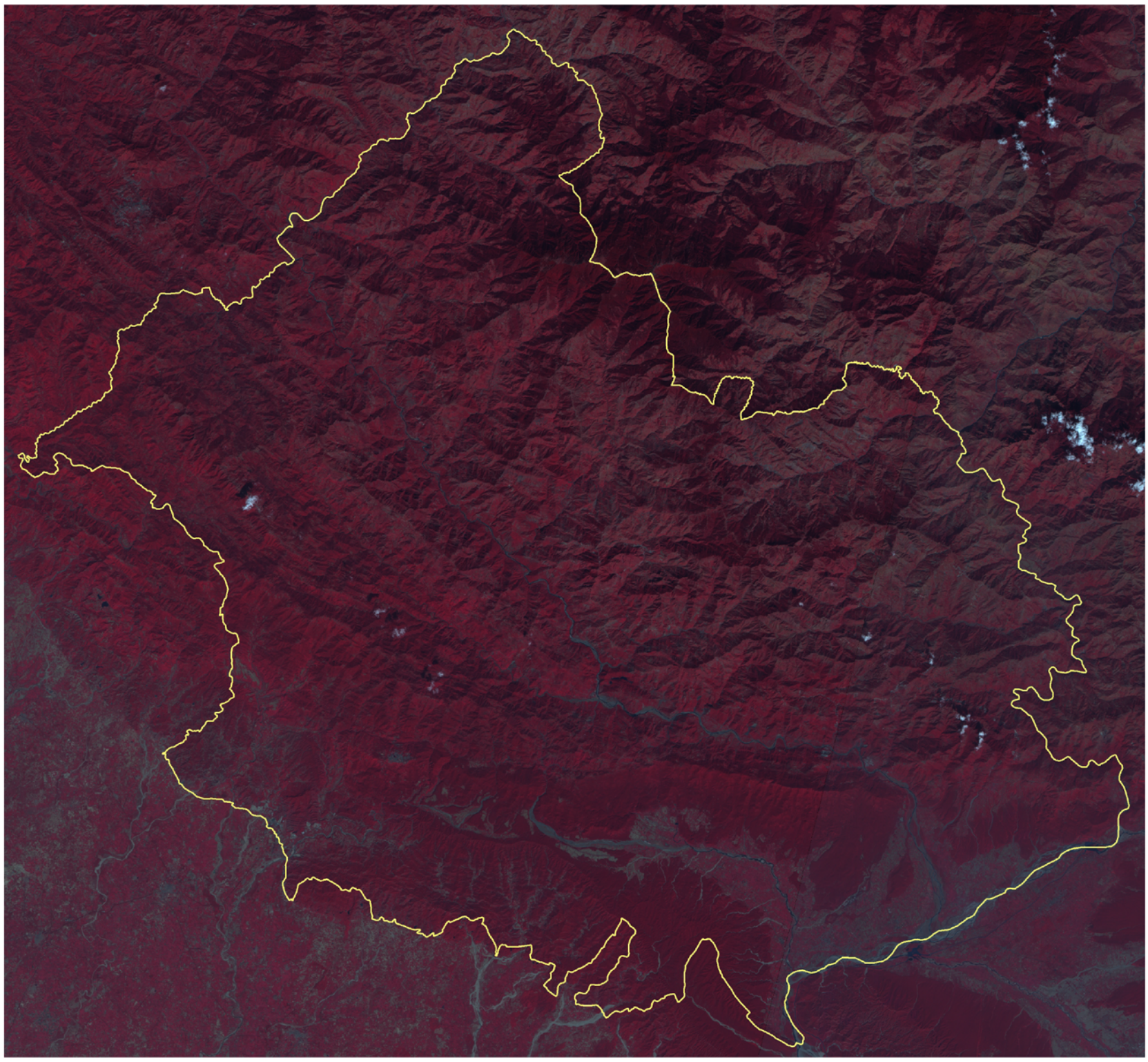
State : Himachal Pradesh

District : Sirmaur



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.11 Solan

It lies between 30^0 05' 00'' and 31^0 15' 00'' North latitude and between 76^0 42' 00'' and 77^0 20' 00'' East longitude. The area of the district is 1936 sq. km. The district is bounded by Shimla district in the north and Ropar district of Punjab and Ambala district of Haryana in the south, Sirmaur district in the east and by Bilaspur district in the west, Mandi district touches the boundary of Solan in north-east. Major rivers of districts are Sutlej, Yamuna, and Ghagar.

Total wetland area in the district is 2720 ha that includes 61 small wetlands (<2.25 ha). River/stream occupies 97.10% of wetlands. Details of wetland statistics is given in Table 16.

The open water spread of wetlands is more in Post-monsoon (1400 ha) than in Pre-monsoon (1040 ha). The qualitative turbidity of water is moderate in both the seasons.

Table 16: Area estimates of wetlands in Solan

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	2	6	0.22	6	4
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	2	0.07	2	1
6	1106	River/Stream	12	2641	97.10	1385	1035
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	7	0.26	7	-
8	1202	Tanks/Ponds	1	3	0.11	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**17**	**2659**	**97.76**	**1400**	**1040**
		Wetlands (<2.25 ha)	61	61	2.24	-	-
		Total	**78**	**2720**	**100.00**	**1400**	**1040**

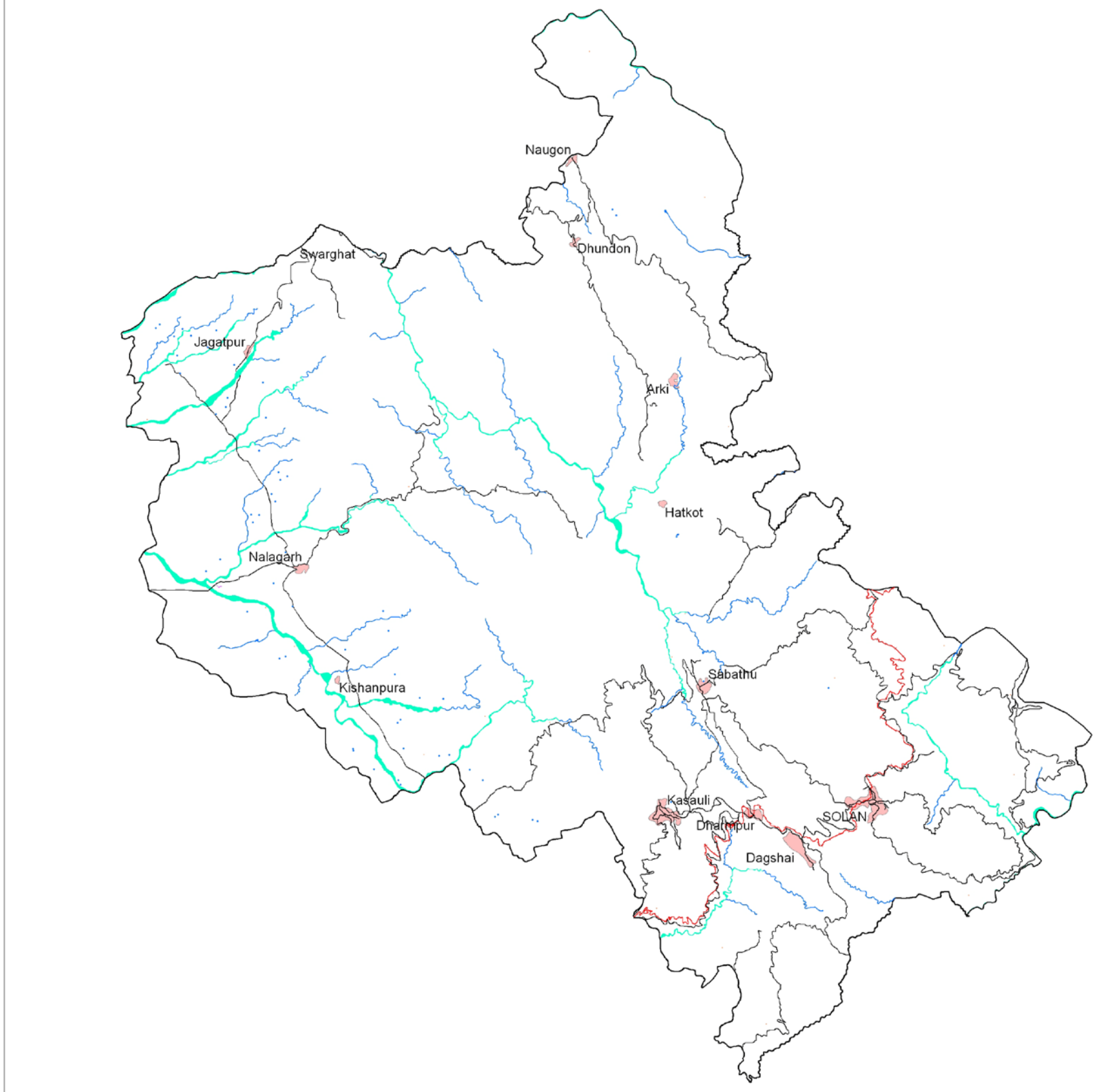
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	137	159
Moderate	1264	881
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Solan

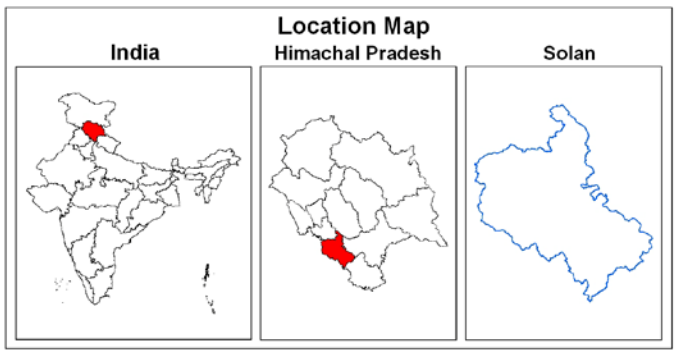


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



8 4 0 8 Kilometers

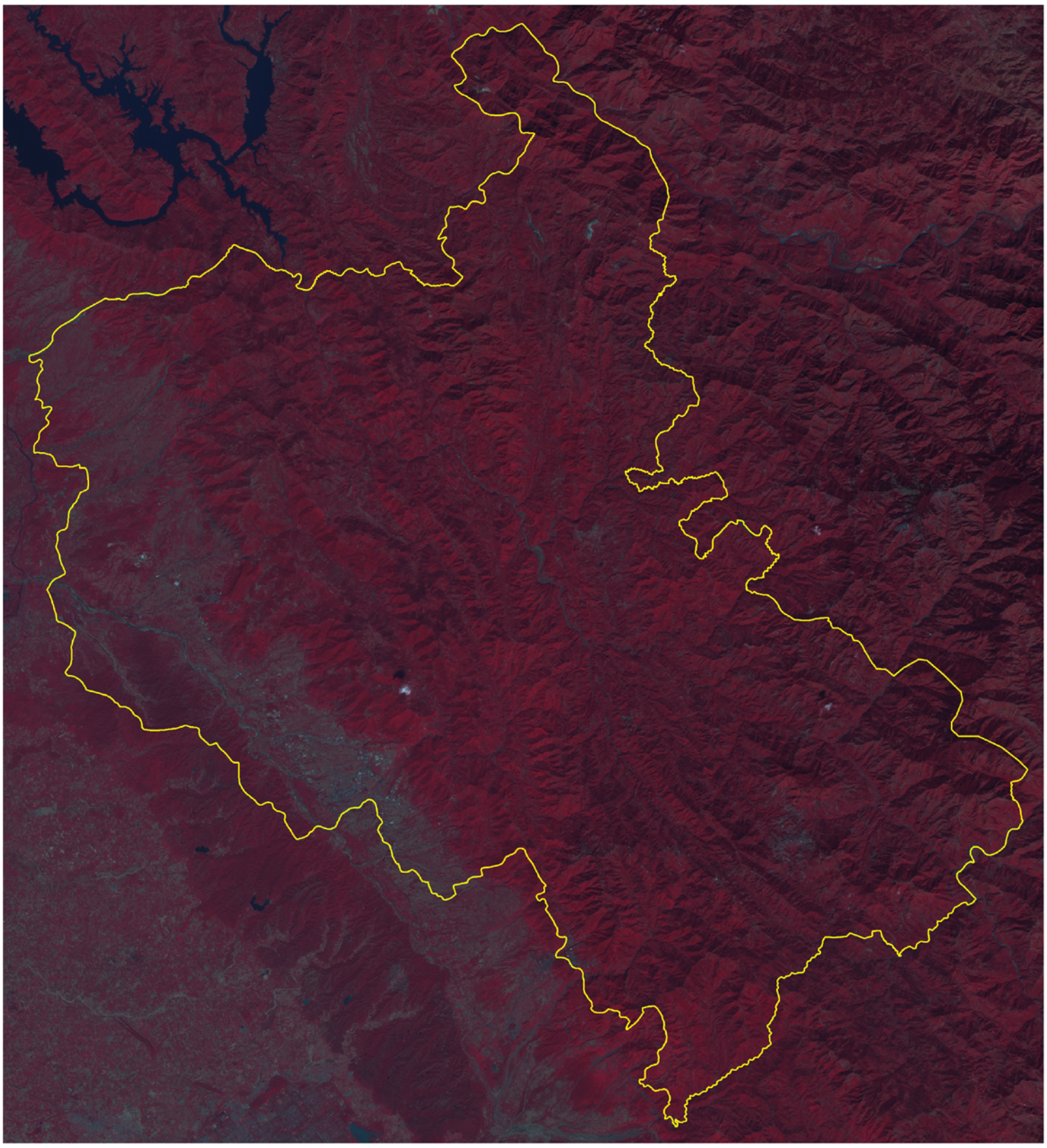
Data Source:
IRS LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

State : Himachal Pradesh

District : Solan



IRS-P6 LISS-III Post-monsoon data(2006-2007)

7.1.12 Una

Una district is in the southwestern part of Himachal Pradesh. Kangra bound it in the north, Hamirpur in the east, and Bilaspur district in the south and by Hoshiarpur district of Punjab in the west. It lies between 31^0 02' 00'' and 31^0 50' 00'' North latitude and between 71^0 55' 00'' and 76^0 28' 00'' East longitude. The geographic area of the district is 1540 sq. km. Two important rivers of the districts Beas river bound it on the north and the river Sutlej in the east.

Total wetland area in the district is 7203 ha that includes 46 small wetlands (<2.25 ha). Reservoir/Barrage occupies 64.45% of wetlands. River/stream is the second large wetland type in the district accounted for 34.75%. Details of wetland statistics is given in Table 17.

The area under aquatic vegetation is 1158 ha in pre monsoon. The open water spread of wetlands is significantly more in Post-monsoon (5281 ha) than in Pre-monsoon (3431 ha). The qualitative turbidity of water is low in both the seasons.

Table 17: Area estimates of wetlands in Una

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of Wetland Area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	3	0.04	3	2
6	1106	River/Stream	11	2503	34.75	627	461
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	4642	64.45	4642	2960
8	1202	Tanks/Ponds	1	9	0.12	9	8
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**14**	**7157**	**99.36**	**5281**	**3431**
		Wetlands (<2.25 ha)	46	46	0.64	-	-
		Total	**60**	**7203**	**100.00**	**5281**	**3431**

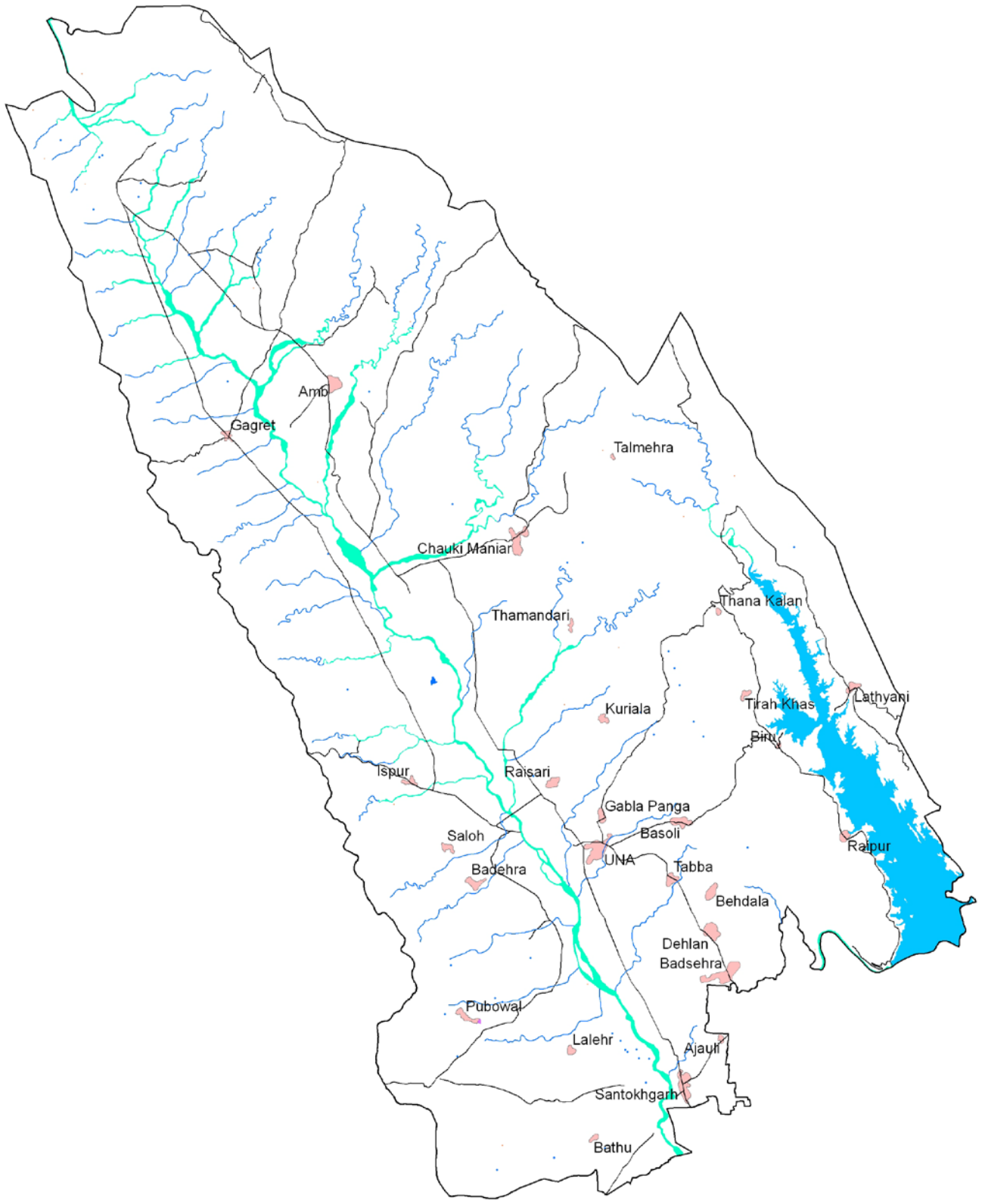
Area under Aquatic Vegetation	-	1158

Area under turbidity levels		
Low	4755	2989
Moderate	524	442
High	-	-

State : Himachal Pradesh

WETLAND MAP

District : Una



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
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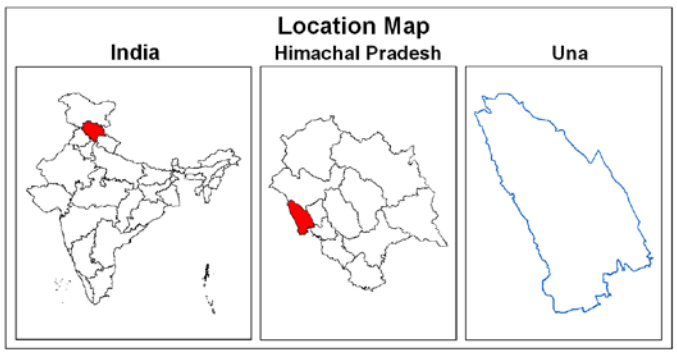
Location Map



5 2.5 0 5 Kilometers

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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
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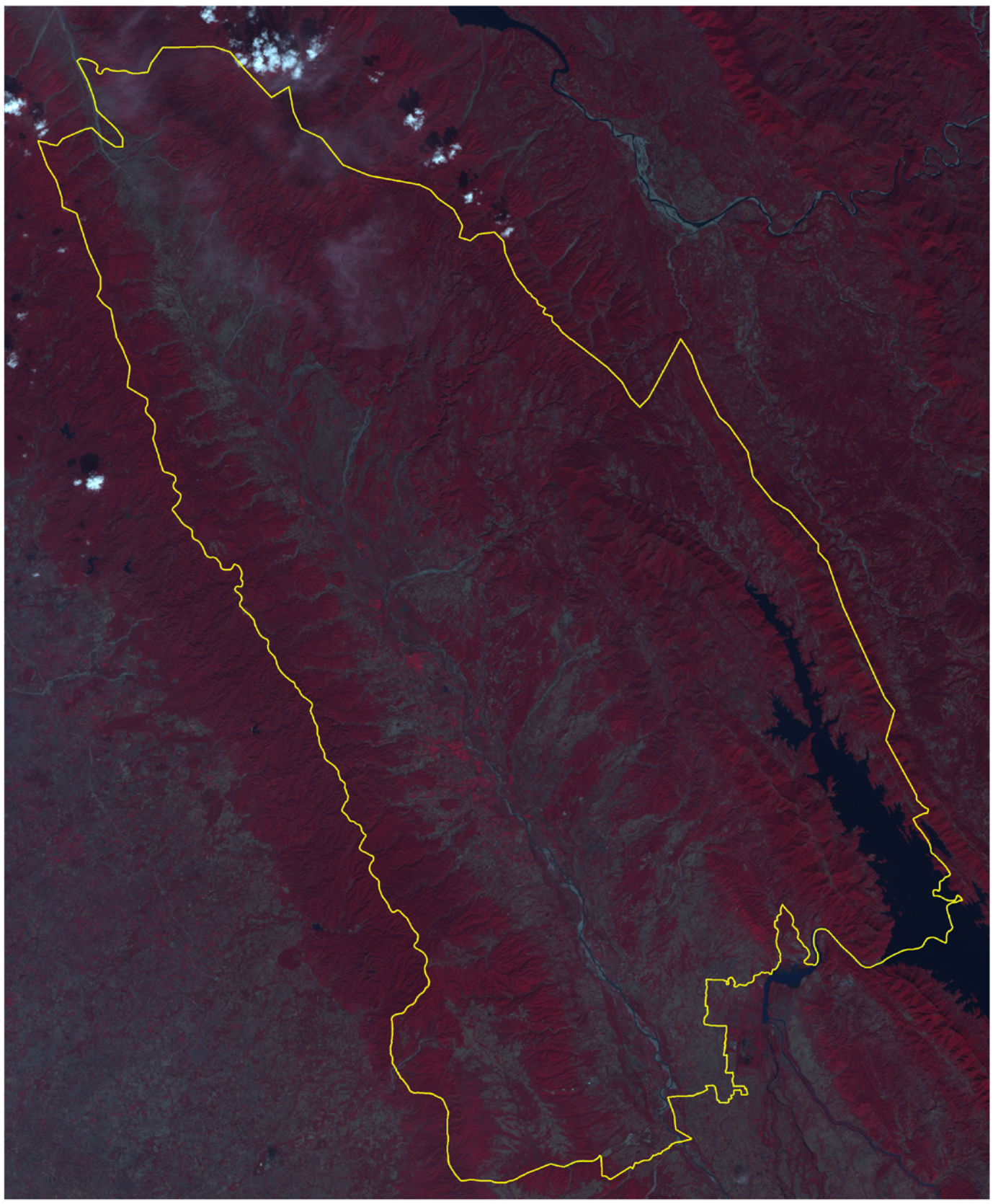
State : Himachal Pradesh

District : Una



IRS-P6 LISS-III Post-monsoon data(2006-2007)

MAJOR WETLAND TYPES

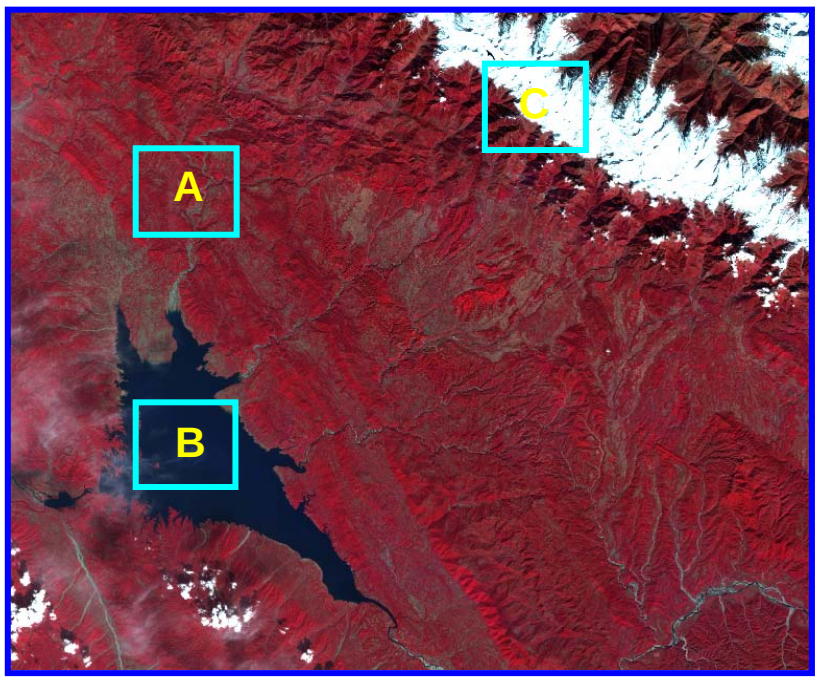
9.0 MAJOR WETLAND TYPES OF HIMACHAL PRADESH

Remotely sensed studies reveled that the wetland category of river/stream is the most dominant wetland type in the state followed by reservoirs and high altitude wetlands. Himachal Pradesh is abounding with majestic rivers, These rivers criss-cross the entire mountain chain forming velleys and deep gorges. These systems are drained by numerous tributaries. The drainage system of the region includes the Chandra Bhaga or the Chenab, the Ravi, the Beas, the Sutlej and the Yamuna. These rivers are perennial and are fed by snow and rainfall. The rivers change significantly from post monsoon to pre monsoon period. The river beds are of rocky composition, with deep blue water during pre monsoon to swirling water flowing from bank to bank during monsoon. They are protected by an extensive cover of natural vegetation.

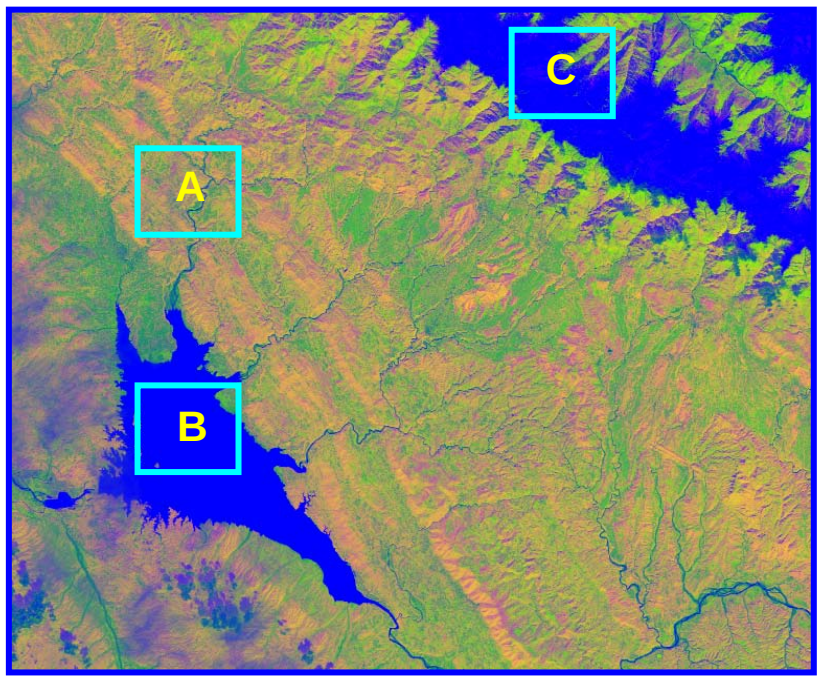
Lakes are numerous in number. Because of the elevation gradient in the state, the lakes are distributed over different elevations giving each one a characteristic hydrology.

Reservoir/barrage is impoundments constructed on major rivers to meet the requirement of irrigation, drinking water, and power generation. The state is known for the Govindsagar reservoir, one of its kind of gravity dam in the country.

The field photographs along with description of representative wetland types are given here along with their manifestation in remote sensing data.

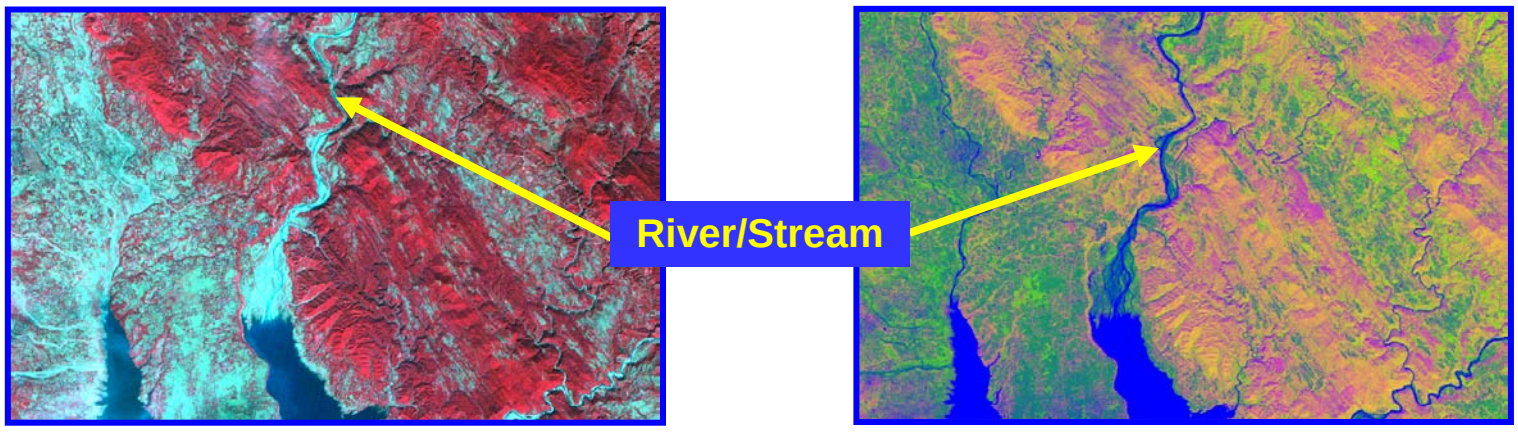


Northern Part of Himachal Pradesh
(IRS P6 LISS-III FCC, October 1, 2005)



Northern Part of Himachal Pradesh
(MNDWI NDPI NDVI from LISS-III data)

A :



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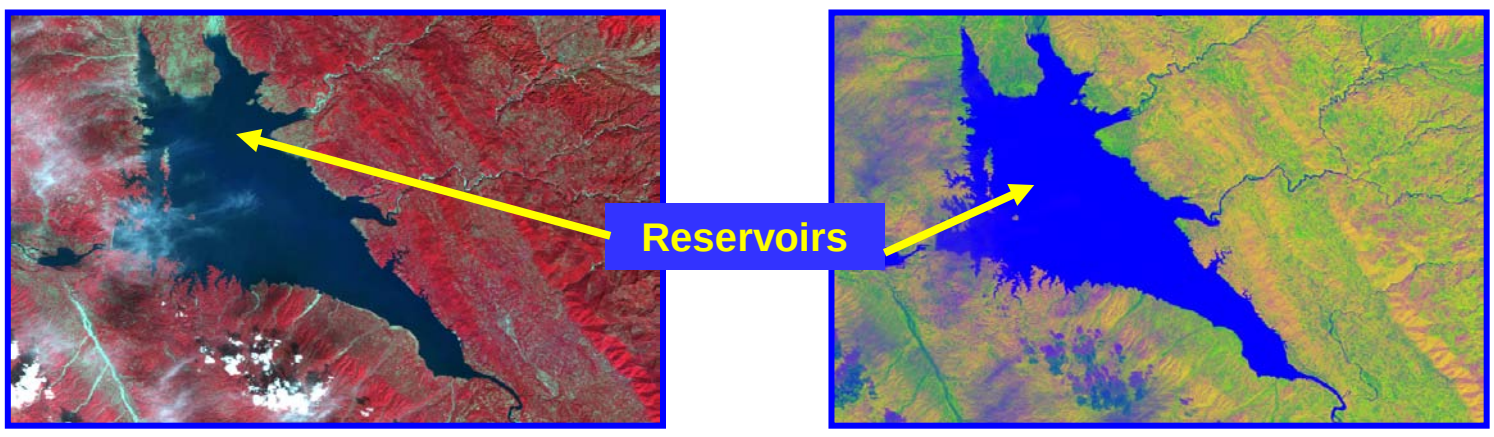

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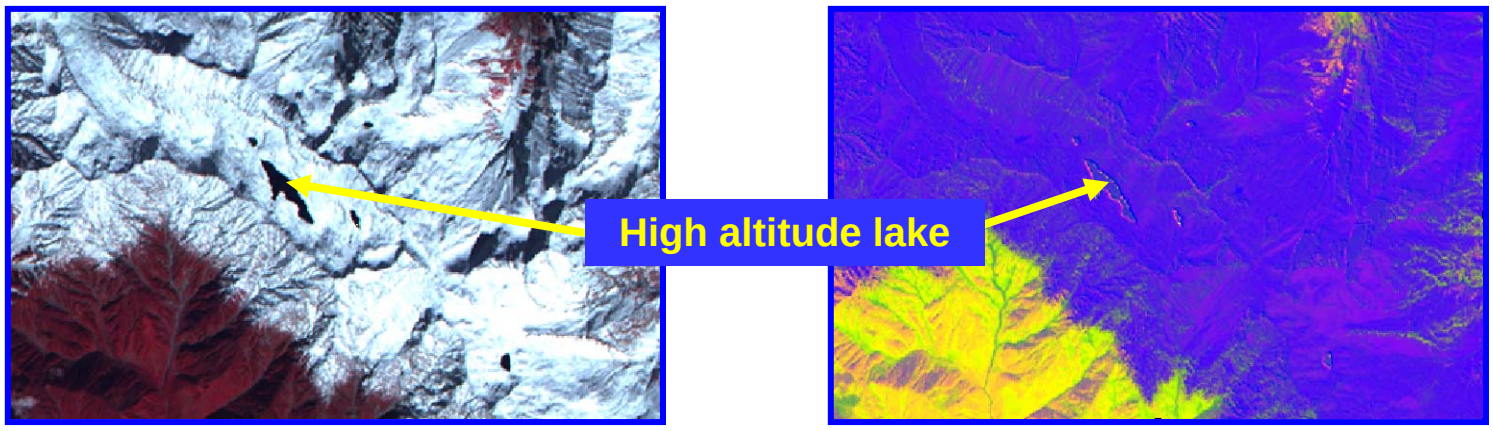


Plate 1: Major wetland types of Himachal Pradesh

Figure 12: Rivers and streams in Himachal Pradesh during pre and post monsoon

Figure 13: Bank vegetation in rivers in plains and higher elevation areas (river Sutlej)

NATURAL LAKES

The state is dotted with many natural lakes of spectacular beauty. Broadly, the lakes can be categorized as low altitude, mid altitude and high altitude ones. Some of the important lakes of different category are:

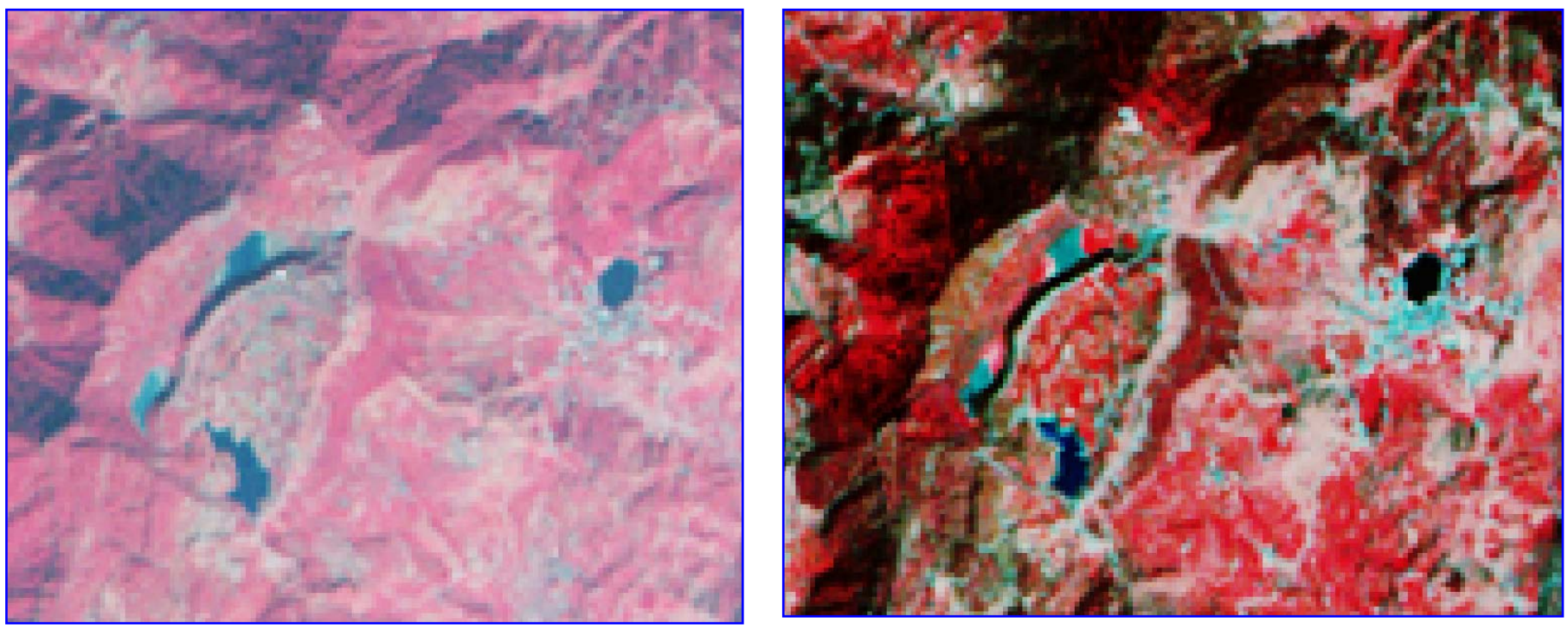
Low Altitude Lakes : Lying in the elevation range of less than 1000m, there are many lakes including Renuka and Macchial Lake.

Renuka lake is the most famous lake in HP and is a Ramsar site. About 45 km from Nahan this legendary natural lake is named after Renuka, mother of Rishi Parsuram. Macchial Lake is situated in Mandi district (6 km from the Jogindernagar town). This lake is considered sacred and is named after Macchendru Devta or Matasya Avtar of Lord Vishnu.

Mid Altitude Lakes : Lying in the elevation range of below 3000 m, there are many lakes viz. Khajjiar Lake, Rewalsar Lake, Kuntisar lake, Sukhasar, Kumarwah Lake, Dal Lake, etc.

Khajjiar lake is in Chamba district. 16 kms from Dalhousie and 25 kms from Chamba. Fed by slim streams, this small lake rests in the centre of the large glade of Khajjiar. The glade and the lake are held sacred to Khajjinag - after whom the place is named. The surrounding area of the lake is 'spongy' due to dense growth of weed called 'vacha' over which dust has formed a thick layer of earth

Rewalsar lake is about 25 km from Mandi,. Lying in a mountain hollow, the lake is held sacred to Hindu, Sikh and Budhist communities. Shaped quite like a square and with a shoreline of 735 meters it lies at elevation of 1330 m amsl. The other two lakes- Kunti and Sukhasar lie near to Rewalsar.



IRS LISS-III post-monsoon data pre-monsoon data

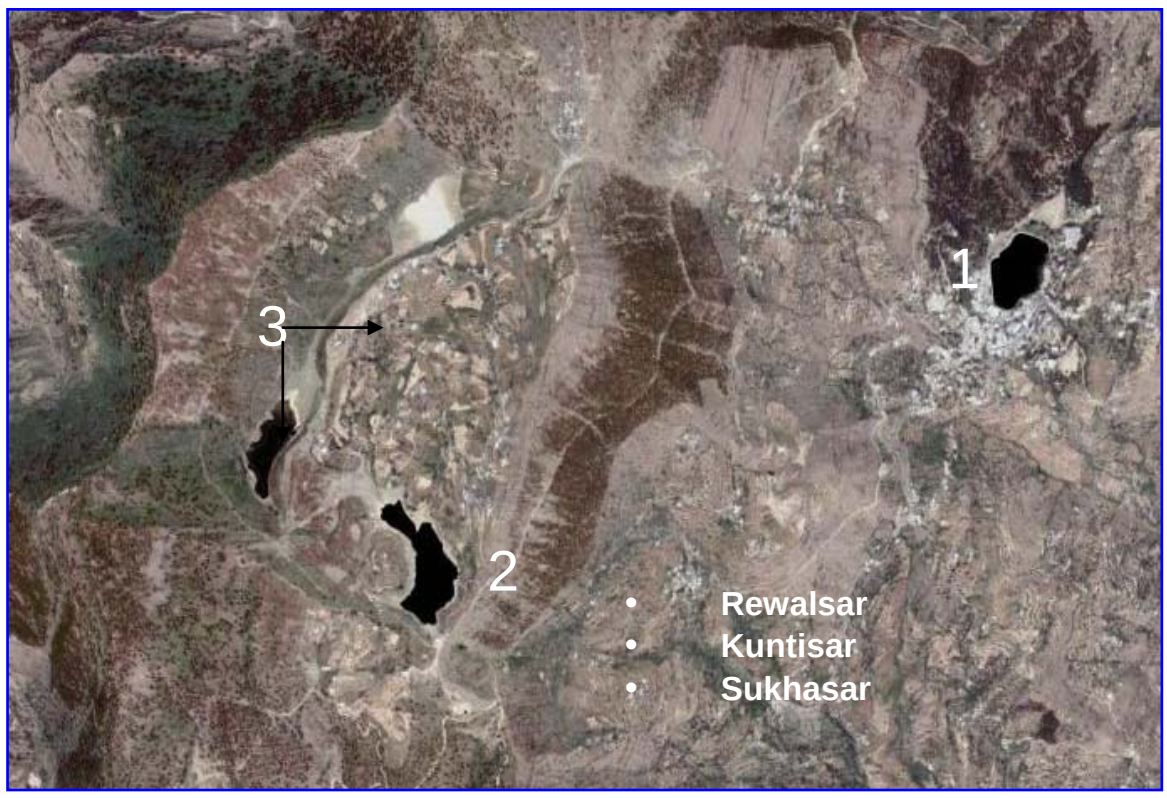


Figure 14: Riwalsar, Kuntisar and Sukhasar: three lakes in Mandi district as seen in satellite image.

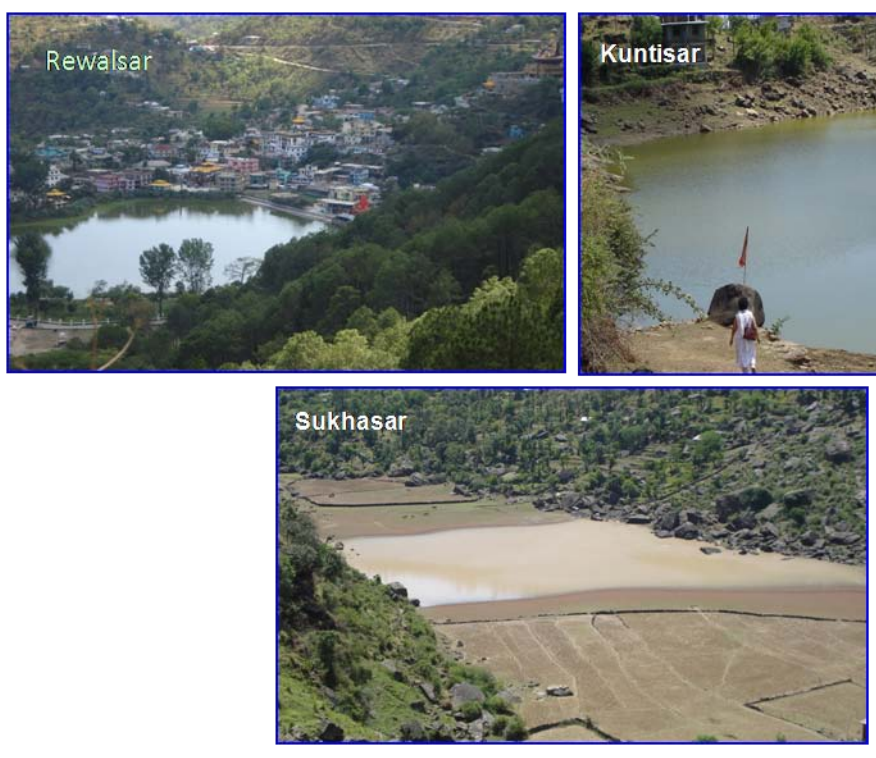


Figure 15: Riwalsar, Kuntisar and Sukhasar: three lakes in Mandi district as seen in field photographs

High Altitude Lakes

There are many high altitude lakes lying above 3000 m elevation range, mainly in Nothern districts of the state. Chadertal lake in Mulkila range at 4000 m amsl, is probably the best and most scenic spot in Lahual Spiti valley. Some of the other famous lakes are:, Brighu lake, Suraj Tal, Nako Lake, Dhankar Lake, Dashair, Seruvalsar, Manimahesh, Ghadhasaru, Mahakali, Lama Dal etc..

Bhrigu lake situated at a height of 4200 m near Manali with Vashist and Gulabo as approach points it draws its name from Bhrigu Peak.

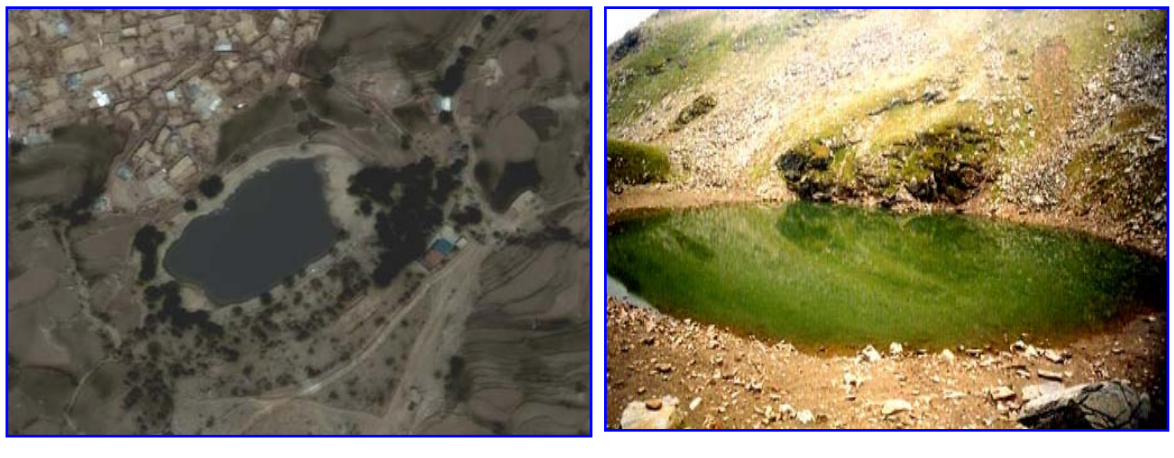


Figure 16: Bhrigu lake as seen in satellite image and the field photograph

Nako Lake is situated at an altitude of 3635 m amsl, surrounded by hills in village Nako, 3-4km from Recong-Peo, the head-quater of district Kinnaur. The lake is surrounded by willow and poplar trees. It is famous for its wonderful climatic conditions. The water for Nako lake comes from its bottom core.

Figure 17: Nako lake

Suraj tal is a small lake situated at 4833 m amsl, with in a short distance from Keylong in Lahaul. This is considered as a sacred lake.

Figure 18: LISS III FCC showing the Suraj tal during post monsoon and the photograph of the scenic view of the lake

Manimahesh Lake located in Chamba district, 32 kms from Bharmaur. Held sacred to lord Shiva this lies in the Budhil valley at the foot of the Manimahesh ranges. The peak of Manimahesh Kailash is regarded as one of the mythical abodes of Shiva. This tarn is the venue of the annual Manimahesh yatra.

MAN-MADE WETLANDS

Barrages, reservoirs, tanks/ponds are some of the man-made wetlands found in the state of Himachal Pradesh.

Barrages

There are few barrages made on Beas and Sutlej river. The Barrage at Sundernagar is one of the famous barrages of the state, situated at 845 m amsl on river Sutlej.

Figure 19: The barrage on Beas river at Marhi

The barrage on Beas river at Marhi (on Manali-Rothang road, 12 km before Rohtang pass) is a very scenic one. Situated at 3255 m amsl, it is the highest barrage in the state.

Reservoirs

Govindsagar reservoir, Pandoh reservoir, Pong dam lake are some of the important reservoirs of the state.

Pong dam is located in Kangra district of Himachal Pradesh. It is one of the most efficient reservoirs in terms of power generation and controlling irrigation to down stream districts of Punjab and Haryana state.

Chamera Reservior is situated near Chowrah village, Chamba district. Chamera Reservoir is linked with Pathankot town by a 97 km long road. The river basin is lying along the Himalayas and touching the Shivalik hills on the Southern fringe. The reservoir has a water spared area of 900 ha and catchments area of 472 sq.km. It has a mean depth of 43.5 m.

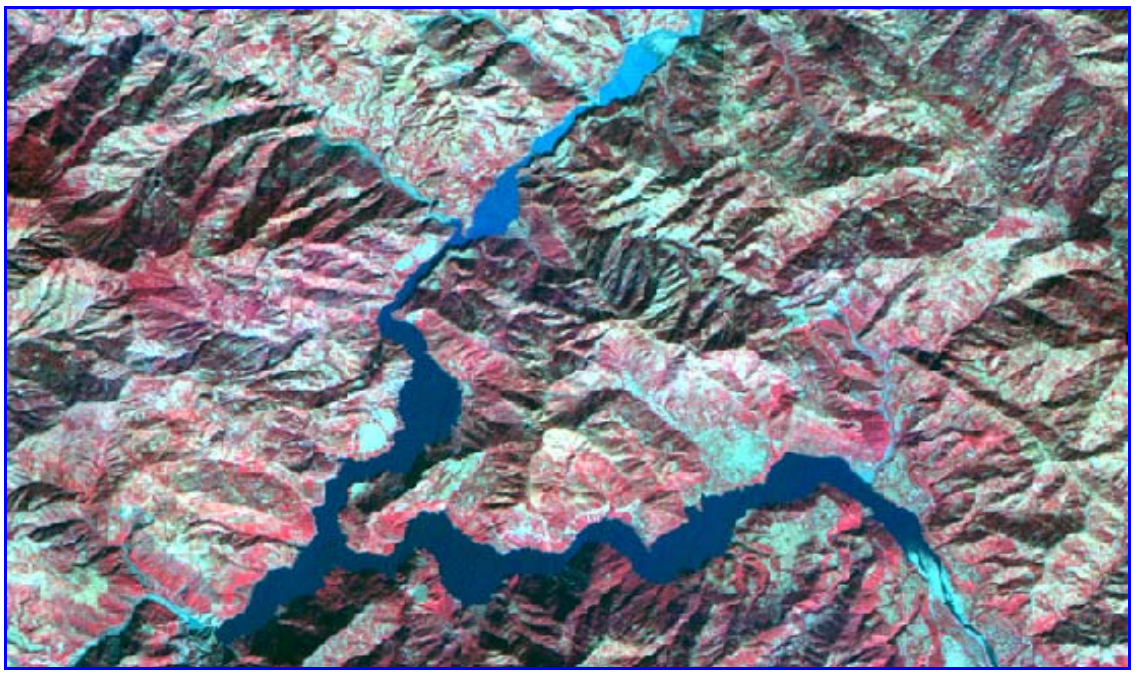


Figure 20: IRS LISS III FCC showing the status of Chamera reservoir during post monsoon (2006)

Pandoh reservoir is a minor irrigation project generates power and controls floods during monsoon season. Plankton studies were carried out before the impoundment and after the construction of dam however, a little is known about its catchment characteristics.

Figure 21: Field photograph of Pandoh reservoir

Man-made ponds/lakes

There are few man made village ponds/lakes, observed mainly in low elevation areas. These pond mainly serve for animal husbandry purpose. Few small ponds in Mandi district are under lotus cultivation.

Figure 22: Field photograph of Village ponds: a shallow pond, a highly eutrophic pond and a lotus pond in Mandi district.

IMPORTANT WETLANDS OF HIMACHAL PRADESH

9.0 IMPORTANT WETLANDS OF HIMACHAL PRADESH

The state is known for many sceinic places of river spots, lakes, reservoirs. Some of the important wetlands of the state are selcted for detailed study is: Chandertal Lake, Renuka wetland, Govindsagar reservoir, Pong dam lake, Prashar lake. Wetland maps have been prepared for 5 km buffer area of each wetland sites. Details of each wetland and wetland map of 5 km buffer area are shown in plates 3-23.
Chandertal lake is one of the high altitude wet lands located in Lahul & Spiti district and fed from neighboring glaciers and snow clad ridges. These wetlands are not visible during post-monsoon season satellite data due to snow cover but during summer season they are visible and show low turbidity.

Pong dam is located in Kangra district of Himachal Pradesh. It is one of the most efficient reservoirs in terms of power generation and controlling irrigation to down stream districts of Punjab and Haryana state.

Renuka wetland has its religious significance also harbors variety of flora and fauna. It was declared Wildlife Sanctuary under the 1972 Wildlife Protection Act.

Prashar lake is a mid altitude lake in Mandi district set in the sub alpine meadows. It is strongly associated with the local religious sentiments and famous tourist destination.

9.1 Chandertal Lake

The Chandertal with its deep blue icy water, surrounded by snow and acres of scree, constitute an important high altitude cold desert wetland of western Himalayas. Its latitudinal and longitudinal positions are 32^{O} 29' N and 77^{O} 36 ' E respectively. The lake is in Lahul and Spiti district and situated at an altitude of 4270 metres. The lake can be approached from 'Batal' which is 120 Kms from Manali on Manali – Kaza State Highway. Alternatively, one can reach Chandertal on foot via 'Kunjam La' (12 kms.) that connects Spiti and Lahul.

Figure 23: View of the beautiful high altitude Chandertal lake, Lahul Spiti district, HP (with crystal clear water, massive scree and snow clad peaks).

This natural lake is about one km in length, half km in breadth at its widest part and has a circumference of 2.5 kms. The total area of the wetland is about 49 ha. The lake owes its name either to the fact that it is the source of the river Chandra, or by virtue of its crescent moon like shape. According to some believers, this is the spot from where the god Indra's chariot took the eldest Pandava brother, Yudhishtra to swarga, heaven in his mortal form. The mountains peaks with snow caps and slopes around the valley rise up to 3000 metres to 6300 metres. The mountain ranges are called Moulkila and Chandrabhaga. This crystal clear blue water lake lies in a broad grassy plain, which in ancient times was a glacier. Thus ,the Chandertal wetland is covered by glacial type of soil, which is not fully developed. The lake has been formed due to blockades of rock basin by scree and para glacial deposits and the glaciers are the main source of inflow. There is also a regular outflow of water that keeps on varying depending upon the season. Chandertal wetland helps in the reduction of floods in downstream as water moves into wetland faster than it moves out downstream part of the channel.

The region of Chandertal is characterized by the oxygen deficiency, low atmospheric pressure, intense radiation, excessive coldness, aridity and revitalizing climate. The average snowfall recorded is 75cm. The winters are extremely cold with mercury dipping down to -37^{o} C to -40^{o} C. The lake begins to freeze in the month of October and by December it is completely frozen. The turbidity is also very low, and free from eutrophication. About 65% of the catchment area is a degraded forest due to glacial action. Herbs and grasses cover rest of 35% of the area. From June to September . shepherds from Kangra, Mandi and Kulu can be seen with their herds of sheep at Chandra pastures.

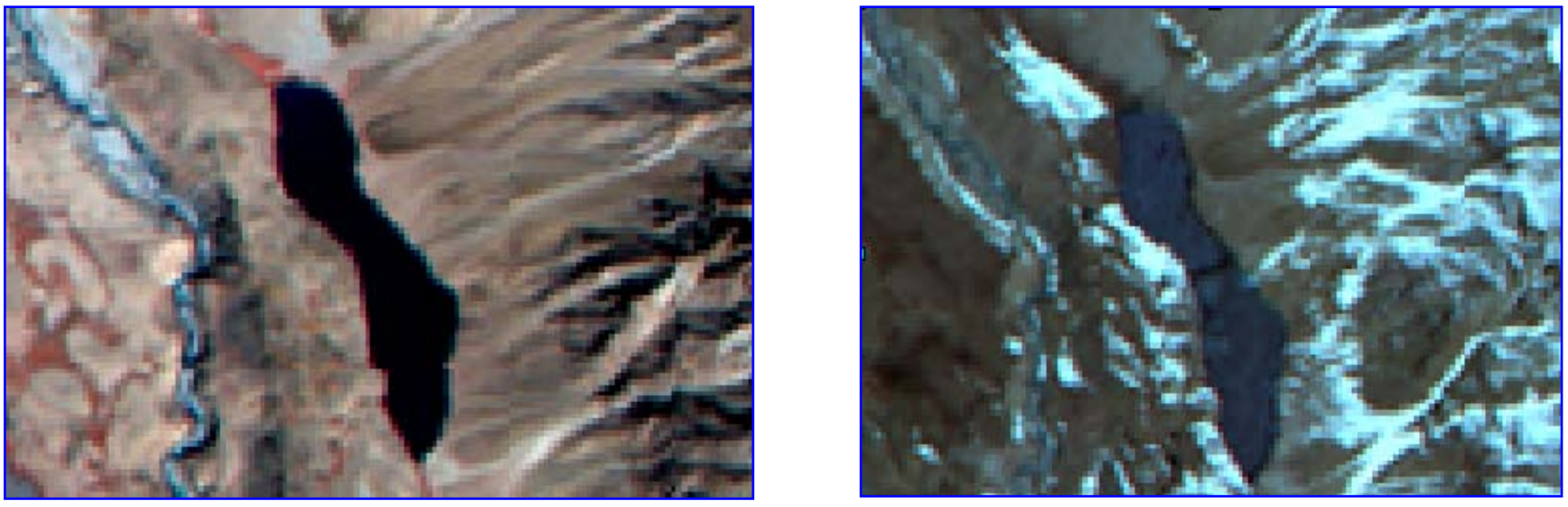


Figure 24: Chandertal as seen in IRS LISS III FCC during post and pre monsoon period (2006-07).

The Chandertal Lake and its catchment area fall in the Alpine zone that is characterized by the absence of trees. Since the lake is free from any human activity in the immediate vicinity it is free from eutrophication. However, many algal species has been reported viz. *Caloneis bacillum, Chroococcus schizodermaticus Cosmarium decoratum, Cymbella laevis Naeg, Fragilaria pinnata Microspora floccose, Navicula cryptocephala, Oedogonium figuratum, Schizomeris leibleinii and Zygnema Khannae.*

The clean water of the lake with small marshy patches around attracts many migratory birds. Important species noted are: Snow cock, Chukar, Black winged stilt, Brahmni duck, Golden eagle and Chugh, Hoopoe, Yellow Headed Wagtail, Jungle crow, Blue rock pigeon, Common rose finch, Black redstart, Short toed Eagle, Common Sandpiper, Teal, Magpie Robin etc. The important wild life species found in the region are Marmota Bobak, Snow leopard, Red fox, Snow wolf, Capra ibex, Blue sheep, Lynx, .

The herbaceous growth in the catchment area is remarkable for its variety. The important species are *Potentila, Ranunculus*, *Acquilegia, Primula, Aconitum, Aster, Asteraglus, Bistorta affinis,Delphinium, Geranium, Oxyria, Potentilla, Polygonum, Ranunculus, Rosularia, Stellaria, and Thymus* species. The common grasses frequently encountered are *Poa* and *Agropyron.* These grasses have rich nutritive value.

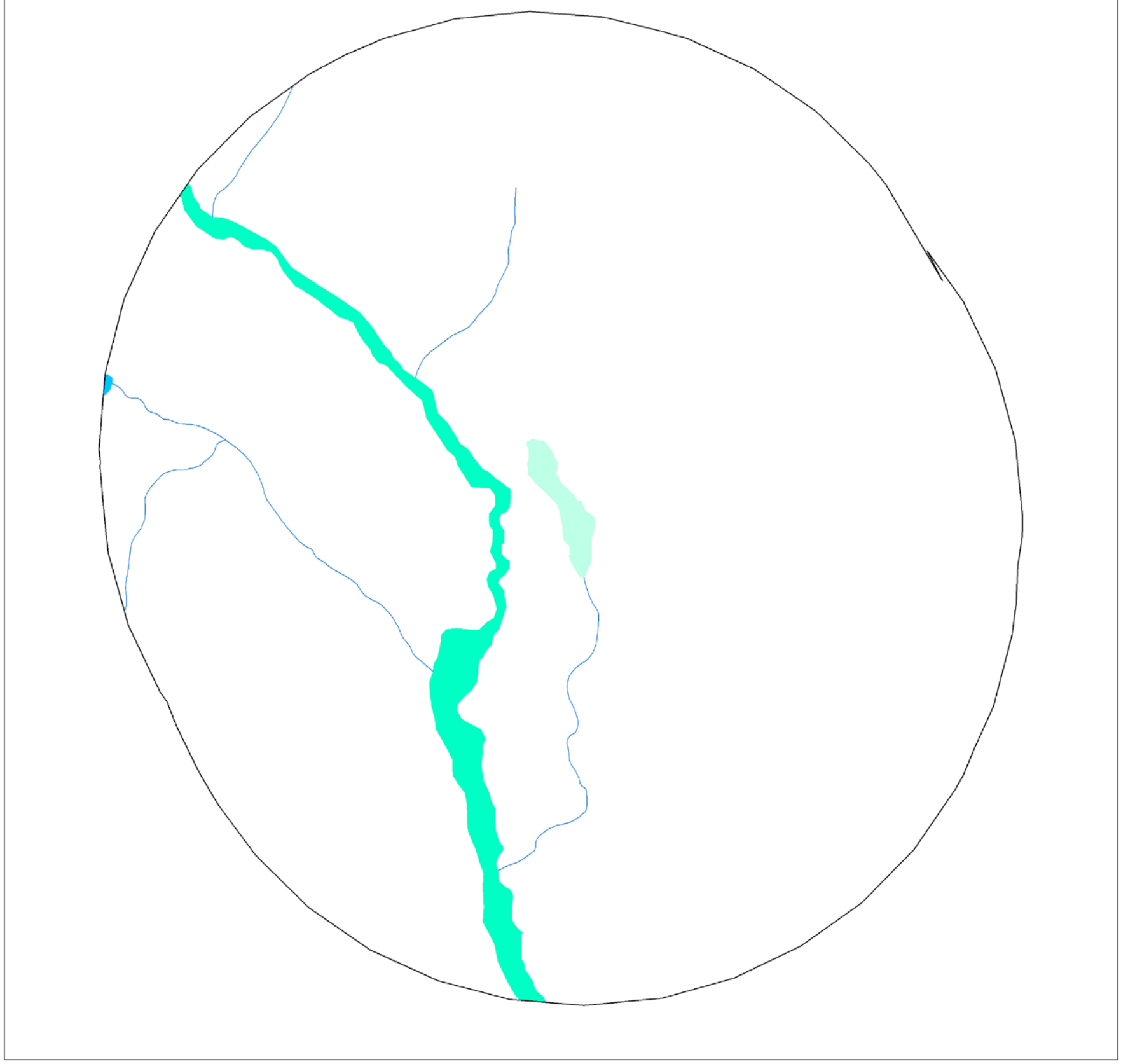
Figure 25: Some of the common herbaceous species found in the grassy catchment of the Chandertal lake

Some of the common herbaceous species found in the grassy catchment (centre photo) of the lake are: (Clock wise): *Geranium Pratense, Jurinella macrocephala (royle) , Duchesnea indica (Andrews) Potentilla atrosanguinea, Oxyria digyna, Bistorta affinis*

State : Himachal Pradesh

WETLAND MAP

Chandertal Lake



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	1105			Waterlogged
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	1201			Reservoirs/Barrages
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			Man-made	
	2201			Salt pans
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Legend

- Wetlands (<2.25ha)
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- District boundary
- State boundary
- International boundary

Location Map

India | Himachal Pradesh | Chandertal Lake

0 0.5 1 2 Kilometers

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

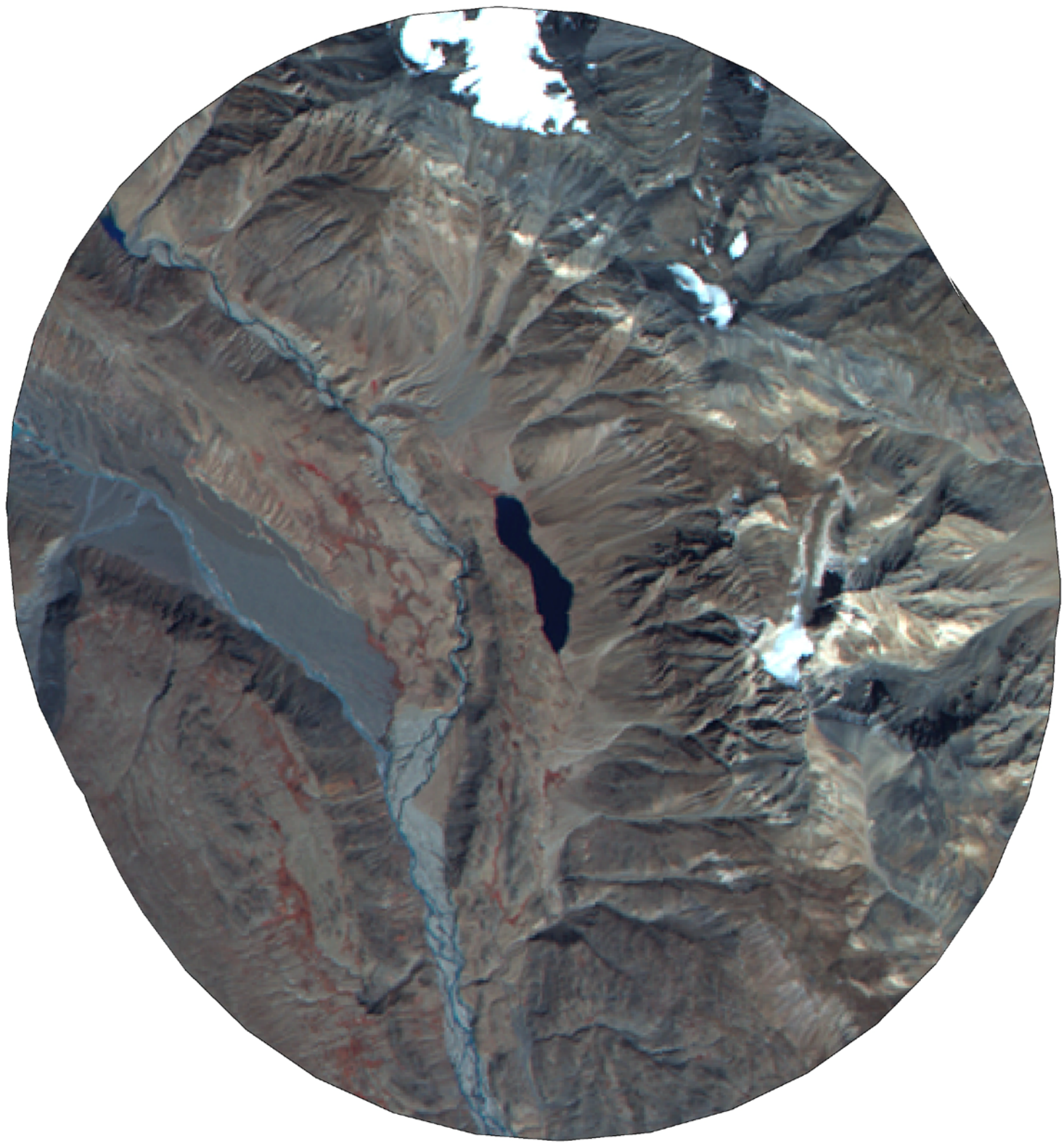
Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
Ministry of Environment and Forests
Government of India

Plate 3: Wetland map - 5 km buffer area of Chandertal Lake

State : Himachal Pradesh

Chandertal Lake



IRS-P6 LISS-III Post-monsoon data(2006-2007)

Plate 4: IRS LISS III FCC - 5 km buffer area of Chandertal Lake

9.2 Govind Sagar :

The Govind Sagar (spread between 31^0 12' 52" N and 31^0 36' 29" N latitudes and 76^0 21' 52" E and 76^0 46' 39" E longitudes) over the river Sutlej, is the result of the huge hydel dam at Bhakra and is named in honour of Gobind Singh the tenth Sikh guru. One of the world's highest gravity dams, the Bhakra rises 225.5 m above its lowest foundations. Its reservoir - the Govind Sagar - is 90 kms long and encompasses an area of 15739 ha.

As far back as 1962, the Govind Sagar was declared a 'water fowl refuge' and even today, hosts a variety of water and shore birds. Fishing is a regular activity and 51 species and sub-species have been recorded. The varieties found, include *Labeo dero, Tor putitora, Mystus seenghala* and mirror carp and allied species.

Figure 26: Views showing bank vegetation of inlets to Govind sagar.

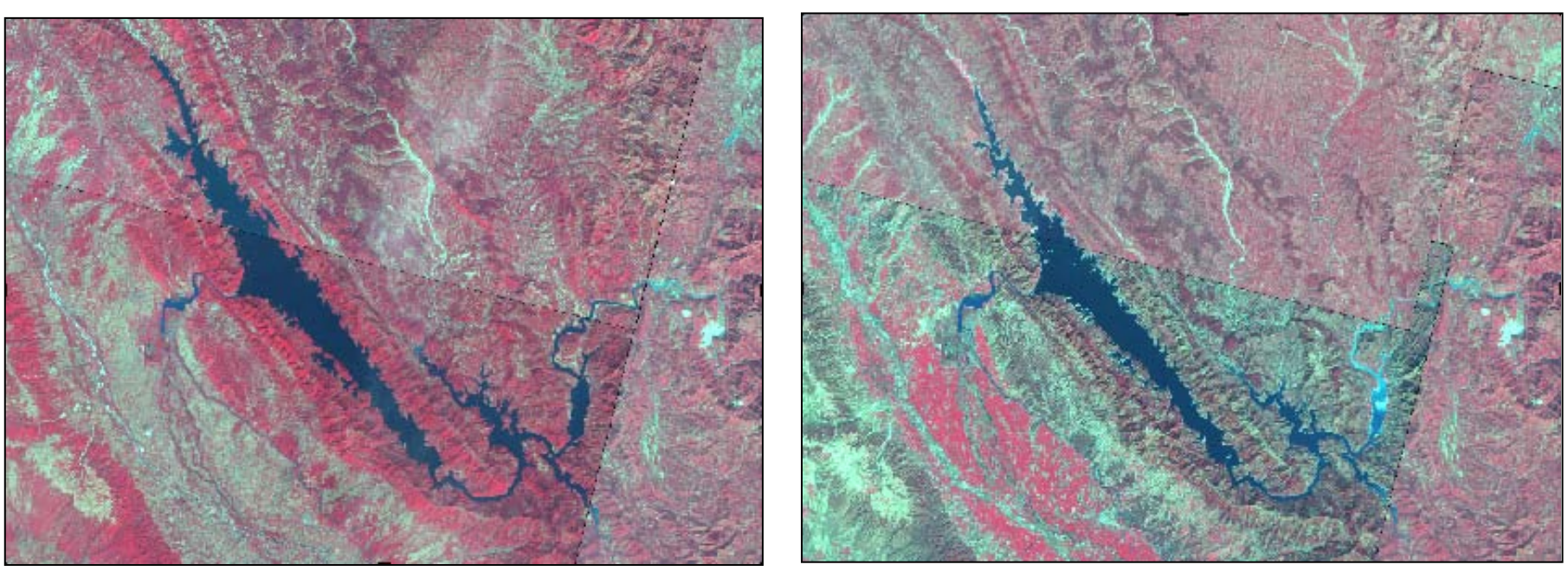


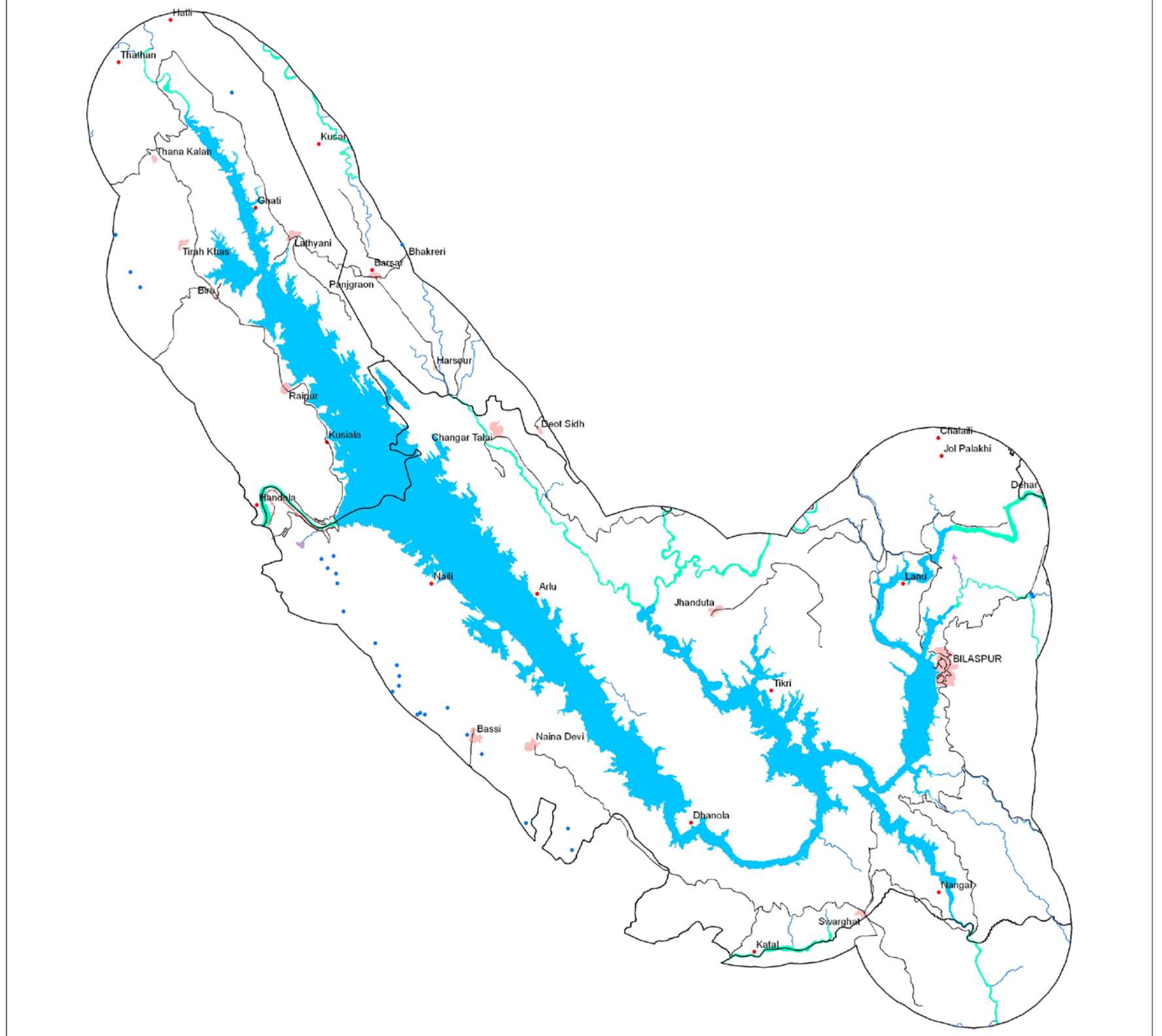
Figure 27: LISS III FCC showing the status of the reservoir during Post and Pre-Monsoon (2006-07)

It is also famous far water sports. In October and November, when the water level of the reservoir is at its peak, a series of regattas are also organised by the Department of Tourism and Civil aviation.

State : Himachal Pradesh

WETLAND MAP

Govindsagar Reservoir

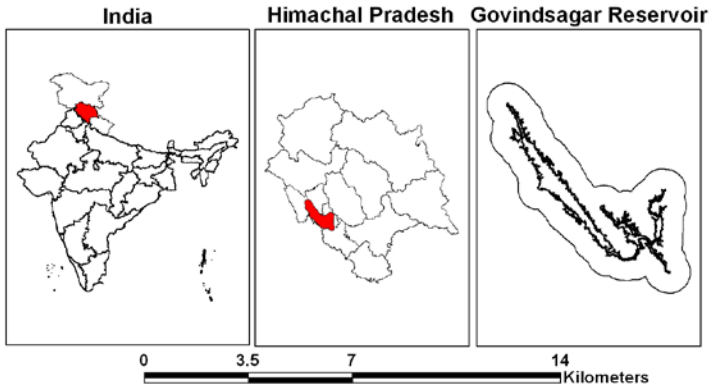


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

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Government of India

Plate 5: Wetland map - 5 km buffer area of Govind Sagar Reservoir

State : Himachal Pradesh

Govindsagar Reservoir

IRS-P6 LISS-III Post-monsoon data(2006-2007)

Plate 6: IRS LISS III FCC - 5 km buffer area of Govind Sagar Reservoir

9.3 Pong Dam (Distt. Kangra) - Ramsar Site (2002)

Pong is a recently created reservoir on the Beas River in the plains of Sansarpur Terrace, district Kangra (between 31^0 52' 14" N and 32^0 07' 31" N latitudes and 75^0 53' 04" E and 76^0 13' 36" E longitudes). Located at an elevation of 450 m amsl, it has a length of 41.80 km, width of 13.73 km and sprawls over an area of 24532 hectares. The dam is an important source of electricity and irrigation. There is some submerged vegetation in the reservoir, but because of the pronounced seasonal changes in water level, the shoreline does not support extensive areas of emergent vegetation. The surrounding hill sides have mixed deciduous and pine *(Pinus roxburghii*) forest.

Zoological Survey of India has recorded 447 faunal species in wetland area. 220 bird species (i.e. Bar headed geese, Northern lapwing, Pintail, Common teal, Mallard and Coot) belonging to 54 families have been recorded. The Black headed gull, Great black headed gull and herring gull species which are fairly uncommon in India away from the coast, visit the reservoir each winter.

A total of 27 fish species belonging to six families have been encountered in the Pong reservoir. Mahseer (*Tor putitora*) is highly precious and sought - after fish of the Pong reservoir. The Cat fish (*Mystus seenghala*) has been showing constant increase during the last 10 years, therefore Pong reservoir may be categorized as a cat fish reservoir.

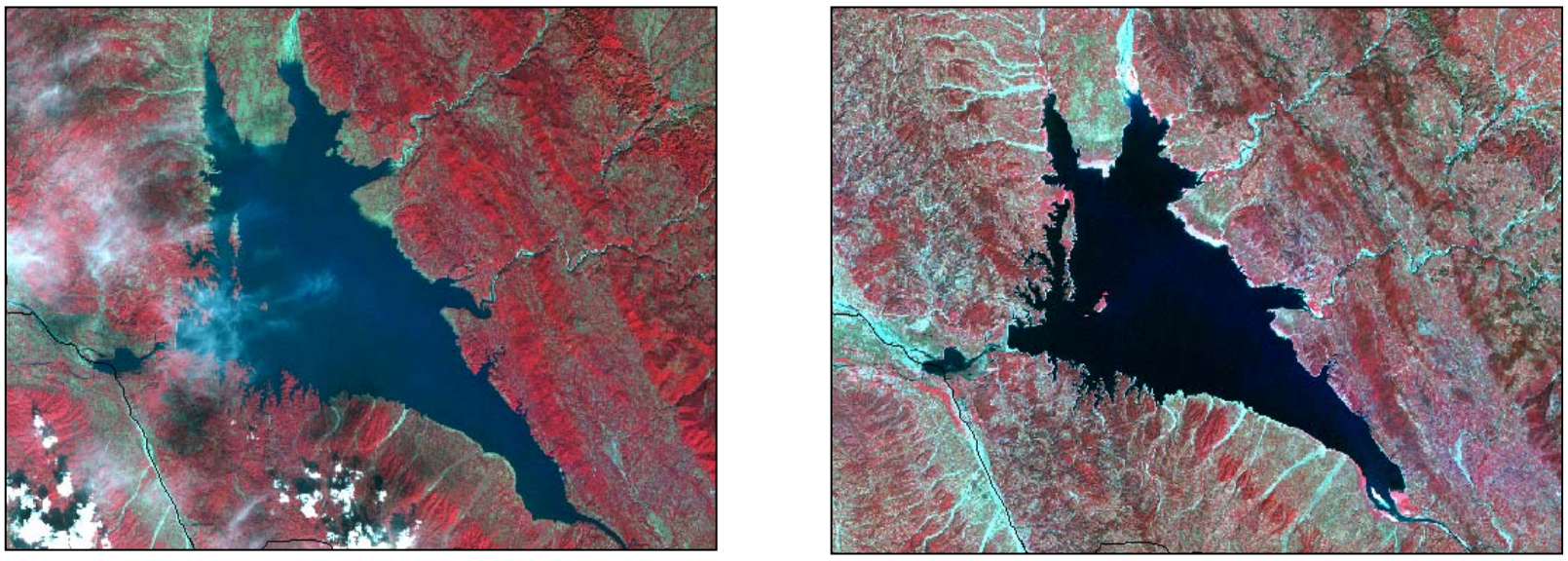


Figure 29: IRS LISS III FCC showing the status of Pong dam during post and pre monsoon (2006).

Figure 30: Views of the Pong Reservoir

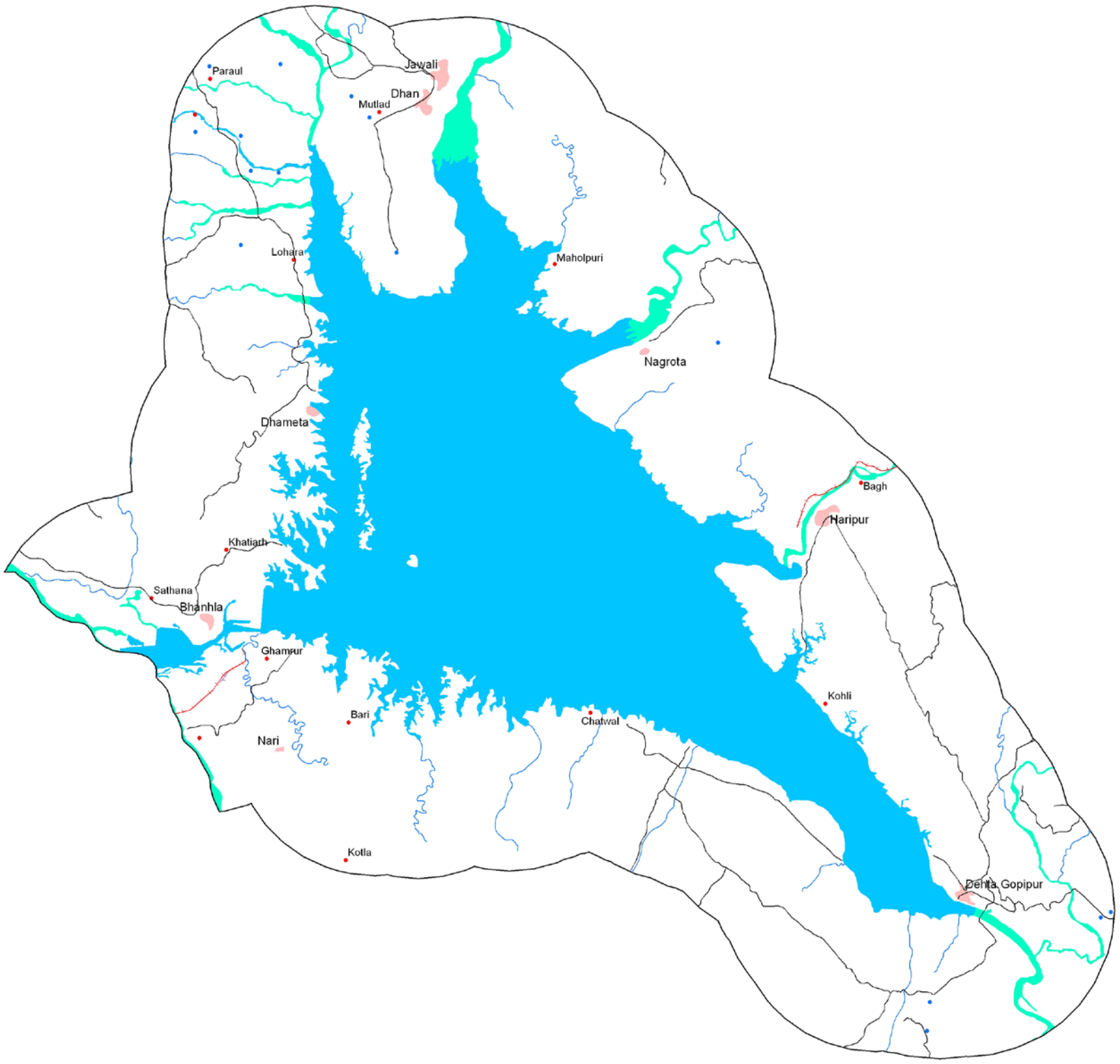
Figure 31: Vegetation in the islands within the Pong reservoir

Figure 32: The migratory birds in Pong (the famous herring gulls and the black headed gulls)

State : Himachal Pradesh

WETLAND MAP

Pong Dam Lake

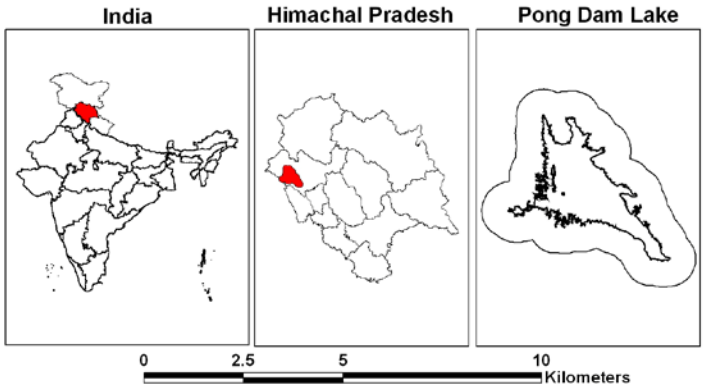


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
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HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

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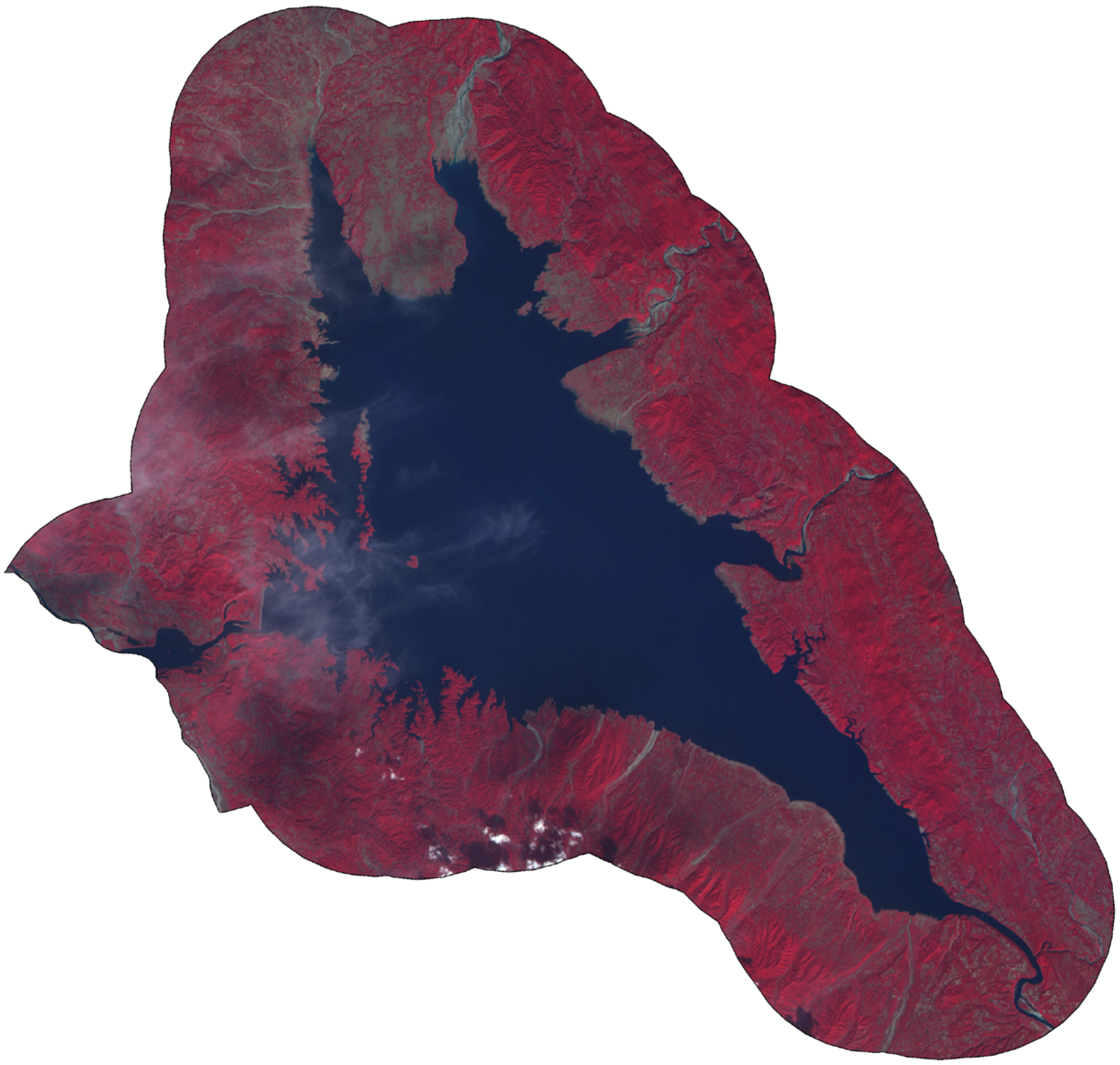
Government of India

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

State : Himachal Pradesh

Pong Dam Lake



IRS-P6 LISS-III Post-monsoon data(2006-2007)

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

9.4 Renuka Lake

Renuka lake, with a circumference of 321m, is the largest natural lake in Himachal Pradesh, situated 37 km from Nahan in district Sirmaur. (Between 30^0 36' 44" N and 30^0 36' 42" N latitudes and 77^0 26' 59" E and 77^0 27' 58" E longitudes). The area of the wetland as derived from remote sensing data is 29 ha.

Renuka wetland besides having religious significance also harbors variety of flora and fauna. It was declared Wildlife Sanctuary under the 1972 Wildlife Protection Act. It is located at an altitude of 660 m above msl. Shaped like the profile of a reclining woman, this is regarded as the embodiment of the goddess Renuka, wife of rishi Jamdagni. The lake rests in a long valley and the surrounding slopes are covered with a variety of vegetation and thick woods. Near the lake's feet is another lake named after her son, Parshurama. Both have temples built around them and the main temple to Renuka is regarded to have been built in the eighteenth century. There is a row of temples along its banks, and a track encircles the water. An annual fair in the month November attracts devotes and Tourists.

The Renuka Lake is surrounded by lush green forests supporting a variety of animal and bird life.The forests support trees like *Anogeissus, Lucinea, Terminalia, Khair, Shisham, Carrie, Cordia* and a veriety of climbers in moist depressions. The fauna of the area include Lepopard, Samber, Spotted Deer, Barking deer Jackal, Hare, Jungle cat, Civet, Porcupine, Blue jay, Black Partridge, , Hill Crow, , Bulbul, Common Cooots, Greenm Pigeons.The threatened Kaleej pheasant and the more common Red jungle fowl are also found here.

There has been great concern about the ecological deterioration, habitat degradation and eutropification of the wetland due to silting, high levels of organic pollution, habitat degradation, dumping of non-biodegradable materials by pilgrims and tourists. This has not only resulted in habitat deterioration, shrinkage of the aquatic life, but also the terrestrial fauna of Renuka Sanctuary as this is the only perennial source of water for wild animals. Number of check dams was and desiltation tanks were constructed on various streams to minimize the silt deposition in the wetland.

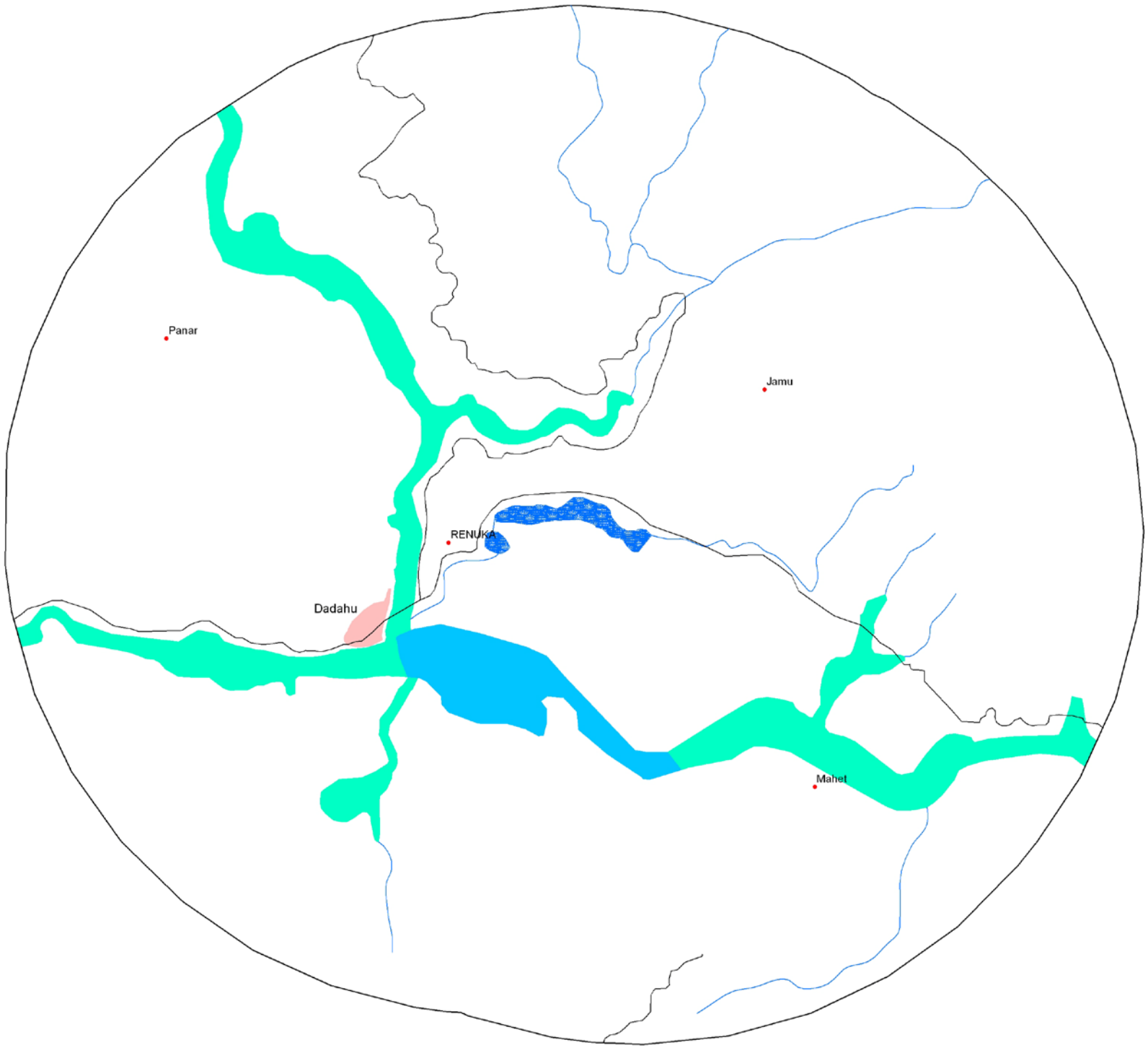
Figure 33: Views of the Renuka lake

Figure 34: Manual desilting at Renuka lake, an action towards reducing siltation of the lake

State : Himachal Pradesh

WETLAND MAP

Renuka Lake



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

Legend

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

Location Map

India | Himachal Pradesh | Renuka Reservoir

0 0.5 1 2 Kilometers

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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

Sponsored by:
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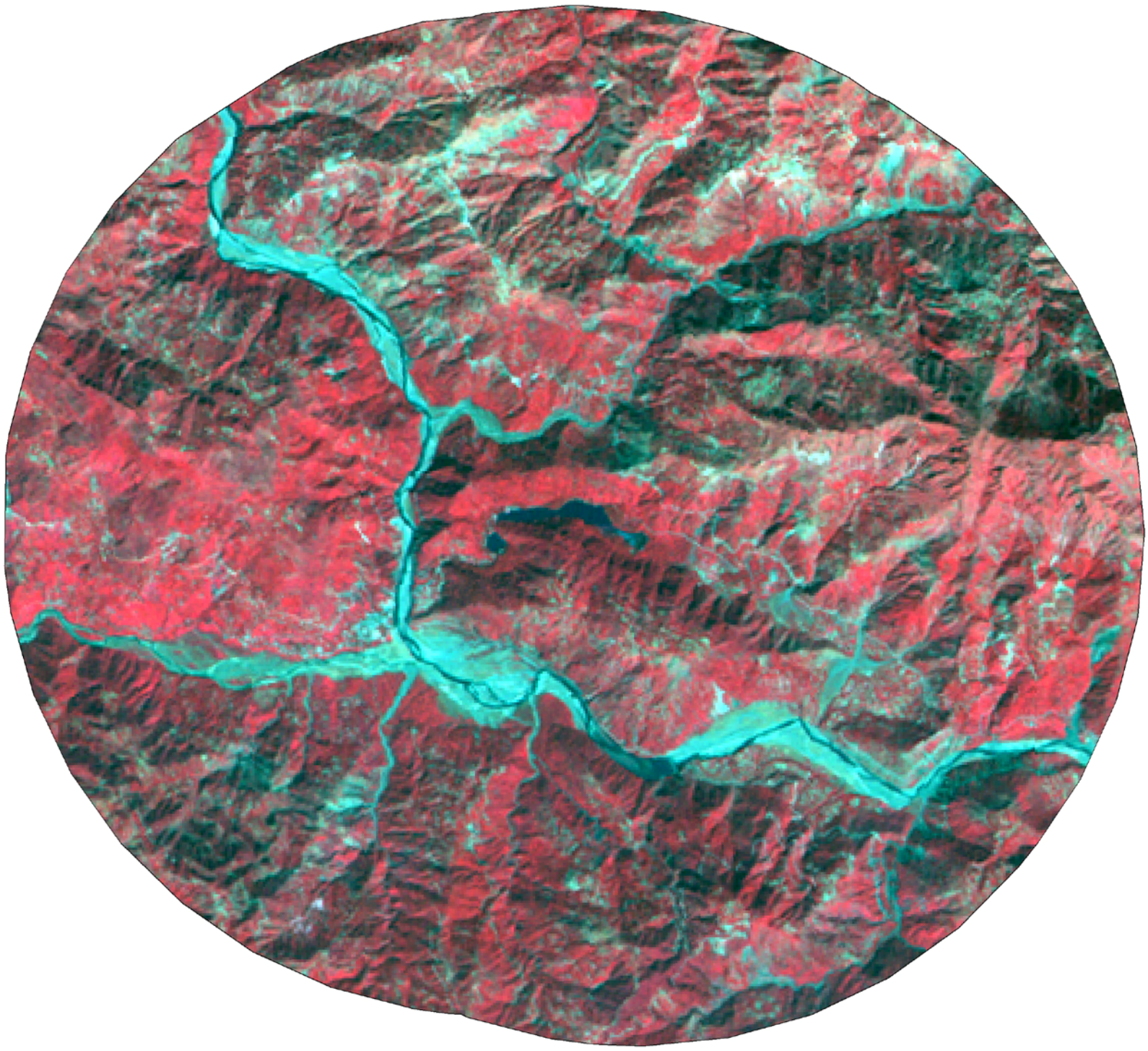
Government of India

Plate 9: Wetland map - 5 km buffer area of Renuka Lake

State : Himachal Pradesh

Renuka Lake



IRS-P6 LISS-III Post-monsoon data(2006-2007)

Plate 10: IRS LISS III FCC - 5 km buffer area of Renuka Lake

9.5 Prashar lake

It is a mid altitude lake located in Mandi district about 40 Kilometre from Mandi town (31.2455 N latitude and 77.090 E longitude) at an altitude of 2600 amsl. The lake is held sacred to the sage Prashar, who had supposed to meditate here. It is a oval lake of around 3 ha area, with crystal clear water. There is a small floating circular island with dense reeds, which shifts position annually. The dimensions of this floating island as deciphered by LISS III data is: Area: 450 sq m, Perimeter: 76.0 m and Diameter: 23.6 m

There is a small picturesque wooden temple dedicated to sage Prashar, who is the principal presiding deity of all the village gods and goddesses of the paraganas of Sanor, Badar and Uttersal in Mandi. Occasional fairs are held at the banks of this lake when hundreds of village folk from the above paraganas gather along with their village godlings. The principal fair is held on and around 15th June every year and is known as Saranahanli, the bathing ceremony of God in the lake.

This lake is set in sub alpine pastureland with evergreen meadows with a large number of rare and medicinal herbs. The lake view undergoes spectacular changes during different seasons from lush green during rainy, to pale gold hue of autumn and snow white during winter. A very favorite destination of tourists, trekkers alike, it has maintained its serenity and not yet polluted. The lake abounds with fishes that had been introduced some times during last decade.

Figure 35: View of Prashar lake (the ancient temple on the bank) during different seasons (autumn, rainy and winter season)

Figure 36: Close view the Prashar lake during September showing the diverse flora of the area

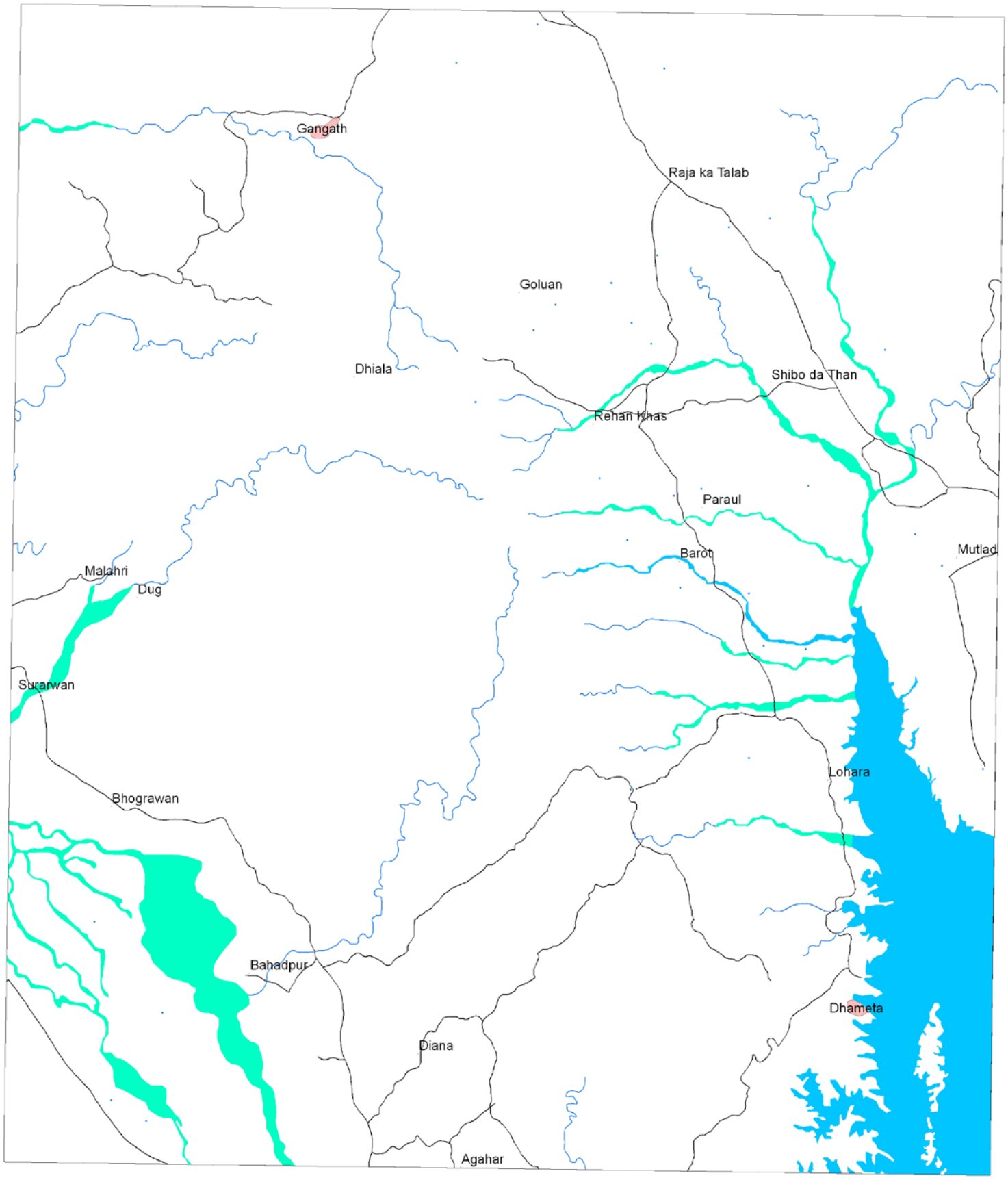
Figure 37: Prashar lake and its surrounding sub-alpine grasslands and forests as seen in post monsoon FCC of remote sensing data.

SOI MAP SHEET-WISE WETLAND MAPS (SELECTED)

State : Himachal Pradesh

WETLAND MAP

Sheet: 43P/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

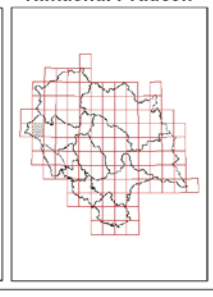
Legend

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

Location Map

India

Himachal Pradesh



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43P/12	43P/16	52D/ 4
44M/ 9	44M/13	53A/ 1

2 1 0 2 Kilometers

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

Prepared by:
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and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

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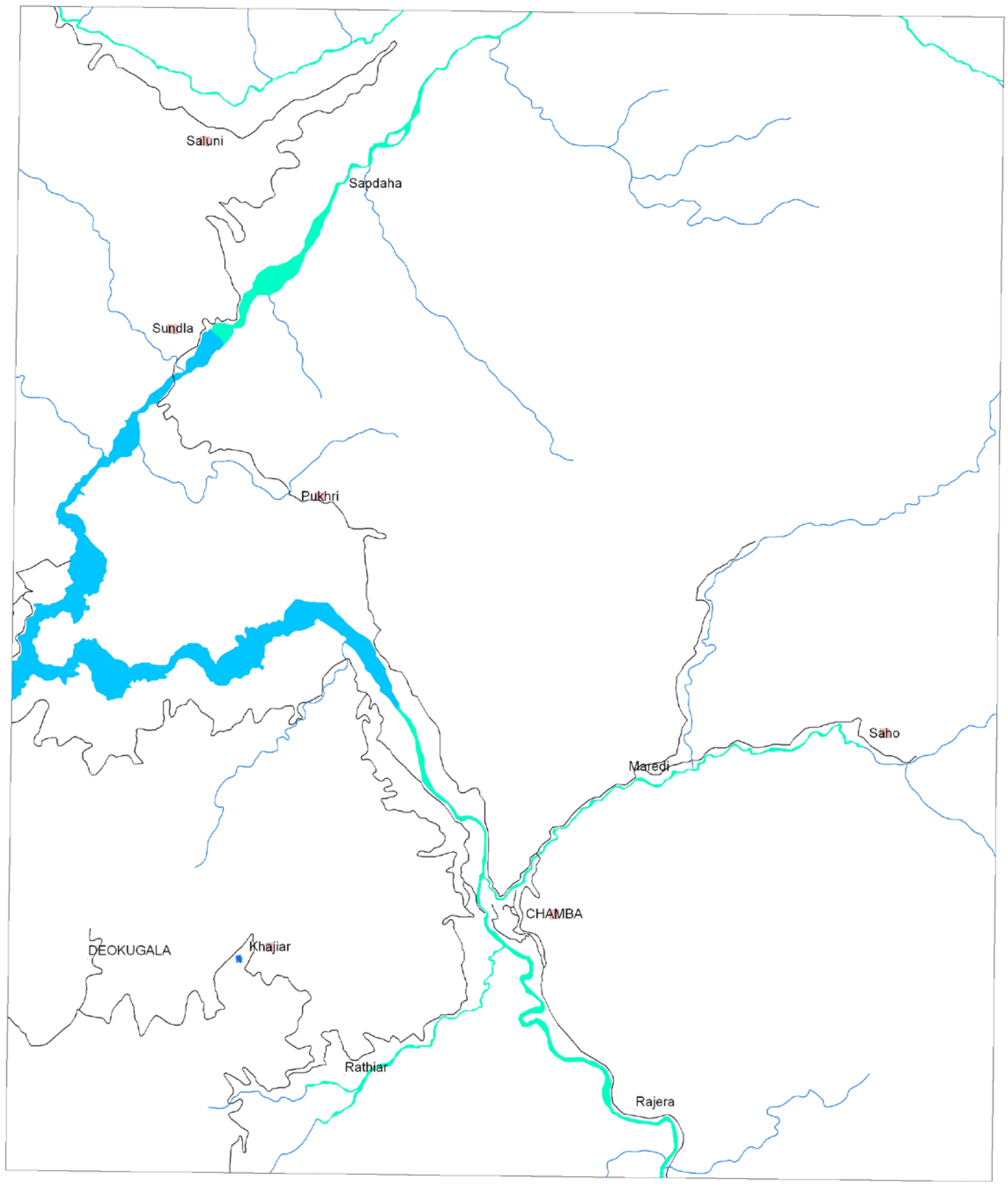
State : Himachal Pradesh

WETLAND MAP

Sheet: 52D/02



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

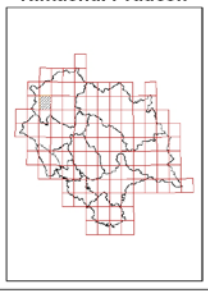
Legend

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

Location Map

India

Himachal Pradesh



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43P/14	52D/ 2	52D/ 6
43P/15	52D/ 3	52D/ 7

2 1 0 2 Kilometers

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

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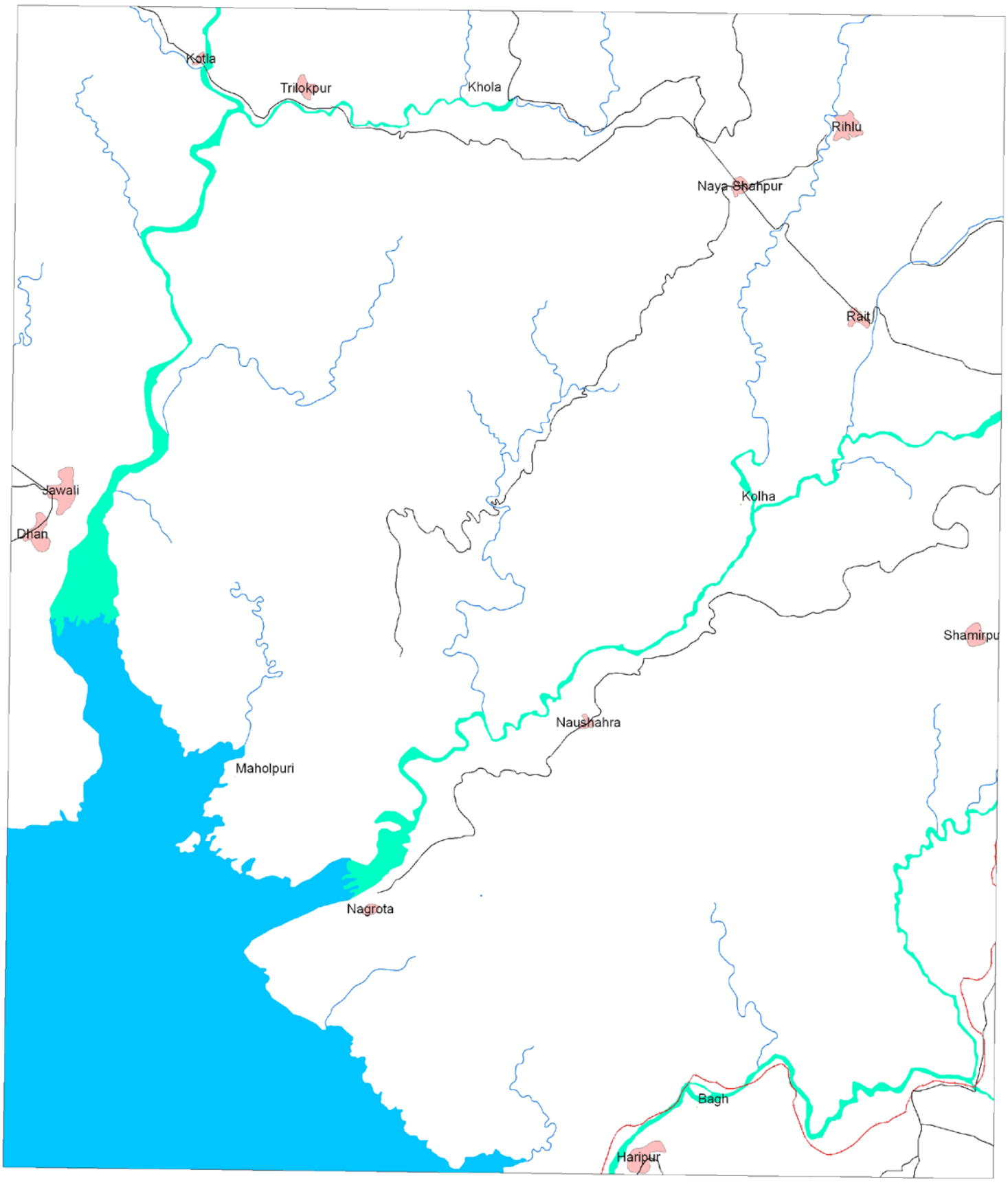
State : Himachal Pradesh

WETLAND MAP

Sheet: 52D/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
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	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
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	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

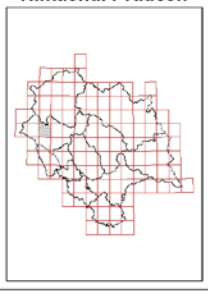
Legend

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

Location Map

India

Himachal Pradesh



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43P/16	52D/ 4	52D/ 8
44M/13	53A/ 1	53A/ 5

2 1 0 2 Kilometers

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

Prepared by:
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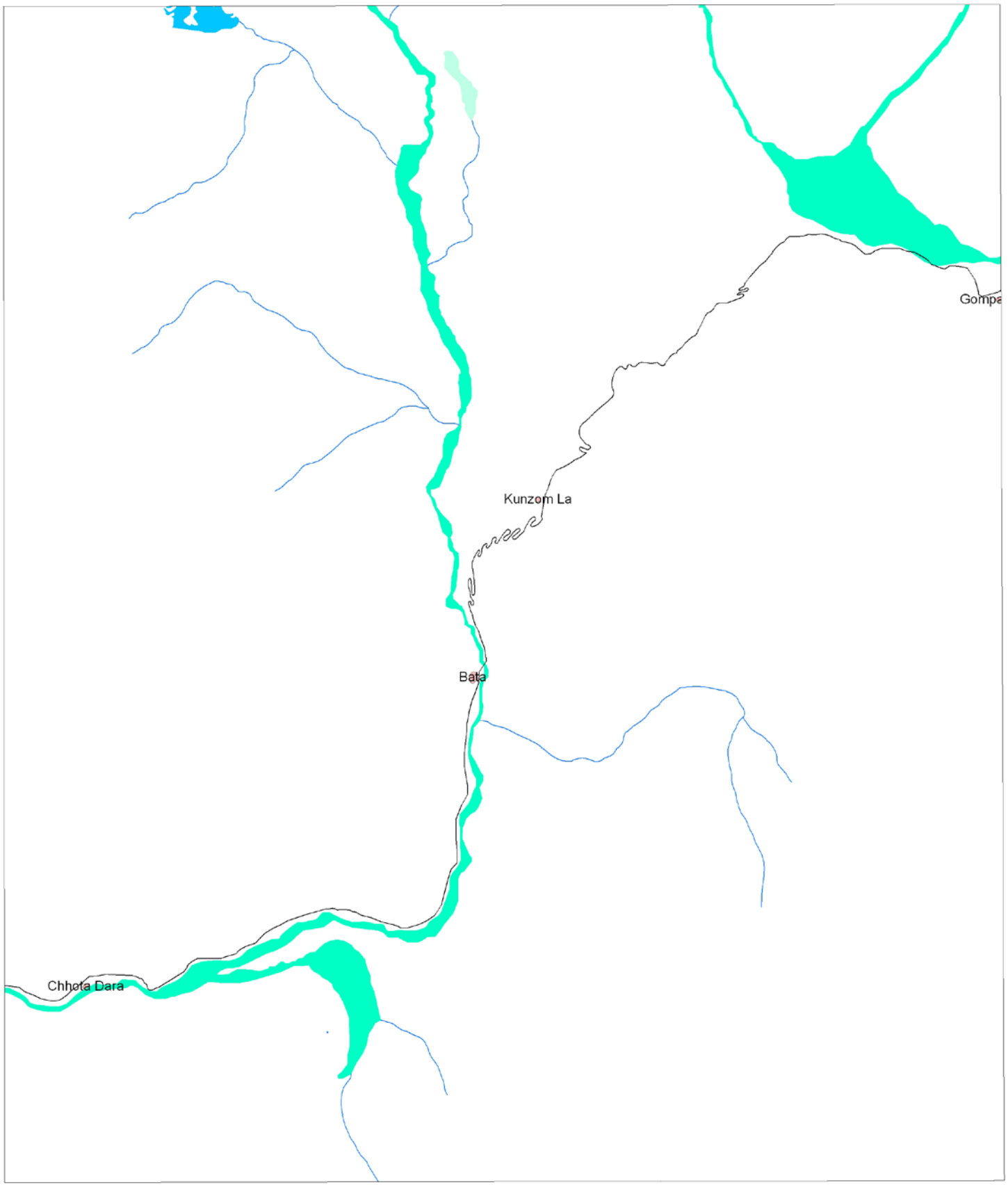
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 52H/11



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

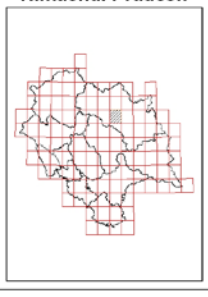
Legend

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

Location Map

India

Himachal Pradesh



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52H/ 7	52H/11	52H/15
52H/ 8	52H/12	52H/16

2 1 0 2 Kilometers

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

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State Council for Science, Technology & Environment, Shimla

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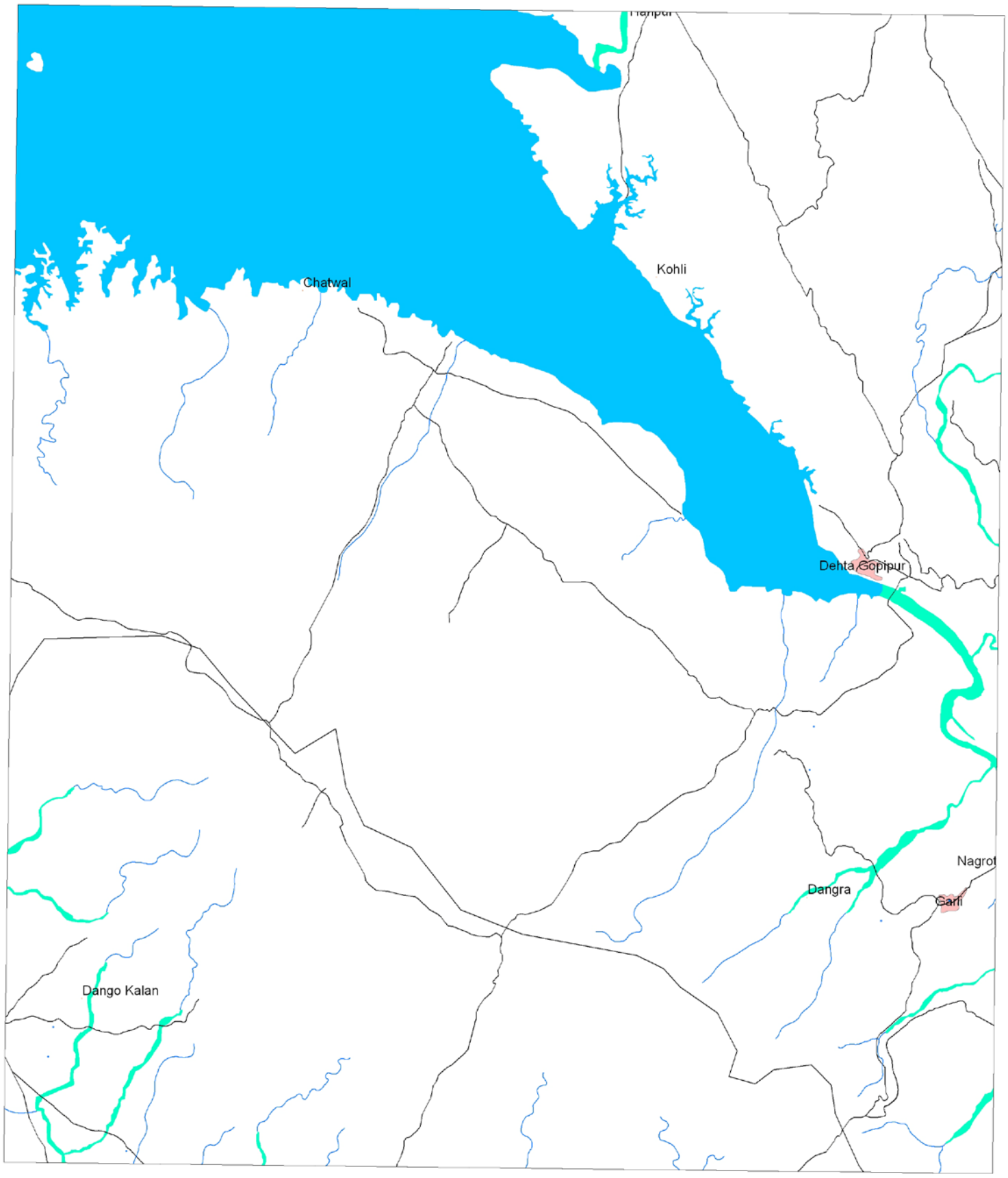
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 53A/01



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

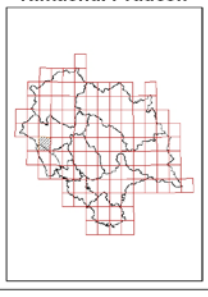
Legend

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

Location Map

India

Himachal Pradesh



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44M/13	53A/ 1	53A/ 5
44M/14	53A/ 2	53A/ 6

2 1 0 2 Kilometers

Data Source:
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Prepared by:
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and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

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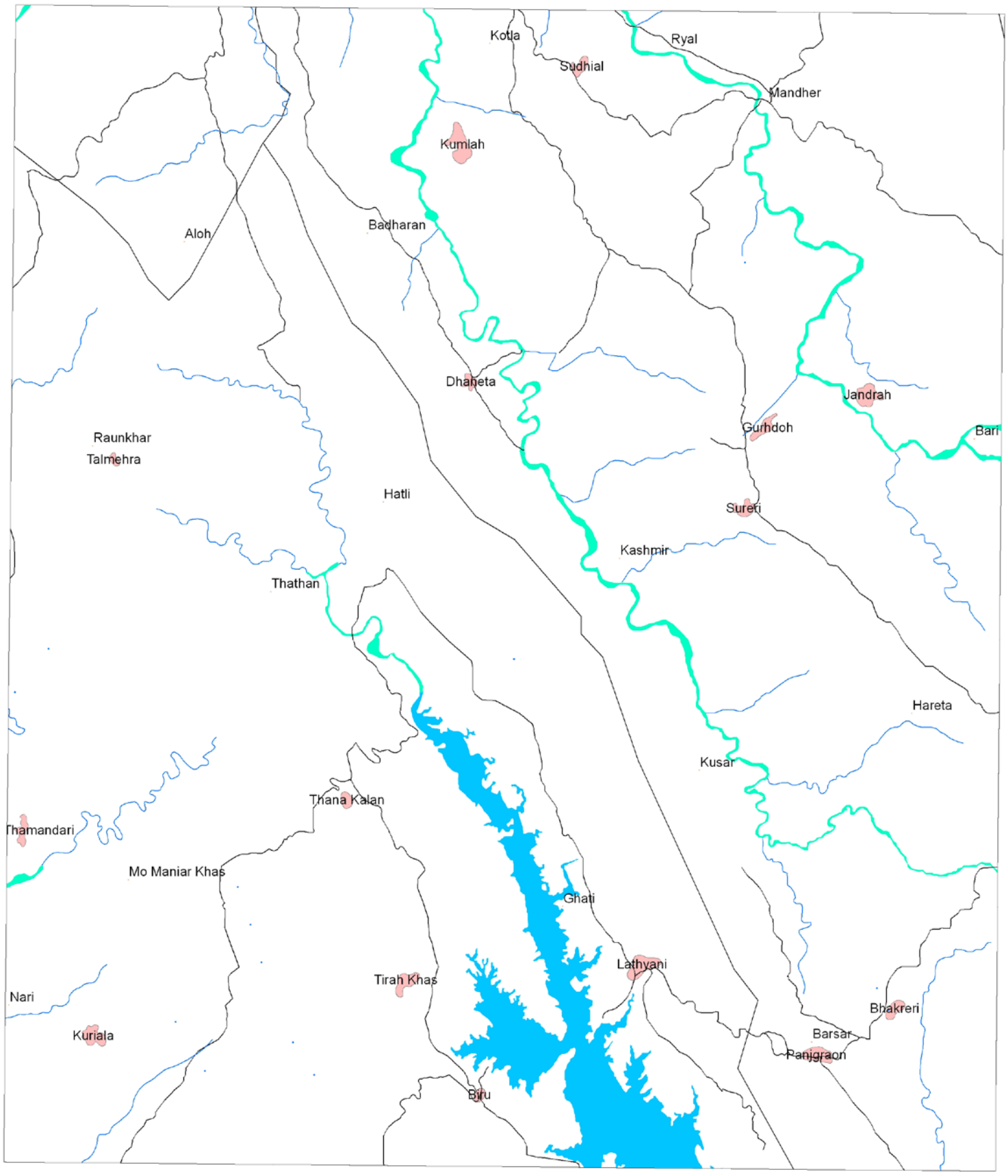
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 53A/06



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

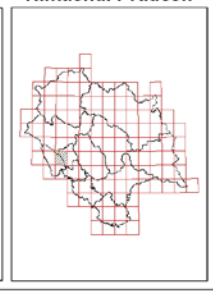
Legend

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

Location Map

India

Himachal Pradesh



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53A/ 3	53A/ 7	53A/11

2 1 0 2 Kilometers

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

Prepared by:
Space Applications Centre (ISRO), Ahmedabad
and
HP Remote Sensing Cell
State Council for Science, Technology & Environment, Shimla

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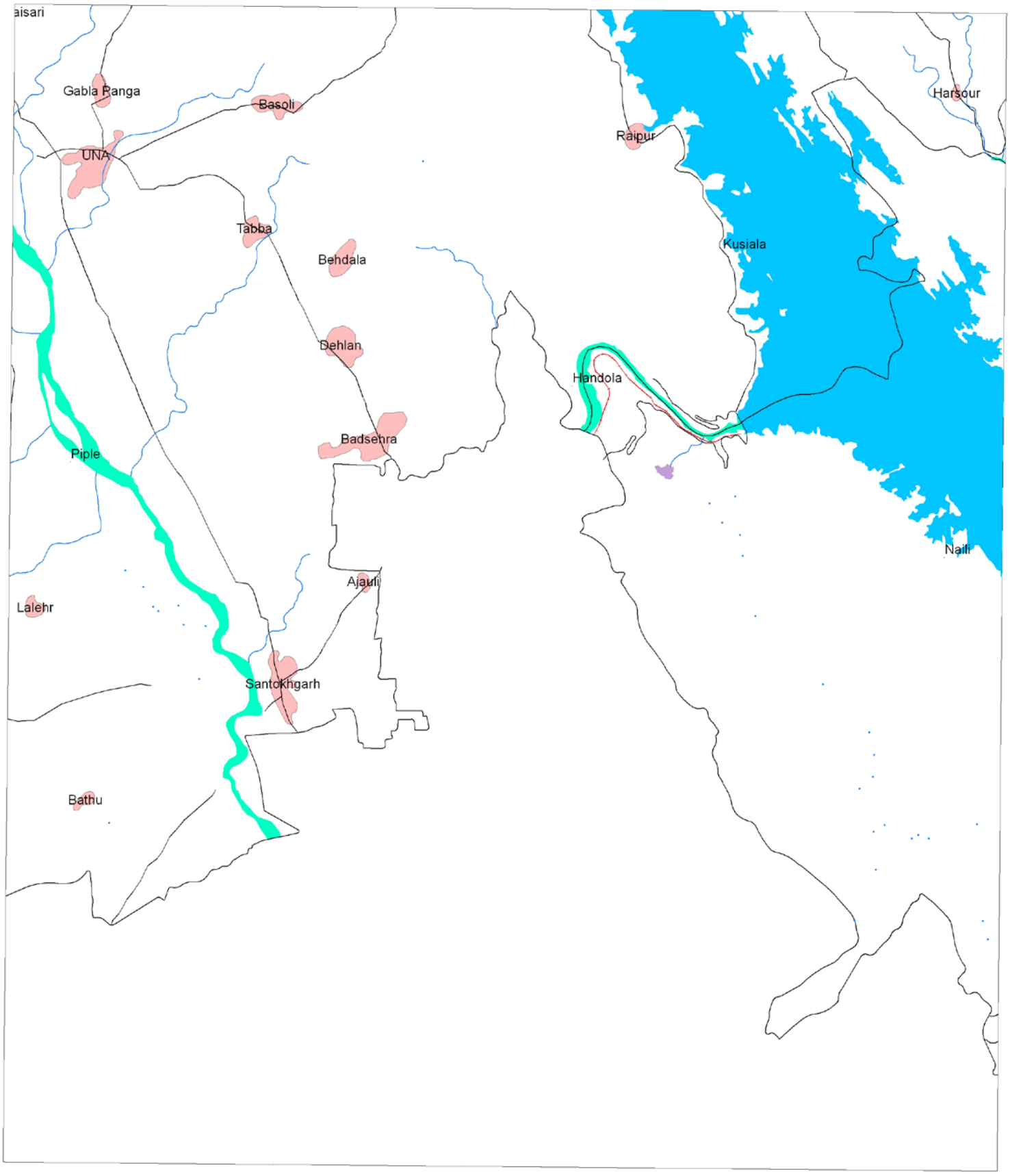
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 53A/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
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			Man-made	
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		Coastal Wetlands		
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	2101			Lagoons
	2102			Creeks
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	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

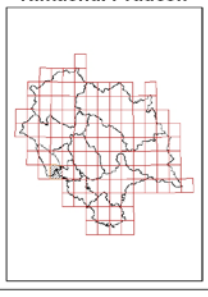
Legend

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

Location Map

India

Himachal Pradesh



Index to sheet

53A/ 2	53A/ 6	53A/10
53A/ 3	53A/ 7	53A/11
53A/ 4	53A/ 8	53A/12

2 1 0 2 Kilometers

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

Prepared by:
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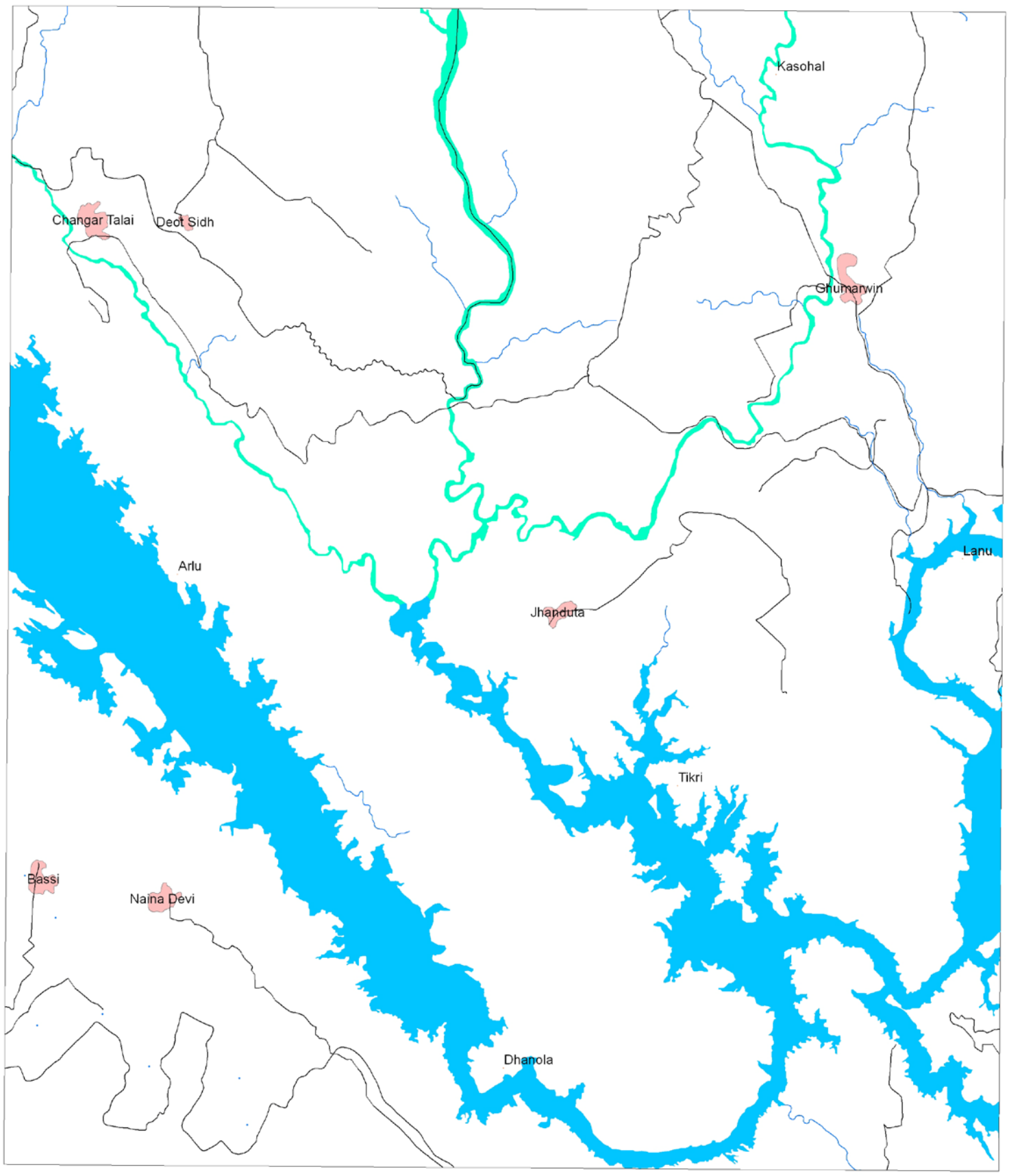
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 53A/11



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

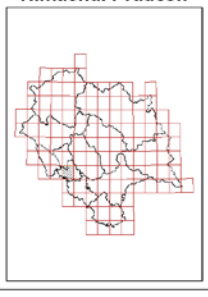
Legend

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

Location Map

India

Himachal Pradesh



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53A/ 6	53A/10	53A/14
53A/ 7	53A/11	53A/15
53A/ 8	53A/12	53A/16

2 1 0 2 Kilometers

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

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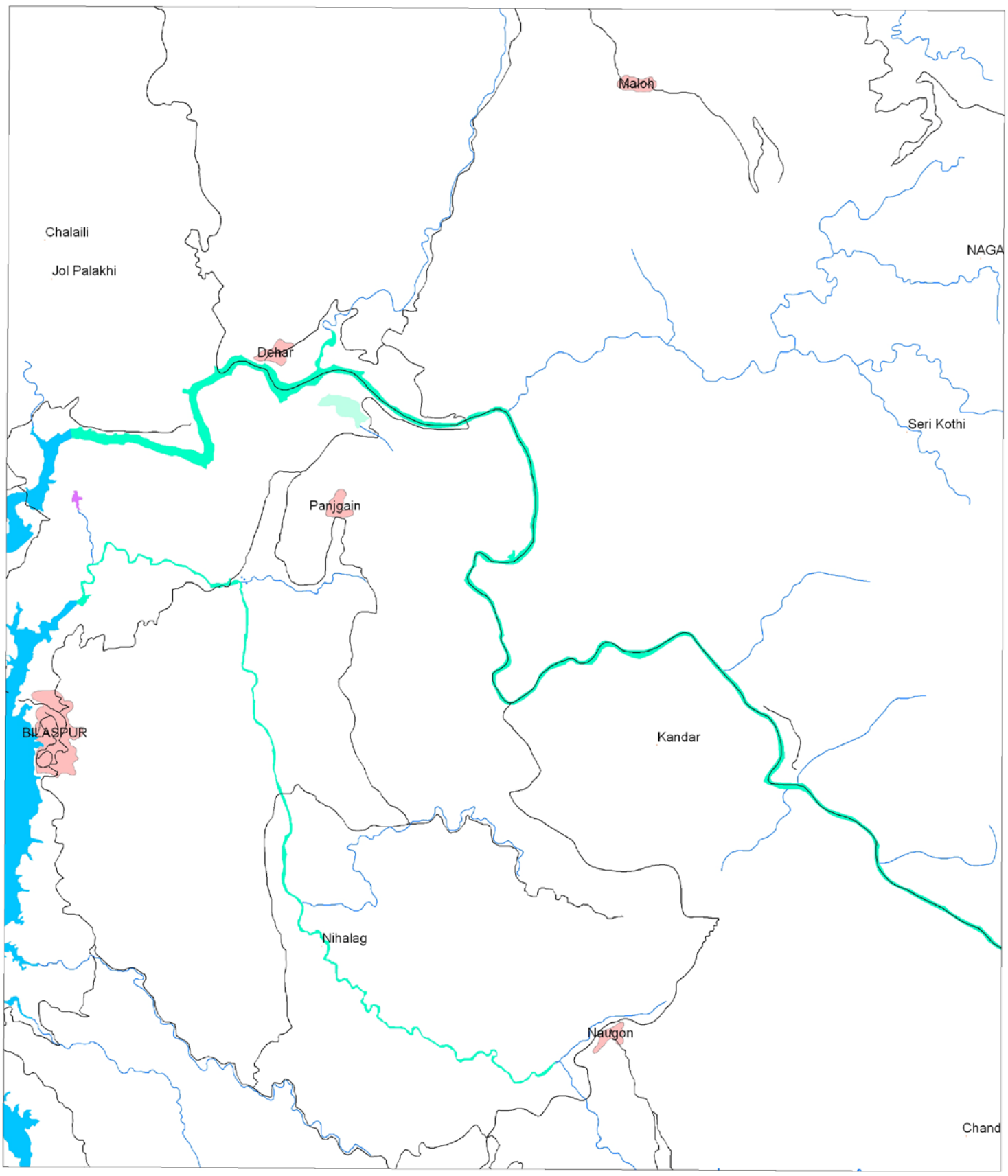
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 53A/15



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

Legend

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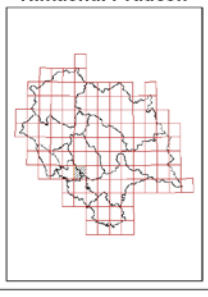
- Railways
- Town/Settlements
- District Boundary
- State Boundary
- International Boundary

Location Map

India

Himachal Pradesh



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53A/10	53A/14	53E/ 2
53A/11	53A/15	53E/ 3
53A/12	53A/16	53E/ 4

2 1 0 2 Kilometers

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

Prepared by:
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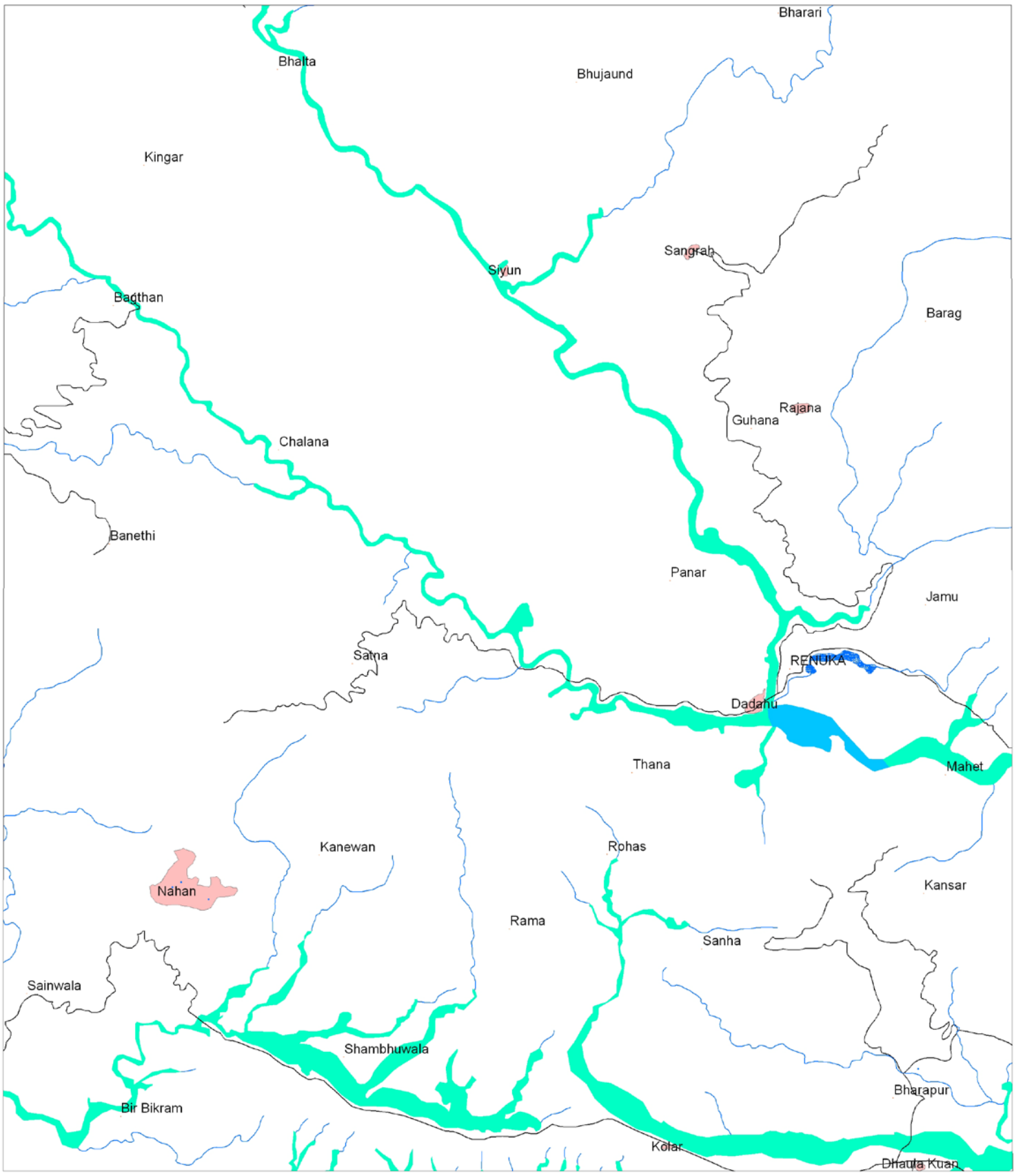
Government of India

State : Himachal Pradesh

WETLAND MAP

Sheet: 53F/06



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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	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
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	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

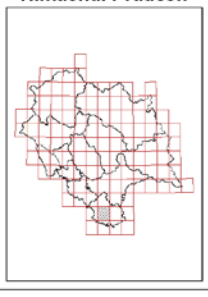
Legend

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

Location Map

India

Himachal Pradesh



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53F/ 1	53F/ 5	53F/ 9
53F/ 2	53F/ 6	53F/10
53F/ 3	53F/ 7	53F/11

2 1 0 2 Kilometers

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

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Ministry of Environment and Forests
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Annexure I
Definitions of wetland categories used in the project

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

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

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

Annexure – II
Details of District information followed in the atlas

State : Himachal Pradesh

District Boundary Map

List of Districts

District Code	District Name
01	Chamba
02	Kangra
03	Lahul & Spiti
04	Kullu
05	Mandi
06	Hamirpur
07	Una
08	Bilaspur
09	Solan
10	Sirnaur
11	Shimla
12	Kinnaur

Legend

State Boundary

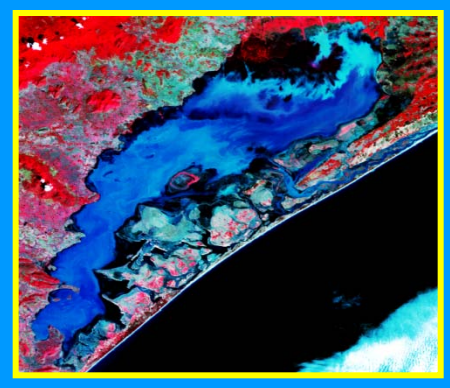
District Boundary

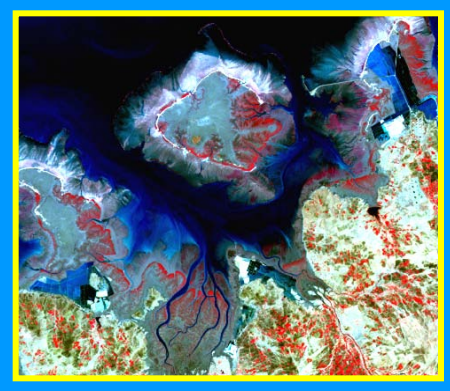
Source : Survey of India (Surveyed in 2004 and published in 2005)

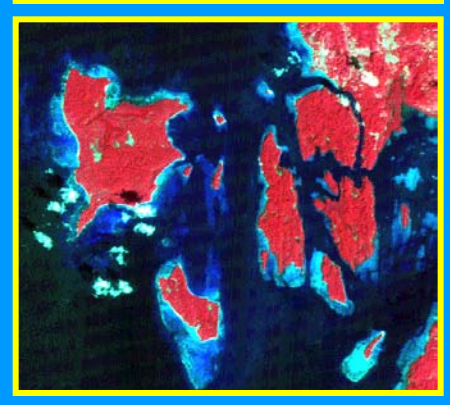
Space Applications Centre (SAC) is one of the major centres of the Indian Space Research Organisation (ISRO). It is a unique centre dealing with a wide variety of disciplines comprising design and development of payloads, societal applications, capacity building and space sciences, thereby creating a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

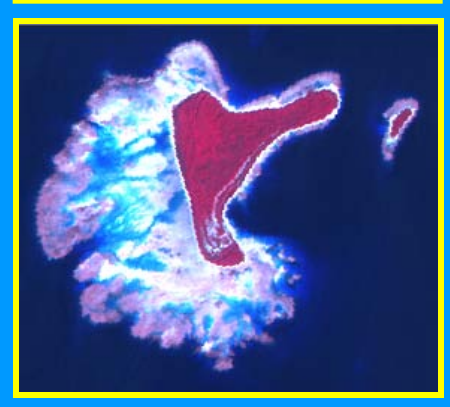
SAC is a host institution for the training programmes related to Satellite Communication, Satellite Meteorology and global change under the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations (UN).

http://www.isro.org









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