NATIONAL WETLAND ATLAS:

UTTARAKHAND

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
Uttarakhand state Remote Sensing Applications Centre, Dehradun

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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 Uttarakhand, 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.

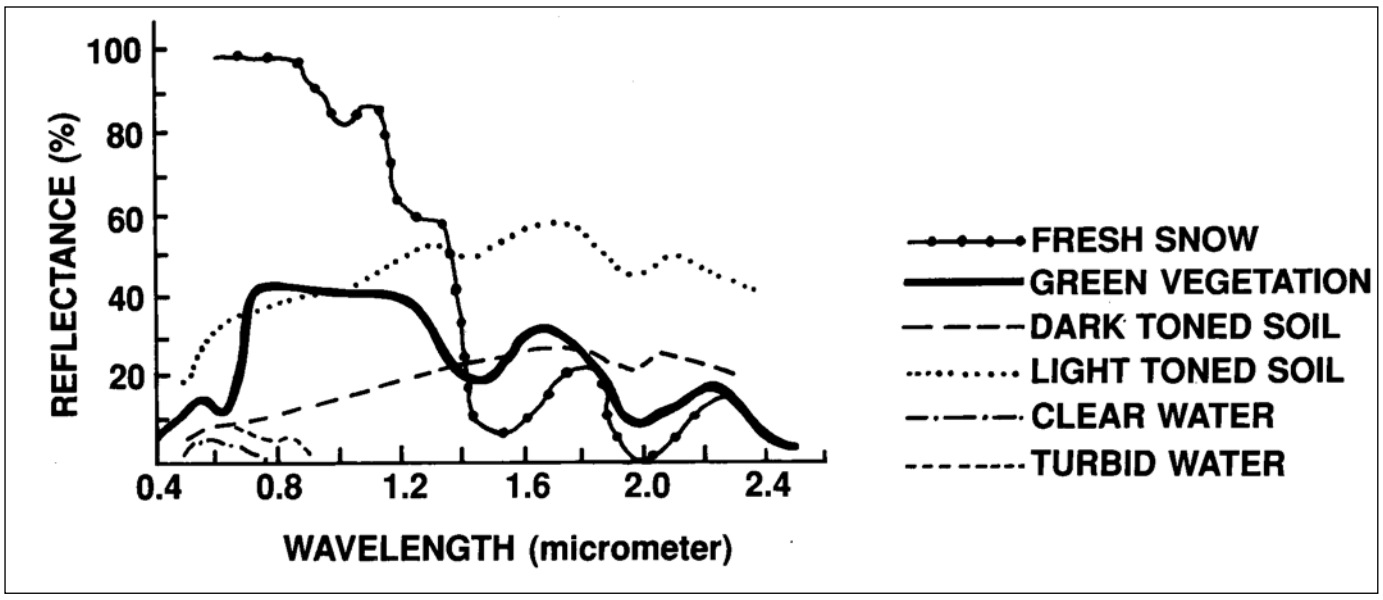
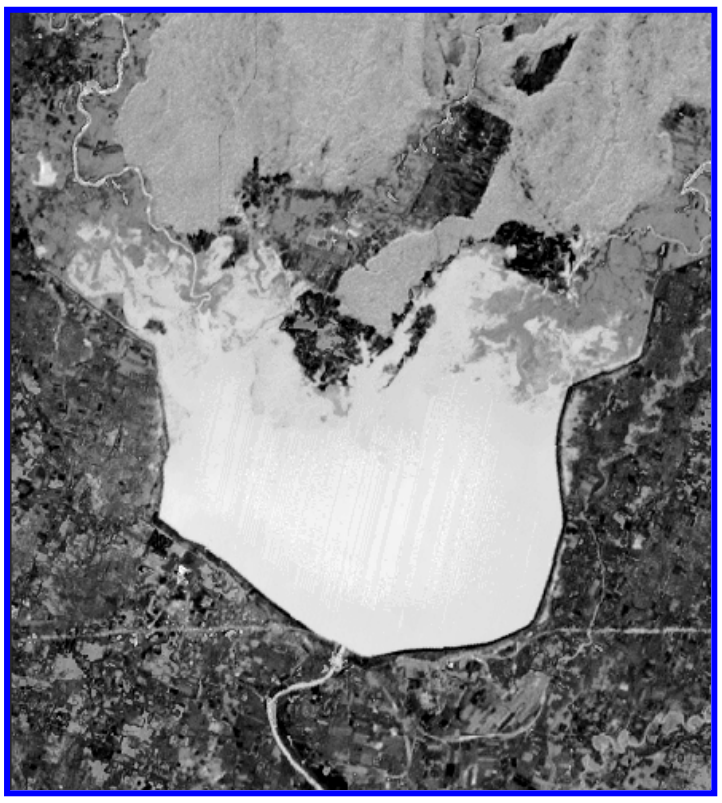
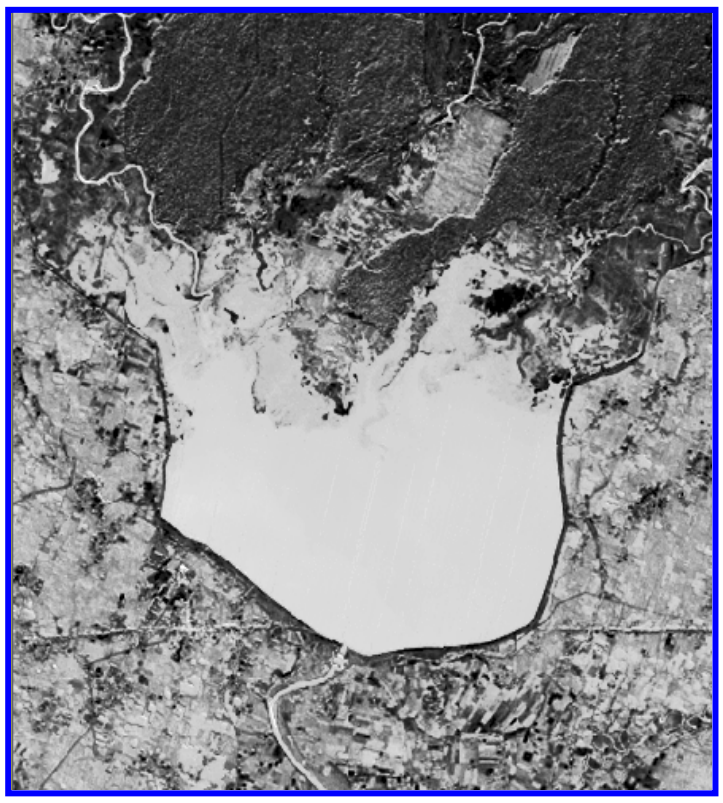


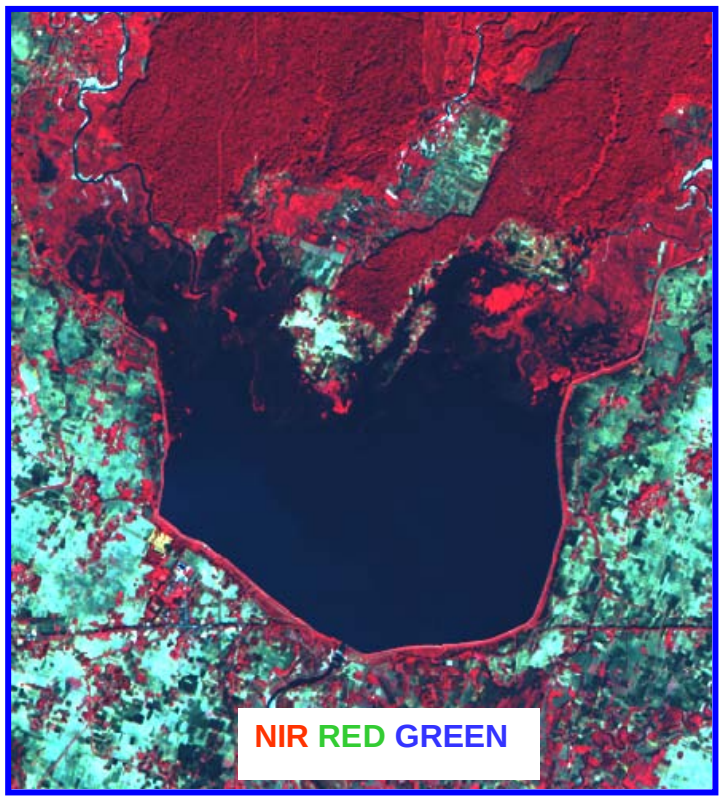
Figure 1: Spectral Signature of various targets

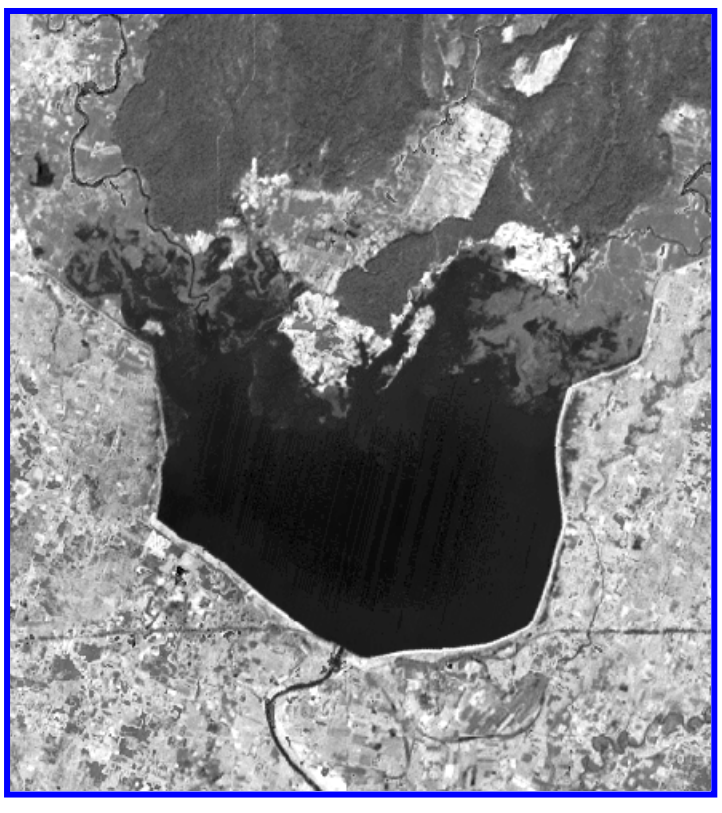


Red

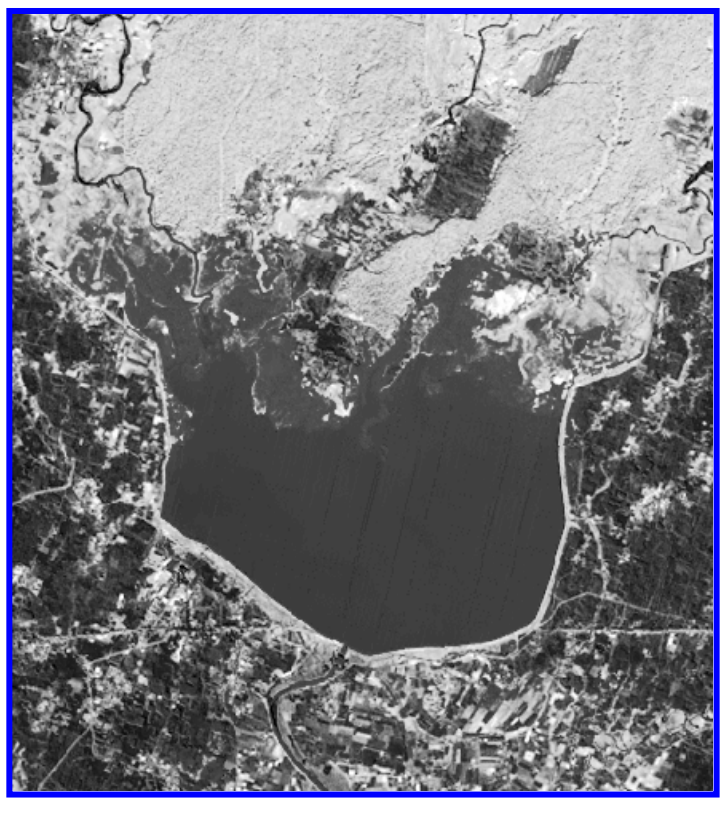


Green





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 Uttarakhand.

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

Uttarakhand is a state located in the northern part of India. The capital of Uttarakhand is Dehradun which is also a rail-head and the largest city in the region. Uttarakhand borders Tibet to the north, Nepal to the east, and the states of Himachal Pradesh and Uttar Pradesh in the west and south respectively. Uttarakhand is situated between 77^0 34` to $81^0$ 2` east longitude and 28^0 4` to $31^0$ 27` North latitude (Figure - 3). The total geographical area of the state is 53,566 km^2 of which 93% is mountainous and 64% is covered by forest. Most of the northern parts of the state are part of Greater Himalaya ranges, covered by the high Himalayan peaks and glaciers, while the lower foothills were densely forested. The climate of the state varies from subtropical in valleys to temperate on higher slopes. There are 13 districts in Uttarakhand which are grouped into two divisions. Kumaon division and Garhwal division.The Kumaon division includes six districts viz. Almora,Bageshwar,Champawat, Nainital,Pithoragarh, and Udham Singh Nagar. The Garhwal division includes seven districts viz. Dehradun, Haridwar,Tehri, Garhwal,Uttarkashi,Chamoli, Pauri Garhwal (commonly known as Garhwal) and Rudraprayag. Important cities in the state are Dehradun, Haridwar, Haldwani, Roorkee and Rudrapur. The state government recognizes 15,620 villages and 81 cities and urban areas. According to 2001 census, Uttarakhand had a population of 8.48 million.

Geologically, Uttarakhand state belongs to the young folded mountains of the Himalayan system. Half-schistose, gneissose and Precambrian are the three major rock constituents of the geology of Uttarakhand. Precambrian rock is found in a big part of the state of Uttarakhand and hence is a significant part of Uttarakhand geology. The region taken up by this rock has a relatively smaller age than the hilly regions of the state. The Precambrian rock is made up of schists and phyllites. The presence of schists and phyllites makes the slopes of the region prone to erosion and weathering. The possibility of erosion of soil and the reduction of mineral content is increased by excessive rainfall. Such geology is susceptible to natural disasters like landslides. The hilly regions of Uttarakhand mainly constitutes of two kinds of rocks - half-schistose and gneissose. The soil does not have a high content of organic matter and is not rich in minerals. The texture of this soil is coarse.

Uttarakhand has a very rugged and formidable topography and flat lands. The towering mountains that define this paradise of nature also create a barrier to efficient agriculture. These mountains fall directly in the path of the monsoon clouds making the state one of the wettest in the country. Numerous snow-fed streams in Uttarakhand have carved out river valleys in the eastern part of the state. The state has big-dams such as Tehri dam on the Bhagirathi-Bhilangana rivers. It is a source water for irrigation, dringking water and hydopower gneration.

Along with the mountains, Glaciers and passes, the state of Uttarakhand also has many lakes though not of very large size. These lakes are both spring fed as well as river fed. The premier lakes of the state are Arolital, Badhanital, Bhikaltal, Devtal, Hemkund, Roopkund, Sahstrabahu Lake, Ramganga reservoir, Nainital lake, Kedar tal, Nanak sagar, Tehri reservoir, Dhauliganga, and Tumaria reservoir etc. These lakes also form the source of many rivers. The main rivers of Uttarakhand are Alaknanda, Dhualiganga, Yamuna and the mighty Ganges.Two of India's mightiest perineal rivers, the Ganga and the Yamuna take birth in the glaciers of Uttarakhand, and are fed by myriad lakes, glacial melts and streams in the region.

Uttarakhand is covered in one hundred and six (106) Survey of India topographical maps (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.

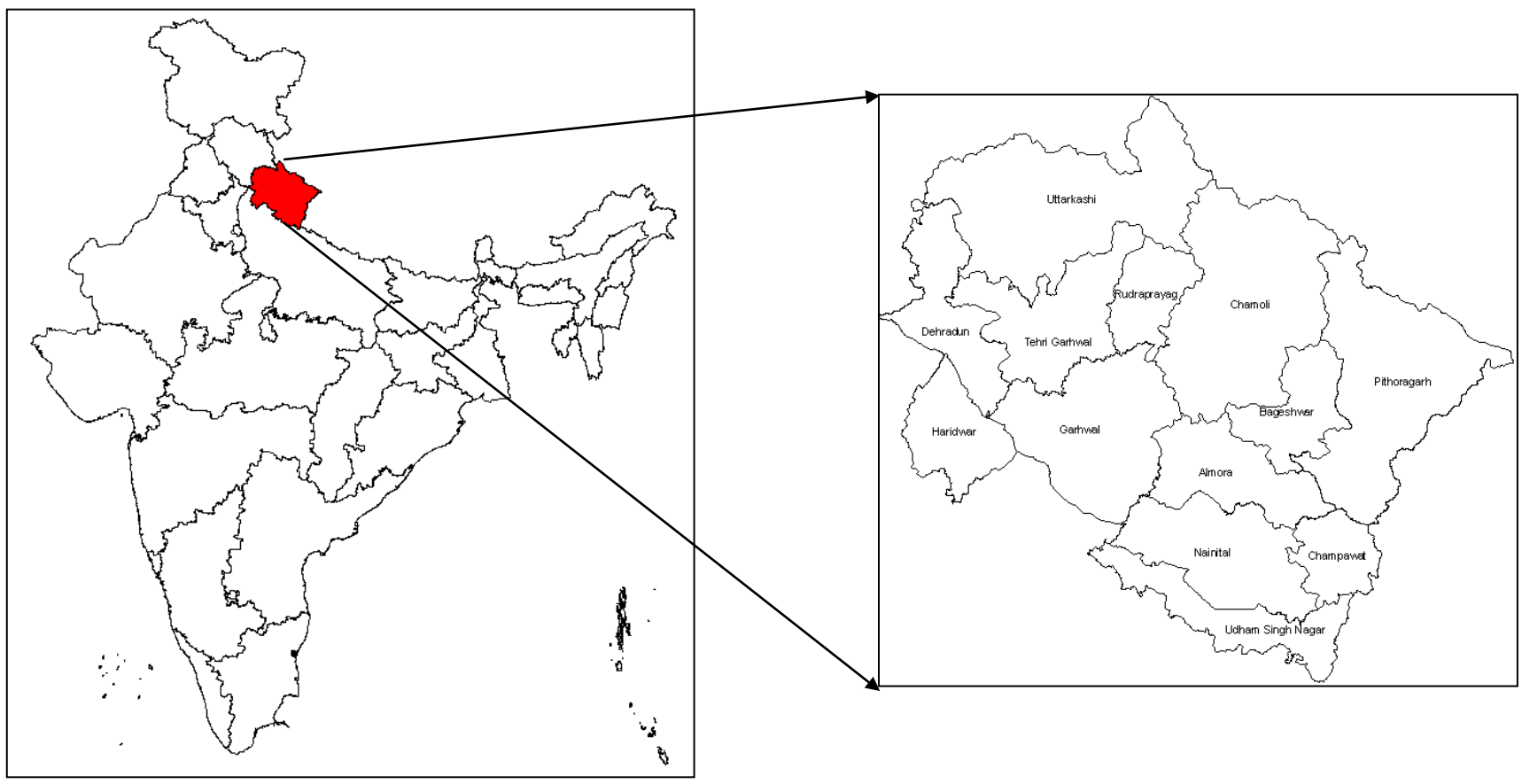


Figure 3: Location Map

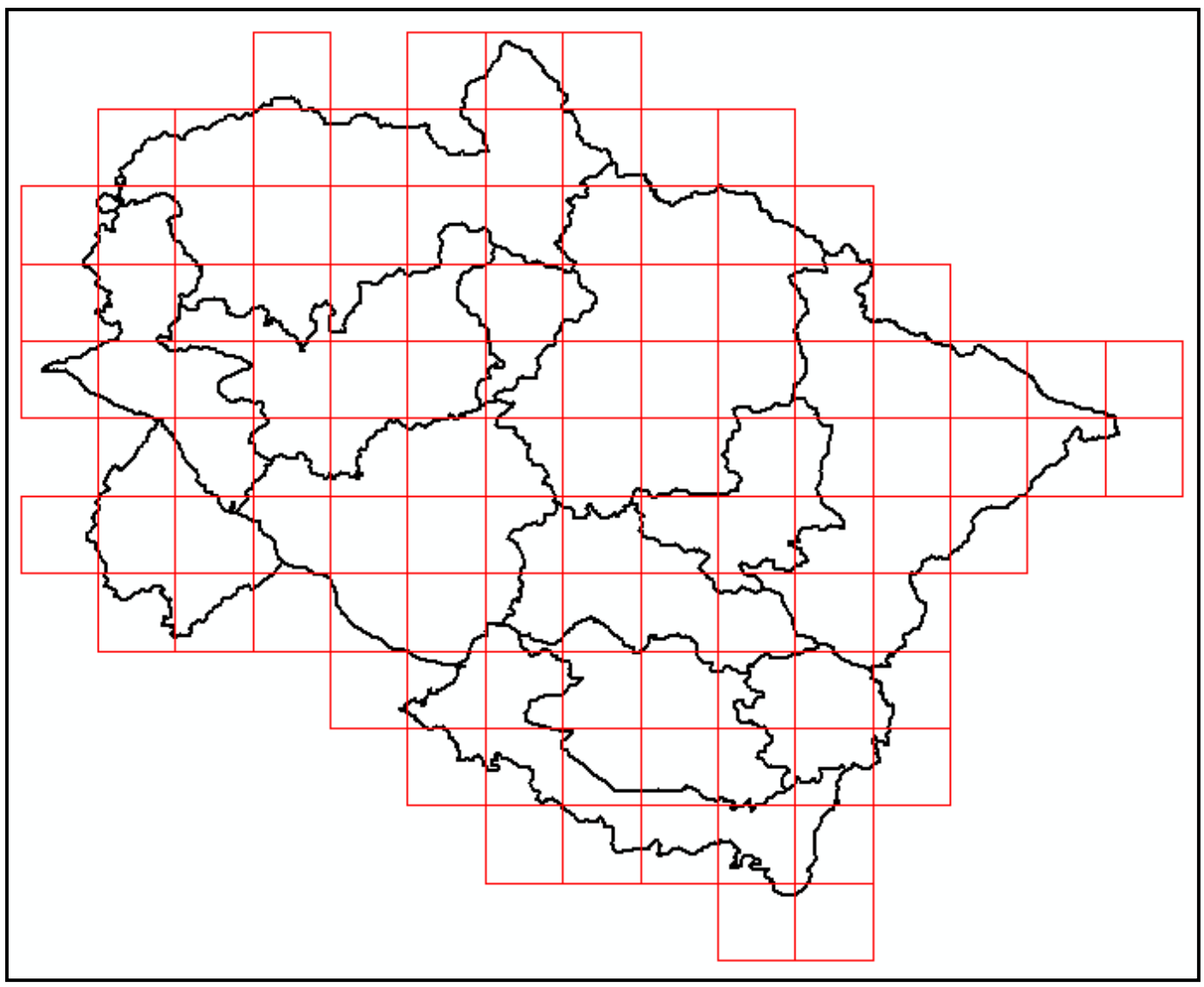


Figure 4: Spatial Framework of Uttarakhand

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 Uttarakhand is covered in 9 IRS LISS-III scenes (Figure 5).

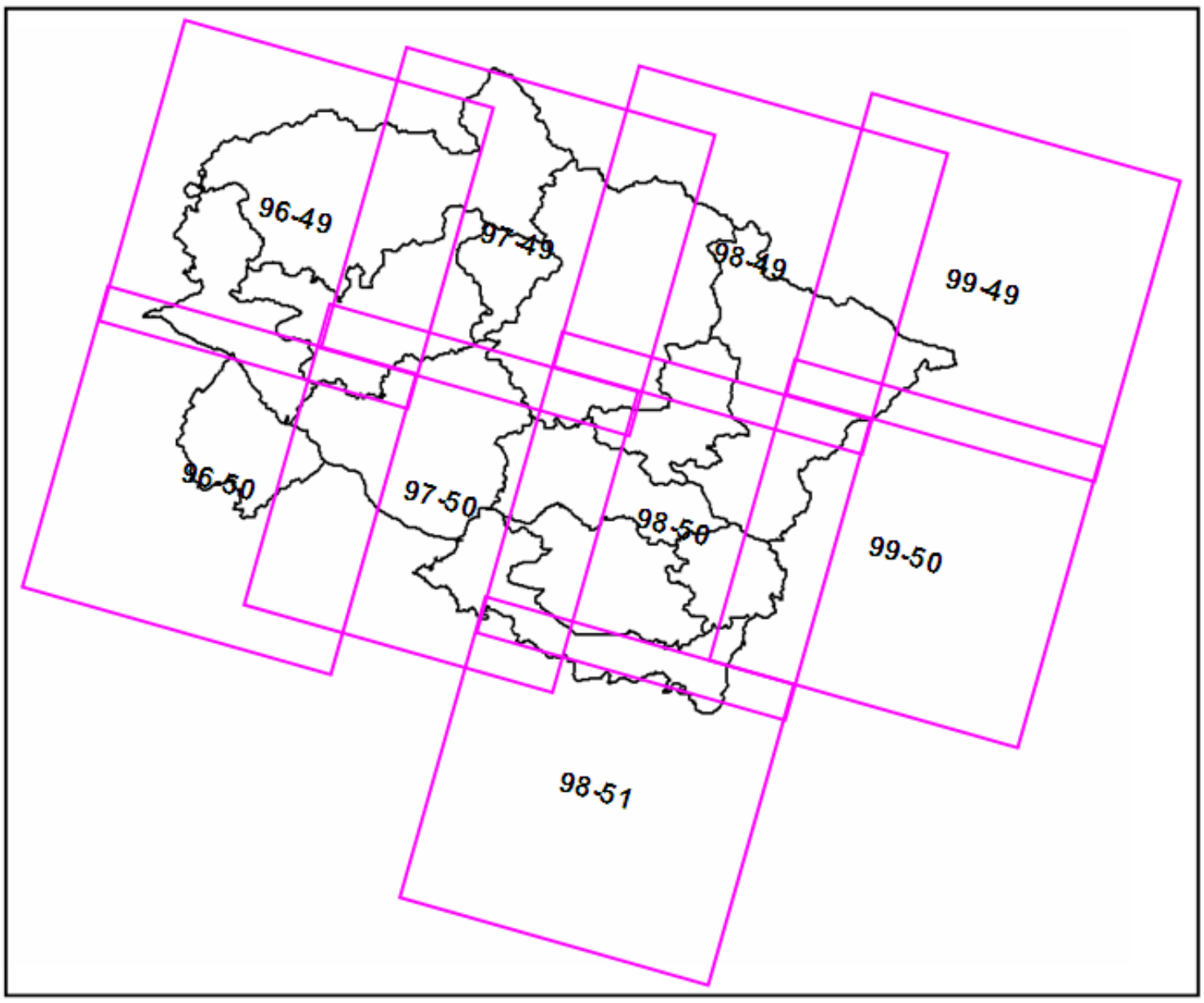


Figure 5: IRS P6 LISS-III coverage (path-row) of Uttarakhand

Two date data, one acquired during March and another during January were used to capture the pre-monsoon and post-monsoon hydrological variability of the wetlands respectively (Table-2). Figure 6 shows the overview of the part of Uttarakhand 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	96-49	Oct 10, 2006	May 14, 2006
2	97-49	Oct 15, 2006	Apr 1, 2007
3	97-50	Oct 15, 2006	Apr 1, 2007
4	98-49	Dec 31, 2006	Apr 6, 2007
5	98-50	Dec31, 2006	Apr 6, 2007
6	98-51	Nov 13, 2006	May 24, 2007
7	99-50	Nov 18, 2006	Apr 11, 2007
8	99-51	Nov 18, 2006	Apr 11, 2007
9	96-50	Oct 10, 2006	May 14, 2006

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 scales were 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 Uttarakhand state is shown in Figure 4.

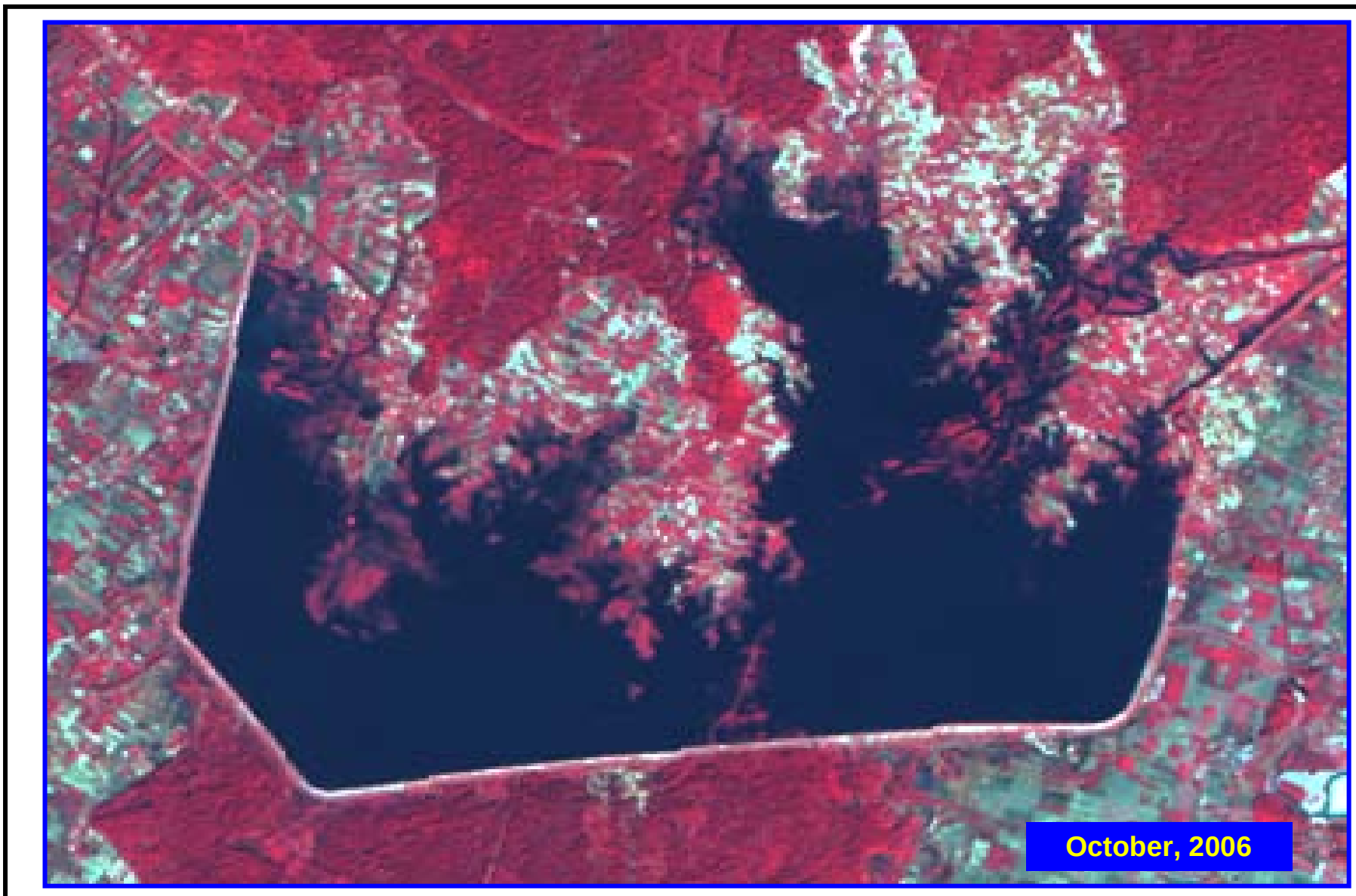
5.2 Geo-referencing of Satellite Data

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.



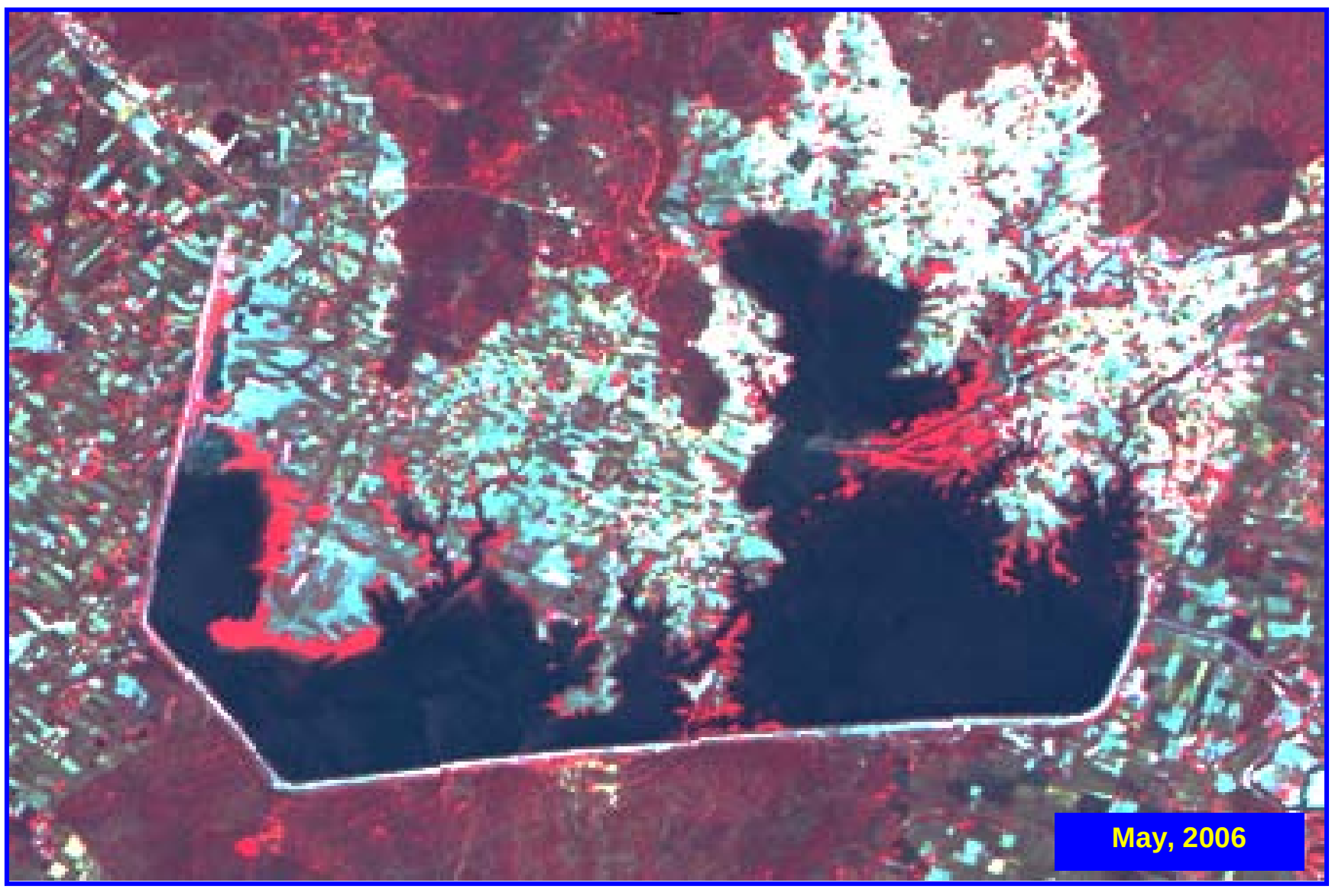


Figure 6: IRS LISS-III FCC (Post-monsoon and Pre-monsoon): Part of Uttarakhand state

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)

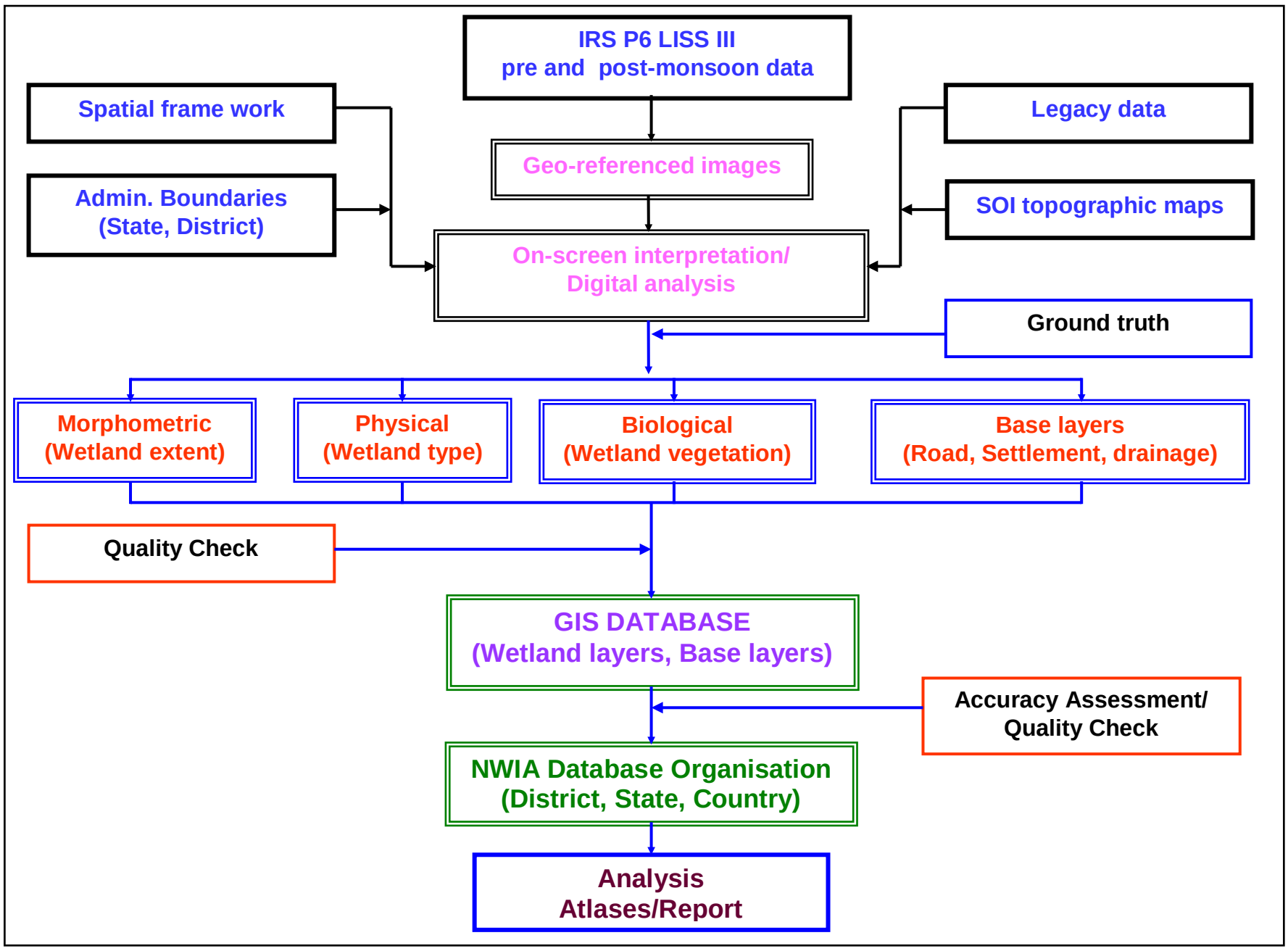


Figure 7: Flow chart of the methodology used

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

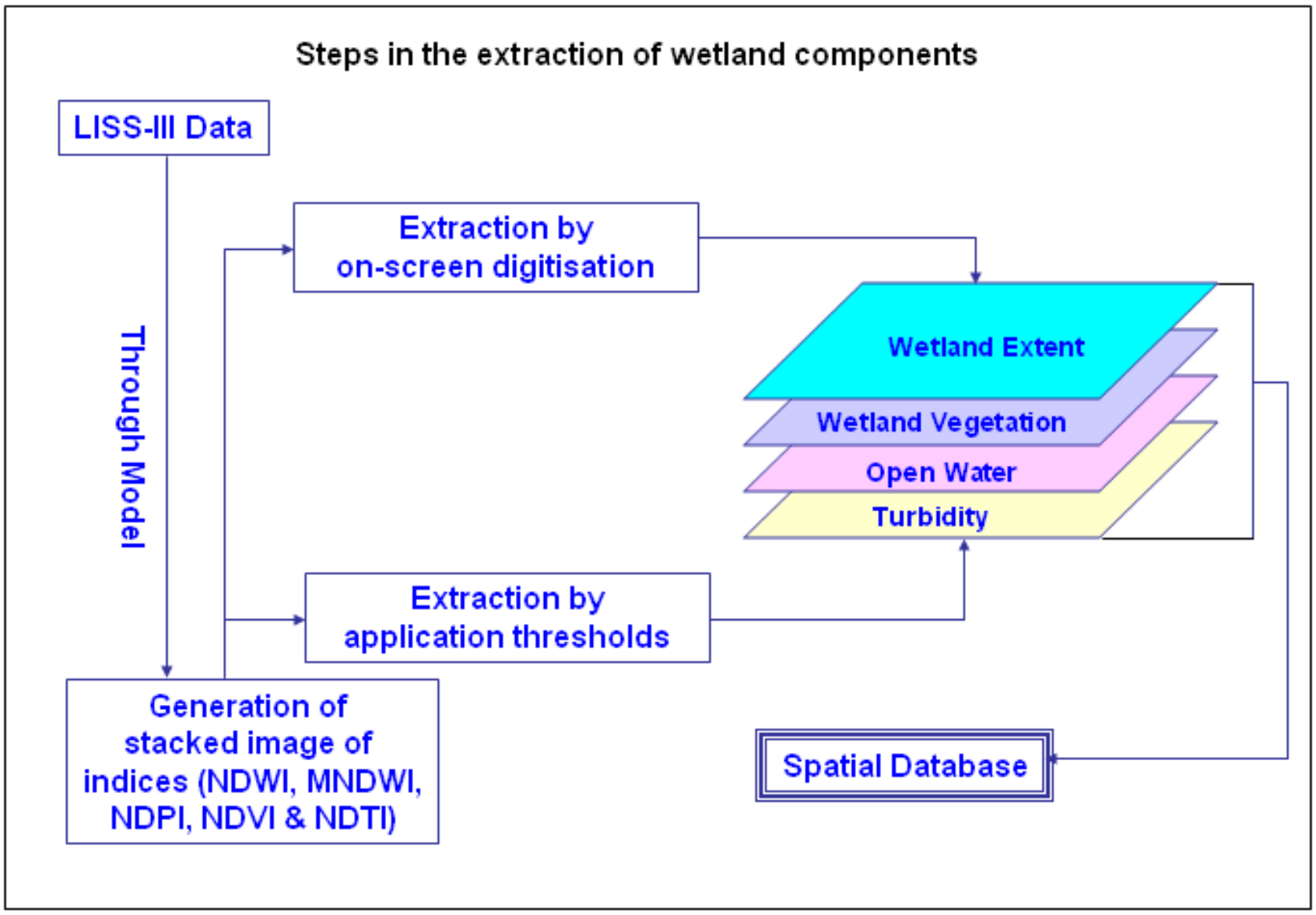


Figure 8: Steps in the extraction of wetland components

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

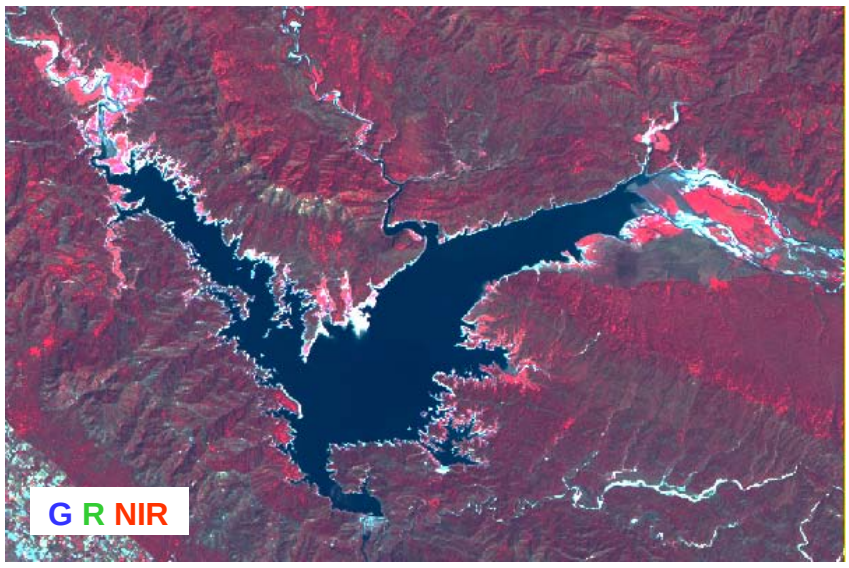
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as location accuracy. In addition, GIS database(s) contents have been also evaluated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

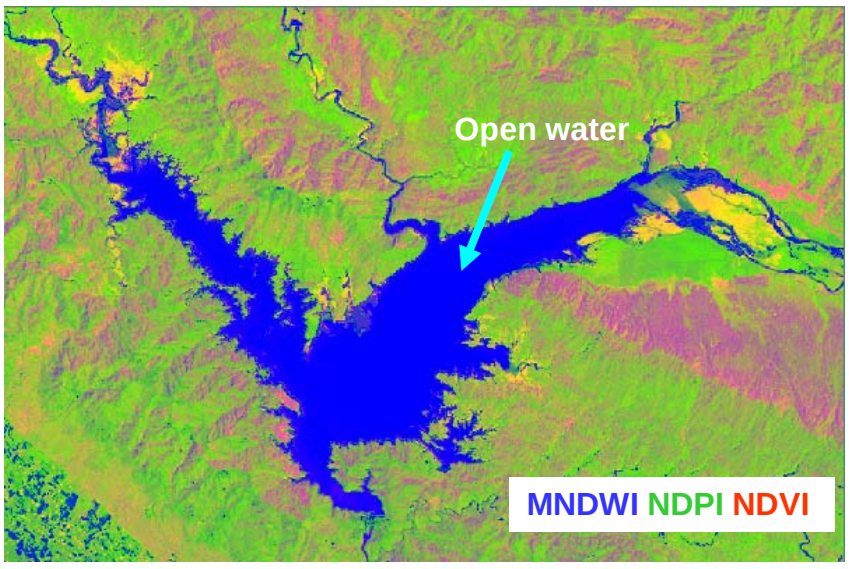
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imagery was reviewed by technical expert team for accuracy and code. The reviewing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

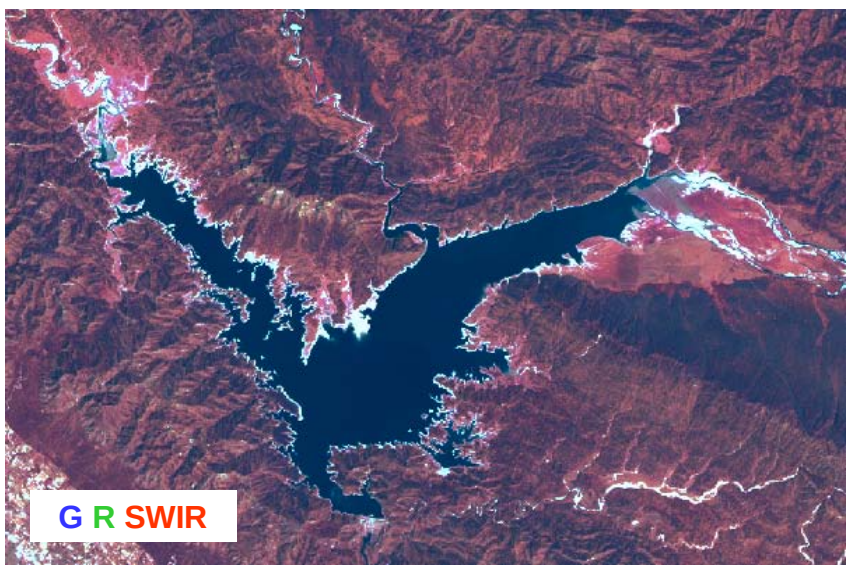
6.1 Data verification and quality assurance of output digital data files

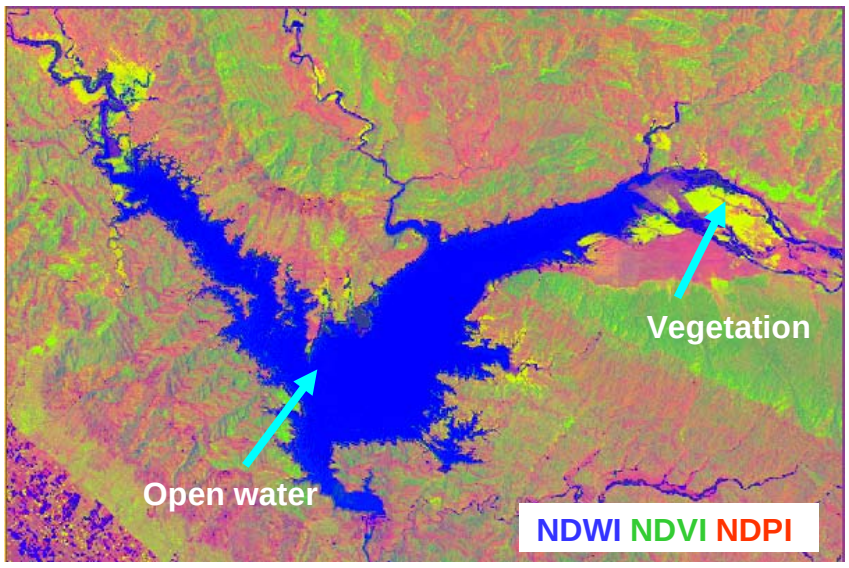
All digital data files were subjected to rigorous quality control inspections. Digital data verification included quality control checks that addressed the geospatial correctness, digital integrity and some cartographic aspects of the data. Implementation of quality checks ensured that the data conformed 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.



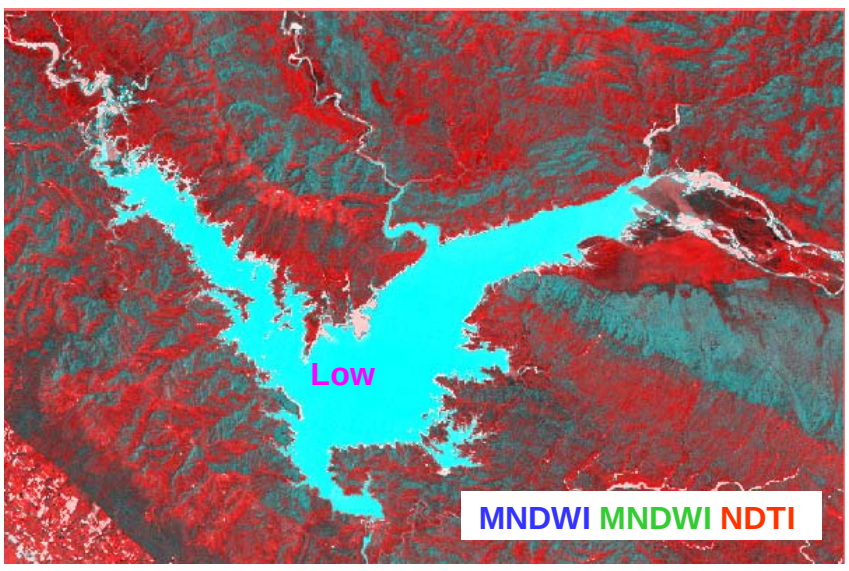


Useful for wetland boundary extraction/delineation





Useful for wetland vegetation & open water features



Useful for qualitative turbidity delineation

Part of Ram Ganga Reservoir,
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 UTTARAKHAND: MAPS AND STATISTICS

Area estimates of various wetland categories and structural components for Uttarakhand have been carried out using GIS database. Structural components include wetland boundary, water-spread, aquatic vegetation and qualitative turbidity of water.

Total 994 wetland are mapped, including 816 small wetlands (<2.25 ha area). The total area under the wetlands is 103882 ha which is 1.92 per cent of the total geographic area of the state (Table-4). River/stream is the most dominant one with 77.14 per cent share of wetlands (81033 ha). Reservoirs/Barrages are the second largest wetland category.

Total 10 Reservoirs/Barrages are mapped with 20319 ha area, contributing 19.56 per cent of wetland area of the state. High altitude wetlands, mainly lakes are of specific feature of the state. Total 29 such wetlands are mapped which lie above 3000 m altitude. However, there are numerous small (<2.25 ha) high altitude wetlands in the state which are mapped as point features. The other wetland types are: Lakes/ponds (2081 ha), Tank/pond and Waterlogged. Graphical distribution of wetland type is shown in Figure 10.

The open water area of these wetlands ranges from 54221 ha during post-monsoon season and 46244 ha in pre-monsoon season. Most of the wetlands are oligotrophic in nature. The turbidity of water is mainly moderate.

Table-4: Area estimates of wetlands in Uttarakhand

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	12	2081	2.00	1747	757
2	1102	Ox-bow lakes/ Cut-off meanders	15	63	0.06	49	57
3	1103	High altitude wetlands	29	142	0.14	142	115
4	1104	Riverine wetlands	-	-	0.00	-	-
5	1105	Waterlogged	1	9	0.01	5	9
6	1106	River/Stream	81	80133	77.14	37567	34945
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	10	20319	19.56	14411	10213
8	1202	Tanks/Ponds	21	108	0.10	89	108
9	1203	Waterlogged	9	211	0.20	211	40
10	1204	Salt pans	-	-	0.00	-	-
		Sub-Total	**178**	**103066**	**99.21**	**54221**	**46244**
		Wetlands (<2.25 ha)	816	816	0.79	-	-
		Total	**994**	**103882**	**100.00**	**54221**	**46244**

Area under Aquatic Vegetation	5288	11697

Area under turbidity levels		
Low	22893	11235
Moderate	31328	35009
High	-	-

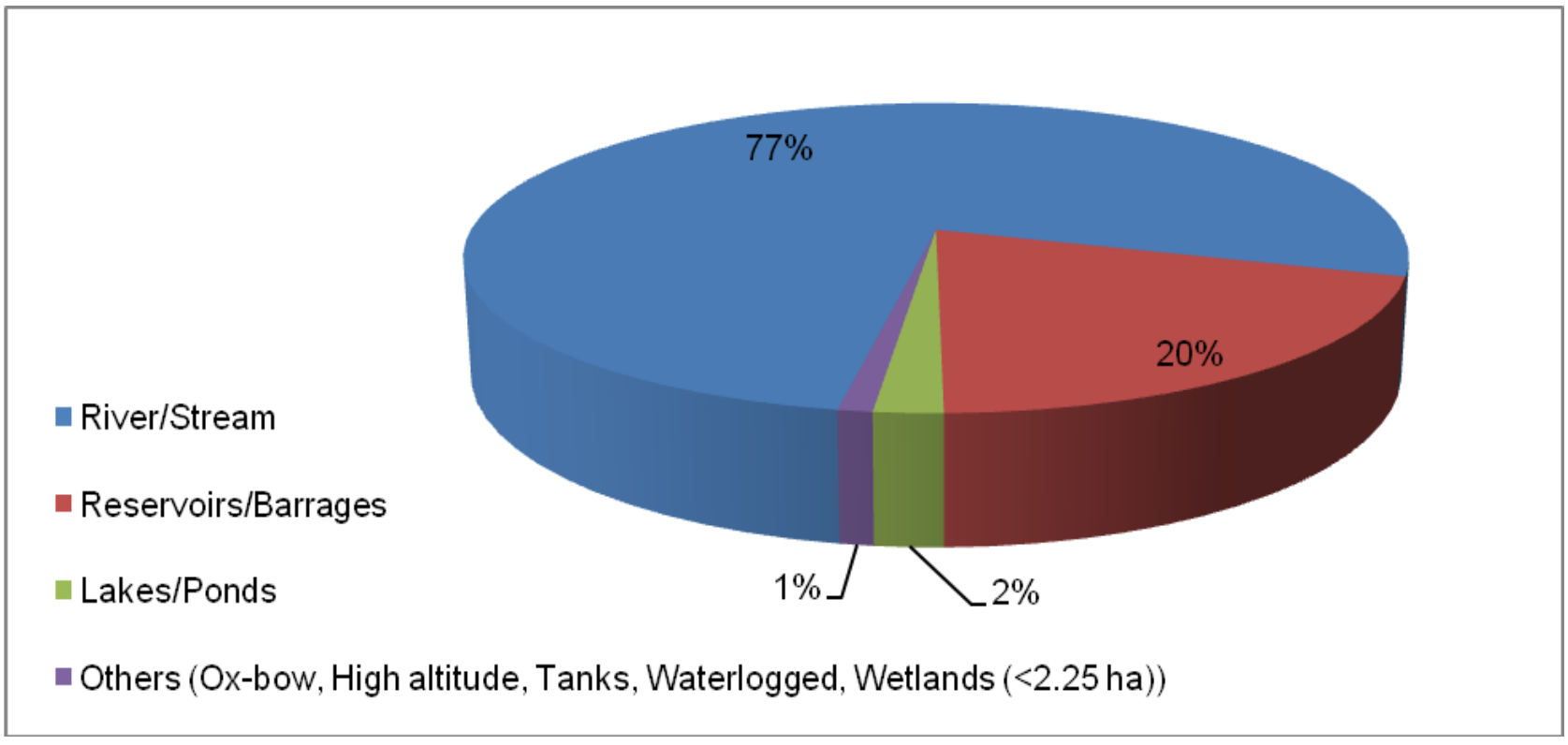


Figure 10: Type-wise wetland distribution in Uttarakhand

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has 13 districts. The geographic area of districts varied from 1781 sq km (Champawat) to 7951 sq km (Uttarkashi). The wetland area in districts varied from as low as 0.42 per cent (Chamoli) to as high as 6.9 per cent (Udham singh nagar) of the geographic area of the district. The major wetland districts, which contributed more than 10.0 per cent of the wetland area of the state are Udhams Singh Nagar, Hardwar, Nainital and Dehradun. The districts having high altitude wetlands are Chamoli, Pithoragarh, Uttarkashi and Rudraprayag. Chamoli has the highest number of high altitude wetlands (16), followed by Pithoragarh (11). District-wise wetland area estimates are given in Table-5. Figure 11 shows district-wise graphical distribution of wetlands.

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.

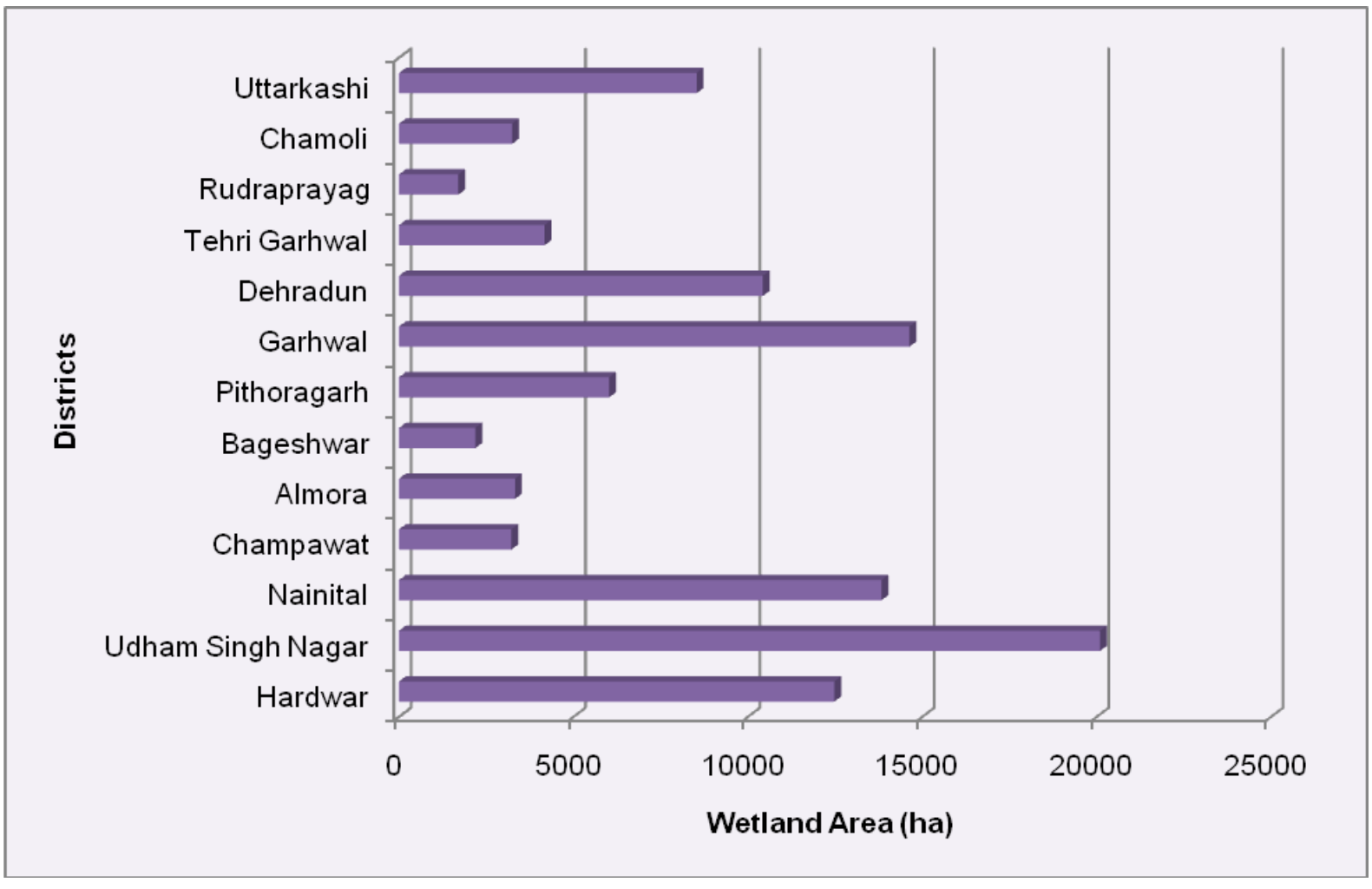


Figure 11: District-wise graphical distribution of wetlands

Table-5: District-wise wetland highlights

Sr. No.	District	Geographic Area (sq. km)	Wetland Area (ha)	% of total wetland area	% of district geographic area
1	Uttarkashi	7951	8532	8.21	1.07
2	Chamoli	7692	3240	3.12	0.42
3	Rudraprayag	1896	1702	1.64	0.90
4	Tehri Garhwal	4085	4173	4.02	1.02
5	Dehradun	3088	10432	10.04	3.38
6	Garhwal	5438	14631	14.08	2.69
7	Pithoragarh	7110	6023	5.80	0.85
8	Bageshwar	2310	2187	2.11	0.95
9	Almora	3090	3326	3.20	1.08
10	Champawat	1781	3222	3.10	1.81
11	Nainital	3853	13835	13.32	3.59
12	Udham Singh Nagar	2912	20099	19.35	6.90
13	Hardwar	2360	12480	12.01	5.29
	Total	**53566**	**103882**	**100.00**	**1.94**

State : Uttarakhand

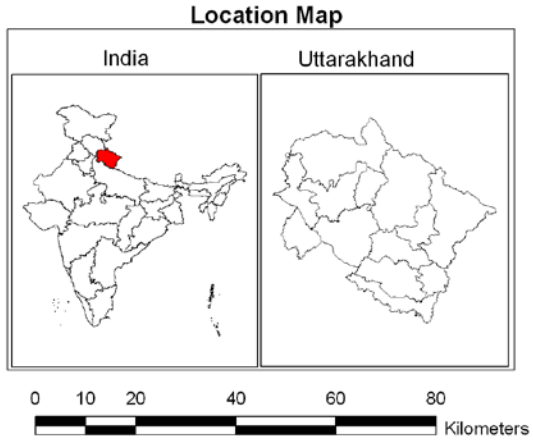
WETLAND MAP

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

Legend

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

Location Map



0 10 20 40 60 80 Kilometers

Data Source :

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

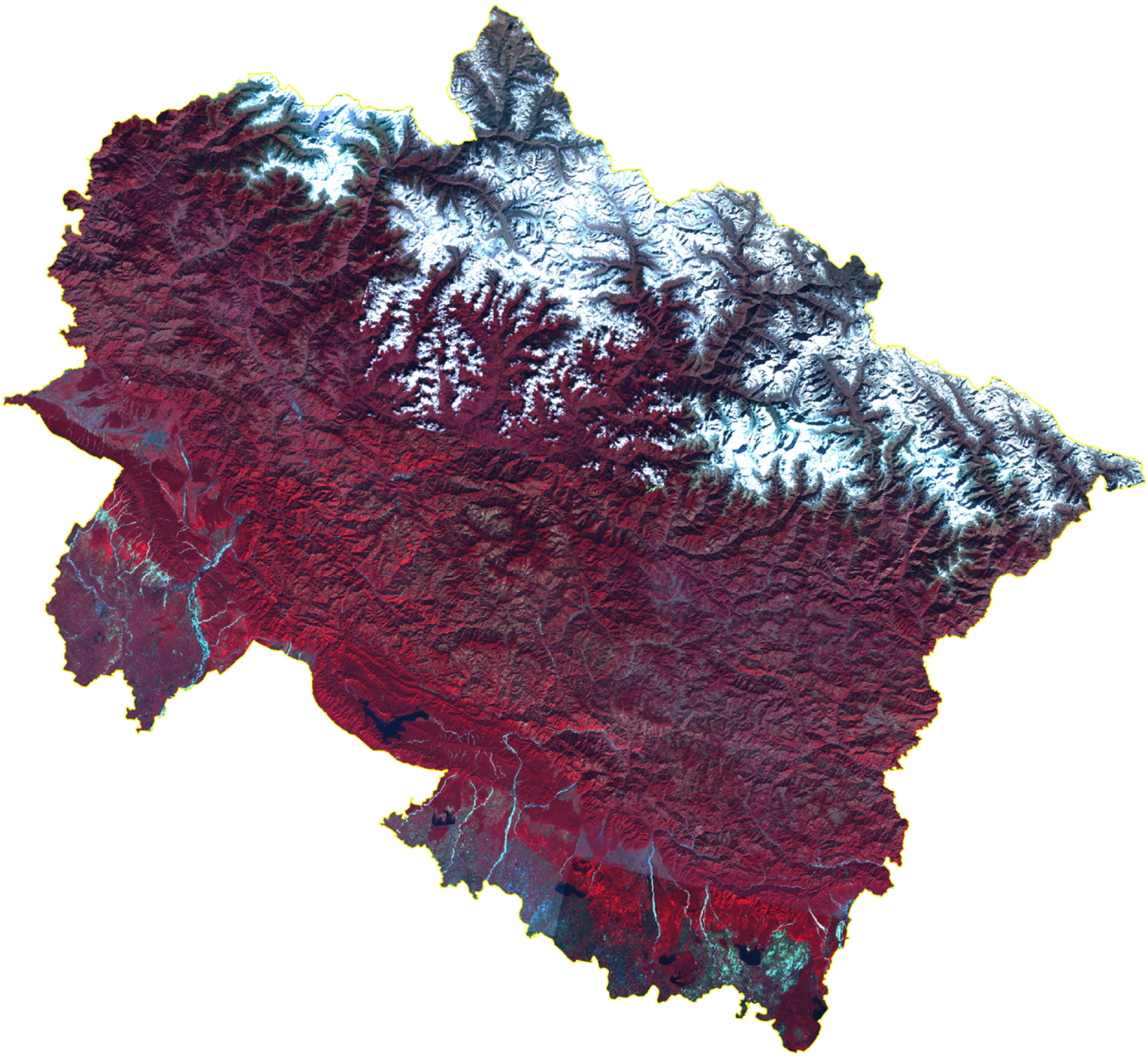
Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand



IRS P6 AWiFS post monsoon data (2007)

7.1.1 Uttarkashi

Uttarkashi is one of the 13 administrative districts of Uttarakhand surrounded by Himachal Pradesh state on the north, Tibet on the northeast, Chamoli District on the east, Rudraprayag District on the southeast and Tehri Garhwal District on the south. Uttarkashi is the source of two major rivers of India the Ganga and Yamuna. These two rivers originate from the glaciers known as ' Gangotri' and ' Yamunotri' which are important Hindu pilgrimages. Places of tourist interests in and around Uttarkashi are: Uttarkashi Town, Maneri, Gangnani, Dodital, Dayara Bugyal, Harsil, Sat-Tal, Gangotri, Kedartal, Nachiketa Tal, Gaumukh, Nandan-Van Tapovan, Yamunotri and Harkidoon etc.

High altitude wetlands are the only wetland type found in the district besides the rivers/streams. Three high altitude wetlands are mapped. However, there are 43 small wetlands (<2.25 ha area), which are identified as point features, and are mainly high altitude ones. The total area under wetlands in the district is 8532 ha.. the wetlands are devoid of any aquatic vegetation. Low and moderate turbidity prevail. In both the seasons. Details of estimates of wetlands in Uttarkashi are given in Table 6.

Table-6: Area estimates of wetlands in Uttarkashi

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	3	12	0.14	12	12
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	12	8477	99.36	3970	8477
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**15**	**8489**	**99.50**	**3982**	**8489**
		Wetlands (<2.25 ha)	43	43	0.50	-	-
		Total	**58**	**8532**	**100.00**	**3982**	**8489**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2595	4805
Moderate	1387	3684
High	-	-

State : Uttarakhand

WETLAND MAP

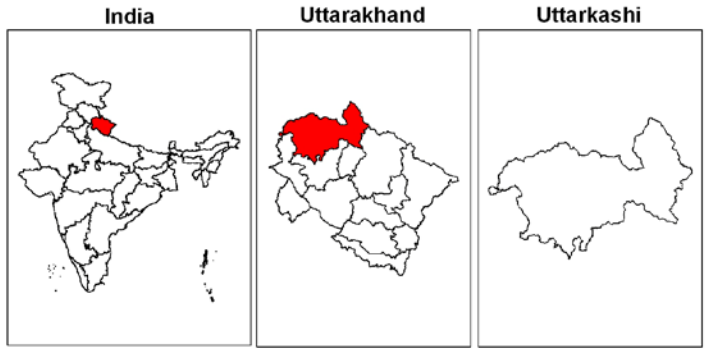
District : Uttarkashi

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

Prepared By :

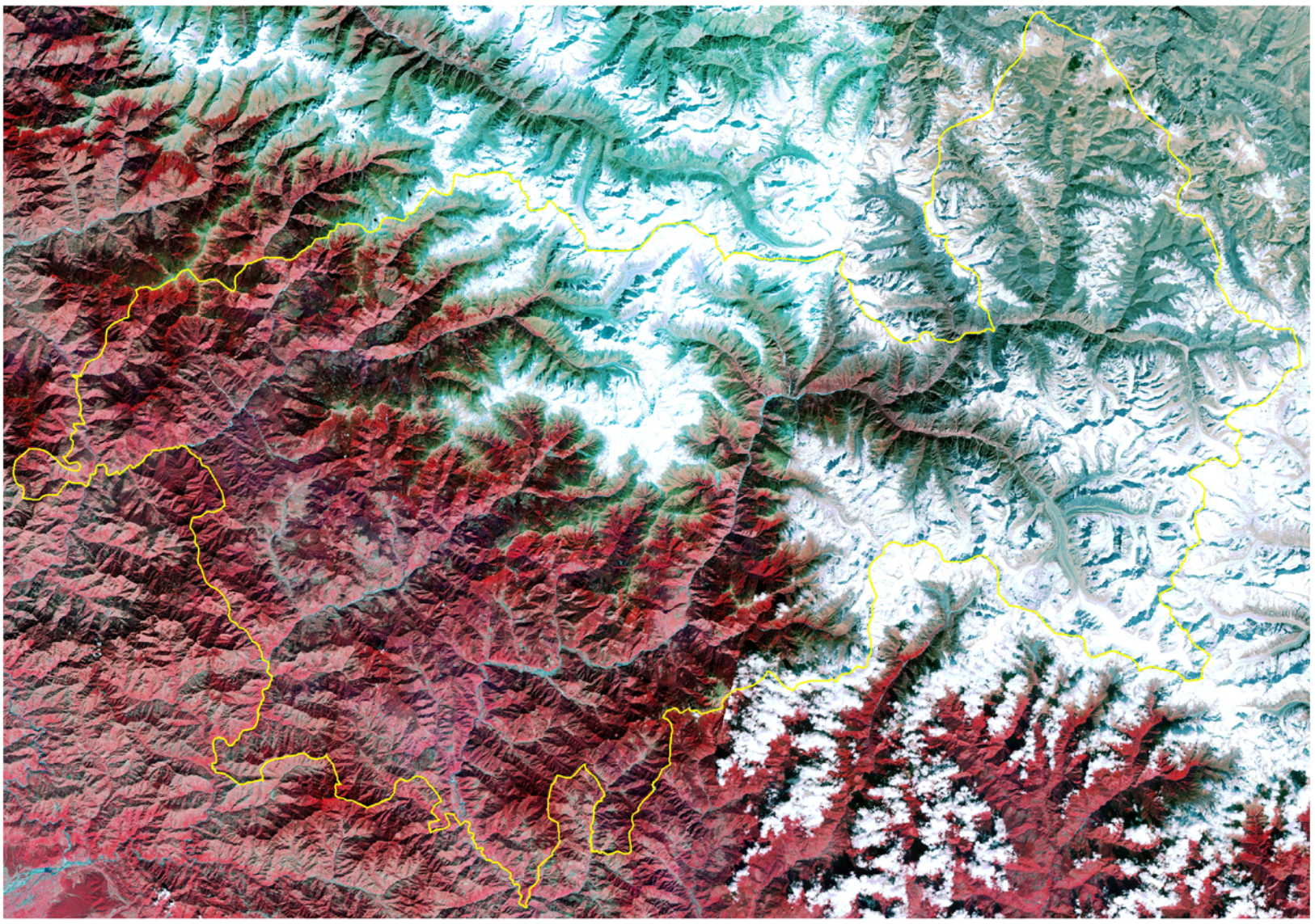
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Uttarkashi



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

7.1.2 Chamoli

Chamoli is one of the hill districts of Uttarakhand known for its shrines and temples. Chamoli is surrounded by Uttarkashi in North-West, Pithoragarh in South-West, Almora in South East, Rudraprayag in South-West and Tehri Grahwal in West. The district has several important rivers and their tributaries. Alaknanda, traversing a distance of 229 kms before it confluence with Bhagirathi at Devprayag and constituting the Ganga, is the major river. The average elevation of the district is 1,293 m.

The total wetland area in the district is 3240 ha. The most dominate wetland type in the district is River/Stream, occupying around 96.45 per cent. The other wetland type is the high altitude wetlands. Total 14 high altitude wetlands are mapped with 66 ha area. There are 49 small wetlands (<2.25 ha) identified and demarcated as point feature, which are also mainly high altitude ones.

Aquatic vegetation in wetlands is nil. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Chamoli are given in Table 7.

Table-7: Area estimates of wetlands in Chamoli

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	14	66	2.04	66	39
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	8	3125	96.45	2898	3125
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**22**	**3191**	**98.49**	**2964**	**3164**
		Wetlands (<2.25 ha)	49	49	1.51	-	-
		Total	**71**	**3240**	**100.00**	**2964**	**3164**

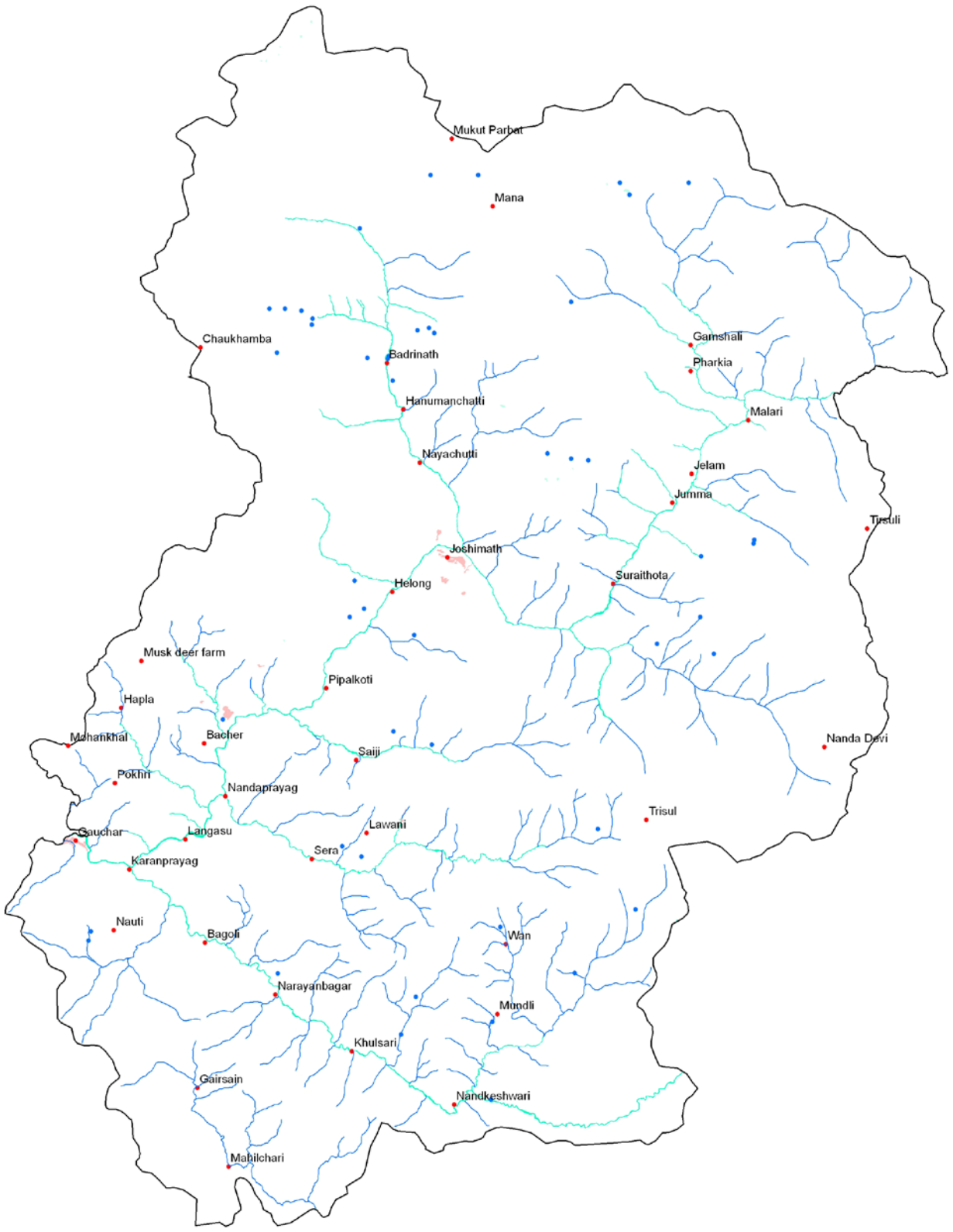
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	66	40
Moderate	2898	3124
High	-	-

State : Uttarakhand

WETLAND MAP

District : Chamoli

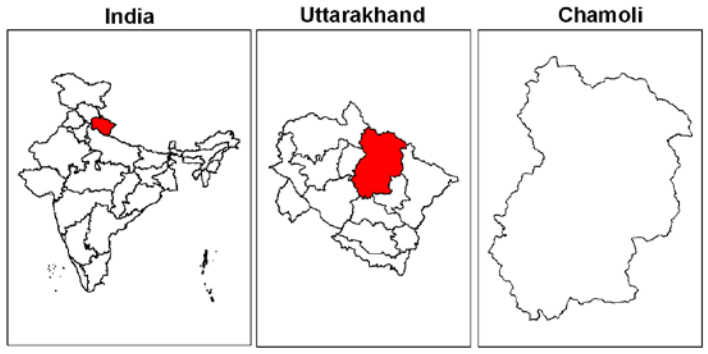


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			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 P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)

Prepared By :

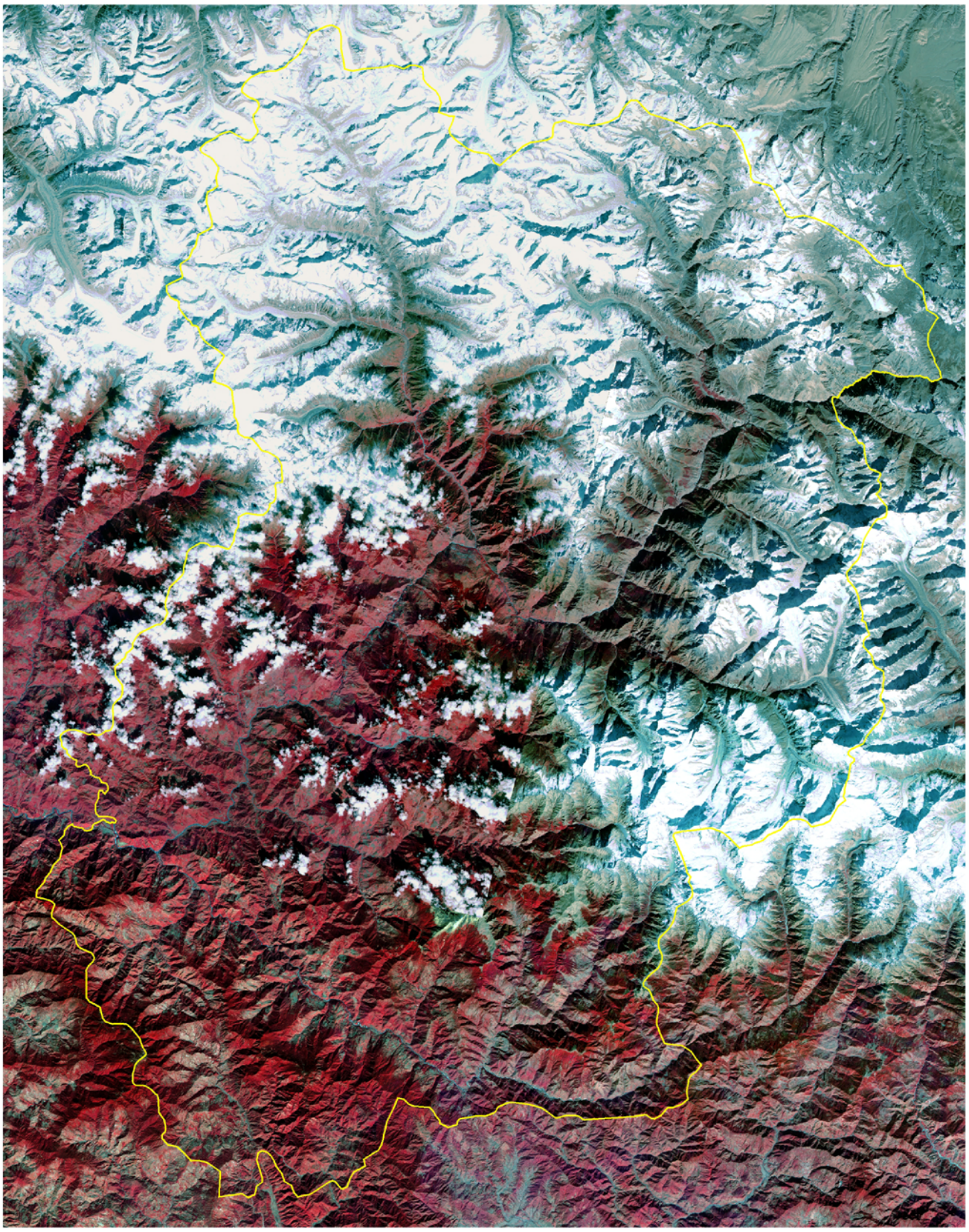
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Chamoli



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

7.1.3 Rudraprayag

Rudraprayag was carved out from the Districts of Chamoli and Tehri and was made a separate administrative district in 1997. Rudraprayag is bounded by Uttarkashi District on the north, Chamoli District on the east, Pauri Garhwal District on the south, and Tehri Garhwal District on the west. The elevation of the district ranges from 800 mts. to 8000 mts above sea level.Some of the important lakes of the district are Gaurikund, Deoria Tal, Gandhi Sarovar and Vasuki Tal etc.

The district has one river/strem, one high altitude wetland and one small wetland total wetland area in the district is 1702 ha. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Rudraprayag are given in Table 8.

Table-8: Area estimates of wetlands in Rudraprayag

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	2	0.12	2	2
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	1	1699	99.82	1090	1699
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**2**	**1701**	**99.94**	**1092**	**1701**
		Wetlands (<2.25 ha)	1	1	0.06	-	-
		Total	**3**	**1702**	**100.00**	**1092**	**1701**

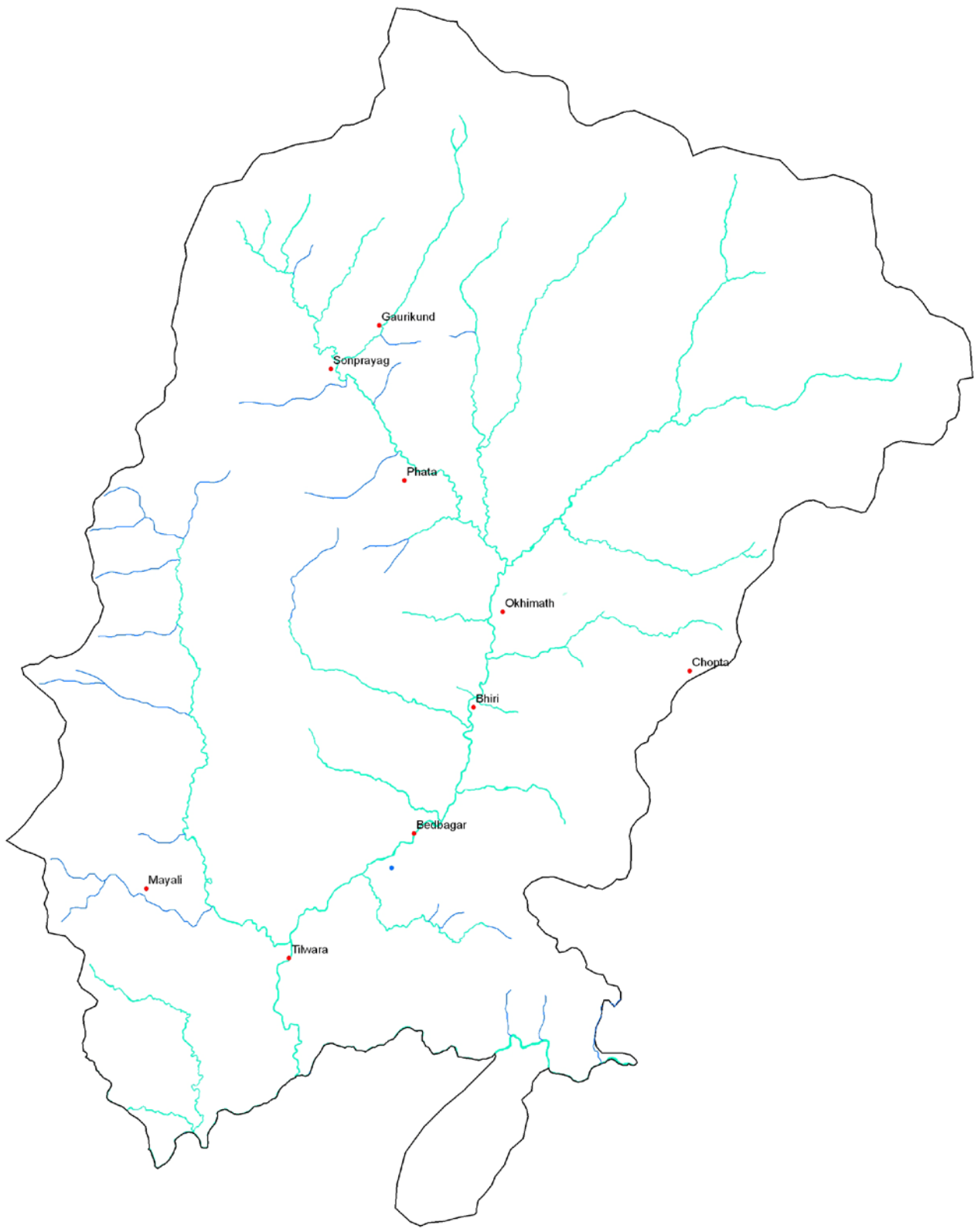
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	1092	2
Moderate	-	1699
High	-	-

State : Uttarakhand

WETLAND MAP

District : Rudraprayag

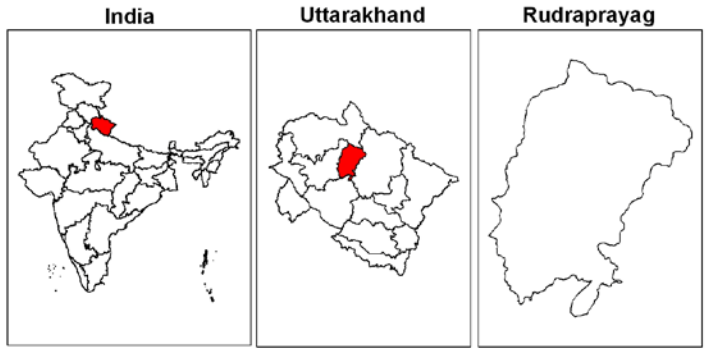


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 1.5 3 6 9 12 Kilometers

Data Source :

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

Prepared By :

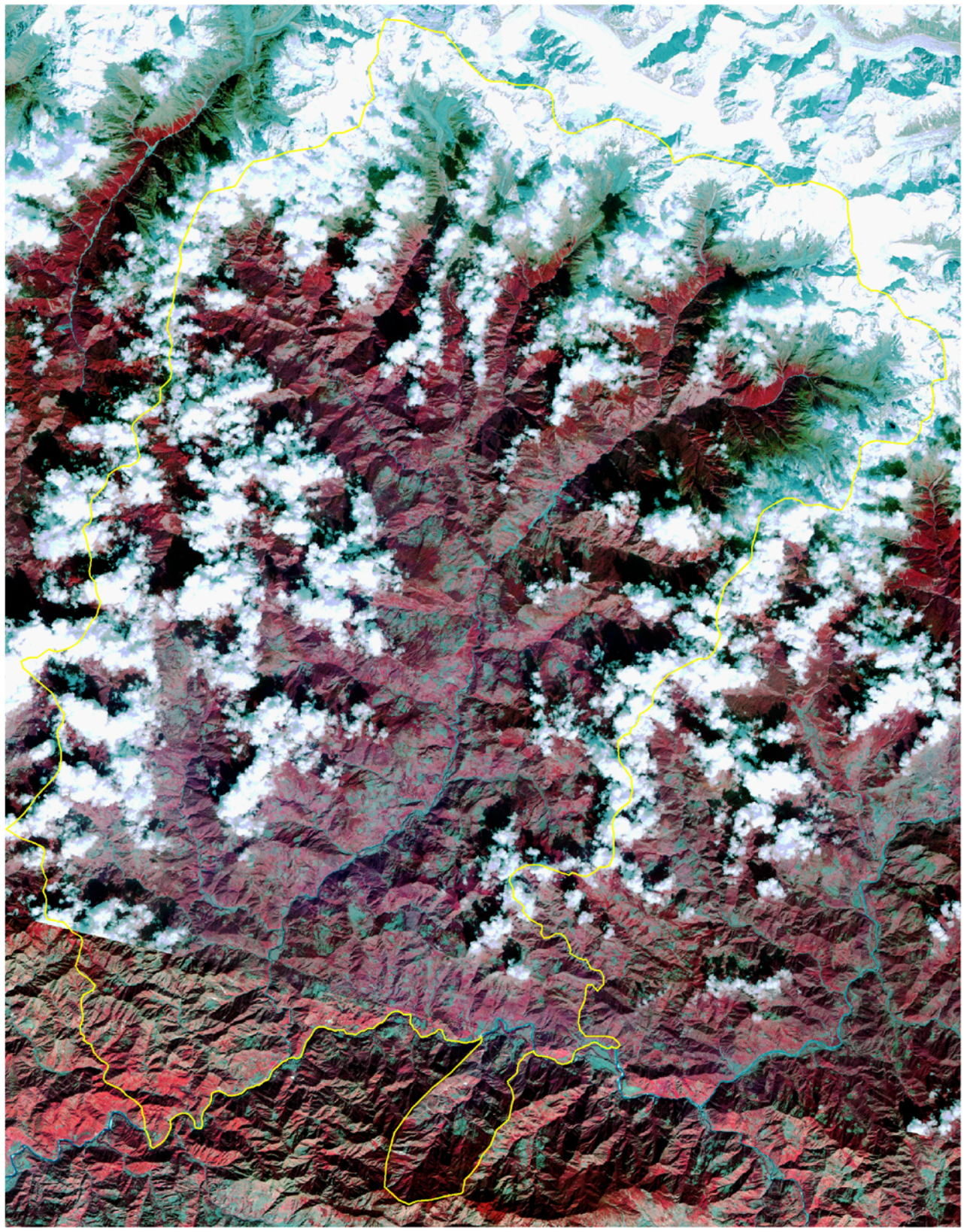
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Rudraprayag



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

7.1.4 Tehri Garhwal

The district of Tehri Garhwal is spread from the snow clad Himalayan peaks of Thalaiya Sagar, Jonli and the Gangotri group to the foothills near Rishikesh. The river Bhagirathi seems to divide it into two, while the Bhilangna, Alaknanda, Ganga and Yamuna rivers border it on the east and west. The district is surrounded by Uttarkashi, Chamoli, Pauri, Rudraprayag and Dehradun in different directions. The district headquarter is located at New Tehri town. A major portion of the district is covered by hills and forests.

The total wetland area in the district is 4173 ha. Besides the River/stream, occupying around 69.71 per cent of the total wetland are, there is one Reservoirs, contributing 29.88 per cent. There are 17 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Tehri Garhwal are given in Table 9.

Table-9: Area estimates of wetlands in Tehri Garhwal

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-Bow Lakes/Cutt-Off Meanders	-	-	-	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Riverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	11	2909	69.71	2300	2530
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1	1247	29.88	258	1246
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**12**	**4156**	**99.59**	**2558**	**3776**
		Wetlands (<2.25 ha)	17	17	0.41	-	-
		Total	**29**	**4173**	**100.00**	**2558**	**3776**

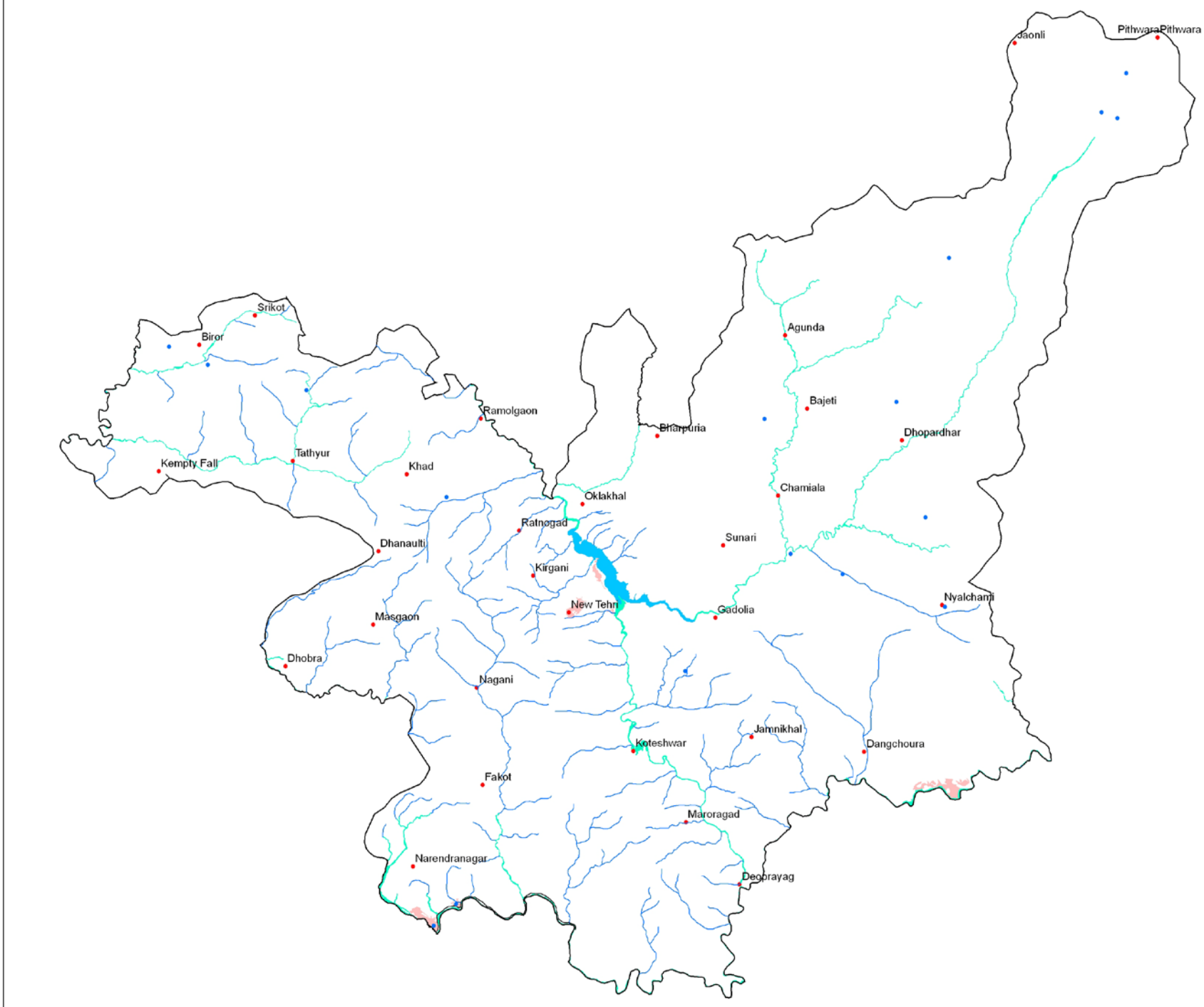
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2300	1065
Moderate	258	2711
High	-	-

State : Uttarakhand

WETLAND MAP

District : Tehri Garhwal

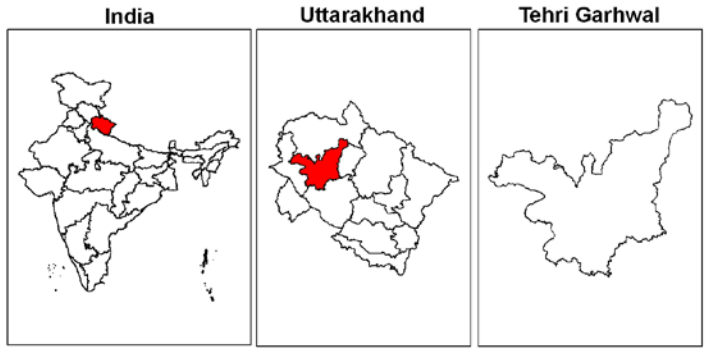


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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



0 4 8 16 24 32 Kilometers

Data Source :

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

Prepared By :

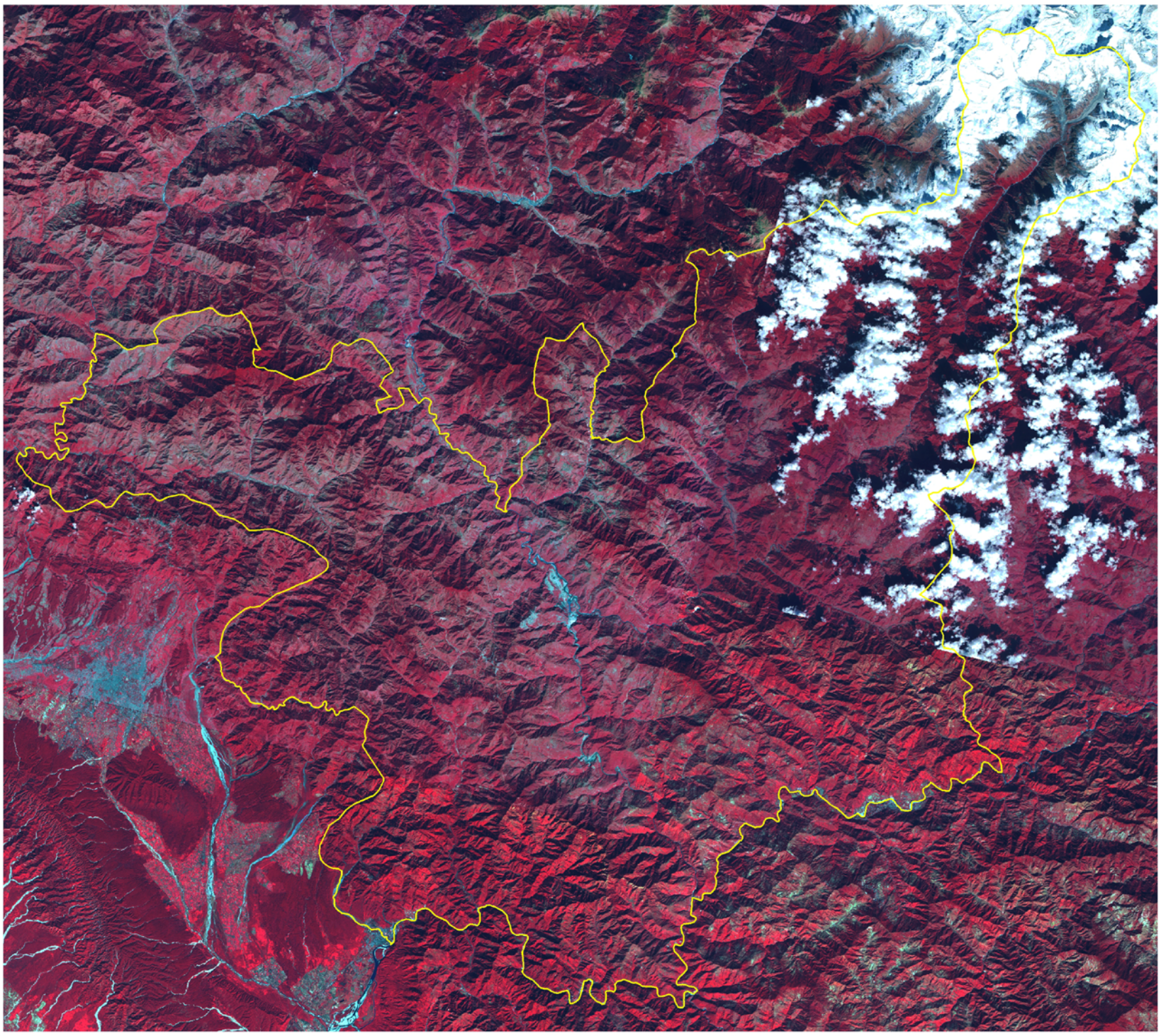
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Tehri Garhwal



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

7.1.5 Dehradun

Dehradun is one of the oldest cities of Uttarakhand, situated in the foothills of the Great Himalayas. This is one of the 13 administrative districts of the state and is important from tourism point of view. The district is surrounded by the Himalayan Mountains in the north, Shivalik Hills in the south, the river Ganga in the east, and the river Yamuna in the west. The two pristine rivers Ganga and Yamuna pass through the district.

The total wetland area in the district is 10432 ha. The most dominate wetland type in the district is River/Stream, occupying around 97.83 per cent. There are 104 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Dehradun are given in Table 10.

Table-10: Area estimates of wetlands in Dehradun

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	27	10206	97.83	2500	1573
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	2	104	1.00	77	77
8	1202	Tanks/Ponds	3	18	0.17	18	18
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**32**	**10328**	**99.00**	**2595**	**1668**
		Wetlands (<2.25 ha)	104	104	1.00	-	-
		Total	**136**	**10432**	**100.00**	**2595**	**1668**

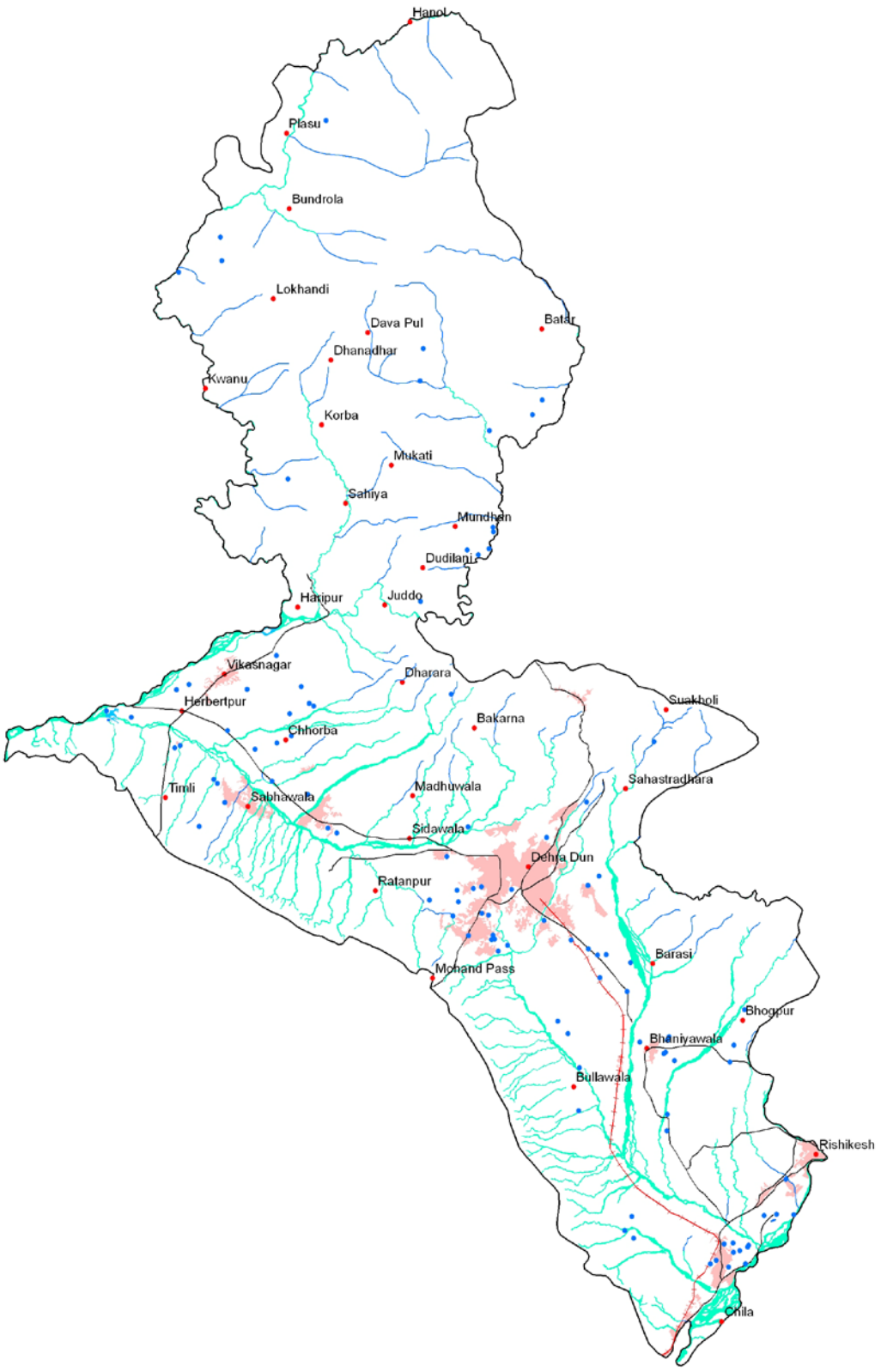
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	2290	1244
Moderate	305	424
High	0	0

State : Uttarakhand

WETLAND MAP

District : Dehradun

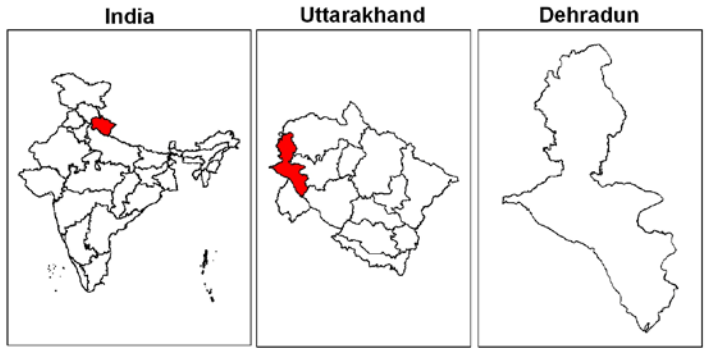


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 3 6 12 18 24 Kilometers

Data Source :

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

Prepared By :

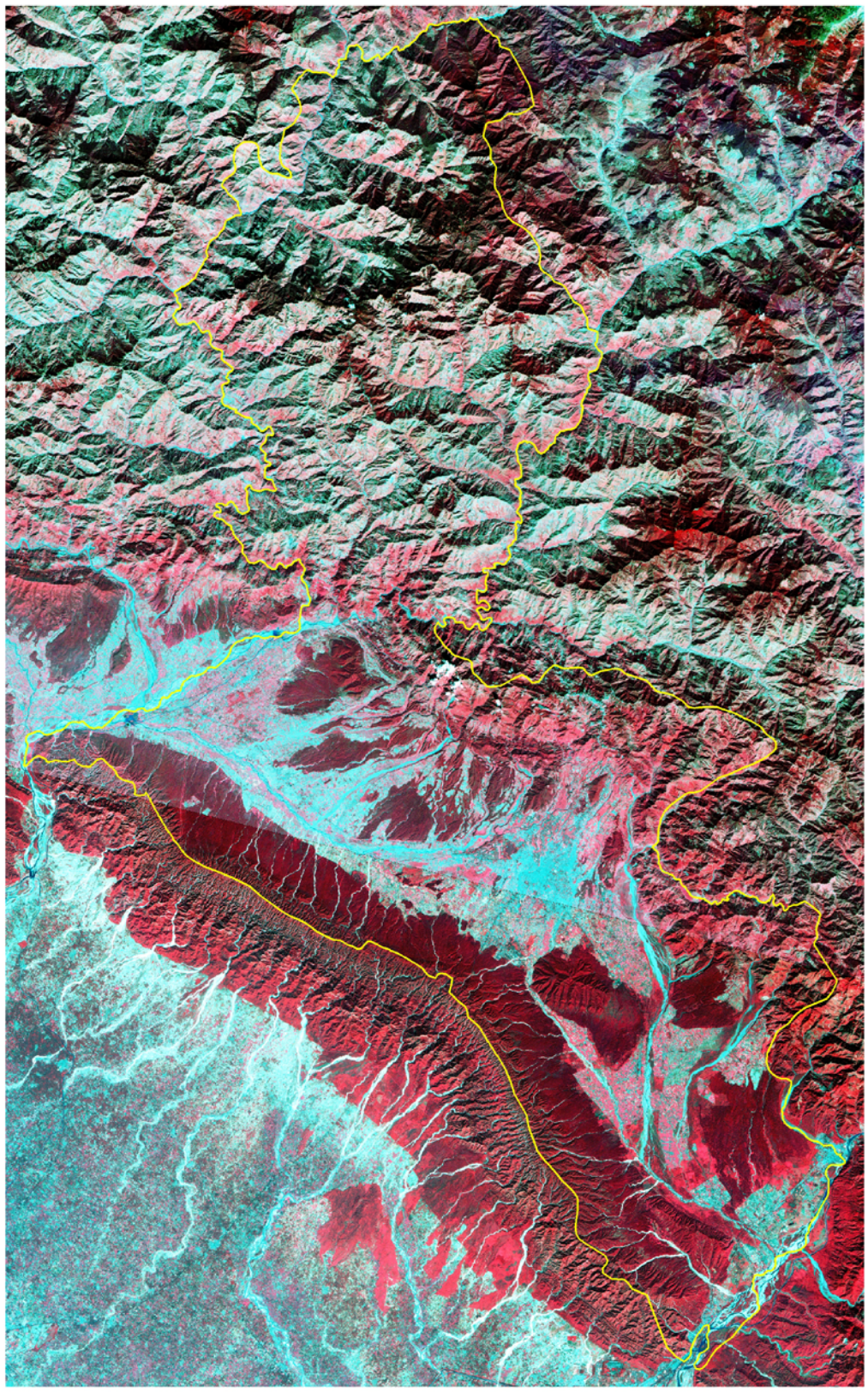
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Dehradun



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

7.1.6 Garhwal

The central coordinates of Garhwal district are Latitude 29°53'05" North and longitude 78°44'50" East. Geographic area of the district is 5438 sq km. The district is surrounded by Dehradun and Tehri Garhwal in northern part, Chamoli in eastern side, in south and south-east by Udham Singh Nagar and Almora respectively, Bijnor district of Uttar Pradesh in south-western part and Haridwar in the western side of the district.

The total wetland area in the district is 14631 ha. The most dominate wetland type in the district are River/Stream, occupying around 51.42 per cent and Reservoir/Barrage around 48.48 per cent. There are 15 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Garhwal are given in Table 11.

Table-11: Area estimates of wetlands in Garhwal

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	-	-	-	-	-
2	1102	Ox-Bow Lakes/ Cut-Off Meanders	-	-	-	-	-
3	1103	High altitude Wetlands	-	-	-	-	-
4	1104	Reverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	60	7523	51.42	3461	3336
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/ Barrages	1	7093	48.48	7092	4036
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**61**	**14616**	**99.90**	**10553**	**7372**
		Wetlands (<2.25 ha)	15	15	0.10	-	-
		Total	**76**	**14631**	**100.00**	**10553**	**7372**

Area under Aquatic Vegetation	-	3059

Area under turbidity levels		
Low	3461	81
Moderate	7092	7291
High	-	-

State : Uttarakhand

WETLAND MAP

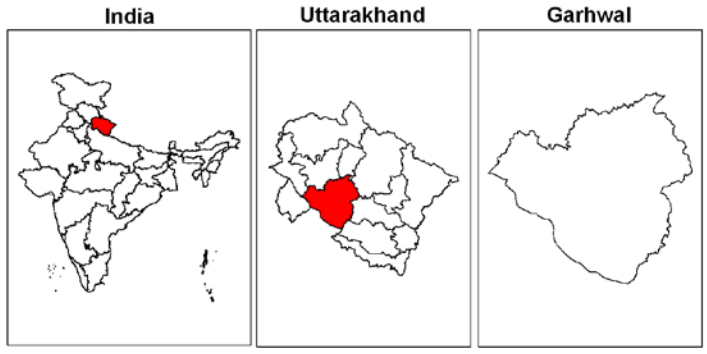
District : Garhwal

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



0 3 6 12 18 24 Kilometers

Data Source :

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

Prepared By :

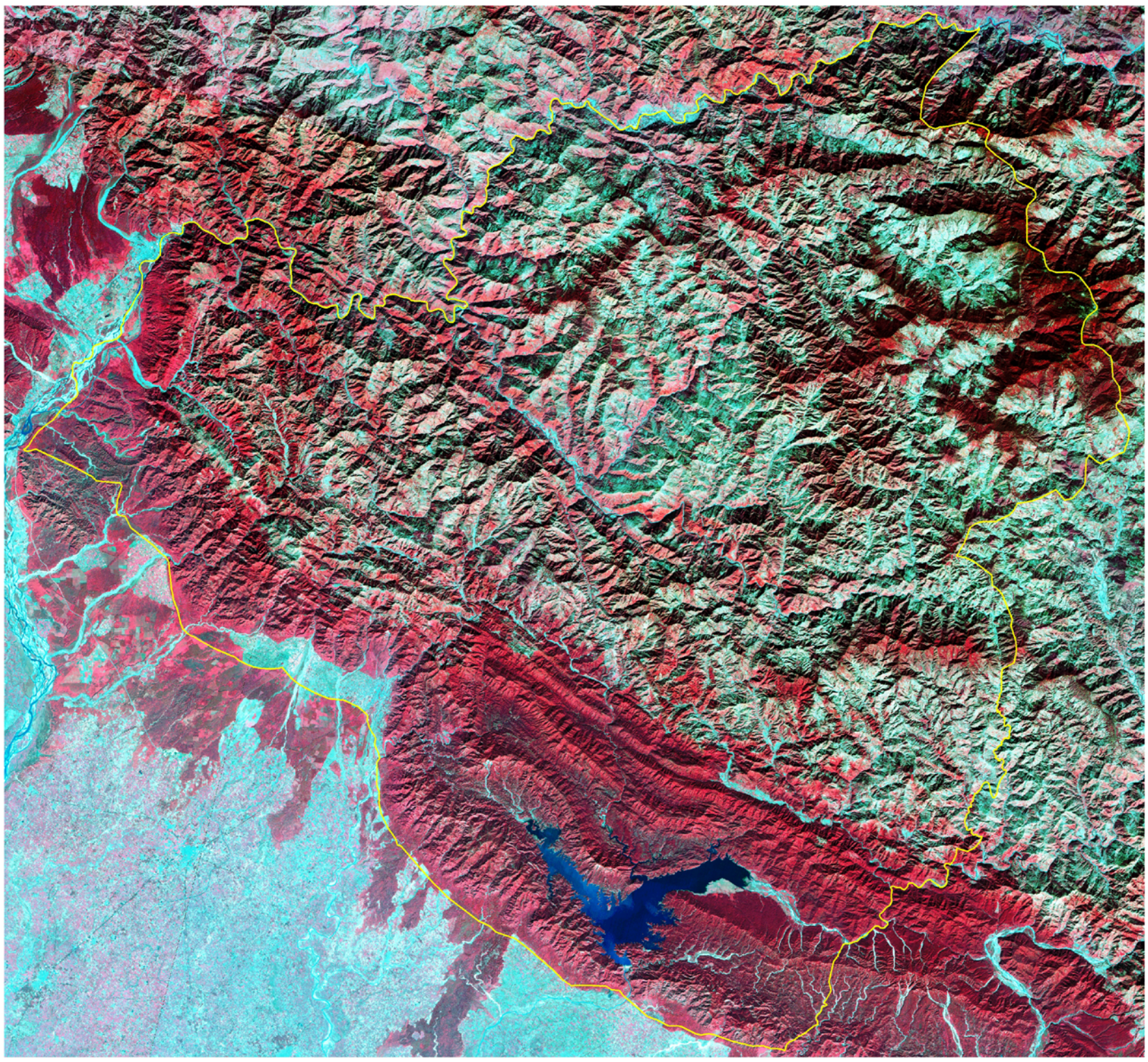
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Garhwal



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

7.1.7 Pithoragarh

Pithoragarh, is set in a valley popularly known as Soar and lying in the centre of four hills Chandak, Dhwaj, Kumdar and Thal Kedar. The district stretches in the southern flank to Jhulaghat demarcated by the Kali River adjoining the barren peaks of Nepal Hills. It is nestled in the folds of four kots Bhatkot, Dungerkot, Udaikot and Unchakot.The district is surrounded by the national boundaries of Almora, Champawat, Bageshwar and Chamoli districts. Being the district adjoining Tibbet, it has great strategic importance as the passes of Lipulekh, Kungribingri, Lampia Dhura, Lawe Dhura, Belcha and Keo, open out to Tibet.

The total wetland area in the district is 6023 ha. The most dominate wetland type in the district is River/Stream, occupying around 98.56 per cent. There are 11 high altitude wetlands with 62 ha area. There are 25 small wetlands (<2.25 ha) identified and demarcated as point feature. The turbidity of water is low and moderate. The wetland statistics of the district is given in Table 12.

Table-12: Area estimates of wetlands in Pithoragarh

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	11	62	1.03	62	62
4	1104	Reverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	12	5936	98.56	4944	5936
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**23**	**5998**	**100**	**5006**	**5998**
		Wetlands (<2.25 ha)	25	25	0.42	-	-
		Total	**48**	**6023**	**100**	**5006**	**5998**

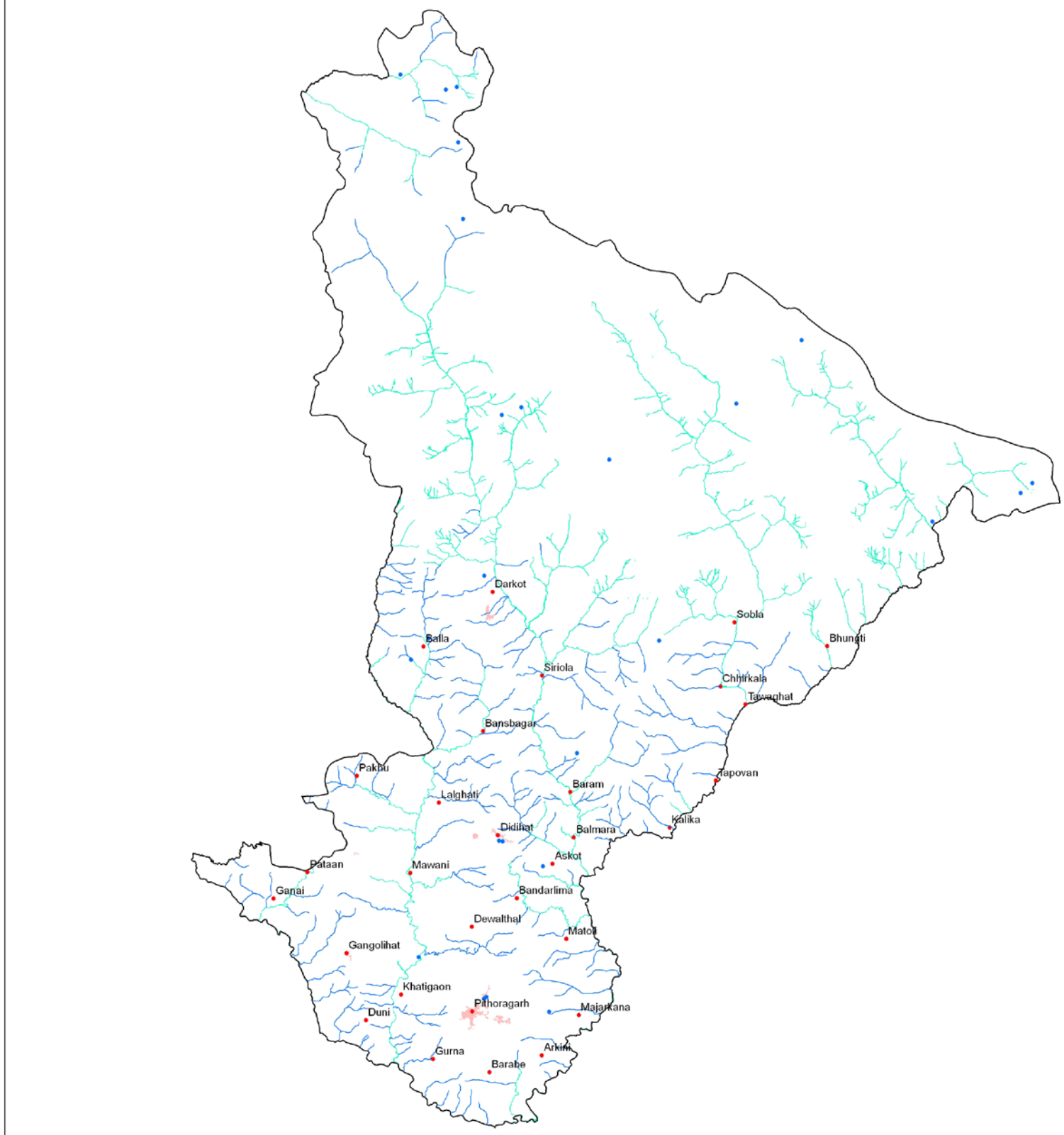
Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	62	62
Moderate	4944	5936
High	-	-

State : Uttarakhand

WETLAND MAP

District : Pithoragarh

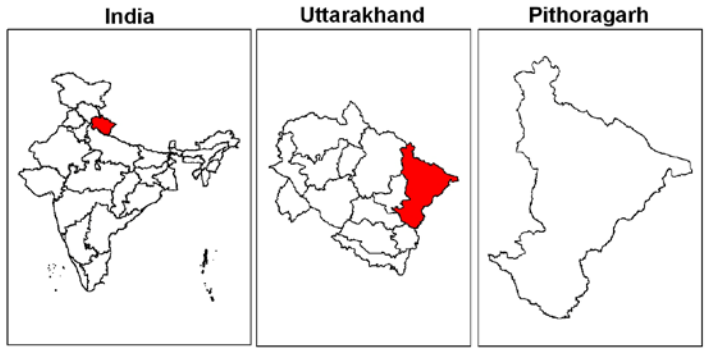


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 4 8 16 24 32 Kilometers

Data Source :

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

Prepared By :

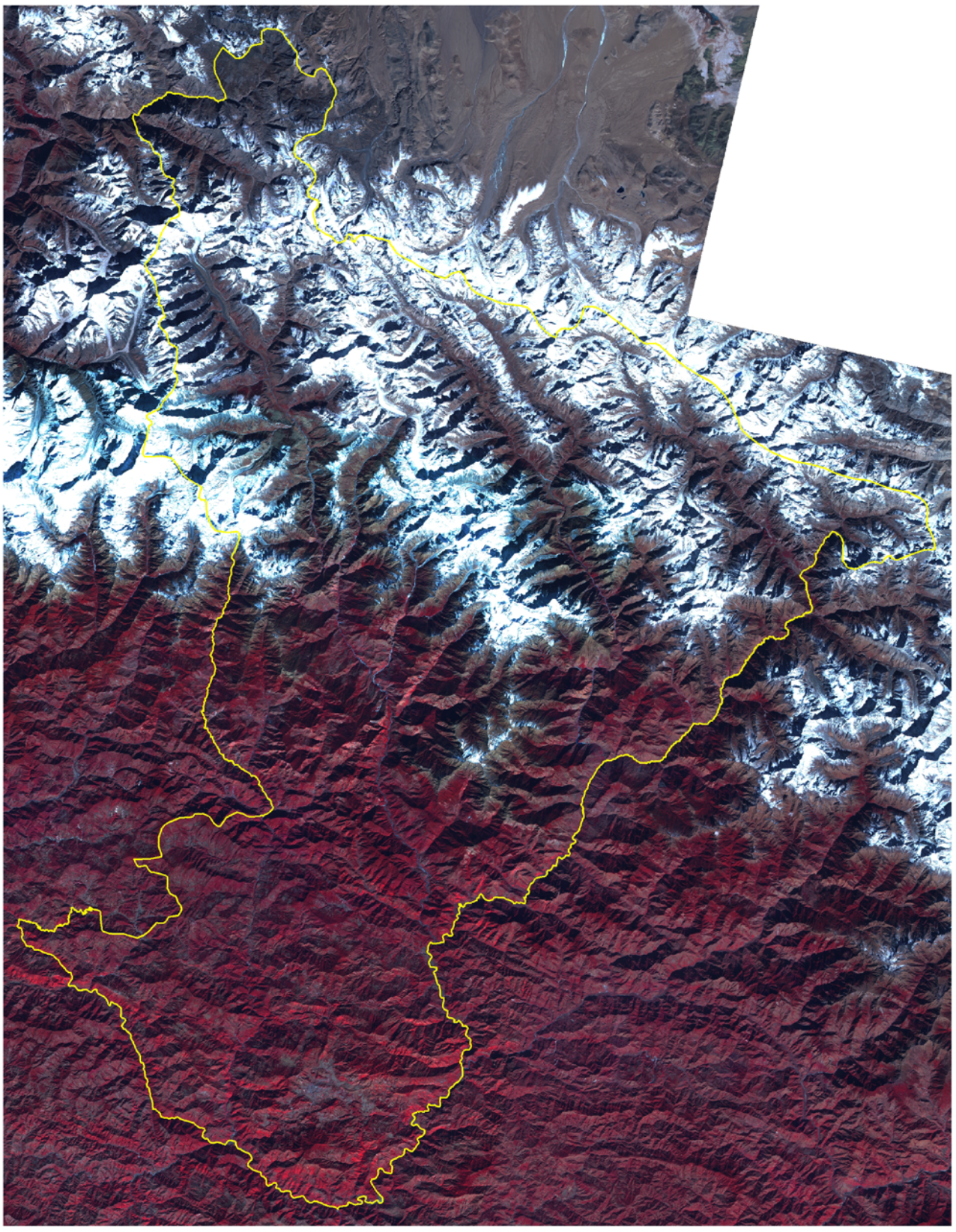
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Pithoragarh



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

7.1.8 Bageshwar

Bageshwar district is situated at the confluence of rivers Saryu, Gomti and latent Bhagirathi. Lying in the northern part of Uttarakhand, Bageshwar is bordered by Tibet in the east; district Chamoli in the west and Great Himalayas in the north and south. The district is flanked by the Bhileswar and Nileshwar mountains in the east and west respectively and surrounded by Suraj Kund in the north and Agni Kund in the south. Bageshwar town is the administrative head quarter of the district. This holy township of Bageshwar is a pious land associated with Lord Sadashiva.

The total wetland area in the district is 2187 ha. The most dominate wetland type in the district is River/Stream, occupying around 99.73 per cent. There are 6 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Bageshwar are given in Table 13.

Table-13: Area estimates of wetlands in Bageshwar

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	Reverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	24	2181	99.73	2060	2181
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**24**	**2181**	**99.73**	**2060**	**2181**
		Wetlands (<2.25 ha)	6	6	0.27	-	-
		Total	**30**	**2187**	**100.00**	**2060**	**2181**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	610	691
Moderate	1450	1490
High	-	-

State : Uttarakhand

WETLAND MAP

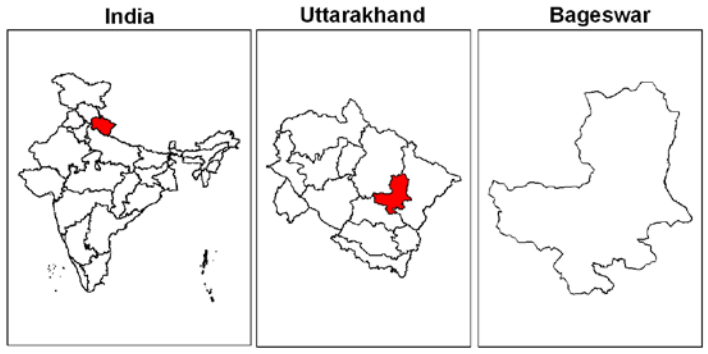
District : Bageswar

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



0 1.5 3 6 9 12 Kilometers

Data Source :

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

Prepared By :

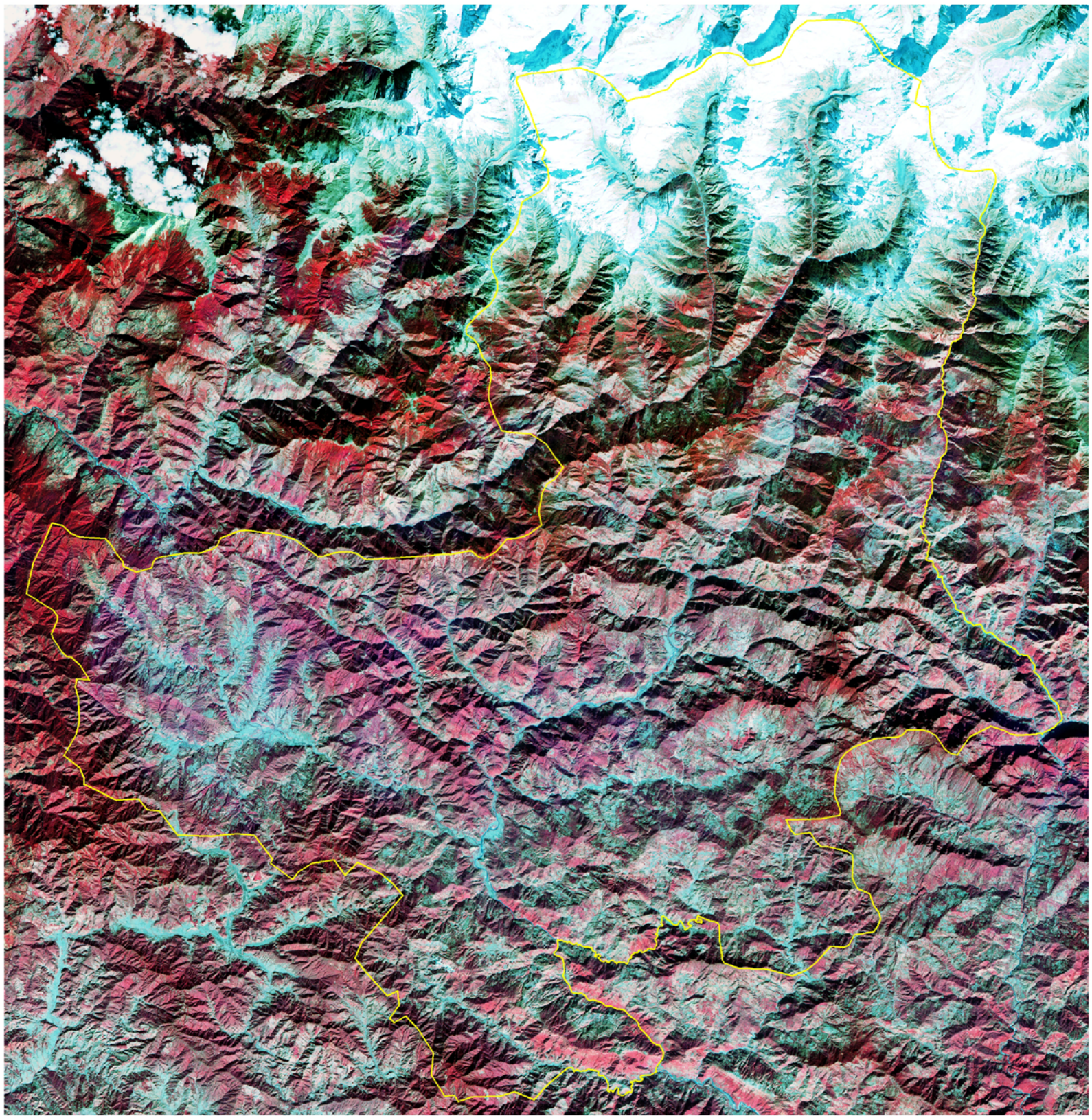
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Bageswar



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

7.1.9 Almora

Almora is a picturesque district located in the Kumaun region, east of Uttarakhand. The district is surrounded by Pithoragarh district in the east, Garhwal in the west, Bageshwar to its north and district Nainital in its south. The whole district offers breathtaking views of Himalayas; hence attracts tourists from the whole world to have the grandeur of its natural beauty. The most widely visited spots in and around Alomora are: Ranikhet, Kausani, Binsar, Bageshwer, Shitla Khet, Jalana, Baijnath, Dwarahat, Manila, Katarmal, Patal Bhubneshwer , Jageshwer, Chitai Temple, Jageshwar and Doonagiri.

The total wetland area in the district is 3326 ha. The most dominate wetland type in the district is River/Stream, occupying around 99.85 per cent. There are 5 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Almora are given in Table 14.

Table-14: Area estimates of wetlands in Almora

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	Reverine Wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	32	3321	99.85	3098	2292
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**32**	**3321**	**99.85**	**3098**	**2292**
		Wetlands (<2.25 ha)	5	5	0.15	-	-
		Total	**37**	**3326**	**100.00**	**3098**	**2292**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	897	0
Moderate	2201	2292
High	-	-

State : Uttarakhand

WETLAND MAP

District : Almora

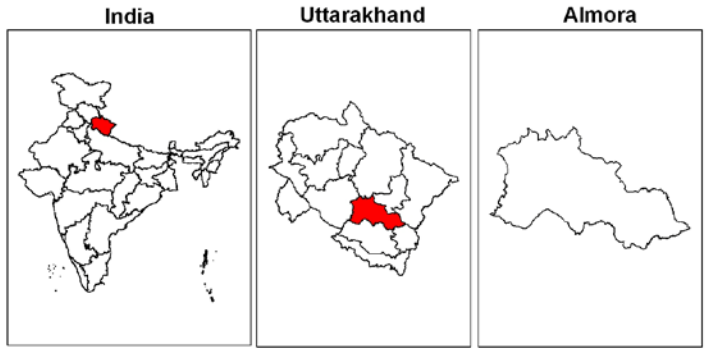
Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 2 4 8 12 16 Kilometers

Data Source :

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

Prepared By :

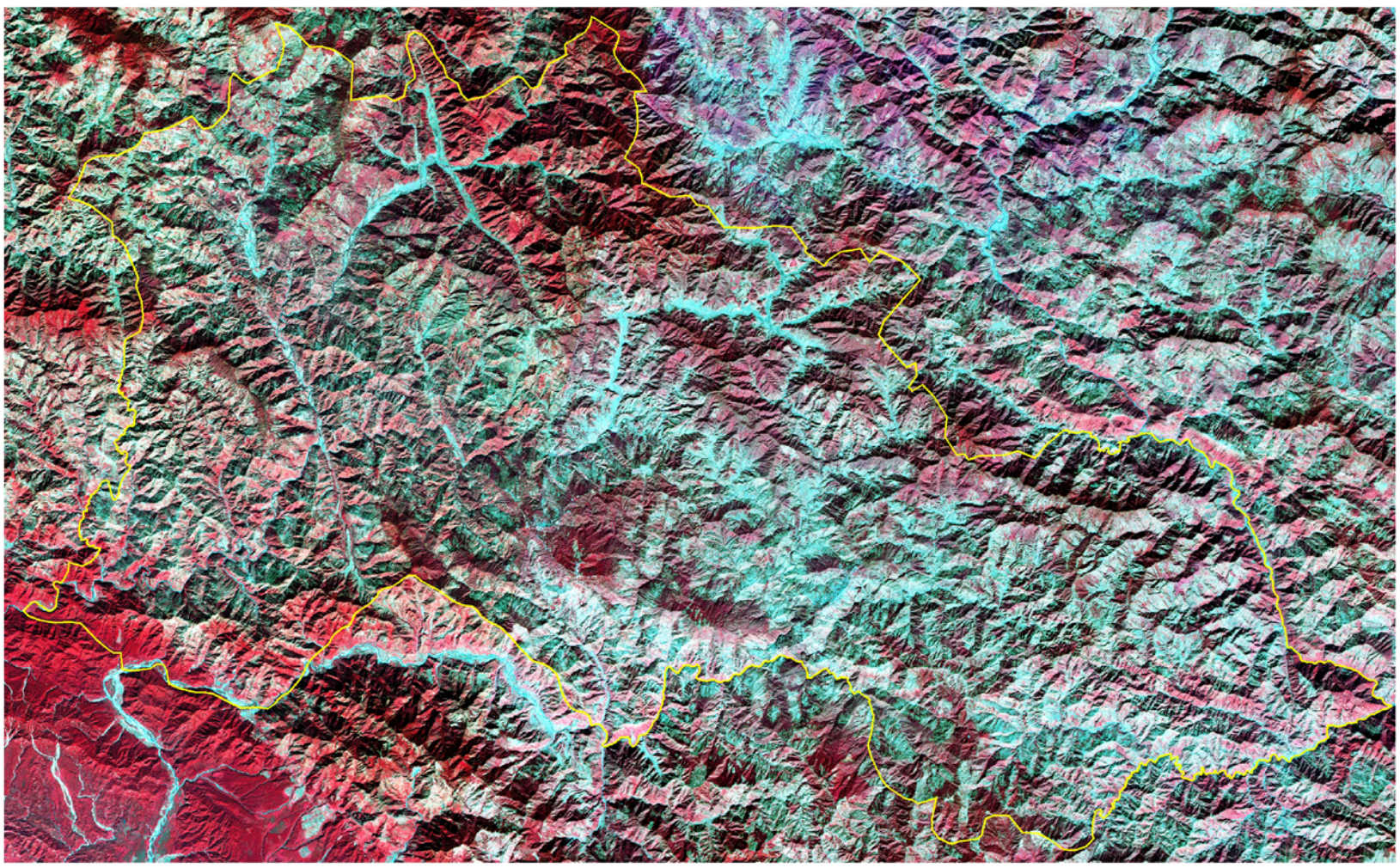
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Almora



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

7.1.10 Champawat

The central coordinates of Champawat district are Latitude 29°17'57" North and longitude 80°5'27" East. Geographic area of the district is 1781 sq km. The district of Champawat was established in the year 1997. The Ram Ganga River acts as a border between Champawat and Pithoragarh in north while Jabgura and Pannar rivers in south and west act as a border between Champawat, Udham Singh Nagar and Almora districts simultaneously. The long chain of mountain in south-western region acts as a border between the district Champawat and Nainital district. Champawat mainly consists of mountain ranges, large valleys, uneven landscapes, rivers and rivulets.

Terai area of the district includes plain and agricultural land. This area is tropical in nature having warm climate with an average height of 200 to 250 meter, having abundance of water and good soil. Shivalik range is situated at a height of 250 to 1200 meter and represents a sloping and uneven topographical land.

The total wetland area in the district is 3222 ha. The most dominate wetland type in the district is River/Stream, occupying around 99.32 per cent. There are 19 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Champawat are given in Table 15.

Table-15: Area estimates of wetlands in Champawat

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	3	0.09	3	3
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Reverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	14	3200	99.32	1574	383
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**15**	**3203**	**99.41**	**1577**	**386**
		Wetlands (<2.25 ha)	19	19	0.59	-	-
		Total	**34**	**3222**	**100.00**	**1577**	**386**

Area under Aquatic Vegetation	-	-

Area under turbidity levels		
Low	754	3
Moderate	823	383
High	-	-

State : Uttarakhand

WETLAND MAP

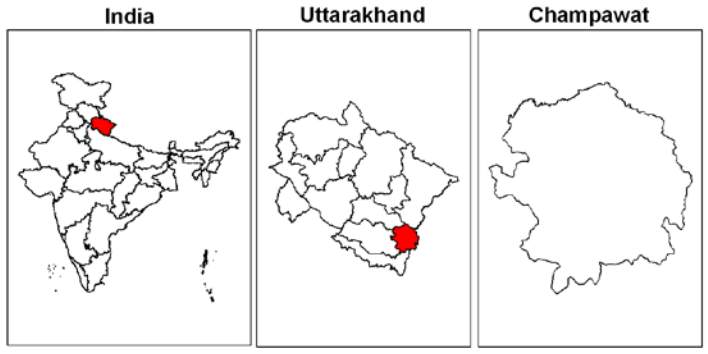
District : Champawat

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



0 1.5 3 6 9 12 Kilometers

Data Source :

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

Prepared By :

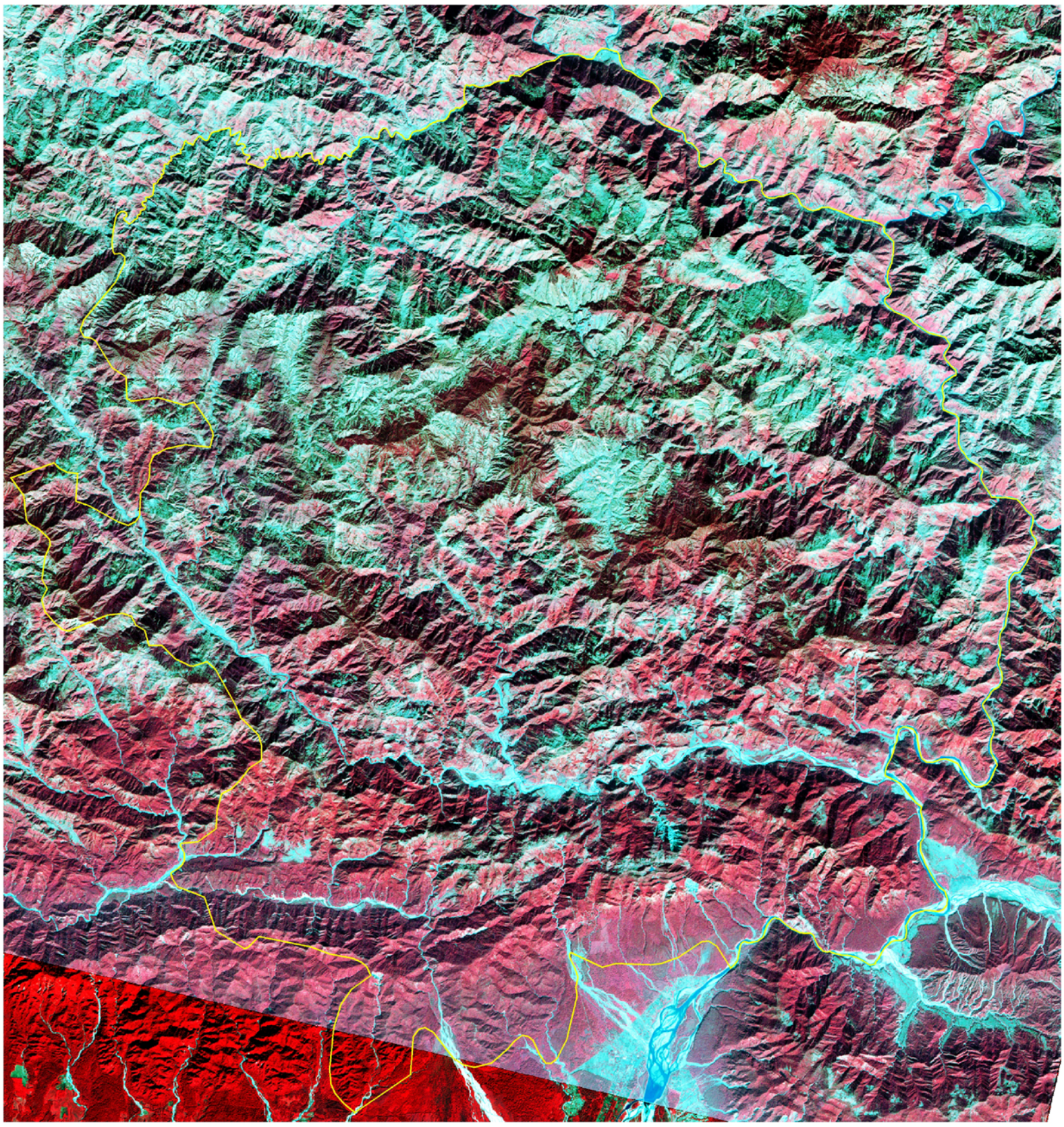
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Champawat



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

7.1.11 Nainital

The central coordinates of Nainital district are Latitude 29°19'40" North and longitude 79°23'53" East. Geographic area of the district is 3853 sq km. Nainital has earned the epithet of 'Lake District' of India. Geographically the district is divided in to two zones viz. Hilly and Bhabar. The hilly region in outer Himalayas is known to geologist as Krol. The highest peak of the district is Baudhansthali 2623 mts. high near Binayak adjoining Nainital town. The foothill area of the district is known as Bhabhar. The prime attractions in Nainital are: Naina Lake, Khorpa Tal, Kilbury, Gherkhet, High Altitude Zoo, and Corbett National Park.

The total wetland area in the district is 13835 ha. The most dominate wetland type in the district are River/Stream, occupying around 88.77 per cent and Reservoir/barrage around 9.99 per cent. There are 17 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Nainital are given in Table 16.

Table-16: Area estimates of wetlands in Nainital

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	10	155	1.12	155	151
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Reverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	34	12281	88.77	3634	134
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	7	1382	9.99	450	160
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**0**	**13818**	**0.00**	**4239**	**445**
		Wetlands (<2.25 ha)	17	17	0.12	-	-
		Total	**17**	**13835**	**0.12**	**4239**	**445**

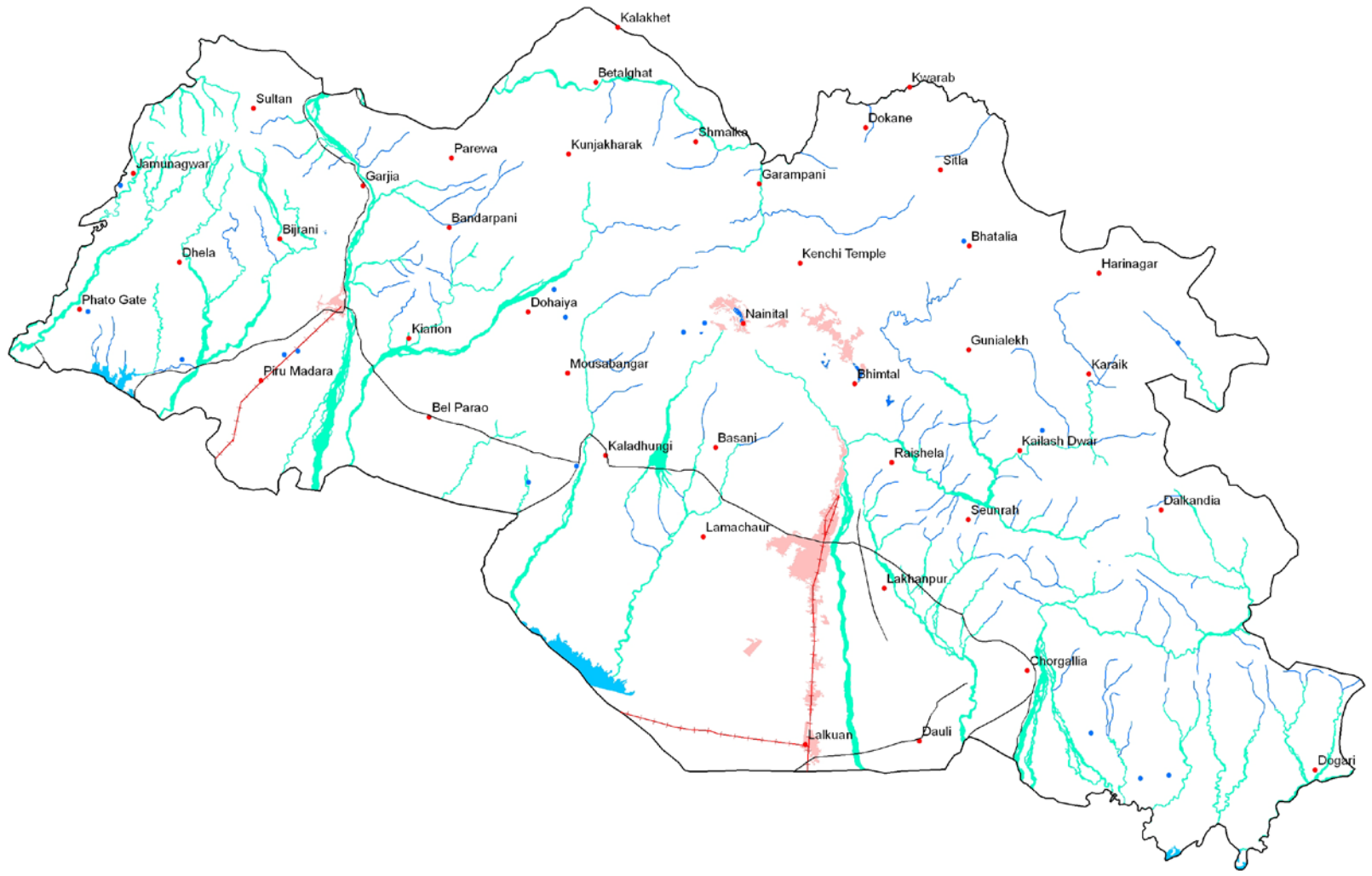
Area under Aquatic Vegetation	953	1331

Area under turbidity levels		
Low	3787	150
Moderate	452	295
High	-	-

State : Uttarakhand

WETLAND MAP

District : Nainital

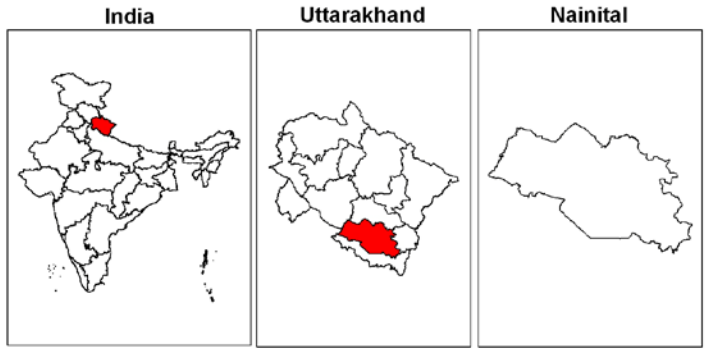


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 2.5 5 10 15 20 Kilometers

Data Source :

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

Prepared By :

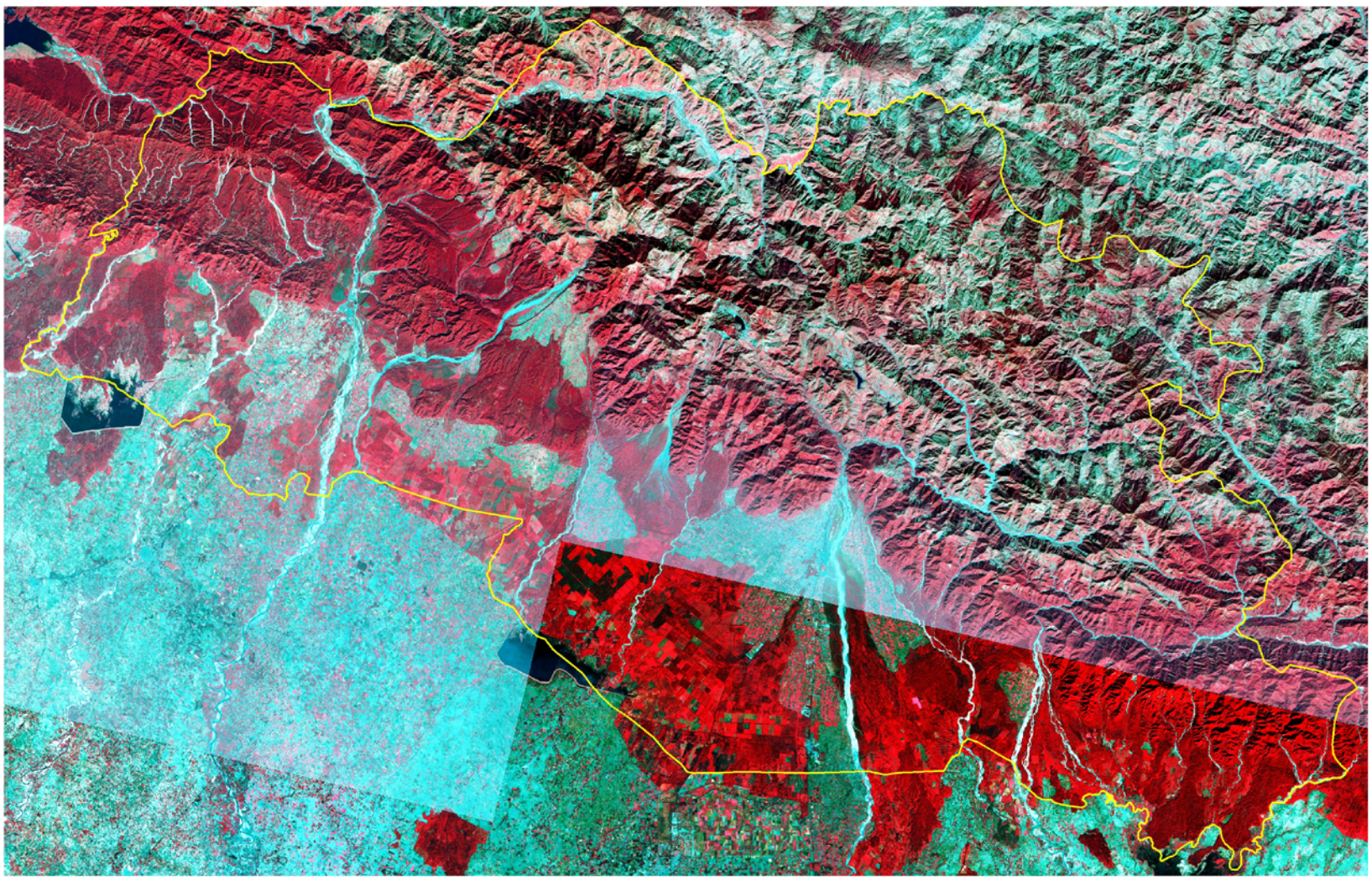
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Nainital



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

7.1.12 Udham Singh Nagar

Udham Singh Nagar is one of the 13 administrative districts of Uttarakhand. It is encompasses by Nainital District on the north, on the northeast by Champawat District, on the east by Nepal, and on the south and west by Uttar Pradesh state. The district was created in October 1995 out of Nainital District, and is named after Raja Udham Singh. The administrative head quarter is located at Rudrapur. The district is situated in the Terai region, also part of Kumaon Division and it shares an international border with Nepal. Udham Singh Nagar is basically an industrial district and many industries are located here.

The total wetland area in the district is 20099 ha. The most dominate wetland type in the district are Reservoir/barrage, occupying around 52.21 per cent, River/Stream around 36.90 and lakes/Ponds around 9.57 per cent. There are 173 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Udham Singh Nagar are given in Table-17.

Table-17: Area estimates of wetlands in Udham Singh Nagar

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	1923	9.57	1589	603
2	1102	Ox-bow lakes/ Cut-off meanders	11	45	0.22	38	39
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Reverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	9	0.04	5	9
6	1106	River/Stream	30	7416	36.90	2077	894
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	6	10493	52.21	6534	4694
8	1202	Tanks/Ponds	-	-	-	-	-
9	1203	Waterlogged	8	40	0.20	39	40
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**57**	**19926**	**99.14**	**10282**	**6279**
		Wetlands (<2.25 ha)	173	173	0.86	-	-
		Total	**230**	**20099**	**100.00**	**10282**	**6279**

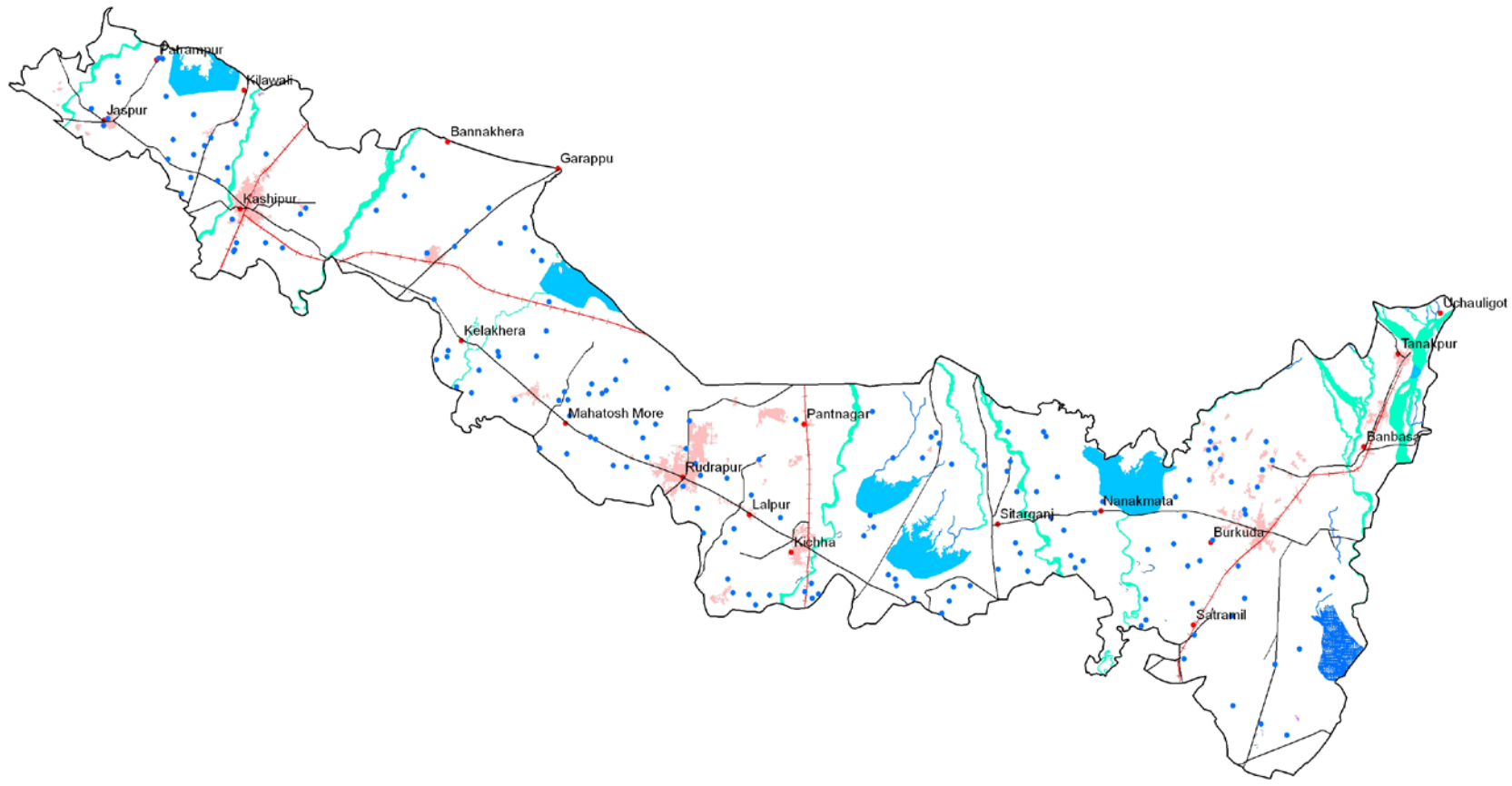
Area under Aquatic Vegetation	4305	7098

Area under turbidity levels		
Low	3748	1585
Moderate	6534	4694
High	-	-

State : Uttarakhand

WETLAND MAP

District : Udham Singh Nagar

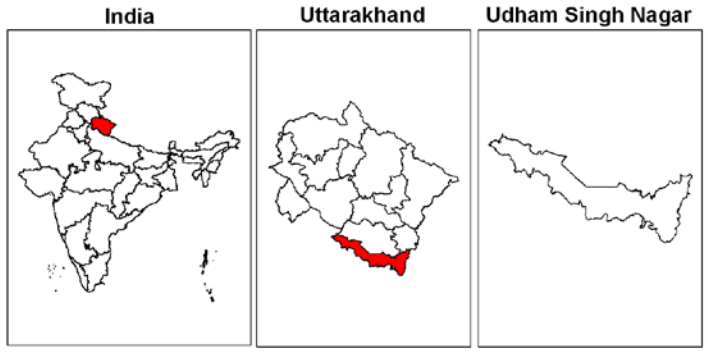


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 3.5 7 14 21 28 Kilometers

Data Source :

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

Prepared By :

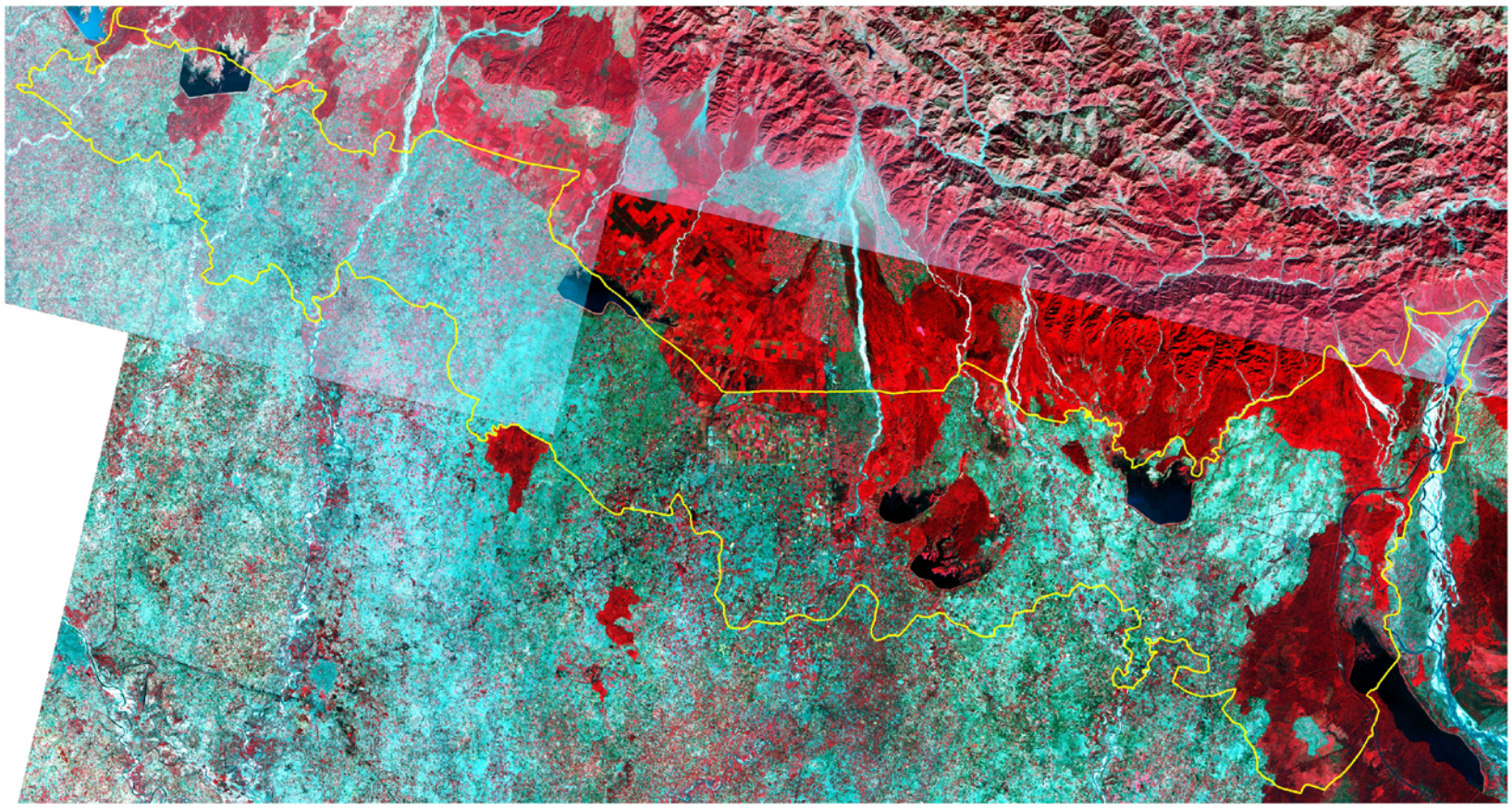
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Udham Singh Nagar



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

7.1.13 Hardwar

The central coordinates of Hardwar district are Latitude 29°53'16" North and longitude 77°59'22" East. Geographic area of the district is 2360 sq km. Hardwar is one of the 13 administrative districts of Uttarakhand surrounded by Saharanpur in the west, Dehradun in the north and east, Pauri Garhwal in the east, Muzzaffar Nagar and Bijnor in the south. The district headquarter is located at Roshnabad. The city is located on the banks of river Ganga that gives the town a unique status and religious importance. Major attractions in Hardwar are: Sapt Sarovar and Rajaji National Park (Chilla).

The total wetland area in the district is 12480 ha. The most dominate wetland type in the district is River/Stream, occupying around 95.02 per cent. There are 342 small wetlands (<2.25 ha) identified and demarcated as point feature. Qualitative turbidity analysis of the open water showed that low and moderate turbidity prevail. Details of estimates of wetlands in Hardwar are given in Table 18.

Table-18: Area estimates of wetlands in Hardwar

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	4	18	0.14	11	18
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Reverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	9	11859	95.02	3961	2385
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	18	90	0.72	72	90
9	1203	Waterlogged	1	171	1.37	171	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**32**	**12138**	**97.26**	**4215**	**2493**
		Wetlands (<2.25 ha)	342	342	2.74	-	-
		Total	**374**	**12480**	**100.00**	**4215**	**2493**

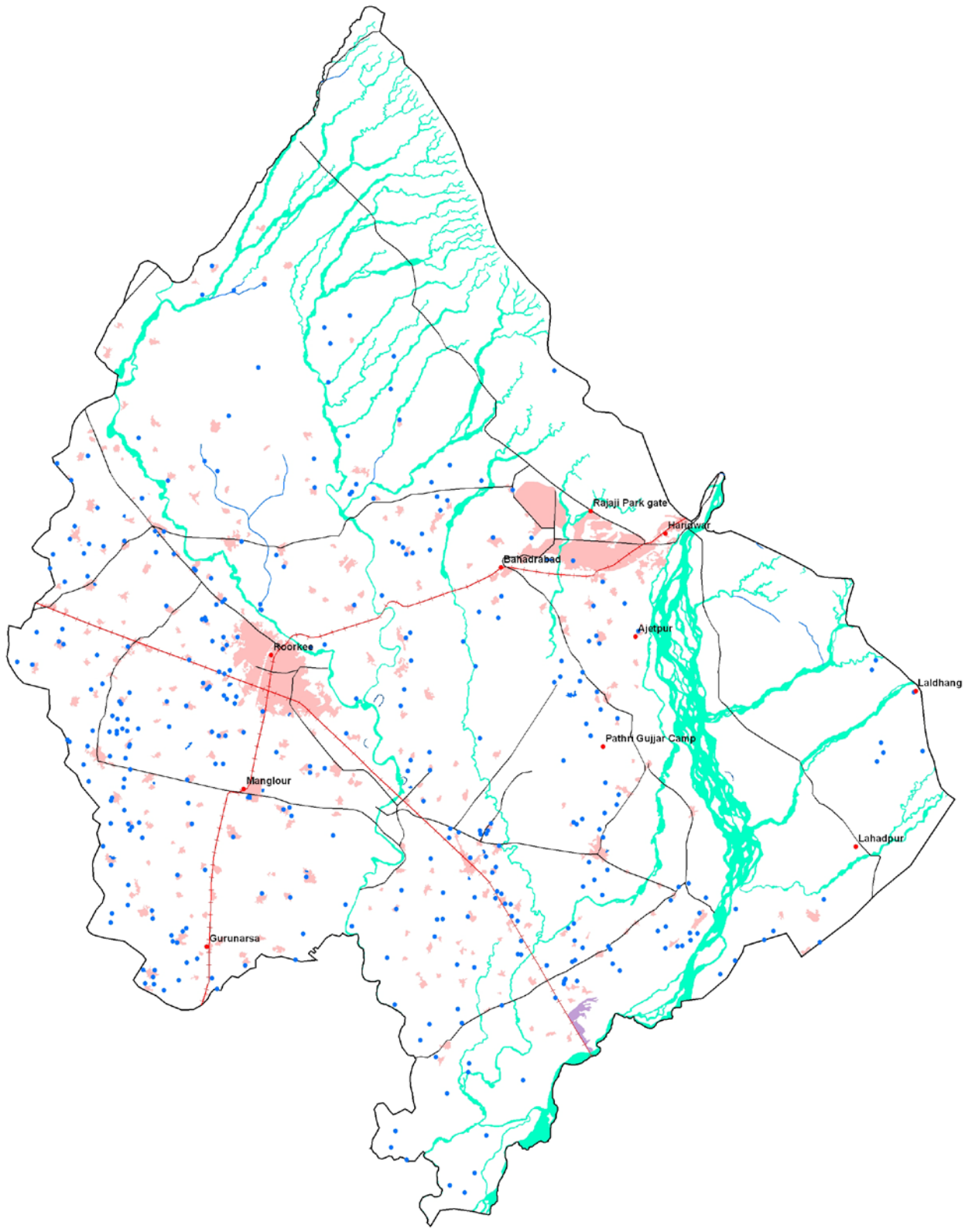
Area under Aquatic Vegetation	30	209

Area under turbidity levels		
Low	1231	1507
Moderate	2984	986
High	-	-

State : Uttarakhand

WETLAND MAP

District : Hardwar

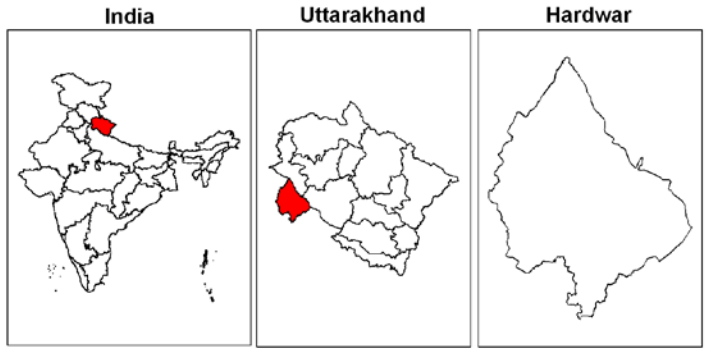


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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



0 2 4 8 12 16 Kilometers

Data Source :

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

Prepared By :

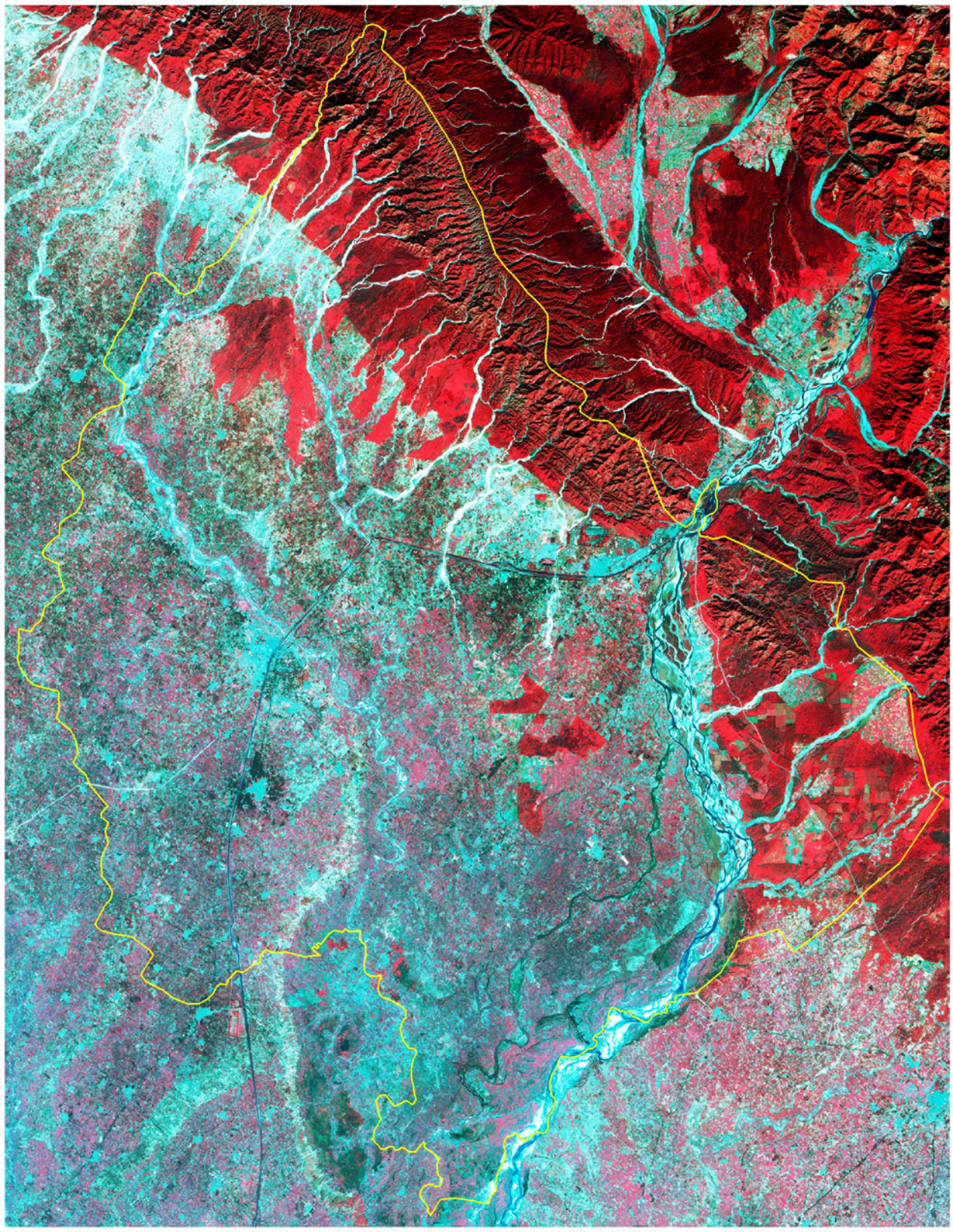
Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

District : Hardwar



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

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF UTTARAKHAND

Major wetland types observed in the state are Rivers, Reservoirs and Tanks/ponds. Details are given in Plate-1. Ground truth data was collected for selected wetland sites. The standard proforma was used to record the field data. Field photographs are also taken to record the water quality (subjective), status of aquatic vegetation and water spread. The location of the features was recorded using GPS. Field photographs of different wetland types are shown in Plates 2a and 2b.

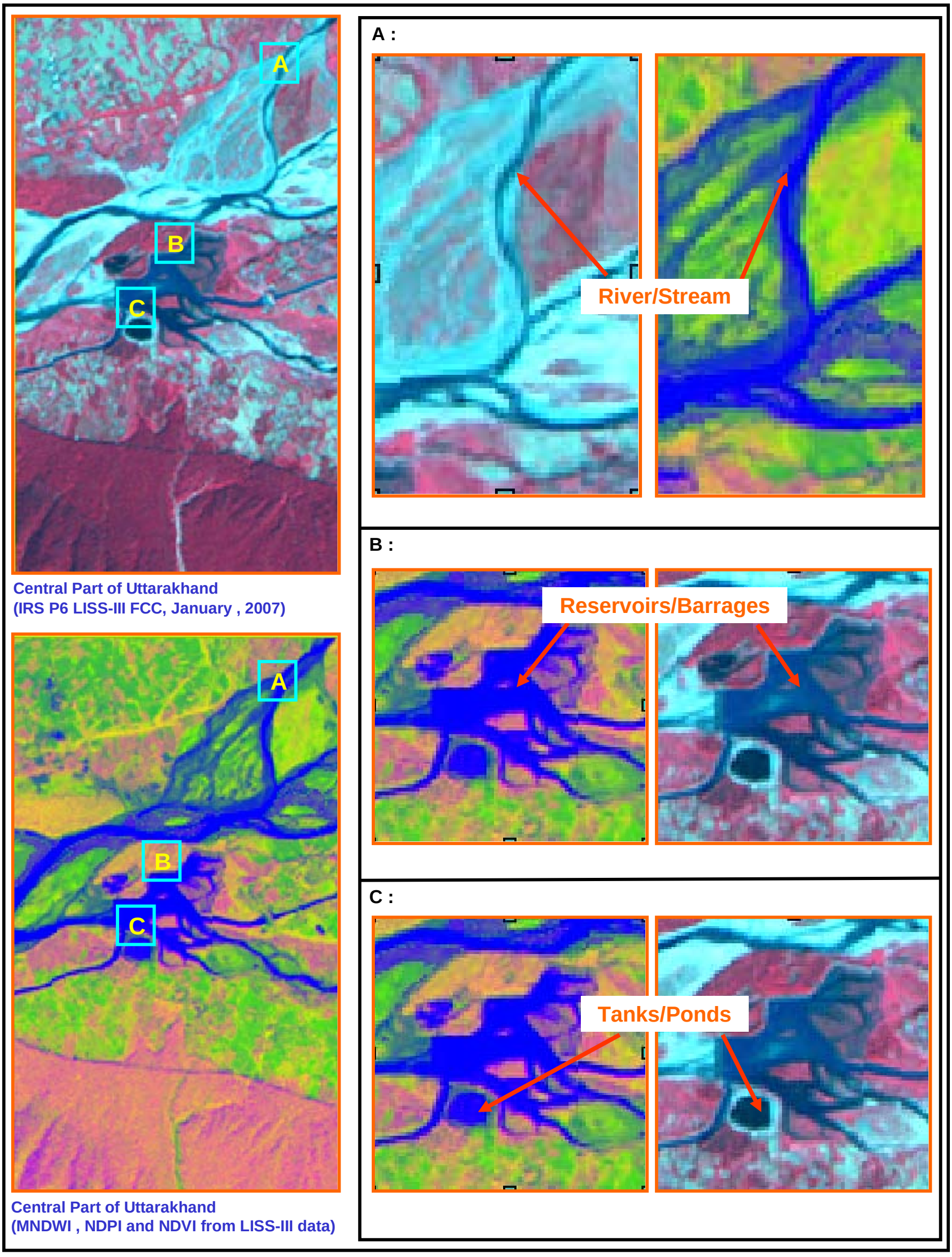


Plate - 1: Major wetland types of Uttarakhand

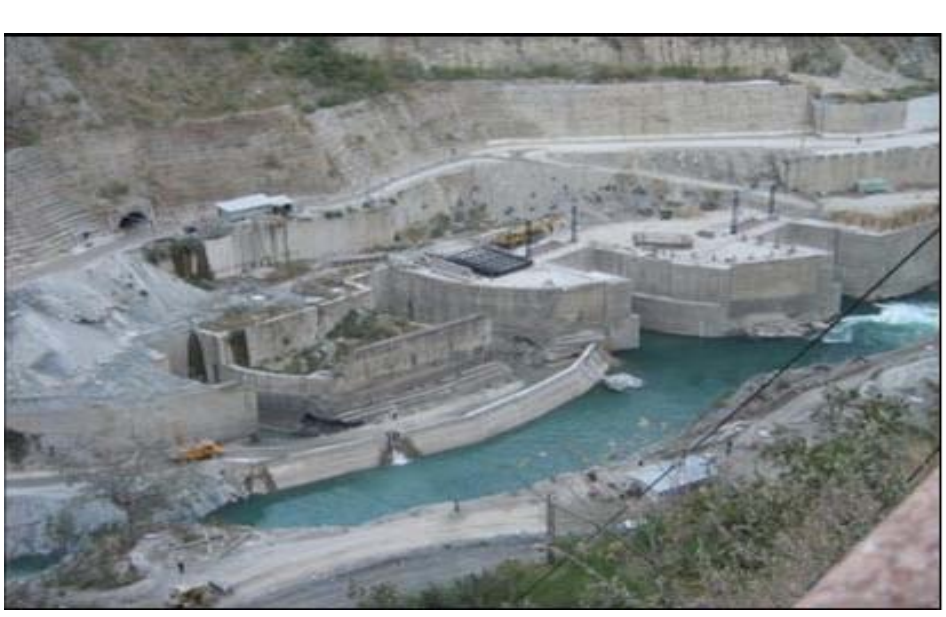
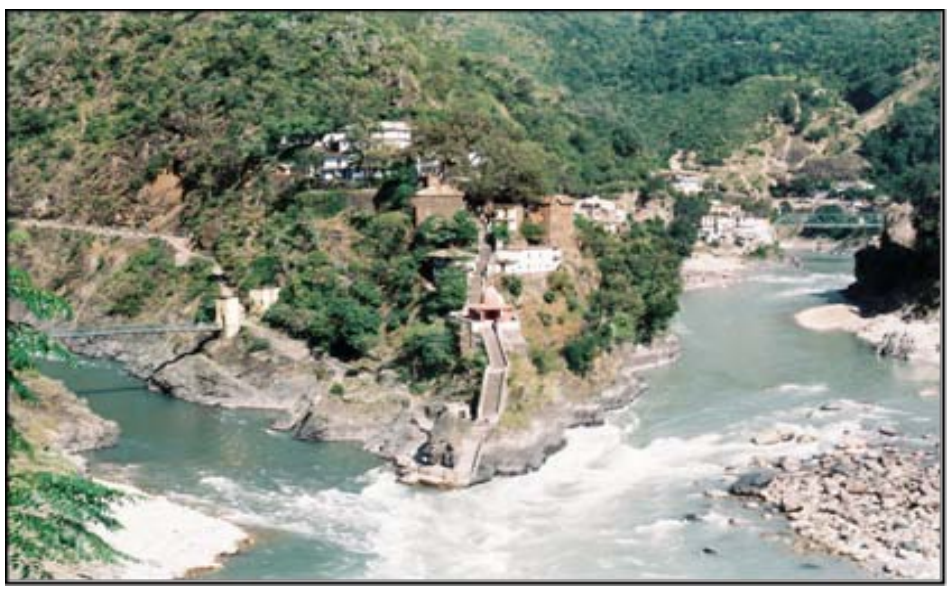
Sr. No.	Description	Field photograph
1	Wetland Type : Lake/Pond Location : longitude: 79^0 34’ 54” E latitude : 29^0 20’ 55” N Turbidity : Low Aquatic Vegetation : No	
2	Wetland Type : Reservoir/Barrage Location : longitude: 78° 28′ 50″ E latitude : 30° 22′ 40″ N Turbidity : Moderate Aquatic Vegetation : No	
3	Wetland Type : River/Stream Location : longitude: 78^0 58’ 42” E latitude : 30^0 17’ 17” N Turbidity : Low Aquatic Vegetation : No	
4	Wetland Type : Tank/Pond Location : longitude: 77^0 57’ 32” E latitude : 29^0 55’ 15” N Turbidity : Low Aquatic Vegetation : No	

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

Sr. No.	Description	Field photograph
5	Wetland Type : River (at Rudraprayag) Location : longitude: 78^0 59’ 42” E latitude : 30^0 18’ 17” N Turbidity : Moderate	
6	Wetland Type : Lake/pond Location : longitude: 78° 07′ 07″ E latitude : 29° 55′ 16″ N Turbidity : Moderate Aquatic Vegetation : No	
7	Wetland Type : River/Stream Location : longitude: 78^0 46’ 32” E latitude : 31^0 02’ 32” N Turbidity : Low Aquatic Vegetation : No	
8	Wetland Type : Lake/Pond Location : longitude: 79^0 33’ 33” E latitude : 29^0 20’ 35” N Turbidity : Moderate Aquatic Vegetation : Yes	

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

IMPORTANT WETLANDS OF UTTARAKHAND

9.0 IMPORTANT WETLANDS OF UTTARAKHAND

The wetlands of the state comprise of a large as well as small wetlands in the southern portion of the Uttarakhand valley. There are also few freshwater swamps and marshes which are very small to map. The lakes besides the rivers constitute the major part of the wetlands of the state. There is drastic change in the water budget of the rivers because of impoundments on the rivers. Major wetlands of the state are Bahgul Dhora, Bour Dam, Nanaksagar, Ramganga, Tehri Dam and Tumaria.

Ram Ganga

Ramganga reservoir is vast collection of water on Ramaganga River which flows through Corbett tiger reserve. The construction of a 125-m-high earth-and-rock-fill dam across the river Ramganga near Kalagarh was completed in early 1974. The reservoir has a capacity of 2.49 x 10^9 m^3 was partially filled during the 1974 summer monsoon. The Ramganga is the lifeline of Corbett National Park. A rain-fed river, Ramganga originates near Gairsain in the Lower Himalayas and a hundred kilometres later, enters Corbett near Marchula. Once inside Corbett, this largest of the perennial water source in the park winds it way for about 40 kms. till it reaches Kalagarh where it enters the plains. While in the Park, the Ramganga collects waters from the Palain, Mandal and Sonanadi rivers. Ramganga River is famous for the fishes like Mahseer, Malee, Rohu, Goonch and Trout. The Ramganga is one of the finest North Indian Rivers for angling.

Tehri Dam

The Tehri Dam on India's Bhagirathi River, the main tributary of the Ganges, is one of the world's largest hydroelectric projects. Tehri is located between 30°22′40″N & 78°28′50″E in the state of Uttarakhand. With a height of 855 feet (261 m), making it the 5th tallest dam in the world. The dam's projected capabilities include a power generation capacity of 2400, stabilize irrigation to an area of 6,000 km^2 and add another area of 2,700 km^2, and a supply of 270 million gallons of drinking water to industrialized cities in Delhi, Uttar Pradesh and Uttarakhand. The dam project was approved in 1972 and construction was started in 1978. The Tehri Hydel Development Corporation (THDC) was constituted in 1989 to supervise the construction of the dam. The main dam of the project is built near the old Tehri town that lies at the confluence of the rivers Baghirathi, (one of the major tributary of the river Ganga) and Bhilangana. The main dam will produce 2000 MW of electricity when completed. There is another smaller dam 14 km downstream at Koteshwar that will produce 400 MW of electricity. The main reservoir comprises of an area of 42 km^2. This has sunk the old Tehri town and 112 villages around the town, thereby displacing more than 1 lakh people. This dam has been the object of intense protests from environmental groups and the people of this region. Besides this, environmental concerns regarding the location of large dams in the fragile ecosystem of the Himalaya foothills, there are also concerns regarding the dam's safety. The Tehri dam is located in the high Seismic zone. This region was the site of a magnitude 6.8 earthquake in October 1991, epicentred 50 Km from the location of the dam.

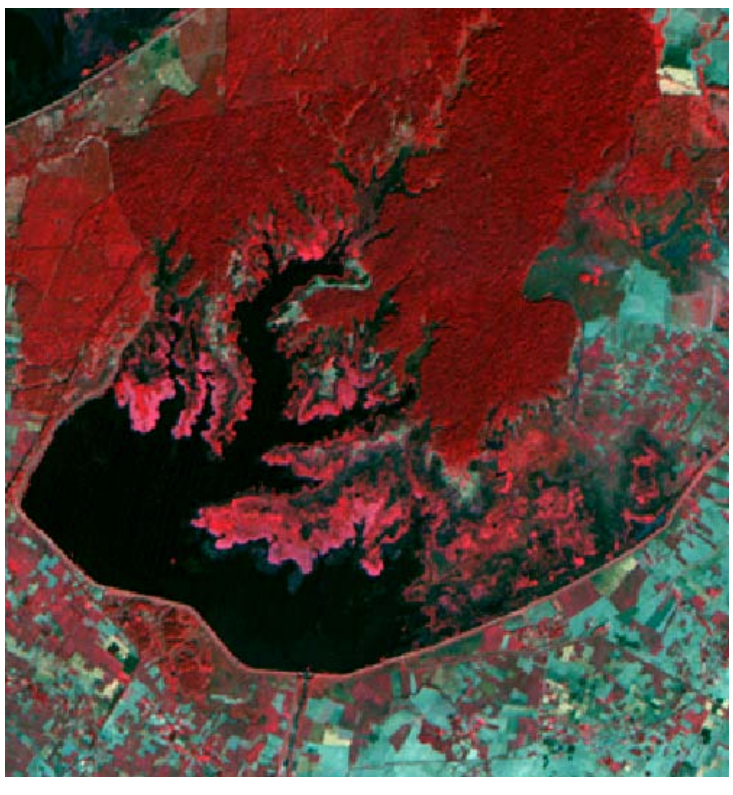
Nanak Sagar

Nanak Sagar is a lake created by the damming of the stream called Deoha, near Gurdwara Nanak Mata. This is a historical Sikh shrine in a town also named Nanak Mata (often pronounced Matta) in district Udham Singh Nagar, Uttarakhand northern India. The town is associated withGuru Nanak Dev and Guru Hargobind. The Gurdwara is located 15 kilometres west of Khatima Railway Station on the Pilibhit-Tanakpur metre-gauge section of North-Eastern Railway. The holy shrine is near the town of Sitarganj.

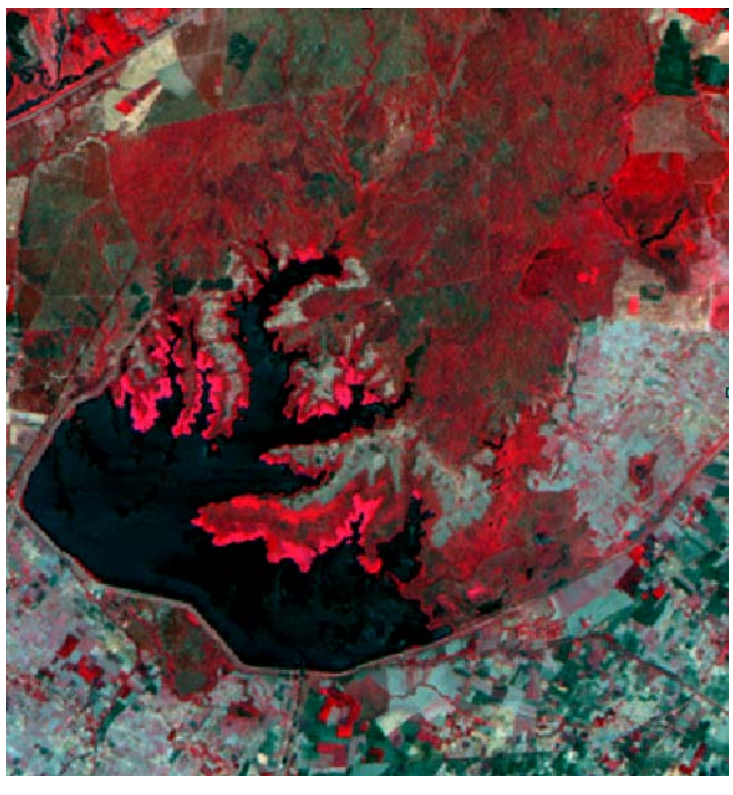
Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of each wetland sites. Details of the wetlands and wetland maps of 5 km buffer area are shown in plates 3 to 20.

9.1 Bahgul Dhora

Name	**Bahgul Dhora**
Location	Between 28^0 52’ 56”N and 28^0 56’ 20”N latitudes and 79^0 35‘ 46”E and 79^0 40‘ 55” E longitudes
Area	2278 ha
Climate	Temperature: 8^o to 41.5^o C.
Salient features	This lake is located at the foot hills and receives a large amount of silt and clay. The periphery is dominated by aquatic vegetation and also *Lantana Sps.* as bushes. It is used mainly for irrigation purposes.
Turbidity	Low-Moderate
Vegetation	Species of *Hydrilla, Myriophyllum, and Potamogeton* in the ponds, and Carex sp., other sedges, and grass.
Fauna	An important breeding area for several species of waterfowl.



Post-Monsoon 2006



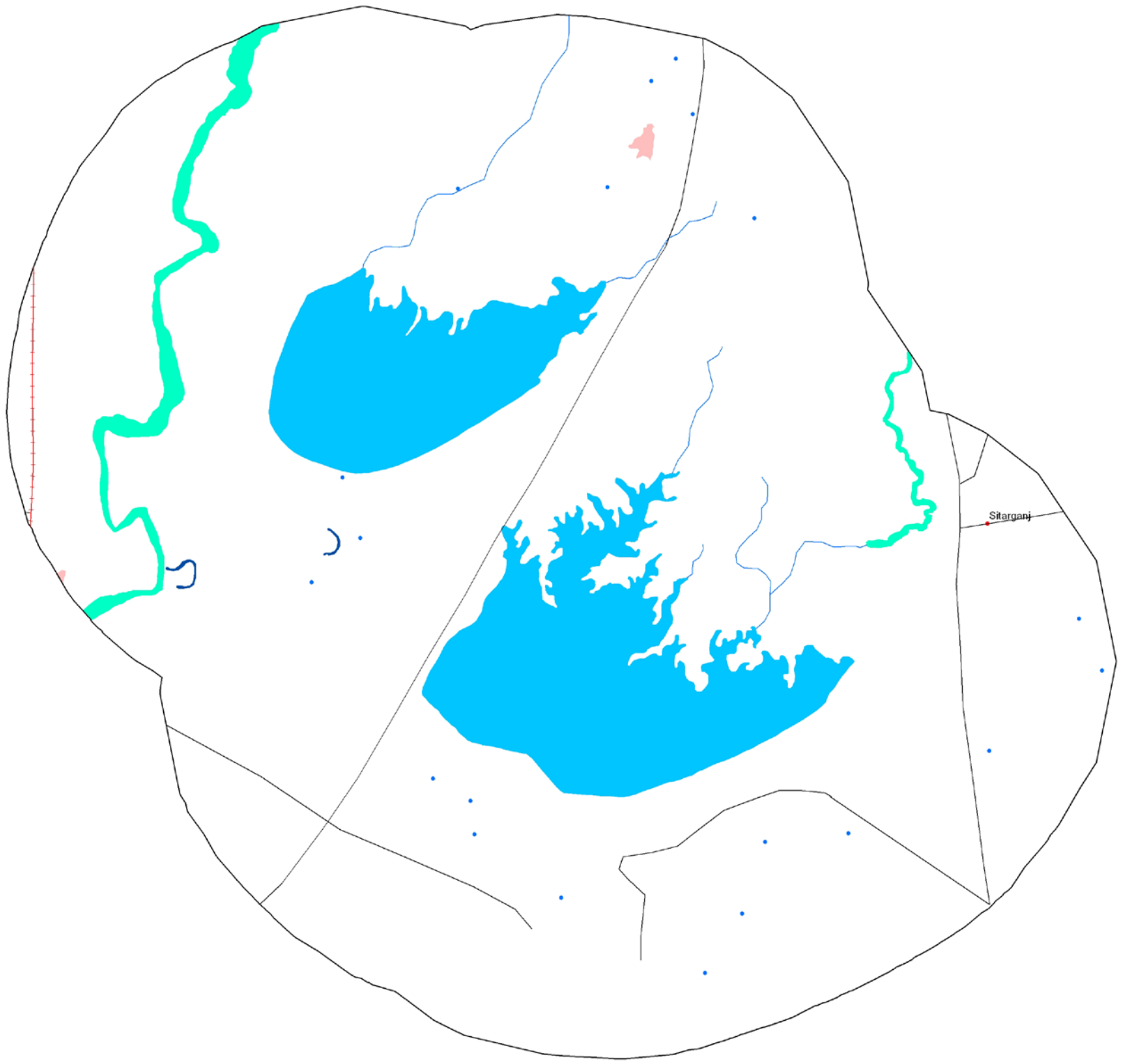
Pre-Monsoon 2007

Plate 3: Bhagul Dhora

State : Uttarakhand

WETLAND MAP

Bahgul Dhora

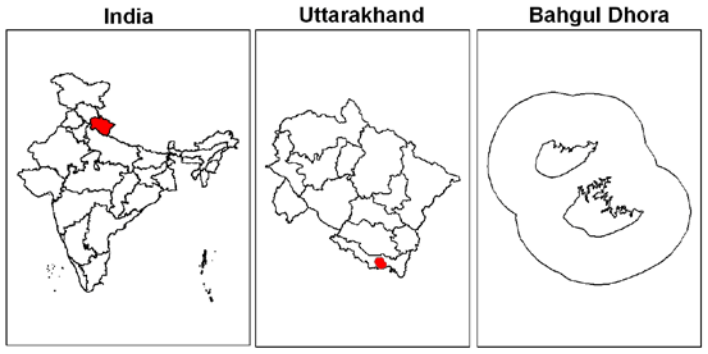


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



0 0.375 0.75 1.5 2.25 3 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

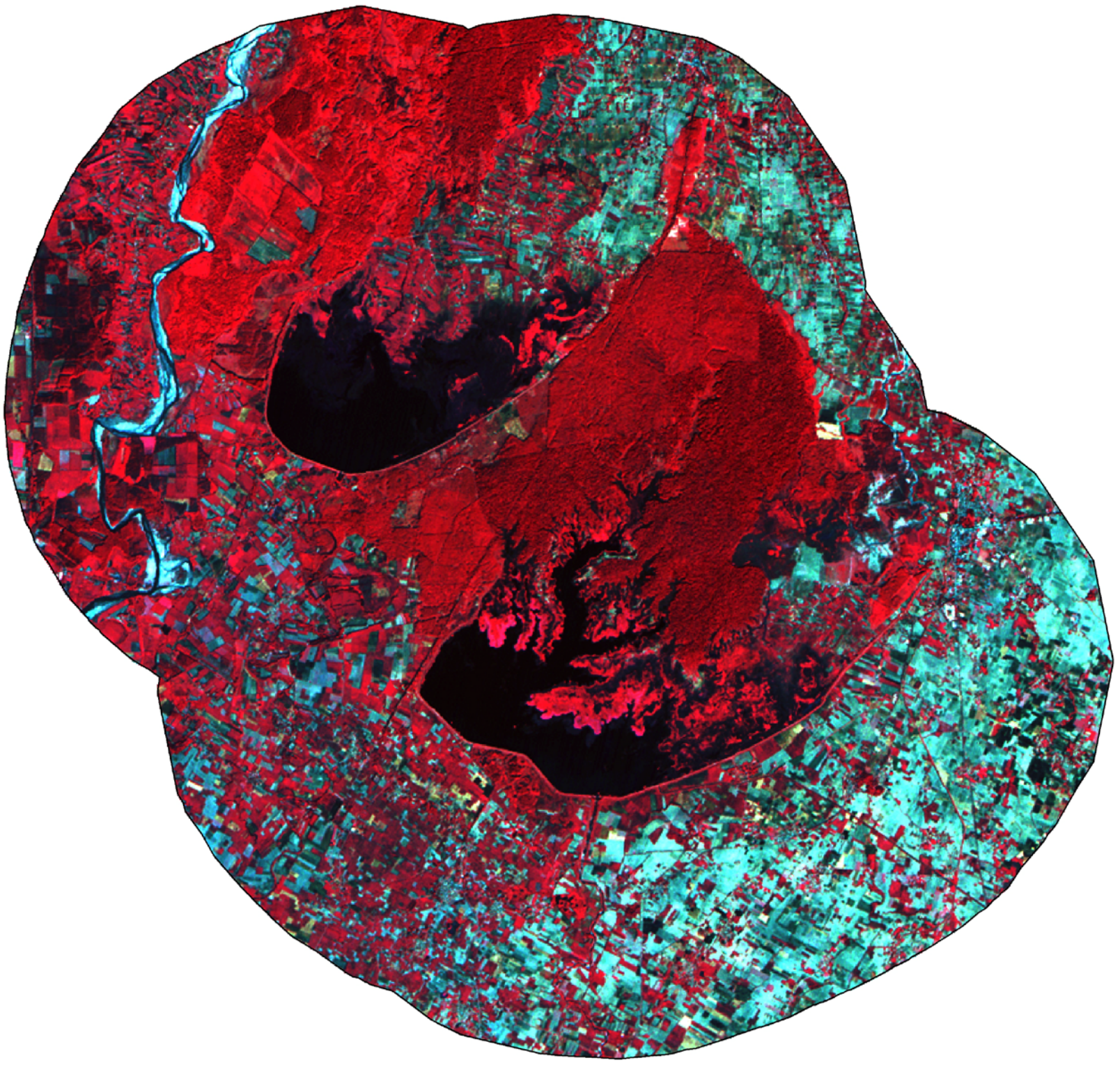
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 4: Wetland map - 5 km buffer area of Bhagul Dhora

State : Uttarakhand

Bahgul Dhora



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

Plate 5: IRS LISS III FCC - 5 km buffer area of Bhagul Dhora

9.2 Bour Dam

Name	Bour Dam
Location	Between 29^0 06' 26" N and 29^0 09' 41" N latitudes and 79^0 15' 12" E and 79^0 22' 22" E longitudes
Area	2,612 ha
Salient features	This is earthen dam receives water from two rivers. The catchment is dominated by forests and most of area is used for irrigation. The periphery is dominated by agricultural activities. It is used mainly for irrigation purposes.
Turbidity	Moderate
Fauna	Reported to be attracting waterfowl, though no census appears to have been conducted.

Post-Monsoon 2006

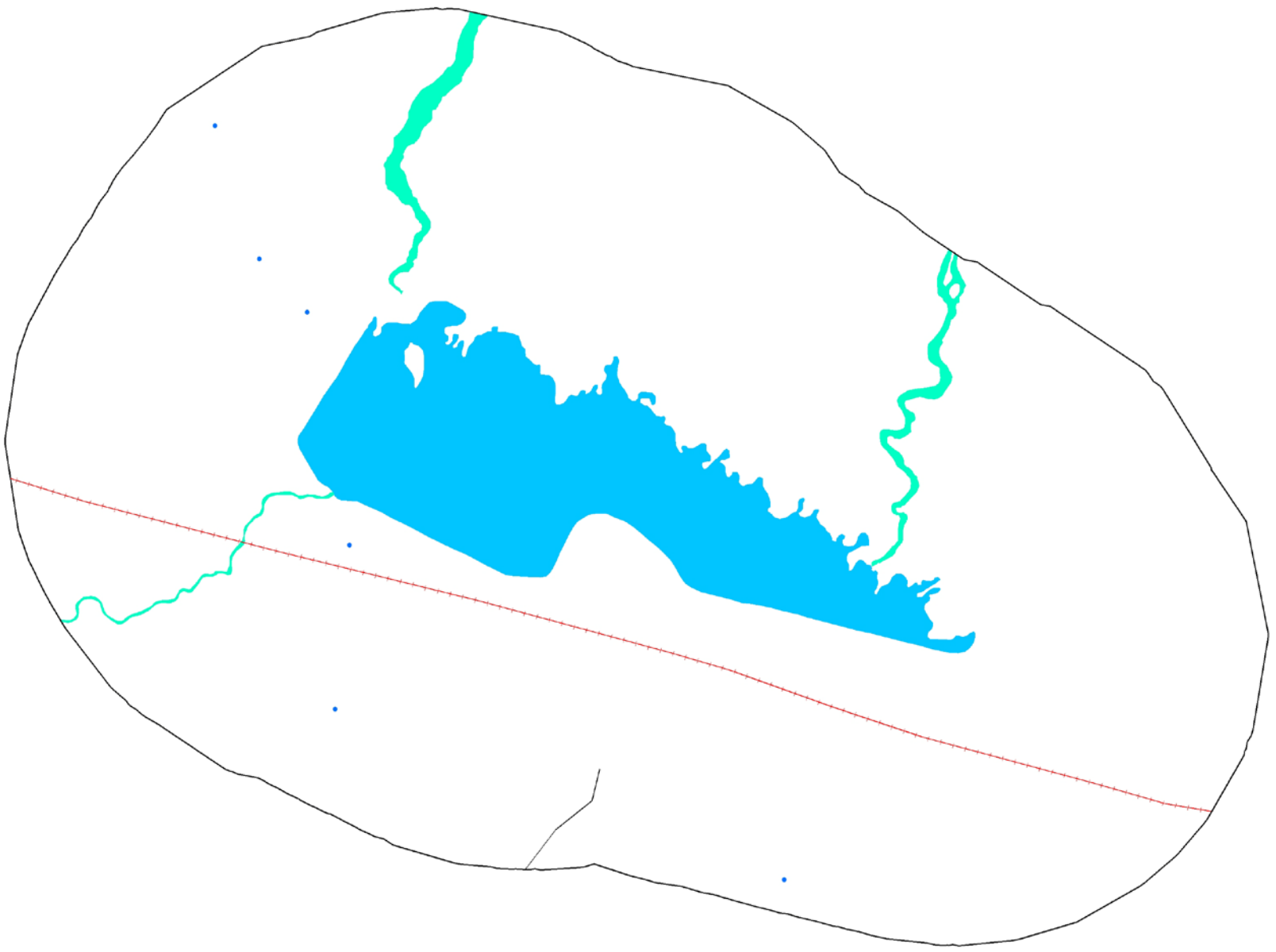
Pre-Monsoon 2007

Plate 6: Bour Dam

State : Uttarakhand

WETLAND MAP

Bour Dam



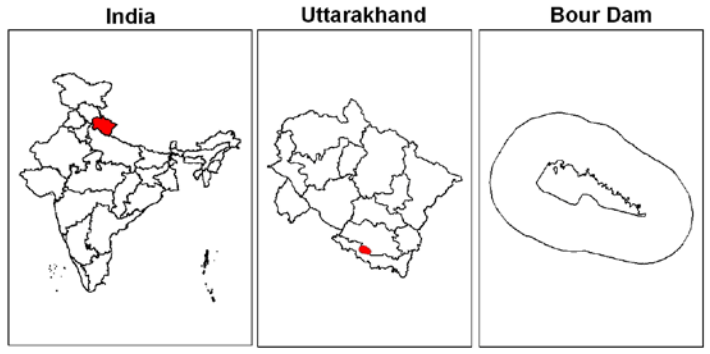
Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map

India | Uttarakhand | Bour Dam



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

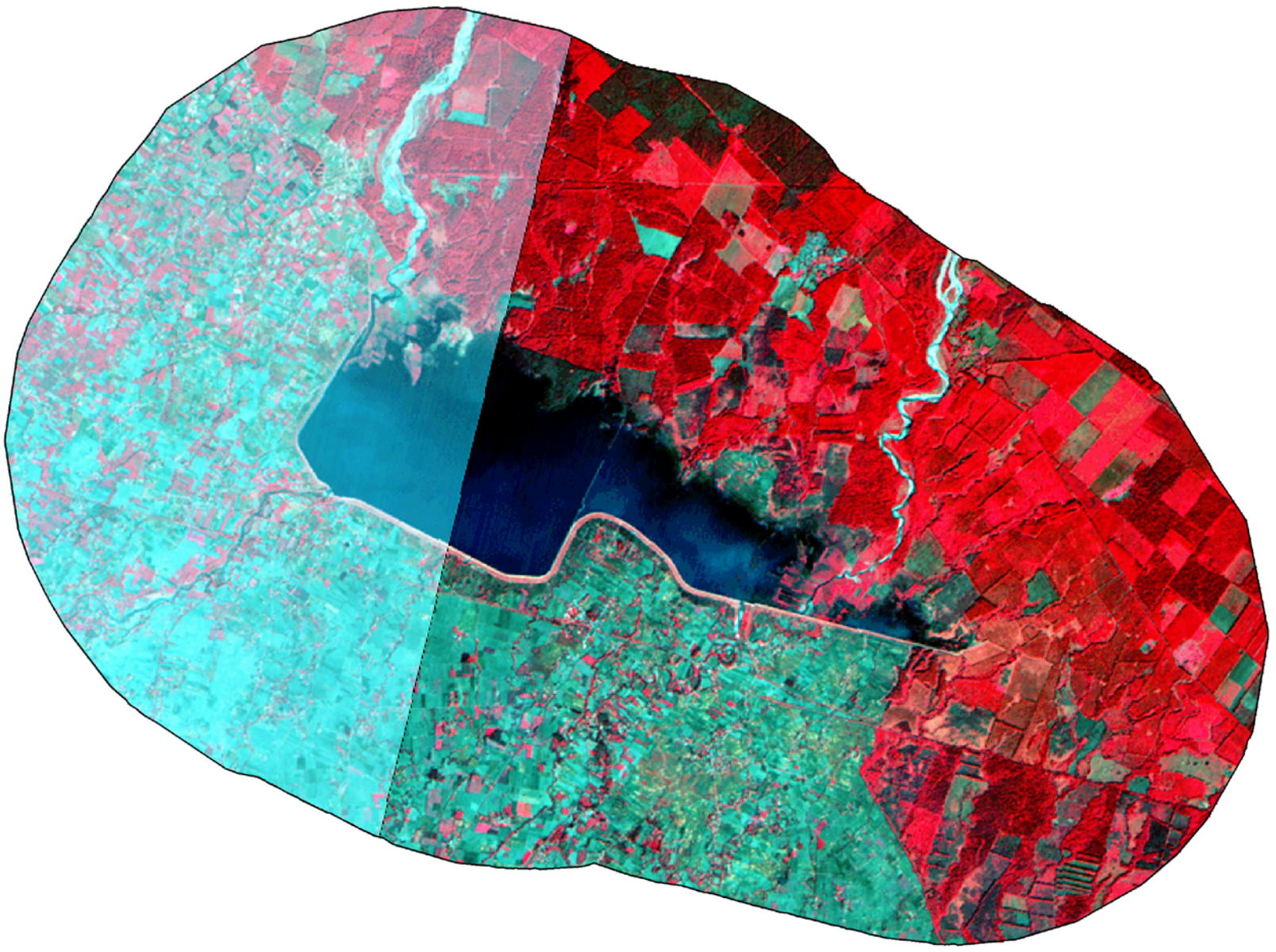
Sponsored By:

Ministry of Environment and Forests
Government of India

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

State : Uttarakhand

Bour Dam



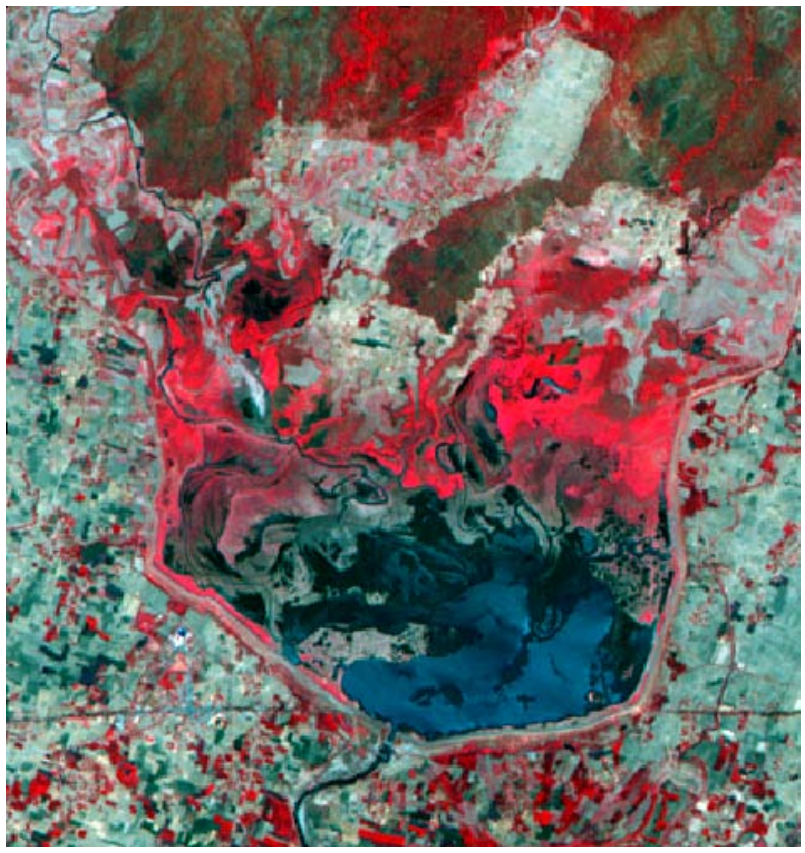
IRS P6 LISS-III post-monsoon data (2006)

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

9.3 Nanaksagar

Name	**Nanaksagar**
Location	Between 28^0 56' 13" N and 28^0 59' 54" N latitudes and 79^0 47' 28" E and 79^0 53' 09" E longitudes
Area	3330 ha
Salient features	Nanak Sagar is a lake created by the damming of the stream called Deoha, near Gurdwara Nanak Mata. This is a historical Sikh shrine in a town also named Nanak Mata (often pronounced Matta) in district Udham Singh Nagar, Uttarakhand northern India. The town is associated withGuru Nanak Dev and Guru Hargobind. The Gurdwara is located 15 kilometres west of Khatima Railway Station on the Pilibhit-Tanakpur metre-gauge section of North-Eastern Railway. The holy shrine is near the town of Sitarganj.
Turbidity	Moderate-High
Vegetation	Species of *Hydrilla, Myriophyllum, and Potamogeton* are dominant sps of the lake. Detail information on phytoplankton and zooplankton and fish fauna is not available.

Post-Monsoon 2006



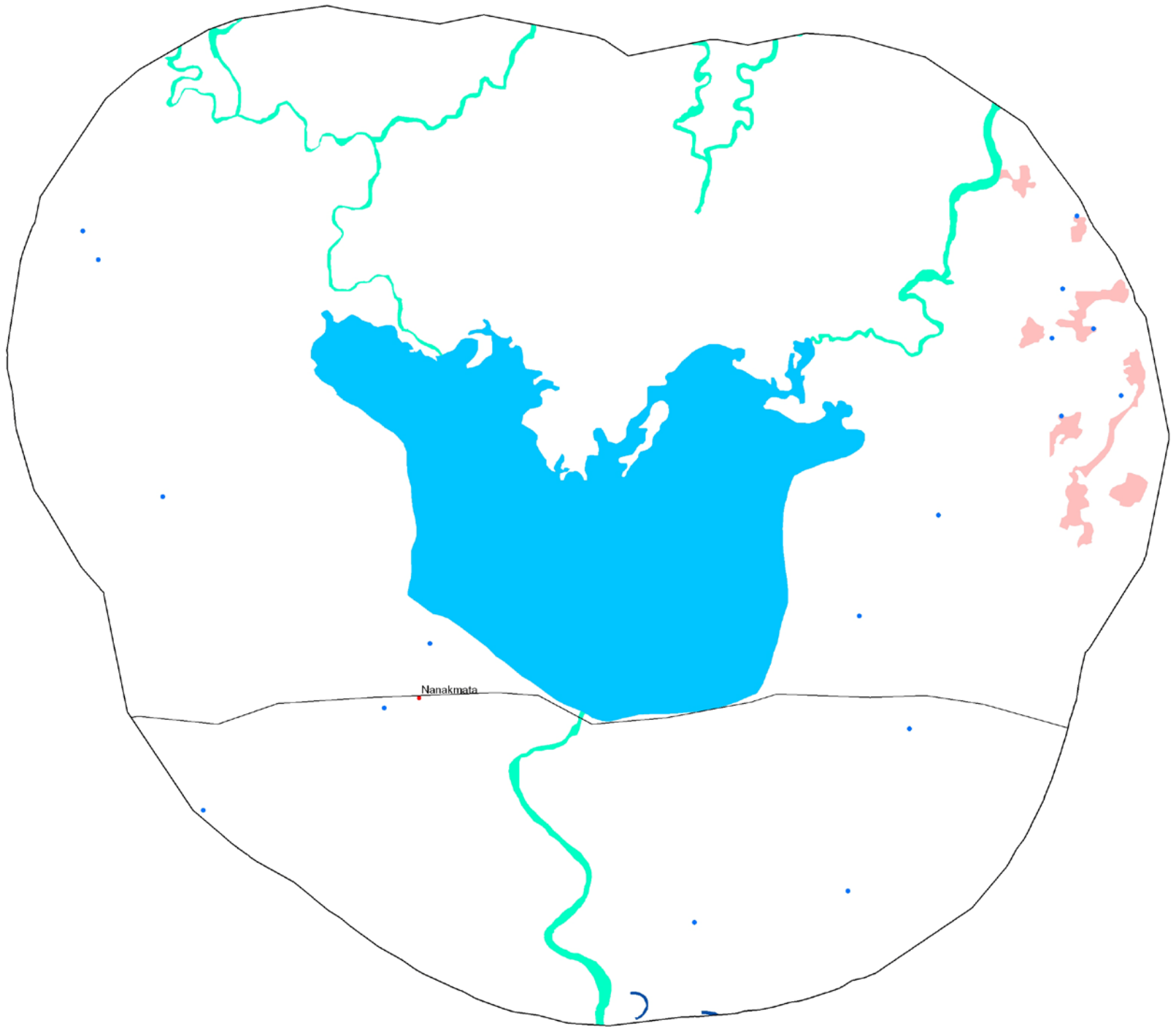
Pre-Monsoon 2007

Plate 9: Nanaksagar

State : Uttarakhand

WETLAND MAP

Nanak Sagar Reservoir



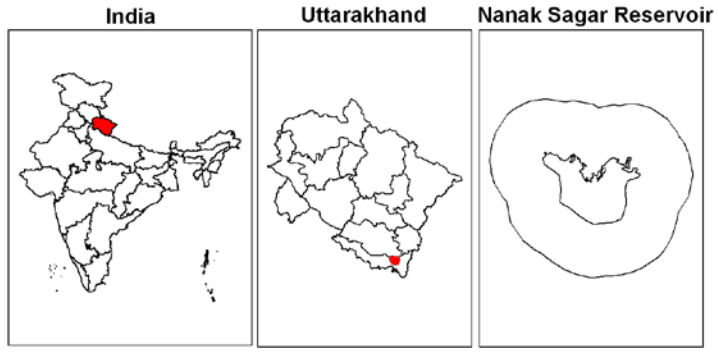
Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map

India | Uttarakhand | Nanak Sagar Reservoir



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

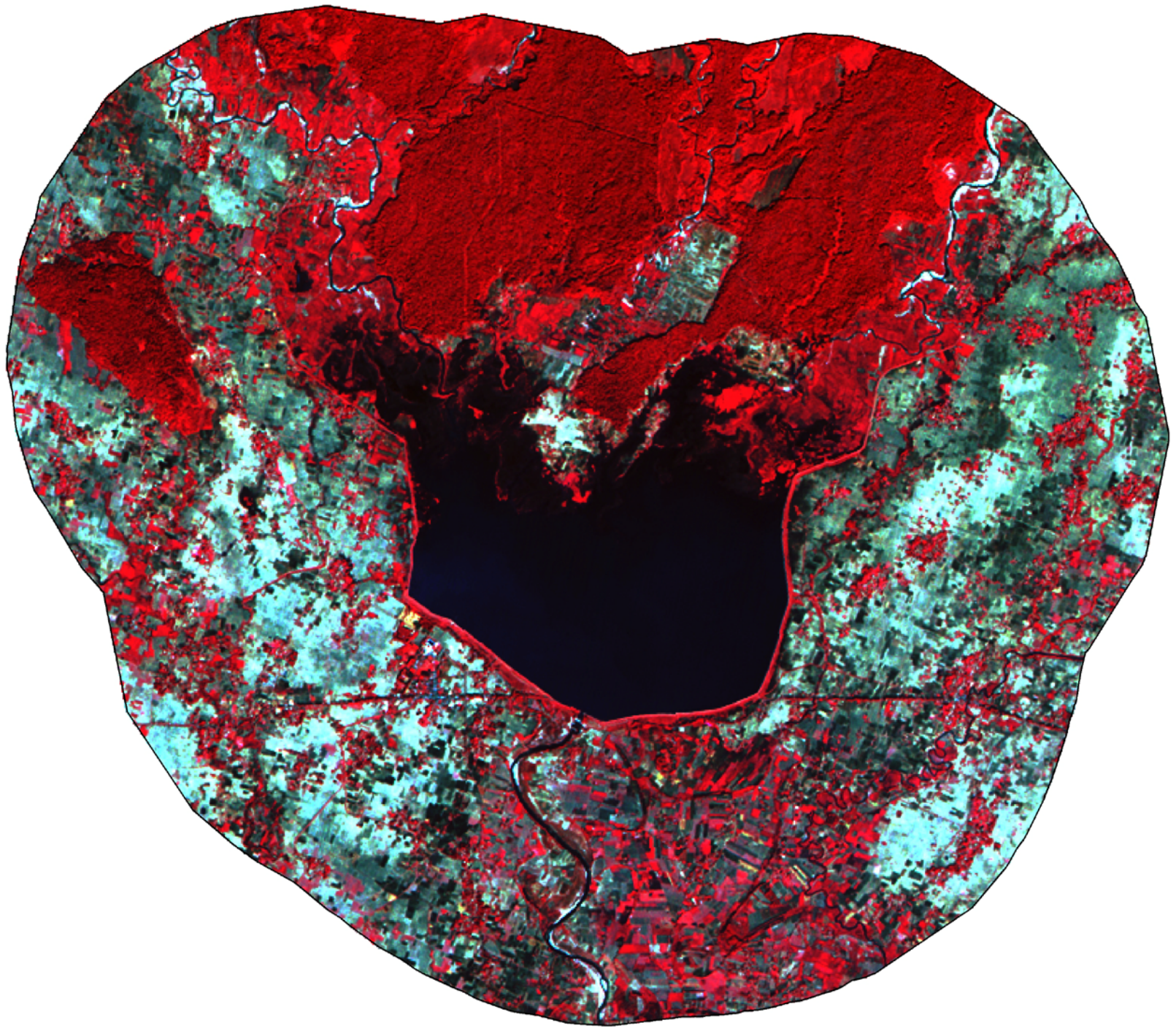
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 10: Wetland map - 5 km buffer area of Nanaksagar

State : Uttarakhand

Nanak Sagar Reservoir

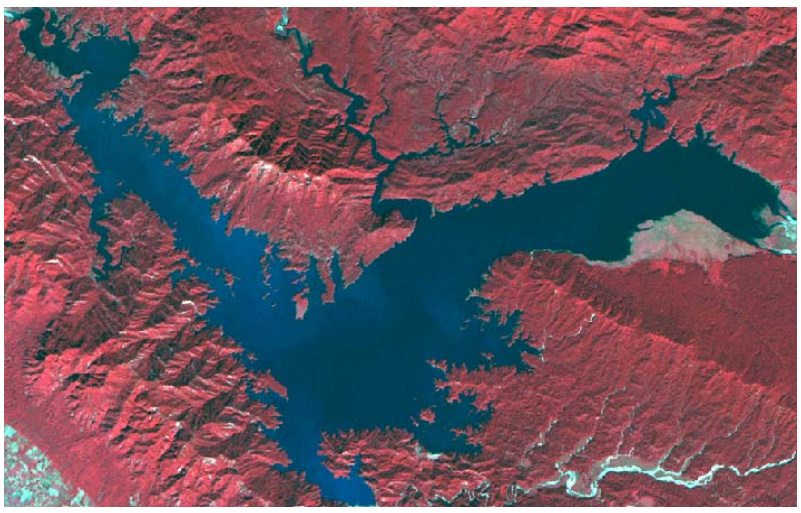


IRS P6 LISS-III post-monsoon data (2006)

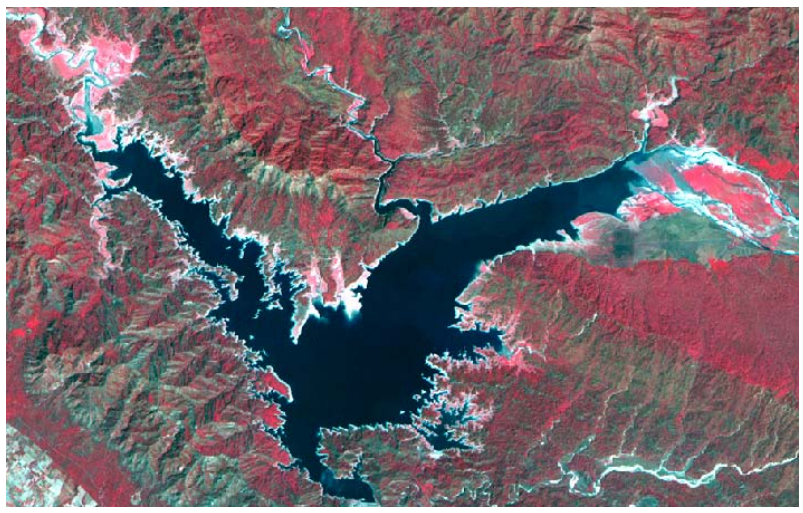
Plate 11: IRS LISS III FCC - 5 km buffer area of Nanaksagar

9.4 Ramganga

Name	Ramganga
Location	Between 29^0 31' 05" N and 29^0 38' 66" N latitudes and 79^0 39' 26"E and 79^0 52' 49" E longitudes
Area	7,093 ha
Climate	Temperature: 1.3^o to 45^o C.
Salient features	Ramganga reservoir is constructed on Ramaganga River which flows through Corbett tiger reserve. The construction of a 125-m-high earth-and-rock-fill dam across the river Ramganga near Kalagarh was completed in early 1974. Its reservoir with a capacity of 2.49 x 109 m3 was partially filled during the 1974 summer monsoon. The Ramganga is the lifeline of Corbett National Park. A rain-fed river, Ramganga originates near Gairsain in the Lower Himalayas and a hundred kilometers later, enters Corbett near Marchula. Once inside Corbett, this largest of the perennial water source in the park winds it way for about 40 kms till it reaches Kalagarh where it enters the plains. While in the Park, the Ramganga collects waters from the Palain, Mandal and Sonanadi rivers. Ramganga River is famous for the fishes like Mahseer, Malee, Rohu, Goonch and Trout. The Ramganga is one of the finest North Indian Rivers for angling.
Turbidity	Moderate
Vegetation	The hills abound wild cherry, wild Apple, Spindle Wood, Oak, Fig, Poplar, Holly, Rhododendron, Masuri Berry, Dogwood, Horse Chestnut and hill tuna. At higher altitudes, forests are crowded with Himalayan cypress, Deodar, Blue pine, Fir and Long leafed pine.
Fauna	The valleys of Garhwal are quite rich in wild life and are excellent grounds for the naturalist. Shielded from trigger-happy populace, animals and birds abound in the thick forests.



Post-Monsoon 2006



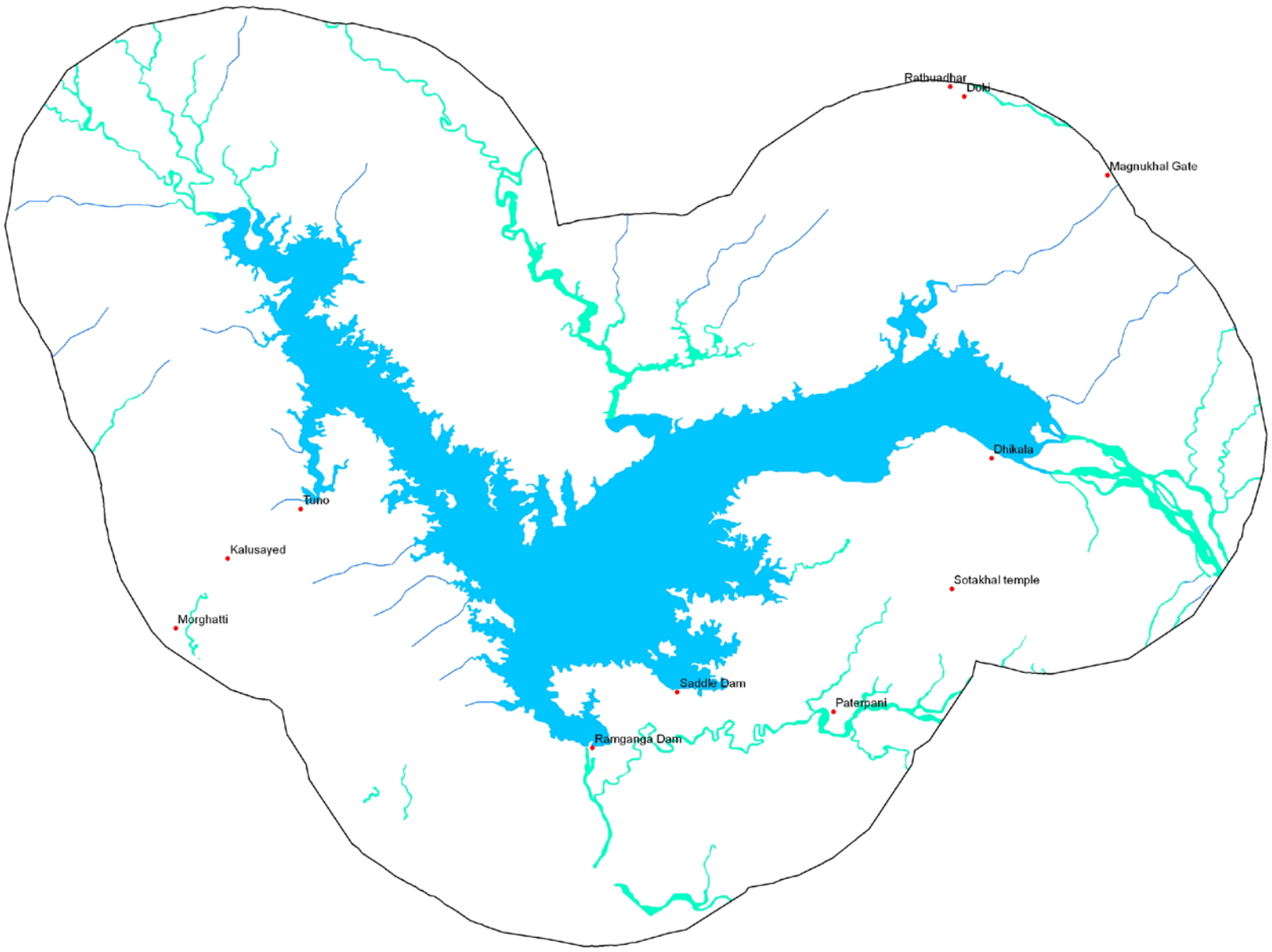
Pre-Monsoon 2007

Plate 12: Ramganga

State : Uttarakhand

WETLAND MAP

Ramganga Reservoir

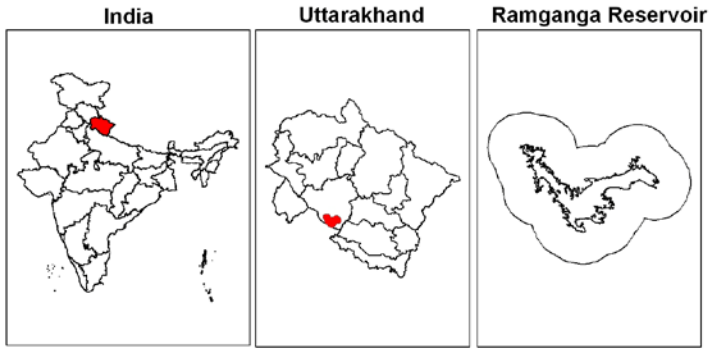


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

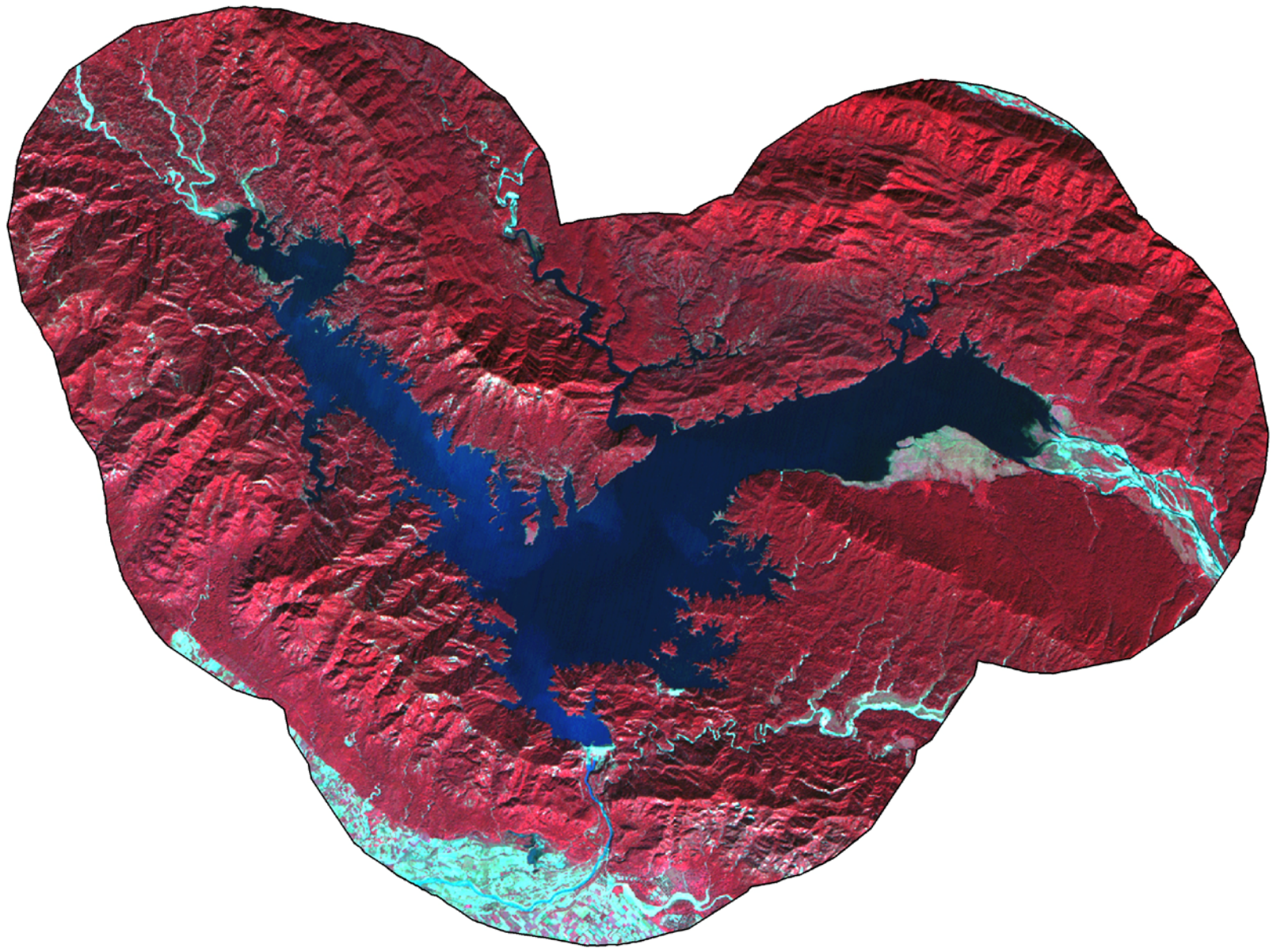
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 13: Wetland map - 5 km buffer area of Ramganga

State : Uttarakhand

Ramganga Reservoir

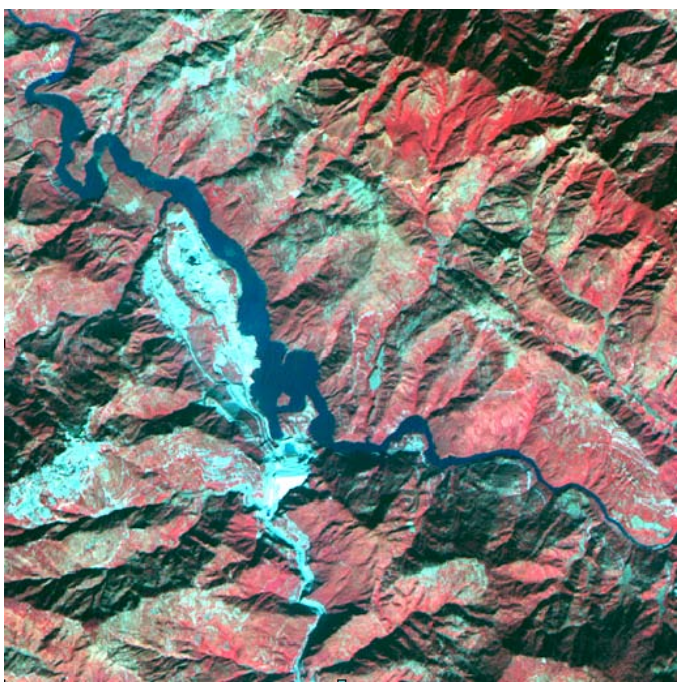


IRS P6 LISS-III post-monsoon data (2006)

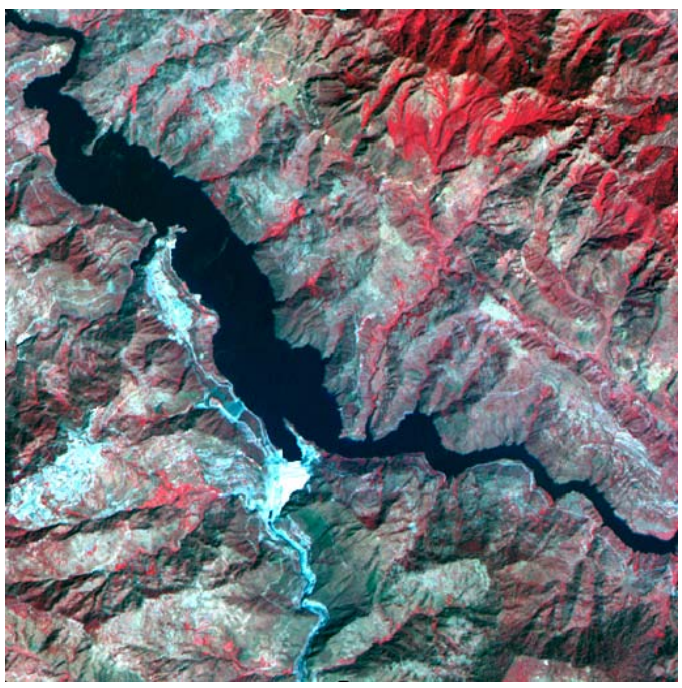
Plate 14: IRS LISS III FCC - 5 km buffer area of Ramganga

9.5 Tehri Dam

Name	Tehri Dam
Location	Between 30^0 21' 54" N and 30^0 26' 45" N latitudes and 78^0 25' 44" E and 78^0 33' 08" E longitudes
Area	1,245 ha
Altitude	1550 m
Climate	Temperature: 3^o to 28^o C.
Turbidity	Low-Moderate
Salient features	The Tehri Dam on India's Bhagirathi River, the main tributary of the Ganges, is one of the world's largest hydroelectric projects. This has sunk the old Tehri town and 112 villages around the town, thereby displacing more than 1 lakh people. This dam has been the object of intense protests from environmental groups and the people of this region. Besides this, environmental concerns regarding the location of large dams in the fragile ecosystem of the Himalaya foothills, there are also concerns regarding the dam's safety. The Tehri dam is located in the high Seismic zone. This region was the site of a magnitude 6.8 earthquake in October 1991and the epicenter was 50 Km away from the location of the dam.
Vegetation	The plant life of Tehri Garhwal can be divided into six main categories of tropical dry deciduous forests, Sal forests, Chir forests, oak deodar, fir and spruce forests, and finally the Alpine pastures. These forests not provide a safe haven for animals but also help the villagers to maintain the ecological balance and give them firewood and food. There are many trees like Chir, Oaks, Conifers, Sal, Deodar, Haldu, Yew, Cypress, Rhododendron, Birch, Horse-Chestnut, Willow and Alder are found here. A large variety of medicinal herbs, shrubs and bushes like Brahmi and Ashwagandha are found in abundance here. One can also savor fruits like Cornel, Figs, Kaiphal, Mulberry, Kingora, Raspberry, Blackberry, Currants, Medlars, Gooseberries, Hazelnuts, Apples, Pears, Apricots, Plums, Peaches, Oranges, Limes, Bananas, Pomegranates and Walnuts.
Fauna	The district of Tehri Garhwal is full of rich animal life which includes mammals, reptiles, and birds. The forests are full of animals like Monkey, Langur, Wild-Cat, Goat, Pig, Fox, Wild-Dog, Black Bear and the Flying Squirrel.The star (and elusive) attraction in the forests of Tehri Garhwal is the critically endangered Musk Deer or the Kastura The avian species consist of Pheasants, Kalij, Koklas, Cheers, Monal, Wild Fowls, Harial, Parrots, Chatak, Papiha, Haldu, Neelkanth, Pigeons, Partridges, Kala Titar, Chakor and Neora. The reptile population is represented by Rat Snake, Leech and Blood-Sucking Lizard.



Post-Monsoon 2006



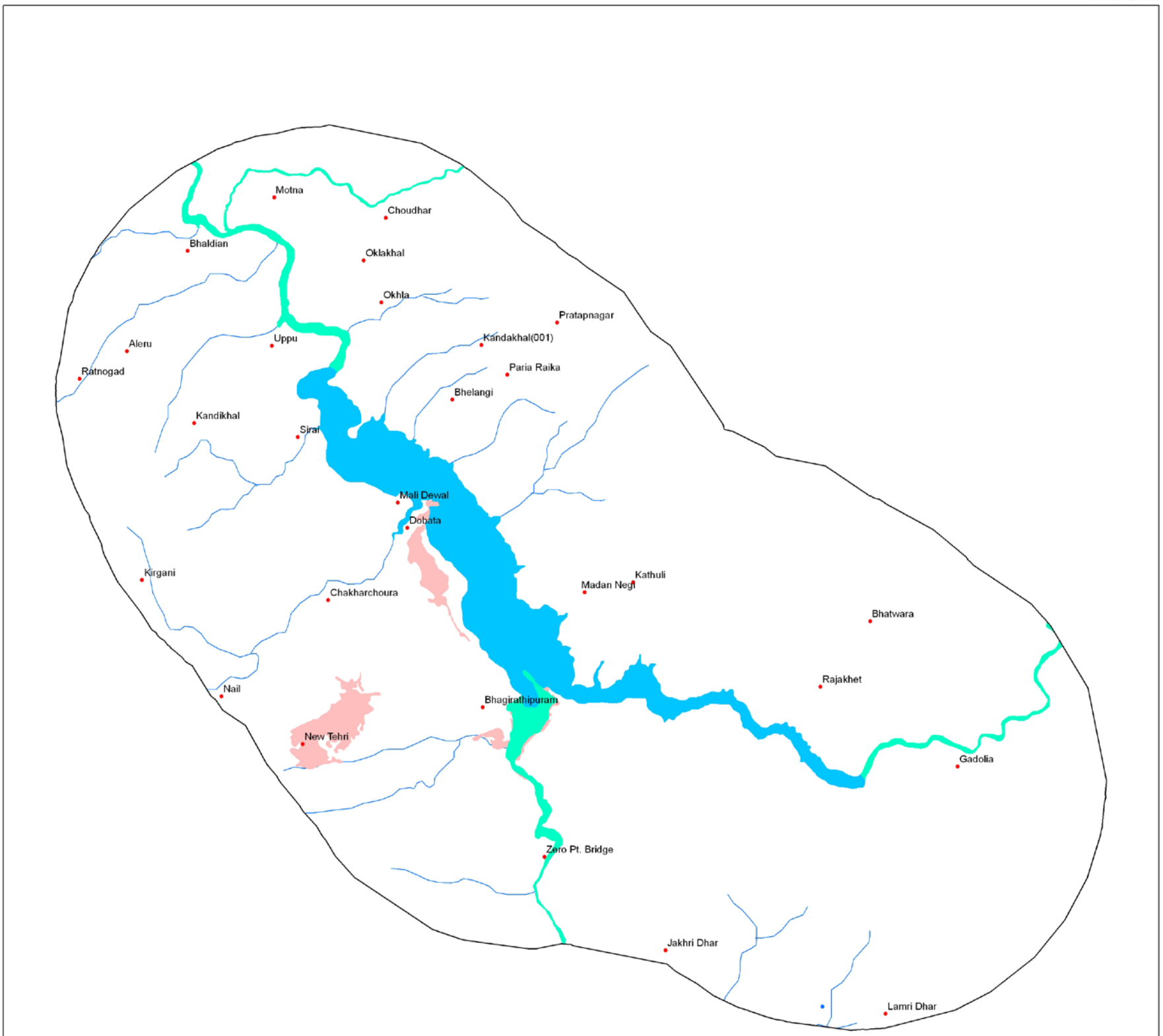
Pre-Monsoon 2007

Plate 15: Tehri Dam

State : Uttarakhand

WETLAND MAP

Tehri Dam

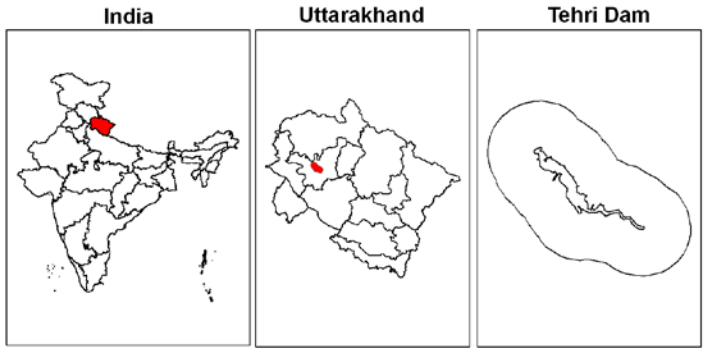


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

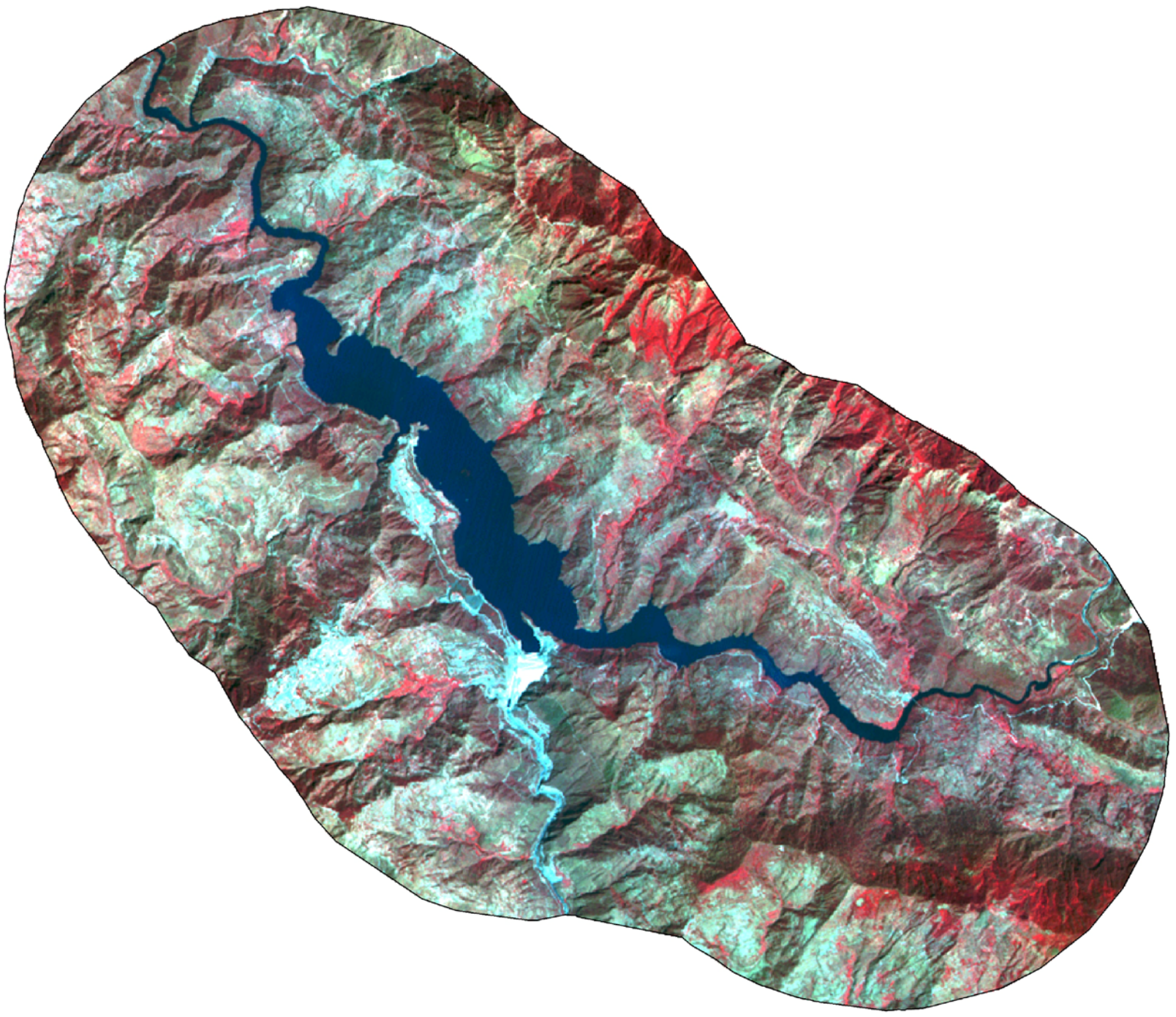
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 16: Wetland map - 5 km buffer area of Tehri Dam

State : Uttarakhand

Tehri Dam

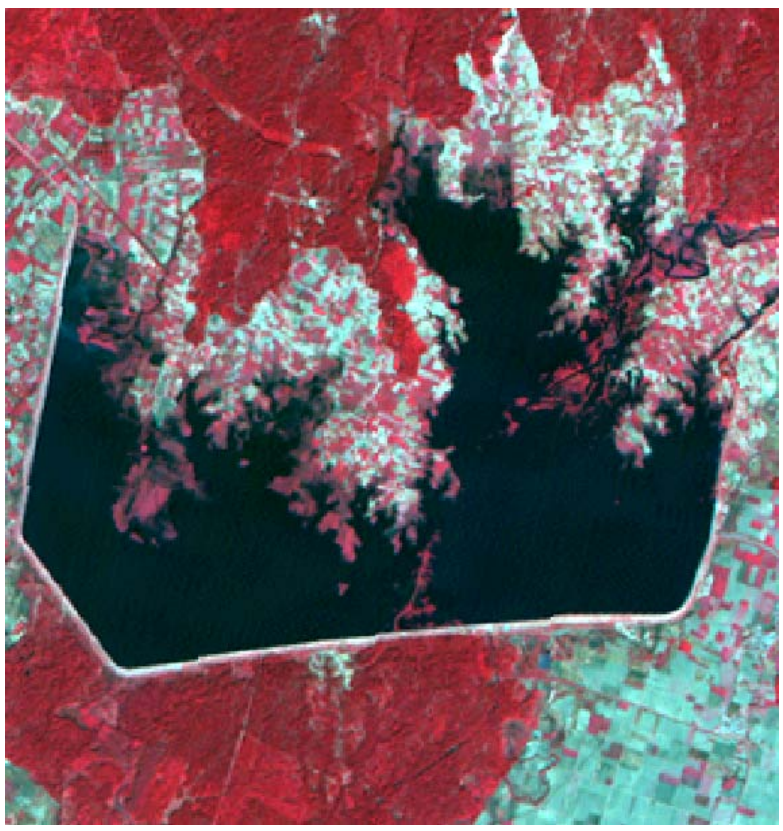


IRS P6 LISS-III pre-monsoon data (2007)

Plate 17: IRS LISS III FCC - 5 km buffer area of Tehri Dam

9.6 Tumaria

Name	Tumaria
Location	Between 29^0 18’ 08 ”N and 29^0 21’ 05” N latitudes and 78^0 52‘ 59” E and 78^0 57‘ 39” E longitudes
Area	2,094 ha
Salient features	It is an earthen dam constructed to meet the requirement of drinking water and irrigation for agriculture. It is shallow lake and receives water during rainy season from the catchment which is dominated by moderate to dense fo0rest.
Turbidity	Low- Moderate
Vegetation	Vegetation dominated by reeds during summer otherwise it devoid to hydrophytes.
Fauna	A great diversity of ichthiological fauna is recorded from this lake but species composition is not available.



Post-Monsoon 2007

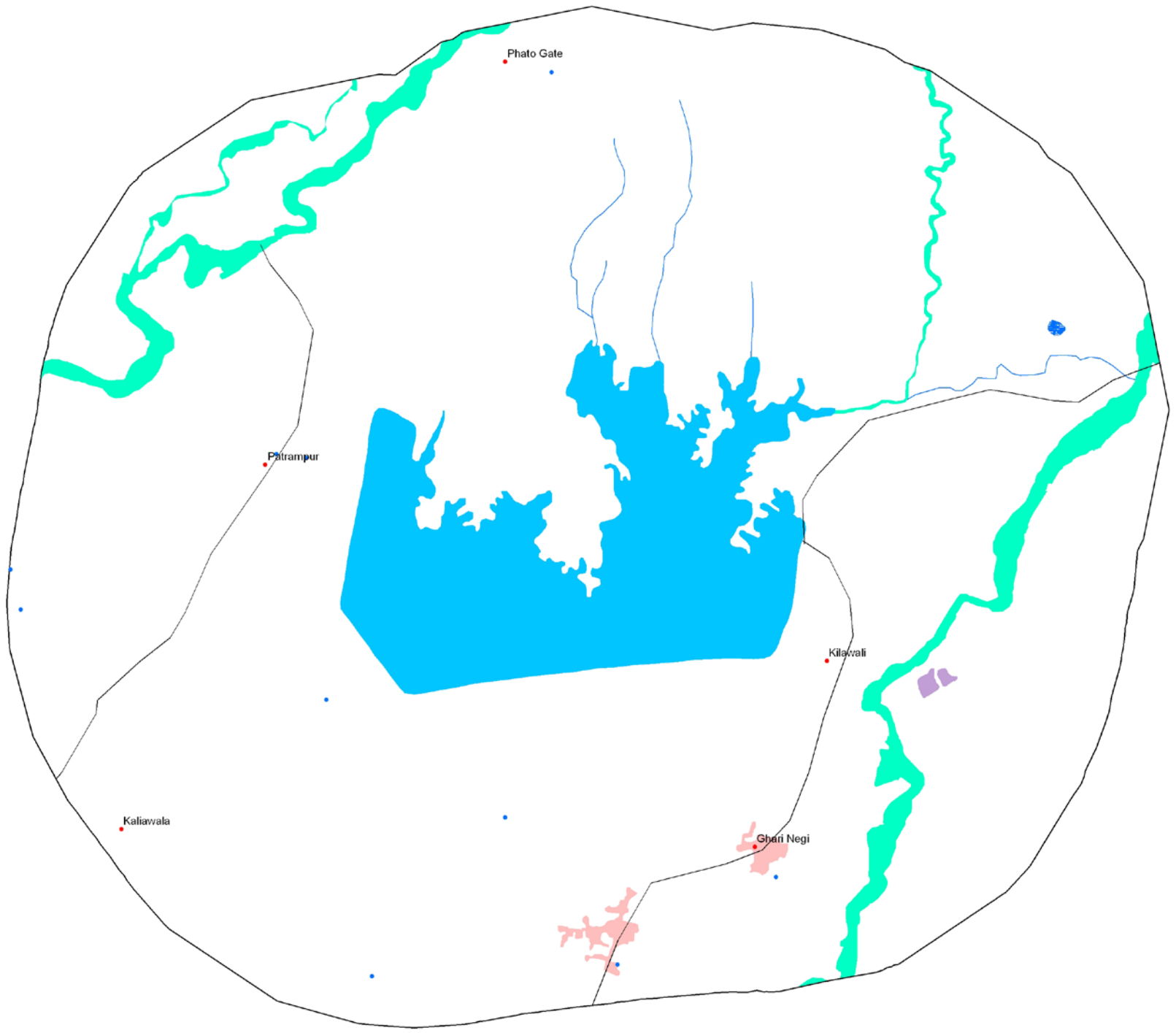
Pre-Monsoon 2007

Plate 18: Tumaria

State : Uttarakhand

WETLAND MAP

Tumaria

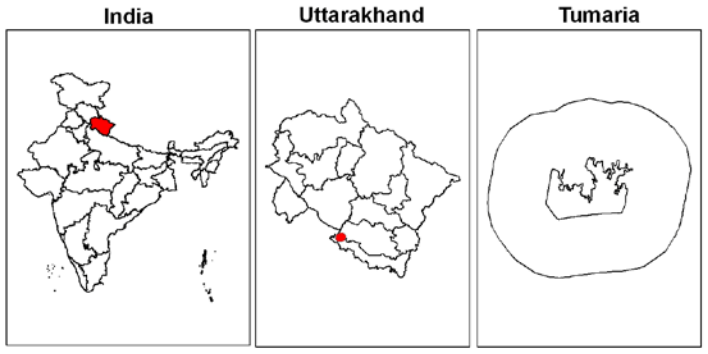


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Location Map



0 1 2 4 Kilometers

Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

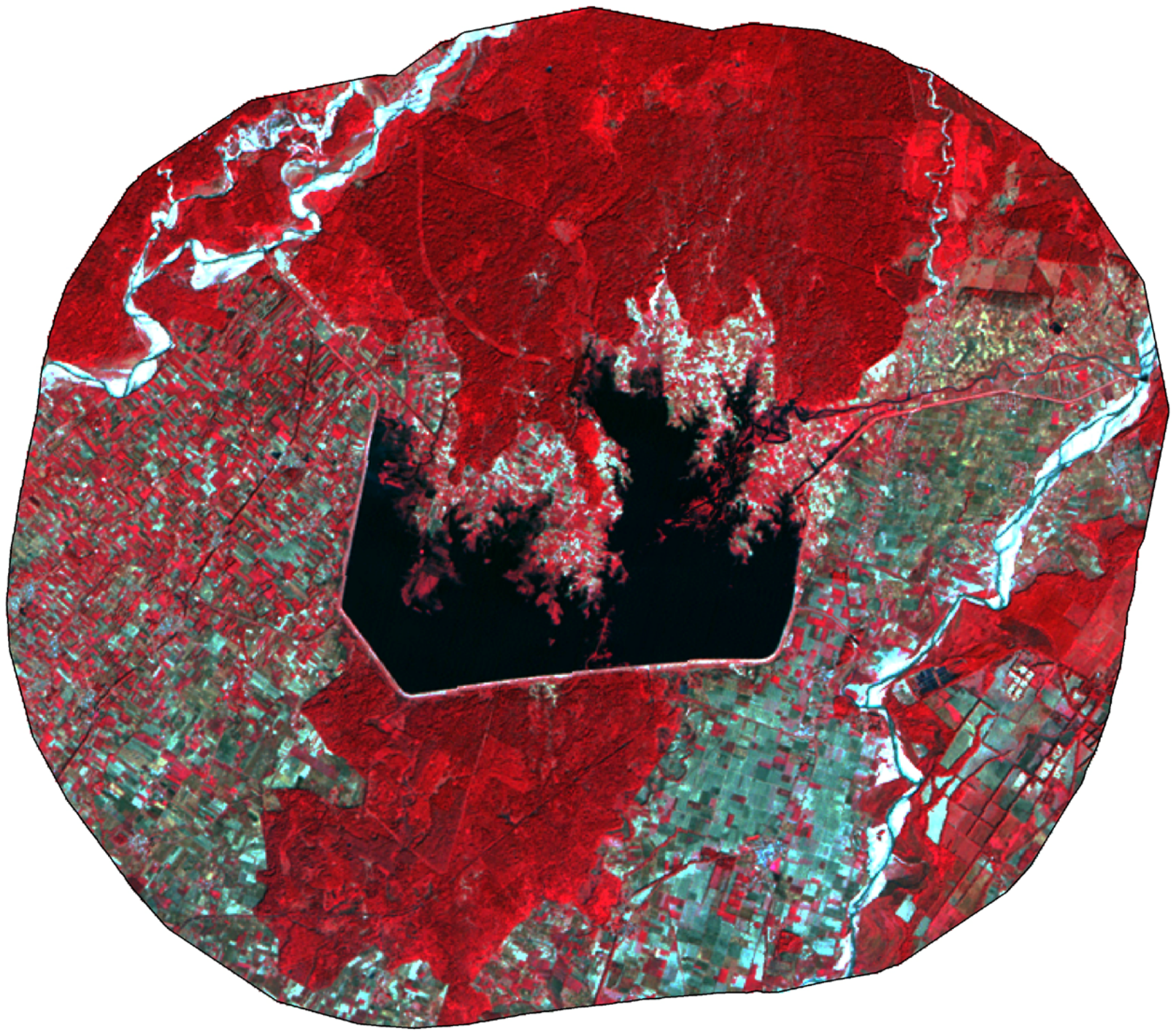
Sponsored By:

Ministry of Environment and Forests
Government of India

Plate 19: Wetland map - 5 km buffer area of Tumaria

State : Uttarakhand

Tumaria



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

Plate 20: IRS LISS III FCC - 5 km buffer area of Tumaria

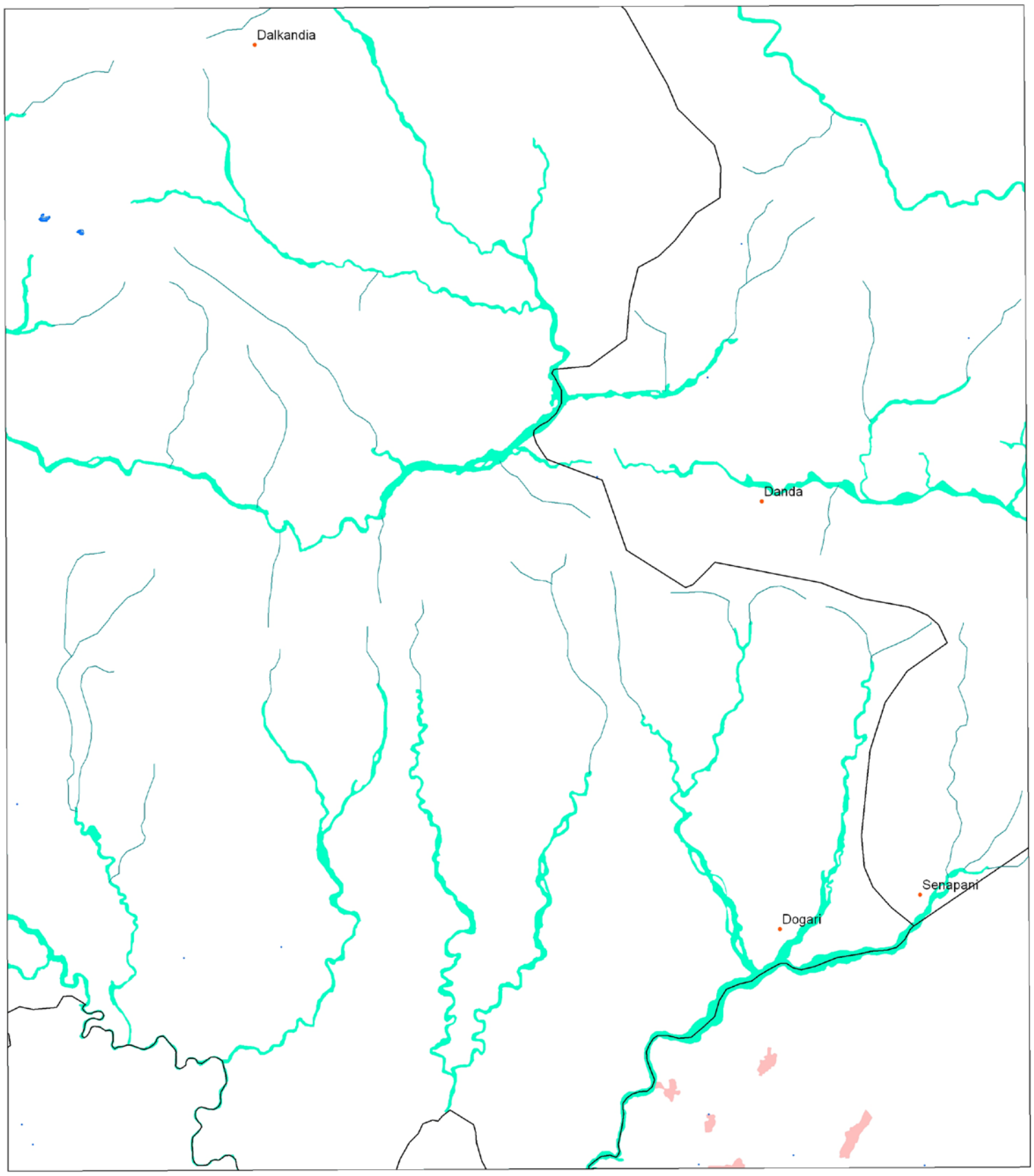
SOI MAP SHEET-WISE WETLAND MAPS

(Selected)

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53O/16

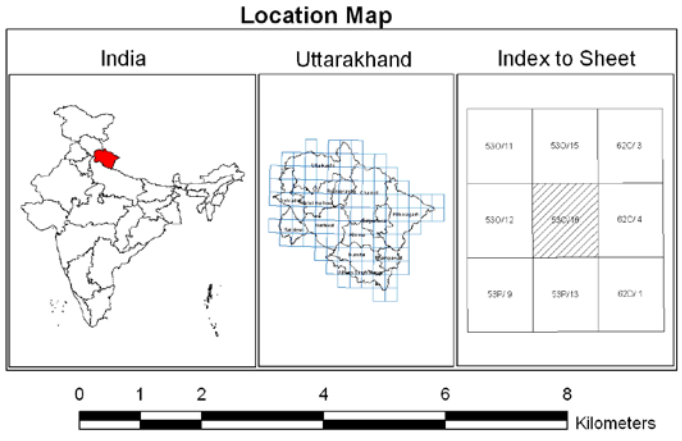


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

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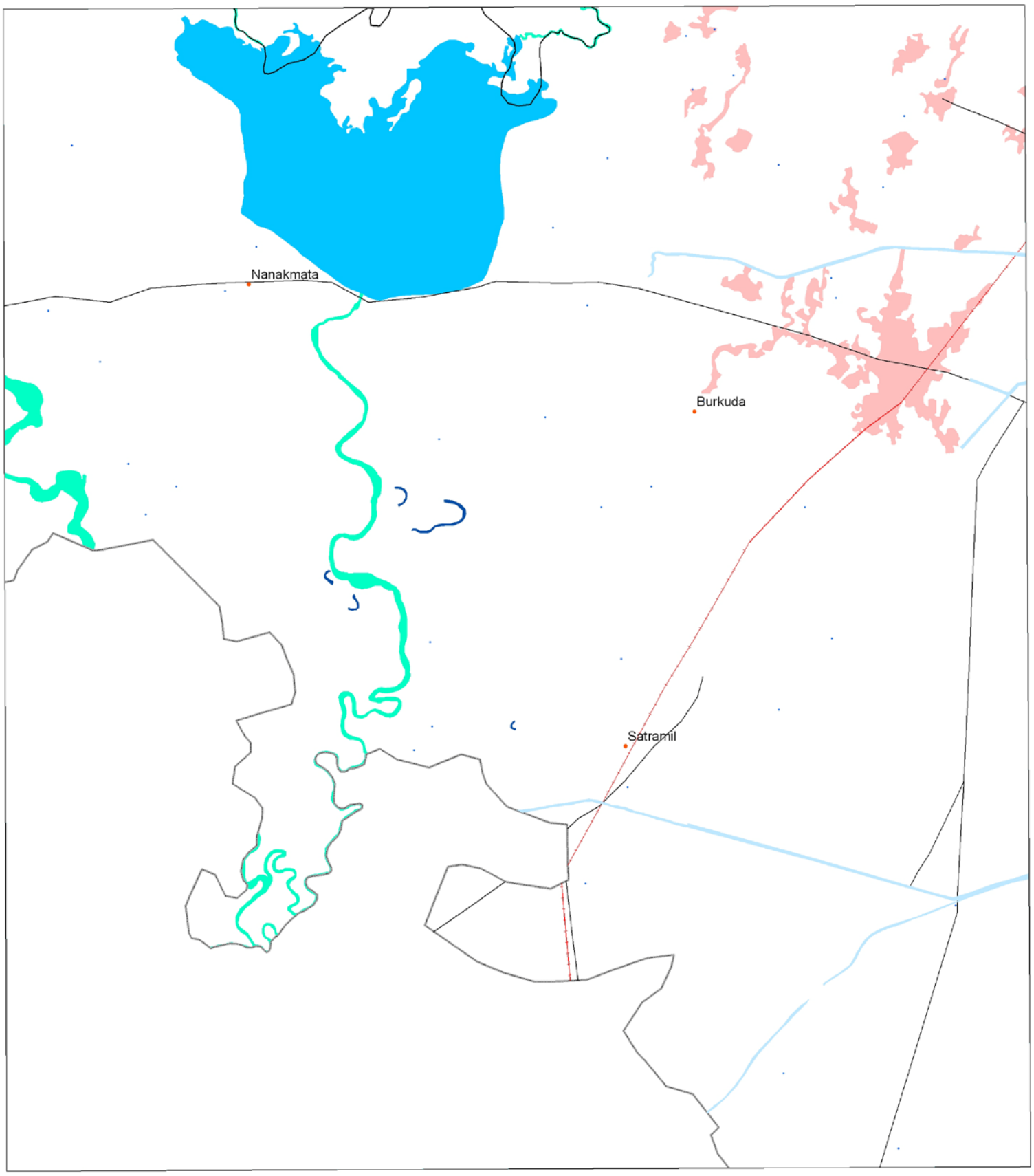
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53P/13

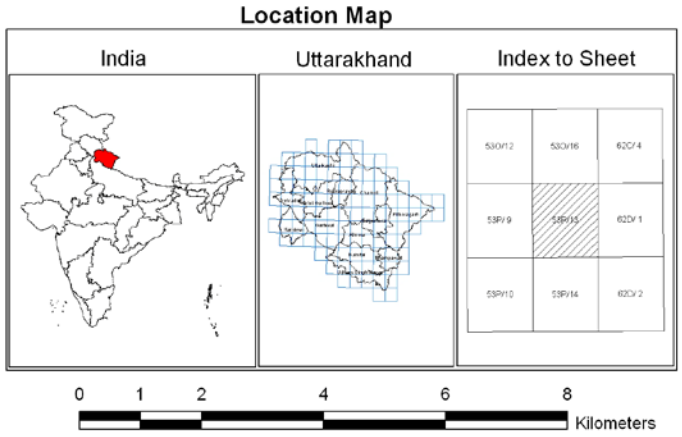


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

Sponsored By:

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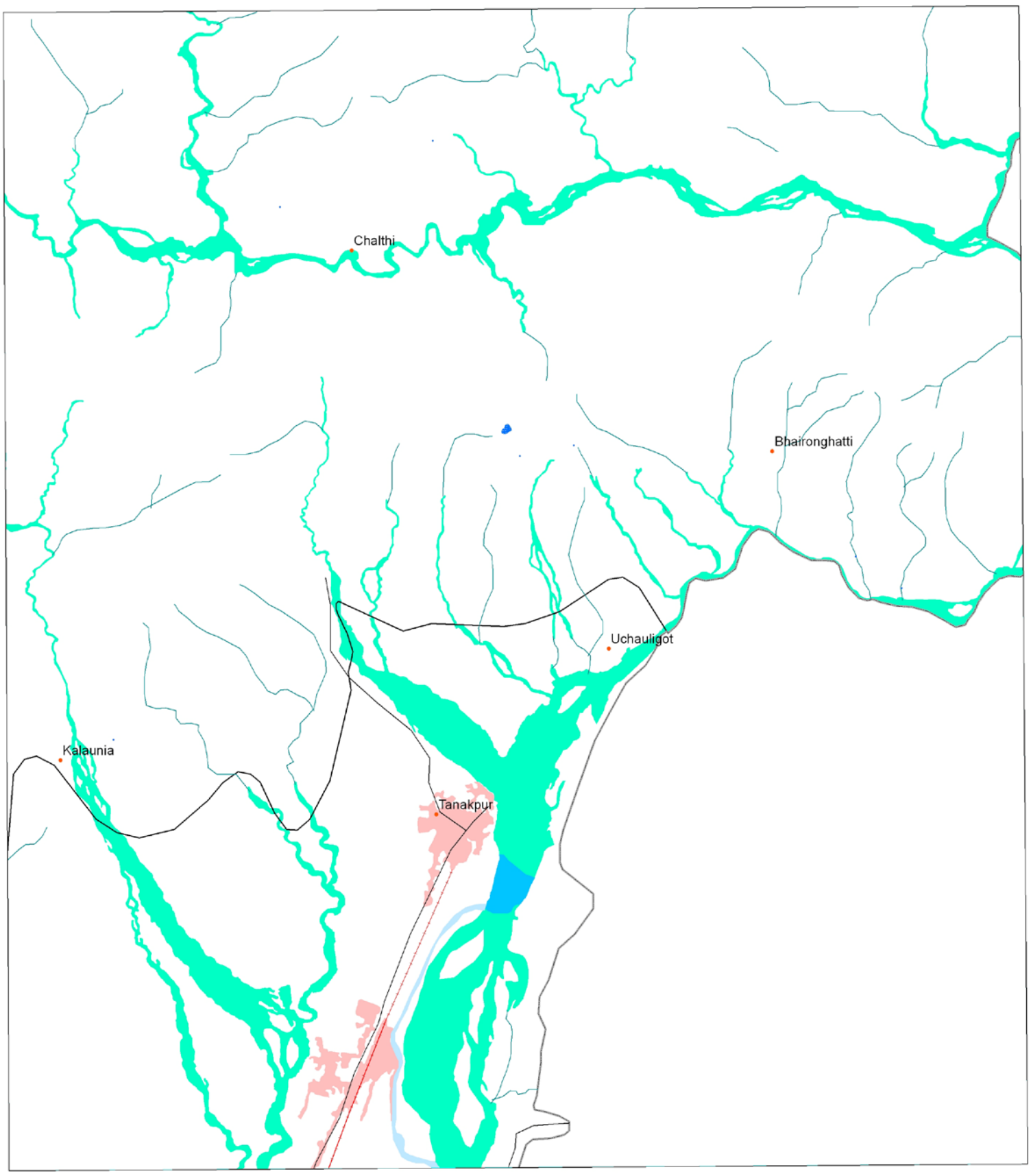
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 62C/04

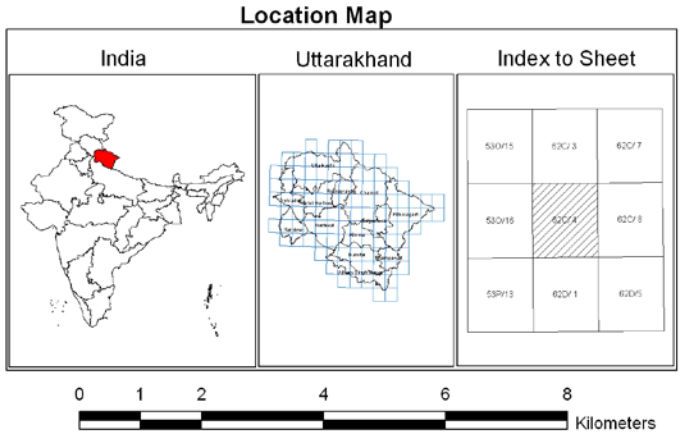


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
and
Uttarakhand Space Applications Centre, Dehradun

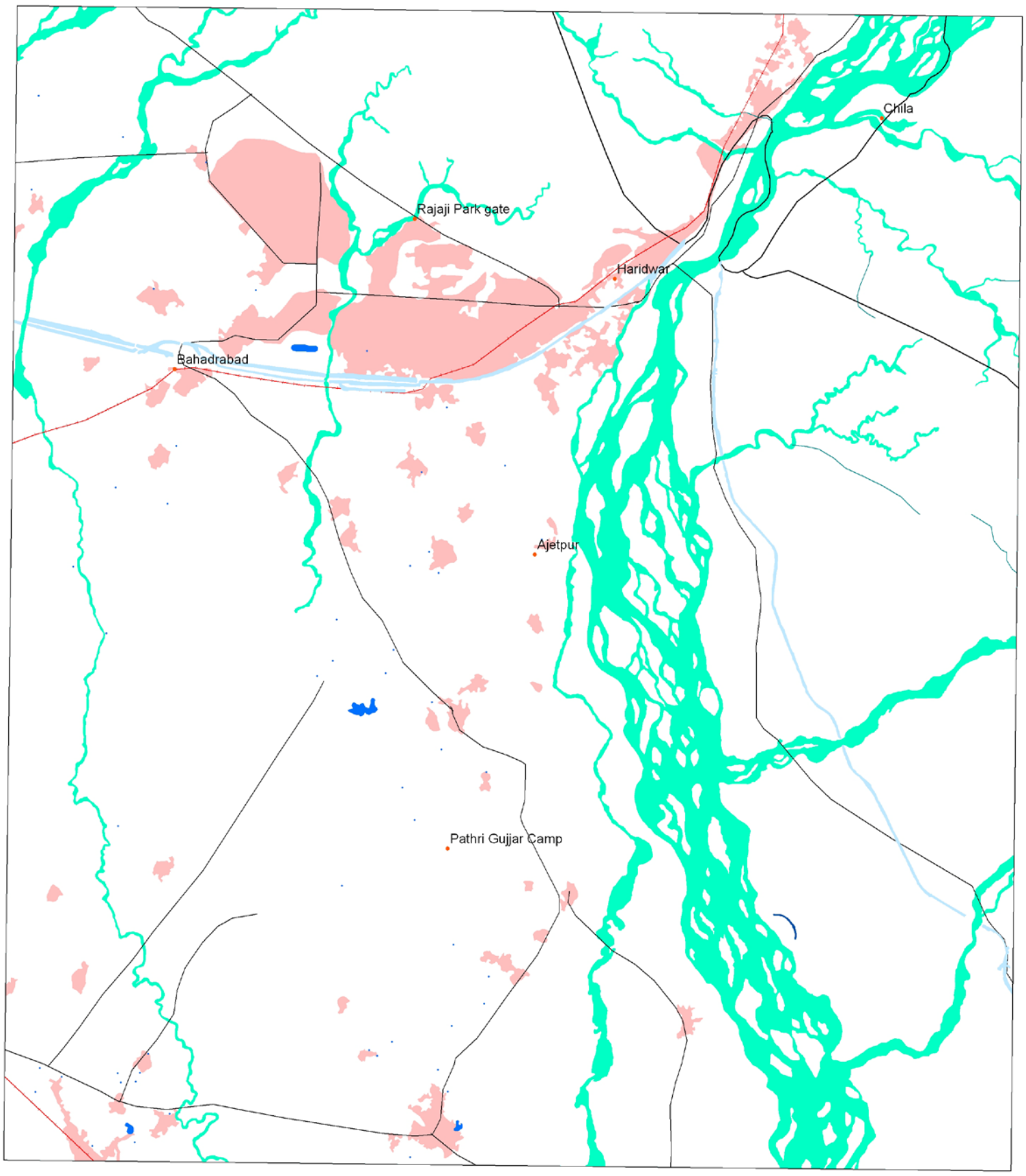
Sponsored By:

Ministry of Environment and Forests
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53K/01



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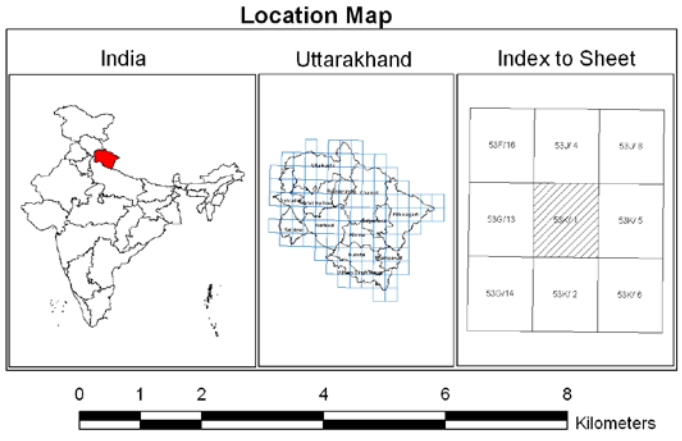
2104			Intertidal mud flats
2105			Salt marsh
2106			Mangroves
2107			Coral reefs
		Man-made	
2201			Salt pans
2202			Aquaculture ponds

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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Uttarakhand Space Applications Centre, Dehradun

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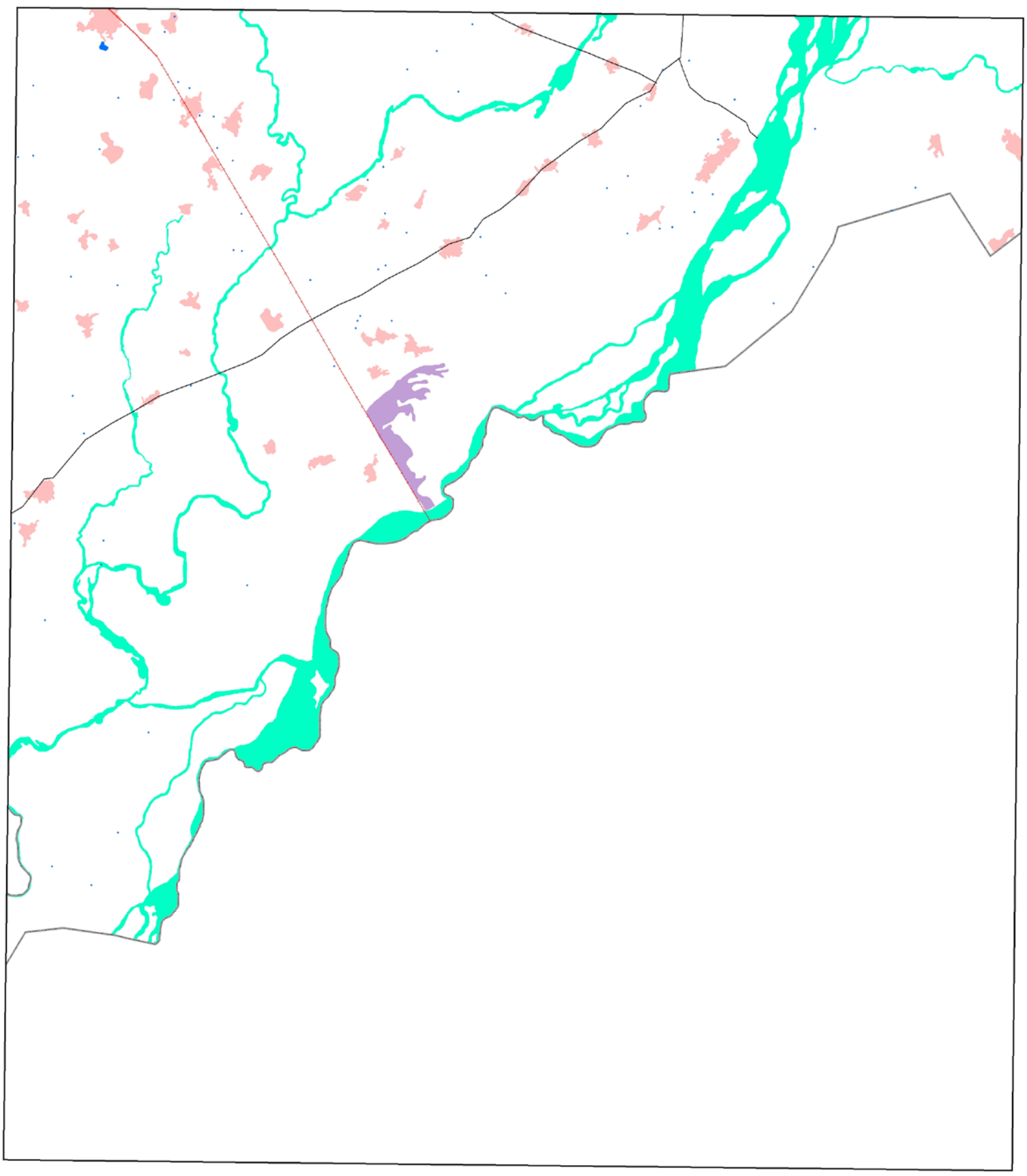
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53K/02

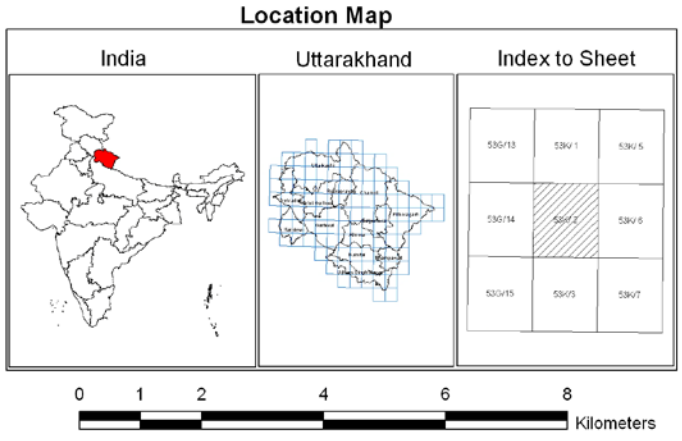


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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



Data Source :

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

Prepared By :

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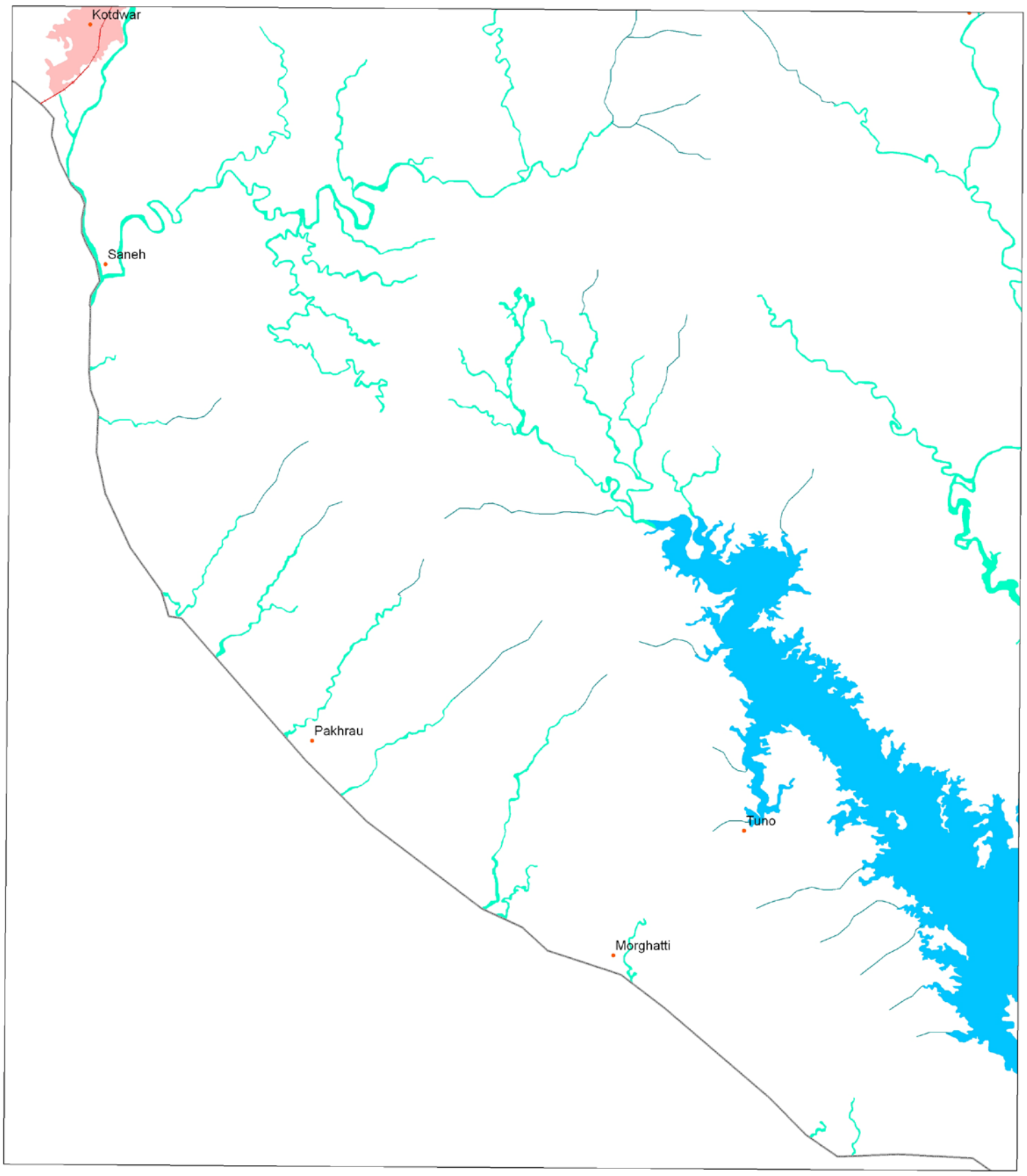
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53K/10

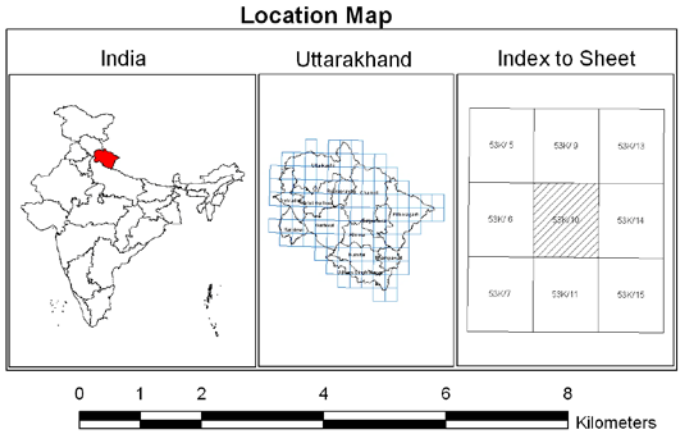


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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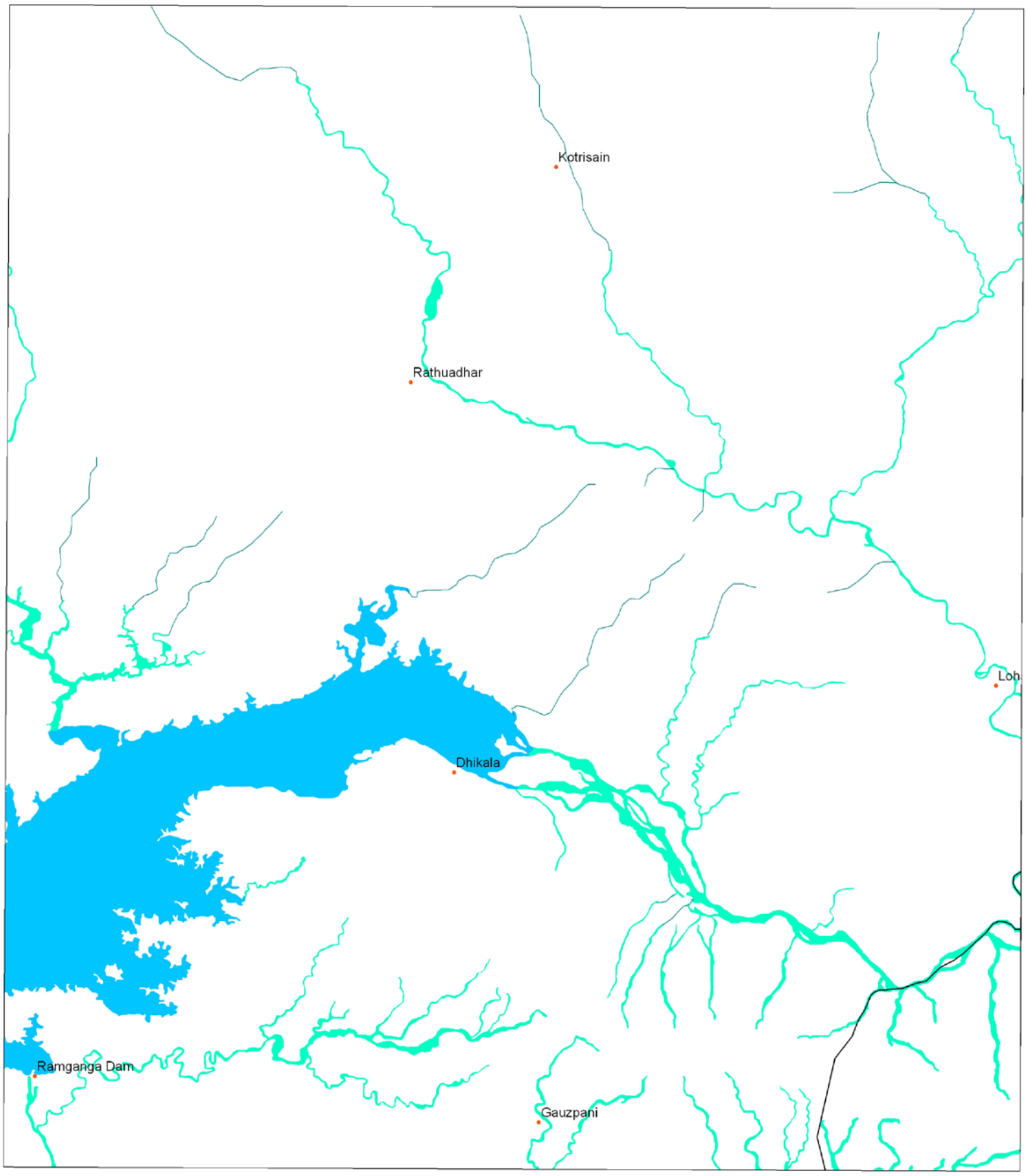
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53K/14

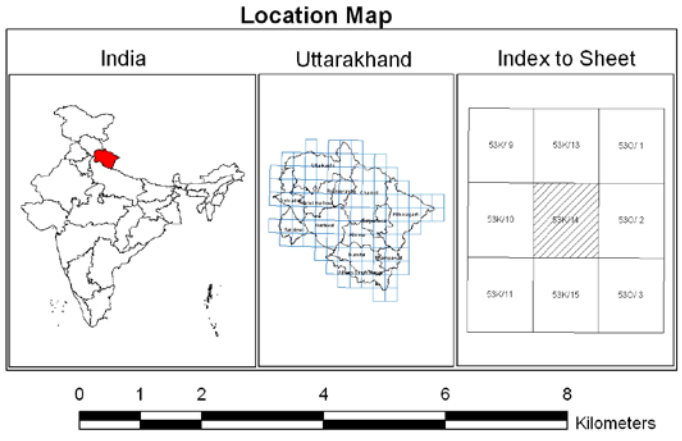


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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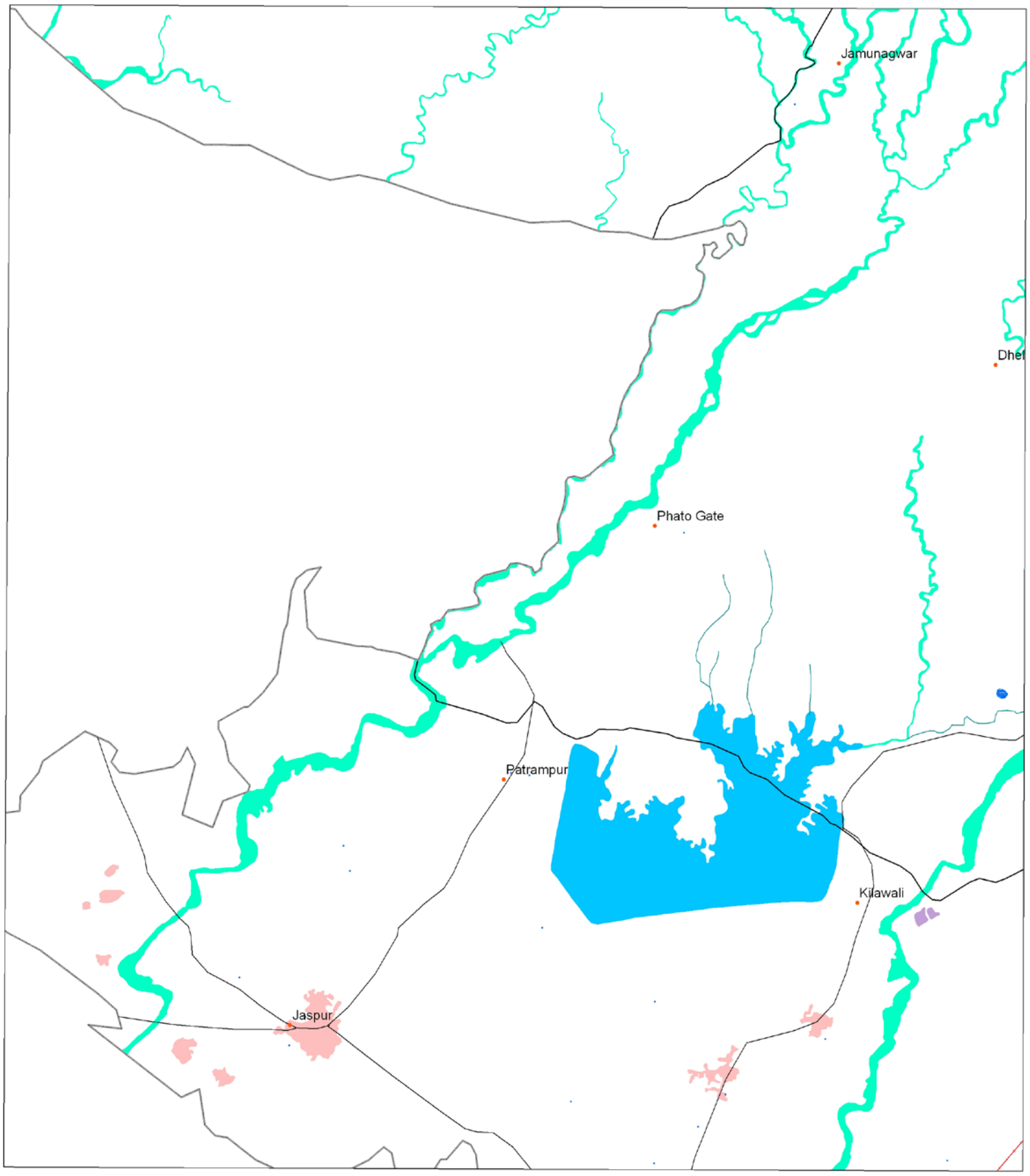
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53K/15

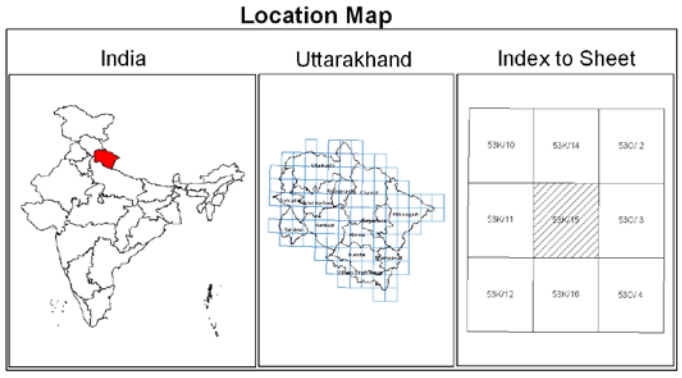


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



0 1 2 4 6 8 Kilometers

Data Source :

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

Prepared By :

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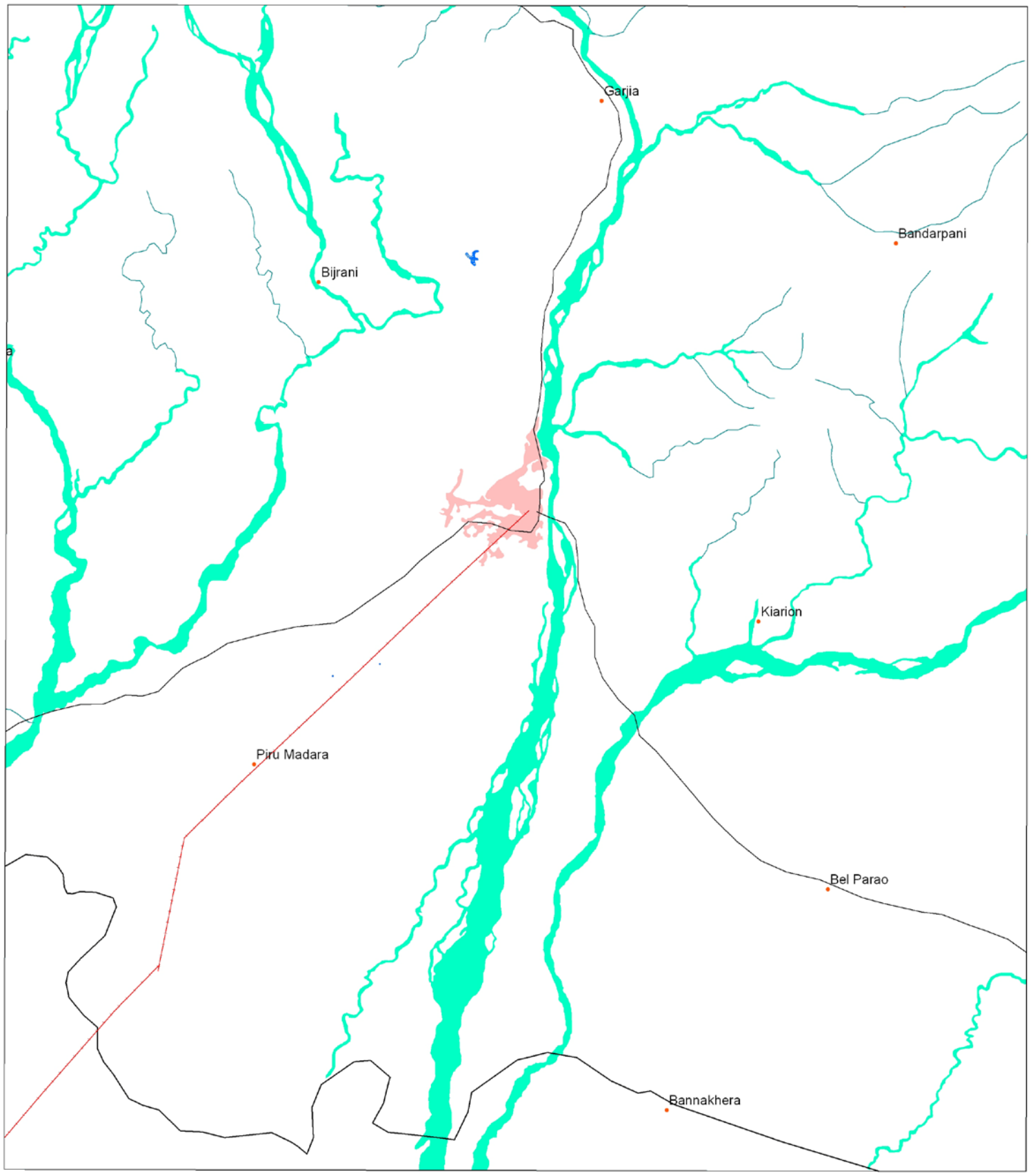
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53O/03

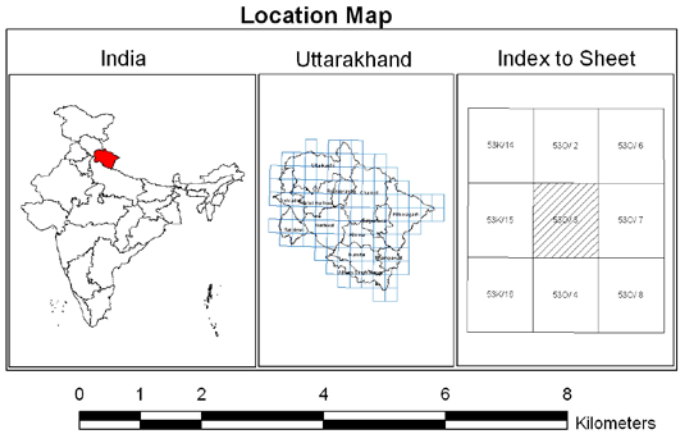


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad
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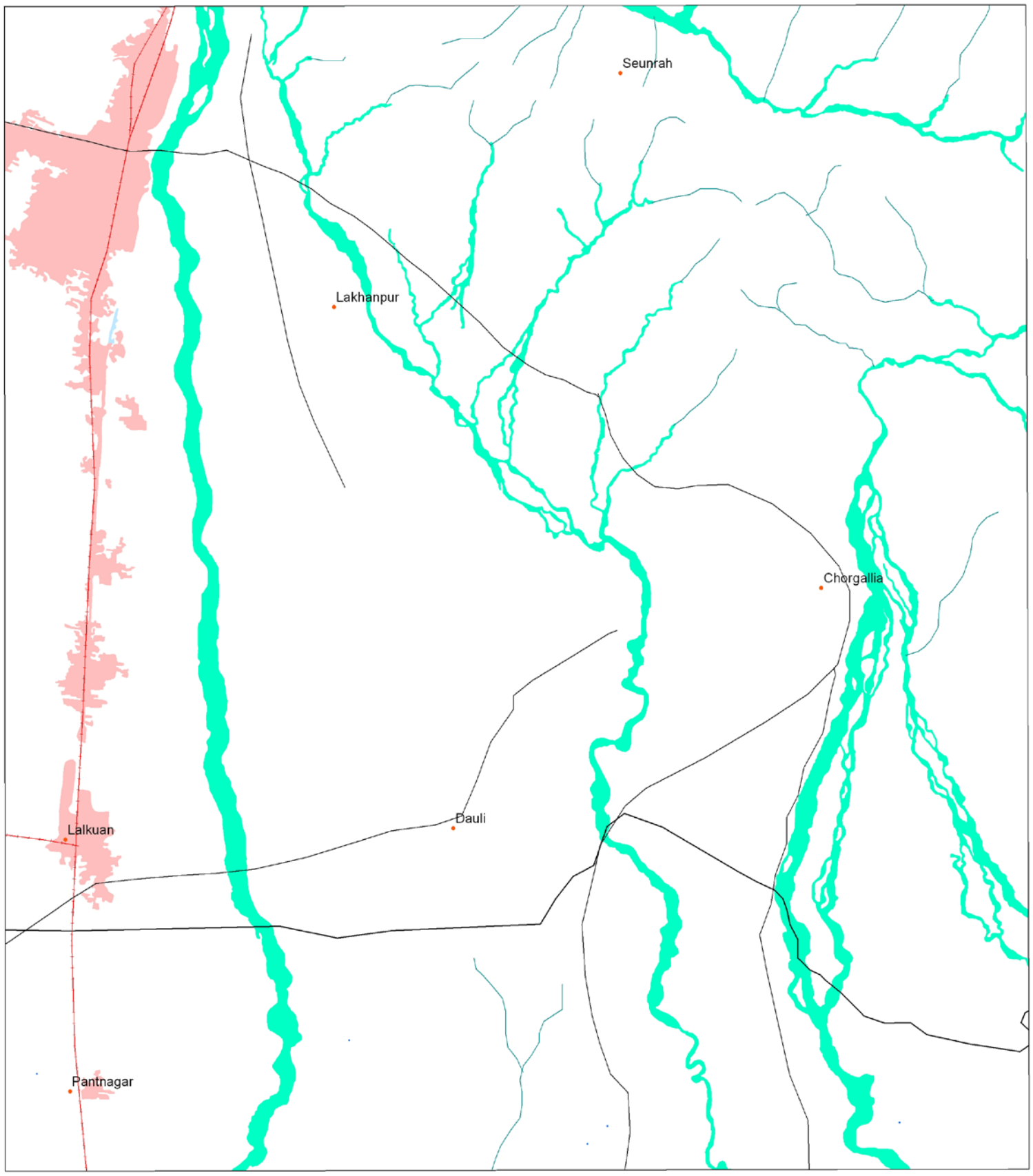
Government of India

State : Uttarakhand

WETLAND MAP

SHEET NO. : 53O/12

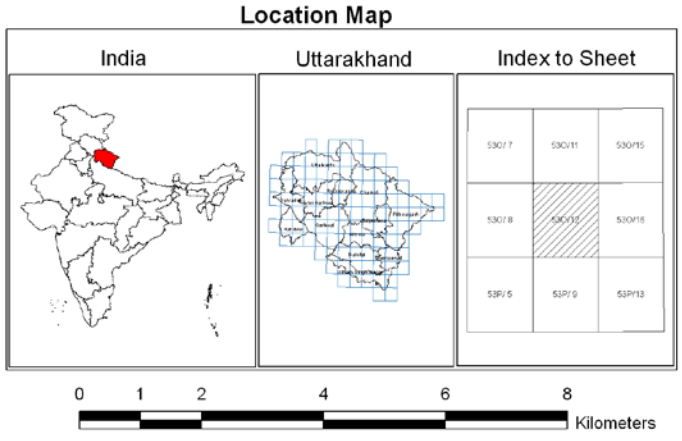


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Reverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged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

Legend

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

Location Map



Data Source :

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

Prepared By :

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Sponsored By:

Ministry of Environment and Forests
Government of India

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Annexure I
Definitions of wetland categories used in the project

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

Wetland type code	Definition and description
1000	**Inland Wetlands**
1100	**Natural**
1101	**Lakes**: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different hues of blue interspersed with pink (aquatic vegetation), islands (white if unvegetated, red in case of terrestrial vegetation). Vegetation if scattered make texture rough.
1102	**Ox-bow lakes/ Cut off meanders**: A meandering stream may erode the outside shores of its broad bends, and in time the loops may become cut-off, leaving basins. The resulting shallow crescent-shaped lakes are called oxbow lakes (Reid *et al*, 1976). On the satellite image Ox-bow lakes occur near the rivers in plain areas. Some part of the lake normally has aquatic vegetation (red/pink in colour) during pre-monsoon season.
1103	**High Altitude lakes:** These lakes occur in the Himalayan region. Landscapes around high lakes are characterized by hilly topography. Otherwise they resemble lakes in the plain areas. For keeping uniformity in the delineation of these lakes contour line of 3000 m above msl will be taken as reference and all lakes above this contour line will be classified as high altitude lakes.
1104	**Riverine Wetlands**: Along the major rivers, especially in plains water accumulates leading to formation of marshes and swamp. **Swamps** are 'Wetland dominated by trees or shrubs' (U.S. Definition). In Europe, a forested fen (a peat accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly *Sphagnum*) could be called a swamp. In some areas reed grass - dominated wetlands are also called swamps). (Mitsch and Gosselink, 1986). **Marsh**: A frequently or continually inundated wetland characterised by emergent herbaceous vegetation adapted to saturated soil conditions. In European terminology a marsh has a mineral soil substrate and does not accumulate peat (Mitsch and Gosselink, 1986). Tone is grey blue and texture is smooth. **Comment**: Using satellite data it is difficult to differentiate between swamp and marsh. Hence, both have been clubbed together.
1105	**Waterlogged:** Said of an area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die (Margarate *et al*, 1974). Floods or unlined canal seepage and other irrigation network may cause 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
Definitions of wetland categories used in the project

State : Uttaranchal

District Boundary Map

List of Districts

District Code	District Name
01	Uttarkashi
02	Chamoli
03	Rudraprayag
04	Tehri Garhwal
05	Dehradun
06	Garhwal
07	Pithoragarh

District Code	District Name
08	Bageshwar
09	Almora
10	Champawat
11	Nainital
12	Udham Singh Nagar
13	Hardwar

Legend

State Boundary

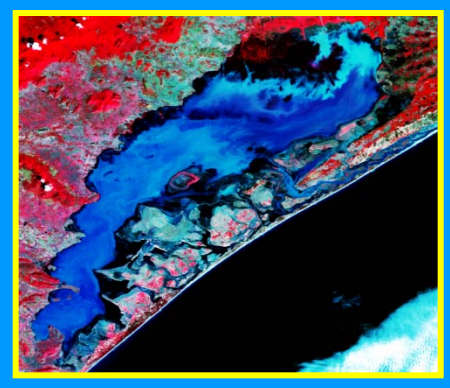
District Boundary

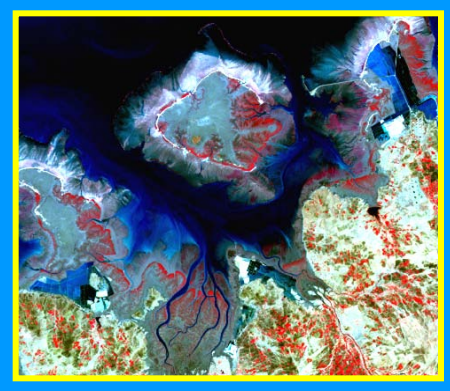
Source : Survey of India (Surveyed in 2004 and published in 2005)

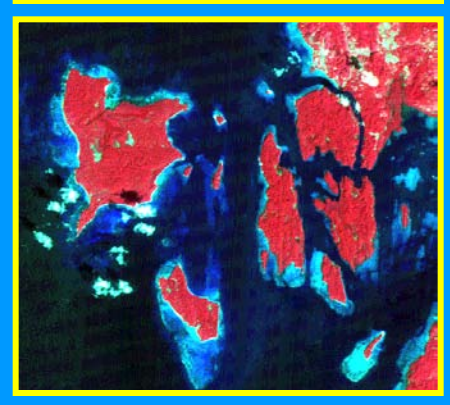
Space Applications Centre (SAC) is one of the major centres of the Indian Space Research Organisation (ISRO). It is a unique centre dealing with a wide variety of disciplines comprising design and development of payloads, societal applications, capacity building and space sciences, thereby creating a 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.

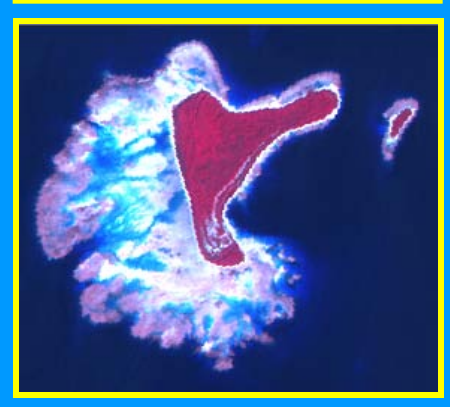
SAC is a host institution for the training programmes related to Satellite Communication, Satellite Meteorology and global change under the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations (UN).

http://www.isro.org









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