NATIONAL WETLAND ATLAS:

JHARKHAND

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
Jharkhand Space Applications Centre, Ranchi

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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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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 difficulties most frequently faced for decision making is lack of scientific data of our natural resources. Often the data are sparse or unconvincing, rarely in the form of geospatial database (map), thus open to challenges. Thus, the current thrust of every country is to have an appropriate geospatial database of natural resources that is based on unambiguous scientific methods. The wetland atlas of Jharkhand, 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 (Westlake & Pratt, 2006).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 wetlands is estimated to already have disappeared worldwide 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 are essential for monitoring and quantifying change over time scale, assist in decision making. The technique used in the preparation of map started with ground survey. The Survey of India (SOI) topographic 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 recognized 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, 2000; Lillesand and Keifer, 1987). Today, we define satellite remote sensing as the use of satellite borne sensors to observe, measure, and record the electromagnetic radiation (EMR) reflected or emitted by the earth and its environment for subsequent analysis and extraction of information. EMR sensors includes visible light, near-, mid- and far-infrared (thermal), microwave, and long-wave radio energy. The capability of multiple sources of information is unique to remote sensing. Of specific advantage is the spectral, temporal, and spatial resolution. Spectral resolution refers to the width or range of each spectral band being recorded. Since each target affects different wavelengths of incident energy differently, they are absorbed, reflected or transmitted in different proportions. Currently, there are many land resource remote sensing satellites that have sensors operating in the green, red, near infrared and short wave Infra red regions of the electromagnetic spectrum giving a definite spectral signature of various targets due to difference in radiation absorption and reflectance of targets. These sensors are of common use for land cover studies, including wetlands**.** Figure 1 shows typical spectral signature of few targets from green to SWIR region. Converted to image, in a typical false colour composite (FCC) created using NIR, red and green bands assigned as red, green and blue colour, the features become very distinct as shown in Figure 2. In FCC, the vegetation thus appears invariably red (due to high reflection in NIR from green leaves).

Since the early 1960s, numerous satellite 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.

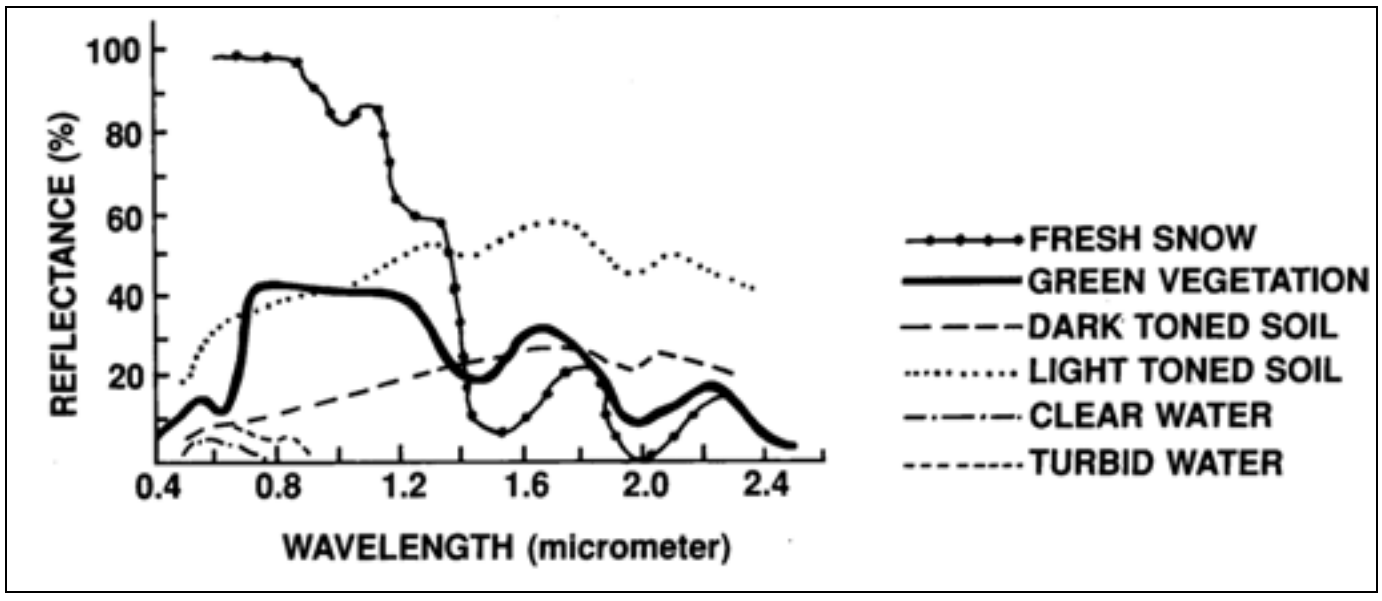


Figure 1: Spectral Signature of various targets

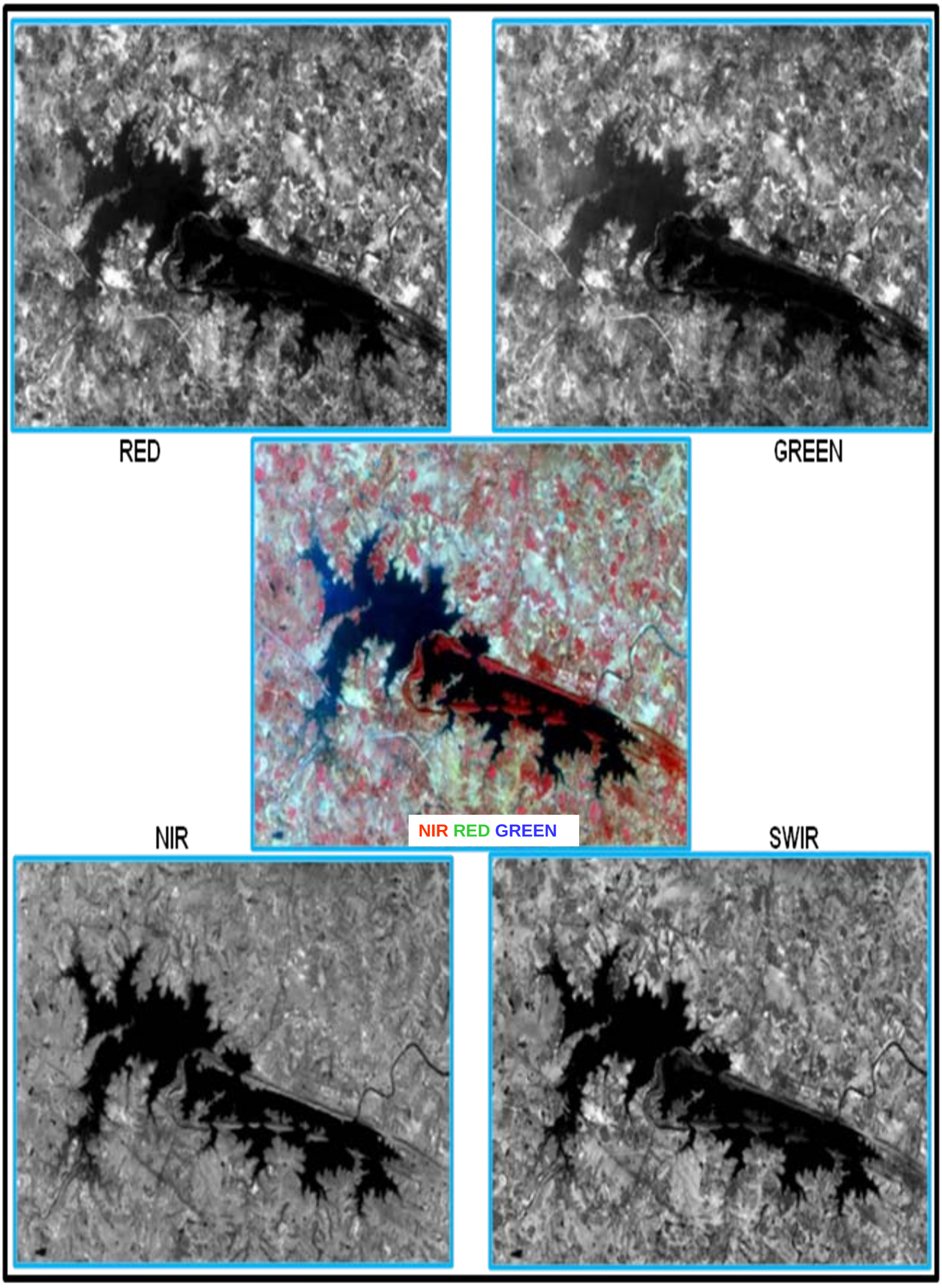


Figure 2: Various land features as they appear in four spectral bands and in a typical three band FCC.

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

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

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

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

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

The first scientific mapping of wetlands of India was carried out during1992-93 by Space Applications Centre (ISRO), Ahmedabad, at the behest of the Ministry of Environment and Forests (MoEF), Govt. of India using remote sensing data from Indian Remote Sensing 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 scales 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 in June 2007 where wetland experts and database experts participated and finalized the classification system. It was agreed to follow the classification system that has been used for the earlier project of 1:250,000 scale, with slight modification. Modified National Wetland Classification system for wetland delineation and mapping comprise 19 wetland classes which are organized under a Level III hierarchical system. The definition of each wetland class and its interpretation method was finalized. The technical/procedure manual was prepared as the standard guideline for the project execution across the country (Garg and Patel, 2007). The present atlas is part of the national level data base and deals with the state of Jharkhand.

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.

2.2.1 Spatial Framework and GIS Database

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

Following wetland layers are generated for each inland wetland:

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

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

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

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

- Turbidity level 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) are mapped as point features.

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

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

Table 1: Wetland Classification System and coding

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

* Wetland type code

3.0 STUDY AREA

The Jharkhand State is one of the newly established States of Indian Union carved out of the state of Bihar in November 2000 separating 18 districts. The state has at present 24 districts. It comprises of the Chotanagpur Plateau, which forms a part of Deccan bio-geographic province. It is a hilly undulating plateau characterized by predominantly tropical forests and tribal settlements. The state is one of the largest producers of the mineral resources of the country spreading over majority of the districts with a paradox to be among the bottom lying states in terms of development. This State is endowed with natural resources that need to be conserved and utilized in a sustainable manner for all-round development of the state in general and the marginalized tribal population in particular. The total geographical area is 79,714 Sq km lies between 21^{o} 58' 00" to 25^{o}20' 00" N latitude and 83^{o} 20' 00" to 87^{o} 57' 00" E longitude (Figure 3). Jharkhand shares its border with the states of Bihar in the north, Uttar Pradesh and Chhattisgarh in the west, Orissa to the south, and West Bengal in the east.

Climate of the state in general is tropical with hot summers and cold winters. There are regional variations and some parts of the state like Ranchi, Netarhat, and Parasnath have a pleasant climate even during the summers. Maximum rainfall takes place during the months from July to September that accounts for more than 90% of total rainfall in the state.

The major west-flowing rivers that crease the territory are: Ganga, Subernarekha, Damodar, Barakar, Son, Sankh, Mayurakshi, North Koel , South Koel , Ajay, Gumani, Kharkai etc. The rivers of Jharkhand play an integral role in the socio-economic aspect of the society. Damodar, Barakar, Koel and Subarnarekha are the principal rivers of Jharkhand that largely contribute towards the agriculture in the territory. In fact, many dams such as Konar, Maithon, Panchet and Tilaiya have been created, to manage the water of the rivers. Thermal power stations at Bokaro and Patratu also contribute towards the economy of the state.

The important wetlands of Jharkhand are Udhwa lake bird sanctuary, Getalsud dam, Kansjor dam, Konar dam, Tilaiya dam, Massanjore dam, Maithon dam and Tenughat dam.

According to the census 2001 the state has 18 districts covered in 163 on 1:50,000 scale of SOI topographical maps that form the spatial frame work for mapping (Figure 4).

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

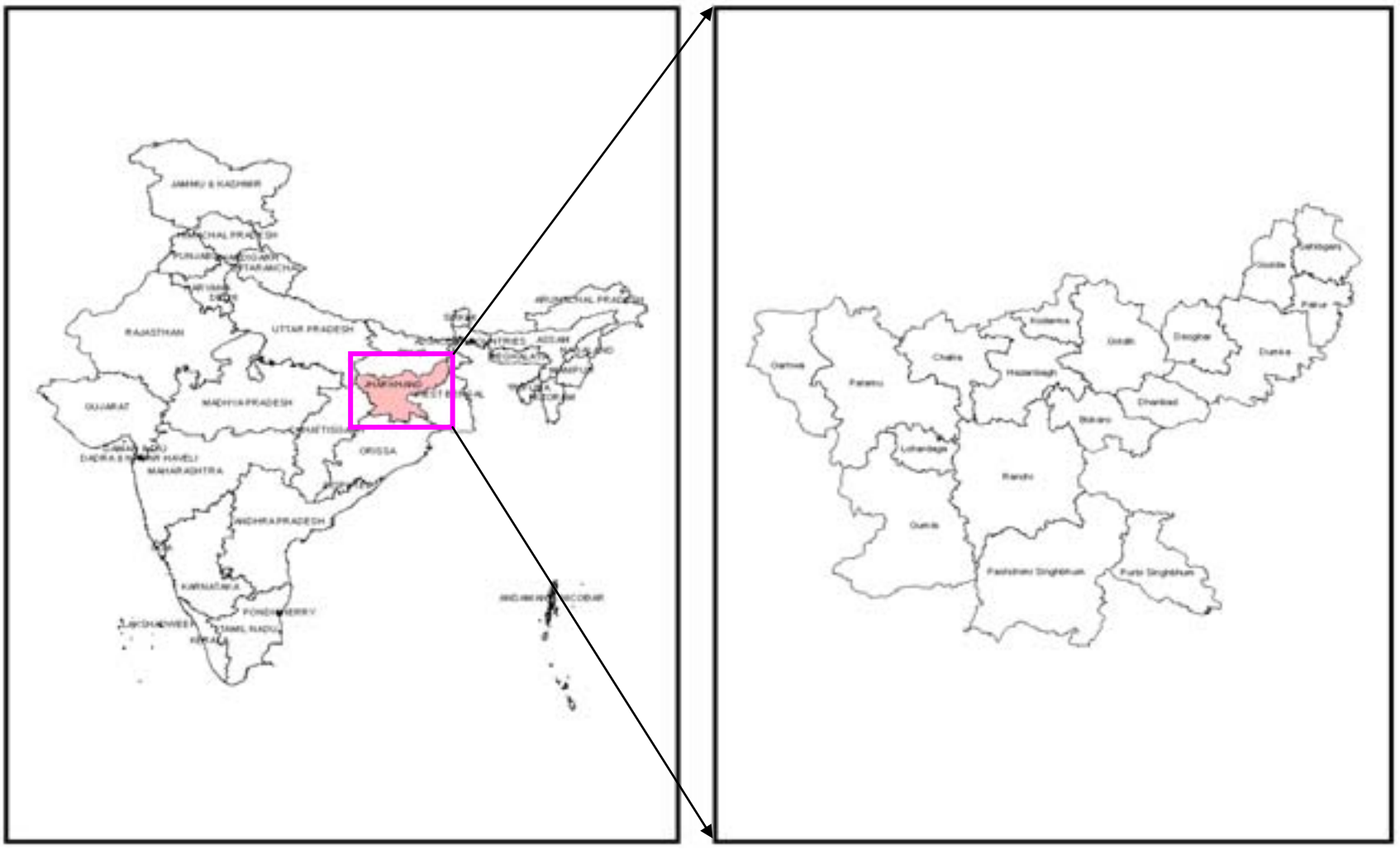


Figure 3: Location map

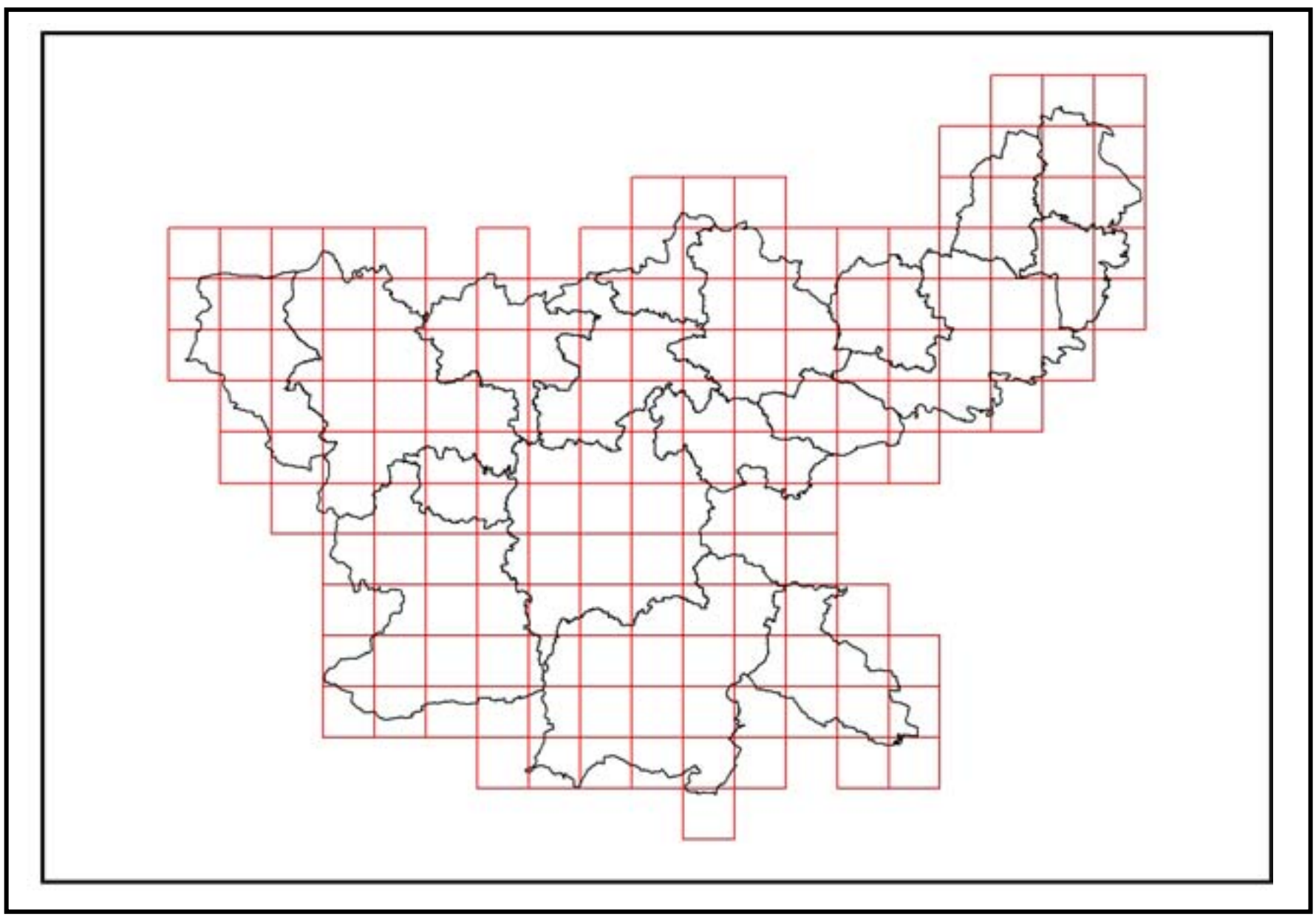


Figure 4: Spatial Framework of Jharkhand

4.0 DATA USED

Remote sensing data

IRS P6 LISS III data was used to map the wetlands. IRS P6 LISS III provides data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23.5 m spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The state of Jharkhand is covered in 15 IRS LISS III scenes (Figure 5). Two date data, one acquired during March-May and another during September-December 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 study area as seen in the LISS III FCC of pre- monsoon and post-monsoon data respectively.

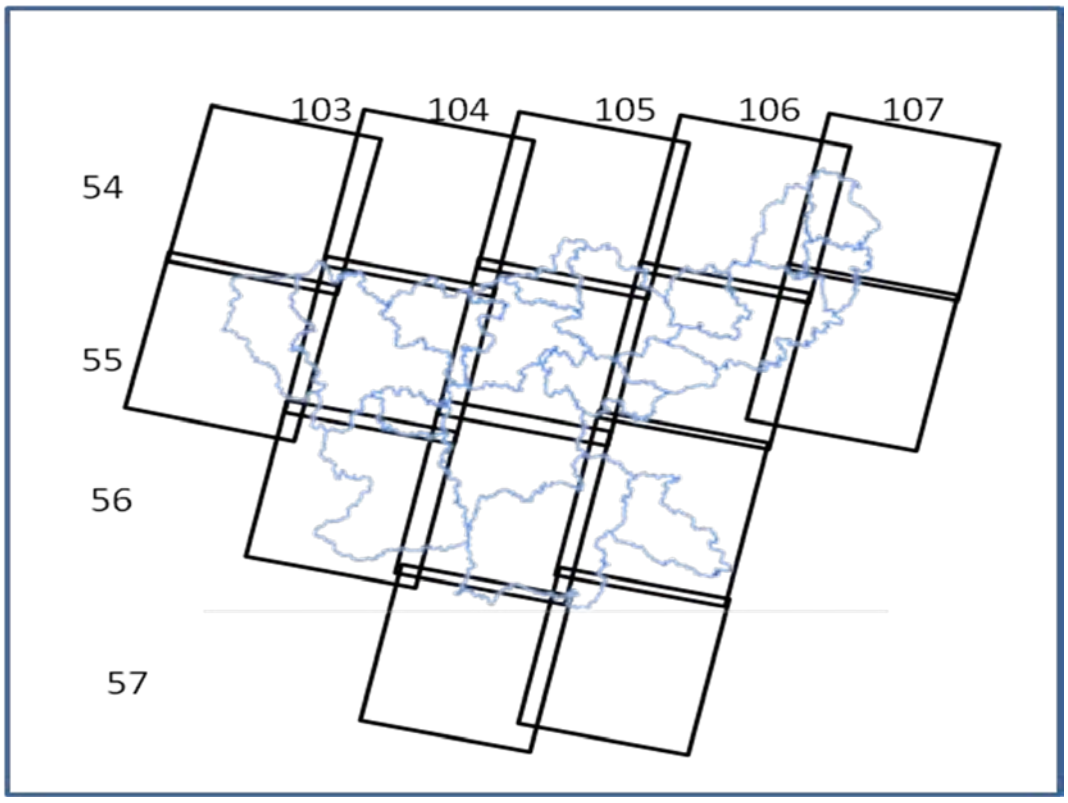


Figure 5: IRS P6 LISS-III coverage (path-row) of Jharkhand

Table-2: Satellite data used

S.N.	Sensor	Path-Row	Pre- monsoon Date	Post- monsoon
1	IRS-P6 LISS III	103-54	25May 2007	14November2006
2	IRS-P6 LISS III	103-55	25May 2007	14November2006
3	IRS-P6 LISS III	104-54	30May2007	19November2006
4	IRS-P6 LISS III	104-55	30May2007	19November2006
5	IRS-P6 LISS III	104-56	30May2007	19November2006
6	IRS-P6 LISS III	105-54	4June 2007	18December2006
7	IRS-P6 LISS III	105-55	17April2007	18December2006
8	IRS-P6 LISS III	105-56	17April2007	18December2006
9	IRS-P6 LISS III	105-57	22April2006	18December2006
10	IRS-P6 LISS III	106-54	29March2007	29November2006
11	IRS-P6 LISS III	106-55	29March2007	29November2006
12	IRS-P6 LISS III	106-56	29March2007	12September2006
13	IRS-P6 LISS III	106-57	22April2007	12September2006
14	IRS-P6 LISS III	107-54	03April2007	04December2006
15	IRS-P6 LISS III	107-55	03April2007	04December2006

Ground truth data

Remote sensing techniques require certain amount of field observations called “ground truth” in order to convert into meaningful information. Such work involves visiting a number of test sites, usually taking the satellite dates. 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 May and December 2008.

Other data

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

5.0 METHODOLOGY

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

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

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

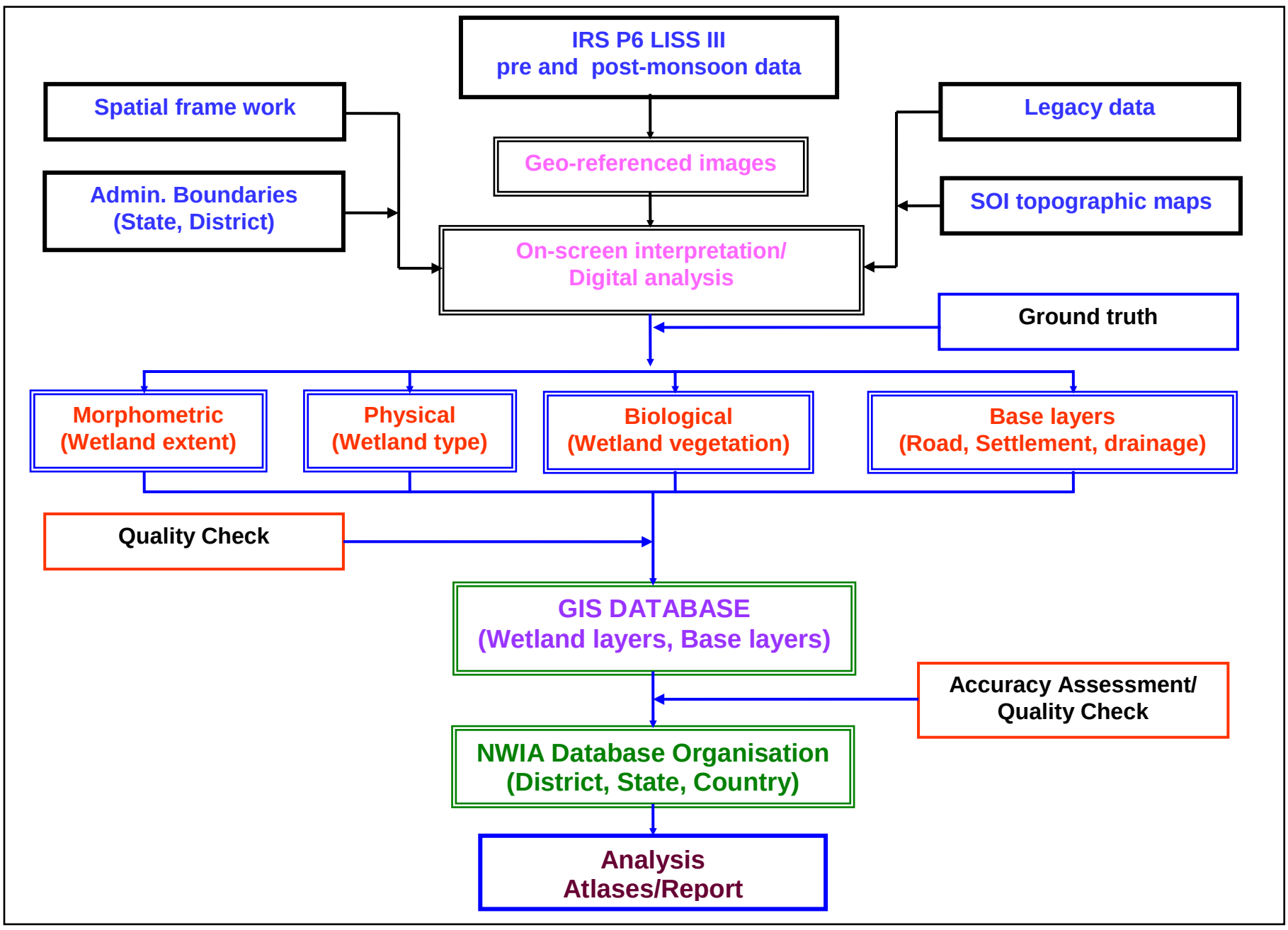


Figure 7: Flow chart of the methodology used

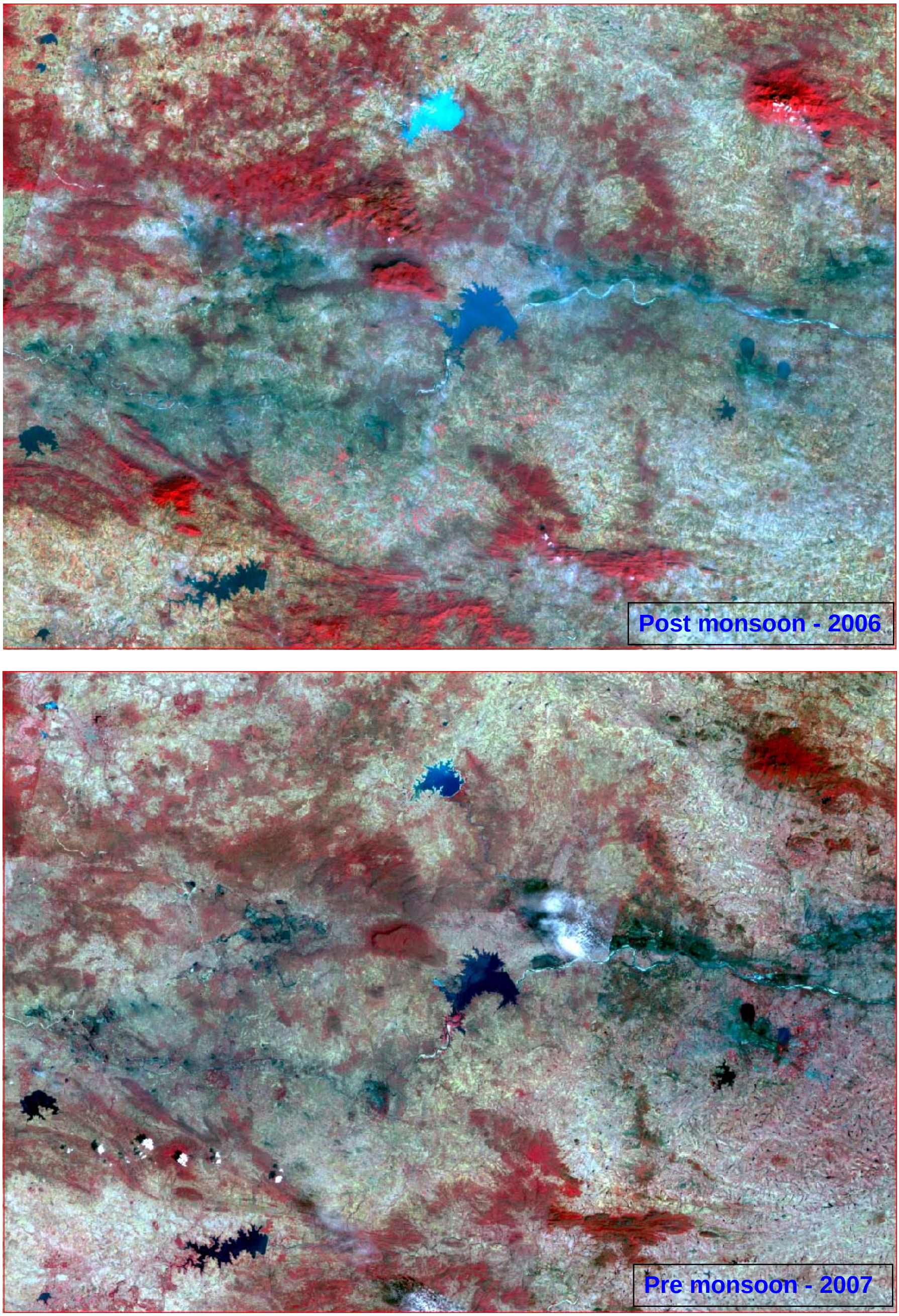


Figure 6: IRS LISS-III FCC (Post-monsoon-2006 and Pre-monsoon-2007) of part of Jharkhand

5.1 Creation of spatial framework

This is the most important task as the state forms a part of the national frame work and is covered in multiple map sheets. To create NWIA database, NNRMS/NRDB standards is followed and four corners of the 1:50,000 (15' x 15') 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 (Garg and Patel, 2007). The spatial framework for Jharkhand 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 archived geometrically corrected LISS III data (ISRO-NRC-land use / land cover project). Standard image processing software was used for geo-referencing. First one date data was registered with the archived image. The second date data was then registered with the first date data.

5.3 Mapping of wetlands

The delineation of wetlands through image analysis forms the foundation for deriving all wetland classes and results. Consequently, a great deal of emphasis has been placed on the quality of the image Interpretation. In the present study, the mapping of wetlands was done following digital classification and onscreen visual interpretation. Wetlands were identified based on vegetation, visible hydrology and geography. There are various methods for extraction of water information from remote sensing imagery, which according to the number of bands used, are generally divided into two categories, i.e. Single-band and multi-band methods. Single-band method usually involves choosing a band from multi-spectral image to distinguish water from land by subjective threshold values. It may lead to over- or under-estimation of open water area. Multi-band method takes advantage of reflective differences of each band. In this project, five indices known in literature that enhances various wetland characteristics were used (McFeeters, 1996; Xu Hanqiu, 2006; Townshend and Justice, 1996; Tucker and Sellers, 1986; Lacaux et al, 2007) as given below:

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

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

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

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

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

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

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

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

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

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

5.4 Conversion of 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 digitisation.

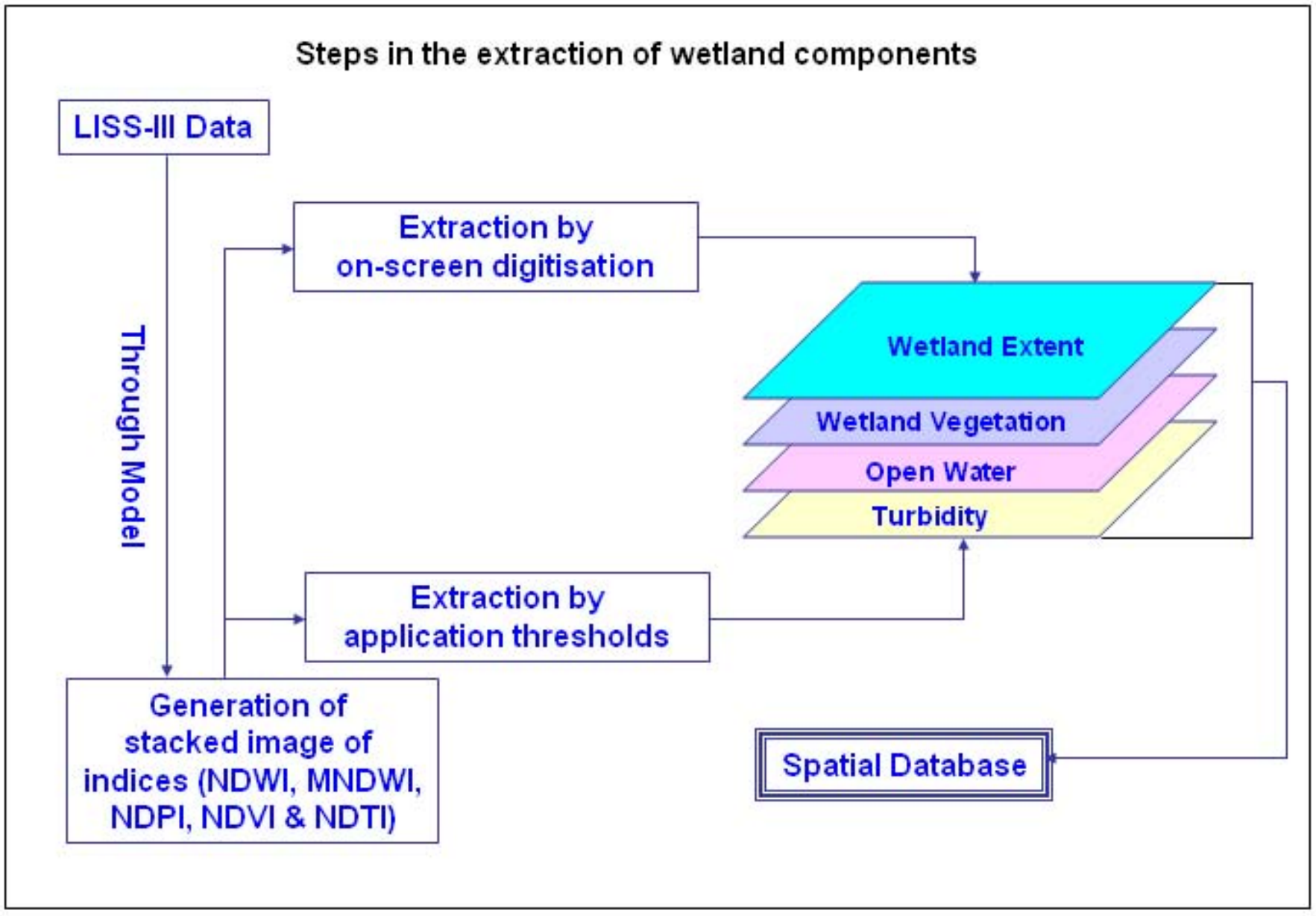


Figure 8: Steps in the extraction of wetland components

5.5 *Generation of reference layers*

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

5.6 *Coding and attribute scheme*

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

5.7 Map composition and output

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

6.0 ACCURACY ASSESSMENT

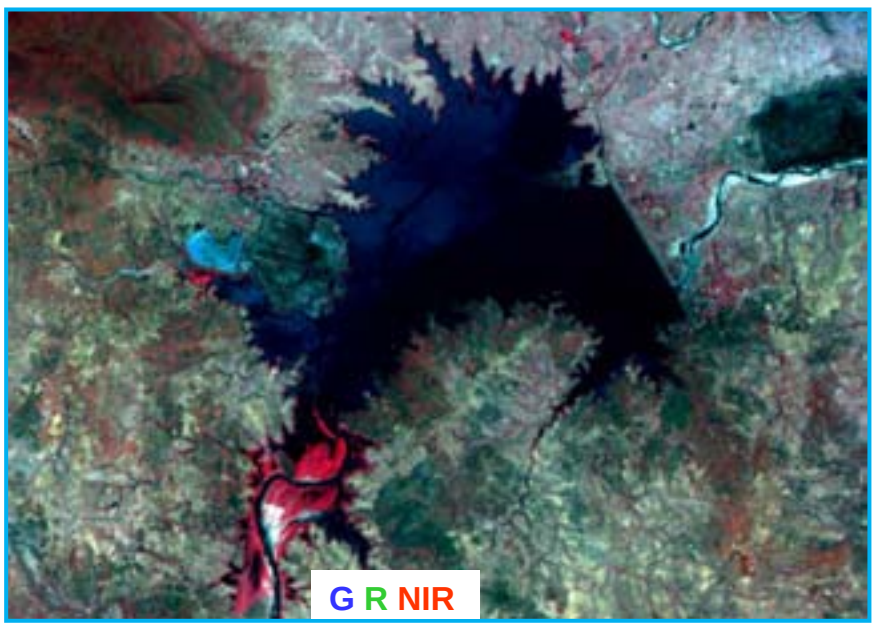
A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as locational accuracy. In addition, GIS database(s) contents have been also evaluated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

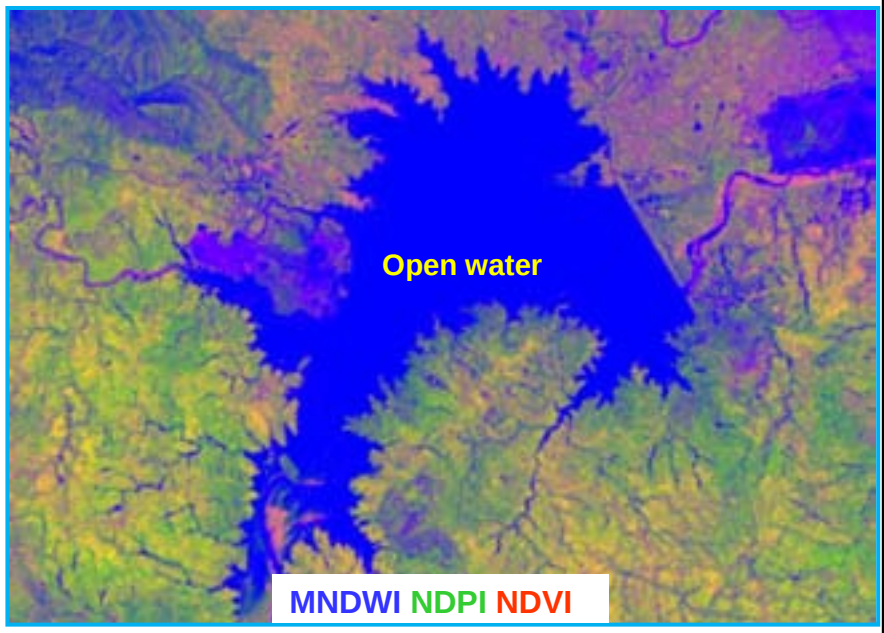
This study used well established, time-tested, fully documented data collection conventions. It employed skilled and trained personnel for image interpretation, processing and digital database creation. All interpreted imagery were reviewed by technical expert team for accuracy and code. The reviewing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

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

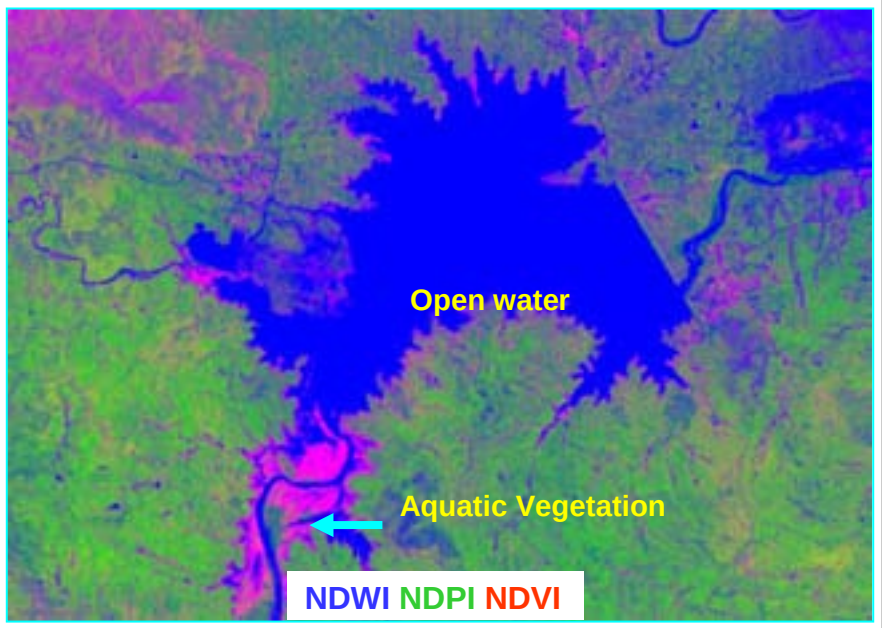
6.1 Data verification and quality assurance of output digital data files

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

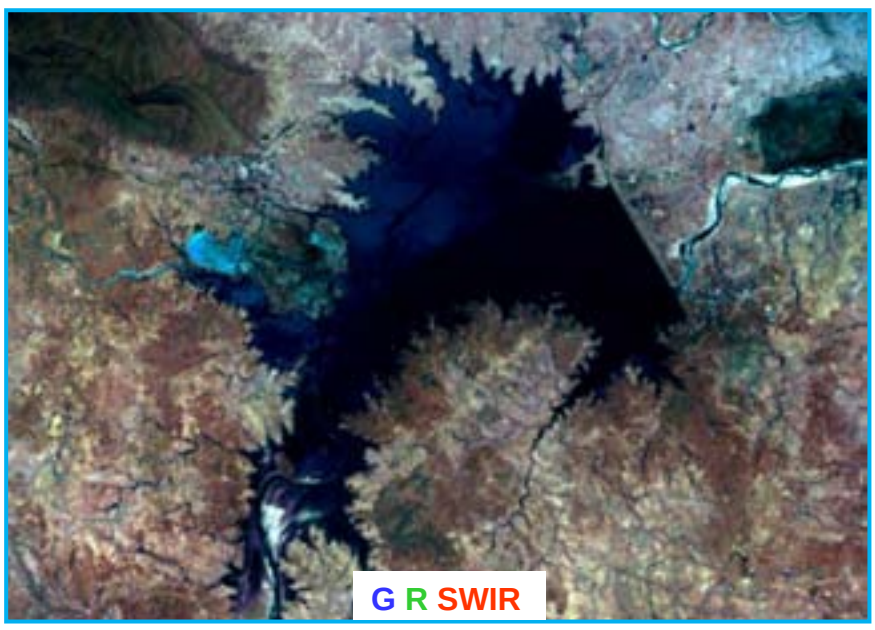


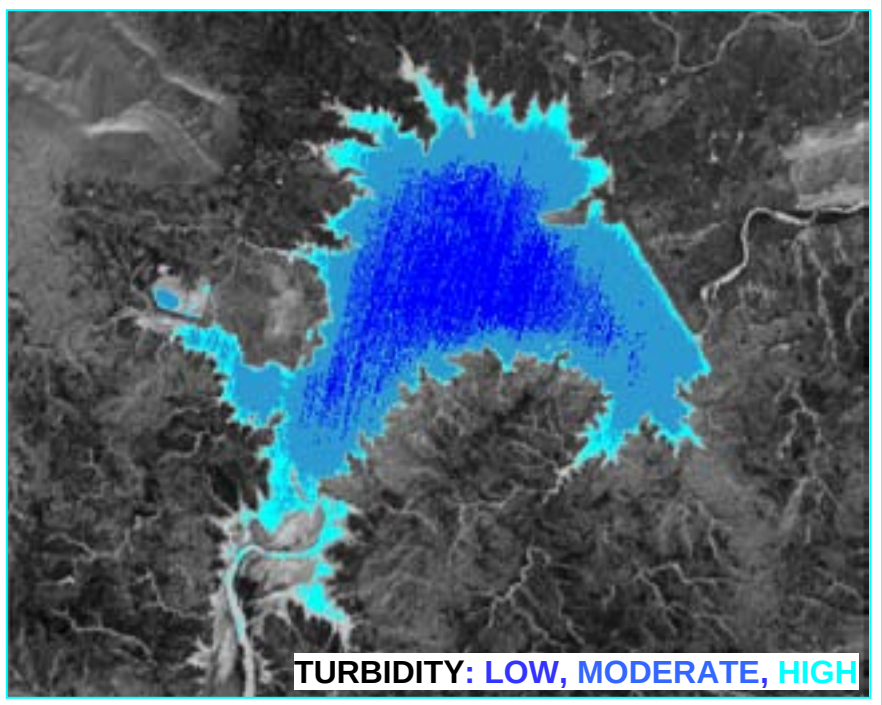


Useful for wetland boundary extraction/delineation



Useful for wetland vegetation & open water features





MNDWI is useful for qualitative turbidity delineation

Tenughat Reservoir
IRS LISS III data, 18 December 2006

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

MAPS AND STATISTICS

7.0 WETLANDS OF JHARKHAND: MAPS AND STATISTICS

Area estimates of various wetland categories for Jharkhand have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. In the state of Jharkhand 2463 wetlands have been delineated. In addition 13227 wetlands smaller than 2.25 ha have also been discerned. Total wetland area estimated is 170051 ha (Table 4), which accounts for about 2.1 % of geographical area of Jharkhand. The major wetland types are River/Stream (97743 ha), Reservoirs (48177 ha), Tanks/Ponds (5688 ha), Lakes (3204 ha), Riverine wetlands (1629 ha), Waterlogged-Natural (231 ha), Ox-bow Lakes (83 ha), Waterlogged-Man-Made (61 ha) and Aquaculture Ponds (8 ha)**.** There is a significant reduction (about 32 %) in the open water from 152879 in post-monsoon to 103225 ha in pre-monsoon. Wetlands in Jharkhand mostly indicate moderate turbidity (88410 ha) in post-monsoon and 64127 ha in pre-monsoon season. Extent of wetlands showing low turbidity is 21014 ha and 12147 ha in post monsoon and pre-monsoon season respectively. Turbidity in pre-monsoon season also followed a similar pattern with decreased area owing to the reduction in open water extent. Area under aquatic vegetation in pre-monsoon season is 7244 ha which is more than double that of post-monsoon season indicating submergence or reduction in growth of aquatic vegetation during post-monsoon season.

Table 4: Area estimates of wetlands in Jarkhand

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	16	3204	1.88	1343	385
2	1102	Ox-bow lakes/ Cut-off meanders	18	83	0.05	71	70
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	42	1629	0.96	781	552
5	1105	Waterlogged	58	231	0.14	231	16
6	1106	River/Stream	344	97743	57.48	97743	63442
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	1062	48177	28.33	47386	34476
8	1202	Tanks/Ponds	910	5688	3.34	5266	4241
9	1203	Waterlogged	11	61	0.04	50	35
10	1204	Salt pans	2	8	0.00	8	8
		Sub-Total	**2463**	**156824**	**92.22**	**152879**	**103225**
		Wetlands (<2.25 ha)	13227	13227	7.78	-	-
		Total	**15690**	**170051**	**100.00**	**152879**	**103225**

Area under Aquatic Vegetation	3437	7244

Area under turbidity levels		
Low	21014	12774
Moderate	88410	64127
High	43455	26324

7.1 DISTRICT-WISE WETLAND MAPS AND STATISTICS

The state has 18 districts. Pashchimi Sighbhum district ranks first in terms of area (18939 ha) followed by Sahibganj (16118 ha) and others. In terms of per cent area under wetlands of total wetland extent, Pashchimi Sighbhum also ranks first (11 %). Interestingly, 50 % of the wetland area is concentrated in five districts i.e. Ranchi (9 %), Dumka (9 %), Palamu (10 %), Sahibganj (9 %) and Pashchimi Sighbhum (11 %) and rest of the wetlands are distributed in the remaining 13 districts. In terms of per cent area of wetlands of the geographical area of the districts, the wetlands account for about 2.1 %. Jharkhand state has shown a significant reduction in the extent of open water from post-monsoon (152879 ha) to pre-monsoon (103225 ha), which amounts to approximately 35 %. Minimum seasonal variation (11 %) in open water extent is observed in Sahibganj district while maximum in Lohardaga (69 %). On an average the state has shown a decrease of 35 % of open water extent. District-wise wetland area estimates is given in table-5 as well as graphically represented in figure 11. Type-wise wetland distribution in Jharkhand is shown in figure 10.

Table-5: District-wise wetland area

Sr. No.	District	Total Geographical area (Sq. km)	Wetland area (ha)	% of wetland area	% of geographical area	Open Water	
						Post-monsoon (2006)	Pre-monsoon (2007)
1	Garhwa	4044	9362	6	0.12	9052	5073
2	Palamu	8705	16348	10	0.21	14948	7781
3	Chatra	3706	5253	3	0.07	4751	2117
4	Hazaribagh	6147	11307	7	0.14	10635	5896
5	Kodarma	1312	3160	2	0.04	2971	1382
6	Giridih	4975	7845	5	0.10	7021	3839
7	Deoghar	2479	4046	2	0.05	3661	3008
8	Godda	2110	2445	1	0.03	2028	1475
9	Sahibganj	1599	16118	9	0.20	12979	11504
10	Pakur	1806	2734	2	0.03	2047	1463
11	Dumka	6212	15824	9	0.20	14939	11659
12	Dhanbad	2052	9438	6	0.12	8296	6108
13	Bokaro	2861	11222	7	0.14	9800	8621
14	Ranchi	7698	14728	9	0.18	13709	10165
15	Lohardaga	1491	2110	1	0.03	1809	568
16	Gumla	9077	12423	7	0.16	11729	6147
17	Pashchimi Singhbhum	9907	18939	11	0.24	16732	12354
18	Purbi Singhbhum	3533	6749	4	0.08	5772	4065
	Total	**79714**	**170051**	**100**	**2.13**	**152879**	**103225**

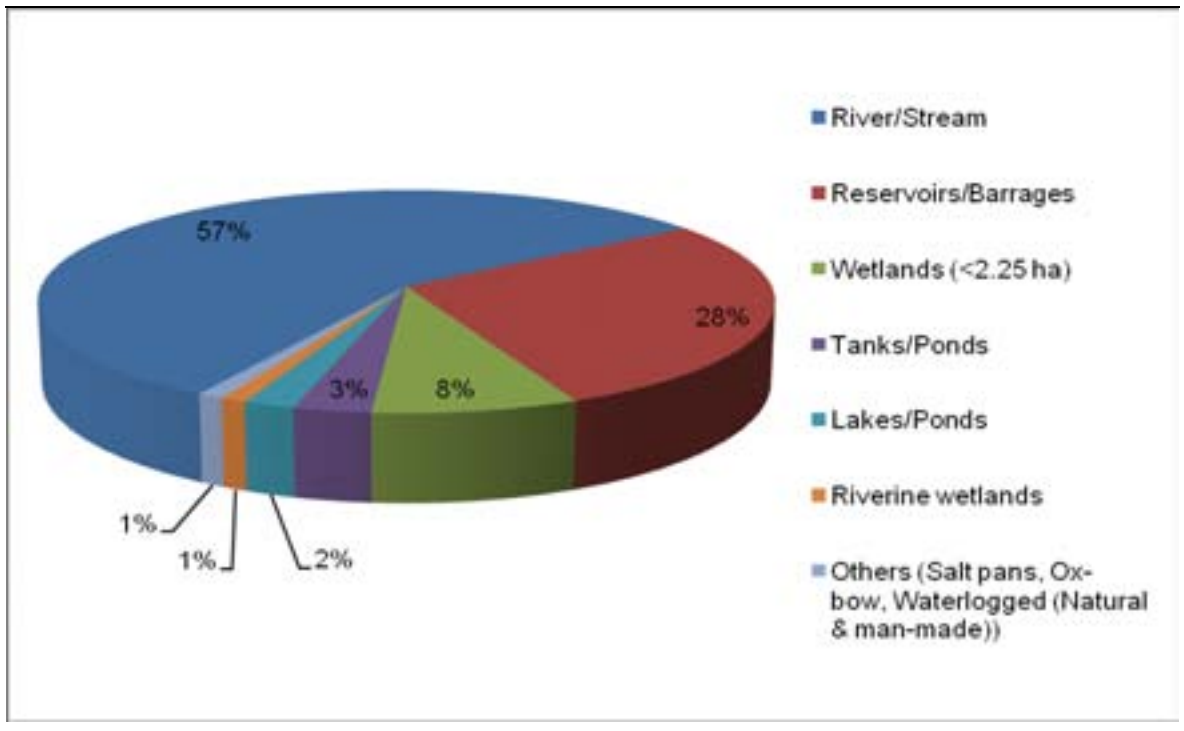


Figure 10: Type-wise wetland distribution in Jharkhand

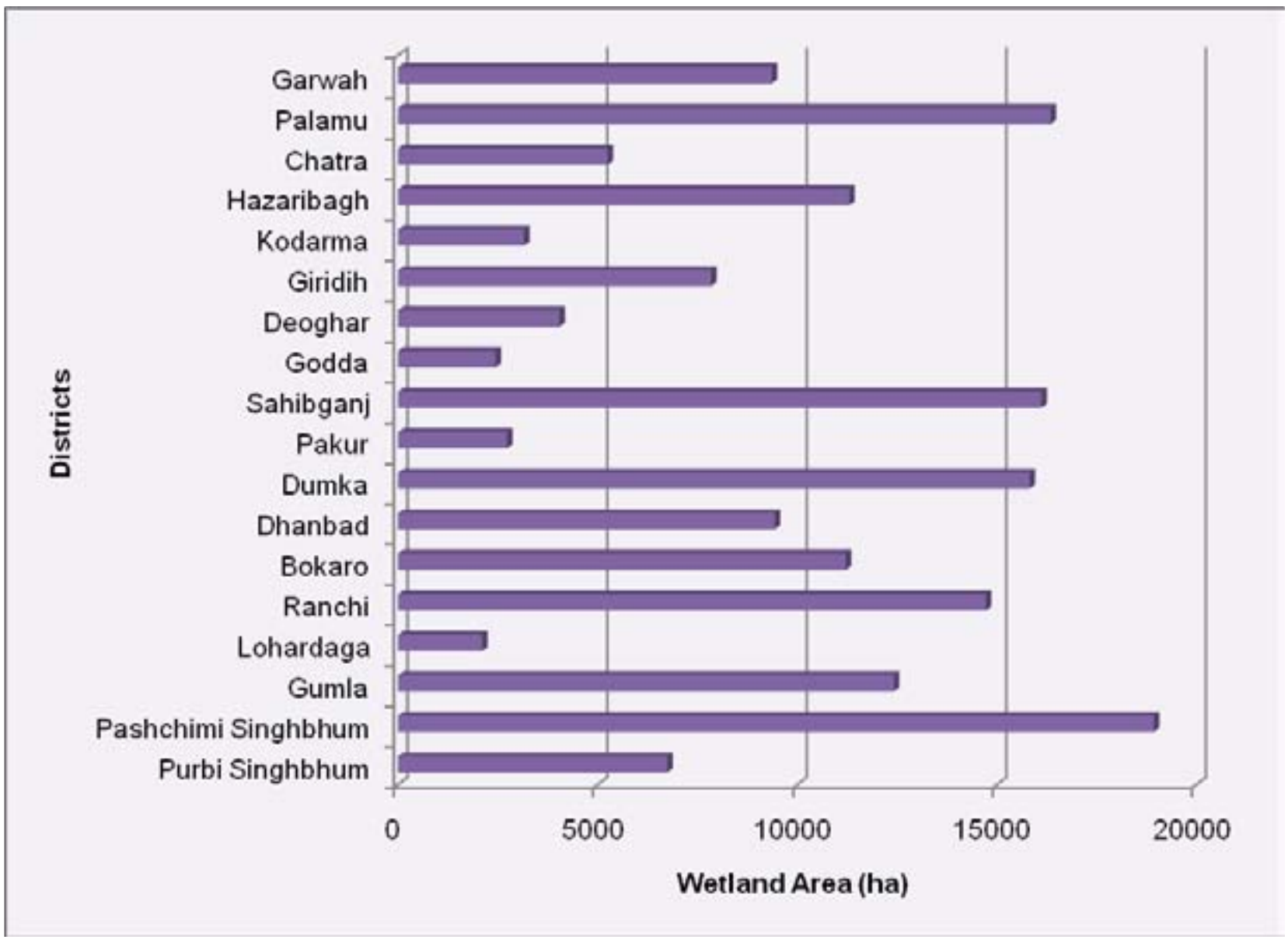
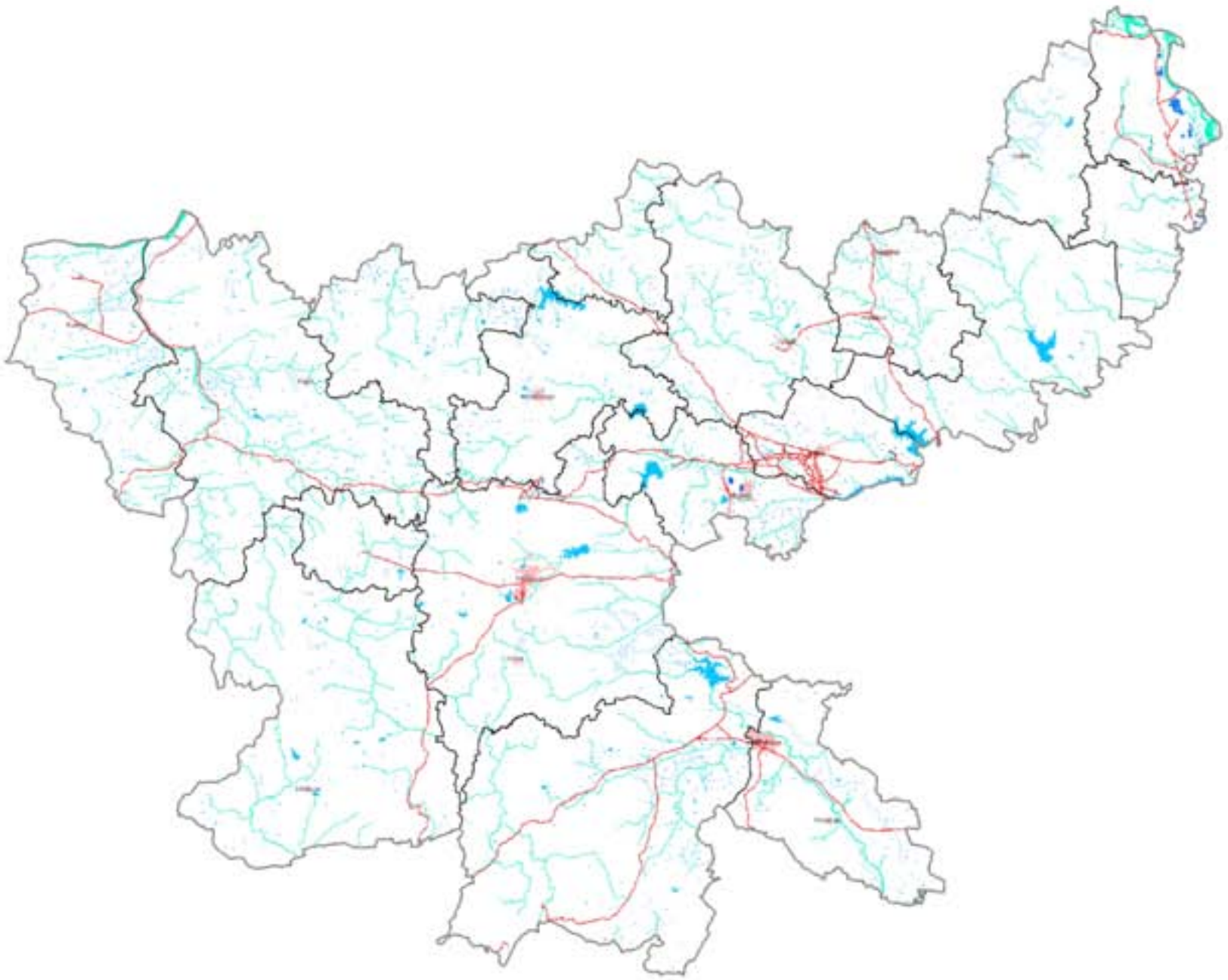


Figure 11: District-wise graphical distribution of wetlands Jharkhand

State : Jharkhand

WETLAND MAP

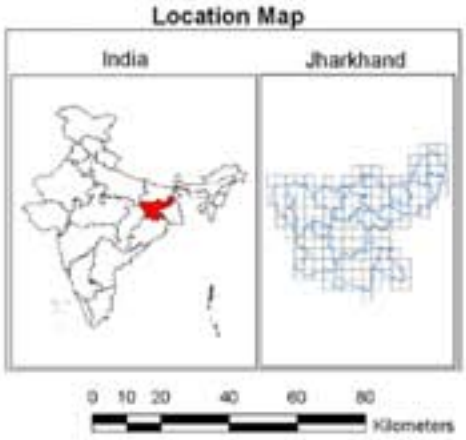


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

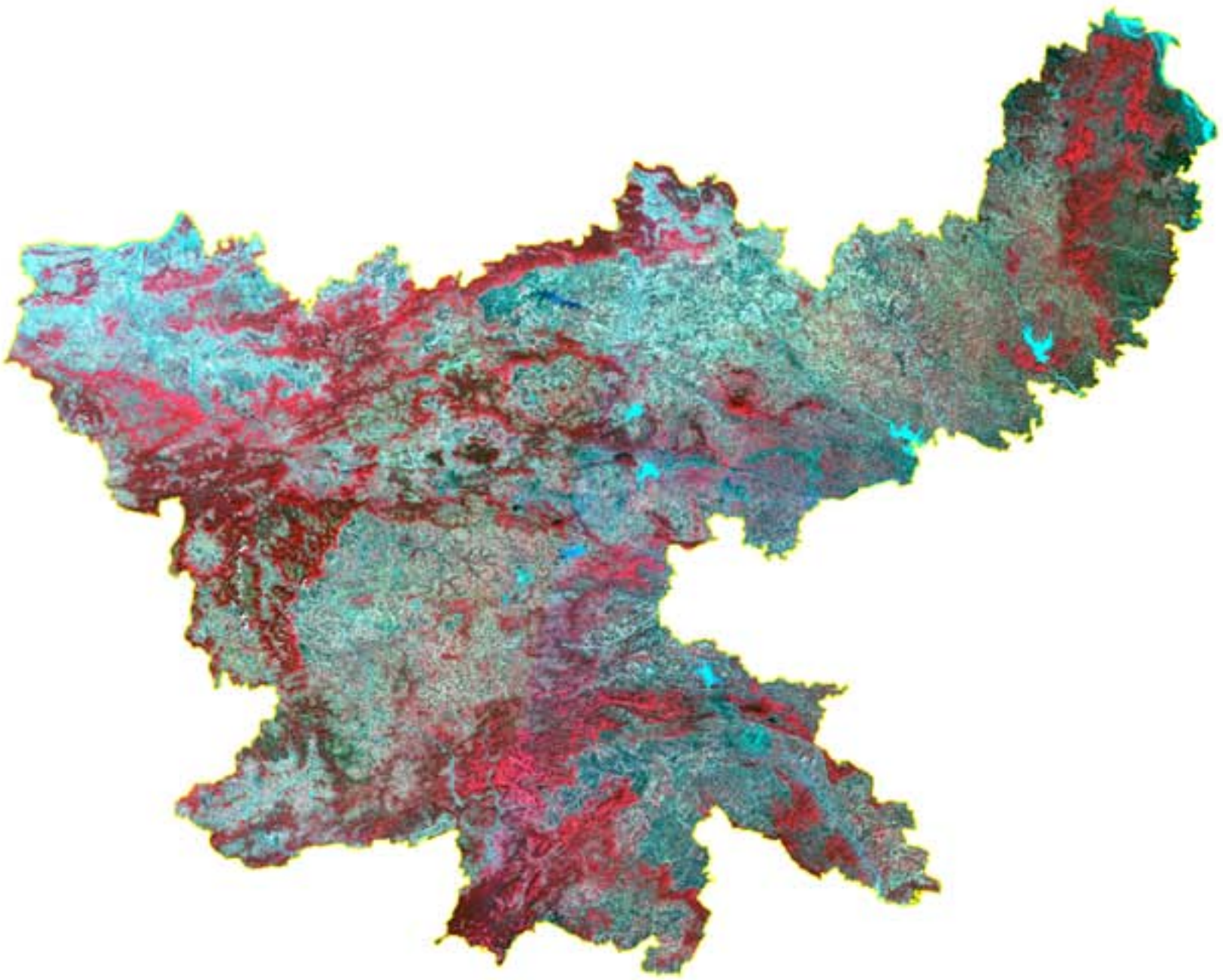
and

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

Ministry of Environment and Forests
Government of India

State : Jharkhand



IRS P6 AWiFS post-monsoon data (2004)

7.1.1 Garhwa

The total geographical area of Garhwa district is 4,044 Sq. km. There are 226 wetlands in Garwah district in addition to 287 which are smaller than 2.25 ha (Table 6). The wetland area estimated is 9362 Major wetland types are River/Stream (7378ha) followed by Reservoir/Barrage (1416 ha) accounting for about 79 and 15 per cent respectively. Rest of the wetland area comprises of waterlogged (natural as well as man-made) and Tank/Pond. Aquatic vegetation is insignificant comprising 23 ha out of 9078 ha in post-monsoon. It had shown an increase to 99 ha during the pre-monsoon. There is drastic reduction (56 %) in open water extent in post-monsoon season (9055 ha) compared to pre-monsoon (5072 ha). It is reflected in all the wetland categories as evident from the table 6. High turbidity (4507 ha) dominated the open water followed by moderate (4050 ha) and low (495 ha) in Garwah district in post-monsoon. It reflects the unsettled sediment being transported during monsoon. However, moderated turbidity (4099 ha) dominated the pre-monsoon while low and high turbidity has drastically reduced owing to the reduction in open water extent as well as gradual settling of sediment. Details are given in Table 6.

Table 6: Area estimates of wetlands in Garhwa district

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	44	183	1.95	183	3
6	1106	River/Stream	40	7378	78.81	7378	4471
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	129	1416	15.12	1402	552
8	1202	Tanks/Ponds	10	80	0.85	71	43
9	1203	Waterlogged	3	18	0.19	18	4
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**226**	**9075**	**96.93**	**9052**	**5073**
		Wetlands (<2.25 ha), mainly Tanks	287	287	3.07	-	-
		Total	**513**	**9362**	**100.00**	**9052**	**5073**

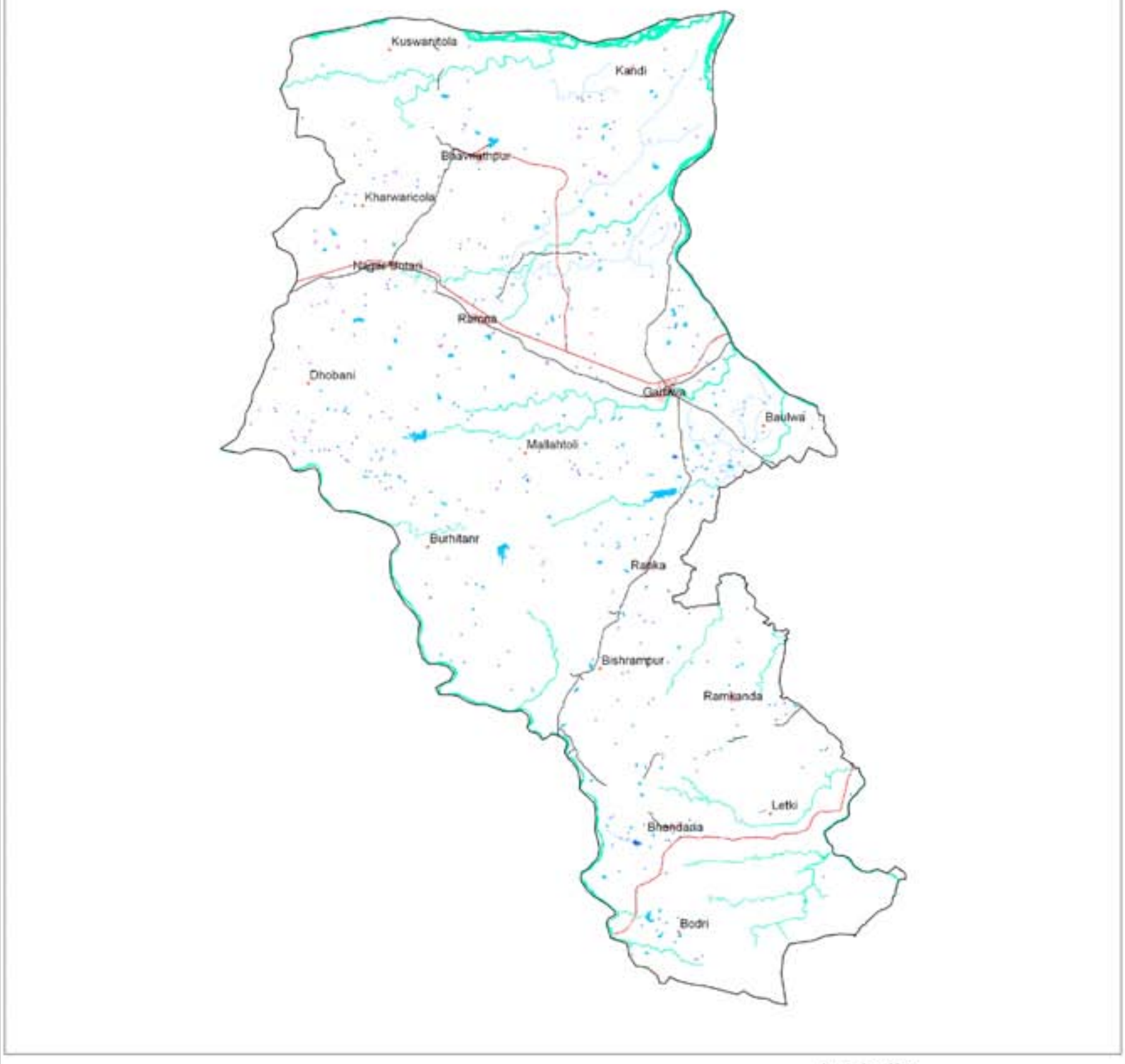
Area under Aquatic Vegetation	23	99

Area under turbidity levels		
Low	495	157
Moderate	4050	4099
High	4507	817

State : Jharkhand

WETLAND MAP

District : Garhwa

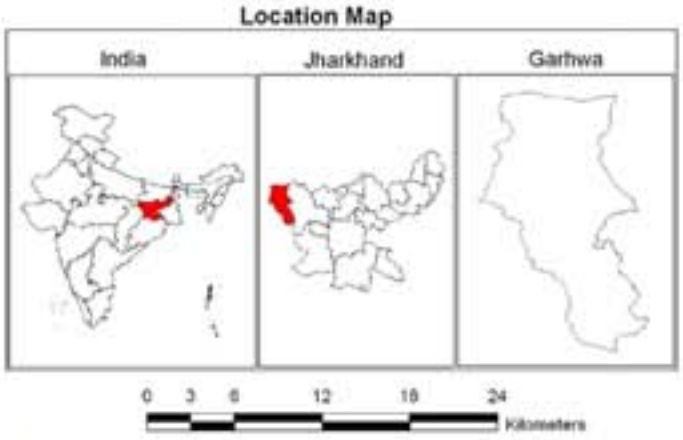


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

Ministry of Environment and Forests
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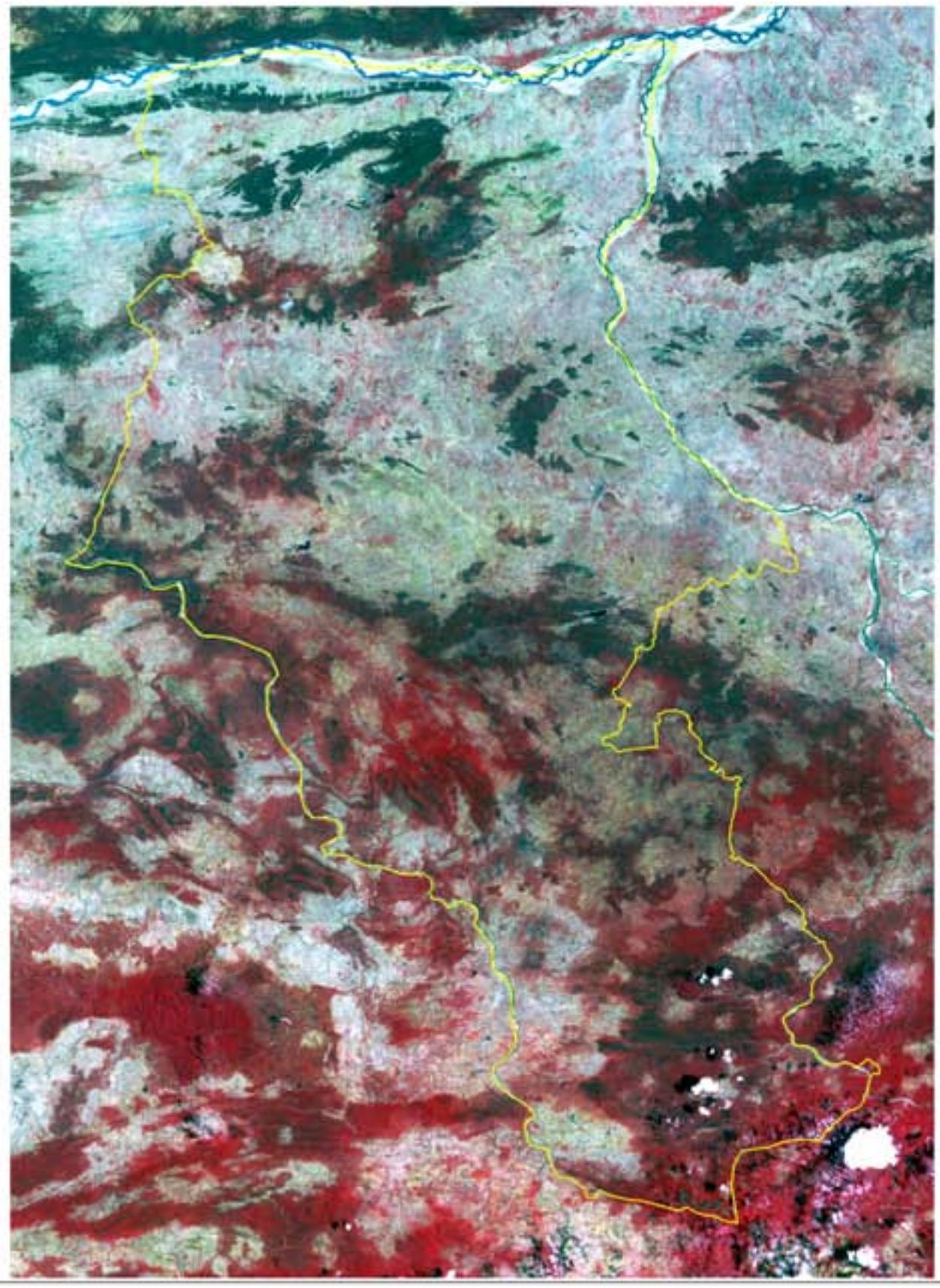


IRS P6 LISS-III post monsoon data (2006)

7.1.2 Palamu

The total geographical area of Palamu district is 8705 Sq. km. The wetland area estimated is 16348 ha which accounts for about 0.2 % of the geographical area of the district. River/Stream is the most dominant wetland type (12655 ha) comprising about 77 % of wetland area (table 7). Reservoir/Barrage (2095 ha) stands next comprising about 13 % of wetland area. Other categories like tank/Pond, Waterlogged areas and are insignificant in extent. It is important to mention that wetlands < 2.25 are significant in number (1359) and contribute about 8 % to wetland area (assumed to be each wetland as one ha). The open water extent has shown about 52 % reduction from post-monsoon (14948 ha) to pre-monsoon (7781 ha). Aquatic vegetation has an increase from 45 ha in post-monsoon to 76 ha in pre-monsoon. Qualitative turbidity remained dominantly moderate (8016 ha) followed by high (6551 ha) and low (381 ha) in post-monsoon season while similar trend is observed in pre-monsoon season also with decreased area in all the three turbidity levels *viz.* low, moderate and high as 268 ha, 5556 ha and 1957 ha respectively. Details are given in Table 7.

Table 7: Area estimates of wetlands in Palamu District

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	1	4	0.02	0	0
5	1105	Waterlogged	6	18	0.11	18	2
6	1106	River/Stream	47	12655	77.41	12655	6727
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	218	2095	12.82	2062	884
8	1202	Tanks/Ponds	38	209	1.28	209	165
9	1203	Waterlogged	2	8	0.05	4	3
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**312**	**14989**	**91.69**	**14948**	**7781**
		Wetlands (<2.25 ha), mainly Tanks	1359	1359	8.31	-	-
		Total	**1671**	**16348**	**100.00**	**14948**	**7781**

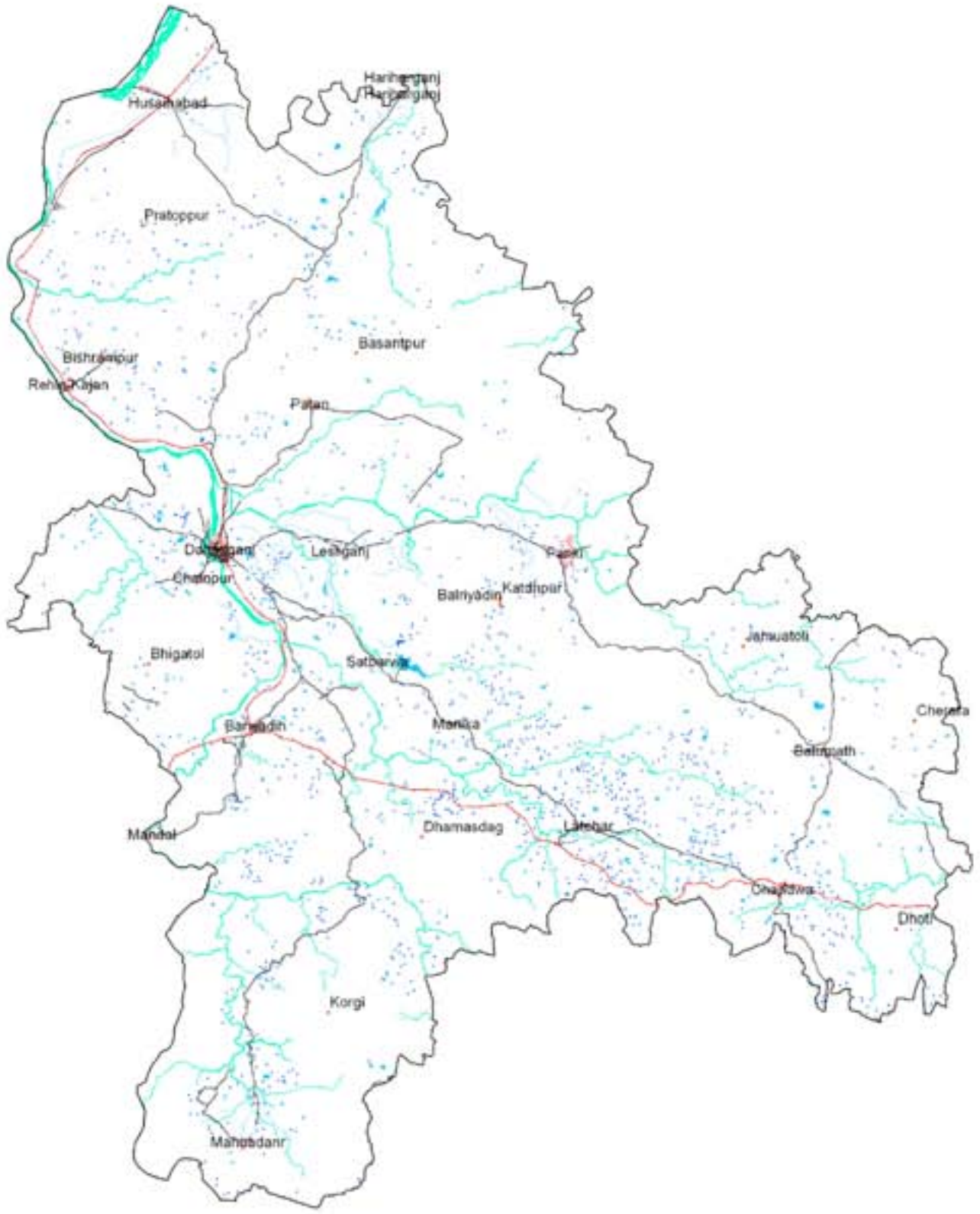
Area under Aquatic Vegetation	45	76

Area under turbidity levels		
Low	381	268
Moderate	8016	5556
High	6551	1957

State : Jharkhand

WETLAND MAP

District : Palamu

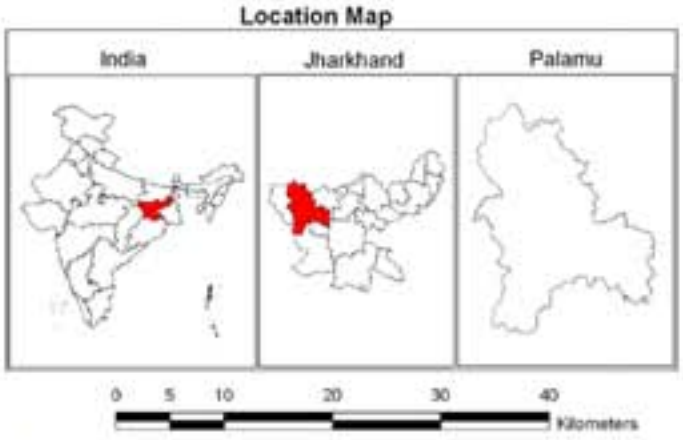


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

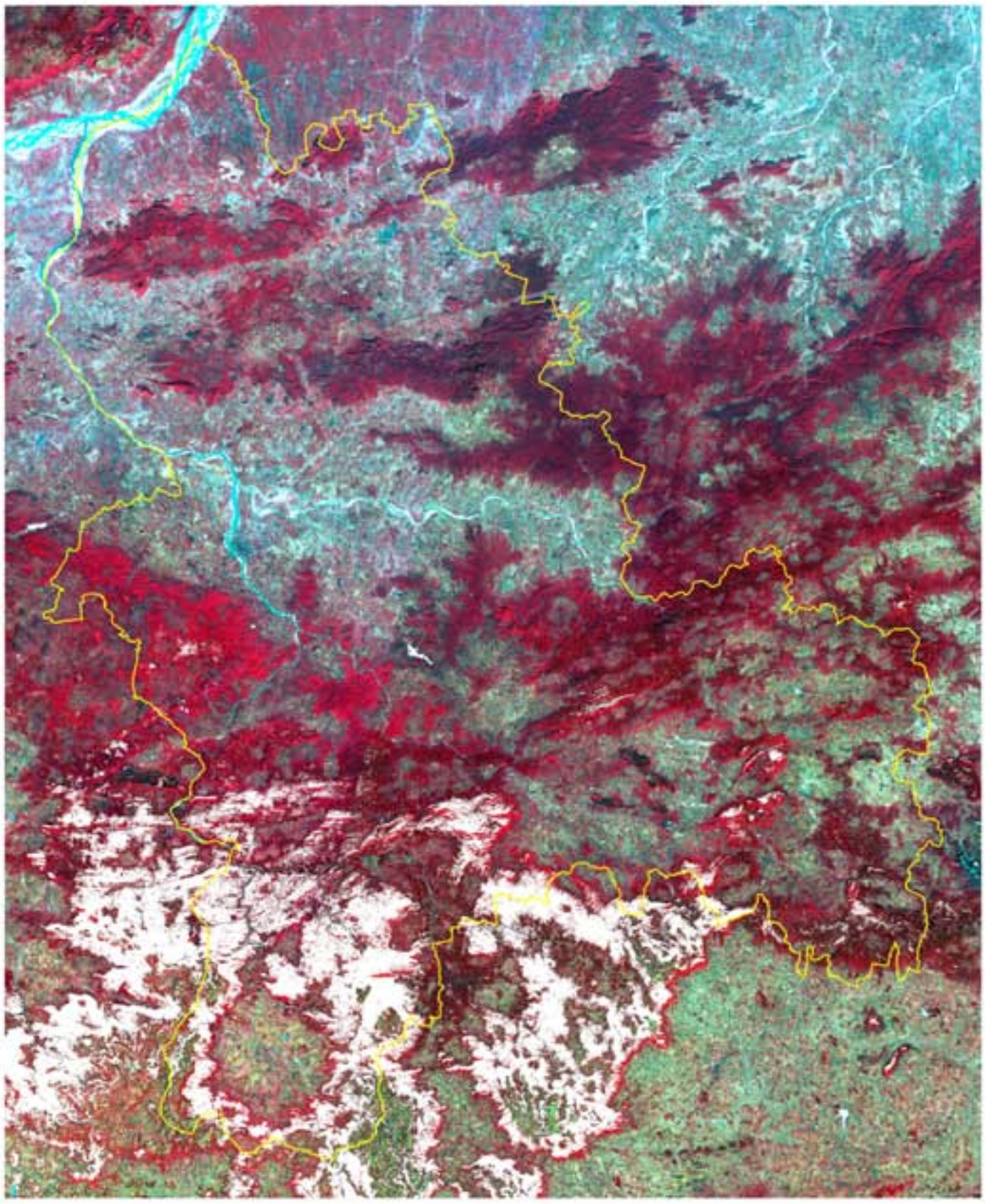
Space Applications Centre (ISRO), Ahmedabad

and

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

Ministry of Environment and Forests
Government of India



IRS P6 LISS-III post monsoon data (2006)

7.1.3 Chatra

The total geographical area of Chatra district is 3,706 Sq. km. The wetland area estimated is 5253 ha comprising 179 wetlands > 2.25 ha and an additional 464 smaller wetlands (<2.25 ha). Like Plamu, this district is also wetland types are dominated by the River/Stream (3535 ha) and Reservoir/Barrage (854 ha) accounting for about 67 and 16 per cent area under wetlands. The next significant wetland type is Tank/Pond with 376 ha comprised of 70 numbers. There is drastic more than fifty per cent reduction in open water extent of 4751 ha in post-monsoon to 2117 ha in pre-monsoon. Aquatic vegetation has shown a marginal increase of 8 ha from 46 ha in post-monsoon to 54 ha in pre-monsoon. Qualitative turbidity is significantly remained moderate (3001) out of 4751 ha of open water extent in post-monsoon followed by high (1608 ha) and low (142 ha). Low turbidity has not been in observed in pre-monsoon season and moderate and high turbidity comprised 1366 ha and 751 ha out of 2117 ha of open water extent. Details are given in Table 8.

Table 8: Area estimates of wetlands in Chatra

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	20	0.38	20	-
6	1106	River/Stream	21	3535	67.29	3535	1657
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	81	854	16.26	820	291
8	1202	Tanks/Ponds	70	376	7.16	376	157
9	1203	Waterlogged	1	4	0.08	-	12
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**179**	**4789**	**91.17**	**4751**	**2117**
		Wetlands (<2.25 ha), mainly Tanks	464	464	8.83	-	-
		Total	**643**	**5253**	**100.00**	**4751**	**2117**

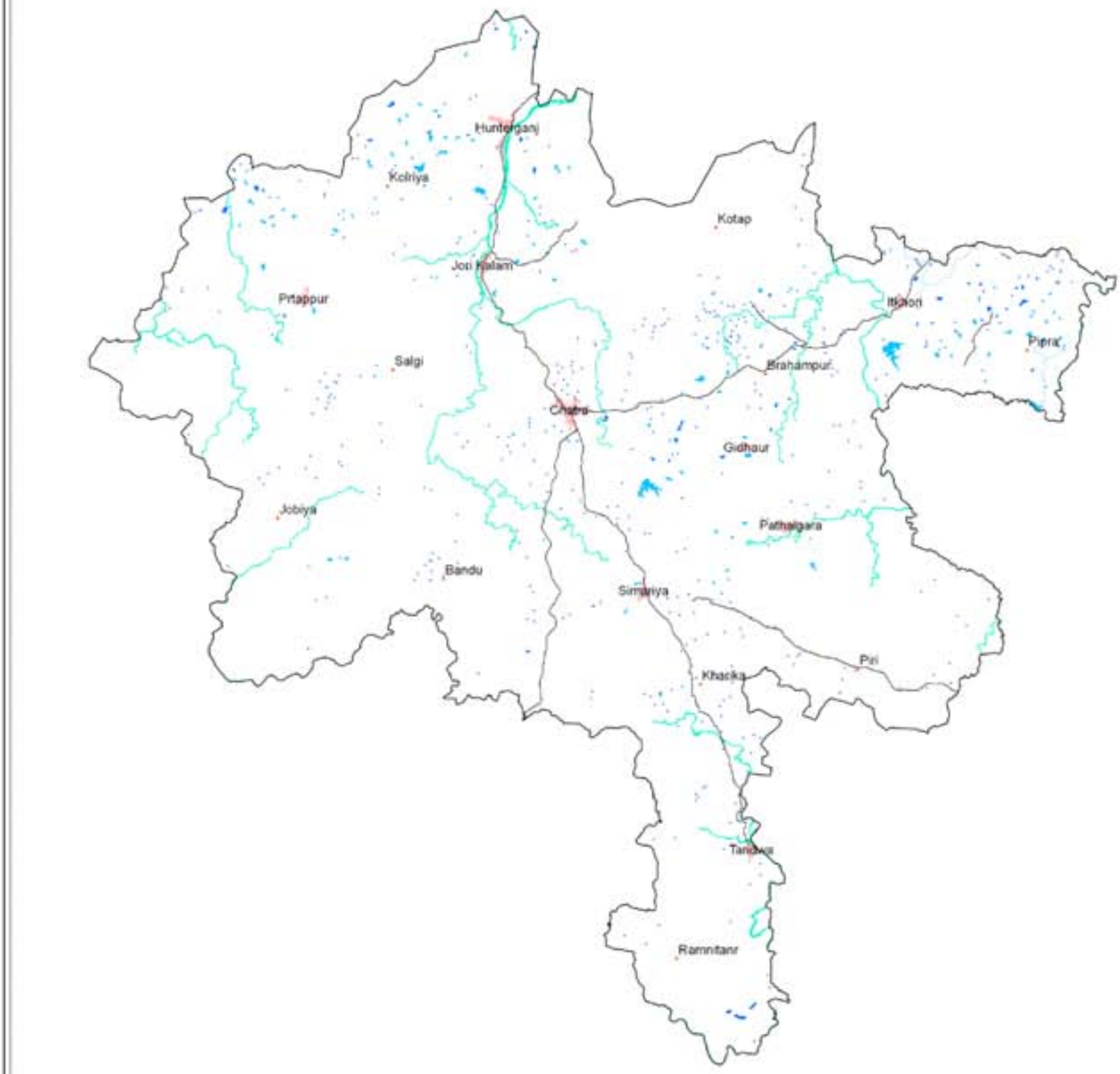
Area under Aquatic Vegetation	46	54

Area under turbidity levels		
Low	142	-
Moderate	3001	1366
High	1608	751

State : Jharkhand

WETLAND MAP

District : Chatra

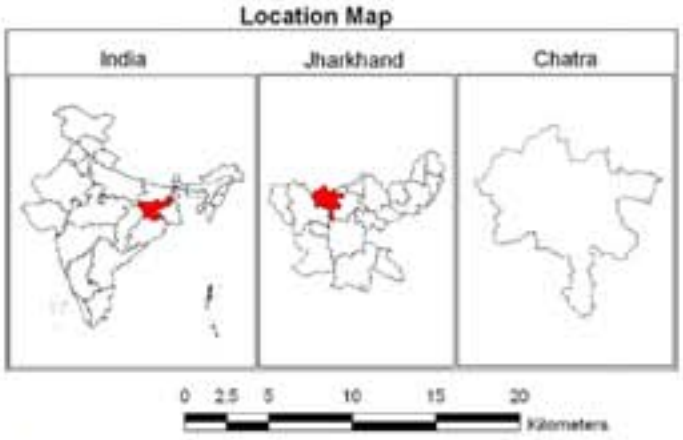


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

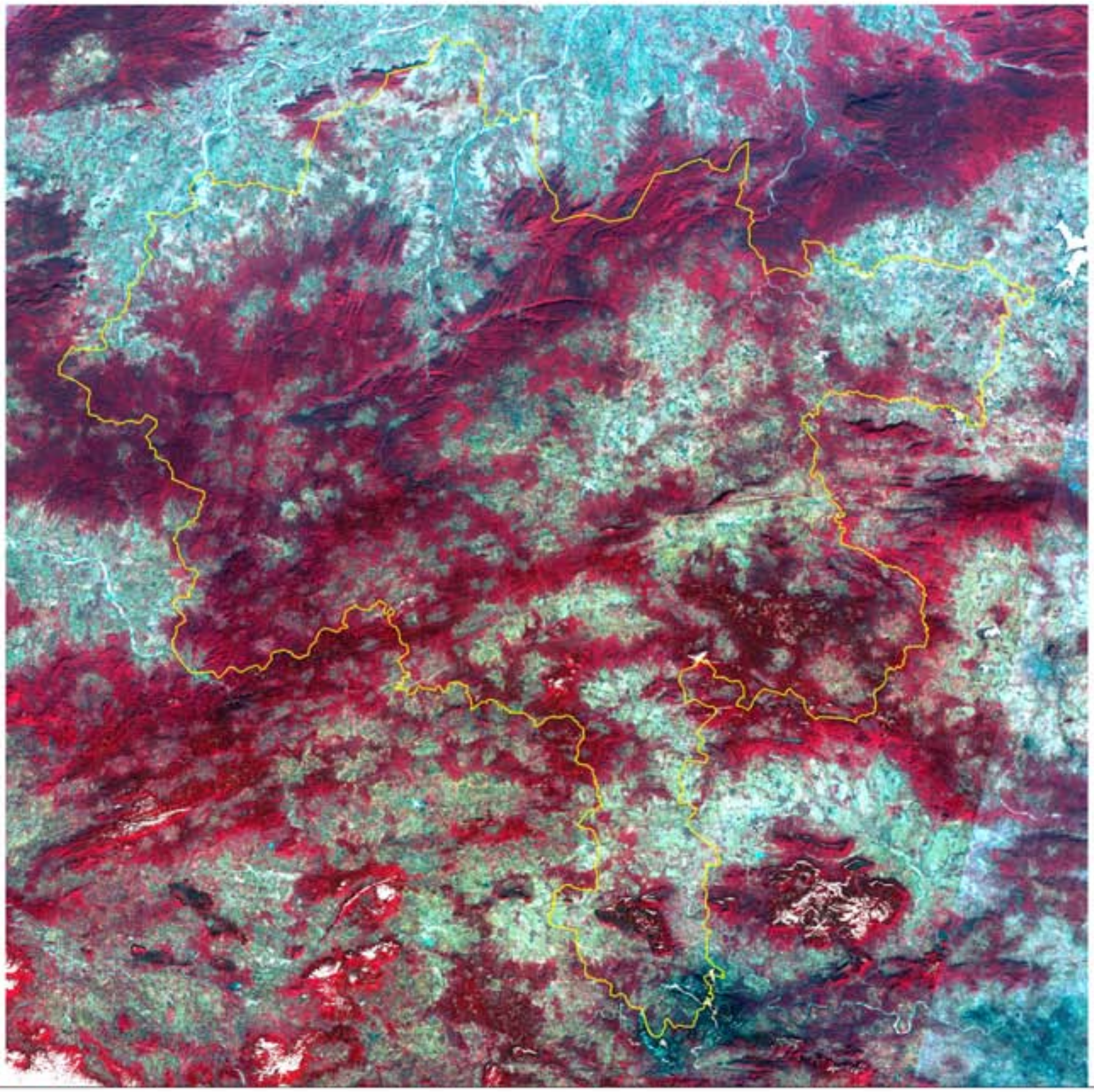
Space Applications Centre (ISRO), Ahmedabad

and

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

Ministry of Environment and Forests
Government of India



IRS P6 LISS-III post monsoon data (2006)

7.1.4 Hazaribagh

The total geographical area of Hazaribagh district is 6,147 Sq. km. The district comprises a sum of 770 wetlands out of which 181 are mapped as > 2.25 ha while 589 are < 2.25. These wetlands occupy an area of 11307 ha. Reservoir/Barrage (6571 ha) is observed to be a dominant type comprising about 58 per cent of wetland extent. The other dominant wetland type is represented by River/Stream (3780 ha), which accounts for about 33 per cent of area (Table 9). Even though the number of Tank/Pond (62) is significant, the contribution towards aerial extent is only about 3 per cent. The smaller wetlands (<2.25 ha) seems to be important, which contribute about 5 per cent of total wetland area in the district. The seasonal fluctuation is about 55 per cent and is reflected in all the wetland categories. Unlike Garwah and Palamu, the aquatic vegetation has shown a marginal decrease from post-monsoon (76 ha) to pre-monsoon (68 ha). Turbidity is dominated by moderate (4241 ha) and low (4171 ha) followed by high (2223 ha) in post-monsoon. However, in pre-monsoon the moderate turbidity (4287 ha) has dominated compared to low (466 ha) and high (1143 ha). Details are given in Table 9.

Table 9: Area estimates of wetlands in Hazaribagh

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	1	3	0.03	3	3
5	1105	Waterlogged	1	4	0.04	4	11
6	1106	River/Stream	19	3780	33.43	3780	1831
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	98	6571	58.11	6502	3792
8	1202	Tanks/Ponds	62	360	3.18	346	259
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**181**	**10718**	**94.79**	**10635**	**5896**
		Wetlands (<2.25 ha), mainly Tanks	589	589	5.21	-	-
		Total	**770**	**11307**	**100.00**	**10635**	**5896**

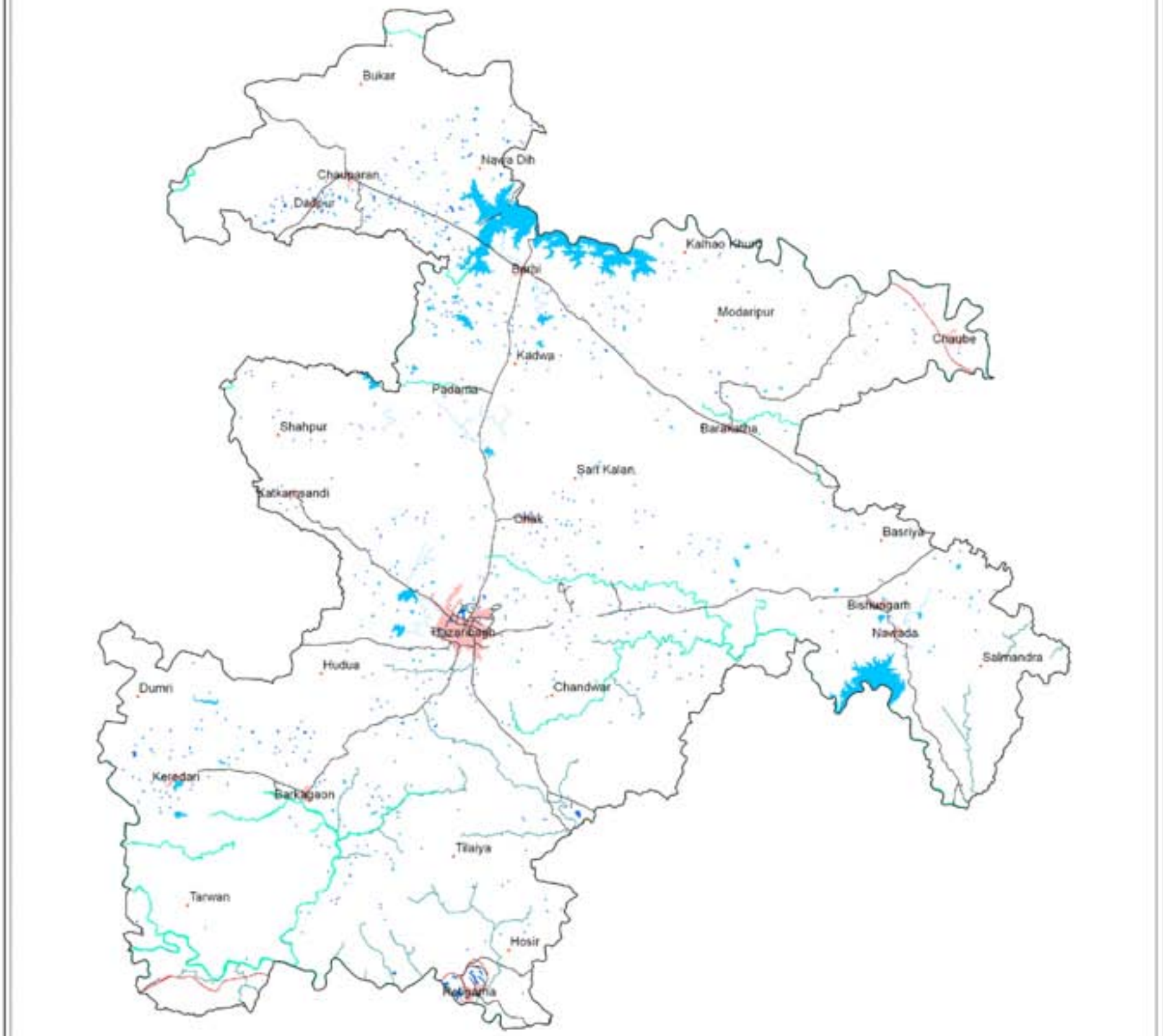
Area under Aquatic Vegetation	76	68

Area under turbidity levels		
Low	4171	466
Moderate	4241	4287
High	2223	1143

State : Jharkhand

WETLAND MAP

District : Hazaribagh

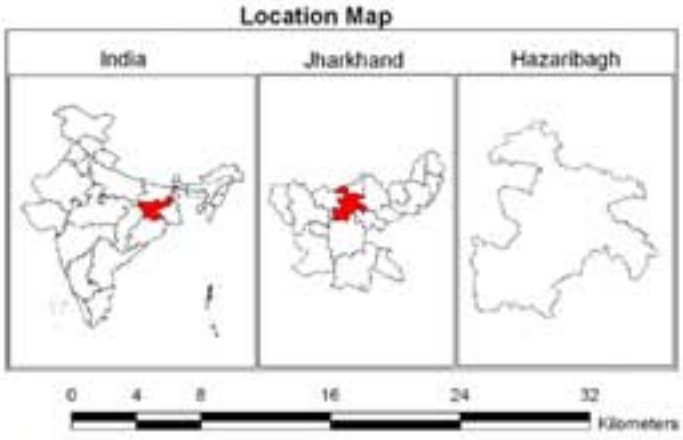


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Sponsored By :

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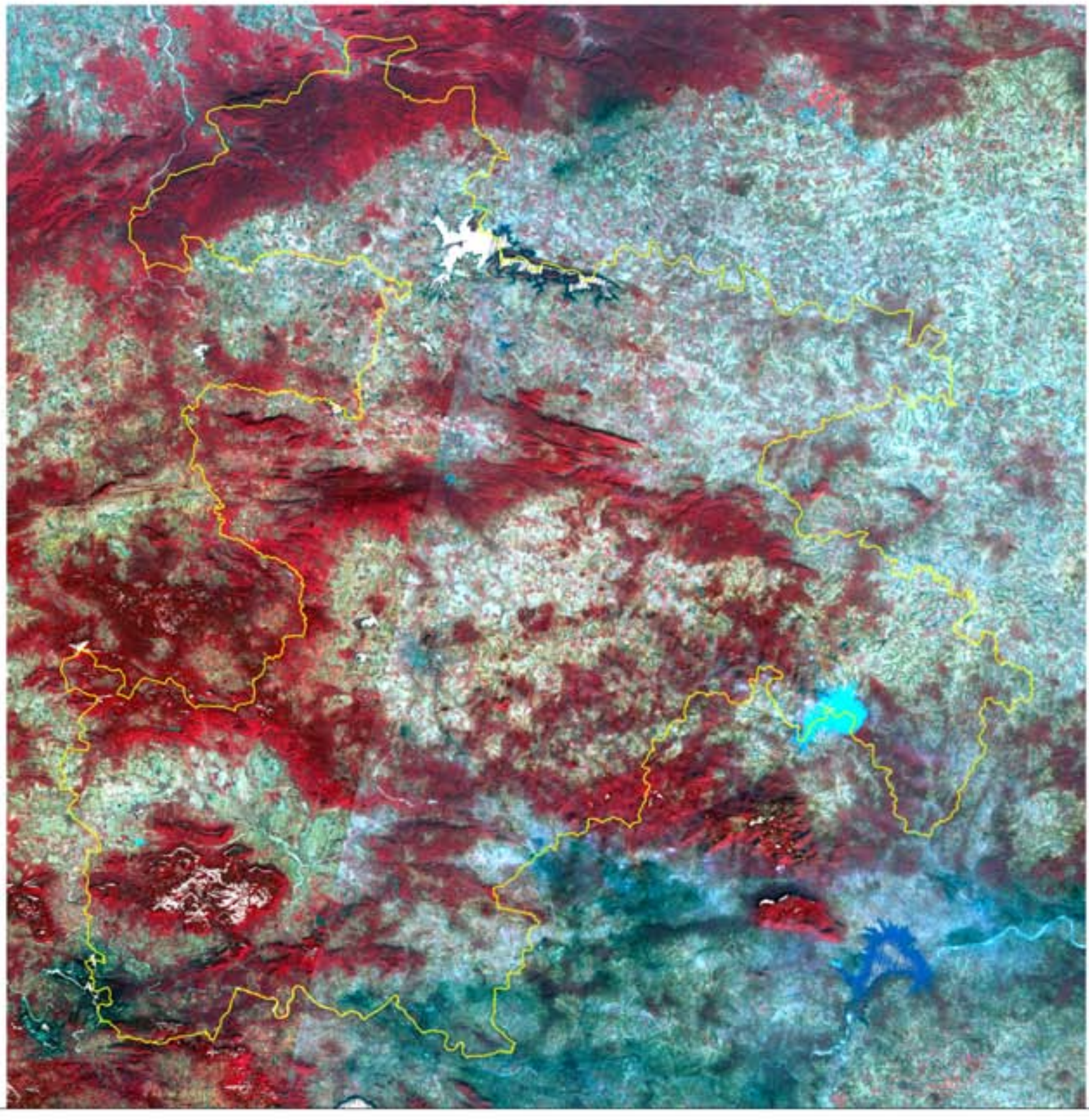


IRS P6 LISS-III post monsoon data (2006)

7.1.5 Kodarma

The total geographical area of Kodarma district is 1,312 Sq. km. The wetland area is estimated to be 3160 ha comprising comparatively fewer wetlands (50) of > 2.25 ha and 189 wetlands of < 2.25 ha size. About 63 per cent under wetland extent is accounted by River/Stream (1995 ha) followed by 28 Reservoir/Barrage with 902 ha of aerial extent. Tank/Pond forms a meager 2.18 per cent of wetland area and waterlogged area constitutes a fraction of one per cent. Details are given in Table 10. The seasonal fluctuation is drastic (63 %) in open water extent from 2971 ha in post-monsoon to 1382 ha in pre-monsoon season. Aquatic vegetation is observed only in pre-monsoon season. Open water is dominated by moderate turbidity (1576 ha) followed by low (759 ha) and high (636 ha) in post-monsoon while in pre-monsoon the open water remained moderately turbid completely.

Table 10: Area estimates of wetlands in Kodarma

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	8	1995	63.13	1995	647
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	28	902	28.54	902	666
8	1202	Tanks/Ponds	13	69	2.18	69	64
9	1203	Waterlogged	1	5	0.16	5	5
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**50**	**2971**	**94.02**	**2971**	**1382**
		Wetlands (<2.25 ha), mainly Tanks	189	189	5.98	-	-
		Total	**239**	**3160**	**100.00**	**2971**	**1382**

Area under Aquatic Vegetation	-	19

Area under turbidity levels		
Low	759	-
Moderate	1576	1382
High	636	-

State : Jharkhand

WETLAND MAP

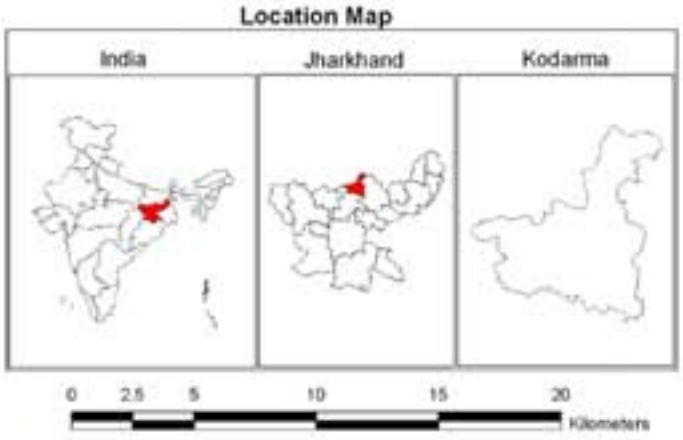
District : Kodarma

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

Legend

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

Location Map



Data Source :

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

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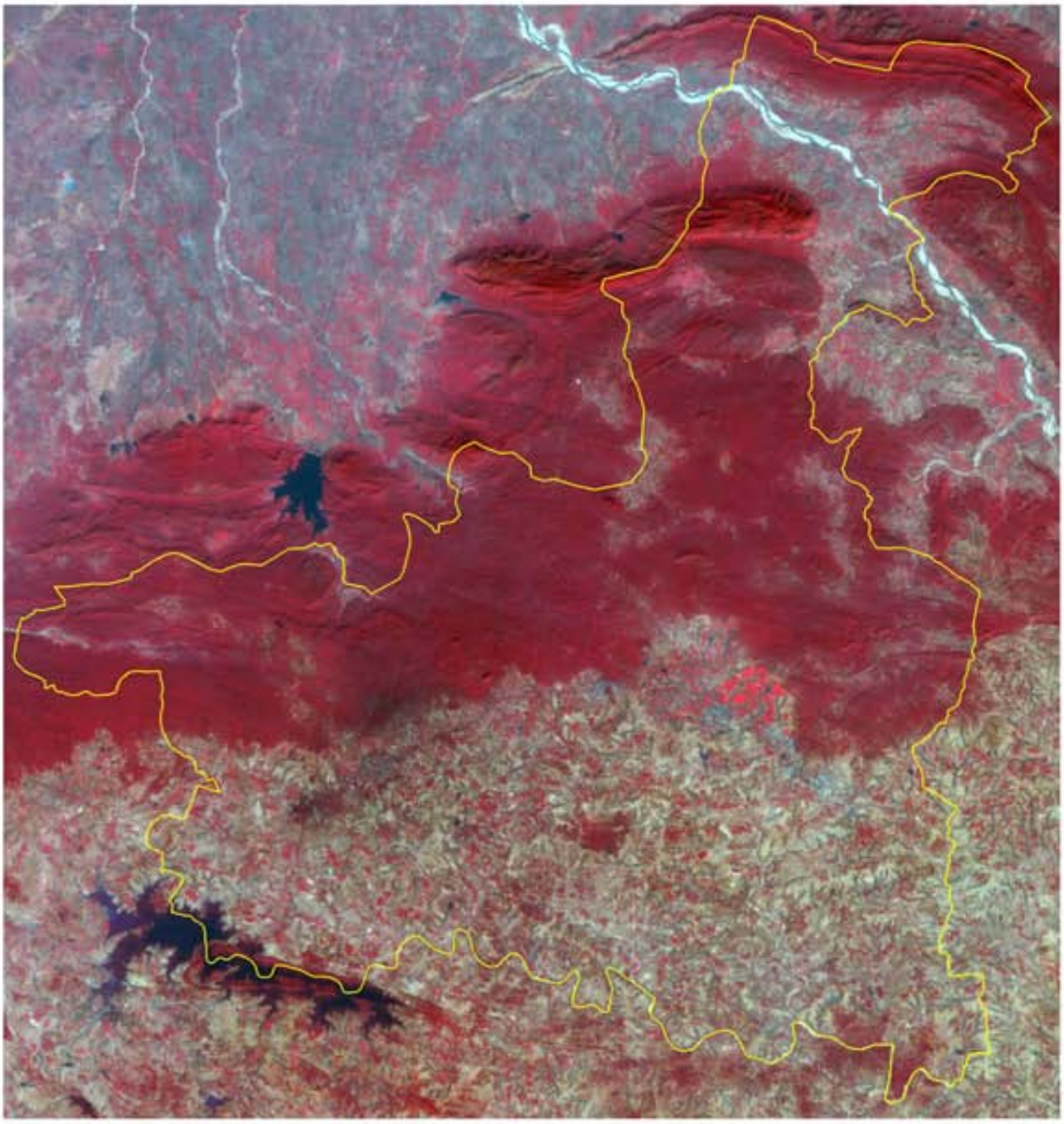


IRS P6 LISS-III post monsoon data (2006)

7.1.6 Giridih

The total geographical area of Giridih district is 4,975 Sq. km. This district comprises of 7845 ha area under wetlands. The extent of these wetlands constitute 151 wetlands of > 2.25 ha and a significant 764 < smaller wetlands. River ranks first in extent (6217 ha) that accounts for about 80 per cent of wetland extent (Table 11). The reservoir/barrage and Tank/Pond constitute about 10 per cent and rest of 10 % is contributed by smaller wetlands. Open water has shown a reduction of 55 per cent from post-monsoon (7021 ha) to 3839 ha in pre-monsoon. It is mainly due to rain-fed seasonal river/stream which has shown a massive reduction while the other wetlands have not shown such drastic reduction. Aquatic vegetation has shown an increase in extent from post-monsoon (55 ha) to 75 ha in pre-monsoon. Open water remained predominantly moderate in turbidity in both post-monsoon as well as pre-monsoon seasons (5071 ha and 3186 ha respectively). Out of 7021 ha of open water extent in post-monsoon, 1950 ha is observed to be under highly turbid while in pre-monsoon it was 653 ha out 3839 ha of open water extent. Low turbidity has not been exhibited in any of the wetlands.

Table 11: Area estimates of wetlands in Giridih

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	2	21	0.27	15	8
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	24	6217	79.25	6217	3179
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	80	657	8.37	617	537
8	1202	Tanks/Ponds	45	186	2.37	172	115
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**151**	**7081**	**90.26**	**7021**	**3839**
		Wetlands (<2.25 ha), mainly Tanks	764	764	9.74	-	-
		Total	**915**	**7845**	**100.00**	**7021**	**3839**

Area under Aquatic Vegetation	55	75

Area under turbidity levels		
Low	-	-
Moderate	5071	3186
High	1950	653

State : Jharkhand

WETLAND MAP

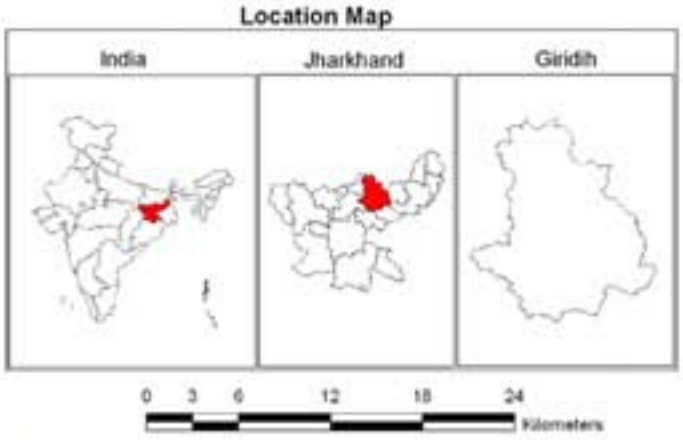
District : Giridih

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

Jharkhand Space Applications Centre, Ranchi

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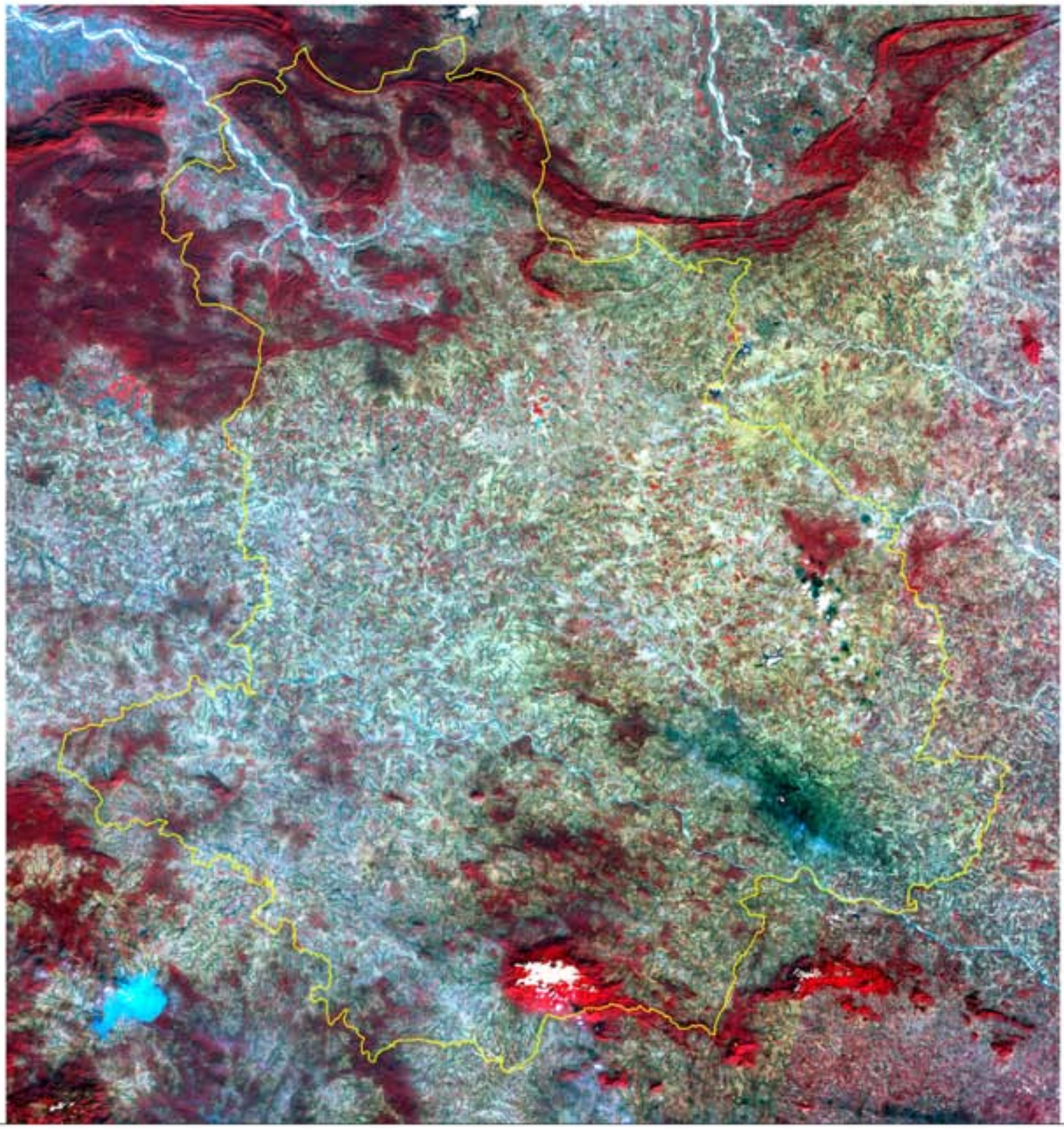
Government of India



IRS P6 LISS-III post monsoon data (2006)

7.1.7 Deoghar

The total geographical area of Deoghar district is 2,479 Sq. km. The wetland area estimated is 4046 ha constituting 491 wetlands, which includes 359 wetlands of < 2.25 ha (Table 12). Wetland area dominated by River/stream occupied 3166 ha of area. It accounted for about 78 % area and made the other two wetland types insignificant, which together comprised the rest of 12 % of area. Significantly the seasonal fluctuation in open water is much small compared to previous districts, which is only about 18 %. The Open water was estimated to be 3661 ha in post-monsoon, which was reduced to 3008 ha in pre-monsoon season. The area under aquatic vegetation is also small, which was observed to be 26 ha in post-monsoon and increased to 29 ha in pre-monsoon period. Open water is observed to be dominated by high turbidity in both the seasons (3014 ha and 2733 ha in post-monsoon and pre-monsoon seasons respectively). Low turbidity has not been encountered in this district while the moderate turbidity, which accounted for 674 ha in post-monsoon, has shown a reduction to 275 ha in pre-monsoon season. Details are given in Table 12.

Table 12: Area estimates of wetlands in Deoghar

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	13	3166	78.25	3166	2733
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	66	293	7.24	277	140
8	1202	Tanks/Ponds	53	228	5.64	218	135
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**132**	**3687**	**91.13**	**3661**	**3008**
		Wetlands (<2.25 ha), mainly Tanks	359	359	8.87	-	-
		Total	**491**	**4046**	**100.00**	**3661**	**3008**

Area under Aquatic Vegetation	26	29

Area under turbidity levels		
Low	-	-
Moderate	647	275
High	3014	2733

State : Jharkhand

WETLAND MAP

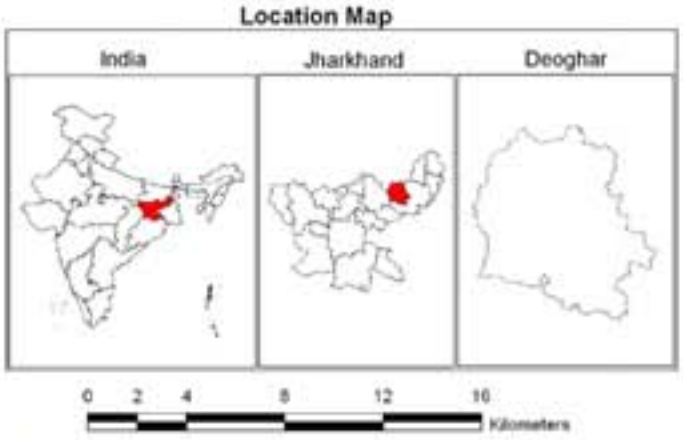
District : Deoghar

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

Jharkhand Space Applications Centre, Ranchi

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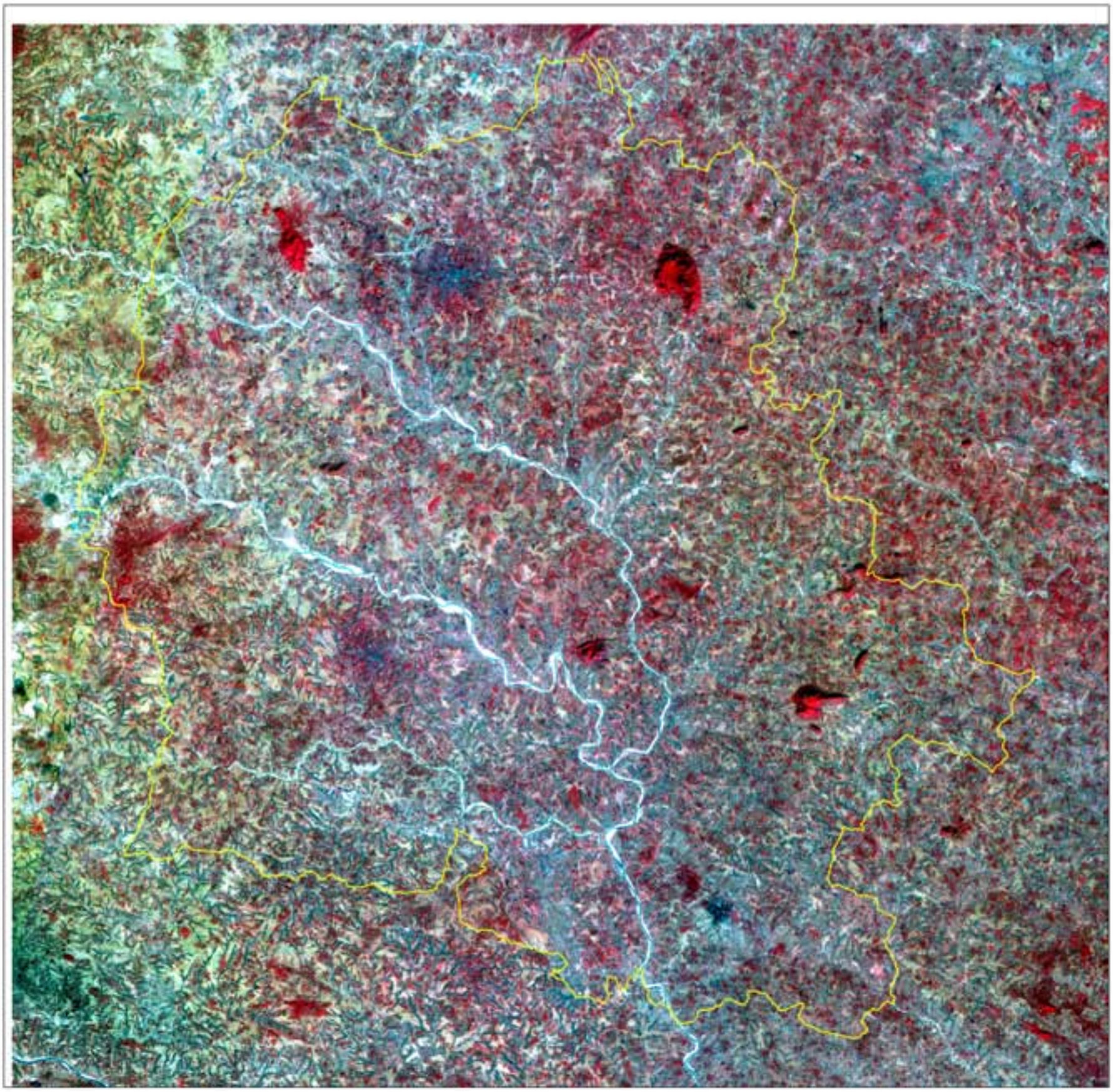


IRS P6 LISS-III post monsoon data (2006)

7.1.8 Godda

The total geographical area of Godda district is 2,110 Sq. km out which wetlands accounts for only a fraction of one per cent. Only 54 wetlands which are > 2.25 ha are observed in this district and 415 wetlands smaller than 2.25 ha have also been identified and shown as point features (Table 13). The wetland area is estimated to be 2445 ha. River/Stream stands first with 1436 ha under its area and accounts for about 59 per cent. Reservoir/Barrage (455 ha) and Tank/Pond (139 ha) together constitute about 24 per cent. The smaller wetlands (< 2.25 ha) constitute a significant area (about 17 %). The post-monsoon open water spread (2028 ha) has shown a reduction of about 37 per cent in pre-monsoon (1475 ha). Aquatic vegetation was not observed in post-monsoon but a significant area was observed in pre-monsoon (119 ha). Details are given in Table 13. Open water was dominantly of high turbidity (1018 ha) followed by moderate (777 ha) and low (233 ha) in post-monsoon. In pre-monsoon season the open water was dominated by high turbidity (848 ha) followed by moderate (469 ha) and low (158 ha).

Table 13: Area estimates of wetlands in Godda

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	7	1436	58.73	1436	1046
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	10	455	18.61	455	307
8	1202	Tanks/Ponds	37	139	5.69	137	122
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**54**	**2030**	**83.03**	**2028**	**1475**
		Wetlands (<2.25 ha), mainly Tanks	415	415	16.97	-	-
		Total	**469**	**2445**	**100.00**	**2028**	**1475**

Area under Aquatic Vegetation	-	119

Area under turbidity levels		
Low	233	158
Moderate	1018	469
High	777	848

State : Jharkhand

WETLAND MAP

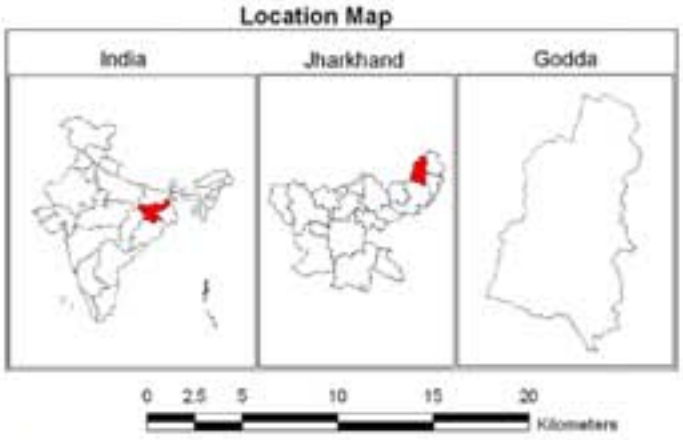
District : Godda

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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Jharkhand Space Applications Centre, Ranchi

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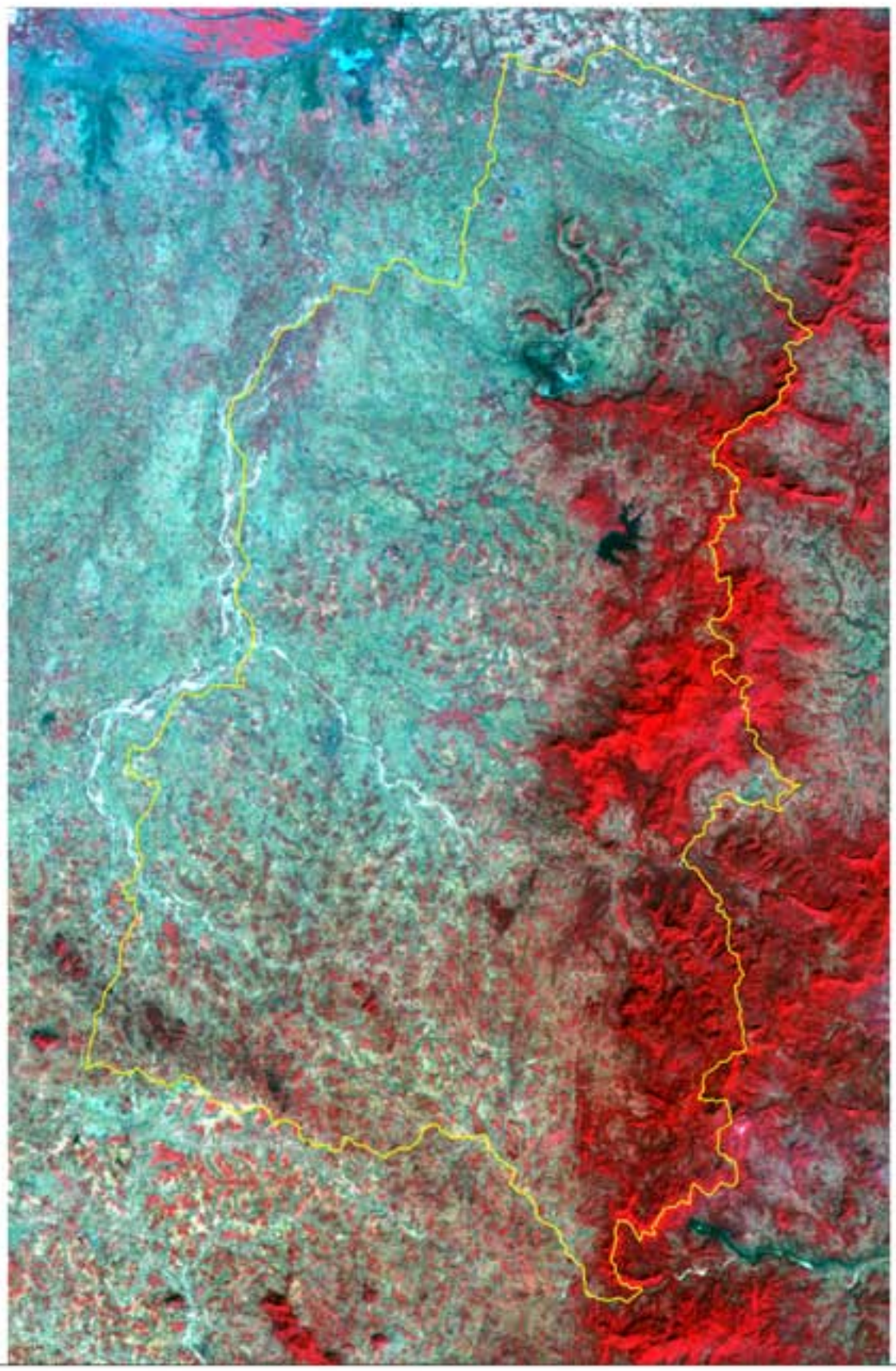


IRS P6 LISS-III post monsoon data (2006)

7.1.9 Sahibganj

The total geographical area of Sahibganj district is 1,599 Sq. km out which the wetlands constitute 0.2 per cent. The wetland area is estimated to be 16118 ha comprising 73 wetlands of > 2.25 ha and 482 wetlands of < 2.25 ha. Together there are 555 wetlands in this district. The seasonal fluctuation in open water is about 11 per cent. River/Stream ranked first in terms of area (11378 ha) accounting for about 71 per cent wetland area. However, presence of Lakes (2861 ha) had accounted for 18 per cent of area. Ox-bow lake/Cut-off meanders, Reservoir/ Barrage and Tank/Pond together comprised an area of about one per cent. There is reduction of about 11 per cent in open water extent from post-monsoon (12979 ha) to pre-monsoon (11504 ha). Open water dominantly remained moderately turbid followed by high and low in both the seasons. Details are given in Table 14. The presence of aquatic vegetation is observed to be significant constituent of wetlands in this district. It was estimated to be 2193 ha in post-monsoon accounting for about 14 per cent of wetland area and had shown an increase to 3392 ha in post-monsoon i.e. about 22 per cent.

Table 14: Area estimates of wetlands in Sahibganj

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	2861	17.75	1018	345
2	1102	Ox-bow lakes/ Cut-off meanders	15	73	0.45	61	60
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	14	1204	7.47	478	352
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	13	11378	70.59	11378	10703
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	3	16	0.10	10	7
8	1202	Tanks/Ponds	18	104	0.65	34	37
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**73**	**15636**	**97.01**	**12979**	**11504**
		Wetlands (<2.25 ha), mainly Tanks	482	482	2.99	-	-
		Total	**555**	**16118**	**100.00**	**12979**	**11504**

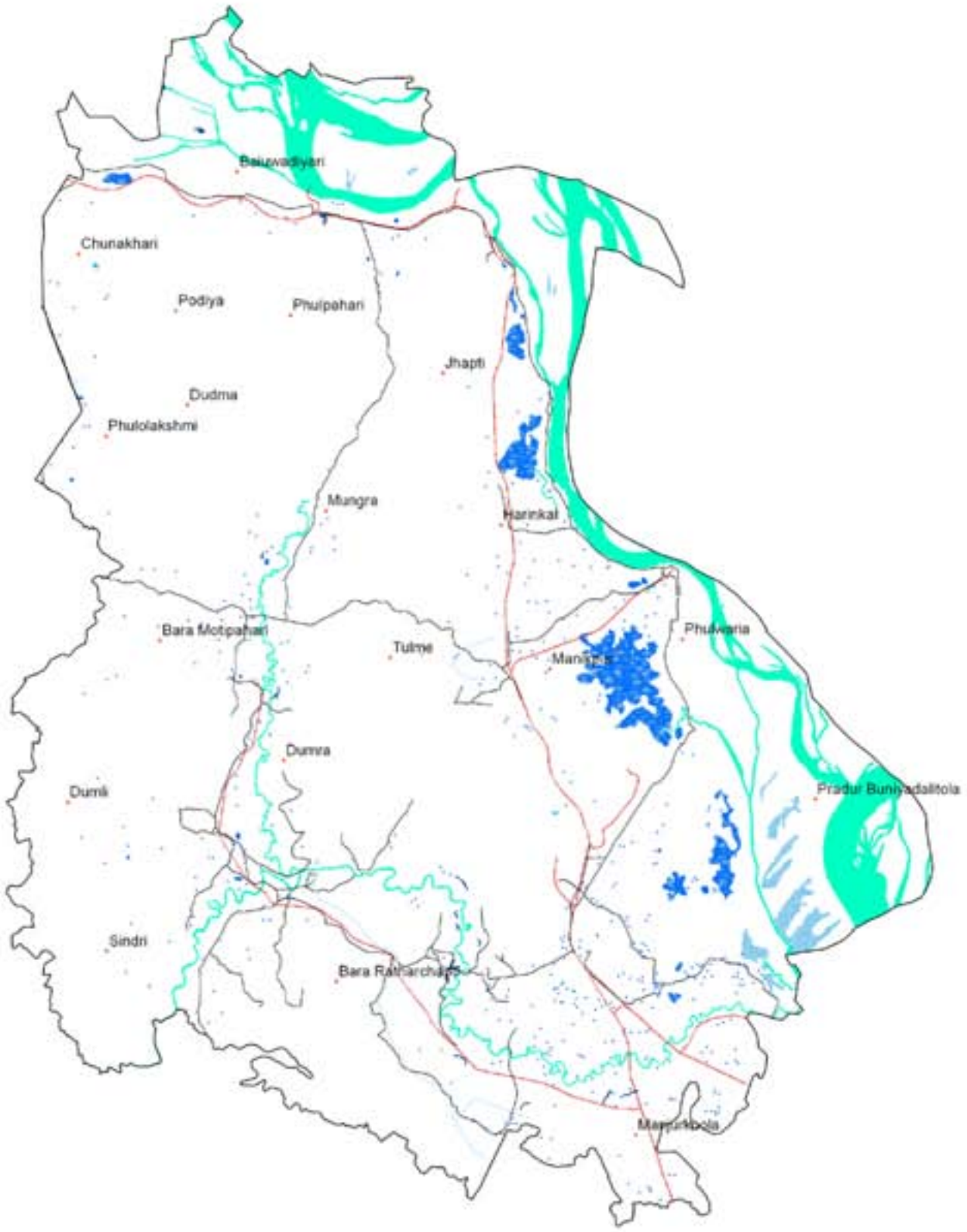
Area under Aquatic Vegetation	2193	3392

Area under turbidity levels		
Low	67	5
Moderate	12457	11235
High	455	264

State : Jharkhand

WETLAND MAP

District : Sahibganj

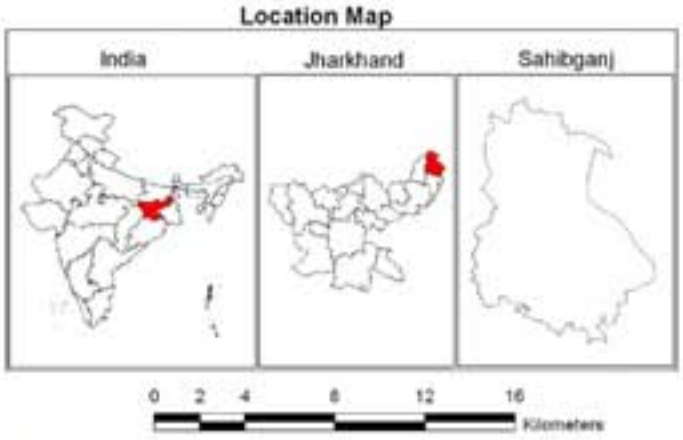


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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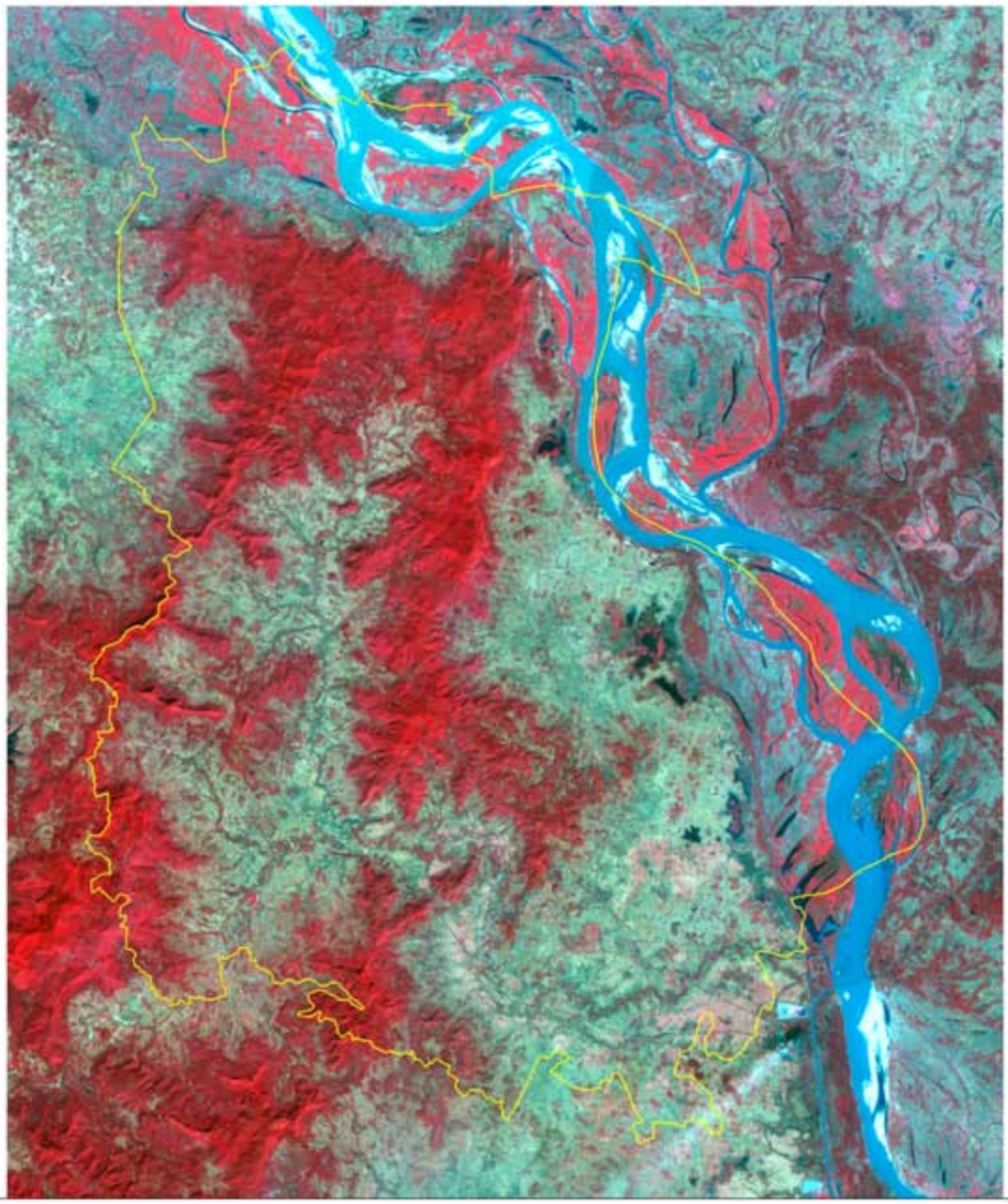


IRS P6 LISS-III post monsoon data (2006)

7.1.10 Pakur

There are 708 wetlands in Pakur district including 667 smaller than 2.25 ha. The area under wetlands constitute 2734 ha which accounts for a fraction of one per cent of the geographical area of Pakur district (1,806 Sq. km). These district show wider wetland types that include lake, ox-bow lakes/Cut-off meanders. River/Stream is the largest wetland category, which accounts for about 54 per cent of the area under wetlands (table 15). Lakes form a sizable fraction of wetlands that comprise about 12 % of area. Together, the rest of the categories account for 8 per cent of wetland area. The smaller wetlands (< 2.25 ha) comprise 667 in number and account for about 24 per cent of the wetland area (assuming that each one has an average area of one ha). Details are given in Table 15. Seasonal fluctuation in open water has shown a decrease of 29 per cent from post-monsoon (2047 ha) to pre-monsoon (1463 ha). This change is not large in case of River/Stream compared to other categories. Aquatic vegetation was a meager 20 ha in post-monsoon had shown a significant increase to 281 ha in pre-monsoon. Open water remained moderately turbid followed by high and low in both the seasons. However, in pre-monsoon low turbidity has not been exhibited by open water in this district.

Table 15: Area estimates of wetlands in Pakur

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	5	322	11.78	304	19
2	1102	Ox-bow lakes/ Cut-off meanders	3	10	0.37	10	10
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	7	1466	53.62	1466	1292
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	5	73	2.67	73	43
8	1202	Tanks/Ponds	20	181	6.62	179	99
9	1203	Waterlogged	1	15	0.55	15	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**41**	**2067**	**75.60**	**2047**	**1463**
		Wetlands (<2.25 ha), mainly Tanks	667	667	24.40	-	-
		Total	**708**	**2734**	**100.00**	**2047**	**1463**

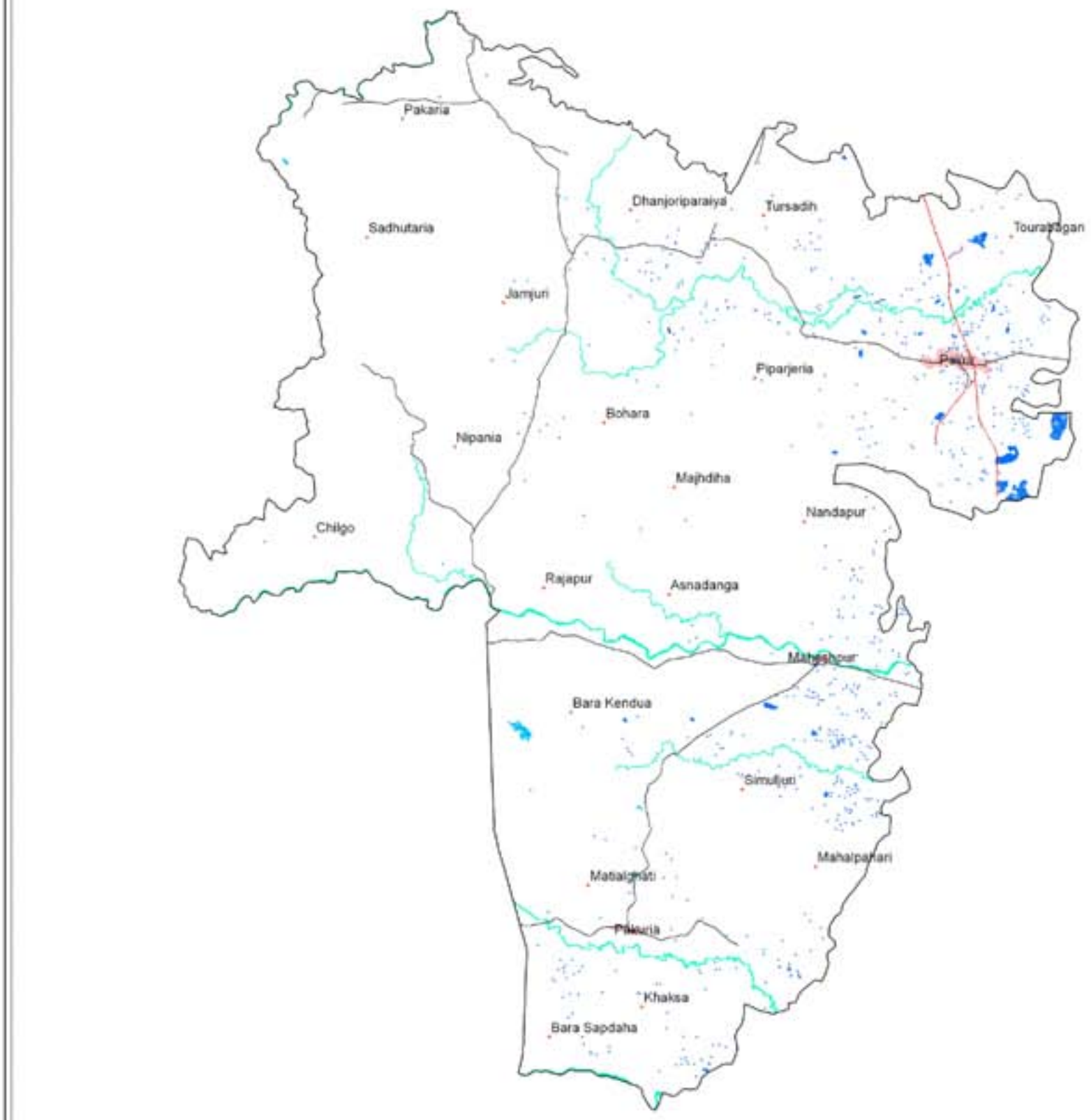
Area under Aquatic Vegetation	20	281

Area under turbidity levels		
Low	79	-
Moderate	1520	799
High	448	664

State : Jharkhand

WETLAND MAP

District : Pakur

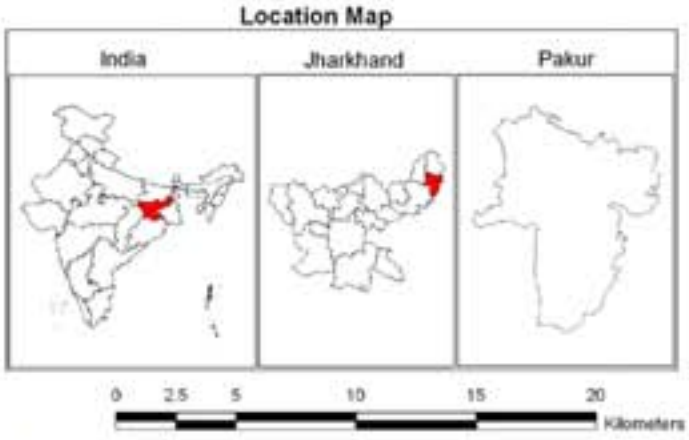


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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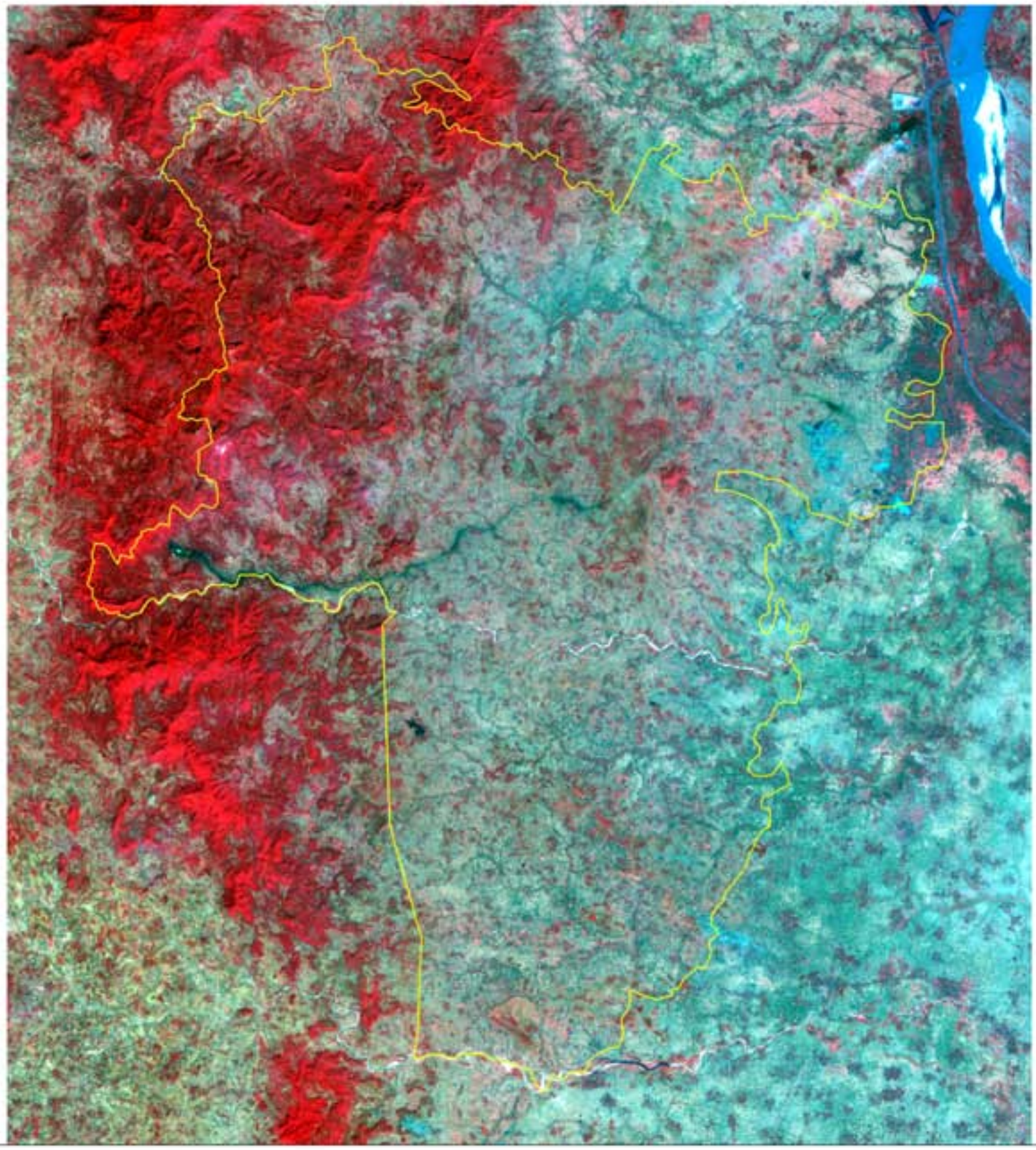


IRS P6 LISS-III post monsoon data (2006)

7.1.11 Dumka

The total geographical area of Dumka district is 6,212 Sq. km. The wetland area is estimated to be 15824 ha which include 857 smaller wetlands of < 2.25 ha. Reservoir/Barrage ranked first with 9000 ha of area accounting for about 57 per cent of wetland area. River/Stream stands next constituting 5487 ha of area (table 16) in this district. The other two types are Riverine wetlands and tank/Pond together forms about 3 per cent area under wetlands. Details are given in Table 16. Aquatic vegetation covers 16 ha of wetland area and remained unchanged in both the seasons. Open water in post-monsoon dominated by moderate turbidity (8456 ha) followed by low (3688 ha) and high (2795 ha). In case of pre-monsoon, the open water was dominated by low turbidity (6821 ha) followed by high (3465 ha) and moderate (1371 ha). Probably the suspended sediments brought through rainfall run-off into Reservoir/Barrage, which is the largest category would have settled resulting in low turbidity.

Table16: Area estimates of wetlands in Dumka

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	16	263	1.66	235	155
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	25	5487	34.68	5487	4445
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	36	9000	56.88	9000	6920
8	1202	Tanks/Ponds	63	217	1.37	217	139
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**140**	**14967**	**94.58**	**14939**	**11659**
		Wetlands (<2.25 ha), mainly Tanks	857	857	5.42	-	-
		Total	**997**	**15824**	**100.00**	**14939**	**11659**

Area under Aquatic Vegetation	16	16

Area under turbidity levels		
Low	3688	6821
Moderate	8456	1371
High	2795	3465

State : Jharkhand

WETLAND MAP

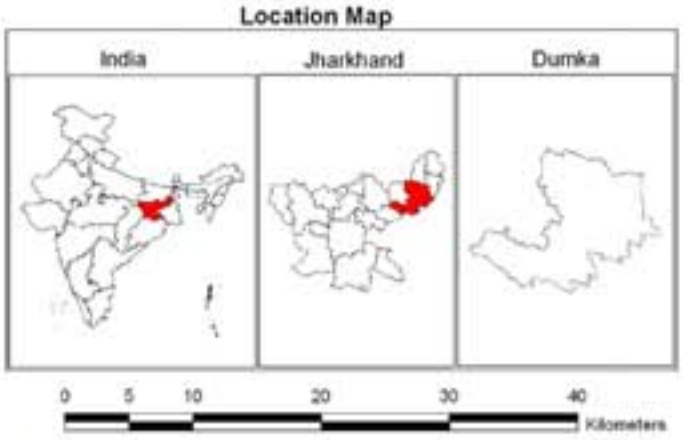
District : Dumka

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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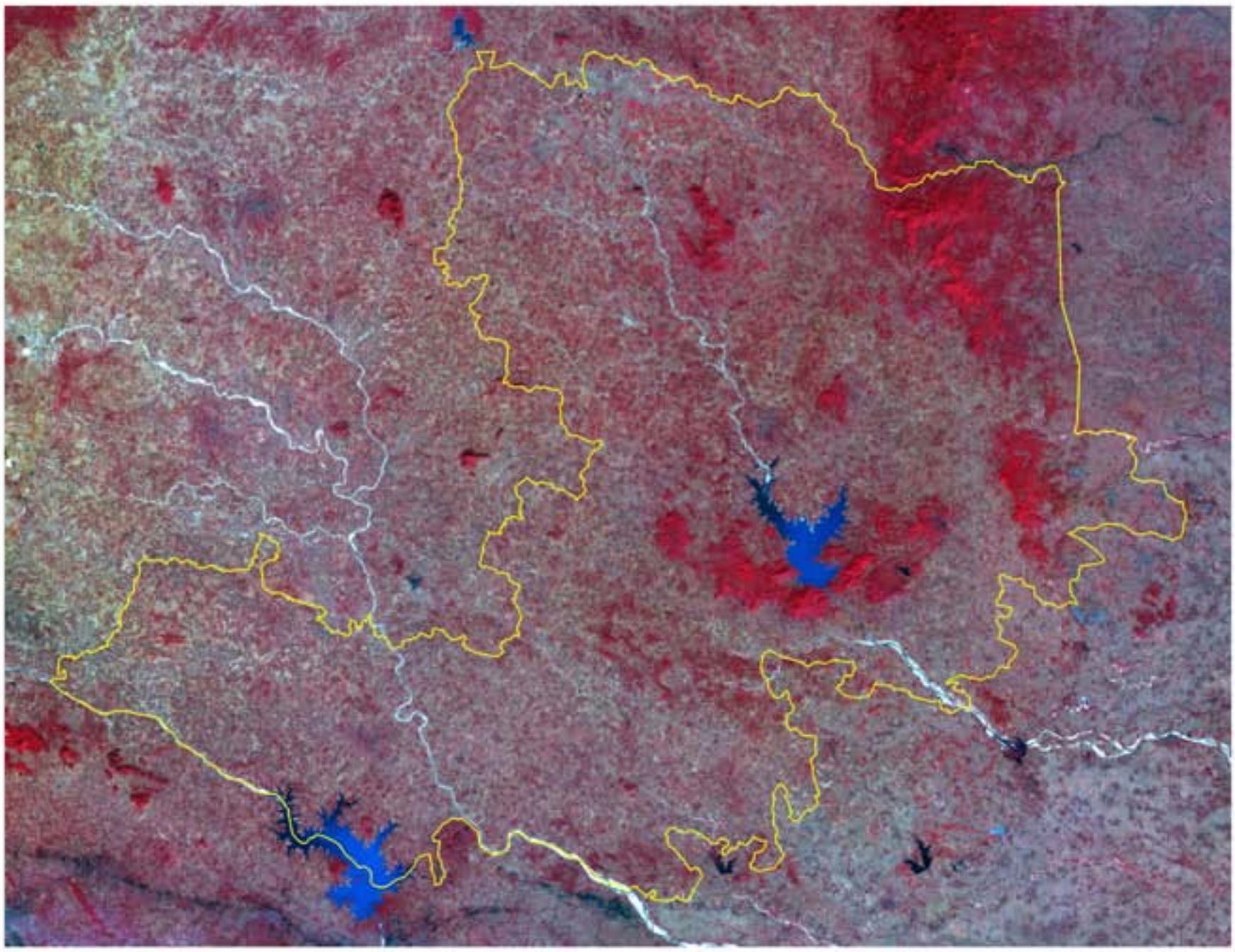


IRS P6 LISS-III post monsoon data (2006)

7.1.12 Dhanbad

The total geographical area of Dhanbad district is 2,052 Sq. km. The number of wetlands > 2.25 ha is 117 and an additional 992 wetlands < 2.25 ha have also been discerned. Reservoir/Barrage topped for the extent under wetlands with 5787 ha that constitute about 61 per cent. River/Stream formed the next significant wetland type with 2111 ha of extent accounting for about 22 per cent of area. The smaller wetlands are also significant and contribute about 11 per cent of wetland area (Table 17). Details are given in Table 17. The variation in open water across the seasons is observed to be 36 per cent from 8296 ha in post-monsoon to 6108 ha in pre-monsoon season. Major reduction in open water is observed in reservoir/Barrage (about 33 %). A 700 fold increase is observed in aquatic vegetation fro post-monsoon (149 ha) to pre-monsoon (1051 ha). Open water was significantly low in turbidity (6097 ha) followed by moderate (1892 ha) and high (307 ha). However, moderate turbidity dominated the open water in pre-monsoon season followed by low and high turbidity.

Table17: Area estimates of wetlands in Dhanbad

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	3	25	0.26	25	9
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	7	2111	22.37	2111	1841
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	17	5787	61.32	5708	3835
8	1202	Tanks/Ponds	90	523	5.54	452	423
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**117**	**8446**	**89.49**	**8296**	**6108**
		Wetlands (<2.25 ha), mainly Tanks	992	992	10.51	-	-
		Total	**1109**	**9438**	**100.00**	**8296**	**6108**

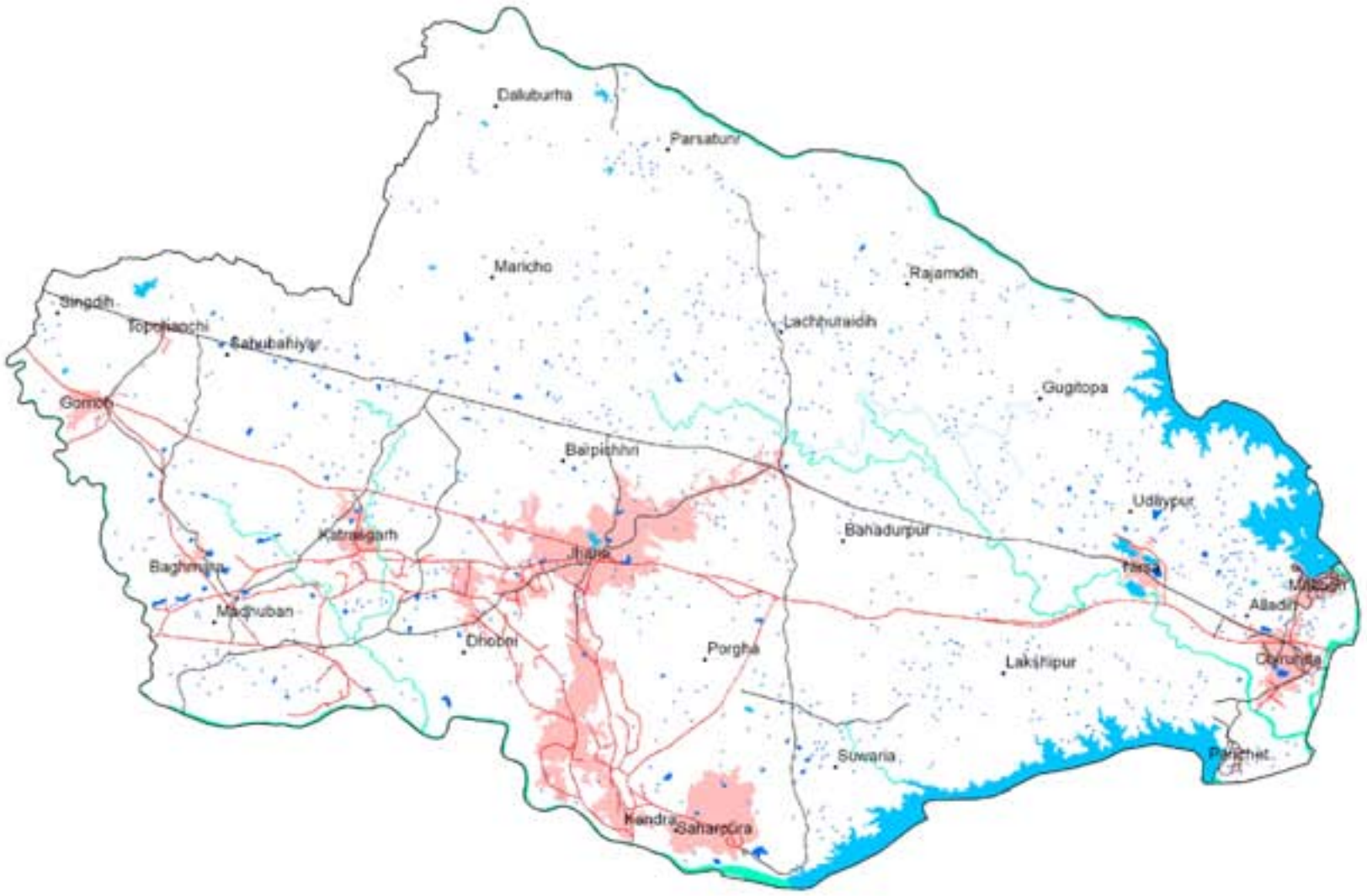
Area under Aquatic Vegetation	149	1051

Area under turbidity levels		
Low	6097	1902
Moderate	1892	4062
High	307	144

State : Jharkhand

WETLAND MAP

District : Dhanbad

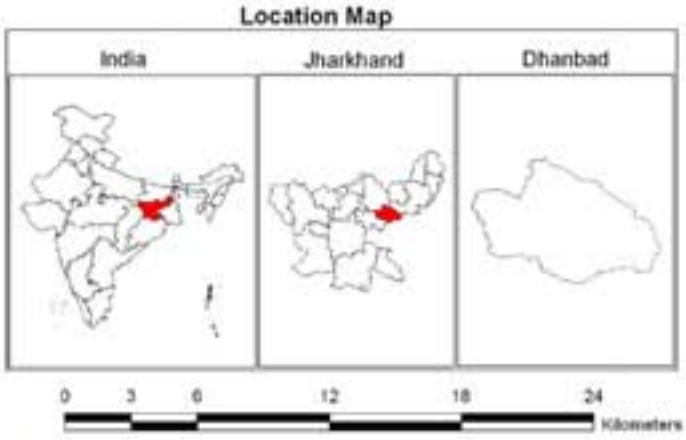


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Jharkhand Space Applications Centre, Ranchi

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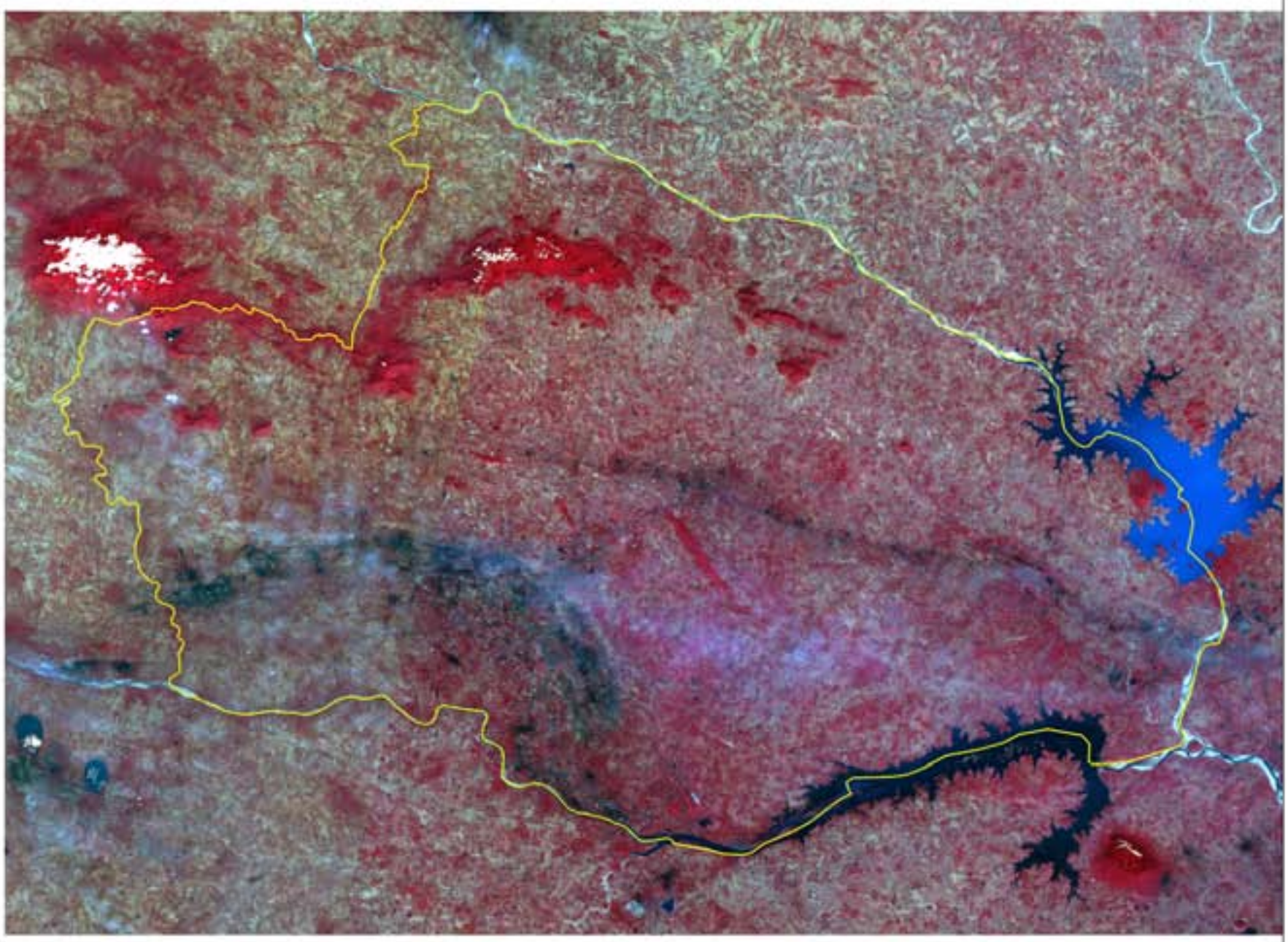


IRS P6 LISS-III post monsoon data (2006)

7.1.13 Bokaro

The total geographical area of Bokaro district is 2,861 Sq. km. The wetland area is estimated to be 11222 ha. Reservoir/barrage ranks first in terms of aerial extent (5121 ha) that accounts for about 46 per cent of wetlands in Bokaro district. River/Stream is the next wetland category that is significant in terms of extent (3899 ha). There are 106 Tank/Ponds in this district which comprise about 12 per cent of wetland area. Riverine wetland (3) does exist but are insignificant in terms of extent accounting for only a fraction of one per cent. The number of smaller wetlands (< 2.25 ha) is significant (838). Details are given in Table 18. There is a marginal increase of 31 ha in the extent of aquatic vegetation from post-monsoon (606 ha) to pre-monsoon (637 ha). The seasonal fluctuation in open water is not significant and found to be about 12 per cent from post-monsoon (9800 ha) to pre-monsoon (8621 ha) which is reflected uniformly in all the wetland categories. Open water is found to be dominated by moderate turbidity followed by low and high in both the seasons.

Table 18: Area estimates of wetlands in Bokaro

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	3	51	0.45	25	25
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	12	3899	34.74	3899	3130
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	19	5121	45.63	4734	4369
8	1202	Tanks/Ponds	106	1313	11.70	1142	1097
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**140**	**10384**	**92.53**	**9800**	**8621**
		Wetlands (<2.25 ha), mainly Tanks	838	838	7.47	-	-
		Total	**978**	**11222**	**100.00**	**9800**	**8621**

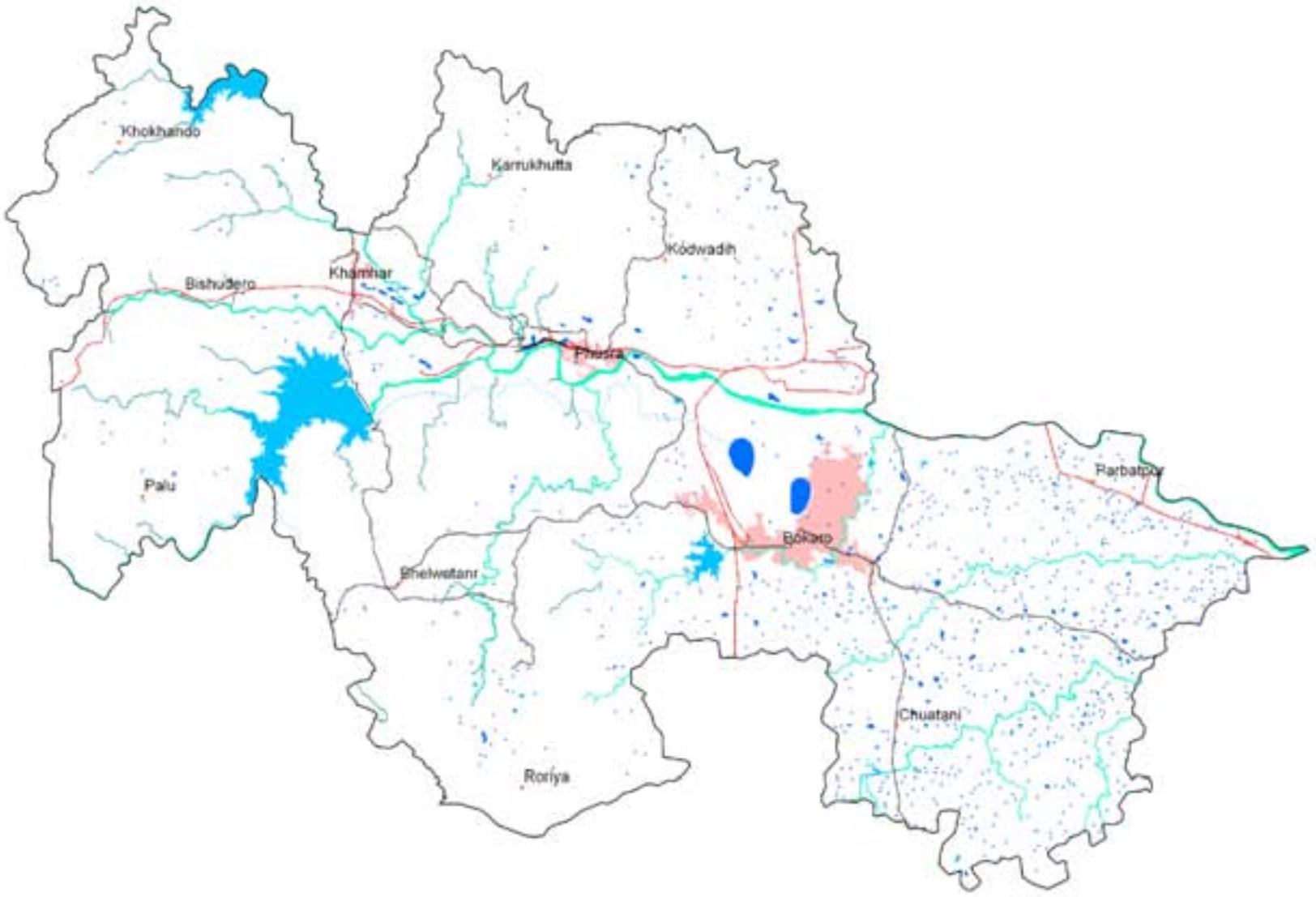
Area under Aquatic Vegetation	606	637

Area under turbidity levels		
Low	3258	2028
Moderate	5162	5974
High	1380	619

State : Jharkhand

WETLAND MAP

District : Bokaro

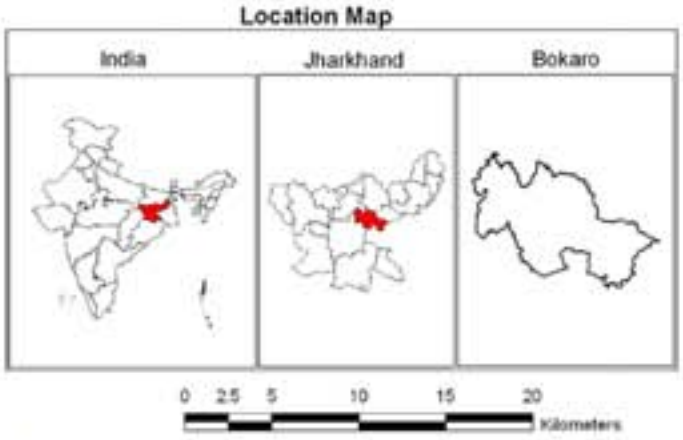


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

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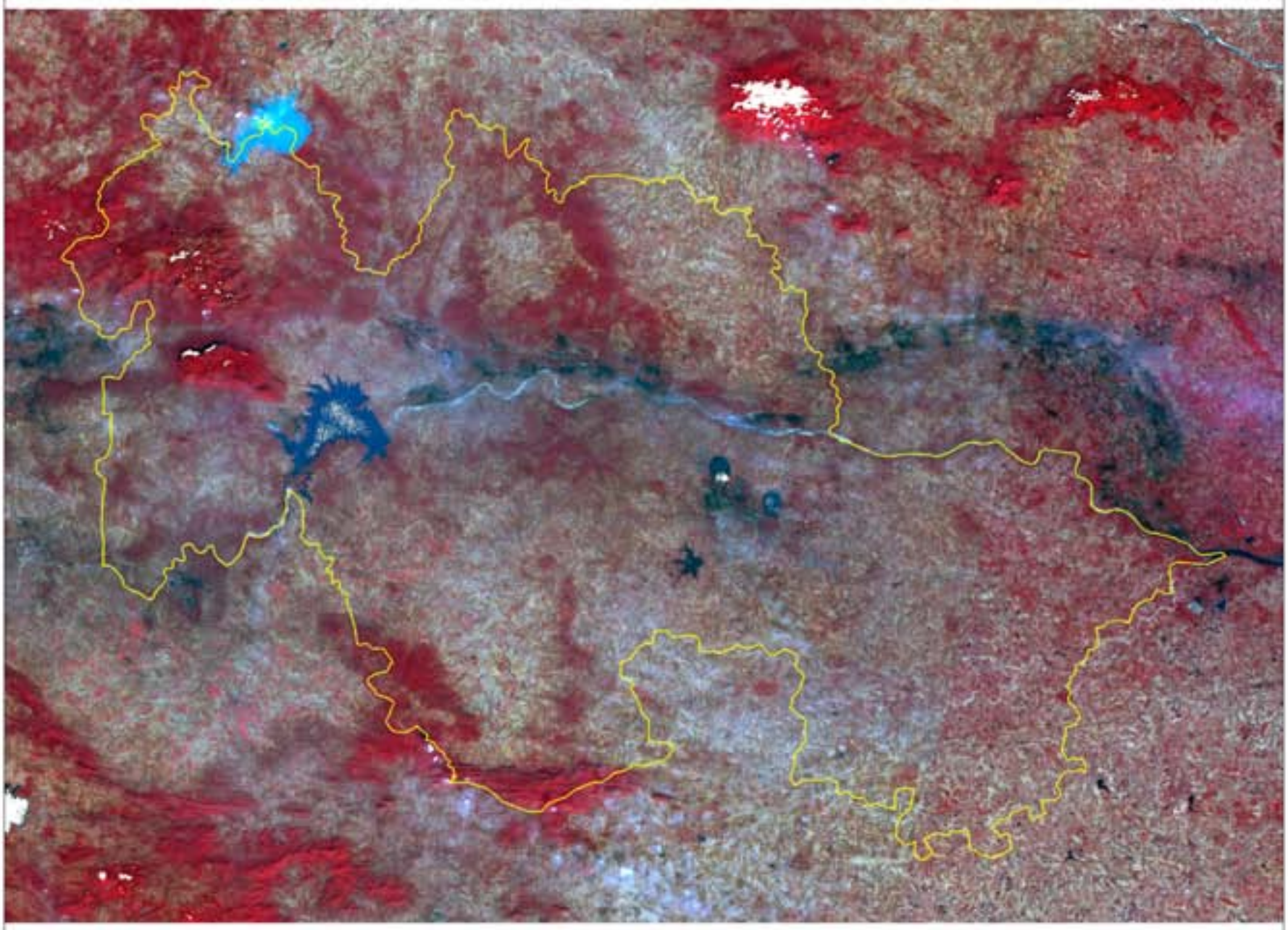


IRS P6 LISS-III post monsoon data (2006)

7.1.14 Ranchi

The total geographical area of Ranchi district is 7,698 Sq. km. There are 1077 wetlands in the district that comprise 164 wetlands of > 2.25 ha and the rest 913 are smaller than 2.25 ha. The aerial extent of wetlands is estimated to be 14728 ha, which is a meager 0.17 per cent of the geographical area of the district. River/Stream occupies the top rank in terms of extent with 8261 ha followed by Reservoir/barrage (4945 ha). The smaller wetlands occupy reasonably significant extent i.e. 6.2 per cent of wetland extent. Aquatic vegetation has shown a significant increase from 94 ha to 276 ha from post-monsoon to pre-monsoon season. Aquaculture ponds have been mapped accounting for 8 ha. Details are given in Table 19. Considerable decrease of 36 per cent in open water is observed from post-monsoon (13709 ha) to 10165 ha in pre-monsoon season. The open water remained moderately turbid followed by high and low with similar pattern in both the seasons. The decrease in area from post-monsoon to pre-monsoon season under various turbidity classes is mainly due to reduction in the extent of open water itself.

Table 19: Area estimates of wetlands in Ranchi district

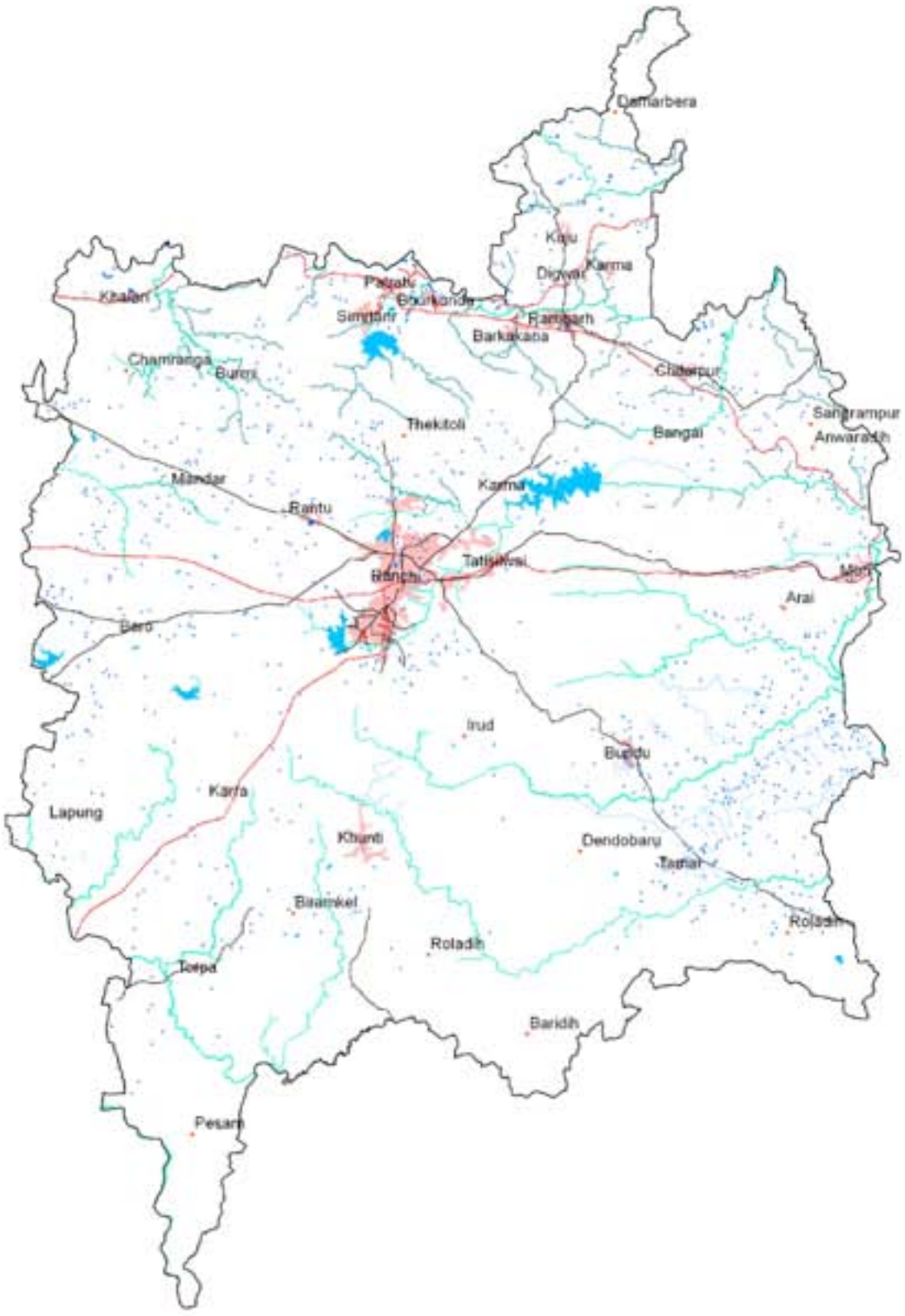
Area in ha

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	21	0.14	21	21
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	2	58	0.39	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	28	8261	56.09	8261	5394
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	58	4945	33.58	4903	4260
8	1202	Tanks/Ponds	72	519	3.52	513	479
9	1203	Waterlogged	1	3	0.02	3	3
10	1204	Salt pans/Aquaculture Pond	2	8	0.05	8	8
		Sub-Total	**164**	**13815**	**93.80**	**13709**	**10165**
		Wetlands (<2.25 ha), mainly Tanks	913	913	6.20	-	-
		Total	**1077**	**14728**	**100.00**	**13709**	**10165**
		Area under Aquatic Vegetation				94	276
		Area under turbidity levels					
		Low				244	136
		Moderate				8033	5752
		High				5432	4277

State : Jharkhand

WETLAND MAP

District : Ranchi

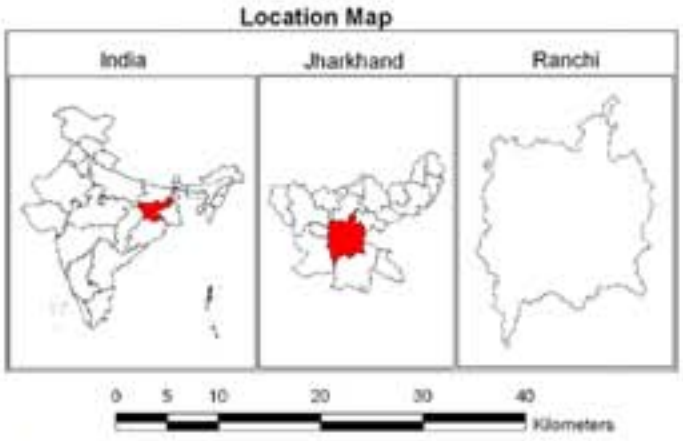


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



Data Source :

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

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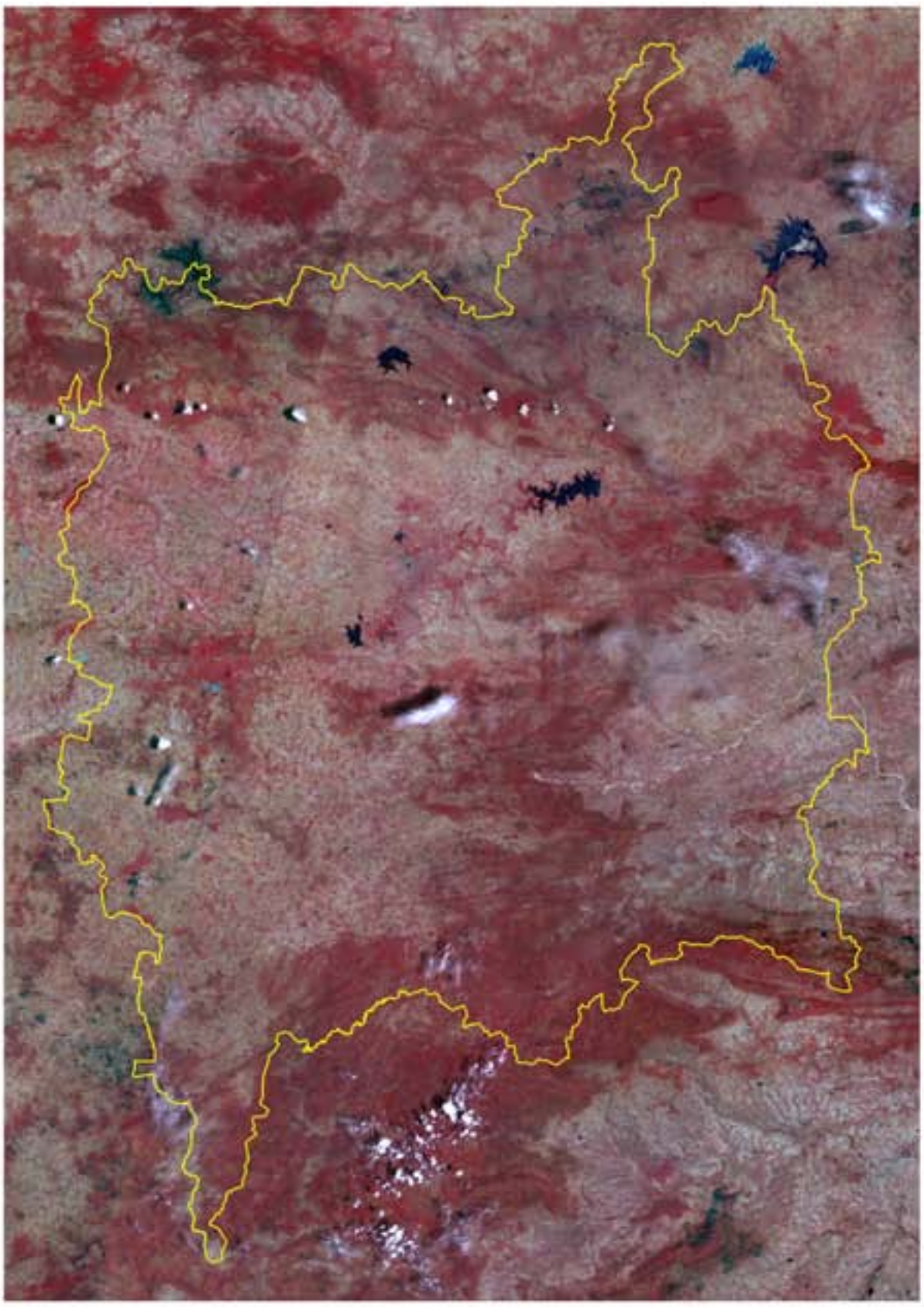


IRS P6 LISS-III post monsoon data (2006)

7.1.15 Lohardaga

The total geographical area of Lohardaga district is 1,491 Sq. km. The aerial extent of wetlands in this district is estimated 2110 ha that include the contribution from 294 wetlands, which are < 2.25 ha. River/Stream is singularly the largest category in terms of extent comprising 66 per cent of the area under wetlands followed by Reservoir/Barrage accounting for about 18 per cent. The smaller wetlands also significantly add to the extent of wetlands by way of constituting about 14 per cent area under them. Open water has shown about 70 per cent reduction from post-monsoon to pre-monsoon elucidating the seasonal fluctuation. This is reflected in both the major categories. Details are given in Table 20. Aquatic vegetation is insignificant in terms of extent, which was a mere 6 ha in post-monsoon and has shown an increase to 12 ha in pre-monsoon. Open water in post-monsoon season dominantly moderately turbid (1062 ha) followed by high (506 ha) and low (241 ha). The extent of open water in pre-monsoon is severely reduced and reflected in the extents of various classes of turbidity. However, high turbidity dominated the pre-monsoon extent of open water.

Table 20: Area estimates of wetlands in Lohardaga

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	9	1393	66.02	1393	389
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	22	390	18.48	390	161
8	1202	Tanks/Ponds	9	33	1.56	26	18
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**40**	**1816**	**86.07**	**1809**	**568**
		Wetlands (<2.25 ha), mainly Tanks	294	294	13.93	-	-
		Total	**334**	**2110**	**100.00**	**1809**	**568**

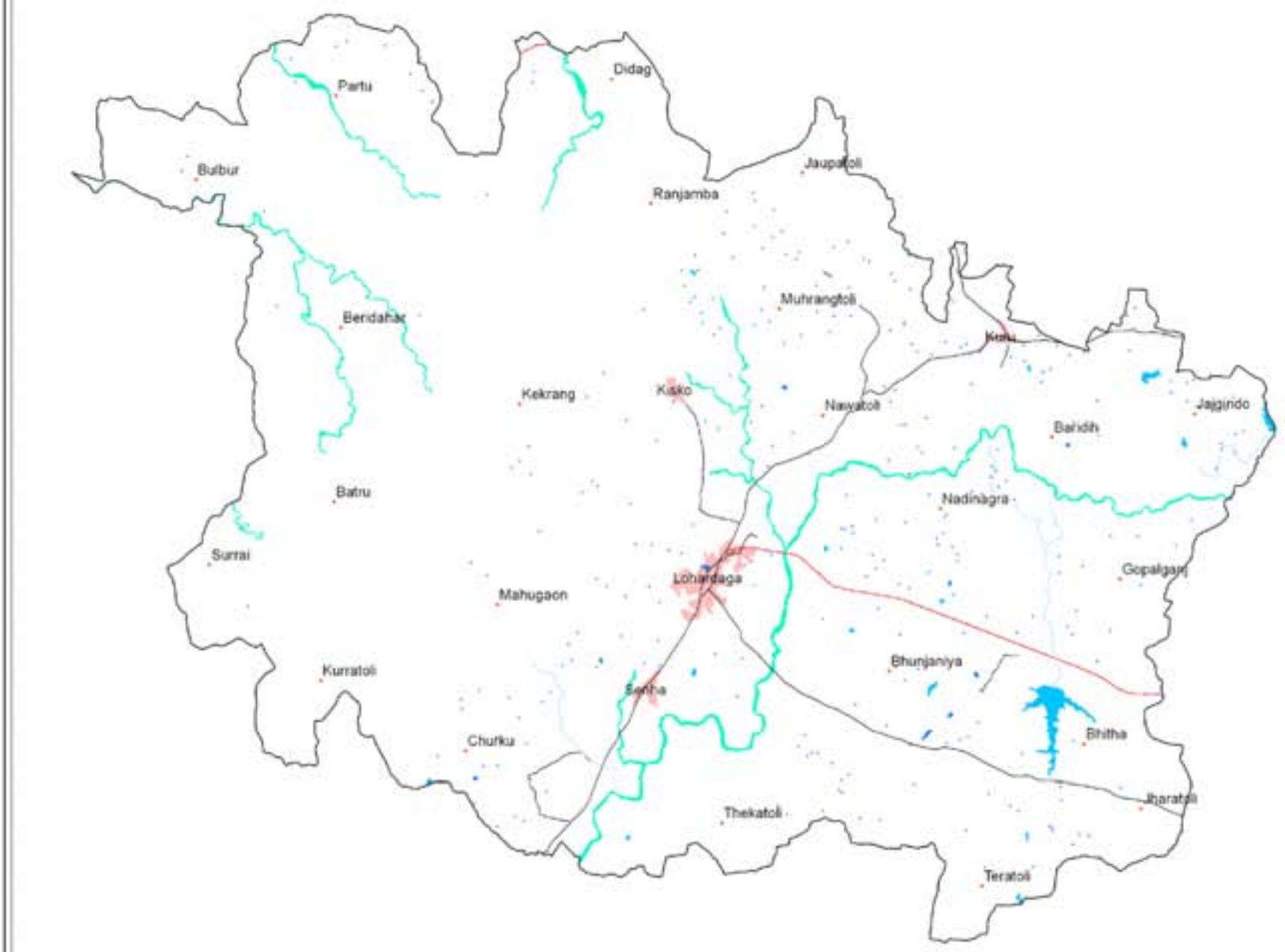
Area under Aquatic Vegetation	6	12

Area under turbidity levels		
Low	241	54
Moderate	1062	124
High	506	390

State : Jharkhand

WETLAND MAP

District : Lohardaga

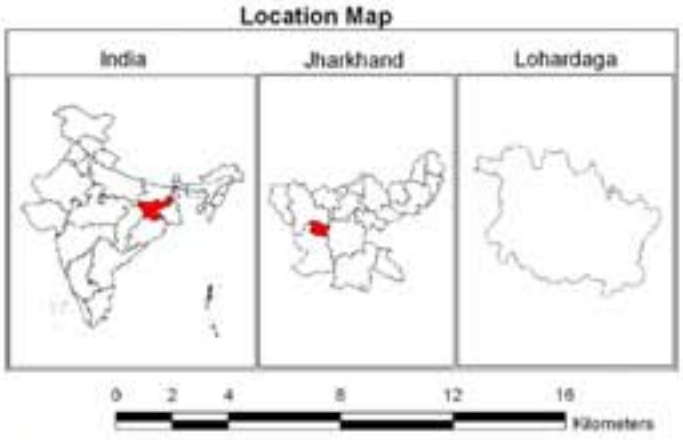


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

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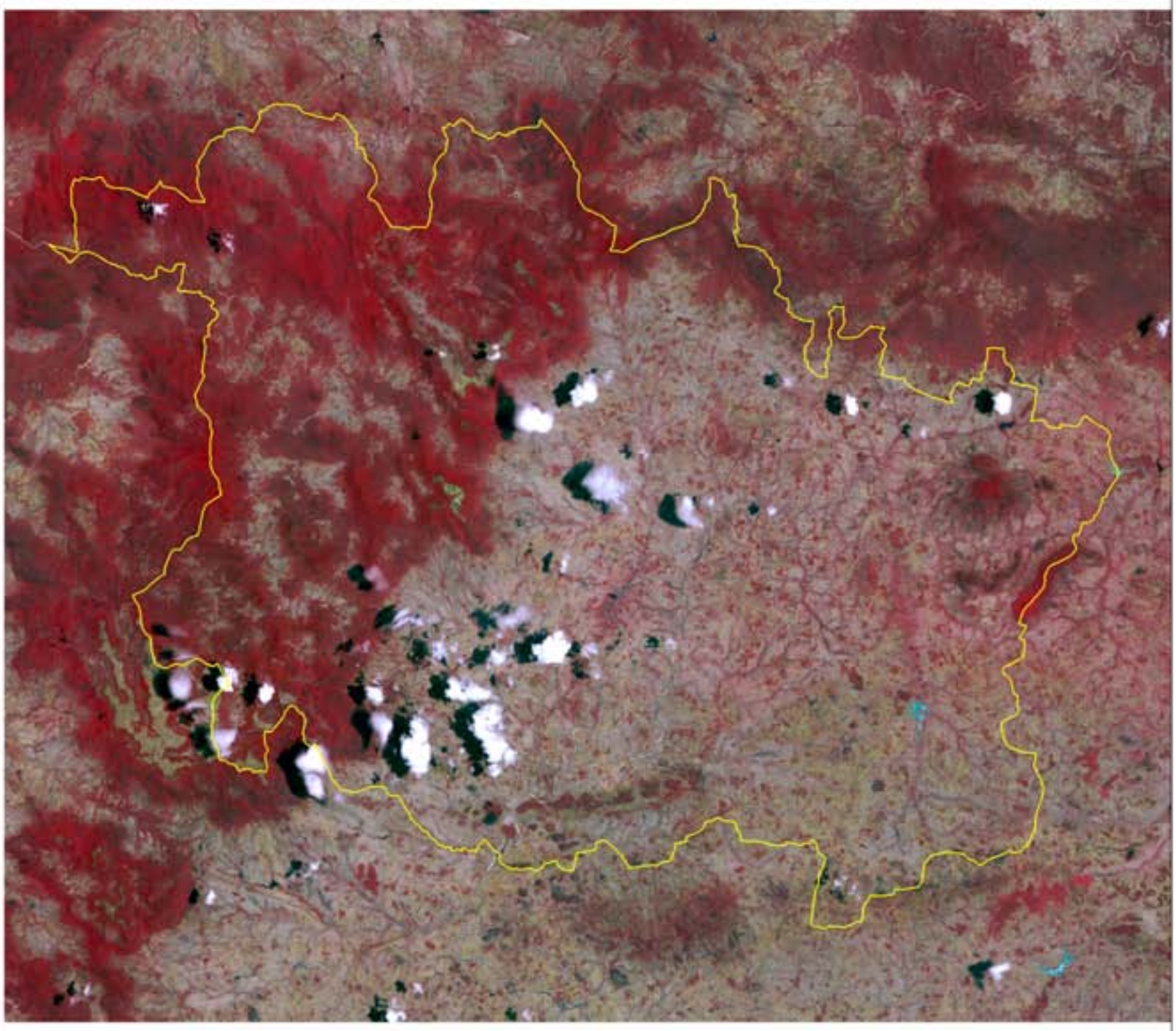


IRS P6 LISS-III post monsoon data (2006)

7.1.16 Gumla

The total geographical area of Gumla district is 9, 077 Sq. km out of which wetlands account for 12423 ha. River/Stream is the single largest wetland category that constitutes about 79 per cent of wetland extent. Reservoir/Barrage forms the next major category that accounts for about 15 per cent (Table 21). Besides 116 wetlands that are larger than 2.25 ha in size, there are 679 wetlands which are < 2.25 ha (shown as point features on map). These constitute about 5 per cent of wetland extent in this district. The open water extent has shown a reduction 58 per cent from post-monsoon (11729 ha) to 6147 ha in pre-monsoon. It is largely because of seasonal nature of River/Streams that are based on rainfall run-off. The impact is seen on the Reservoir/Barrage also from where the water is being drawn for irrigation etc. Details are given in Table 21. Aquatic vegetation formed a small fraction (14 ha) of wetland extent, which remained unchanged in both the seasons. Open water is dominated by high turbidity (7240 ha) followed by moderate (4227 ha) and low (262 ha) in post-monsoon season. The trend remained same in pre-monsoon season except for the reduced the extents of the open water.

Table 21: Area estimates of wetlands in Gumla

Area in ha

Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open Water	
						Post-monsoon Area	Pre-monsoon Area
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	1	6	0.05	6	-
6	1106	River/Stream	8	9769	78.64	9769	4859
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	81	1822	14.67	1822	1190
8	1202	Tanks/Ponds	26	147	1.18	132	98
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**116**	**11744**	**94.53**	**11729**	**6147**
		Wetlands (<2.25 ha), mainly Tanks	679	679	5.47	-	-
		Total	**795**	**12423**	**100.00**	**11729**	**6147**

Area under Aquatic Vegetation	14	14

Area under turbidity levels		
Low	262	155
Moderate	4227	1619
High	7240	4373

State : Jharkhand

WETLAND MAP

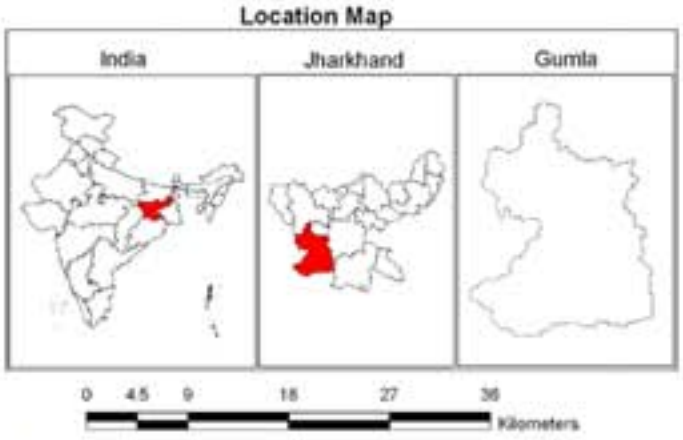
District : Gumla

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 :

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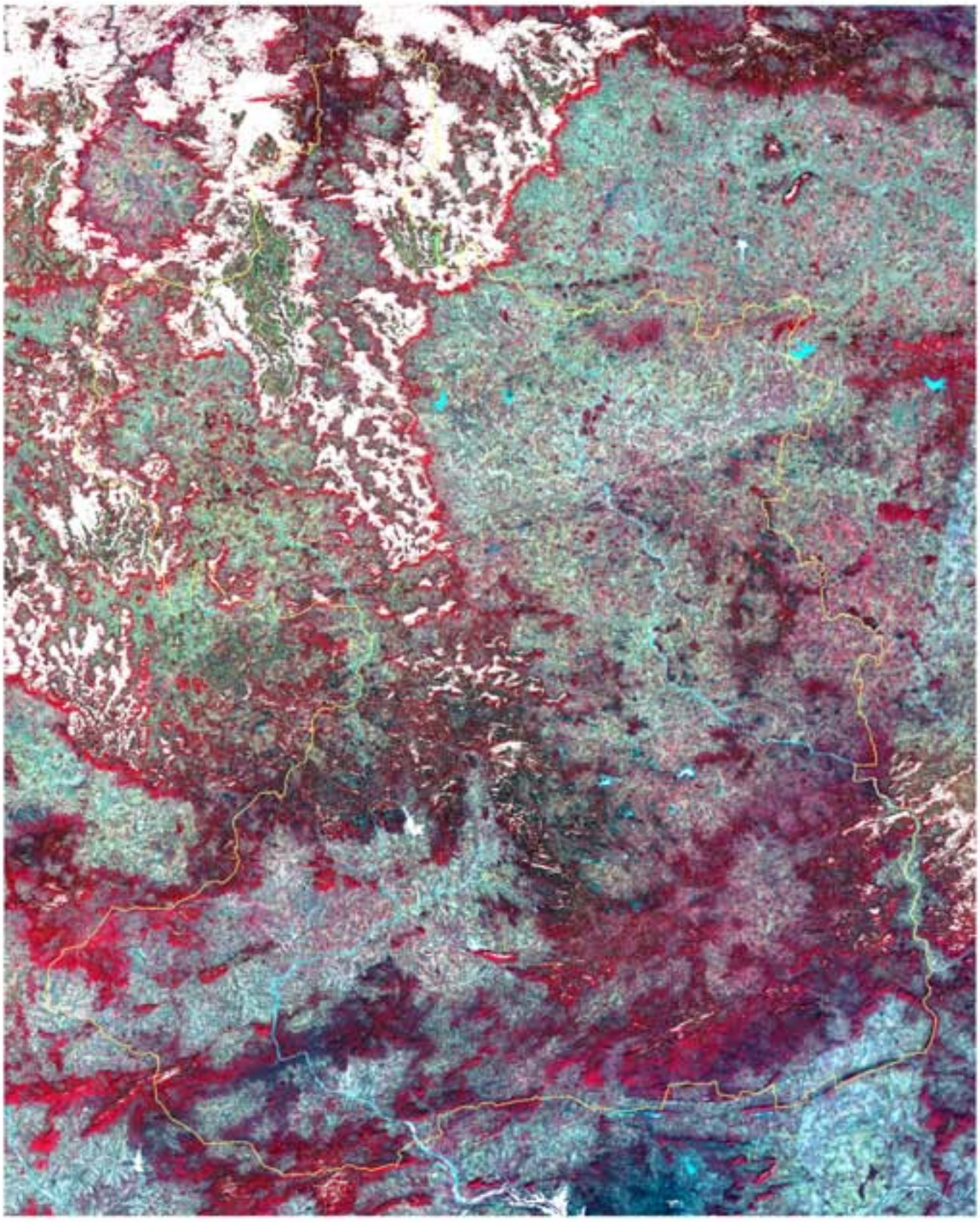


IRS P6 LISS-III post monsoon data (2006)

7.1.17 Pashchmi Singhbhum

The total geographical area of Pashchmi Singhbhum district is 9,907 Sq. km out of which wetlands account for 18939 ha (Table 22). River/Stream ranks first in terms of aerial extent (9140 ha), which constitutes about 48 per cent. Reservoir/Barrage occupy the second position (6914 ha) contributing about 37 per cent to the extent of wetlands in this district. A large number (2131) of smaller wetlands (< 2.25 ha) contribute significantly the extent under wetlands in this district that turns out to be about 11 per cent. The wetland area estimated is 18939 ha. Details are given in Table 22. Aquatic vegetation has shown a tremendous increase from 38 ha in post-monsoon to 856 ha in pre-monsoon season. Open water has a 36 per cent reduction in extent from post-monsoon (16732 ha) to pre-monsoon (12354 ha). High turbidity (12766 ha) dominated the open water extent in post-monsoon followed by high (3069 ha) and low (897 ha). Extent under high turbidity has shown a marginal increase in pre-monsoon from 3069 ha to 3226 ha but the pattern remained similar in both the seasons.

Table22: Area estimates of wetlands in Pashchmi Singhbhum

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	22	9140	48.26	9140	5971
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	96	6914	36.51	6872	5822
8	1202	Tanks/Ponds	144	746	3.94	715	553
9	1203	Waterlogged	2	8	0.04	5	8
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**264**	**16808**	**88.75**	**16732**	**12354**
		Wetlands (<2.25 ha), mainly Tanks	2131	2131	11.25	-	-
		Total	**2395**	**18939**	**100.00**	**16732**	**12354**

Area under Aquatic Vegetation	38	856

Area under turbidity levels		
Low	897	623
Moderate	12766	8505
High	3069	3226

State : Jharkhand

WETLAND MAP

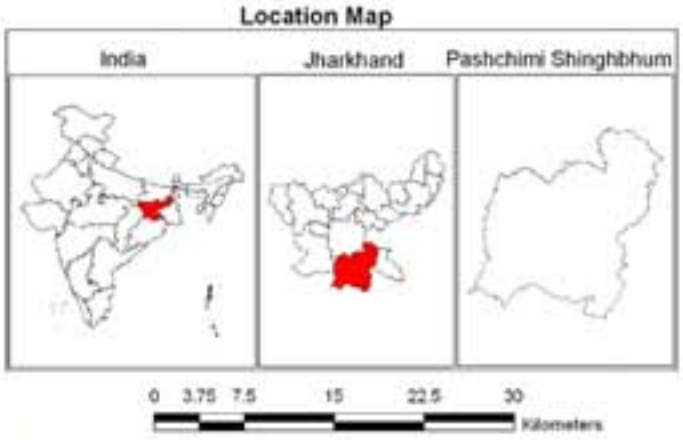
District : Pashchimi Shinghbhum

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

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

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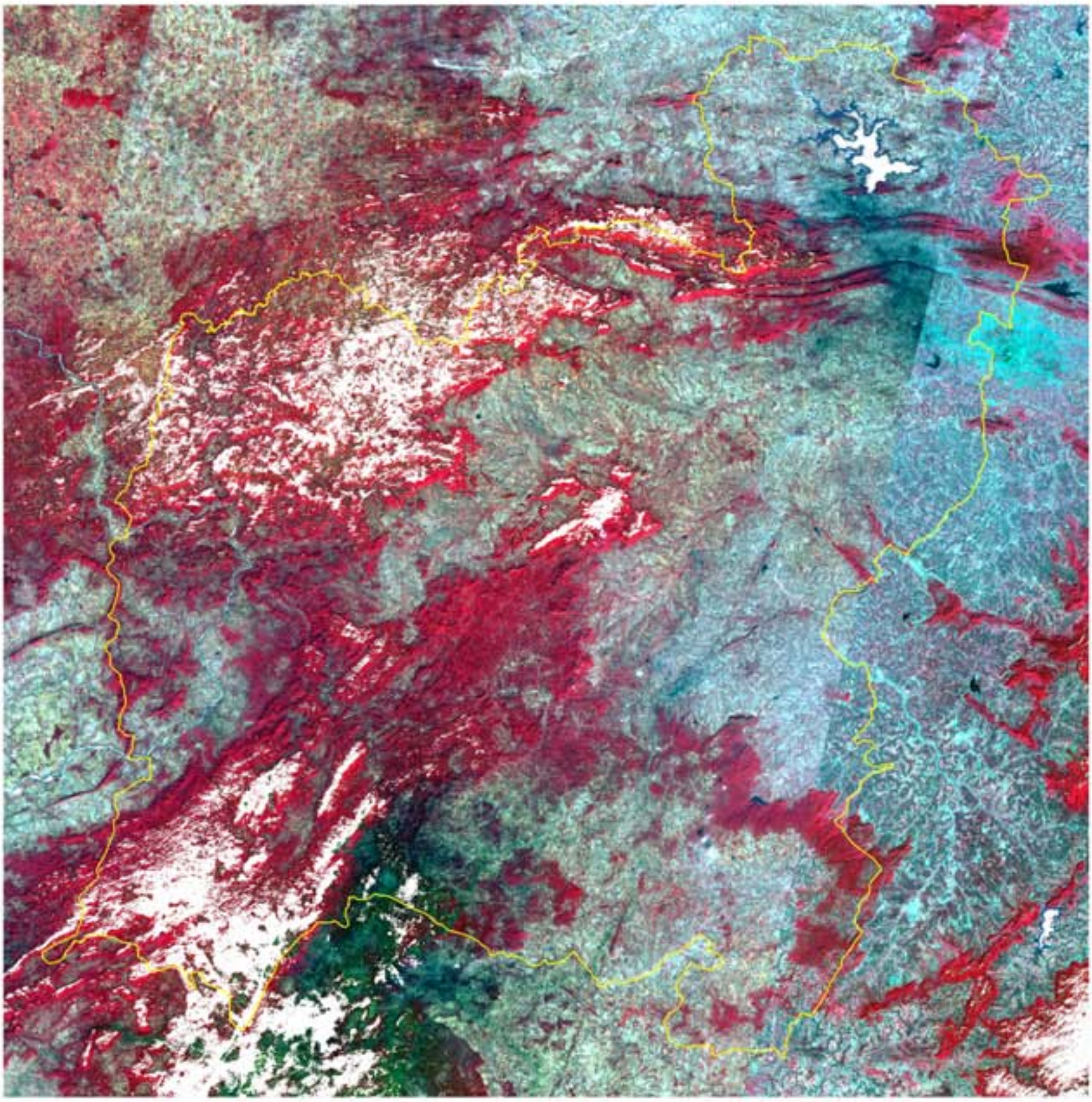
Government of India



IRS P6 LISS-III post monsoon data (2006)

7.1.18 Purbi Singhbhum

The total geographical area of Purbi Singhbhum district is 3,533 Sq. km out of which wetlands account for 6749 ha of area (Table 22). This include 5801 ha by wetlands > 2.25 ha and the rest by the wetlands smaller than 2.25 ha. Singularly, River/Stream (4677 ha) accounts for about 69 per cent of area under wetlands in this district. Reservoir/Barrage contributes about 13 per cent to the wetland extent followed by Tank/Pond (about 4 %). Details are given in Table 23. In addition, 948 wetlands smaller than 2.25 ha have also been discerned. The major wetland types are River/Stream, Reservoirs and Tanks/Ponds. The smaller wetlands (< 2.25 ha) form an important fraction that contribute about 14 per cent to the wetland extent in this district. Open water has shown a 30 per cent reduction in extent from post-monsoon to pre-monsoon season. Aquatic vegetation has registered a steep increase from 30 ha in post-monsoon to 170 ha in pre-monsoon. Open water is dominated by moderate turbidity (5215 ha) followed by high (557 ha) and low turbidity was not exhibited open water in this district. The pre-monsoon open water is moderately turbid (4065 ha) with the presence of low and high.

Table 23: Area estimates of wetlands in Purbi Singhbhum

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	7	4677	69.30	4677	3127
	1200	**Inland Wetlands -Man-made**					
7	1201	Reservoirs/Barrages	34	866	12.83	837	700
8	1202	Tanks/Ponds	37	258	3.82	258	238
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	**78**	**5801**	**85.95**	**5772**	**4065**
		Wetlands (<2.25 ha), mainly Tanks	948	948	14.05	-	-
		Total	**1026**	**6749**	**100.00**	**5772**	**4065**

Area under Aquatic Vegetation	30	170

Area under turbidity levels		
Low	-	-
Moderate	5215	4065
High	557	-

State : Jharkhand

WETLAND MAP

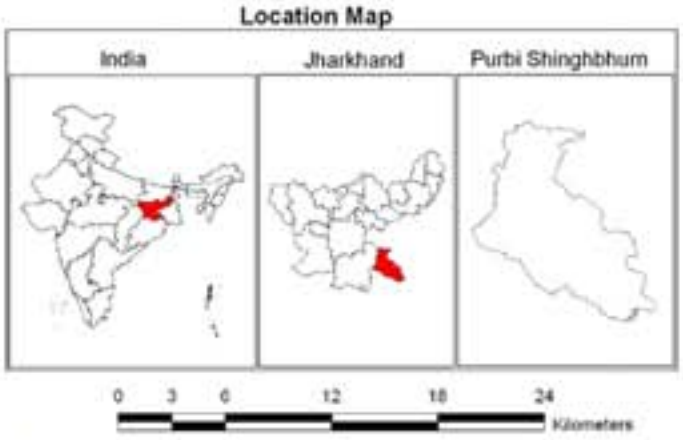
District : Purbi Shinghbhum

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

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

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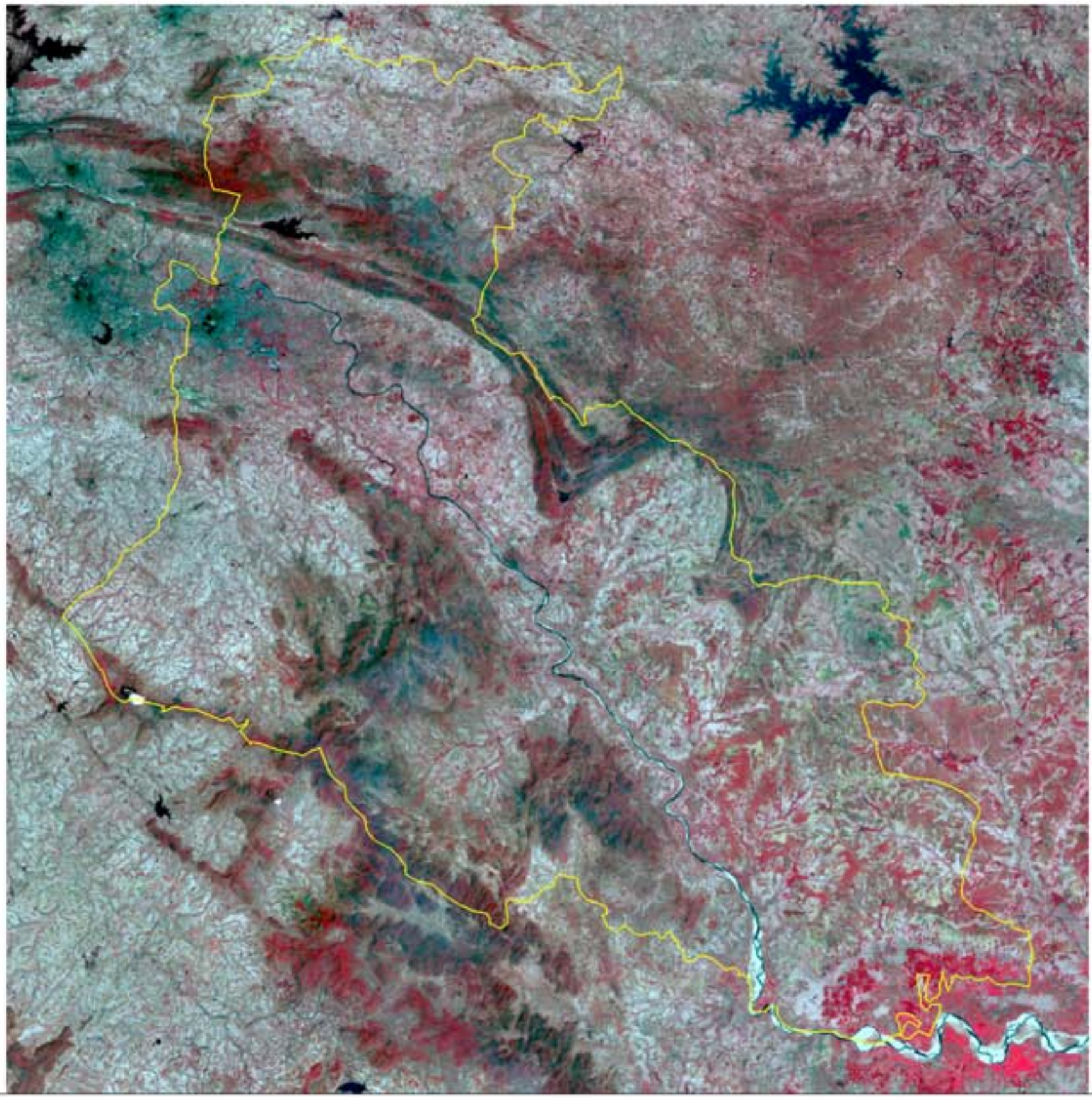


IRS P6 LISS-III post monsoon data (2006)

MAJOR WETLAND TYPES

8.0 MAJOR WETLAND TYPES OF JHARKHAND

Major wetland types observed in the state are River/Stream, Reservoirs, Tanks/Ponds, Lakes, Riverine wetlands, Waterlogged-Natural, Ox-bow Lakes, Waterlogged-Man-Made and Aquaculture Ponds . few of these are depicted 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 and ground truth data of different wetland types are shown in Plates 2a, 2b and 2c, 2d.

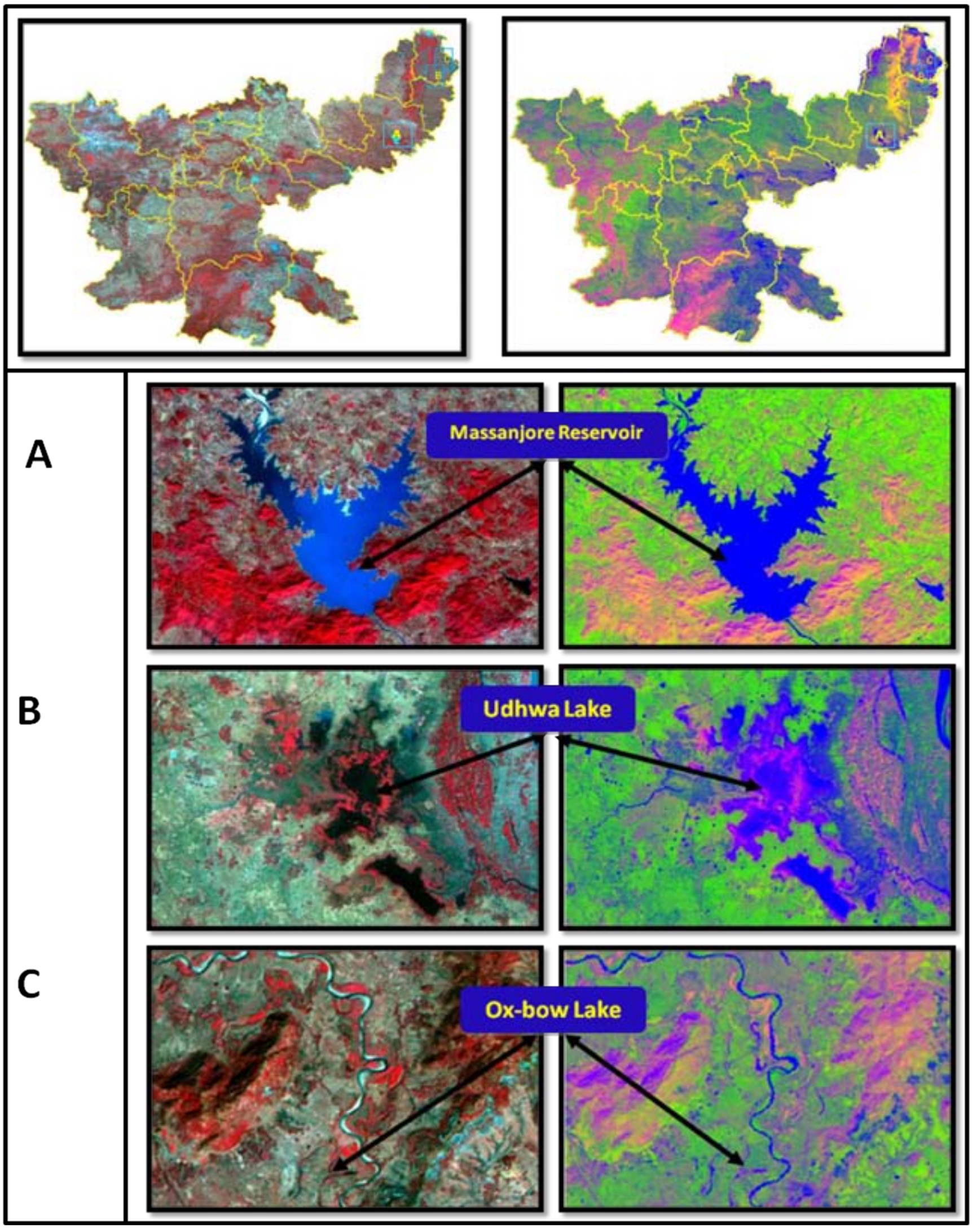


Plate - 1: Major wetland types of Jharkhand

Sr. No.	Description	Field photograph
1.	Wetland Type : Reservoir Name : Getulsud Location : longitude: 85°31'17.874"E latitude : 23°26'38.601"N Turbidity : Moderate	
2.	Wetland Type : Reservoir Name : Chinda Location : longitude: 84°31'17.873"E latitude : 22°35'33.945"N Turbidity : Low	
3	Wetland Type : Reservoir Name : Kansjor Location : longitude: 84°26'47.64"E latitude : 22°43'22.68"N Turbidity : Moderate	
4	Wetland Type : Reservoir Name : Massanjore Location : longitude: 87°18'39.3"E latitude : 24°6'29.9"N Turbidity : Moderate	

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

Sr. No.	Description	Field photograph
5.	Wetland Type : Reservoir Name : Tilaiya Location : longitude: 85°25'56.201"E latitude : 24°20'38.8"N Turbidity : Moderate	
6.	Wetland Type : Reservoir Name : Maithon Location : longitude: 86°47'58.499"E latitude : 23°46'44.501"N Turbidity : Moderate	
7.	Wetland Type : Reservoir Name : Tenughat Location : longitude: 85°50'1.091"E latitude : 23°43'51.677"N Turbidity : Moderate	
8.	Wetland Type: Reservoir Name: Hesla Location : longitude: 85°17'27.6"E latitude : 23°36'53.302"N Turbidity : Moderate	

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

Sr. No.	Description	Field photograph
9.	Wetland Type : Lake Name : Udhwa Location : longitude: 87° 48' 55.500" E latitude : 24° 58' 6.400" N Turbidity : Moderate Aquatic Weeds : *Eichhornia crassipes*, *Salvinia cuculata*, *Marsilea minuta* etc Fauna : Hemiptera, Coleptera, Diptera etc	
10.	Wetland Type : Lake Name : Berail Jhil Location : longitude: 87° 49' 18.100" E latitude: 24° 59' 16.300" N	
11.	Wetland Type : Lake Name : Ranchi lake Location : longitude: 85°19'11.848"E latitude : 23°22'7.925"N Turbidity : High	
12.	Wetland Type : Aquaculture Pond Location : longitude: 85°19'18.566"E latitude : 23°20'35.046"N Turbidity : High Fish Type : Rohu, Catla	

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

Sr. No.	Description	Field photograph
13.	Wetland Type : Tank/Ponds Location : longitude: 84°38'41.27"E latitude : 22°53'2.411"N Aquatic Vegetation : Water Hyacinth and Lotus Turbidity : High	
14.	Wetland Type : Tank/Pond Location : longitude: 85°32'45.564"E latitude : 23°37'1.966"N Turbidity : High	
15.	Wetland Type : River Name : Ganga Location : longitude: 87°46'2.293"E latitude : 25°6'12.582"N Turbidity : Moderate	
16.	Wetland Type : River Name: Sankh Location : longitude: 84°30'25.308"E latitude : 22°39'47.639"N Turbidity : Moderate	

Plate 2d: Field photographs and ground truth data of different wetland types in Jharkhand

IMPORTANT WETLANDS OF JHARKHAND

9.0 IMPORTANT WETLANDS OF JHARKHAND

Udhwa lake (Bird Sanctuary), Getalsud, Tenughat, Panchet, Konar, Tilaiya, Maithon, Masanjore, Malay, Kansjore, and Hatia reservoirs are most important wetland areas of Jharkhand state. Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of each wetland sites.

Udhuwa lake Bird Sanctuary which is the single Bird Sanctuary of Jharkhand State is situated at about 42 km from Sahibgunj. It is situated on the bank of the Ganges about 10 kms southeast of Rajmahal. Two water bodies, namely Pataura and Barhale constitute the 5.65 km^2 Udhuwa lake bird sanctuary. Pataura Lake is perennial and the average depth is about 2 meter. (Kumar *et al*, 2004)

Damodar River comprises five reservoirs (Konar,Tilaiya,Maithon,Panchet,Durgapur) at different stretches to store the rain water and protect the lower valley from floods. Out of five major reservoirs, Tenughat and Panchet are located on Damodar River, Tilaiya and Maithon on Barakar and one on Konar river, a tributary of Damodar river. Tenughat reservoir is mainly constructed to meet the water requirements of Bokaro Steel Plant while Durgapur barrage was constructed on Damodar River to meet the irrigation water requirements of West Bengal. Some important lakes also exist to provide surface water for drinking and industrial purposes out of which Topchanchi and Nalkari lakes are prominent. Topchanchi Lake serves as source of drinking water for Jharia coalfields whereas water from Nalkari is used for Patratu Thermal Power Plant.

Getalsud reservoir is located at 23° 27' N and 85° 33' E, across the river Subarnarekha, 40 km east of Ranchi River Subarnarekha, the main source of inflow, originates at Nagari, in the Chhotanagpur plateau of Jharkhand, about 50 km upstream of Getlasud dam. (Ahmad and Singh, 1992)

Konar dam is situated in the Hazaribagh district. The inflowing river Konar is a seasonal stream joining the river Damodar. Tilaiya dam is constructed across the river Barakar which is rising from the hilly forests of Hazaribagh district, at an elevation of 610 m. (Ahmad and Singh, 1992)

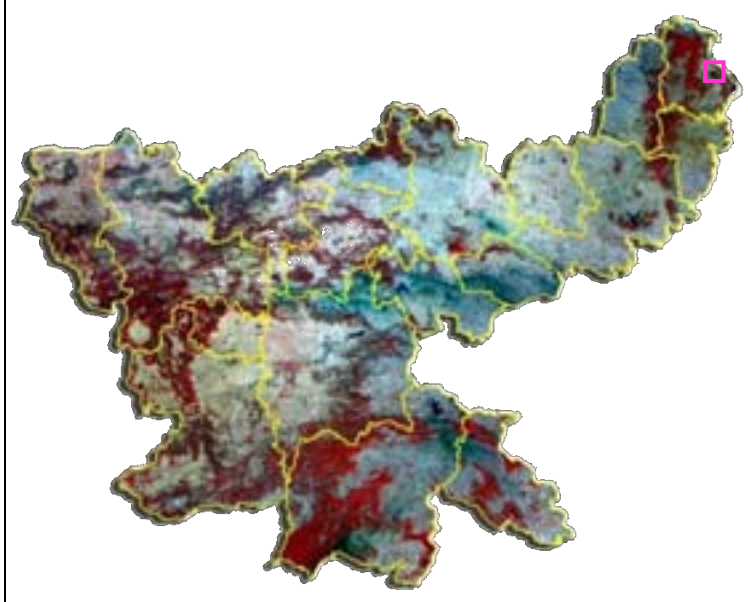
Tenughat Reservoir is situated near Tenu village about 8 miles west to the Bokaro thermal power station in Giridih district of Jharkhand State. It was constructed on Damodar river in the year 1971, to utilize the water resources of river in Damodar and its tributaries to fulfill the needs of Bokaro thermal power station, steel plant and its employees. (Ahmad and Singh, 1992)

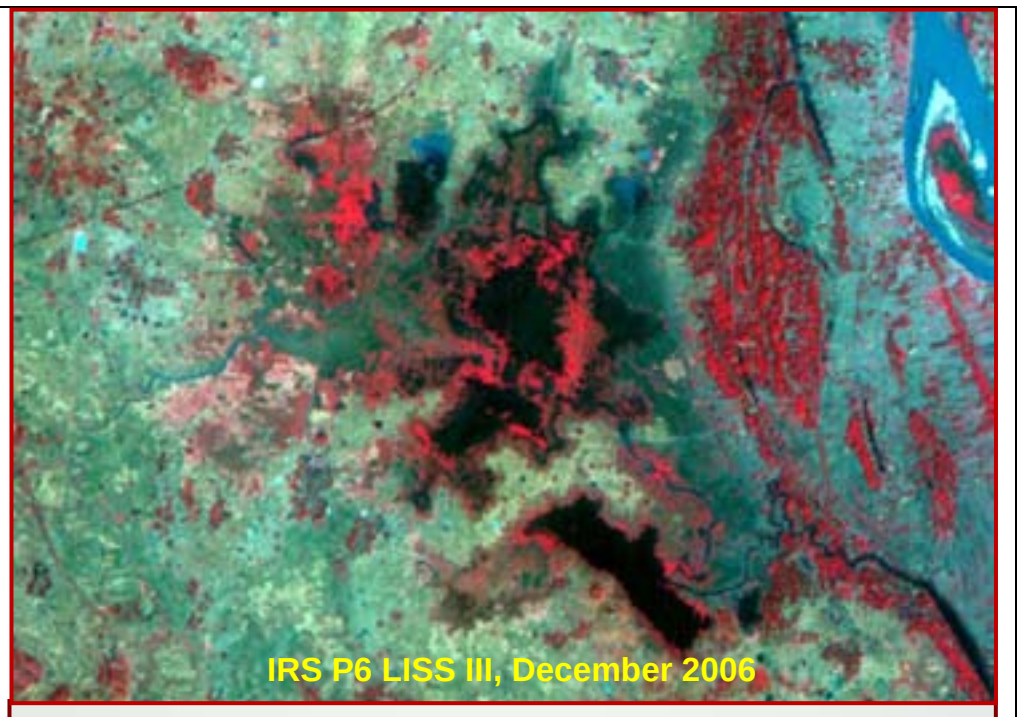
Masanjore dam (also known as Canada dam) was constructed on the river Mayurakshi. The dam was constructed with two primary objectives (a) to generate hydro-electricity and (b) to facilitate irrigation in Jharkhand and West Bengal.

Details of each wetland and wetland map of 5 km buffer area are shown in plates 3-20.

9.1 Udhwa Lake (Bird Sanctuary)

	Name : Udhwa Lake (Bird Sanctuary)
1	**Location** : 87° 48' 55.500" E, 24° 58' 6.400" N Sahibganj known as “Udhwa lake bird sanctuary” in the year 1991. The Sanctuary is situated at about 42 km from sahibganj . It is situated on the bank of the Ganga about 10 kms southeast of Rajmahal. Two water bodies, namely Pataura and Barhale constitute the 5.65 km^2 Udhwa lake bird Sanctuary.
2	**Area:** 1605 ha
3	**Wetland type** : Lake (Bird Sanctuary)
4	**Flora:** The lake is infested with aquatic macrophytes comprising emergent, free floating and submerged forms. Water hyacinth was found to be the dominant form. Over all 50% of the lake surface was covered with aquatic weeds.
5	**Fauna:** It is a home to a variety of birds including different mynas, brahminy kites, Cattel Egret, Pond Heron, Purple Heron, Egret , Open Billed stock, White Ibis, Dab chick or little Grebe, fishing eagles, hose swifts and palm swifts flying at dizzying speeds. A speciality of the sanctuary is Siberian birds flocking from different parts of the world.
6	**Major fish species:** Udhwa lake seems to be rich in fish and fish spawn.Some common fishes of the lake are Rohu(*Labeo rohita*), Catla (*Catla catla*) , Tengra,(*Mystus cavasius*) Bata(*L. bata*), reba(*C. retra*) , Mirka (*Cirrihinus mrigala*) etc.





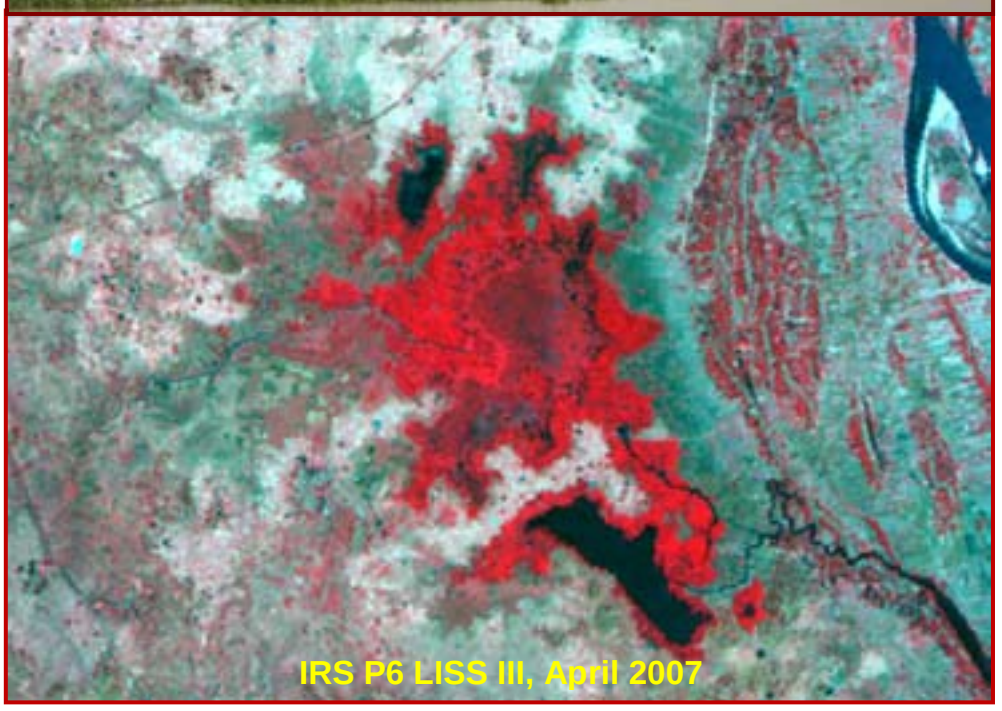
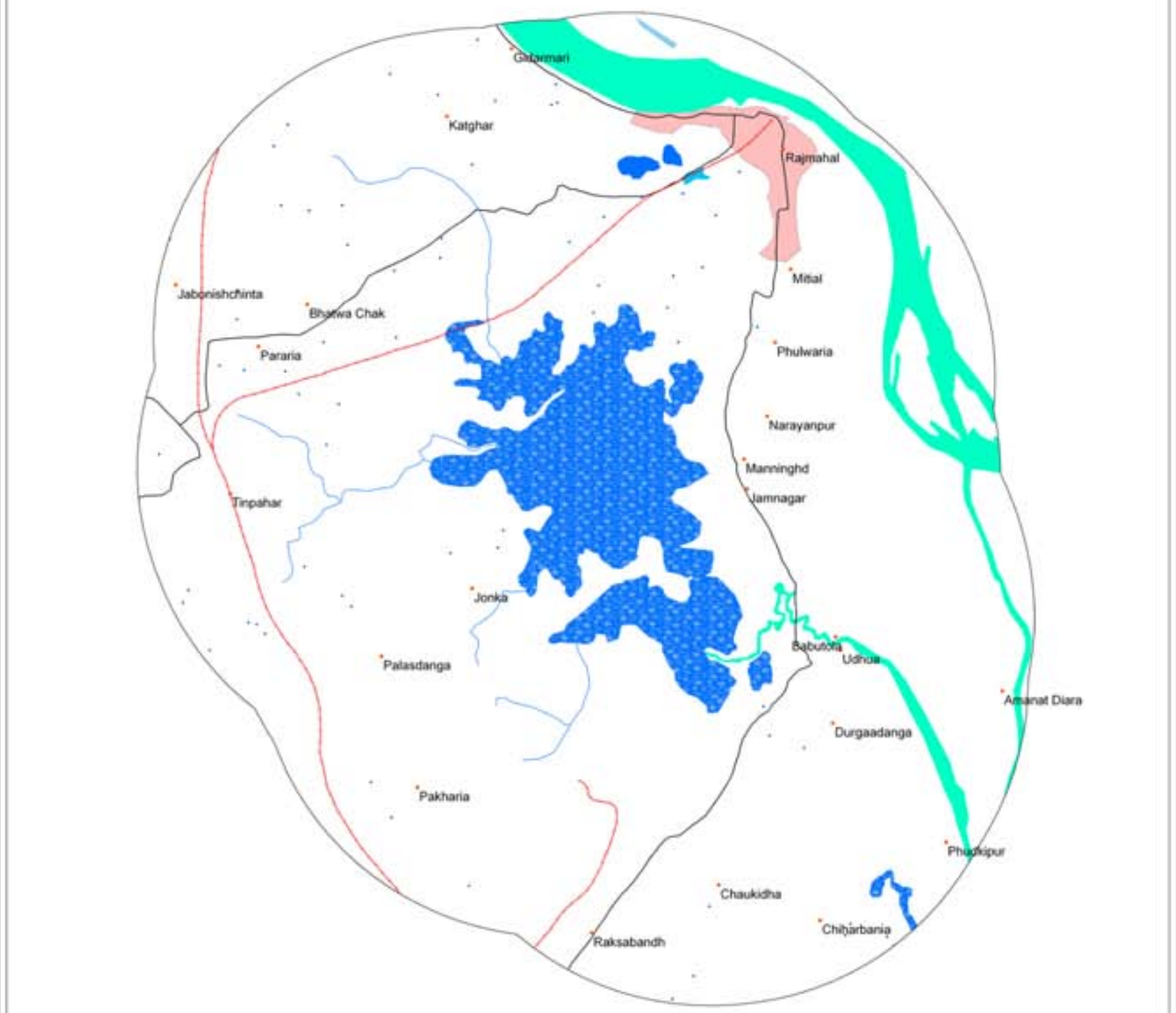


Plate 3: Udhwa Lake (Bird Sanctuary)

State : Jharkhand

WETLAND MAP

Udhwa Lake

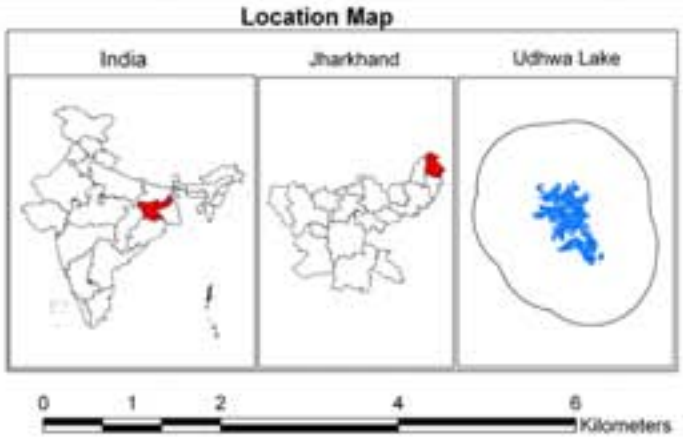


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

- Wetlands (<2.25 ha)
- Settlements
- Canal
- Drainage(line)
- Railway
- Roads
- District Boundary
- Towns/Settlements

Location Map



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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad
and
Jharkhand Space Applications Centre, Ranchi

Sponsored By:
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Plate 4: Wetland map - 5 km buffer area of Udhwa Lake (Bird Sanctuary)

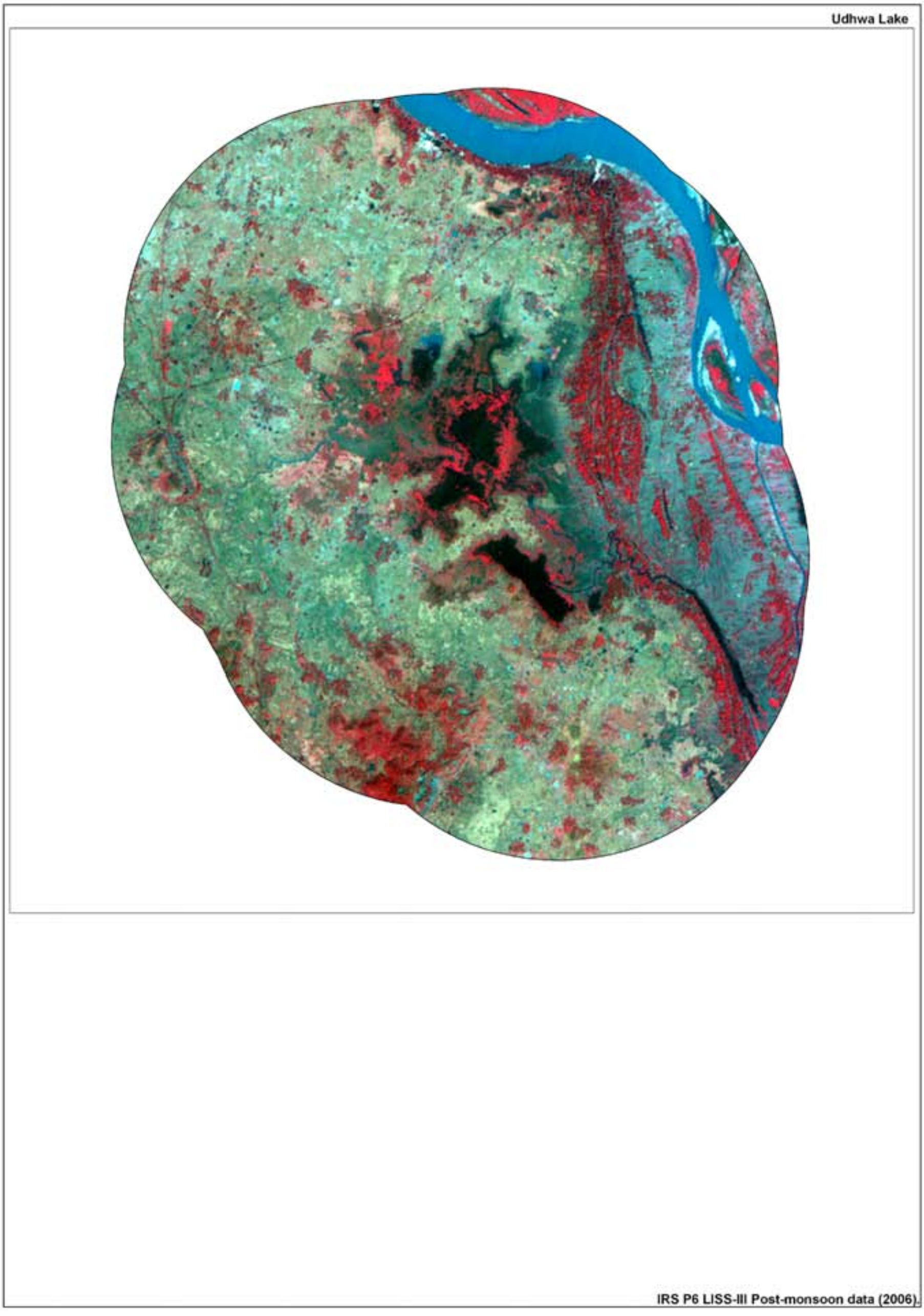


Plate 5: IRS LISS-III FCC – 5 km buffer area of Udhwa Lake (Bird Sanctuary)

9.2 Getalsud Reservoir

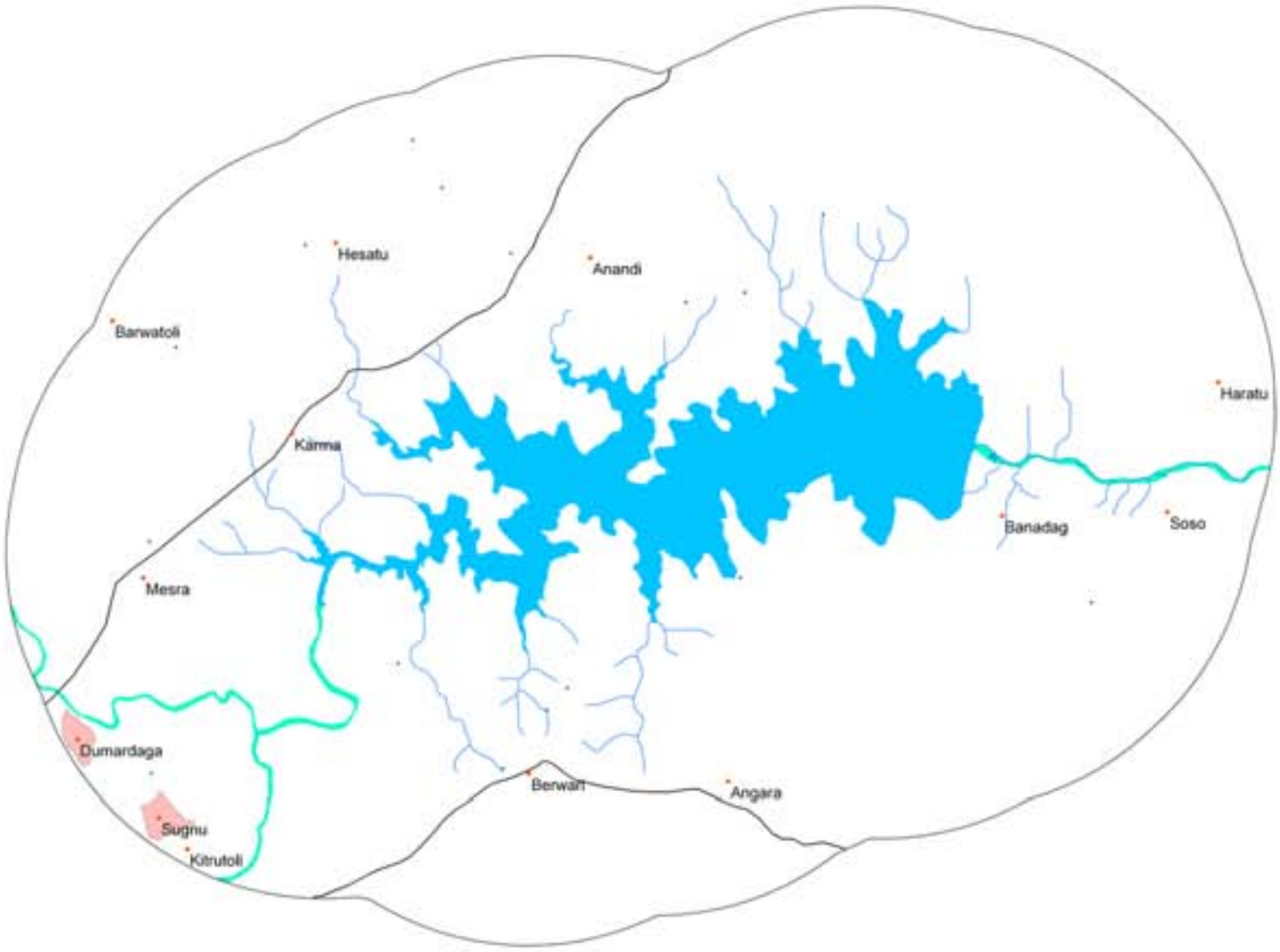
	Name : Getalsud
1	**Location** : 85°31'17.874"E, 23°26'38.601"N Getalsud reservoir is situated in 40 km east of Ranchi city.
2	**Name of the River:** Subernarekha
3	**Area:** 2302 ha
4	**Wetland type :** Reservoir
5	**Average Annual Rainfall :** 100 to 1198 cm
6	**Plankton:** Diatoms have the maximum species diversity, followed by Chlorophyceae and blue- greens. Desmids and Dinophyceae (Ceratium sp.) are also present. Zooplankton is represented by 12 genera of rotifers, 6 of protozoa, 5 cladocerans and 2 of copepods.
7	**Fauna:** Fish, insects and algae are a rich source of food for migratory birds, notable among which are Little Grebe, Bank Myna, Pied Myna, Common Crane, Cattle Egret, Tufted Pochard , Cotton Teal, Shoveller, Little Grebe, Palm Swift etc.(www. Zoosprint.org ,)
8	**Major fish Species:** Rohu(*L. Rohita*), Catla (*Catla catla*), Mirka (*Cirrhinus mrigala*),Reba (*Cirrhinus reba*) etc.
9	**Soil Type:** The bottom soil is acidic and poor in organic carbon (0.46 to 0.60 %). Available phosphorus and nitrogen are present in modest quantities (2.45 to 6.08 mg 100 g^{-1} and 24.38 to 35.06 mg 100 g^{-1}). The morphometric and edaphic indicators of productivity and the estimates on the standing crop send conflicting signals on the status of the water body.
10	**Benthic fauna:** Bottom substrate in the lotic sector is soft and rich in organic matter, comprising decaying vegetation, but during monsoons, silt deposition is reported to blanket the organic matter. Density of benthic organisms is high in the lotic sector, their number attenuating towards the lentic sector.

Plate 6: Getalsud Reservoir

State : Jharkhand

WETLAND MAP

Getalsud Reservoir

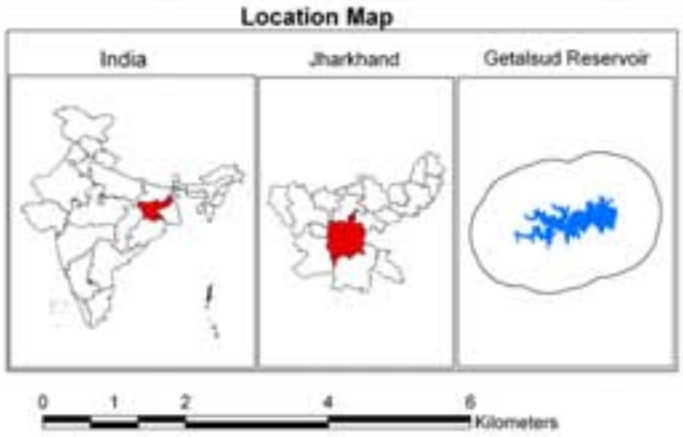


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad
and
Jharkhand Space Applications Centre, Ranchi

Sponsored By:
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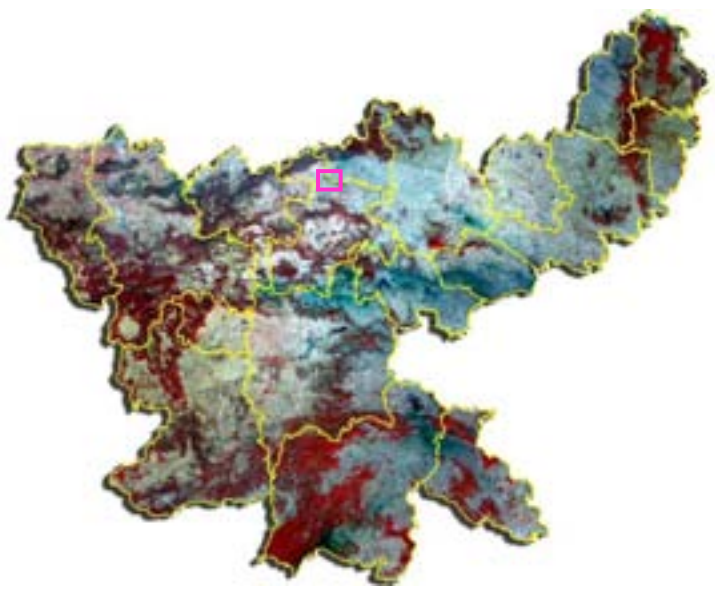
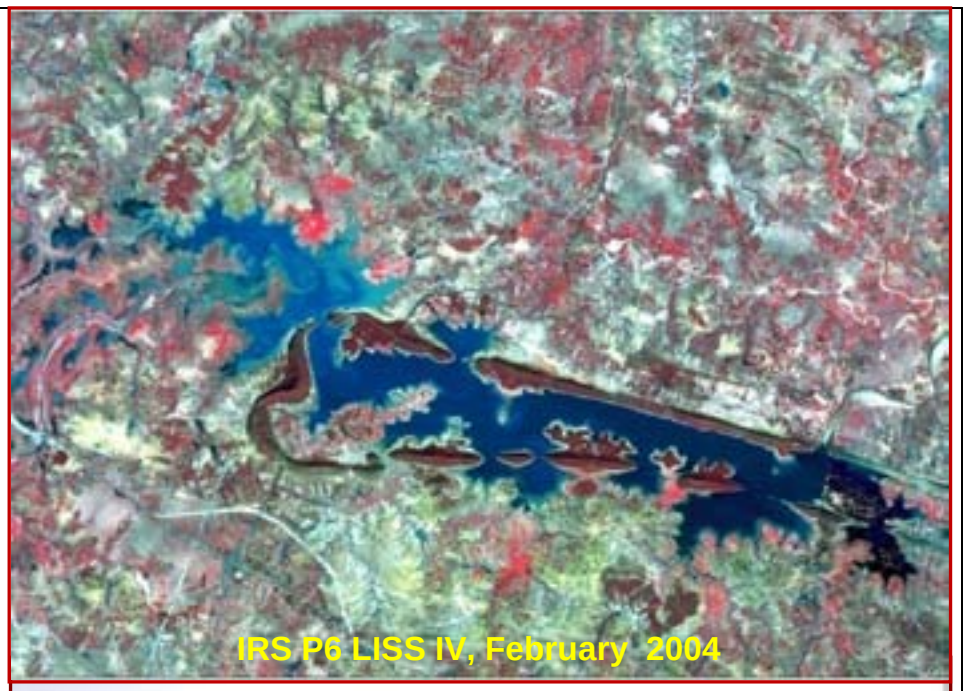
Plate 7: Wetland map - 5 km buffer area of Getalsud Reservoir

Plate 8: IRS LISS-III FCC – 5 km buffer area of Getalsud Reservoir

9.3 Tilaiya Reservoir

	Name : Tilaiya
1	**Location** : 85°25'56.201"E 24°20'38.8"N Tilaiya Dam is situated in Hazaribagh district.
2	**Name of the River:** Barakar
3	**Area:** 4865 ha
4	**Wetland type** : Reservoir
5	**Average Annual Rainfall** : 127 cm.
6	**Major Fish Species:** The major fish species were Catla (*Catla catla*), Mirka (*Cirrhinus mrigala*) *Labeo calbasu*, Rohu (*L. rohita*), Bata (*L. bata)*, *L. dyocheilus, Puntius sarana, Cyprinus carpio, Notopterus notopterus and Ompok bimaculatus* etc.
7	**Soil Characteristics:** The bottom soil is acidic (pH 5.6 to 5.9) and silty clay loam with low organic carbon (0.31 to 0.50%) and available phosphorus (3.0 mg P2O5 100 g-1). Organic nitrogen is in medium productivity range (0.073 to 0.101%). Water is rich in ionic concentration. Alkalinity (53.5 mg 1-1) and specific conductivity (98.7 to 211 µmhos) are indicative of the the reservoir's proclivity to good organic productivity. Values of nitrate (0.25 mg 1-1) and phosphate (0.03 mg 1-1) are satisfactory. Gross primary productivity is estimated at 199 to 300 mg C m3 day-1.





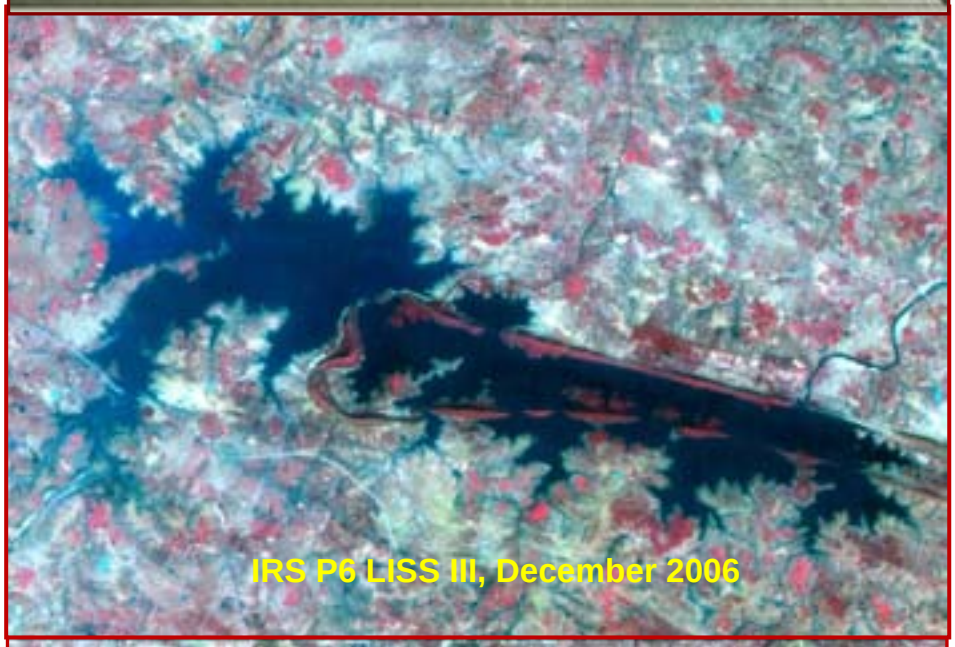
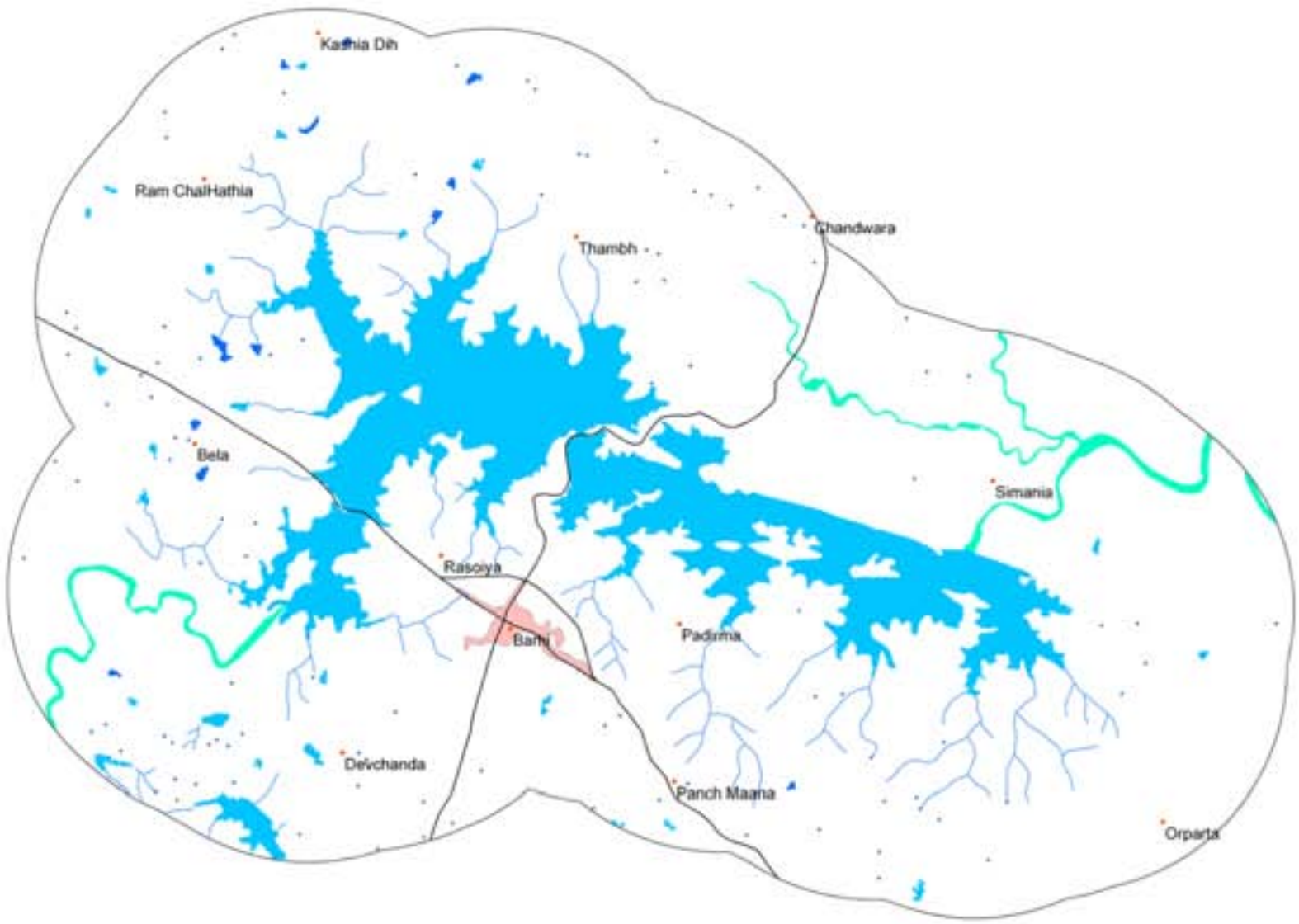


Plate 9: Tilaiya Reservoir

State : Jharkhand

WETLAND MAP

Tilaiya Reservoir

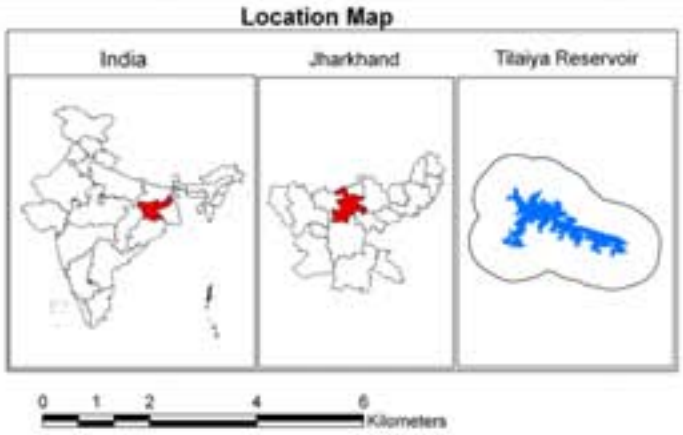


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad
and
Jharkhand Space Applications Centre, Ranchi

Sponsored By:
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Plate 10: Wetland map - 5 km buffer area of Tilaiya Reservoir

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

9.4 Konar Reservoir

	Name : Konar
1	**Location** : 85°45'50.731"E 23°55'50.85"N Konar Dam is situated in Hazaribagh district.
2	**Name of the River:** Konar
3	**Area:** 2149ha
4	**Wetland type** : Reservoir
5	**Plankton:** The plankton in Konar is characterised by a poor species diversity and an overwhelming dominance of *Microcystis aeruginosa* and *Diaptomus* sp. among the phyto- and zooplankton respectively.
6	**Major fish:** The constituent species were Catla (*Catla catla),* Mirka *(Cirrhinus mrigala), Labeo calbasu,* Rohu (*L. rohita*), *Bata* (*L. bata*), *L. dyocheilus*, *Puntius sarana*, *Cyprinus carpio*, *Notopterus notopterus* and *Ompok* bimaculatus etc.
7	**Ionic Concentration:** Konar is the richest in ionic concentration. The total alkalinity varies in the range of 43.5 to 83.0 mg 1-1 and specific conductivity within 81.20 to 147.6µmos during different seasons of the year.
8	**Soil Type:** Basin soil of Konar reservoir is sandy loam to clay with 0.3 to 0.9% of organic carbon. The concentration of available phosphorus is a low 1.2 to 8.0 mg P_2O_4 100 g^{-1}. Organic nitrogen of 0.069 to 0.101% is medium to high and pH of soil is acidic (5.4 to 6.0).

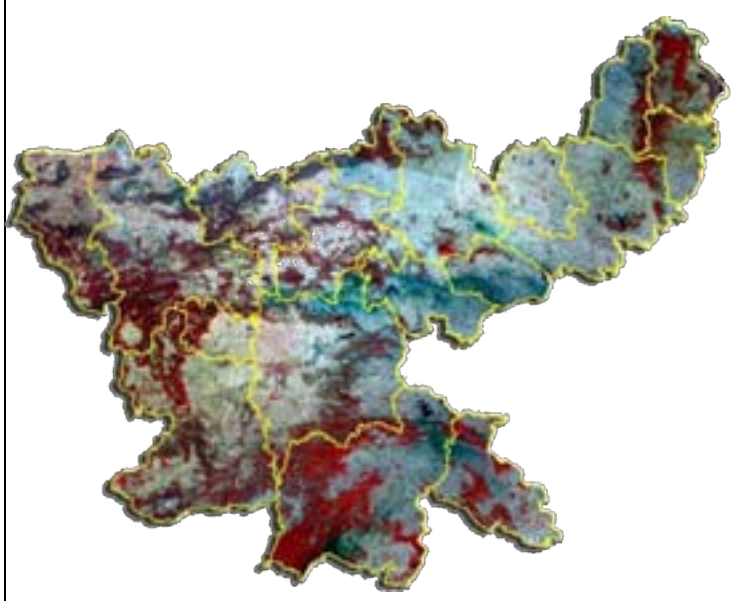
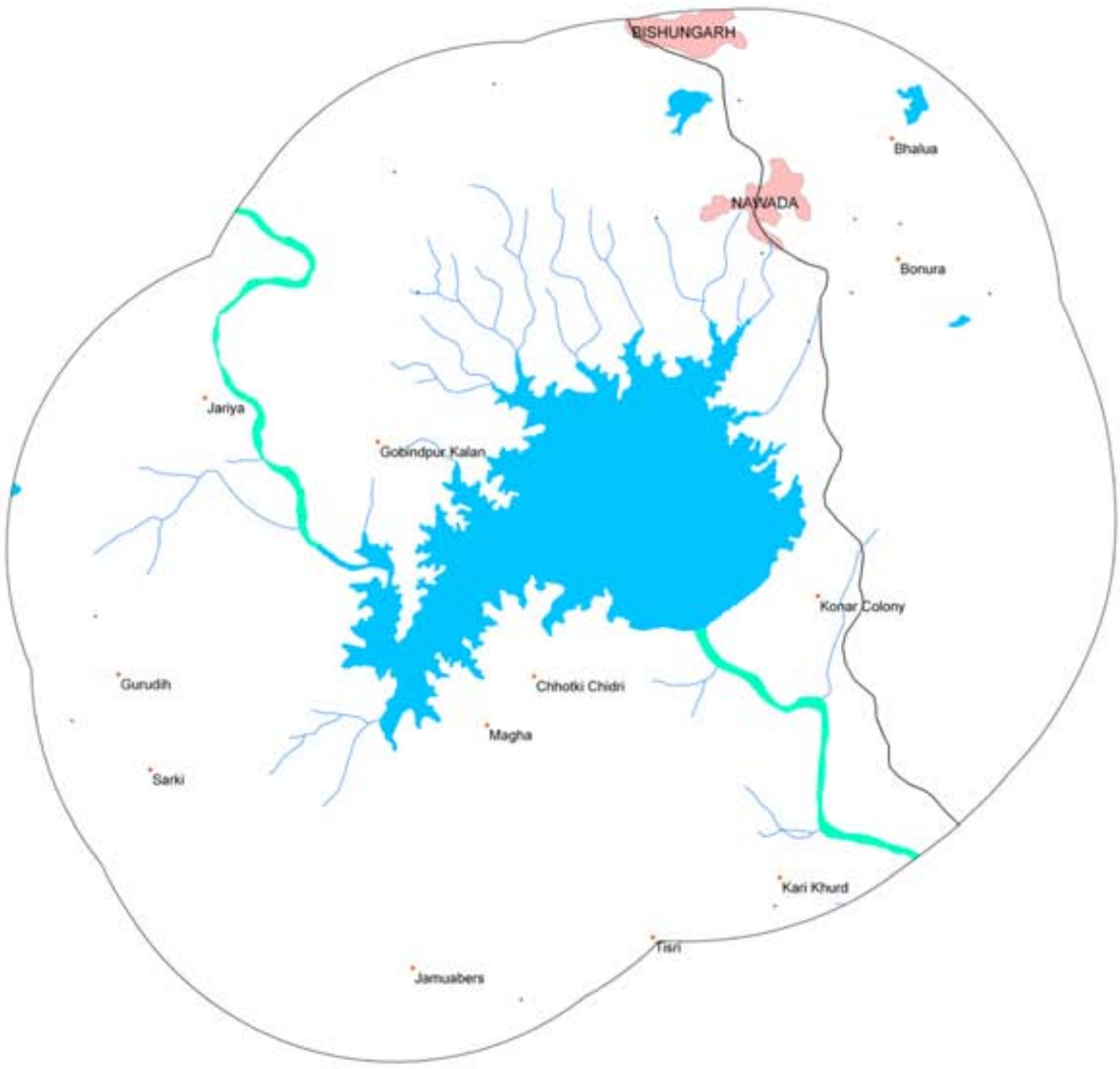


Plate 12: Konar Reservoir

State : Jharkhand

WETLAND MAP

Konar Reservoir

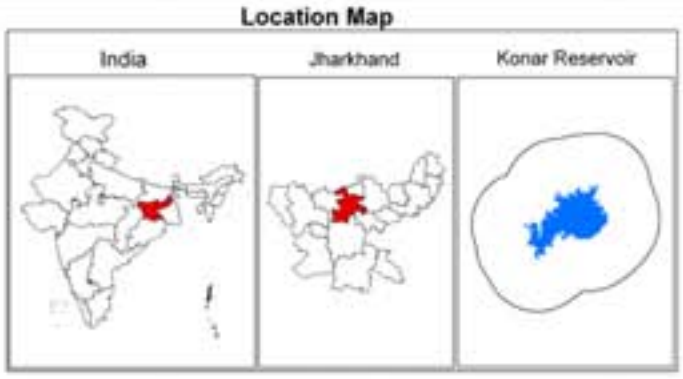


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



0 1 2 4 6 Kilometers

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

Prepared By :
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Jharkhand Space Applications Centre, Ranchi

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Government of India

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

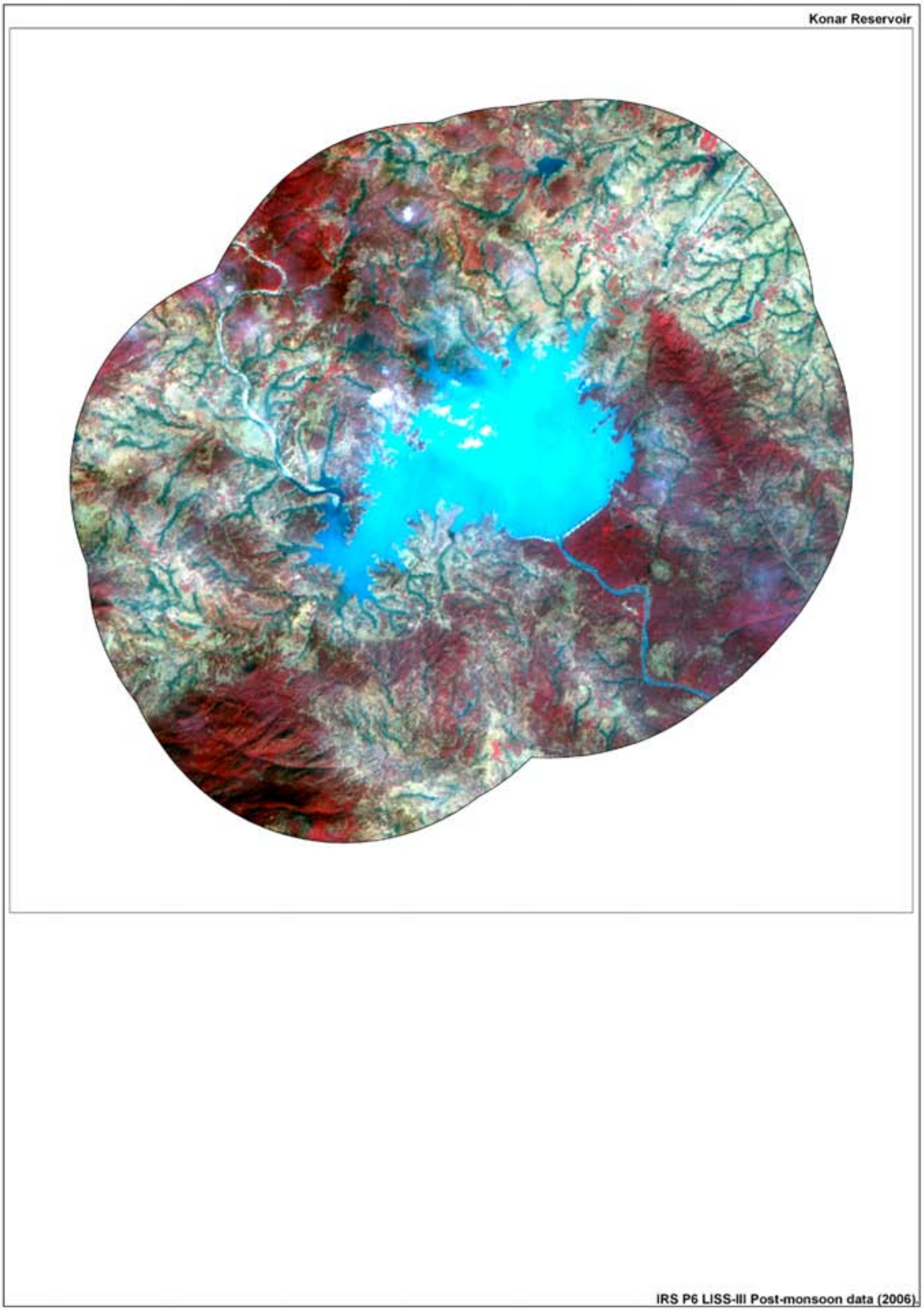


Plate 14: IRS LISS-III FCC – 5 km buffer area of Konar Reservoir

9.5 Tenughat Reservoir

	Name : Tenughat
1	**Location :** 85°50'1.091" E 23°43'51.677" N Tenughat Dam is situated in Bokaro district.
2	**Name of the river:** Damodar
3	**Area:** 3814 ha
4	**Wetland type :** Reservoir
5	**Average Annual Rainfall:** 1320mm
6	**Plankton:** In the Reservoir free floating phytoplanktons and zooplanktons were having a good growth. The phytoplanktons found in the reservoir were *Spirogyra*, C*hlamydomonas lemna*, *Ajola*, *Hydrilla*, *Vacillinaria*, *Chara*, and *potamojiton*. This vegetation was good food for major craps.
7	**Major Fish Species:** Catla *(C. catla),* Mirka *(C. mrigala),* Rohu *(L. rohita), L. calbasu*, Bata*(L. bata), C. carpio ,P. sarana, M. aor, W. attu, B. bagarius* etc.
8	**Irrigation:** Considering the necessity of irrigation in the region, cultivable land between Tenu-Bokaro canal and river Damodar is being irrigated. Only an area of 800 hectares is being irrigated now.

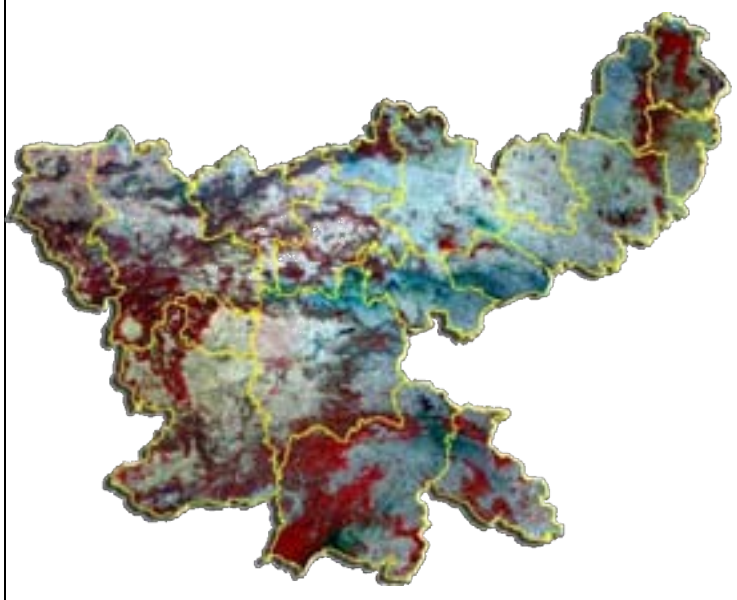
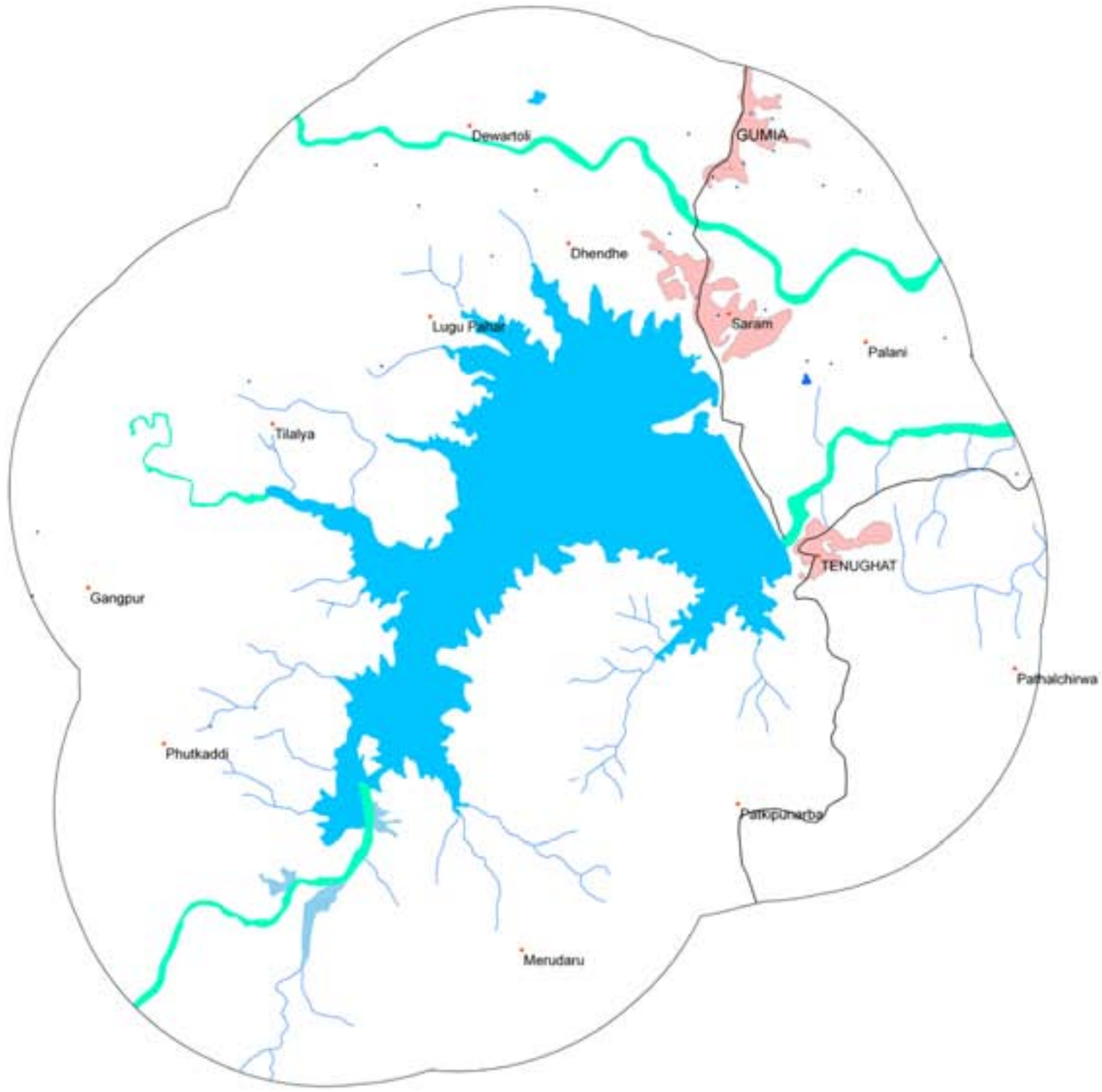


Plate 15: Tenughat Reservoir

State : Jharkhand

WETLAND MAP

Tenughat Reservoir

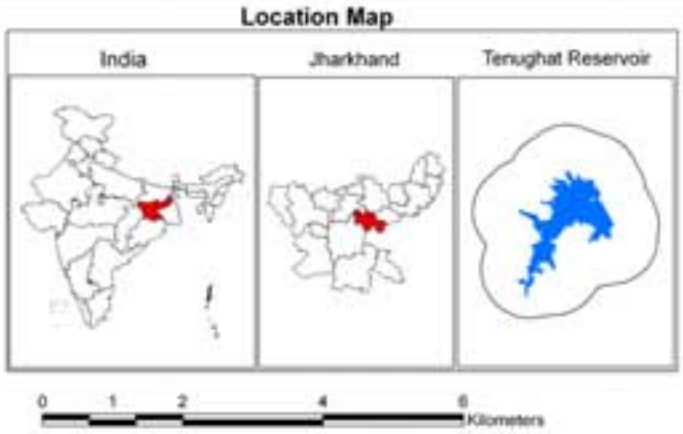


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Legend

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

Location Map



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

Prepared By :
Space Applications Centre (ISRO), Ahmedabad
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Jharkhand Space Applications Centre, Ranchi

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

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

9.6 Massanjor Reservoir

	Name : Massanjor
1	**Location :** 87°18’39.3”E, 24°6’29.9”N Masanjore reservoir is situated in Dumka District of Jharkhand.
2	**Name of the River:** Mayurakshi
3	**Area:** 5027
4	**Wetland type** : Reservoir
5	**Average Annual Rainfall** : 1447mm
6	**Plankton:** *Agmenellum sp., Anabena sp. Ceratophyllum sp., Dentella sp. Diatomella sp.*
7	**Major Fish Species:** *W. attu, C. catla, N. chitala, H. fossilus, Papda, C.mirgala, L. rohita , M.aor etc.*
8	**Major Functions:** To generate hydro-electricity and to facilitate irrigation in Jharkhand and West Bengal.
9	**Major Weeds found were***: Ipomia aquatica, Myriophyllum, Limnathemu, Potamogetan, Hydrilla and Ceratophyllum.*

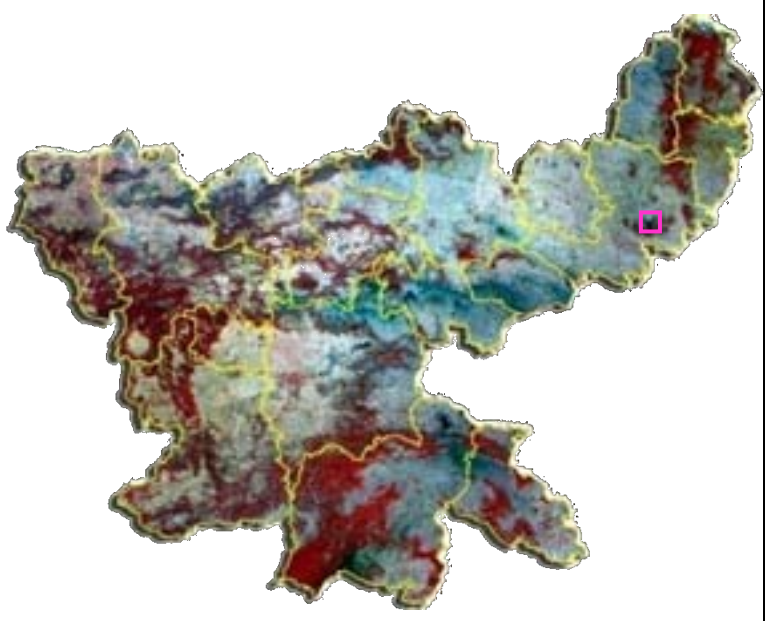
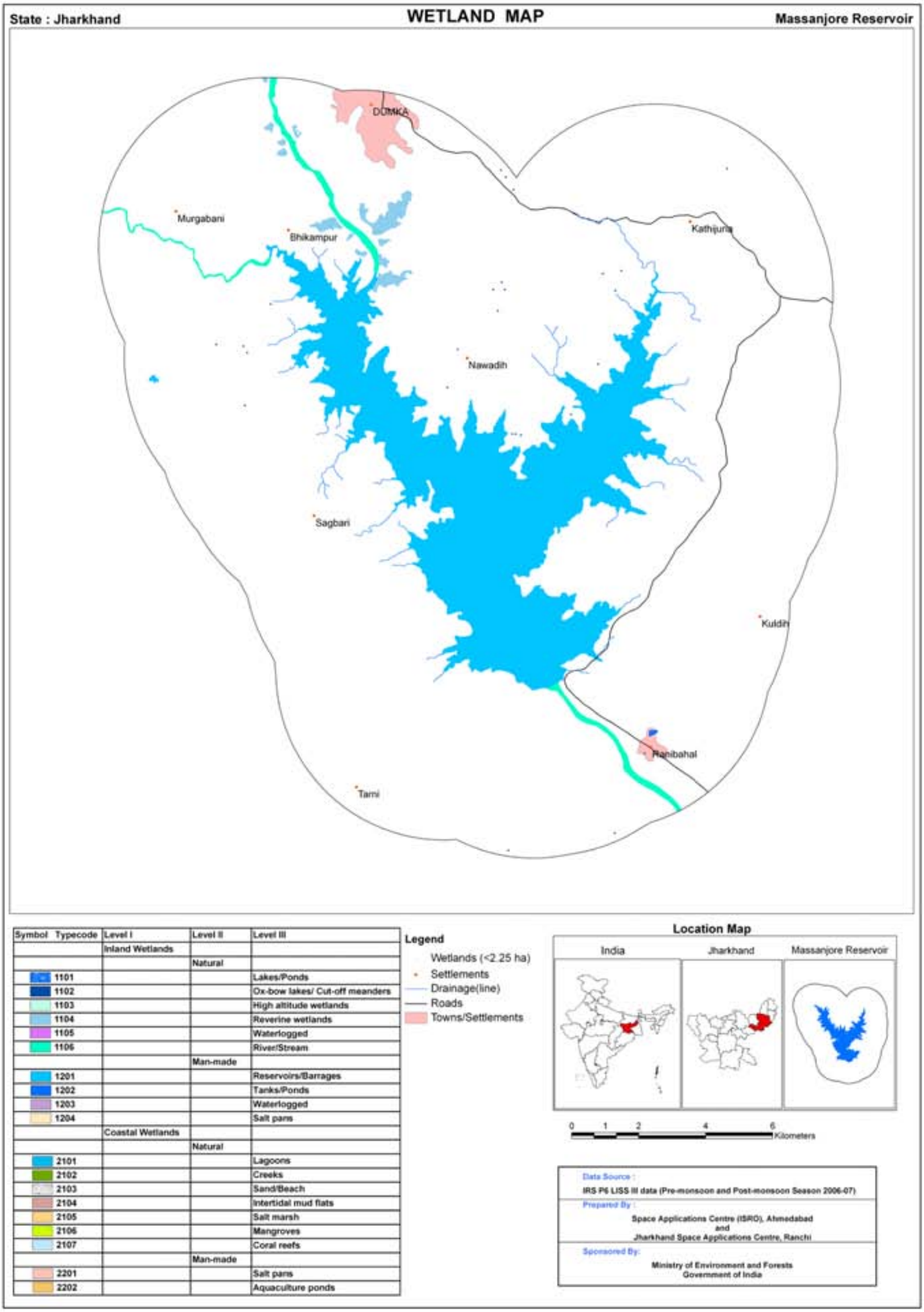


Plate 18: Massanjor Reservoir



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

Plate 19: Wetland map - 5 km buffer area of Massanjor Reservoir

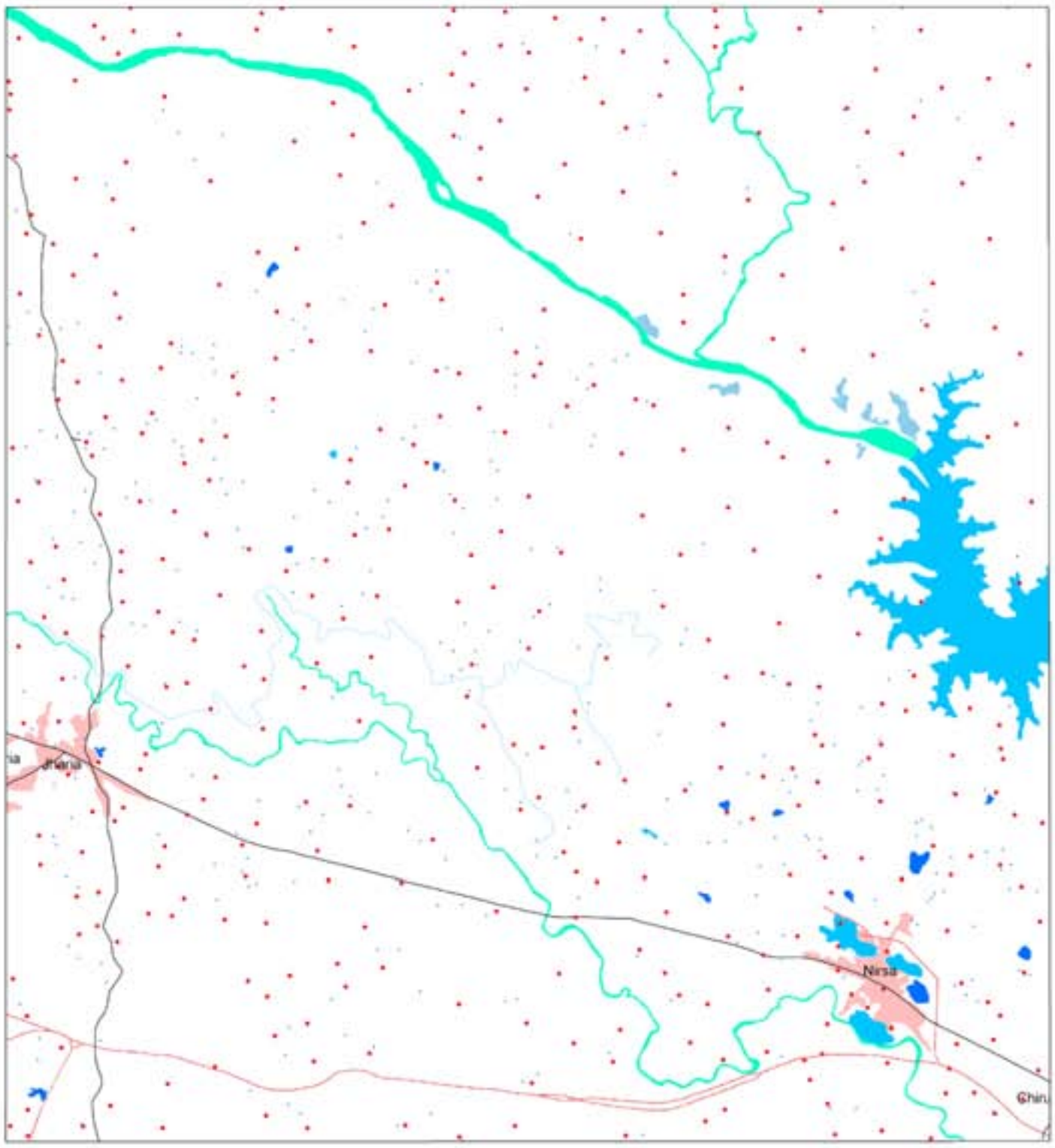
Plate 20: IRS LISS-III FCC – 5 km buffer area of Massanjor Reservoir

SOI MAP-SHEET-WISE WETLAND MAPS
(Selected maps)

State : Jharkhand

WETLAND MAP

Sheet No.: 73I/9

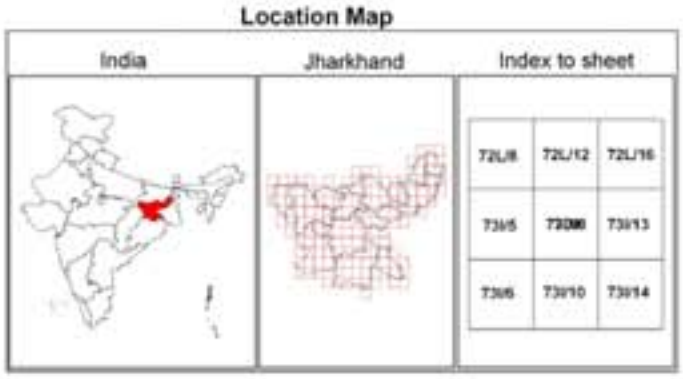


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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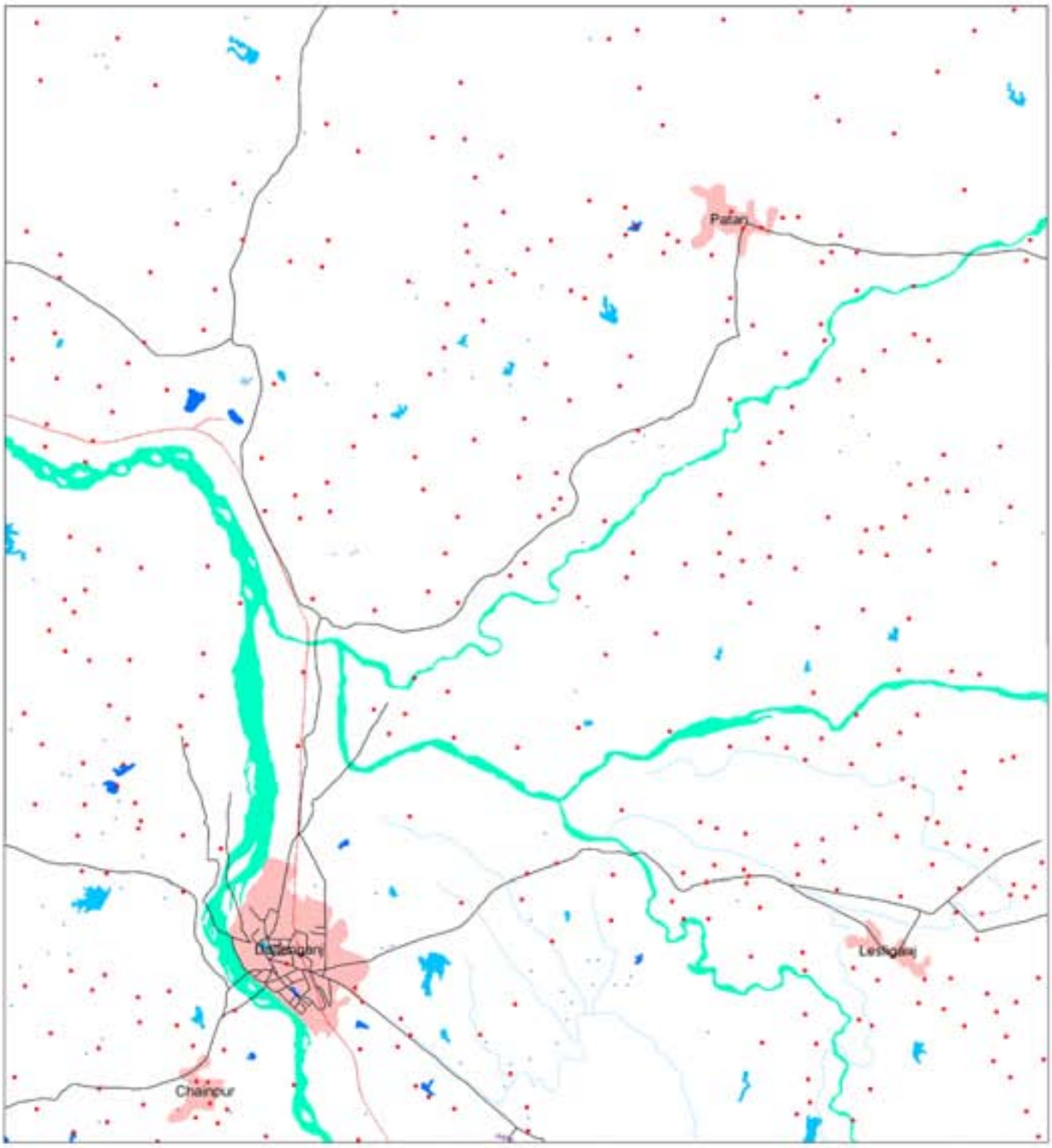
State : Jharkhand

WETLAND MAP

Sheet No.: 72D/4

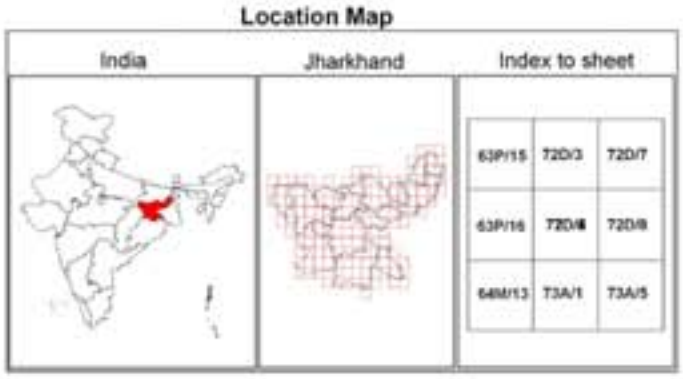


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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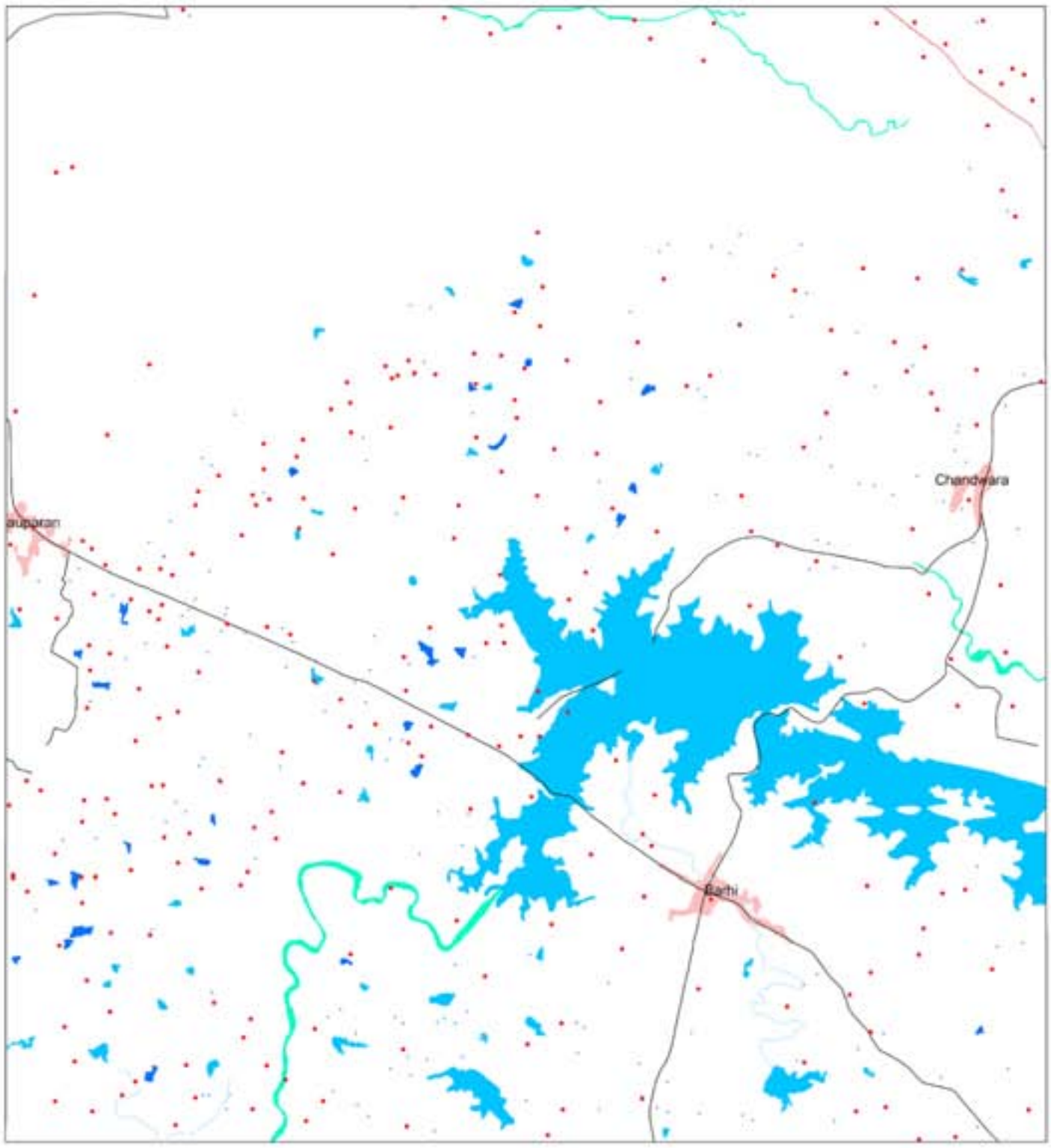
State : Jharkhand

WETLAND MAP

Sheet No.: 72H/7



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	
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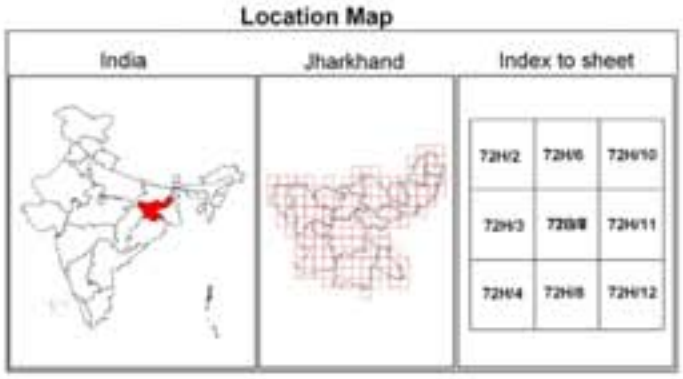
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

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

Jharkhand Space Applications Centre, Ranchi

Sponsored By :

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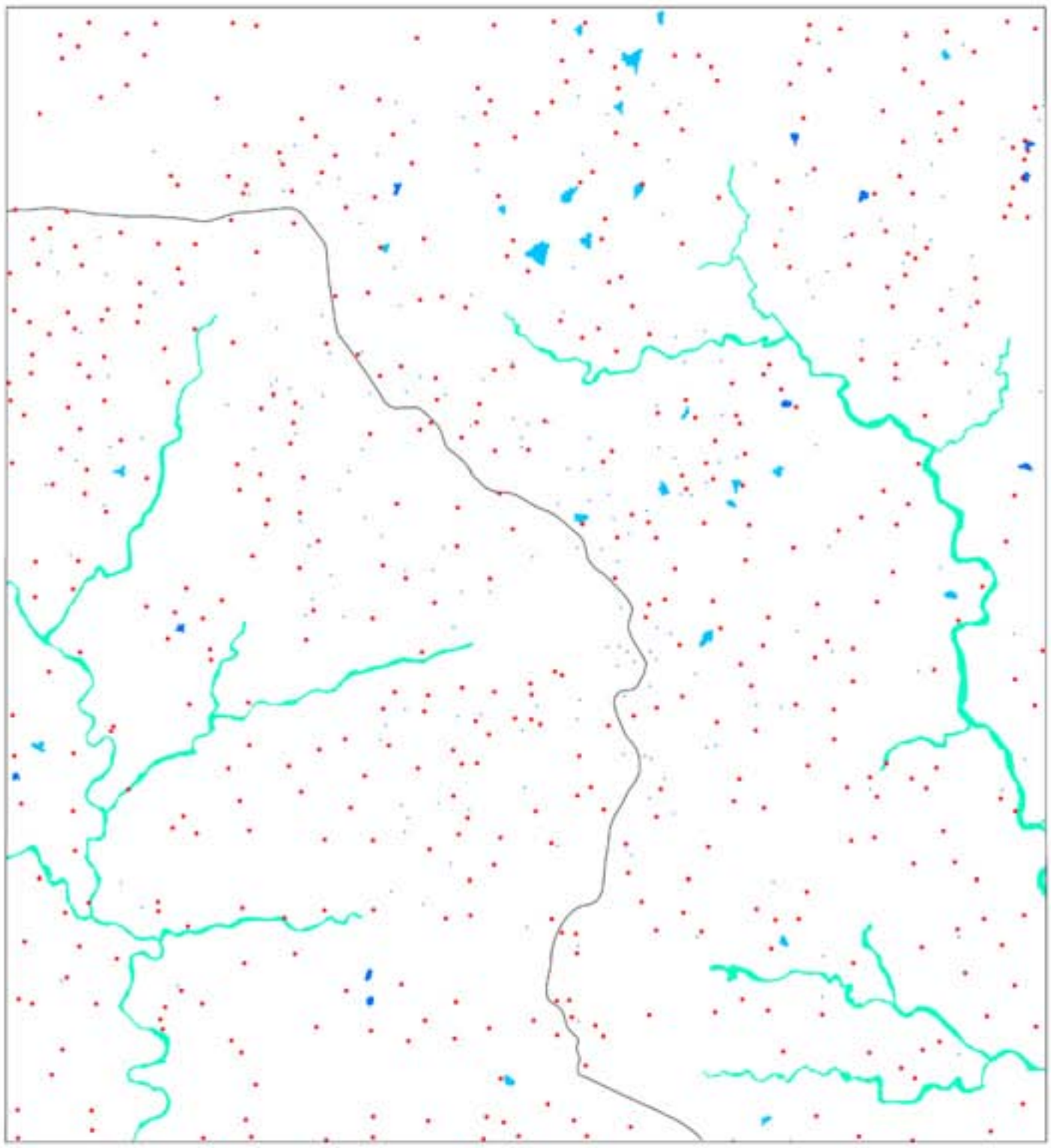
State : Jharkhand

WETLAND MAP

Sheet No.: 72L/3



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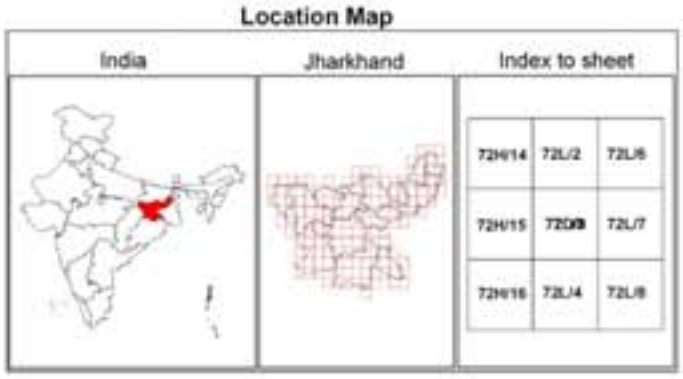
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

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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and

Jharkhand Space Applications Centre, Ranchi

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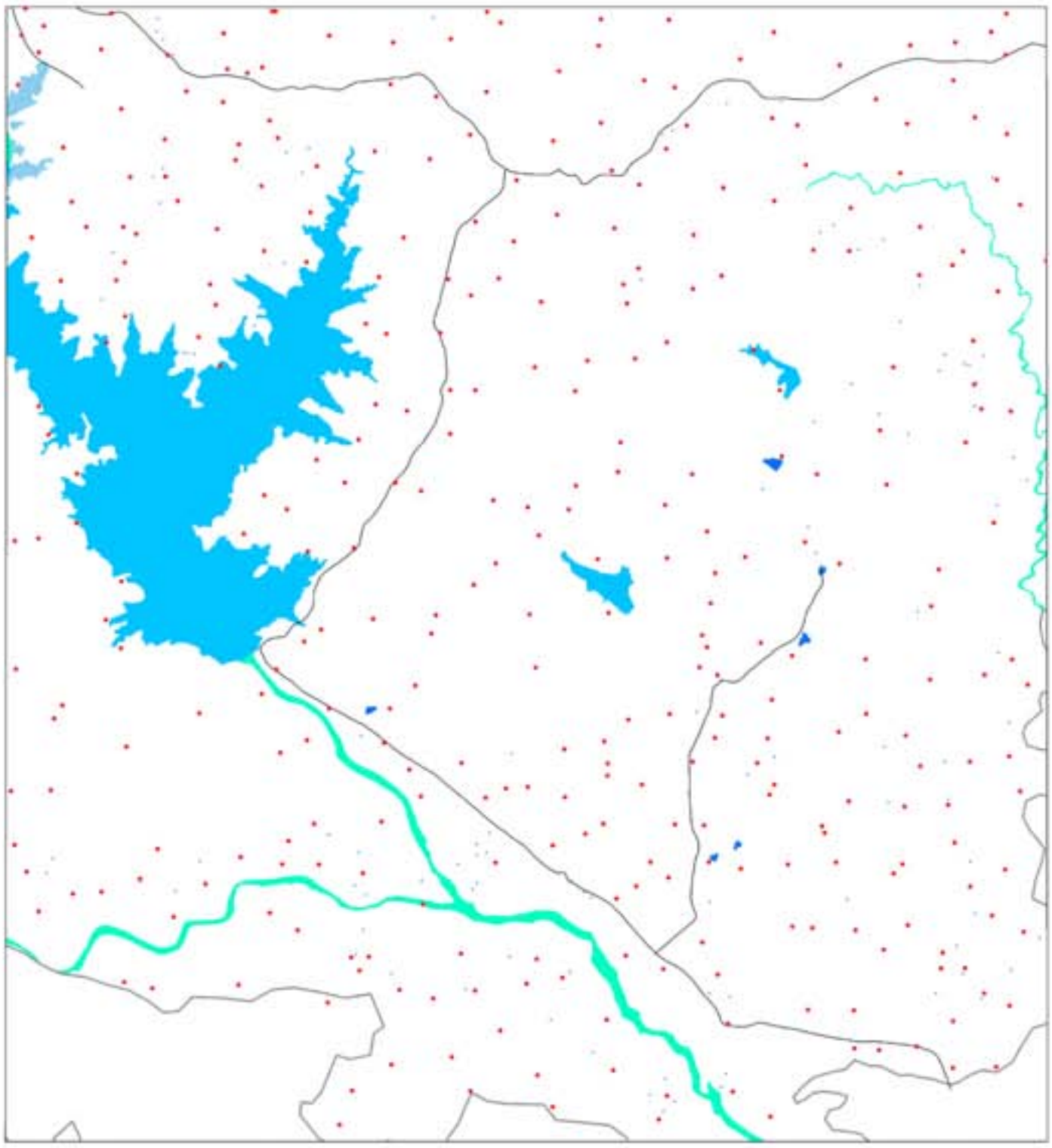
Government of India

State : Jharkhand

WETLAND MAP

Sheet No.: 72P/8

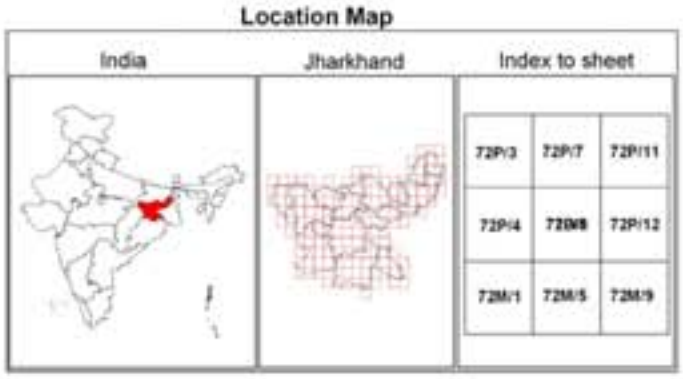


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

Jharkhand Space Applications Centre, Ranchi

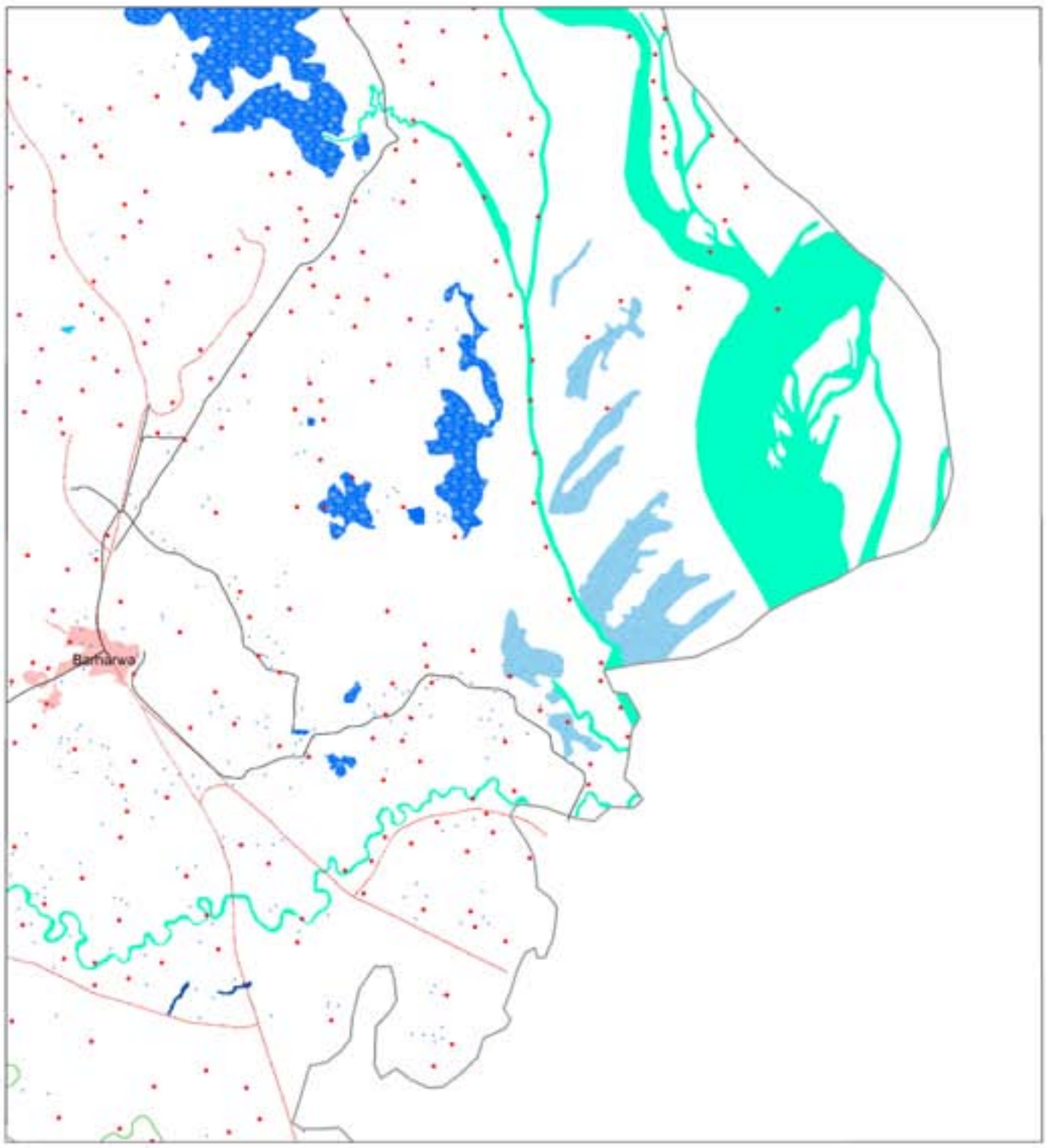
Sponsored By :

Ministry of Environment and Forests
Government of India

State : Jharkhand

WETLAND MAP

Sheet No.: 72P/13

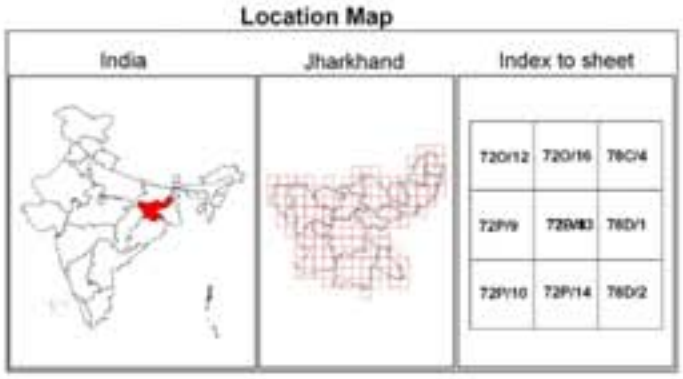


Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
	1103			High altitude wetlands
	1104			Reverine wetlands
	1105			Waterlogged
	1106			River/Stream
			Man-made	
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203		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

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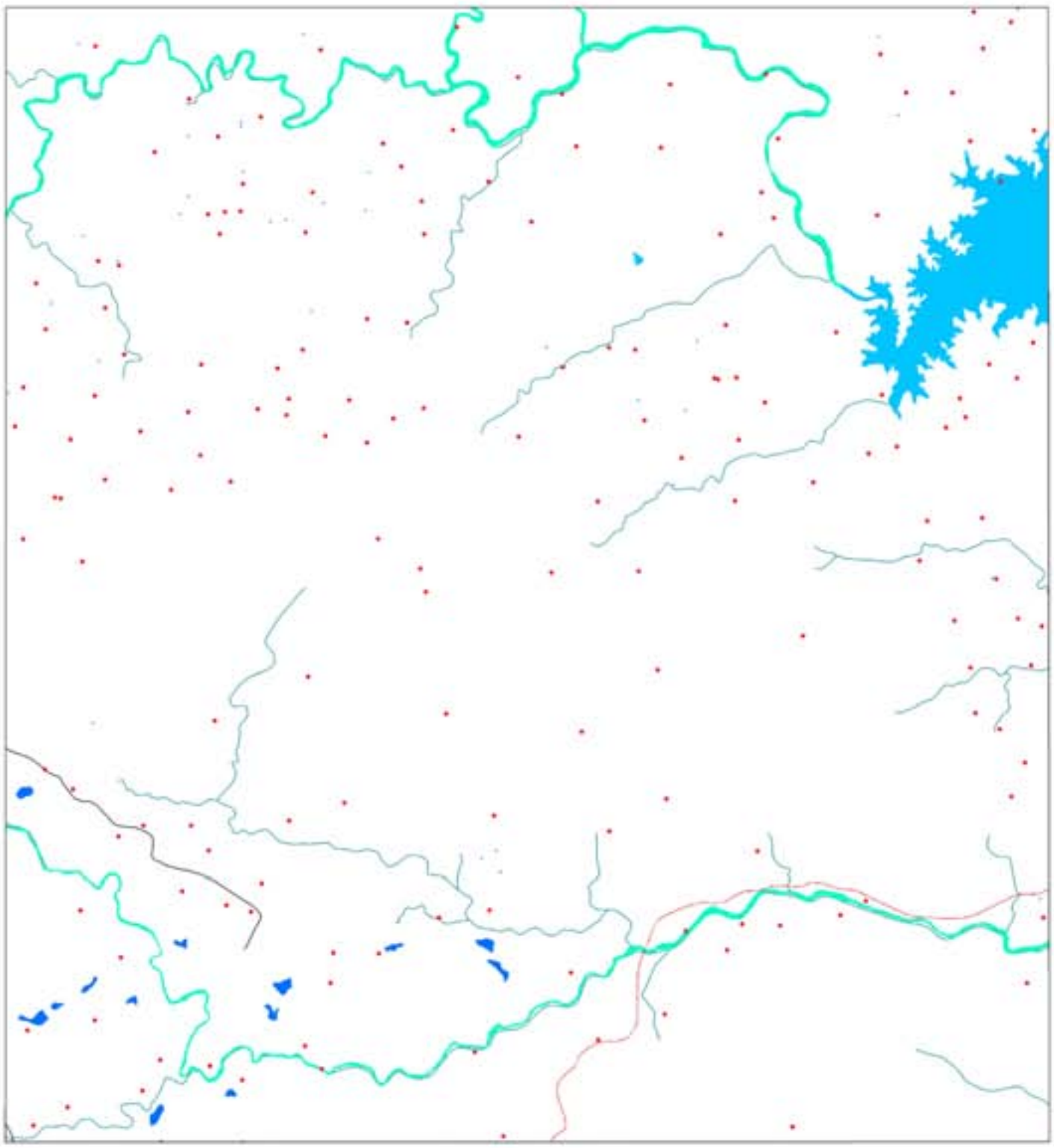
State : Jharkhand

WETLAND MAP

Sheet No.: 73E/9



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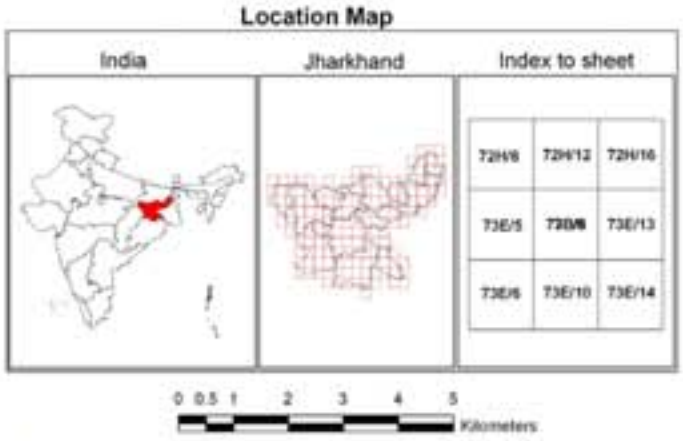
	1201			Reservoirs/Barrages
	1202			Tanks/Ponds
	1203			Waterlogged
	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
	2102			Creeks
	2103			Sand/Beach
	2104			Intertidal mud flats
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture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

Legend

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

Location Map



Data Source :

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

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Jharkhand Space Applications Centre, Ranchi

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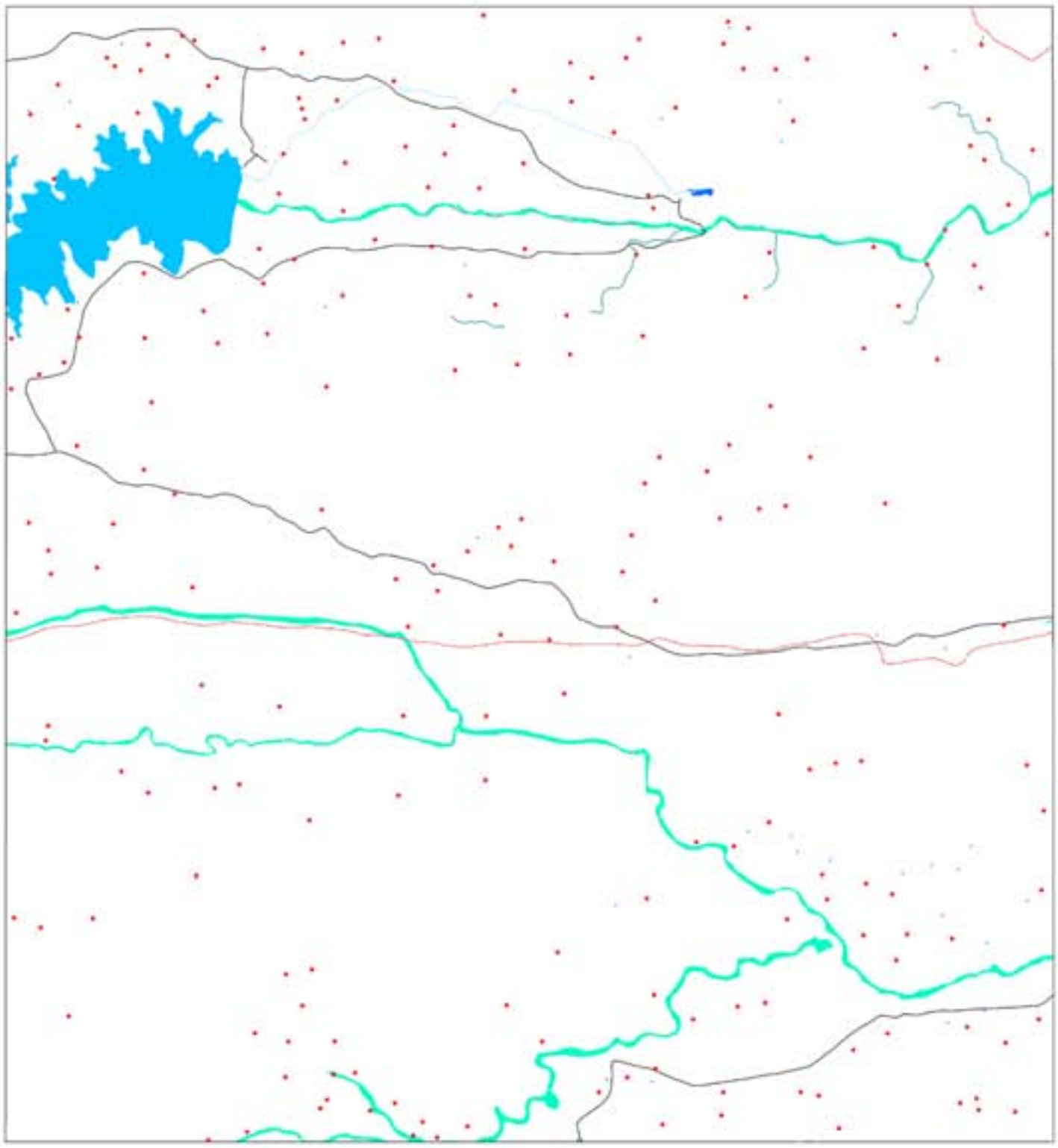
Government of India

State : Jharkhand

WETLAND MAP

Sheet No.: 73E/11



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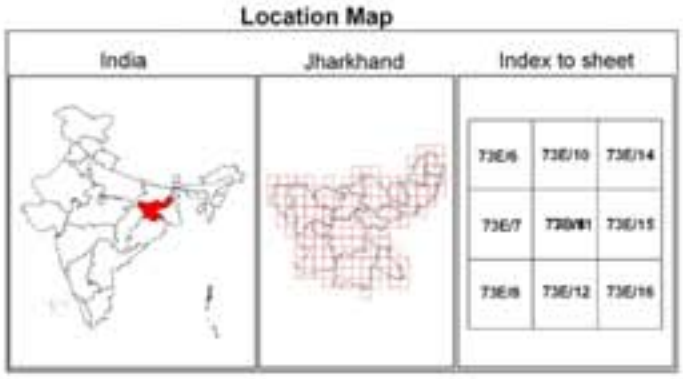
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

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

Location Map



Data Source :

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

Prepared By :

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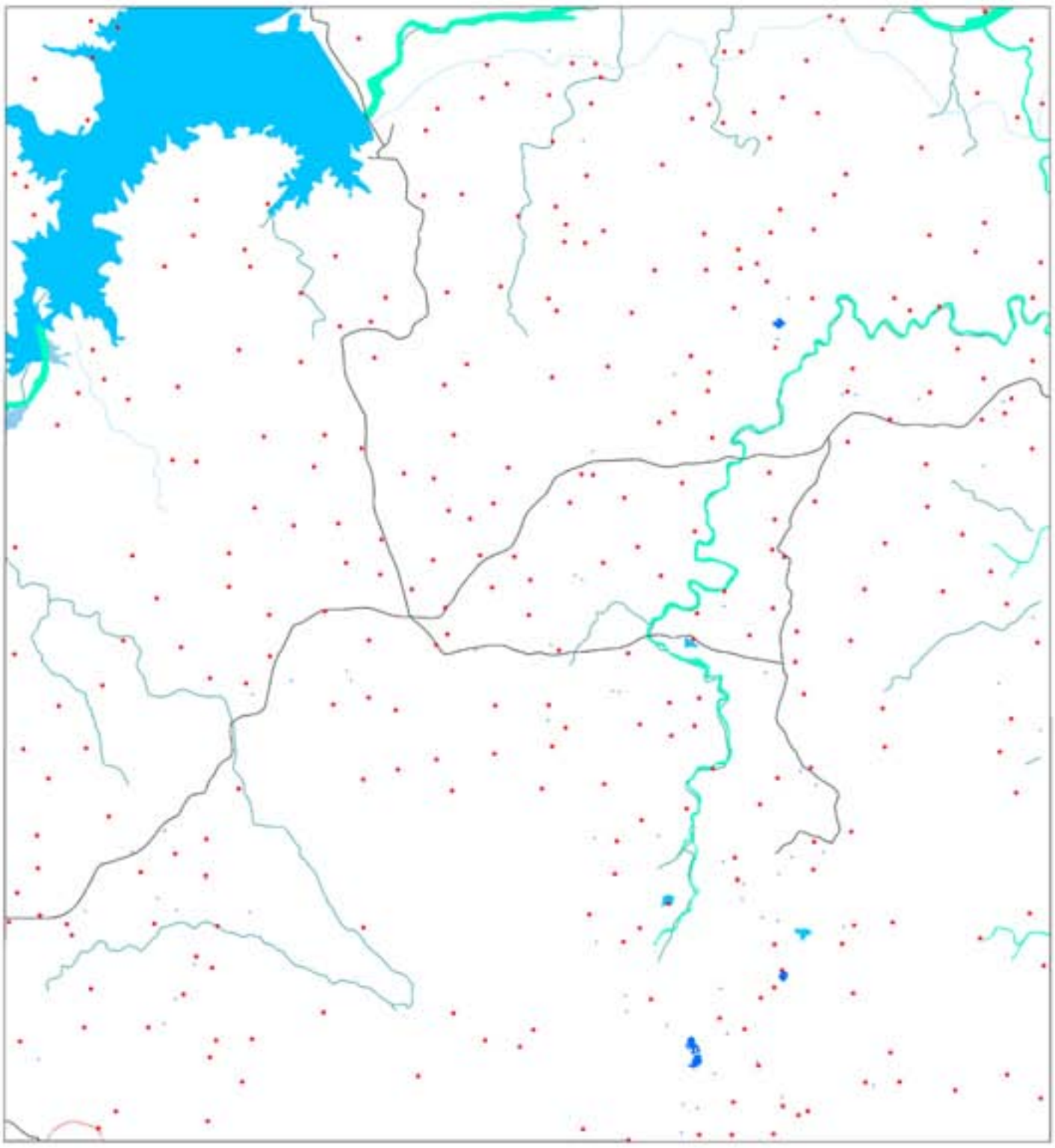
Government of India

State : Jharkhand

WETLAND MAP

Sheet No.: 73E/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
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	1201			Reservoirs/Barrages
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	1204			Salt pans
		Coastal Wetlands		
			Natural	
	2101			Lagoons
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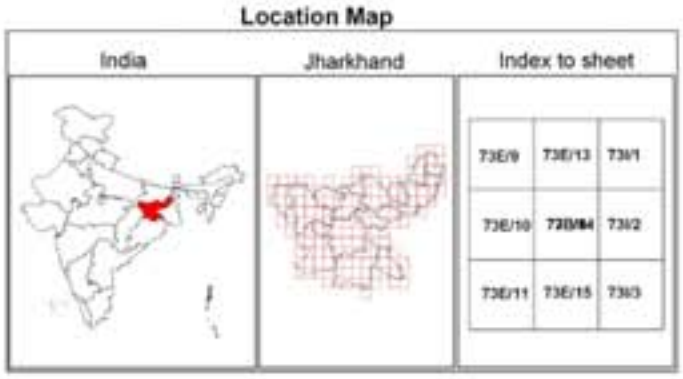
	2105			Salt marsh
	2106			Mangroves
	2107			Coral reefs
			Man-made	
	2201			Salt pans
	2202			Aquaculture ponds

Legend

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

Location Map



Data Source :

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

Prepared By :

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Jharkhand Space Applications Centre, Ranchi

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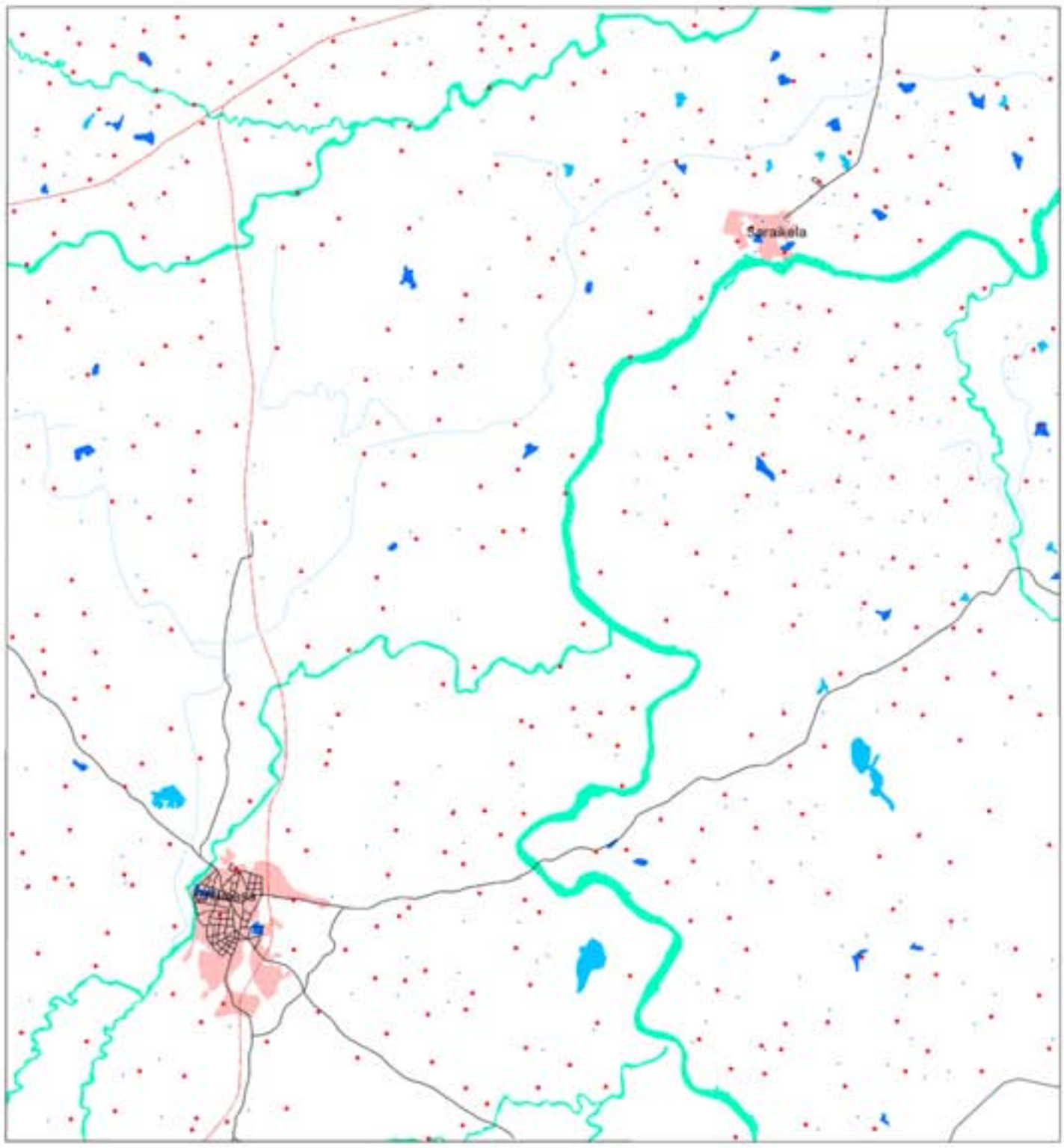
Ministry of Environment and Forests
Government of India

State : Jharkhand

WETLAND MAP

Sheet No.: 73F/14



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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Legend

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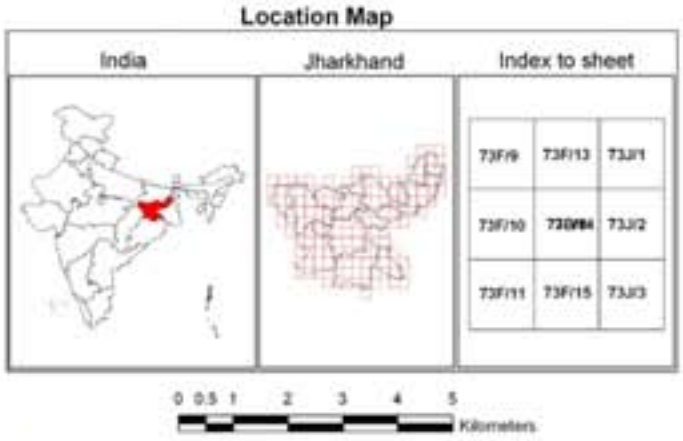
Location Map



Data Source :

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

Prepared By :

Space Applications Centre (ISRO), Ahmedabad

and

Jharkhand Space Applications Centre, Ranchi

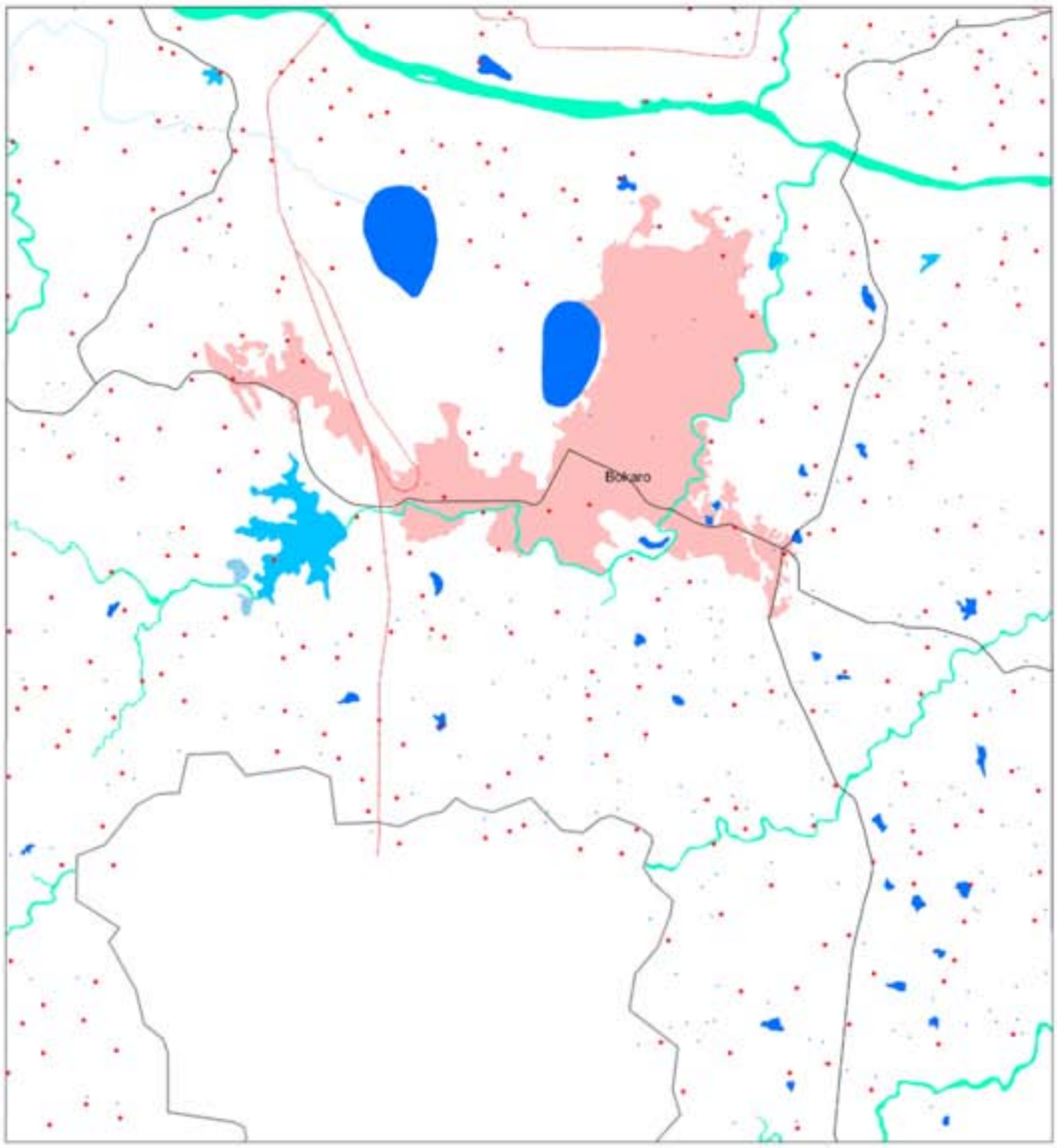
Sponsored By :

Ministry of Environment and Forests
Government of India

State : Jharkhand

WETLAND MAP

Sheet No.: 73I/2



Symbol	Typecode	Level I	Level II	Level III
		Inland Wetlands		
			Natural	
	1101			Lakes/Ponds
	1102			Ox-bow lakes/ Cut-off meanders
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	2107			Coral reefs
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Legend

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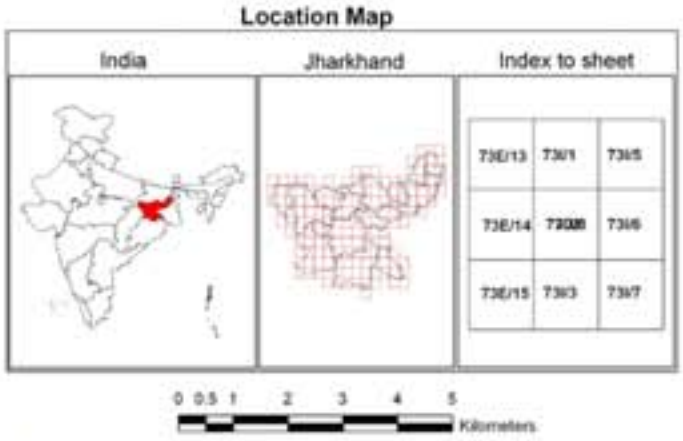

Data Source :

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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 non-vegetated, red in case of terrestrial vegetation). Vegetation if scattered make texture rough.
1102	**Ox-bow lakes/ Cut off meanders**: A meandering stream may erode the outside shores of its broad bends, and in time the loops may become cut-off, leaving basins. The resulting shallow crescent-shaped lakes are called oxbow lakes (Reid *et al*, 1976). On the satellite image Ox-bow lakes occur near the rivers in plain areas. Some part of the lake normally has aquatic vegetation (red/pink in colour) during pre-monsoon season.
1103	**High Altitude lakes:** These lakes occur in the Himalayan region. Landscapes around high lakes are characterized by hilly topography. Otherwise they resemble lakes in the plain areas. For keeping uniformity in the delineation of these lakes contour line of 3000 m above msl will be taken as reference and all lakes above this contour line will be classified as high altitude lakes.
1104	**Riverine Wetlands**: Along the major rivers, especially in plains water accumulates leading to formation of marshes and swamp. **Swamps** are 'Wetland dominated by trees or shrubs' (U.S. Definition). In Europe, a forested fen (a peat accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly *Sphagnum*) could be called a swamp. In some areas reed grass - dominated wetlands are also called swamps). (Mitsch and Gosselink, 1986). **Marsh**: A frequently or continually inundated wetland characterised by emergent herbaceous vegetation adapted to saturated soil conditions. In European terminology a marsh has a mineral soil substrate and does not accumulate peat (Mitsch and Gosselink, 1986). Tone is grey blue and texture is smooth. **Comment**: Using satellite data it is difficult to differentiate between swamp and marsh. Hence, both have been clubbed together.
1105	**Waterlogged:** Said of an area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die (Glossary of Geology, 1974). Floods or unlined canal seepage and other irrigation network may cause waterlogging. Spectrally, during the period when surface water exists, waterlogged areas appear more or less similar to lakes/ponds. However, during dry season large or all parts of such areas dry up and give the appearance of mud/salt flats (grey bluish).
1106	**River/stream:** Rivers are linear water features of the landscape. Rivers that are wider than the mapping unit will be mapped as polygons. Its importance arises from the fact that many stretches of the rivers in Indo-Gangetic Plains and peninsular India are declared important national and international wetlands (Ex. The river Ganga between Brajghat and Garh Mukteshwar, is a Ramsar site, Ranganthattu on the Cavery river is a bird sanctuary etc.). Wherever, rivers are wide and features like sand bars etc. are visible, they will be mapped.
1200	**Man-made**
1201	**Reservoir**: A pond or lake built for the storage of water, usually by the construction of a dam across a river (Glossary of Geology, 1974). On RS images, reservoirs have irregular boundary behind a prominent dyke. Wetland boundary in case of reservoir incorporates water, aquatic vegetation and footprint of water as well. In the accompanying images aquatic vegetation in the reservoir is seen in bright pink tone. Tone is dark blue in deep reservoirs while it is ink blue in case of shallow reservoirs or reservoirs with high silt load. These will be annotated as Reservoirs/Dam. **Barrage:** Dykes are constructed in the plain areas over rivers for creating Irrigation/water facilities. Such water storage areas develop into wetlands (Harike Barrage on Satluj – a Ramsar site, Okhla barrage on the Yamuna etc. – a bird sanctuary). Water appears in dark blue tone with a smooth texture. Aquatic vegetation appears in pink colour, which is scattered, or contiguous depending on the density. Reservoirs formed by barrages will be annotated as reservoir/barrage.
1202	**Tanks/Ponds:** A term used in Ceylon and the drier parts of Peninsular India for an artificial pond, pool or lake formed by building a mud wall across the valley of a small stream to retain the monsoon (Glossary of Geology, 1974). **Ponds** Generally, suggest a small, quiet body of standing water, usually shallow enough to permit the growth of rooted plants from one shore to another (Reid *et al*, 1976). Tanks appear in light blue colour showing

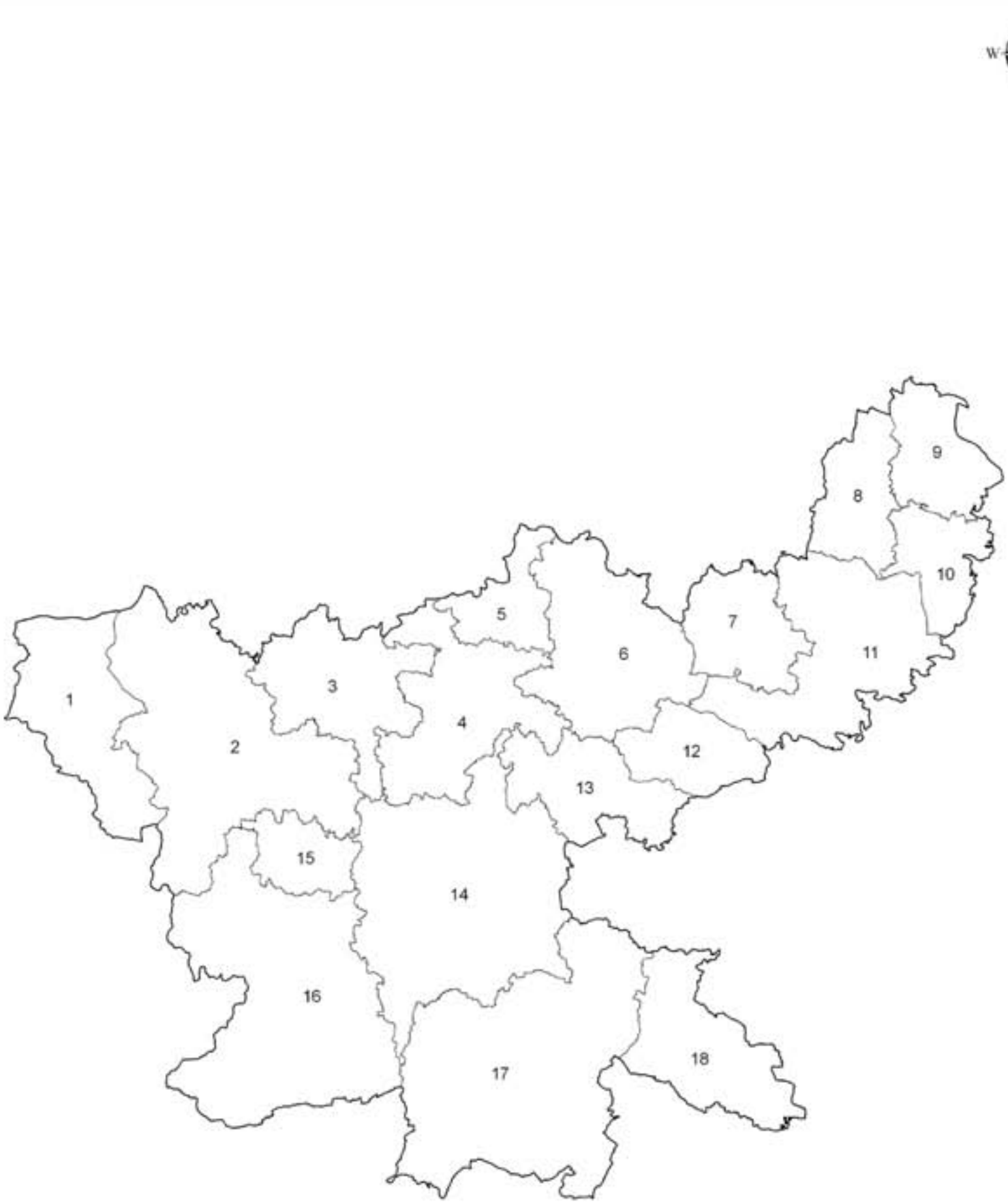
	bottom reflectance. In this category **Industrial ponds/mining pools mainly comprising Abandoned Quarries are also included** Quarry is defined as “An open or surface working or excavation for the extraction of stone, ore, coal, gravel or minerals." In such pits water accumulate (McGraw Hill Encyclopedia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

Annexure – II

Details of District information followed in the atlas

State : Jharkhand

District Boundary Map



List of Districts

District code	District name
01	Garhwa
02	Palamu
03	Chatra
04	Hazaribagh
05	Kodarma
06	Giridih
07	Deoghar
08	Godda
09	Sahibganj
10	Pakur
11	Dumka
12	Dhanbad
13	Bokaro
14	Ranchi
15	Lohardaga
16	Gumla
17	Pashchimi Singhbhum
18	Purbi Singhbhum

Legend

State Boundary

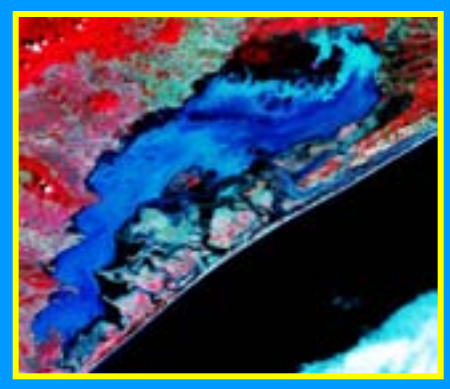
District Boundary

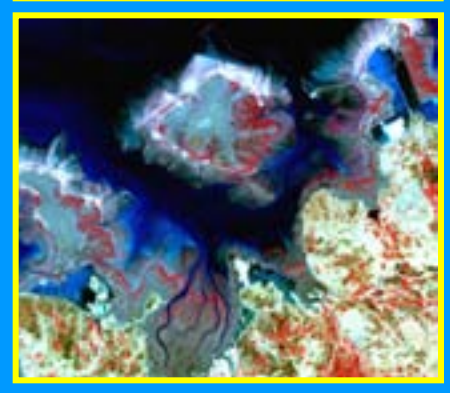
Source : Survey of India (Surveyed in 2004 and published in 2005)

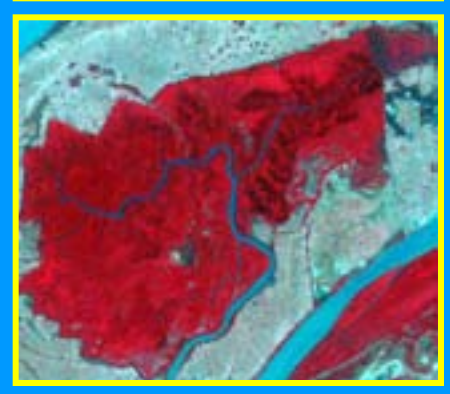
Space Applications Centre (SAC) is one of the major centres of the Indian Space Research Organisation (ISRO). It is a unique centre dealing with a wide variety of disciplines comprising design and development of payloads, societal applications, capacity building and space sciences, thereby creating a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

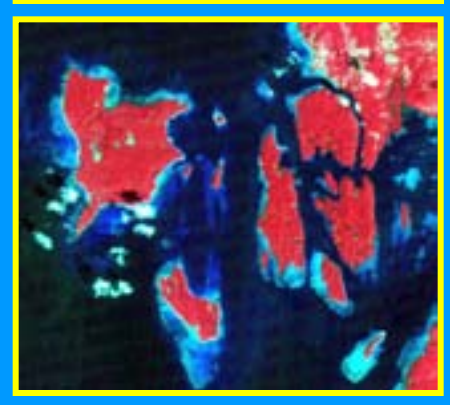
SAC is a host institution for the training programmes related to Satellite Communication, Satellite Meteorology and global change under the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) affiliated to the United Nations (UN).

http://www.isro.org









Space Applications centre
Indian Space Research Organisation
Ahmedabad – 380 015