



# NATIONAL WETLAND ATLAS: WEST BENGAL

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 (postmonsoon and pre-monsoon period) are also given. Similarly the status of aquatic vegetation (mainly floating and emergent types) in two seasons is also accounted for. Status of small wetlands are also accounted as numbers and depicted in maps as points. Wetland map also show important ancillary information like roads/rail, relevant habitations. False Colour Composite (FCC) of the satellite image used (any one season) is shown along with the derived wetland map to give a feeling of manifestation of wetlands in remote sensing data and synoptic view of the area. The status of some of the important wetlands like Ramsar sites, National Parks are shown with recent field photographs.

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## NATIONAL WETLAND ATLAS: WEST BENGAL

Sponsored by Ministry of Environment and Forests, Government of India

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

## Space Applications Centre (ISRO), Ahmedabad and Institute of Environmental Studies and Wetland Management, Kolkata

January 2010

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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.



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We are thankful to the "Technical Review" team of SAC for critical comments and suggestion to finalise the Atlas. Many project scientists of IES&WM, Kolkata were involved in carrying out ground truth data collection, interpretation and mapping using remote sensing data. We sincerely thank the team for their tireless effort put for the project.





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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 West Bengal, which is part of the National Wetland Atlas of India, is an attempt in this direction.

## 1.1 Wetlands

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

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

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

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

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

Despite these benefits, wetlands are the first target of human interference and are among the most threatened of all natural resources. Around 50% of the earth's 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 relating the feature to any given geographical location has a strong visual impact. Maps are thus essential for monitoring and quantifying change over time scale, and 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

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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, 1986; 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 - A typical wetland located in Taoru block, Mewat district. 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











IRS LISS III FCC, December 9, 2006

NIR





SWIR

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

## 1.3 Wetland Inventory of India

India with its large geographical spread supports large and diverse wetland classes, some of which are unique. Wetlands, variously estimated to be occupying 1-5 per cent of geographical area of the country, support about a fifth of the known biodiversity. Like any other place in the world, there is a looming threat to the aquatic biodiversity of the Indian wetlands as they are often under a regime of unsustainable human pressures. Sustainable management of these assets therefore is highly relevant. Realising this, Govt. of India has initiated many appropriate steps in terms of policies, programmes and plans for the preservation and conservation of these ecosystems. India is a signatory to the Ramsar Convention for management of wetland, for conserving their biodiversity and wise use extending its scope to a wide variety of habitats, including rivers and lakes, coastal lagoons, mangroves, 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 scale is essential. The task seemed challenging in view of the vast geographic area of our country enriched with diverse wetland classes. Space Applications Centre with its experience in use of RS and GIS in the field of wetland studies, took up this challenging task. This is further strengthened by the fact that guidelines to create geospatial framework, codification scheme, data base structure etc. for natural resources survey has already been well established by the initiative of ISRO under various national level mapping projects. With this strength, the National Wetland Inventory and Assessment (NWIA) project was formulated by SAC, which was approved and funded by MoEF.

The main objectives of the project are:

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

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

## 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.

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.

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

Table 1: Wetland classification system and coding

\* Wetland type code

## 3.0 STUDY AREA

West Bengal, a state in the eastern portion of India, stretches from the Himalayas in the north to the Bay of Bengal in the south. The western extreme is bounded by the Deccan Plateau Complex while the eastern part of southern West Bengal consists of the Ganga-Brahmaputra delta – the largest of the land mass of the type in the world. On 1<sup>st</sup> May, 1960, West Bengal acquired the status of statehood in the Indian Union on linguistic basis. It covers an area of 88,752 sq km which is about 3% of the total geographical area of India. The state lies between 27°13'15" and 21°25'24" north latitudes and 85°48'20" and 89°53'04" east longitudes. Location map of West Bengal is depicted in Figure 3.

West Bengal has broadly three physiographic divisions

- i) The Sub-Himalayan northern region
- ii) The Gangetic alluvial plains and
- iii) The Coastal region

The Darjeeling Himalayan hill region to the extreme north of the state has Sandakfu, the highest peak of the state. West Bengal is essentially a flat alluvial plain, large portion of which being a part of delta of river Ganga, only one per cent of its area in the far north is really mountainous. The narrow Terai region separates the northern region from the southern plains, which in turn moves into the Ganga delta towards the south.

The climate of the state is that of tropical in the south and humid tropical in the north. The four main seasons are summer, monsoon, autumn and winter. The minimum temperature ranges between 12-15 °C while maximum temperature ranges between of 38-40 °C. West Bengal experiences torrential rainfall during June to September. The annual average rainfall of the state is about 4170 mm. The Ganges is the only perennial river of the state – one branch enters Bangladesh in the name of Padma and the other flows through the state in the names of Bhagirathi and Hooghly. The Ganga delta including the Sunderbans is full of rivers and creeks, which form a web like network.

Most of the wetlands show varied floral and faunal diversity. The common aquatic plants are water hyacinth, water lily, lotus, water-clover, water spinach and water-weeds, apart from algae and phytoplankton. Few plants like *Aeschynomene aspera* ('shola'), *Euryale ferox* ('makhna') and *Trapa bispinosa* ('singara' or 'paniphal') are widely cultivated in the wetlands. The common faunal elements in the water bodies are fishes, amphibians, reptiles and mollusks along with a wide variety of migratory and resident avifauna.

The state is covered by one hundred eighty five SOI topographical maps on 1:50,000 scale that form the spatial framework for mapping (Figure 4).

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



## 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 West Bengal is covered in 13 IRS LISS III scenes (Figure 5). Two-date data, one acquired during April/May and another during November/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 West Bengal as seen on the LISS III FCC of post-monsoon pre-monsoon data respectively.



Figure 5: IRS P6 LISS-III coverage of West Bengal

SR.	Resources at LISS III Path	Post-Monsoon	Pre-Monsoon
No	Row	(2006)	(2007)
1	107-53	December 4, 2006	April 3, 2007
2	107-54	December 4, 2006	April 3, 2007
3	107-55	December 4, 2006	April 3, 2007

Table-2: Satellite data used

4	107-56	December 4, 2006	April 3, 2007
5	106-55	November 29, 2006	March 29, 2007
6	106-56	October 12, 2006	March 29, 2007
7	108-53	December 9, 2006	May 2, 2007
8	108-54	December 9, 2006	May 2, 2007
9	108-55	December 9, 2006	May 2, 2007
10	108-56	December 9, 2006	April 8, 2007
11	109-56	November 20, 2006	April 13, 2007
12	107-52	December 4, 2006	April 3, 2007
13	107-57	December 4, 2006	April 3, 2007

## Ground truth data

Remote sensing techniques require certain amount of field observation called "ground truth" in order to convert into meaningful information. 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 were also taken to record the water quality (subjective), status of aquatic vegetation and water spread.

## Other data

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

## 5.0 METHODOLOGY

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

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

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

#### 5.1 Creation of spatial framework

This is the most important task as the state forms a part of the national frame work and 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') grids 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 West Bengal 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 (McFeetres, 1986; Xu Hanqiu, 2006; Lacaux *et al*, 2007; Townshend and Justice, 1986; Tucker and Sellers, 1986) as given below:

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





## Figure 6: IRS LISS-III FCC (Post-monsoon and Pre-monsoon): Part of West Bengal State

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

• Extraction of wetland extent :

MNDWI, NDPI and NDVI image was used to extract the wetland boundary through suitable hierarchical thresholds.

• Extraction of open water :

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

• Extraction of wetland vegetation :

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

• Turbidity information extraction :

NDTI and MNDWI image was used to generate qualitative turbidity level (high, moderate and low) based on signature statistics and standard deviations (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.	> -1 $\sigma$ to <= +1 $\sigma$	Moderate
3.	>+1o	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.

## 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.



Figure 7: Flow chart of the methodology used



Figure 8: Steps in the extraction of wetland components

## 6.0 ACCURACY ASSESSMENT

A comprehensive accuracy assessment protocol has been followed for determining the quality of information derived from remotely sensed data. Accuracy assessment involves determination of thematic (classification) as well as 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 imageries 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.

## Part of Sunderban region, South Parganas







Useful for wetland boundary delineation



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

MAPS AND STATISTICS

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## 7.0 WETLANDS OF WEST BENGAL: MAPS AND STATISTICS

Inventory and assessment of various wetland categories for West Bengal have been carried out using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity derived from LISS III data. The wetlands comprise 1107907 ha of area accounting for about 12.5 % of geographical area of the state. Total number of wetlands mapped in the state is 147826 including 138707 wetlands smaller than 2.25 ha. The total number of inland wetlands are found to be 8670, under natural (3675) and man-made (4995). The total number of coastal wetlands is 449 comprising of 421 natural and 28 man-made. The total area of inland and coastal wetlands are 747383 ha and 221817 ha respectively. The major wetland types are River/Stream (559192 ha) followed by Mangroves (209330 ha), lakes/ponds (58654 ha), Waterlogged (56603 ha) and Reservoirs (22672 ha). In addition, 138707 smaller wetlands (< 2.25 ha) were also identified. All wetlands with open water features have shown a decrease in water spread from post-monsoon to pre-monsoon. The variation at state level is 48830 ha from 632450 ha to 583620 ha. Graphical distribution of wetland types in West Bengal is shown in figure 10.

						Open Water		
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area	
	1100	Inland Wetlands - Natural	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	1327	58654	5.29	45374	35609	
2	1102	Ox-bow lakes/ Cut-off meanders	867	19550	1.76	15869	11063	
3	1103	High altitude wetlands	3	82	0.01	82	82	
4	1104	Riverine wetlands	490	8654	0.78	7656	6026	
5	1105	Waterlogged	780	56603	5.11	47615	41337	
6	1106	River/Stream	208	559192	50.47	468488	453748	
	1200	Inland Wetlands -Man-made						
7	1201	Reservoirs/Barrages	340	22672	2.05	20728	12744	
8	1202	Tanks/Ponds	4581	20470	1.85	18923	15708	
9	1203	Waterlogged	71	1435	0.13	1354	1076	
10	1204	Salt pans	3	71	0.01	71	71	
		Total - Inland	8670	747383	67.46	626160	577464	
	2100	Coastal Wetlands - Natural						
11	2101	Lagoons	-	-	-	-	-	
12	2102	Creeks	-	-	-	-	-	
13	2103	Sand/Beach	51	3338	0.30	-	-	
14	2104	Intertidal mud flats	17	2726	0.25	-	-	
15	2106	Mangroves	353	209330	18.89	-	-	
16	2107	Coral Reefs	-	-	-	-	-	
	2200	Coastal Wetlands - Man-made						
17	2201	Salt pans	14	4866	0.44	4865	4865	
18	2202	Aquaculture ponds	14	1557	0.14	1425	1291	
		Total - Coastal	449	221817	20.02	6290	6156	
		Sub-Total	9119	969200	87.48	632450	583620	
		Wetlands (<2.25 ha), mainly Tanks	138707	138707	12.52	-	-	
		Total	147826	1107907	100.00	632450	583620	

#### Table 4: Area estimates of wetlands in West Bengal

Area in ha

Area under Aquatic Vegetation	228174	239058
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Area under turbidity levels		
Low	32402	21196
Moderate	537145	500547
High	62904	61878



Figure 10: Type-wise wetland distribution in West Bengal

Qualitative turbidity ratings assigned to open water features of wetlands, showed that wetlands belonging to "water logged class" and lakes/pond in general have high turbidity with 59.0 and 54.0 per cent of the respective classes being under high turbidity during post monsoon.

Digital wetland map as well as the overview of the mosaic of satellite images used for the purpose are given in Figure 12.

## 7.1 District-wise Wetland Maps and Statistics

The state has nineteen districts as administrative units (census 2001). It is observed that extent of wetlands accounts for 12.48 % with variation from a minimum of 2.1 to 58.4 %. When realized in terms of average extent it remained quite high (61764 ha) for the state of West Bengal ranging from a minimum of 724 ha to 477151 ha. In terms of wetland area Kolkata district accounts least (724 ha) compared to south twenty-four parganas (477151 ha). However, in terms of per cent Darjeeling district is least accounting for 2.1 compared to South twenty four Parganas (58.5). The presence of Sunderbans is attributed as the reason for very high per cent of wetland area (150206 ha and 36.7 % respectively). The seasonal variation in open water extent inferred by using two season data, showed that minimum open water extent was observed in Kolkata district i.e. 697 ha in post-monsoon while South twenty four Parganas registered largest area under open water in post-monsoon (306931 ha). The details are given below in the table 5 and graphically depicted in Figure 11.

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Sr.	District	Geographic	Wetland	% of total	% of district
No.	District	Area	Area	wetiand	geographic
		(sq. ĸm)	(na)	area	area
1	Darjiling	3,075	6395	0.58	2.08
2	Jalpaiguri	6,227	41520	3.75	6.67
3	Koch Bihar	3,387	23534	2.12	6.95
4	Uttar Dinajpur	3,180	12806	1.16	4.03
5	Daishin Dinajpur	2,183	9109	0.82	4.17
6	Maldah	3,733	25162	2.27	6.74
7	Murshidabad	5,324	41980	3.79	7.89
8	Birbhum	4,545	27660	2.50	6.09
9	Barddhaman	7,024	49542	4.47	7.05
10	Nadia	3,927	28189	2.54	7.18
11	North Twenty Four Parganas	4094	150206	13.56	36.69
12	Hugli	3,149	21514	1.94	6.83
13	Bankura	6,882	41476	3.74	6.03
14	Puruliya	6,259	38122	3.44	6.09
15	West Medinipur*	14081	40626	3.67	2.89
16	Howrah	3,467	15589	1.41	4.50
17	Kolkata	104	724	0.07	6.96
18	South Twenty Four Parganas	8164	477151	43.07	58.45
19	East Medinipur	NA	56602	5.11	-
	Total	88805	1107907	100.00	12.47

#### Table-5:District-wise wetland area

Data source: Census 2001, \* Include area of both West and East Medinipur.



## Figure 11: District-wise Distribution of Wetlands in West Bengal


	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





# 7.1.1 Darjiling

Extents: Latitude: 26°27′02″ N to 27°13′45″ N; Longitude: 87°59′07″ E to 88°53′01″ E.

The district of Darjiling consists of outlying hills of the lower Himalayas. Some of the hills lying in this district rise more than 10,000 feet in the northwestward direction. The main rivers of the district are Mahanadi, Jaldhaka, Tista, Chota Rangit, and Great Rangit. Many of the rivers of the district originate as small streams from the rear part of the mountain region i.e. from Tibet. They form surface drainage from the snowy parts of the ridges and the southerly direction of the drainage of the Himalayas. The rills, streams and rivers of the district dissect the terrain into many lateral spurs. The valley slopes attain a deep gorge like character near the beds of the streams. The district has no flat valleys or plains which is the reason for the absence of sizeable lakes in the district.

There are 191 wetlands mapped in the district extending over an area of 6395 ha. The total number of small wetlands of <2.25 ha identified in the district is 145. River/Stream ranked first in terms of area (6080 ha) accounting for 95% of wetland area (Table 6). Seasonal variation in open water spread is mainly shown by River/Stream which is 2634 ha in post monsoon and decreased to 2284. Other wetlands remained more or less stable. The area coverage shows that the natural wetlands are quite big in size (Table 6). The turbidity of the wetland is mainly of medium type and aquatic vegetation is almost negligible in the district (Table 6).

Mirik Lake, Sinchol wetland, Jorpukuri wetland, Ghoshpukuri wetland are important wetlands of the district. Jorpukuri is the habitat for the vulnerable amphibian Darjiling Salamander (*Trilototriton vercosus*).

				-	-		Area in ha	
	WettcodeWetland CategoryNumber of WetlandsTotal Wetland Area					Open Water		
Sr. No.		Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area			
	1100	Inland Wetlands - Natural						
1	1101	Lakes/Ponds	4	52	0.81	57	55	
2	1102	Ox-bow lakes/ Cut-off meanders	3	15	0.23	10	7	
3	1103	High altitude wetlands	3	82	1.28	82	82	
4	1104	Riverine wetlands	2	7	0.11	7	3	
5	1105	Waterlogged	-	-	-	-	-	
6	1106	River/Stream	30	6080	95.07	2634	2284	
	1200	Inland Wetlands -Man-made						
7	1201	Reservoirs/Barrages	-	-	-	-	-	
8	1202	Tanks/Ponds	4	14	0.22	14	9	
9	1203	Waterlogged	-	-	-	-	-	
10	1204	Salt pans	-	-	-	-	-	
		Sub-Total	46	6250	97.73	2804	2440	
		Wetlands (<2.25 ha), mainly Tanks	145	145	2.27	-	-	
		Total	191	6395	100.00	2804	2440	

Area under Aquatic Vegetation	4	7

Area under turbidity levels		
Low	134	134
Moderate	2666	2303
High	4	3



	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





## 7.1.2 Jalpaiguri

Extents: Latitude: 26°15′37″ N to 27°00′15″ N; Longitude: 88°23′37″ E to 89°53′18″ E.

The district of Jalpaiguri lies to the south-west of Darjiling district which comprises of mainly the Himalayan ranges. The district lies in the physiographic zone known as Terai. The rivers from the hills flow down to this region meandering resulting numerous lakes many of which are ox-bow lakes and cut-off meanders. The physiography of the area is most suitable to the formation of ox-bow lakes as sediments brought down from the hills are deposited in this more or less flat plain with height being 0-150 m above sea level. Due to abrupt change in gradient of the region numerous riverine wetlands have also been formed. These riverine wetlands are linked to the rivers that have originated from the hills, like the Tista, Torsa, Jaldhaka and Sankosh. In addition to the above mentioned rivers there are also rivers of the Ganga system, namely the Mahananda and its tributaries.

There are 584 wetlands mapped in the district covering an area of 41520 ha. River/Stream ranked first in terms of area (40240 ha) accounting for 97% of wetland area (Table 7). The total numbers of natural wetlands are 107 and the remaining 26 are man-made ones. In addition, small wetland of <2.25 ha identified are 451. The open water of the wetlands has mainly medium turbidity. The aquatic vegetation covers an area of about 164 ha in post-monsoon and 279 ha in pre-monsoon (Table 7).

The important wetlands in this district are Teesta chari, Jalpaiguri Rajar Dighi, Sadbeki beel and Ghoksadanga beel.

		WettcodeWetland CategoryNumber of WetlandsTotal Wetland Area				Open Water		
Sr. No.	Wettcode		Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area		
	1100	Inland Wetlands - Natural						
1	1101	Lakes/Ponds	24	254	0.61	191	140	
2	1102	Ox-bow lakes/ Cut-off meanders	30	346	0.83	263	185	
3	1103	High altitude wetlands	-	-	-	-	-	
4	1104	Riverine wetlands	20	124	0.30	110	105	
5	1105	Waterlogged	-	-	-	-	-	
6	1106	River/Stream	33	40240	96.92	8996	8996	
	1200	Inland Wetlands -Man-made						
7	1201	Reservoirs/Barrages	-	-	-	-	-	
8	1202	Tanks/Ponds	26	105	0.25	104	117	
9	1203	Waterlogged	-	-	-	-	-	
10	1204	Salt pans	-	-	-	-	-	
		Sub-Total	133	41069	98.91	9664	9543	
		Wetlands (<2.25 ha), mainly Tanks	451	451	1.09	-	-	
		Total	584	41520	100.00	9664	9543	

Table 7: Area estimates of wetlands in Jalpaiguri

Area under Aquatic Vegetation	164	279
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Area under turbidity levels		
Low	101	63
Moderate	9443	9363
High	120	117



	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



## 7.1.3 Koch Bihar

Extents: Latitude: 25°57′57″ N to 26°32′58″ N; Longitude: 88°45′28″ E 89°51′50″ E.

The Koch Bihar district has a south-eastern slope along which the rivers of the district flow. Though the district shows slight undulations there are lands which are form inundated areas during the monsoon. The district lies in the physiographic zone known as Terai. The direction of the rivers in the district is from north-west to south-east. The district abounds a large number of rivers and most of them have show channel pattern changes.

There are 390 wetlands, of which 386 are natural and 4 are man-made (Table 8). River/Stream ranked first in terms of area (18478 ha) accounting for 79% of wetland area (Table 8), followed by lakes/ponds in the district (2814 ha). Ox-bow lakes/cut-off meanders have significant aerial extent (1867 ha). They constitute about 8 % of wetland area. Large number of paleo channels of the river most of which establishes a connection during the monsoon exists in this district. In addition, 225 number of small wetland (> 2.25 ha area) are identified.

Qualitative analysis showed that medium turbidity is dominant (9625 ha out of 10093 ha) for the open water features of wetlands of the district in post-monsoon. The total area covered by aquatic vegetation in the district is 1866 ha in post-monsoon season and 3127 ha in pre-monsoon season (Table 8). The wetland map and corresponding satellite imagery are given figure 18.

Important wetlands of the district are Amlaguri beel, Buramansai beel, Chakiarchara river, Ghorghara chara beel, nageswari beel, Nayachara beel, Paschim Panisali Chari, Shaultukui Boropak beel, Sholadanga chara, Sonori Nikutiyar beel.

			Number of wetlands			Open Water		
Sr. No.	Sr. No. Wettcode	Wetland Category		Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area	
	1100	Inland Wetlands - Natural						
1	1101	Lakes/Ponds	276	2814	11.96	1812	924	
2	1102	Ox-bow lakes/ Cut-off meanders	87	1867	7.93	1042	705	
3	1103	High altitude wetlands	-	-	-	-	-	
4	1104	Riverine wetlands	10	132	0.56	85	48	
5	1105	Waterlogged	-	-	-	-	-	
6	1106	River/Stream	13	18478	78.52	7136	6912	
	1200	Inland Wetlands -Man-made						
7	1201	Reservoirs/Barrages	-	-	-	-	-	
8	1202	Tanks/Ponds	4	18	0.08	18	18	
9	1203	Waterlogged	-	-	-	-	-	
10	1204	Salt pans	-	-	-	-	-	
		Sub-Total	390	23309	99.04	10093	8607	
		Wetlands (<2.25 ha), mainly Tanks	225	225	0.96	-	-	
		Total	615	23534	100.00	10093	8607	

Table 8: Area estimates of wetlands in Koch Bihar

Area under Aquatic Vegetation	1866	3127	
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Area under turbidity levels		
Low	425	212
Moderate	9625	8356
High	43	39



	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





#### 7.1.4 Uttar Dinajpur

Extents: Latitude: 25°13′44" N to 26°31′10" N; Longitude: 87°48′10" E to 88°32′54" E.

The district is bounded by Bangladesh on the east, Bihar on the west, Darjiling and Jalpaiguri districts on the north and Malda district on the south. The district came into existence, after the bifurcation of the erstwhile West Dinajpur district, on 1<sup>st</sup> April, 1992. The district is in general a plain area with a gentle southerly slope. The district lies in the physiographic zone known as Barind. The district is famous for its migratory birds that visit the wetlands during the winter from as far as Siberia. The Bird Sanctuary at Raigunj is a major tourist attraction. The sanctuary is a unique one with the river Kulik passing through the sanctuary rendering splendid attraction for the tourists. The main rivers of the district are Kulik, Nagar and Mahananda.

The total number of wetlands are 4336 including 3981 < 2.25 ha. Out of 355 wetlands (> 2.25 ha), 212 are natural and the remaining 143 are man-made. The total area covered by these wetlands is 8825 ha (Table 9). River/Stream ranked first in terms of area (3808 ha) accounting for 30% of wetland area (Table 9). The turbidity rating of open water in wetlands in the district is dominantly medium. The total area covered by aquatic vegetation is 2209 ha in post-monsoon and 2447 ha in pre-monsoon.

The important wetlands of the district are Kachna Bil, Andharia Bil.

	Γ		1				Area in ha
						Open V	Water
Sr. No.	Wettcode	Wetland Category	egory Of Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area	
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	93	2797	21.84	1472	1342
2	1102	Ox-bow lakes/ Cut-off meanders	10	149	1.16	74	59
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	49	602	4.70	328	315
5	1105	Waterlogged	13	833	6.50	295	264
6	1106	River/Stream	47	3808	29.74	3812	3014
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	143	636	4.97	577	504
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	355	8825	68.91	6558	5498
		Wetlands (<2.25 ha), mainly Tanks	3981	3981	31.09	-	-
		Total	4336	12806	100.00	6558	5498

Table 9: Area estimates of wetlands in Uttar Dinajpur

Area under Aquatic Vegetation	2209	2447

Area under turbidity levels		
Low	76	48
Moderate	6273	5148
High	209	302



	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



## 7.1.5 Dakshin Dinajpur

Extents: Latitude: 25°09′57″ N to 25°31′39″ N; Longitude: 88°23′59″ E to 89°00′56″ E.

The district was formed on 1<sup>st</sup> April, 1992. The district lies in the phisyographic zone known as Barind. The surface drainage is formed of rivers like Atreyee, Punarbhaba, Tangon and Brahmani that flow the north-south direction of the district.

Total number of wetlands mapped in the district is 112, out of which 28 are natural and the remaining 84 are man-made wetlands. The total area of wetlands is 9109 ha which includes the area occupied by small wetlands (< 2.25 ha) that count to be 6427. River/Stream ranked first in terms of area (1966 ha) accounting for 22% of wetland area (Table 10). In the case of inland wetlands, the seasonal variation in water spread extent is nearly 50 % from post-monsoon (2258 ha) to pre-monsoon (1147 ha). Turbidity is explicitly medium in the district. The total area covered by aquatic vegetation is 9 ha in post-monsoon season and 59 ha in pre-monsoon season (Table 10). The number of small wetlands (> 2.25 ha area) identified are 6427 (Table 10).

The important wetlands of the district are Baharam Bil, Kanur Bora Bil, Nandan Bil.

					% of wetland area	Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area		Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	3	30	0.33	28	10
2	1102	Ox-bow lakes/ Cut-off meanders	1	10	0.11	6	5
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	3	57	0.63	53	43
5	1105	Waterlogged	12	188	2.06	172	93
6	1106	River/Stream	9	1966	21.58	1578	619
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	84	431	4.73	421	377
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	112	2682	29.44	2258	1147
		Wetlands (<2.25 ha), mainly Tanks	6427	6427	70.56	-	-
		Total	6539	9109	100.00	2258	1147

Table 10: Area estimates of wetlands in Dakshin Dinajpur

Area under Aquatic Vegetation9	59
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Area under turbidity levels		
Low	229	180
Moderate	1919	889
High	110	78



	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





## 7.1.6 Maldah

Extents: Latitude: 24°38′57″ N to 25°32′47″ N; Longitude: 87°45′18″ E to 88°27′57″ E.

Maldah district is a low lying plain with few elevated tracts. The district in general slopes from north to south. The slope is gradual which results in rivers meandering through district. The Mahananda River divides the district into two equal physiographic zones viz the Rarh and the Barind. West of Mahananda is again divided by the river Kalindi flowing from west to east. North of Kalindi exist the Tal lowlands where the flooded water floods through meandering streams Kalindi. is drained during into the swamps of The topography is favorable for the formation of numerous ox-bow lakes by the Kalindi. Huge lakes are formed by the direct and indirect fluvial action of the rivers. The Mahananda in the east is a river that brings down silt during the rains. The effect of this siltation along the river banks resulted in formation of a shallow basin lying between two rivers.

There are 4939 wetlands in this district out of which 502 are > 2.25 ha while 4437 are < 2.25 ha. Out of 502 wetlands 382 are natural and the remaining 120 are man-made. Total area of wetlands is 25162 ha including the small wetlands. River/Stream ranked first in terms of area (12906 ha) accounting for 51% of wetland area (Table 11). Seasonal variation in open water spread is mainly shown by River/Stream which is 19384 ha in post-monsoon and decreased to 15295. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium type. Significant variation in spread of aquatic vegetation was observed in post- and pre-monsoon season. The area covered by aquatic vegetation in the district is 927 ha and 3097 ha in post and pre monsoon (Table 11). The total number of small wetlands (<2.25 ha area) identified in the district is 4437. The wetland map and corresponding satellite imagery are given in figure 24. The important wetlands of the district are Amriti Dhapa, Phular Bil, Lussisar Dighi.

						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	123	4608	18.31	3511	1434
2	1102	Ox-bow lakes/ Cut-off meanders	31	582	2.31	519	360
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	148	1527	6.07	1406	929
5	1105	Waterlogged	48	382	1.52	370	166
6	1106	River/Stream	32	12906	51.29	12883	11856
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	105	558	2.22	536	467
9	1203	Waterlogged	15	162	0.64	159	83
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	502	20725	82.37	19384	15295
		Wetlands (<2.25 ha), mainly Tanks	4437	4437	17.63	-	-
		Total	4939	25162	100.00	19384	15295

Table 11: Area estimates of wetlands in Maldah

Area under Aquatic Vegetation	927	3097
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Area under turbidity levels		
Low	72	47
Moderate	16550	14082
High	2762	1166



	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





#### 7.1.7 Murshidabad

Extents: Latitude: 23°43′00″ N to 24°51′30″ N; Longitude: 87°48′24″ E to 88°44′54″ E.

The river Bhagirathi flowing north to south divides the district into two equal portions. The eastern portion is low-lying and alluvial which is liable to be flooded by the spills of the Bhagirathi. The western portion the land is high and undulating and the soil is hard clay. This western tract is interspersed with numerous swamps and beds of old rivers. The remnants of old river beds have transformed into small lakes or lagoons commonly called bils or jhils. The bils to the west of Bhagirathi are joined to the rivers by streams and shallow lakes which in the rains form a continuous lake. The large bils at the confluence of the hill streams serve during floods as natural drainage basins, into which the river water pour.

There are 392 wetlands > 2.25 ha mapped in the district, of which 256 are natural and the remaining 136 are man-made. The total area of wetlands is 41980 ha including 6453 small wetlands (< 2.25 ha). River/Stream ranked first in terms of area (24963 ha) accounting for 60% of wetland area. Seasonal variation in open water spread is mainly shown by River/Stream which is 18508 ha in post monsoon and decreased to 13725. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium type. The area covered by aquatic vegetation in the district is 1138 ha and 1736 ha in post and pre monsoon (Table 12).

The important wetlands of the district are Ahiron Bil, Krishnasalir Bil, Chautir Bil, Sujapur Bil and Chetiani Bil.

	1		T				Area in ha
						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	82	6692	15.94	5891	3700
2	1102	Ox-bow lakes/ Cut-off meanders	96	1822	4.34	1606	1370
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	40	625	1.49	566	387
5	1105	Waterlogged	19	512	1.22	464	321
6	1106	River/Stream	19	24963	59.46	18508	13725
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	131	518	1.23	505	433
9	1203	Waterlogged	5	395	0.94	384	391
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	392	35527	84.63	27924	20327
		Wetlands (<2.25 ha), mainly Tanks	6453	6453	15.37	-	-
		Total	6845	41980	100.00	27924	20327

Table 12: Area estimates of wetlands in Murshidabad

Area under Aquatic vegetation	1130	1/30
		ł

Area under turbidity levels		
Low	3285	2329
Moderate	23157	16714
High	1482	1284



0 4 5 9 18 27

	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





## 7.1.8 Birbhum

Extents: Latitude 23°32′16″ N to 24°35′12" N; Longitude: 87°05′04″ E to 88°01′52″ E.

In major part of the Birbhum district the surface is covered by a succession of undulations, the general trend of which is from north-west to south-east. In the northern most part of Birbhum there are several swamps. On the Dwaraka-Mayurakshi interfluves large water bodies occupy a low lying depression. Several marshes are also found on the right bank of the Mayurakshi. All of them are connected with the master stream by spill channels. Many derelict channels forming linear or ox-bow lakes are found on the right bank of the Dwaraka. During the monsoon a large part of the low lying area becomes submerged under water. Tanks area also found in the district mostly to carry out irrigational purposes.

There are 14351 wetlands that include 408 wetlands > 2.25 ha and 13943 wetlands < 2.25 ha in this district. Out of 408 mappable wetlands, 93 are natural and the remaining 315 are man-made. The wetlands occupy an area of 27660 ha including the small wetlands. River/Stream ranked first in terms of area (10499 ha) accounting for 37% of wetland area (Table 13). Seasonal variation in open water spread is mainly shown by River/Stream which is 5621 ha in post monsoon and decreased to 5063 ha. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium type. The area covered by aquatic vegetation in the district is 202 ha and 358 ha in post and pre monsoon (Table 13). The total number of small wetlands (>2.25 ha area) identified in the district is 13943.

The important wetlands of the district are Zela bandh, Raipur reservoir, Bakreswar reservoir, Lal dighi. Important wetlands in this district are Bakreswar dam, Raipur reservoir, Patelnagar zilla bandh, Lal Dighi.

						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	14	220	0.80	171	123
2	1102	Ox-bow lakes/ Cut-off meanders	15	77	0.28	72	34
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	8	36	0.13	34	22
5	1105	Waterlogged	23	884	3.20	842	856
6	1106	River/Stream	33	10499	37.96	5621	5063
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	4	899	3.25	832	699
8	1202	Tanks/Ponds	311	1102	3.98	1046	895
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	408	13717	49.59	8618	7692
		Wetlands (<2.25 ha), mainly Tanks	13943	13943	50.41	-	-
		Total	14351	27660	100.00	8618	7692

Table 13: Area estimates of wetlands in Birbhum

Area under Aquatic Vegetation	202	358
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Area under turbidity levels		
Low	612	626
Moderate	7152	6153
High	854	913



	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



#### 7.1.9 Barddhaman

Extents: Latitude: 22°55′47" N to 23°53′08" N; Longitude: 86°47′46" E to 88°25′22" E.

The lower Damodar valley in Barddhaman being a prematurely reclaimed deltaic tract, there are numerous debased pockets. The most important depressions are: the Purbasthali swamps formed by the changing course of the Bhagirathi and water-logged abandoned channels of the river and its tributaries. Ox bow lakes also occur along the river Ajay. There are numerous water-bodies of similar origin.

There are 860 wetlands mapped in the district, of which 169 are natural and the remaining 691 are manmade. In addition, 21918 small wetlands (<2.25 ha) identified in the district. The wetlands occupy an area of 49542 ha inclusive of small wetlands. River/Stream ranked first in terms of area (19983 ha) accounting for 40% of wetland area (Table 14). Seasonal variation in open water spread is mainly shown by River/Stream which is 8824 ha in post monsoon and decreased to 7819. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium type. Not much variation is observed in aquatic vegetation spread in two seasons, with 624 ha and 589 ha area in post and pre monsoon respectively (Table 14).

Some of the important wetlands of the district are Karajgram Bil, Kalo Baur Bil, Jalangi Bil, Chupichor Bil.

						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	75	1405	2.84	1086	1050
2	1102	Ox-bow lakes/ Cut-off meanders	54	944	1.91	919	663
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	17	445	0.90	389	325
5	1105	Waterlogged	17	303	0.61	280	220
6	1106	River/Stream	6	19983	40.34	8824	7819
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	7	1392	2.81	1377	1369
8	1202	Tanks/Ponds	677	2974	6.00	2793	2393
9	1203	Waterlogged	7	178	0.36	158	112
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	860	27624	55.76	15826	13951
		Wetlands (<2.25 ha), mainly Tanks	21918	21918	44.24	-	-
		Total	22778	49542	100.00	15826	13951

Table 14: Area estimates of wetlands in Barddhaman

Area under Aquatic Vegetation 622 58
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Area under turbidity levels		
Low	2063	1669
Moderate	13201	11852
High	562	430


	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



### 7.1.10 Nadia

Extents: Latitude: 22°51′57″ N to 24°12′48″ N; Longitude: 88°07′28″ E to 88°48′27″ E.

The district has a gentle slope with south-east gradient in general. The area is interspersed with jhils and marshes and the old beds of rivers. The origin of the marshes or bils all over the district is the oscillations of the river Bhairab, Jalangi and the Mathabhanga. Heavy rain fall and severe inundation of the district lead to low lying land being waterlogged.

There are 702 wetlands mapped in the district, of which 570 are natural and the remaining 132 are manmade. The total number of small wetlands (<2.25 ha area) identified in the district is 3763 (Table 15). Together these wetlands occupy an area of 28189 ha. Ox-bow lake/Cut-off meanders ranked first in terms of area (7411 ha) accounting for 26% of wetland area. Seasonal variation in open water spread is mainly shown by Ox-bow lakes/Cut-off meanders and River/Stream. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium type. The area covered by aquatic vegetation in the district is 3233 ha and 3985 ha in post and pre monsoon respectively (Table 15).

Some of the important wetlands of the district are Gopia Bil, Bhaluka Bil, Hansadanga Bil, Margangi Bil, Arangsarisha Bil.

						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	191	6282	22.29	4965	1991
2	1102	Ox-bow lakes/ Cut-off meanders	249	7411	26.29	5829	3384
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	21	879	3.12	683	211
5	1105	Waterlogged	98	1582	5.61	1256	576
6	1106	River/Stream	11	7254	25.73	7062	5624
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	117	927	3.29	756	346
9	1203	Waterlogged	15	91	0.32	77	47
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	702	24426	86.65	20628	12179
		Wetlands (<2.25 ha), mainly Tanks	3763	3763	13.35	-	-
		Total	4465	28189	100.00	20628	12179

Table 15: Area estimates of wetlands in Nadia

	Area under Aquatic Vegetation	3233	3985
-			

Area under turbidity levels		
Low	2308	1357
Moderate	15764	9423
High	2556	1399



	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



### 7.1.11 North Twenty Four Parganas

Extents: Latitude: 21°54′48″ N to 23°15′54″ N; Longitude: 88°24′04" E to 88°06′13" E.

North Twenty Four Parganas generally encompasses a moribund delta of the Ganga-Brahmaputra river system. It comes under the physiographic division known as Coastal/Sunderban region. The land is characterized by cut-off meanders, which have lost their connection with the rivers. The rivers do not deposit silt even during the floods. There are 748 inland wetlands and 76 coastal wetlands > 2.25 ha mapped in the district extending over an area of 146682 ha. However, there are 3634 wetlands < 2.25 ha that accounts for about 2 per cent of wetland extent. Out of the 748 inland wetlands 475 are natural and 273 are man-made. Out of 76 costal wetlands 74 are natural and 2 are man-made. River/Stream ranked first in terms of area (38647 ha) accounting for 26% of wetland area (Table 16). Seasonal variation in open water spread is mainly shown by Lake/Ponds, waterlogged and River/Stream which is 18166, 23737 and 37849 ha in post-monsoon and decreased to 18165, 22362 and 37667 respectively. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium and high type. The area covered by aquatic vegetation in the district is 57346 ha and 58486 ha in post and pre monsoon (Table 16). Some of the important wetlands of the district are Gopalnagar Bil, Harinagar ghat baor, Kanchir Bil, Bediyar Baur, Boller Bil, Bamun Bil.

			Number	Total	otal % of Ope		n Water	
Sr. No.	Wettcode	Wetland Category	of Wetlands	Wetland Area	wetland area	Post- monsoon Area	Pre- monsoon Area	
	1100	Inland Wetlands - Natural						
1	1101	Lakes/Ponds	90	22912	15.25	18166	18165	
2	1102	Ox-bow lakes/ Cut-off meanders	139	4445	2.96	3816	2812	
3	1103	High altitude wetlands	-	-	-	-	-	
4	1104	Riverine wetlands	13	461	0.31	290	155	
5	1105	Waterlogged	206	24702	16.45	23737	22362	
6	1106	River/Stream	27	38647	25.73	37849	37667	
	1200	Inland Wetlands -Man-made						
7	1201	Reservoirs/Barrages	-	-	-	-	-	
8	1202	Tanks/Ponds	257	1980	1.32	1838	1019	
9	1203	Waterlogged	14	283	0.19	260	185	
10	1204	Salt pans	2	43	0.03	43	43	
		Total - Inland	748	93473	62.23	85999	82408	
	2100	Coastal Wetlands - Natural						
11	2101	Lagoons	-	-	-	-	-	
12	2102	Creeks	-	-	-	-	-	
13	2104	Intertidal mud flats	-	-	-	-	-	
14	2106	Mangroves	74	52759	35.12	-	-	
15	2107	Coral Reefs	-	-	-	-	-	
	2200	Coastal Wetlands - Man-made						
16	2201	Salt pans	-	-	-	-	-	
17	2202	Aquaculture ponds	2	340	0.23	340	331	
		Total - Coastal	76	53099	35.35	340	331	
		Sub-Total	824	146572	97.58	86339	82739	
		Wetlands (<2.25 ha), mainly Tanks	3634	3634	2.42	-	-	
		Total	4458	150206	100.00	86339	82739	

Table 16: Area estimates of wetlands in North Twenty Four Parganas

Area under Aquatic Vegetation	57346	58486
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Area under turbidity levels		
Low	450	397
Moderate	50537	45143
High	35352	37199



	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



# 7.1.12 Hugli

Extents: Latitude: 22°35′41″ N to 23°13′50″ N; Longitude: 87°29′36″ E to 88°30′59″ E.

There are very few lakes in the district, but a large number of catchment basin is seen in which water accumulates during the rain forming swamps. These marshes contain water even during the summer months. In between the high riparian strips (locally known as *jangals*) occur depressions lower in elevation form vast marshes. These depressions receive run-off during the monsoon. In the western parts of the Hugli these surface drainages are narrow and silted, and fail to carry the volume of water with sufficient rate. Consequently they overflow. After the cessation of the monsoon the deeper parts of the river beds become represented by stagnant pools. Some places have numerous shallow basins alternately containing lakes and swamps according to the seasons. Another type of flood-plain lakes is the ox-bow lakes of the Bhagirathi which are discernible by their meander scars.

There are 298 inland wetlands and 2 coastal man-made wetlands that are > 2.25 ha in addition to 13108 wetlands < 2.25 ha in the district extending over an area of 21514 ha. Out of the mappable 298 inland wetlands 53 are natural and 245 are man-made. River/Stream ranked first in terms of area (5646 ha) accounting for 26% of wetland area (Table 17). Seasonal variation in open water spread is mainly shown by River/Stream which is 4268 ha in post-monsoon and increased to 4422 ha. The turbidity of the region is mainly of medium type (Table 17). The area covered by aquatic vegetation in the district is 191 ha and 214 ha in post and pre monsoon. Some of the important wetlands of the district are Khan pukur, Daho Bil, Dekal Bil.

			Number		% of	Open Water	
Sr. No.	Wettcode	Wetland Category	of Wetlands	Total Wetland Area	wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	7	414	1.92	328	242
2	1102	Ox-bow lakes/ Cut-off meanders	17	176	0.82	165	129
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	1	31	0.14	27	28
5	1105	Waterlogged	24	936	4.35	913	105
6	1106	River/Stream	4	5646	26.24	4268	4422
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	240	1060	4.93	1042	826
9	1203	Waterlogged	5	55	0.26	55	21
		Total - Inland	298	8318	38.66	6798	5773
	2100	Coastal Wetlands - Natural					
10	2101	Lagoons	-	-	-	-	-
11	2106	Mangroves	-	-	-	-	-
12	2107	Coral Reefs	-	-	-	-	-
	2200	Coastal Wetlands - Man-made	1				
13	2201	Salt pans	-	-	-	-	-
14	2202	Aquaculture ponds	2	88	0.41	88	67
		Total - Coastal	2	88	0.41	88	67
		Sub-Total	300	8406	39.07	6886	5840

Table 17: Area estimates of wetlands in Hugli

	Total	13408	21514	100.00	6886	5840
	Wetlands (<2.25 ha), mainly Tanks	13108	13108	60.93	-	-

Area under Aquatic Vegetation 191	214
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Area under turbidity levels		
Low	96	16
Moderate	6138	5434
High	652	390



	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





### 7.1.13 Bankura

Extents: 22°37′06" N to 23°38′42" N; Longitude: 86°36′21" E to 87°46′21" E.

The district Bankura consists of two distinct tracts. The western portion marks the rolling uplands and isolated hills, whereas, the deltaic tract of river Ganga is present in the east. Along with natural lakes or riverine wetlands many excavated tanks are also found in the level portion of the district.

There are 15838 wetlands, which include 1202 of >2.25 ha and 14636 of < 2.25 ha in the district extending over an area of 41476 ha. Out of the 1202 wetlands (>2.25 ha) 215 are natural and 987 are man-made. River/Stream ranked first in terms of area (14427 ha) accounting for 35% of wetland area (Table 18). Seasonal variation in open water spread is mainly shown by Reservoir/Barrage which is 7666 ha in post-monsoon and decreased to 4651 ha. The turbidity of the region is mainly of low and medium type (Table 18). The area covered by aquatic vegetation in the district is 564 ha and 929 ha in post and pre monsoon (Table 18).

The important wetlands of the district are Krishno bandh, Mukutmanipur Dam, Uttampur bandh, Boro Royen bandh.

						Open Water	
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	126	888	2.14	760	687
2	1102	Ox-bow lakes/ Cut-off meanders	17	92	0.22	92	70
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	9	75	0.18	75	71
5	1105	Waterlogged	46	377	0.91	358	264
6	1106	River/Stream	17	14427	34.78	4915	3648
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	165	7853	18.93	7666	4651
8	1202	Tanks/Ponds	820	3022	7.29	2791	2608
9	1203	Waterlogged	2	106	0.26	106	106
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	1202	26840	64.71	16763	12105
		Wetlands (<2.25 ha), mainly Tanks	14636	14636	35.29	-	-
		Total	15838	41476	100.00	16763	12105

Table 18: Area estimates of wetlands in Bankura

	Area under Aquatic Vegetation	564	929	
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Area under turbidity levels		
Low	6062	3056
Moderate	9357	7815

74



	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



# 7.1.14 Puruliya

Extents: Latitude: 22°42′35" N to 23°43′18" N; Longitude: 85°48′47" E to 86°54′13" E.

The district of Puruliya forms the connector between the hills of central India and the Chotanagpur plateau to the plain of Damodar in West Bengal. The topography of the district is gently undulating with occasional hillocks made up of hard rock. The district has numerous small storage pools, some of which have been constructed in the recent years during the famine relief operations. The storage pools are constructed at a higher level to prevent the rain water from draining off too quickly. In the undulating terrain conservation of water is carried out by the construction of embankments across the drainage lines. The lake is the chief source of drinking water. There are numerous lakes in the district. The undulating topography of the district highly facilitates the occurrence of water logging in the depressions.

There are 18002 wetlands in the district extending over an area of 38122 ha including 16738 wetlands < 2.25 ha. Out of the 1264 wetlands (> 2.25 ha) 128 are natural and1136 are man-made. Reservoir/Barrage ranked first in terms of area (11741 ha) accounting for 54% of wetland area (Table 19). Seasonal variation in open water spread is mainly shown by Reservoir/Barrage which is 10965 ha in post monsoon and decreased to 6183 ha. The area coverage shows that the man-made wetlands are quite big in size. The turbidity of the region is mainly of low and medium type (Table 19). The area covered by aquatic vegetation in the district is 1157 ha and 2477 ha in post and pre monsoon.

The important wetlands of the district are Rani bandh, Pathak bandh, Murguma Dam, Panchet Dam.

						Open V	Vater
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	52	462	1.21	389	336
2	1102	Ox-bow lakes/ Cut-off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	2	5	0.01	5	4
5	1105	Waterlogged	52	651	1.71	671	519
6	1106	River/Stream	22	4509	11.83	3930	3803
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	107	11741	30.80	10965	6183
8	1202	Tanks/Ponds	1024	3912	10.26	3569	3022
9	1203	Waterlogged	5	104	0.27	104	91
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	1264	21384	56.09	19633	13958
		Wetlands (<2.25 ha), mainly Tanks	16738	16738	43.91	-	-
		Total	18002	38122	100.00	19633	13958

Table 19: Area estimates of wetlands in Puruliya

Area under Aquatic Vegetation	1157	2477

Area under turbidity levels		
Low	11278	6347
Moderate	8078	7402
High	277	209



	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



### 7.1.15 West Medinipur

Extents: Latitude: 21°45′06" N to 22°57′42" N; Longitude: 86°33′40" E to 87°54′09" E

The district was formed on 1<sup>st</sup> January, 2002. There are two natural divisions; the eastern portion of the district is flat having alluvial soil and the western part is undulating. The eastern alluvial tract of the district is interspersed by numerous waterways and tidal creeks. Much of this area is waterlogged especially the tract bounded by the Kasai river on the south and the Silai river on the north. The riverbed is raised by the constant deposition of silt above the level of the surrounding country. Thus, the latter needs protection from inundation and waterlogging.

There are 744 inland wetlands and 2 coastal man-made wetlands in the district extending over an area of 23766 ha. Out of the 742 inland wetlands 320 are natural and 422 are man-made. River/Stream ranked first in terms of area (17696 ha) accounting for 44% of wetland area (Table 20). Seasonal variation in open water spread is mainly shown by River/Stream which is 7658 ha in post monsoon and decreased to 7119 ha. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the region is mainly of medium type (Table 20). The aquatic vegetation in wetlands is 395 ha and 2116 ha in post and pre monsoon season respectively. The total number of small wetlands (<2.25 ha) identified in the district is 16860 comprise a significant area (42 %) if each wetland is assumed to be of 1 ha.

The important wetlands of the district are Ghosh Bandh, Mela Bandh and Naranja salt pan.

		-					Area in ha
	Wettcode				o( 6	Open Water	
Sr. No.		Wettcode Wetland Category	Number of Wetlands	l otal Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	128	789	1.94	720	565
2	1102	Ox-bow lakes/ Cut-off meanders	30	307	0.76	243	142
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	10	58	0.14	53	38
5	1105	Waterlogged	145	2813	6.92	2742	613
6	1106	River/Stream	7	17696	43.56	7658	7119
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	65	737	1.81	638	597
8	1202	Tanks/Ponds	357	1350	3.32	1234	1133
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	742	23750	58.46	13288	10207
	2200	Coastal Wetlands - Man-made					
11	2202	Aquaculture ponds	2	16	0.04	12	10
		Wetlands (<2.25 ha), mainly Tanks	16860	16860	41.50	-	-
		Total	17604	40626	100.00	13300	10217

Table 20: Area estimates of wetlands in West Medinipur

Area under Aquatic Vegetation	395	2116

Area under turbidity levels		
Low	614	92
Moderate	9884	7989
High	2802	2136



0 5 10 20 30

	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





### 7.1.16 Howrah

Extents: Latitude: 22°12′14" N to 22°57'42" N; Longitude: 87°50′15" E to 88°31′45" E.

In between the levees, wetlands are formed around the rivers in the form of extensive swamps (jheels) or depressions (jalas) which hold vast sheet of water during the rainy season. The western part of the district occupies a portion of the Dankuni and Howrah swamps extending north to south between the Bhagirathi and the Saraswati. There are other well known swamps in the district, namely the Rajapur swamp which lies between the Saraswati and the Kana Damodar, the Amta swamp which lies between the Kana Damodar and the Saraswati.

There are 178 inland wetlands > 2.25 ha in the district extending over an area of 13340 ha. Out of the 178 inland wetlands 60 are natural and 118 are man-made. In addition, 2249 small wetlands (<2.25 ha) have been identified in the district, which accounts for about 14 per cent of wetland area. River/Stream ranked first in terms of area (9193 ha) accounting for 59% of wetland area (Table 21). Seasonal variation in open water spread is mainly shown by River/Stream which is 9113 ha in post monsoon and decreased to 8710 ha. The area coverage shows that the natural wetlands are quite big in size. The turbidity of open water is mainly of medium type. The area covered by aquatic vegetation in the district is 1076 ha and 1890 ha in post- and pre-monsoon (Table 21).

The important wetlands of the district are Satragachi Bil, Jagannathpur Daha, Keduar Math, Puber par.

							Area in ha
						Area Open Water Post- monsoon Area 7 7 1232 6 179 - - - 2 334 7 559 7 9113 - - - - - - - - - - - - -	Vater
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area		Pre- monsoon Area
	1100	Inland Wetlands - Natural	· · · · · ·				
1	1101	Lakes/Ponds	20	2209	14.17	1232	383
2	1102	Ox-bow lakes/ Cut-off meanders	9	228	1.46	179	177
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	11	315	2.02	334	264
5	1105	Waterlogged	19	666	4.27	559	1199
6	1106	River/Stream	1	9193	58.97	9113	8710
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	2	47	0.30	47	42
8	1202	Tanks/Ponds	114	662	4.25	515	516
9	1203	Waterlogged	2	20	0.13	20	3
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	178	13340	85.57	11999	11294
		Wetlands (<2.25 ha), mainly Tanks	2249	2249	14.43	-	-
		Total	2427	15589	100.00	11999	11294

Table 21: Area estimates of wetlands in Howrah

Area under Aquatic Vegetation	1076	1890
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Area under turbidity levels		
Low	11	5
Moderate	10286	10289
High	1702	1000



	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



# 7.1.17 Kolkata

Extents: Latitude: 22°29′51" N to 22°38′05" N; Longitude: 88°16′22" E to 88°24′43" E;

The district is spread linearly along the bank of river Hooghly in a north south direction. The Kolkata city was originally a vast wetland reclaimed gradually by the burgeoning population.

There are 25 inland wetlands in the district extending over an area of 697 ha. Out of the 25 inland wetlands 8 are natural and 17 are man-made. River/Stream ranked first in terms of area (476 ha) accounting for 68% of wetland area (Table 22). Seasonal variation in open water spread is mainly shown by River/Stream which is 476 ha in post-monsoon and pre-monsoon. The total number of small wetlands (<2.25 ha area) identified in the district is 27. The turbidity of water is mainly of medium type. No aquatic vegetation could be identified at the given scale.

The East Kolkata wetland is 'the Wetland of International Importance' under the Ramsar Convention declared n the year 2002

						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					
1	1101	Lakes/Ponds	5	96	13.26	96	96
2	1102	Ox-bow lakes/ Cut-off meanders	2	37	5.11	37	37
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	1	476	65.75	476	476
	1200	Inland Wetlands -Man-made					
7	1201	Reservoirs/Barrages	-	-	-	-	-
8	1202	Tanks/Ponds	17	88	12.15	88	85
9	1203	Waterlogged	-	-	-	-	-
10	1204	Salt pans	-	-	-	-	-
		Sub-Total	25	697	96.27	697	694
		Wetlands (<2.25 ha), mainly Tanks	27	27	3.73	-	-
		Total	52	724	100.00	697	694

Table 22: Area	estimates	of wetlands	in	Kolkata
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Area under Aquatic Vegetation	-	-
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Area under turbidity levels		
Low	-	-
Moderate	487	483
High	210	211

90



	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



### 7.1.18 South Twenty Four Parganas

Extents: Latitude: 21°28'21" N to 22°37'48" N; Longitude: 87°53'45" E to 89°08'44" E.

The region is covered by swamps and marshes formed by the river Ganga. The land is intricately connected with a mesh of river channels making the district ideal for the formation of depressions covered by water commonly called Bils.

There are 390 inland wetlands and 367 coastal wetlands mapped in the district which are > 2.25 ha. The wetlands occupied an area of 477151 ha. Out of the 390 inland wetlands 292 are natural and 98 are man-made. Out of the 367 coastal wetlands 365 are natural and 2 are man-made. River/Stream ranked first in terms of area (285922 ha) accounting for 60% of wetland area (Table 23). Seasonal variation in open water spread is mainly shown by River/Stream which is 285918 ha in post-monsoon and decreased to 285897 ha in pre monsoon season. The area coverage shows that the natural wetlands are quite big in size. The turbidity of the open water is mainly of medium type (Table 23). The area covered by aquatic vegetation in the district is 156102 ha and 156161 ha in post- and pre-monsoon (Table 23) out of which mangroves account for 155669 ha. The total number of small wetlands (<2.25 ha area) identified in the district is 2300. The important wetlands of the district are Banogram Bil, Payna Abad Bil, Saranga Abad Bil, Gangar math.

	1	1				Γ	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	33	5730	1.20	4499	4366	
2	1102	Ox-bow lakes/ Cut-off meanders	84	970	0.20	927	861	
3	1104	Riverine wetlands	122	3105	0.65	3045	2909	
4	1105	Waterlogged	48	18300	3.84	11497	10551	
5	1106	River/Stream	5	285918	59.92	285918	285897	
	1200 Inland Wetlands -Man-made							
6	1202	Tanks/Ponds	95	603	0.13	580	494	
7	1203	Waterlogged	2	9	0.00	9	9	
8	1204	Salt pans	1	28	0.01	28	28	
		Total - Inland	390	314663	65.95	306507	305115	
	2100	Coastal Wetlands - Natural						
9	2103	Sand/Beach	39	1627	0.34	-	-	
10	2104	Intertidal mud flats	16	2367	0.50	-	-	
11	2106	Mangroves	310	155669	32.62	-	-	
	2200	Coastal Wetlands - Man-made						
12	2202	Aquaculture ponds	2	525	0.11	424	317	
		Total - Coastal	367	160188	33.57	424	317	
		Sub-Total	757	474851	99.52	306931	305432	
		Wetlands (<2.25 ha), mainly Tanks	2300	2300	0.48	-	-	
		Total	3057	477151	100.00	306931	305432	

Table 23: Area estimates of wetlands in South Twenty Four Parganas

rea under Aquatic Vegetation	156102	156161
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Area under turbidity levels		
Low	3577	3615
Moderate	296450	295757
High	6904	6060


	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



IRS P6 LISS-III post monsoon data (2006)

#### 7.1.19 East Medinipur

Extents: Latitude: 21°36′25" N to 22°31′07" N; Longitude: 87°24′19" E to 88°12′34" E. (Medinipur district is divided into East Medinipur and West Medinipur on 1<sup>st</sup> January, 2002).

Two natural divisions are evident in this district. The eastern portion of the district is flat having alluvial soil, the western part is undulating. There are alternate ridges and depressions present on most of the surface of the district. The eastern alluvial tract of the district is interspersed by numerous waterways and tidal creeks. Much of this area is waterlogged especially the tract bounded by the Kasai river on the south and the Silai river on the north.

Total 181 wetlands are mapped in the district, comprising of 143 Inland and 38 Coastal wetlands. Of the total of 143 Inland wetlands 59 are natural and the remaining 84 are man-made. The coastal wetlands can again be divided into 18 natural and 20 man-made. River/Stream ranked first in terms of area (36503 ha) accounting for 64% of wetland area. Costal wetlands (15 %) are dominated upon by inland wetlands which comprise about 72 per cent. The total number of small wetlands (< 2.25 ha area) identified is 7412 (Table 24) which accounts for 13 per cent of wetland extent in this district. The turbidity of the open water is generally medium. The area covered by aquatic vegetation in the district is 969 ha and 1101 ha in post-monsson and pre-monsoon (Table 24).

The important wetlands of the district are Ghosh Bandh, Mela Bandh and Naranja salt pan.

						Open	Water
Sr. No.	Wettcode	Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Post- monsoon Area	Pre- monsoon Area
	1100	Inland Wetlands - Natural					I
1	1102	Ox-bow lakes/ Cut-off meanders	14	72	0.13	70	63
2	1104	Riverine wetlands	7	170	0.30	166	169
3	1105	Waterlogged	36	3474	6.14	3459	3228
4	1106	River/Stream	2	36503	64.49	36503	35294
	1200	Inland Wetlands -Man-made					
5	1201	Reservoirs/Barrages	1	3	0.01	3	3
6	1202	Tanks/Ponds	82	510	0.90	496	446
7	1203	Waterlogged	1	32	0.06	22	28
		Total - Inland	143	40764	72.02	40719	39231
	2100	Coastal Wetlands - Natural					·
8	2103	Sand/Beach	12	1711	3.02	-	-
9	2104	Intertidal mud flats	1	359	0.63	-	-
10	2106	Mangroves	5	902	1.59	-	-
	2200	Coastal Wetlands - Man-made					·
11	2201	Salt pans	14	4866	8.60	4865	4865
12	2202	Aquaculture ponds	6	588	1.04	561	566
		Total - Coastal	38	8426	14.89	5426	5431
		Sub-Total	181	49190	86.91	46145	44662

Table 24: Area estimates of wetlands in East Medinipur

	Wetlands (<2.25 ha), mainly Tanks	7412	7412	13.09	-	-
	Total	7593	56602	100.00	46145	44662

Area under Aquatic Vegetation	969	1101
-------------------------------	-----	------

Area under turbidity levels		
Low	1009	1003
Moderate	40177	35951
High	4959	7708



	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



IRS P6 LISS-III post monsoon data (2006)

**MAJOR WETLAND TYPES** 

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#### 8.0 MAJOR WETLAND TYPES OF WEST BENGAL

Major wetland types observed in the state are River/Stream, Mangroves, lakes/ponds, Waterlogged and Reservoirs. Plate-1 shows mangroves, waterlogged and reservoir categories. Ground truth data was collected for selected wetland sites in the standard proforma. 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.



Plate - 1: Major wetland types of West Bengal

Sr. No.	Description	Field photograph
1.	Wetland Type: Waterlogged Location: Longitude: 87 <sup>0</sup> 58' 30" E Latitude : 25 <sup>0</sup> 47' 43" N Turbidity: Moderate Aquatic vegetation: <i>Ipomoea carnea,</i> <i>Typha angustifolia</i>	
2.	Wetland Type: Waterlogged Location: Longitude: 88 <sup>0</sup> 28' 07" E Latitude : 25 <sup>0</sup> 25' 58" N Turbidity : Low Aquatic vegetation : <i>Eichhornia crassipes,</i> <i>Nymphaea alba,</i> <i>Hydrilla verticillata,</i> <i>Vallisneria</i>	
3.	Wetland Type: Riverine wetland Location: Longitude : 88 <sup>0</sup> 01' <b>16</b> " E Latitude : 24 <sup>0</sup> 04' 11" N Turbidity: Moderate	
4.	Wetland Type : Aquaculture ponds Location : Longitude : 87 <sup>0</sup> 37' 00" E Latitude : 21 <sup>0</sup> 39' 02" N Turbidity: Moderate	



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

Sr. No.	Description	Field photograph
5.	Wetland Type : Salt pans Location : Longitude: 87 <sup>0</sup> 36' 56" E Latitude : 21 <sup>0</sup> 40' 50" N Turbidity: Moderate Aquatic Vegetation: Nil	
6.	Wetland Type: Tank/Pond Location: Longitude: 86 <sup>0</sup> 03' 11" E Latitude : 23 <sup>0</sup> 25' 31" N Turbidity: Low Aquatic Vegetation: <i>Nymphaea alba,</i> <i>Marsilea quadrifolia,</i> <i>Hydrilla verticillata</i>	
7.	Wetland Type: Cut-off meanders Location: Longitude: 89 <sup>0</sup> 30' 26" E Latitude : 26 <sup>0</sup> 16' 48" N Name: Panishala Chari bil Aquatic Vegetation: <i>Eichhornia crassipes,</i> <i>Salvinia cucullata,</i> <i>Lemna acquinoctalis</i>	
8.	Wetland Type: Inter-tidal mud flats Location : Longitude : 88 <sup>0</sup> 43' 39" E Latitude : 22 <sup>0</sup> 07' 12" N Turbidity : Moderate	



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

Sr. No.	Description	Field photograph
9.	Wetland Type: Ox-bow Lake Location: Longitude: 88 <sup>0</sup> 27' 40" E Latitude : 23 <sup>0</sup> 27' 02" N Turbidity: Low Aquatic Vegetation:	
	Ipomoea aquatica, Eichhornia, Cassia tora, Cassia fistula	
10.	Wetland Type: Reservoir Location: Longitude: 86 <sup>0</sup> 47' 11" E Latitude : 22 <sup>0</sup> 57' 45" N	

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

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**IMPORTANT WETLANDS OF WEST BENGAL** 

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#### 9.0 IMPORTANT WETLANDS OF WEST BENGAL

East Kolkata Wetlands, Rasik Bil, and the Sunderbans are some of the important wetland sites. Extensive field work was carried out for these wetland areas. Wetland maps have been prepared for 5km buffer area of each wetland sites. Details of each wetland and wetland map of 5 km buffer area are shown in plates 3 to 11.

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## 9.1 East Kolkata wetlands

	Name	: East Kolkata Wetlands
1	Location	: Latitude: 20°25′00"N to 22°35′00"N; Longitude: 88°20′00" E to 88°35′00" E.
		The East Kolkata Wetlands supports the food of a large number of people through natural resource use. It is the largest waste water recycling system in the world comprising of 12,000 ha of Waste Recycling Region (WRR) for Calcutta City in which waste water is used to produce fish and rice, and solid waste is used to produce vegetables.
2	Area	: 12512 ha
3	Wetland type	: Waterlogged
4	Floral Diversity	: Floating macrophytes and phytoplankton are the major floral component of East Kolkata Wetland. Algae like Anabaena, Spirullina, Oscillatoria, Euglena, Chlorella and diatoms dominate the phytoplankton diversity. The commonly occurring aquatic macrophytes are Hygrophila difformis, water hyacinth (Eichhornia crassipes), water clover (Marsilea minuta), mosquito fern (Azolla pinnata) and water weed (Hydrilla verticillata). The herbaceous floral diversity on the banks of the water bodies are Blumea lacera, Bacopa monnieri, Colocasia esculenta, Ipomoea aquatica and Eclipta prostrata.
5	Faunal Diversity	Y: The wetland fauna is dominated by zooplankton, aquatic insects, crustaceans, mollusks and aquatic vertebrates like fishes, amphibians, reptiles and aquatic birds. Asplnchana (Rotifer), Diaptomus sp, Mesocyclops hyalinus (Copepoda), Moina mirura, (Cladocera) are the major zooplanktons. The common crustaceans are Macrobrachium lamacaei, M. malcomonii, M. rude popularly known as 'Pukure chingri' and Sartoriana spinigera called as 'Telo kakra'. Aquatic insects like Sphaerodema annulatum, Ranatra elongata and Hygrophilus olivaceous. The mollusks found in the waterbodies are Bellamya bangalensis (geri), Pila globosa (samuk), Lymnaea luteola (googli) and Lamellidens marginalis (jhinuk). The major amphibians are Rana tigrina (bull frog), R. hexadactyla (green frog), R. limnocharis (cricket frog) and Bufo melanostictus (common toad). Most common fishes are Labaeo rohita (rui), L. bata (bata), Oreochromis mossambica (tilapia), O. niliotica (nilotica), Liza parsia (parse), Puntinus chola (punti) and Mastacembetus panalas (pankal). Among the reptiles are Varanus bangalensis (go sap), Naja naja (gokhro), Xenochropes piscator (jal dhora) and Calotes versicolor (girgiti). The common birds are kingfisher (Ceryle rudis), common hoopoe (Upupa epos), green barbet (Megalaima zeylanica), coppersmith barbet (M. haemacephala), bee eater, (Merops orientalis), black winged stilt (Himantopush imantopus) and crow pheasant (Centropus sinensis).



Plate 3: East Kolkata Wetlands



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

	data (Pro-monsoon and Post-monsoon Season 2006-07)
K5 F6 LI55 II	r data (Fre-monsoon and Fost-monsoon Season 2006-07)
Prepared By :	
s	pace Applications Centre (ISRO), Ahmedabad
	and
Institute of E	nvironmental Studies and Wetland Management, Kolkata
ponsored By	<i>r</i> :
	Ministry of Environment and Forests
	Government of India

## Plate 4: Wetland map - 5 km buffer area of East Kolkata wetlands



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

## Plate 5: IRS LISS-III FCC of 5 km buffer area of East Kolkata wetlands

# 9.2 Rasik Bil & surrounding area

	Name	: Rasik Bil
1	Location	: Latitude: 26°24'33" N; Longitude: 89°43'24" E.
		The Rasik Bil lies in the Cooch bihar district of West Bengal. It is situated about 42 km from Cooch bihar Town. It is a recognized bird sanctuary. It has a deer park and a recently built aquariam where fishes, turtles and Ghraials (a type of crocodiles), seven nos. of leopards, Peafowl are kept. Rasikbil is a complex of wet lands. The name of important water bodies are Bochamari Bil, Rasik Bil, Batikata Bil and Raichangmari Bil. The area of water boby complex is 178 ha. The whole area comes under protected forest and is managed by Cooch bihar Forest Division.
2	Area	: 178 ha
3	Wetland type	: Lake
4	Floral Diversi	ty: Wetland and surrounding flora is dominated by aquatic rooted emergent plants like <i>Eichhornia crassipes, Hydrilla,</i> water cups, <i>Ipomoea aquatica</i> and fringe area plants like <i>Cynodon dactylon, Fibristylis sp</i> and <i>Amaranthus spinosus</i> (colmi).
5	Faunal Divers	<b>Sity</b> : Wetland fauna is represented by leech (Hirudinaria granulosa), snails (Bellamya sp, Pila sp, Lymnaea sp), giant water bug (Sphaerodema rusticum, S. annulatum), water strider (Aquarius sp), water scorpion (Ranatra sp), giant water scorpion (Lithocerus sp), aquatic stripped beetle, brown beetle, small black beetle, dragon fly and damsel fly. The main migratory birds found in this wet land are Lesser Whistling Teal, Common Teal, Cotton Teal, Dapchick, Barheaded goose. Except this a lot of other aquatic bird like small and large Cormorant, Kingfisher, open bil stork are found





Plate 6: Rasik Bil



	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 7: Wetland map - 5 km buffer area of Rasik Bil

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

### Plate 8: IRS LISS-III FCC of 5 km buffer area of Rasik bil

# 9.3 The Sunderbans

	Name	: Sundarbans
1	Location	: Latitude: 21°56′00" N; Longitude: 88°51′00" E.
		The Sunderbans consist of flat alluvial plains in which the process of land making is still going on. This land is mostly covered with forests and swamps, intersected from north to south by wide tidal rivers or estuaries and from west to east by narrow tidal creeks. All of these estuaries carry saline water. There is no current down them except tidal inflows and outflows. They are connected with each other by an intricate mesh of channels, so that the whole tract is a tangled network of estuaries, rivers and watercourses which enclose a large number of islands of various shapes and sizes. Most of these islands are mere swampy marshes covered with mangrove.
2	Area	: 209330 ha
3	Wetland type	: Mangroves
4	Floral Diversity	:Sunderbans is the largest single block of tidal halophytic mangrove forest in the world. The freshwater swamps are composed of tropical moist broad-leaved forest characterized by <i>Heritiera fomes</i> , locally known as 'sundari', <i>H. minor, Xylocarpus molluccensis, X. mekongensis, X. granatum, Bruguiera conjugata, B. gymnorrhiza, Cereops decandra, Sonneratia apetala, Avicennia officinalis, Aegiceras corniculatum, Rhizophora mucronata and Sonneratia caseolaris, Pandanus tectorius, Hibiscus tiliaceus and Nypa fruticans.</i>
5	Faunal Diversit	<b>y</b> :The mangroves provide critical habitat for numerous species of fishes, birds, reptiles, crustaceans and mammals among which are the crocodiles, ( <i>Crocodylus porosus and Crocodylus palustris</i> ), the Gangetic gavial ( <i>Gavialis gangeticus</i> ), the water monitor lizard ( <i>Varanus salvator</i> ) sharks, the Gangetic freshwater dolphins ( <i>Platanista gangetica</i> ), mudskippers, crabs, hermit crabs and shrimps. The Royal Bengal tigers ( <i>Panthera tigris</i> ) are the most significant mammal of the Sunderbans. They prey upon chital deer ( <i>Cervus axis</i> ), barking deer ( <i>Muntiacus muntjak</i> ), wild pig ( <i>Sus scrofa</i> ) and macaques ( <i>Macaca mulatta</i> ). Some threatened mammal species like the capped langur ( <i>Semnopithecus pileatus</i> ), smooth-coated otter ( <i>Lutrogale perspicillata</i> ), oriental small-clawed otter ( <i>Aonyx cinerea</i> ), and great Indian civet ( <i>Viverra zibetha</i> ) are also found in the waterbodies. The region also contains leopard ( <i>Panthera pardus</i> ) and several smaller predators such as the jungle cat ( <i>Felis chaus</i> ), fishing cat ( <i>Prionailurus viverrinus</i> ), and leopard cat ( <i>Prionailurus bengalensis</i> ).



Plate 9: The Sunderbans



	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 10: Wetland map - The Sunderbans



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

# Plate 11: IRS LISS-III FCC of the part of Sunderbans

SOI MAP SHEET-WISE WETLAND MAPS (SELECTED)

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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

Waterlogged





Symbol	Typecode	Level I	Level II	Level III	Legend	<b>L</b>			
		Inland Wetlands			Nothenda (20.05 ha)	India	West Bengal	Index to She	eet
			Natural		vietiands (<2.25 ha)				
	1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5	SPh-		
	1102			Ox-bow lakes/ Cut-off meanders	Canal	XCE	Josef 3	73I/15 73M/3	736/7
	1103			High altitude wetlands	Legend Wetlands (<2.25 ha) Settlements Canal Drainage(line) Railway Roads District Boundary Towns/Settlements	AN A			
	1104			Reverine wetlands	Railway	In a some the			
	1105			Waterlogged	— Roads	Jam June V		73016 7364/4	73M/8
	1106			River/Stream		1 and a start	was set		
			Man-made			YET .	51232	731/43	7794
	1201			Reservoirs/Barrages	Iowns/Settlements	N. M.	3 Karl	753715 73871	7310/5
	1202			Tanks/Ponds			mel 3		
	1203			Waterlogged					
	1204			Salt pans					
		Coastal Wetlands				0 1.5 3	6	9 K	liometers
			Natural						
	2101			Lagoons		Data Source :			
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 2006-07)	
	2103			Sand/Beach		Prepared By :			
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad	
	2105			Salt marsh		Institute of Environment	and al Studies and Wetland Man	agement, Kolkata	
	2106			Mangroves		Sponsored By:	in ordares and rectand man	agement, riolitata	-
	2107			Coral reefs		Ministry	of Environment and Forests		
			Man-made				Government of India		
	2201			Salt pans					
	2202			Aquaculture ponds	]				





Symbol	Typecode	Level I	Level II	Level III	Legend		eeution map		
		Inland Wetlands				India	West Bengal	Index to She	et
			Natural		vietiands (<2.25 ha)				
	1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5	S Phone		
	1102			Ox-bow lakes/ Cut-off meanders	Canal	XX	Jos J	729/4 729/8	72P/12
	1103			High altitude wetlands	Drainage(line)	AR A			
	1104			Reverine wetlands	Railway	2 some the			
	1105			Waterlogged	— Roads	The way was a second way of the		73M/1 /738//5	73M/9
	1106			River/Stream		1 Alexandre	Joseph Start		
			Man-made			YET.	51222		
	1201			Reservoirs/Barrages	Towns/Settlements	1 N. M.	S X S	73M/2 73M/6	73M/10
	1202			Tanks/Ponds			Were as		
	1203			Waterlogged					
	1204			Salt pans					
		Coastal Wetlands				0 1.5 3	6	9 IKil	lometers
			Natural						
	2101			Lagoons		Data Source :			
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 2006-07)	
	2103			Sand/Beach		Prepared By :			-
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad	
	2105			Salt marsh		Institute of Environment	and al Studios and Wetland Man	agement Kolkata	
	2106			Mangroves		Sponsored By:	al Studies and Wettand Man	agement, Koikata	-
	2107			Coral reefs	]	Ministry	of Environment and Forest		
			Man-made		]	liningay	Government of India	-	
	2201			Salt pans	]				
	2202			Aquaculture ponds	]				
					-				





Symbol	Typecode	Level I	Level II	Level III	Legend	L	ocation Map	
		Inland Wetlands			Vetlanda (22.25 ha)	India	West Bengal	Index to Sheet
			Natural		vvetiands (<2.25 ha)			
	1101			Lakes/Ponds	Settlements	500	John Strange	
	1102			Ox-bow lakes/ Cut-off meanders	Canal	702	Jos J	73W 2 73W 6 73W10
	1103			High altitude wetlands	—— Drainage(line)	AN and		
1782	1104			Reverine wetlands	→→ Railway	Josepher 30		
	1105			Waterlogged	— Roads	Jamp my V		73M/3 73M/7 73M/1
	1106			River/Stream		- And - Contraction		
			Man-made		Towno/Sottlemente	155 .	50 -23	73M/4 73M/A 73M/92
	1201			Reservoirs/Barrages	Towns/Settlements	8 T 1	2 x x	
	1202			Tanks/Ponds			met 3	
	1203			Waterlogged				
	1204			Salt pans		0 15 2	0	0
		Coastal Wetlands				0 1.5 3	0	Kilometers
			Natural					
	2101			Lagoons		Data Source :		
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 2006-07)
	2103			Sand/Beach		Prepared By :		
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad
	2105			Salt marsh		Institute of Environment	and al Studies and Wetland Man	agement, Kolkata
	2106			Mangroves		Sponsored By:		<b>3</b>
	2107			Coral reefs		Ministry	of Environment and Forest	s
			Man-made				Government of India	
	2201			Salt pans				
	2202			Aquaculture ponds				




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





Symbol	Typecode	Level	Level II	Level III	]	L	ocation Map			
eynizer	Typecede	Inland Wetlands			Legend	India	West Rengal	Ind	ex to Sh	neet
			Natural		Wetlands (<2.25 ha)	India	Vest Deligar			
	1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5	Statutes -			
	1102			Ox-bow lakes/ Cut-off meanders	—— Canal	Sas	225-7			
	1103			High altitude wetlands	Drainage(line)	AR A		72P/14	78DY 2	76D/ 6
	1104			Reverine wetlands	Railway	S. Somer EA			///////	
	1105			Waterlogged	Roads	Chang State 9		72P/15	780/3	78D/ 7
	1106			River/Stream		1 States				
			Man-made		District Boundary	YES .	51220			
	1201			Reservoirs/Barrages	Towns/Settlements	Professional I	1 2 2 2 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	72P/16	78D/ 4	78D/ 8
	1202			Tanks/Ponds			m2 4			
	1203			Waterlogged						
	1204			Salt pans			_			
		Coastal Wetlands				0 1.5 3	6		9	Kilomete
			Natural							alemete
	2101			Lagoons		Data Source :				
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 2	006-07)	
	2103			Sand/Beach		Prepared By :			,	
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad		
	2105			Salt marsh		Institute of Environment	and al Studies and Wetland Man	agement l	Kolkata	
	2106			Mangroves		Sponsored By:	ar oldules and Wetland Man	agement, i	Voikata	
	2107			Coral reefs		Ministry	of Environment and Forest	s		
			Man-made				Government of India			
	2201			Salt pans						
	2202			Aquaculture ponds						





Symbol	Typecode	Level I	Level II	Level III	Lowend	L	ocation Map		
		Inland Wetlands				India	West Bengal	Index to Sh	neet
			Natural		Vvetlands (<2.25 ha)				
ŝ.	1101			Lakes/Ponds	Settlements	5	States 1		
	1102			Ox-bow lakes/ Cut-off meanders	Canal	202	2245 3		
	1103			High altitude wetlands	Drainage(line)	AR		729/15 780/3	76077
	1104			Reverine wetlands	Railway	In some and the			
	1105			Waterlogged	Roads	James June V		729/16 780(4	780/8
	1106			River/Stream		1 and a start	- All		1
			Man-made			YES.	51 235	73M/13 79A/ 1	79A/5
	1201			Reservoirs/Barrages	Iowns/Settlements	S. K.	3 Karl		
	1202			Tanks/Ponds		· · · · · ·	met y	· · · ·	,
	1203			Waterlogged					
	1204			Salt pans					
		Coastal Wetlands				0 1.5 3	6	9	, Kilometer
			Natural						
	2101			Lagoons		Data Source :			
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 2006-07)	
	2103			Sand/Beach		Prepared By :			
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahmee	labad	
	2105			Salt marsh		Institute of Environment	and al Studies and Wetland Mana	gement, Kolkata	
	2106			Mangroves		Sponsored By:	in oldales and mediana man	igenient, rtoikutu	
	2107			Coral reefs		Ministry	of Environment and Forests		
			Man-made				Government of India		
	2201			Salt pans					
	2202			Aquaculture 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

Tanks/Ponds Waterlogged

1202





201011	Leven	Leven	Legena					
Inland Wetlands			$M_{\text{etlands}}$ (<2.25 ha)	India	West Bengal	Inde	ex to Sh	neet
	Natural				Nech			
		Lakes/Ponds	Settlements	500				Γ
		Ox-bow lakes/ Cut-off meanders	—— Canal	302	225	78F/6		78F/1
		High altitude wetlands	— Drainage(line)	AN AG			78F/10	
		Reverine wetlands	Railway	in some the				1
		Waterlogged	Roads	The former of the second		78817	10465	78F/1
		River/Stream		1 and and a start	Jose Jose			1
	Man-made			YET .	Sol Drite			1
		Reservoirs/Barrages	Towns/Settlements	8 K3 1	Starl	78F/8	78F/12	78F/1
		Tanks/Ponds			mer y			
		Waterlogged						
		Salt pans						
Coastal Wetlands				0 1.5 3	6			9 ■Kilon
	Natural							
		Lagoons		Data Source :				
		Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 200	06-07)	
		Sand/Beach		Prepared By :				
		Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad		
		Salt marsh			and			
		Mangroves	1	Institute of Environment	al Studies and Wetland Man	agement, Ko	oikata	-+
		Coral reefs	1	Sponsored By:	of Environment and Forest			
	Man-made		1	winistry	Government of India			
		Salt pans	1					
		Aquaculture ponds	1					
	Coastal Wetlands	Inland Wetlands Inland Wetlands Natural Natural Natural Nan-made Natural	Inland Wetlands       Inland Wetlands         Natural       Lakes/Ponds         Ox-bow lakes/ Cut-off meanders         High altitude wetlands         Reverine wetlands         Man-made         Reservoirs/Barrages         Tanks/Ponds         Vaterlogged         Salt pans         Coastal Wetlands         Natural         Lagoons         Creeks         Sand/Beach         Intertidal mud flats         Salt marsh         Mangroves         Coral reefs         Man-made	Inland Wetlands       Inland Wetlands       Wetlands       Wetlands (<2.25 ha)	Inland Wetlands       Legend         Inland Wetlands       Wetlands (<2.25 ha)	Lindard Wetlands       Lakes// Cut-off meanders         Ox-bow lakes/ Cut-off meanders       Canal         Drainage(line)       Reverine wetlands         Reverine wetlands       Drainage(line)         Reverine wetlands       Railway         Reverine wetlands       District Boundary         Man-made       District Boundary         Waterlogged       Towns/Settlements         Man-made       Towns/Settlements         Salt pans       Coastal Wetlands         Castal Wetlands       Salt pans         Coastal Wetlands       Salt pans         Coreeks       Intertidal mud flats         Salt marsh       Man-made         Man-made       Salt pans         Coral reefs       Man-made         Salt pans       Coreal reefs         Man-made       Salt pans         Coral reefs       Manistry of Environment and Forests Government of India         Man-made       Coral reefs         Man-made       Coral reefs         Man-made       Coral reefs         Man-made       Coreal reefs         Man-made       Coreal reefs         Man-made       Coreal reefs         Man-made       Coreal reefs         Man-made	Initiand Wetlands       Legend         Natural	Intrade Wetlands       Legend         Natural





Symbol	Typecode	Level	Level II	Level III	1	L	ocation Map		
	.,,	Inland Wetlands				India	West Bengal	Index	to Sheet
			Natural		VVetlands (<2.25 ha)				
1. Sec. 1. Sec	1101		1	Lakes/Ponds	<ul> <li>Settlements</li> </ul>	$\sim$	12 mar		
	1102			Ox-bow lakes/ Cut-off meanders	Canal	505	2 AST		20140
	1103			High altitude wetlands	Drainage(line)	AR a		78947.2	7947.6 794710
12.01	1104			Reverine wetlands		Salan En 50			
	1105			Waterlogged	— Roads	Jamp June V		79A/ 3	794/7 794/11
	1106			River/Stream		and the second	A A A A A A A A A A A A A A A A A A A		
			Man-made			YE	Sol angle	79A/4	79A/8 79A/12
	1201			Reservoirs/Barrages	Iowns/Settlements	e Ma	2 Ray		
	1202			Tanks/Ponds			med 3		
	1203			Waterlogged					
	1204			Salt pans			<u>^</u>		<u> </u>
		Coastal Wetlands				0 1.5 3	6		9 Kilomet
			Natural						
	2101			Lagoons		Data Source :			
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 200	5-07)
	2103			Sand/Beach		Prepared By :			-
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad	
	2105			Salt marsh		Institute of Environment	and I Studies and Wetland Man	agement. Ko	Ikata
	2106			Mangroves		Sponsored By:			
	2107			Coral reefs		Ministry	of Environment and Forests	5	
			Man-made				Government of India		
	2201			Salt pans					
	2202			Aquaculture ponds	]				





Symbol	Typecode	Level	Level II	Level III	l	L	ocation Map			
oymoor	Typecouc	Inland Wetlands	201011		Legend	India	West Bengal	Ind	lex to Sł	neet
			Natural		vvetiands (<2.25 ha)					
	1101			Lakes/Ponds	Settlements	5	Service 1			
	1102			Ox-bow lakes/ Cut-off meanders	Canal	202	2 and 3	794/7	794/11	798/15
	1103			High altitude wetlands	—— Drainage(line)	AR			1	
	1104			Reverine wetlands	Railway	Sector Sector			//////	
	1105			Waterlogged	Roads	Jam June V		79A/ 8	784112	79A/16
	1106			River/Stream		1 and and a start	JAC AN			1
			Man-made			YES	Sol and the			700.003
	1201			Reservoirs/Barrages	Iowns/Settlements	81 1 1	3 25-35	198/5	/90/9	796/13
	1202			Tanks/Ponds		· · · · ·	W W			
	1203			Waterlogged						
	1204			Salt pans						
		Coastal Wetlands				0 1.5 3	6		9	Kilomete
			Natural							
	2101			Lagoons		Data Source :				
	2102			Creeks		IRS P6 LISS III data (Pre-n	nonsoon and Post-monsoon	Season 2	006-07)	
	2103			Sand/Beach		Prepared By :			,	
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad		
	2105			Salt marsh		Institute of Environment	and al Studios and Wotland Man	agomont	Kolkata	
	2106			Mangroves		Sponsored By:	al Studies and Wetland Man	agement,	Noikata	_
	2107			Coral reefs		Ministry	of Environment and Forest	•		
			Man-made		]	Ministry	Government of India			
	2201			Salt pans						
	2202			Aquaculture ponds						





Symbol	Typecode	Level I	Level II	Level III	Legend	L	ocation Map			
		Inland Wetlands			Vetlende (<2.25 he)	India	West Bengal	Inde	ex to She	eet
			Natural		vvetiands (<2.25 ha)					
1	1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	500	2 Phone			
	1102			Ox-bow lakes/ Cut-off meanders	—— Canal	XX	Pro 7	798/1	798/5	79B/ 9
	1103			High altitude wetlands	Drainage(line)	AR and				
17.82	1104			Reverine wetlands	→→ Railway	in some 30	22			
	1105			Waterlogged	— Roads	Jamp my W		79B/2	79B/6	79B/10
	1106			River/Stream		1 and a start	- ALANC			
			Man-made			155	Sol and the	798/3	798/7	750/11
	1201			Reservoirs/Barrages	Iowns/Settlements	ST 1	Tray		10011	
	1202			Tanks/Ponds		Y Y	nely			
	1203			Waterlogged						
	1204			Salt pans			<u>,</u>			
		Coastal Wetlands				0 1.5 3	6		9 	liometers
			Natural							
	2101			Lagoons		Data Source :				
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 20	06-07)	
	2103			Sand/Beach		Prepared By :				
	2104			Intertidal mud flats		Space Applic	ations Centre (ISRO), Ahme	dabad		
	2105			Salt marsh		Institute of Environment	and al Studies and Wetland Man	agement K	olkata	
	2106			Mangroves		Sponsored By:		agement, rt	omata	
	2107			Coral reefs		Ministry	of Environment and Forest	5		
			Man-made				Government of India	-		
	2201			Salt pans						
	2202			Aquaculture ponds						





Symbol	Typecode				1	L	ocation Map			
Symbol	Typecode	Inland Wetlands			Legend	India	W/set Densel	le d		a a t
		mand wettands	Natural		Wetlands (<2.25 ha)	India	vvest Bengal	ina	ex to Sr	leet
	1101		Natural	Lakes/Bonds	Settlements	~				
	1101			Ox how lokes / Cut off meendors	Canal	2.72	455-7			
	1102			Use altitude wetlande		22		798/5	798/9	79B/13
	1103			Righ altitude wetlands	Drainage(line)	5 Martin				
	1104		ļ	Revenue wetlands	→ Railway	mar and a series of the				
	1105			Waterlogged	—— Roads	James .		79B/6	79B/10	796/14
	1106			River/Stream	District Boundary		125 - 25 - 25 - 25 - 25 - 25 - 25 - 25 -		///////////////////////////////////////	
			Man-made			155 1	Tel All	79B/ 7	79B/11	79B/15
	1201			Reservoirs/Barrages	Towns/Settlements		16 20 3			
	1202			Tanks/Ponds		Y Y	MAR 3			
	1203			Waterlogged						
	1204			Salt pans						
		Coastal Wetlands				0 1.5 3	6		P	lometers
			Natural							
	2101			Lagoons		Data Source :				
	2102			Creeks		IRS P6 LISS III data (Pre-m	onsoon and Post-monsoon	Season 20	06-07)	
	2103			Sand/Beach		Prepared By :			,	-
	2104			Intertidal mud flats	1	Space Applic	ations Centre (ISRO). Ahme	dabad		
	2105			Salt marsh	1		and			
	2106			Mangroves	1	Institute of Environment	al Studies and Wetland Man	agement, I	Kolkata	_
	2107			Coral reefs		Sponsored By:				
			Man-made			Ministry	of Environment and Forest Government of India	S		
	2201			Salt pans	1					
	2202			Aquaculture ponds	1					
		I			1					





Symbol	Typecode	Level	Level II	Level III	]		Location Map			
oynio or	Typecouc	Inland Wetlands	Leven		Legend	India	West Bengal	Ind	lex to Sh	leet
			Natural		VVetlands (<2.25 ha)			]		
11 av 1	1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5	Status			
	1102			Ox-bow lakes/ Cut-off meanders	—— Canal	505	22007			700.04
	1103			High altitude wetlands	Drainage(line)			7987.0	798/10	/30/14
17981	1104			Reverine wetlands		So some 50			(//////////////////////////////////////	
	1105			Waterlogged	Roads	Champer 9		79B/7	796/11	798/15
	1106			River/Stream		1 Aller	Joseph Land			
			Man-made			YES .	Sal Jonate			-
	1201			Reservoirs/Barrages	Towns/Settlements	8 M 1	- Brank	796/8	796/12	798/16
	1202			Tanks/Ponds			We	∥└───		
	1203			Waterlogged						
	1204			Salt pans						
		Coastal Wetlands				0 1.5 3	6		9 9	lometer
			Natural							
	2101			Lagoons		Data Source :				
	2102			Creeks		IRS P6 LISS III data (Pre	-monsoon and Post-monsoor	n Season 2	006-07)	
90.03	2103			Sand/Beach		Prepared By :			,	
	2104			Intertidal mud flats		Space App	lications Centre (ISRO), Ahme	dabad		
	2105			Salt marsh		Institute of Environme	and ntal Studies and Wetland Man	agement.	Kolkata	
	2106			Mangroves		Sponsored By:		agement, i	tomata	
	2107			Coral reefs		Minis	ry of Environment and Forest	ts		
			Man-made				Government of India			
	2201			Salt pans						
	2202			Aquaculture ponds						





Symbol	Typecode				1	L	ocation Map	
Symbol	Typecode	Inland Wetlands	Levern	Level III	Legend	India	West Bengal	Index to Sheet
			Natural		VVetlands (<2.25 ha)			
	1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5~	States -	
	1102			Ox-bow lakes/ Cut-off meanders	—— Canal	202	2003	769/14 709/15 767/3
	1103			High altitude wetlands	Drainage(line)	AR AR		
17.84	1104			Reverine wetlands	Railway	in a some and 30		
	1105			Waterlogged	Roads	Jam June V		798/12 798/16 797/4
	1106			River/Stream		1 allow	JAC TON	
			Man-made			155	Sol and the	700/0 700/03 700/1
	1201			Reservoirs/Barrages		8: N.	Brand Brand	10010 10013 10011
	1202			Tanks/Ponds		V V	Well &	
	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





Symbol Typecode	Level I	Level II	Level III	Lanand	Location Map				
,	Inland Wetlands			Legend	India	West Bengal	Inde	x to Sheet	
		Natural		Wetlands (<2.25 ha)		l liter beingar			
1101			Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5	1 Provention			
1102		1	Ox-bow lakes/ Cut-off meanders	—— Canal	505	2 and		20010	
1103			High altitude wetlands	—— Drainage(line)	AR . A		79874	196/15	
1104			Reverine wetlands	Railway	S. Bon in 50				
1105			Waterlogged	— Roads	Jamp 2 V		79C/ 1	796/5 796/9	
1106			River/Stream		1 Star	John March			
		Man-made			185	Sol and the	700/0	70016 70010	
1201			Reservoirs/Barrages	Iowns/Settlements	11 1	A Karl	10012	10010	
1202			Tanks/Ponds			mel y			
1203			Waterlogged						
1204			Salt pans		0 15 2	6		0	
	Coastal Wetlands				0 1.5 3	0		9 Kilome	
		Natural							
2101			Lagoons		Data Source :				
2102			Creeks		IRS P6 LISS III data (Pre-monsoon and Post-monsoon Season 2006-07)				
2103			Sand/Beach		Prepared By :				
2104			Intertidal mud flats		Space Applications Centre (ISRO), Ahmedabad				
2105			Salt marsh		Institute of Environment	and al Studies and Wetland Man	agement, Ko	olkata	
2106			Mangroves		Sponsored By:				
2107			Coral reefs		Ministry of Environment and Forests				
		Man-made				Government of India			
2201			Salt pans						
2202			Aquaculture ponds						





Symbol	Typecode	Level		Level III	1	Location Map				
oymbol	Typecode	Inland Wetlands	Leven		Legend	India	West Bengal	Inde	x to Sheet	
			Natural		Vvetlands (<2.25 ha)					
	1101		1	Lakes/Ponds	<ul> <li>Settlements</li> </ul>	5	Stature .			
	1102		1	Ox-bow lakes/ Cut-off meanders	Canal	505	22 AL	770.00	700.00 705/4	
	1103			High altitude wetlands	] —— Drainage(line)	AR a		795/12	790/16	
	1104			Reverine wetlands	Railway	In some the				
	1105			Waterlogged	Roads	Jam June V		790/9	796/15 796/1	
	1106			River/Stream		1 miles	A A A A A A A A A A A A A A A A A A A			
			Man-made			YET .	51 220		700/2	
	1201			Reservoirs/Barrages	Iowns/Settlements	27	J Karl	790710	10012	
	1202			Tanks/Ponds	]	Nor Y	The s			
	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



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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	Definition and description
type code	
1000	Inland Wetlands
1100	Natural
1101	<b>Lakes</b> : Larger bodies of standing water occupying distinct basins (Reid et al, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different hues of blue interspersed with pink (aquatic vegetation), islands (white if unvegetated, red in case of terrestrial vegetation). Vegetation if scattered make texture rough.
1102	<b>Ox-bow lakes/ Cut off meanders</b> : A meandering stream may erode the outside shores of its broad bends, and in time the loops may become cut-off, leaving basins. The resulting shallow crescent-shaped lakes are called oxbow lakes (Reid 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	<b>High Altitude lakes:</b> These lakes occur in the Himalayan region. Landscapes around high lakes are characterized by hilly topography. Otherwise they resemble lakes in the plain areas. For keeping uniformity in the delineation of these lakes contour line of 3000 m above msl will be taken as reference and all lakes above this contour line will be classified as high altitude lakes.
1104	<ul> <li>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).</li> <li>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.</li> <li>Comment: Using satellite data it is difficult to differentiate between swamp and marsh. Hence, both have been clubbed together.</li> </ul>
1105	<b>Waterlogged:</b> Said of an area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die (Margarate et al, 1974). Floods or unlined canal seepage and other irrigation network may cause waterlogging. Spectrally, during the period when surface water exists, waterlogged areas appear more or less similar to lakes/ponds. However, during dry season large or all parts of such areas dry up and give the appearance of mud/salt flats (grey bluish).
1106	<b>River/stream:</b> Rivers are linear water features of the landscape. Rivers that are wider than the mapping unit will be mapped as polygons. Its importance arises from the fact that many stretches of the rivers in Indo-Gangetic Plains and peninsular India are declared important national and international wetlands (Ex. The river Ganga between Brajghat and Garh Mukteshwar, is a Ramsar site, Ranganthattu on the 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	<b>Reservoir</b> : A pond or lake built for the storage of water, usually by the construction of a dam across a river (Margarate et al, 1974). On RS images, reservoirs have irregular boundary behind a prominent dyke. Wetland boundary in case of reservoir incorporates water, aquatic vegetation and footprint of water as well. In the accompanying images aquatic vegetation in the reservoir is seen in bright pink tone. Tone is dark blue in deep reservoirs while it is ink blue in case of shallow reservoirs or reservoirs with high silt load. These will be annotated as Reservoirs/Dam. <b>Barrage:</b> Dykes are constructed in the plain areas over rivers for creating Irrigation/water facilities. Such water storage areas develop into wetlands (Harike Barrage on Satluj – a Ramsar site, Okhla barrage on the Yamuna etc. – a bird sanctuary). Water appears in dark blue tone with a smooth texture. Aquatic vegetation appears in pink colour, which is scattered, or contiguous depending on the density. Reservoirs formed by barrages will be annotated as reservoir/barrage.

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

	corraline algae with the intervening space connected with sand, which consists largely of shells of foraminifera. Present reefs are living associations growing on this accumulation of past (Clark, 1977). Reefs appear in light blue shade.
2200	Man-made
2201	<b>Salt pans</b> : An undrained usually small and shallow rectangular, man-made depression or hollow in which saline water accumulates and evaporates leaving a salt deposit (Margarate et al, 1974). Salt pans are square or rectangular in shape. When water is there appearance is blue while salt is formed tone is white.
2202	<b>Aquaculture ponds</b> : Aquaculture is defined as "The breeding and rearing of fresh-water or marine fish in captivity. Fish farming or ranching". The water bodies used for the above are called aquaculture ponds (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

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

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