NATIONAL WETLAND INVENTORY AND ASSESSMENT

TECHNICAL GUIDELINES AND PROCEDURE MANUAL

Space Applications Centre,
Indian Space Research Organisation
Ahmedabad 380015

June 2007

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9.	Abstract	:	The document provides technical guidelines for use by the participating agencies in the execution of the project on National Wetland Inventory and Assessment undertaken by Space Applications Centre, ISRO, Ahmedabad at the behest of the Ministry of Environment and Forests, Govt. of India. Data needs, methodology for data analysis using remote sensing, accuracy assessment, GIS database organization etc. required to implement the project are given.
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जय हिन्द

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निदेशक
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FOREWORD

Wetlands are the cradles of biodiversity and harbour a wide variety of flora and fauna. They also provide a host of benefits such as nutrition, drinking water and act as buffers for minimising the impact of floods besides being habitats for a wide variety of avifauna. India has designated 25 wetlands as wetlands of international importance under the Ramsar Convention to conserve and preserve the wetland ecosystems besides notifying wetlands and bird sanctuaries as well.

An updated and accurate inventory of wetlands is the pre-requisite for management and planning of natural resources like wetlands. Modern tools like satellite remote sensing and Geographic Information System (GIS) are now increasingly used for this purpose. Space Applications Centre (SAC), ISRO, Ahmedabad has pioneered the use of remote sensing technology for wetland inventory and ecosystem management in India. SAC, Ahmedabad carried out the first scientific inventory of wetlands at national level on 1: 250000 scale using satellite remote sensing data of 1992-93. This has been followed by many projects related to wetland information system, management planning and biodiversity conservation etc. The Centre is now poised to carry out the wetland inventory on 1:50 000 scale sponsored by The Ministry of Environment and Forests, Govt. of India.

The objectives of the project is to carry out inventory of the wetlands on 1:50 000 scale using IRS LISS III data of recent years, organise the digital data base in GIS and develop an information system for retrieval of the data for easy access by users, planners and researchers. The project will be executed with collaboration and partnership of relevant national, state agencies and private enterprises and entrepreneurs. Thus, a procedural manual is the first step to facilitate execution and ensure uniform standard of work. The document entitled "National Wetland Inventory and Assessment – Technical Guidelines and Procedure Manual" aims to serve as the technical guideline/manual for this project. This contains the Wetland Classification System, technical details of identifying them on the satellite imagery, ground truth data collection, methodology of spatial database creation and accuracy assessment. We hope the document will help in achieving the desired level of accuracy and uniformity while keeping the timeliness of the project.
I wish all the success to the project team in execution of the project on "National Wetland Inventory and Assessment".

March 4, 2008

(R. R. Navalgund)
Director, SAC

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PREFACE

Wetland ecosystems are the harbinger of biodiversity and one of the most productive ecosystems providing an array of benefits to the mankind. They are not only important for the survival of fishes, birds, turtles, crocodiles etc. but also serve as habitat for many insects during their reproductive phase. Another important aspect of wetlands is the emission of green house gases. They play very significant role in methane emission as well as carbon sequestration. Despite importance given to wetlands worldwide, their conservation in India has been sadly neglected. Wetlands have been lost, degraded, polluted and their ecological functions impaired.

In order to create a national registry of wetlands it is prudent to carry out scientific inventory and monitoring of wetlands periodically. In India, first such attempt was made by Space Applications Centre, ISRO, Ahmedabad using IRS satellite data of 1992-93 timeframe. However, as the mapping was done on 1:250 000 scale for most of the states, only 56 ha and larger wetlands were mapped.

Realising the importance of wetlands in the country, Ministry of Environment and Forests, Govt. of India requested Space Applications Centre, Ahmedabad to formulate and implement a national project for wetland inventory and assessment using remote sensing techniques on 1:50000 scale. Accordingly, project was formulated and is being implemented. To ensure uniformity in the execution of the project on National Wetland Inventory and Assessment, it was desirable to have a procedure manual. Accordingly, the document on technical guidelines and procedure manual has been prepared. It gives details of classification system, satellite data analysis, database creation, accuracy assessment and colour coding for map etc.

I hope the procedure manual will help in carrying out the project and ensure maintaining uniformity in execution. Database will further help in wetland networking and gap analysis for wetland conservation at national/regional level.

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Chapter – 1

INTRODUCTION AND BACKGROUND

Chapter 1

Since time immemorial human civilisations and their socio-cultural values have primarily been shaped by wetlands such as the rivers, lakes, swamps and many other types of water habitats. Ancient Indian literature is replete with folklore and stories describing the value of wetlands. However, during the recent past wetlands were recklessly destroyed to create land for 'development' and only in recent years their uses and values have begun to be understood and appreciated.

Wetlands usually occur in depressions or along rivers, lakes, and coastal waters where they are subjected to periodic flooding. Some wetlands also occur on slopes associated with the ground water seeps. Conceptually, wetlands lie between well-drained upland and permanently flooded deep waters of lakes, rivers and coastal embankments.

Wetlands are among the most productive ecosystems besides being a rich repository of biodiversity, and are known to play a significant role in carbon sequestration. Space Applications Centre (ISRO), Ahmedabad, at the behest of the Ministry of Environment and Forests (MoEF), Govt. of India, carried out first scientific inventory of wetlands for India using IRS satellite data (of 1992-93 timeframe). Subsequently, a need was felt for creation of wetland database in GIS environment for monitoring, conservation and planning in the 16th Meeting of SC-B.

In pursuance of the decision of the 16th SC-B (Standing Committee on Bioresources and Environment) of NNRMS (National Natural Resources Management System) meeting, Space Applications Centre (ISRO), Ahmedabad was requested to formulate a project proposal for creating a digital database of wetlands in the country and to develop a wetland information system. Consequently, a pilot project for development of GIS based wetland information system (WINSYS) for W. Bengal was funded by MoEF and executed by Space Applications Centre, Ahmedabad. Like-wise, a wetland information

system for Loktak lake (Loktak Resources Information System) was also developed with the financial assistance from the Ministry of Environment and Forests, Govt. of India.

In view of the global importance of wetlands, SAC (ISRO) on its own initiative has recently carried out updation of wetland inventory of India (created earlier using 1992/93 satellite data) using Resourcesat 2004-05 IRS AWiFS data on 1:250000 scale. In view of the foregoing, the proposal was submitted to MoEF for carrying out satellite databased inventory and assessment of wetlands at 1: 50 000 scale. Inventory for the state of Sikkim will be carried out on 1:25000 scale.

1.1 REMOTE SENSING BASED INVENTORY OF WETLANDS IN INDIA

The first scientific national inventory of wetlands in the India (Table 1.1) carried out by Space Applications Centre (ISRO), Ahmedabad at the behest of the Ministry of Environment and Forests (MoEF), Govt. of India, using IRS satellite data (1992-93 timeframe) puts the wetland extent (inland as well as coastal) at about 8.26 million ha. These estimates (24 categories) do not include rice paddies, rivers, canals and irrigation channels etc.

1.2 OBJECTIVES

Main objective of the project is to generate a wetland inventory of the country on 1:50000 scale using latest IRS Satellite data, creation of a digital database of wetlands as per NNRMS Standards, and development of a query shell for information retrieval.

Detailed Objectives/tasks

- *Wetland mapping and inventory on 1: 50 000 scale by analysis of digital IRS LISS III data of post and pre-monsoon seasons (2005/06 or latest).*
- *Creation of digital database in GIS environment.*
- *Development of query shell for information retrieval.*
- *Preparation of State-wise wetland atlases.*

Table 1.1: Type-Wise Estimates of Wetlands in India

WETLAND CATEGORY		NUMBER	AREA (ha)
INLAND WETLANDS			
Natural	Lakes/Ponds	4646	679530
	Ox-Bow Lakes	3197	151051
	Waterlogged (Seasonal)	4921	285744
	Playas	79	118519
	Swamp/Marsh	1814	197784
SUB-TOTAL		14657	1432627
MAN-MADE	Reservoirs	2208	1481987
	Tanks	5549	558344
	Waterlogged	892	77302
	Abandoned Quarries (Water)	105	5774
	Ash Pond/Cooling Pond	33	2881
SUB-TOTAL		8787	2126288
TOTAL INLAND		23444	3558915
COASTAL WETLANDS			
Natural	Estuaries	97	153966
	Lagoons	34	156403
	Creeks	241	19230
	Backwater	32	17075
	Tidal /Mud Flat	663	2362056
	Sand/Beach/Spit/Bar	772	421019
	Coral Reefs	487	84137
	Rocky Coast	85	17686
	Mangroves	858	340055
	Salt Marsh/ Marsh Vegetation	161	169840
	Other Vegetation	117	139102
SUB-TOTAL		3497	3880569
	Salt Pans	106	65496
	Aquaculture Ponds	356	76891
SUB-TOTAL		462	142387
TOTAL COASTAL		3959	4022956
TOTAL INDIA		27403	7581871

In addition, 80,000 wetlands smaller than the minimum-mapping unit were also detected and shown on the maps. Of these 10630 are smaller than 56.25 ha (1:250 000 scale) and 69370 less than 2.25 ha (1:50 000 scale, majority being in W. Bengal). Assuming each wetland occupies 50 % area of the minimum mapping unit; these wetlands might occupy 675979 ha area. Thus the total wetland area excluding rivers, canals and rice in the country using Remote sensing data is estimated as 8257850 ha (~8.26 Mha).

(Source: Garg et al, 1998)

Chapter – 2

WETLANDS AND CLASSIFCATION SYSTEM

Chapter 2

2.1 WETLANDS-DEFINITIONS

Wetlands are halfway world between terrestrial and aquatic ecosystems and share properties of both. Scientists working in specialised fields such as botany or hydrology in their own way define wetlands. A botanical definition focus on the plants adapted to flooding and/or saturated soil conditions, while a hydrologist's definition place greater emphasis on the position of the water table relative to the ground surface. A more complete definition of wetlands involves a multidisciplinary approach wherein plants, water, and duration of flooding are involved. Some of the prevalent important definitions of wetlands are as follows:

U.S. Fish and Wildlife Service's Official Classification System

“Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water level. For purposes of this classification, wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water level at some time during the growing season of each year" (Cowardin, *et al*. 1979).

Soil Conservation Service (SCS) of the U.S. Department of Agriculture

In defining wetlands from an ecological standpoint, the SCS emphasises three key attributes: 1) hydrology - the degree of flooding or soil saturation, 2)-wetland vegetation (hydrophytes), and 3) hydric soils. All areas considered wetlands must have enough water at some time during the growing season to stress plants and animals not adapted for life in water or saturated soils present. Accordingly, "Wetlands are defined as areas that have a predominance of hydric soils and are inundated or saturated by surface or

ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions".

US Environmental Protection Agency (EPA) and Army Corps of Engineers (CE)

"Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas".

International Union for the Conservation of Nature and Natural Resources (IUCN)

“Submerged or water saturated lands, both natural and man made, 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 6 meters".

International Biosphere Programme (IBP)

"Part of the surrounding ecological structure and several stages in the succession from open water to dry land or vice versa, occurring at sites situated as a rule between the highest and lowest water levels as long as the flooding or waterlogging of the soil is of substantial ecological significance".

Ramsar Convention

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 and now has contracting parties from all over the world. 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”.

Resultantly, a wide variety of habitats including rivers, shallow coastal waters and even coral reefs are included under the wetlands. However, deep seas are not treated as wetlands.

Wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics. Existing definitions of wetlands recognize that wetlands are driven by wetland hydrology (permanent or periodic inundation) hydric soils, and characteristic hydrophytes. Wetlands are normally associated with the following major systems:

Marine (coastal wetlands including rock shores and coral reefs.
Estuarine (including deltas, tidal marshes, and mangrove swamps).
Lacustarine (wetlands associated with lakes)
Riverine (wetlands along rivers and streams)
Palustarine (meaning 'marshy'- marshes, swamps and bogs)

There has been lot of confusion in setting the boundary of wetlands. However, developments in remote sensing technology have made it easier to set wetland boundary with a reasonable accuracy. This has also helped in devising a Wetland Classification System for operational use. India was among the few countries in the world which have pioneered the use of remote sensing technology for national wetland inventory and conservation.

2.2 WETLAND CLASSIFICATION SYSTEM

For devising a suitable wetland classification system it is essential that it should be simple, easy to replicate and incorporate all or most of wetland types. In India no suitable wetland classification existed for comprehensive inventory of wetlands in the country prior to the execution of Nation-wide Wetland Mapping Project based on satellite remote sensing by the Space Applications Centre, Ahmedabad. The classification system is based on Ramsar Convention definition of wetlands, which provides a broad framework for delineating wetlands and is amenable to remote sensor data, has been used for inventory of wetlands. It considers all parts of a water mass including its ecotonal area as wetland. In addition, Ramsar Convention, considers fish and shrimp ponds, saltpans, reservoirs, gravel pits etc. as wetlands. In the present wetland inventory of India, Modified National Wetland Classification system will be used for wetland delineation and mapping (Table 2.1). The Wetland Classification System besides including all wetlands incorporates deep-water habitats and impoundments. Main criteria followed in this system are:

- Wetland hydrology, *i.e*. manifestation of water on the satellite imagery.
- Wetland vegetation -- mainly hydrophytes and other aquatic vegetation in a part or whole of the water body as observed on satellite data.

Salient features of the classification system are:

- It takes into account all wetlands whether inland or coastal, natural or man-made.
- It provides information on the extent of vegetation present in the wetlands, both in pre-monsoon and post-monsoon seasons, wherever discernible on satellite imagery.

Table 2.1: Wetland Classification System

1. The extent of vegetation, if present, in the inland wetlands will be indicated on the maps.

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

2. Qualitative turbidity ratings (low, moderate, high) to be given, wherever possible.
3. Wetlands put to regular agriculture use have not been included.

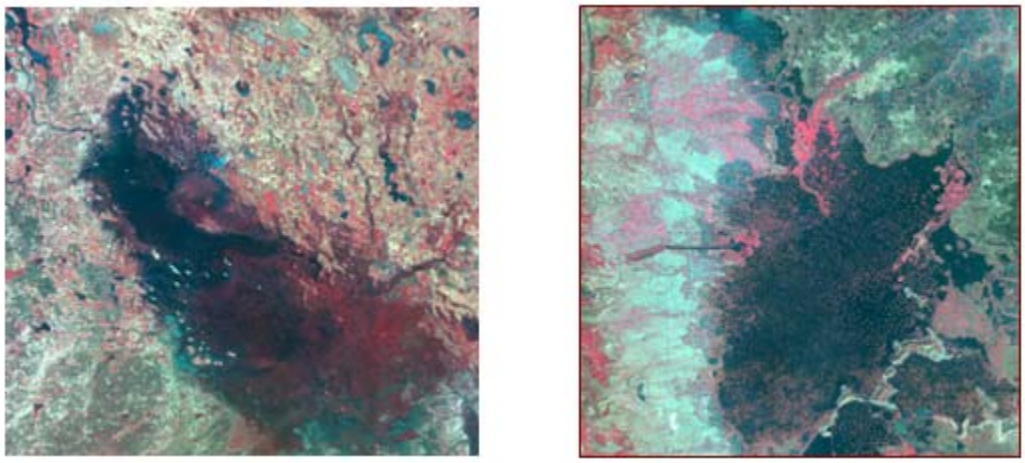
2.3 DEFINITION OF WETLAND TYPES AND IDENTIFICATION KEY

For ease of understanding by participating agencies and execution of the project, definitions of wetland categories and their typical appearance on satellite imagery is given below:

1000 Inland Wetlands

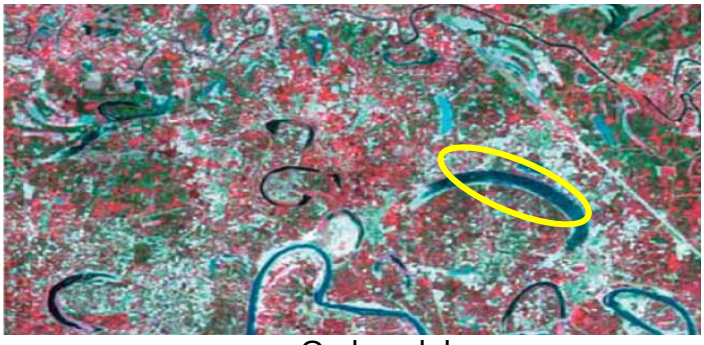
1100 Natural

1101 Lakes: Larger bodies of standing water occupying distinct basins (Reid *et al*, 1976). These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images lakes appear in different hues of blue interspersed with pink (aquatic vegetation), islands (white if unvegetated, red in case of terrestrial vegetation). Vegetation if scattered make texture rough.



Lakes

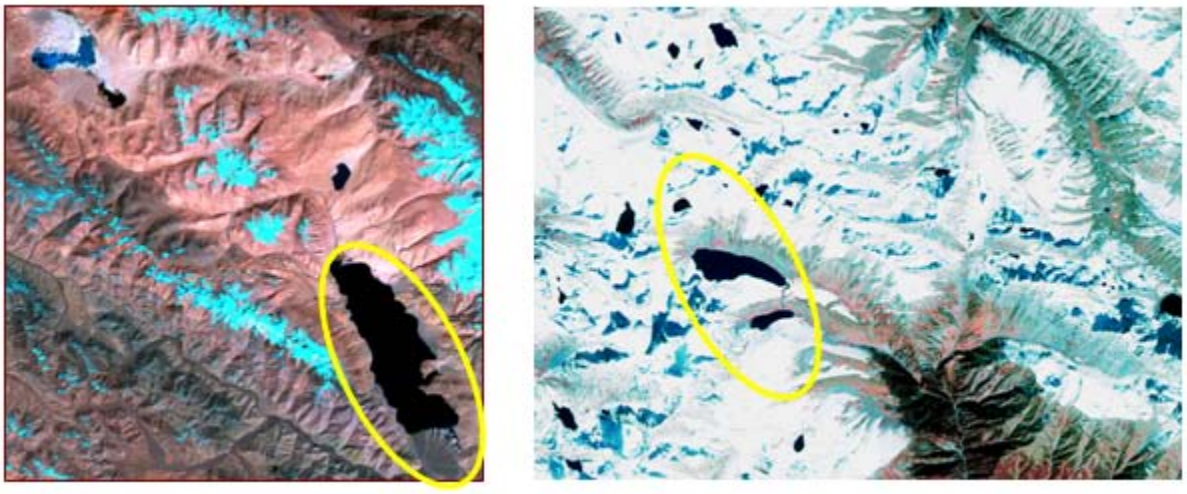
1102 Ox-bow lakes/ Cut off meanders: A meandering stream may erode the outside shores of its broad bends, and in time the loops may become cut-off, leaving basins. The resulting shallow crescent-shaped lakes are called oxbow lakes (Reid *et al*, 1976). On the satellite image Ox-bow lakes occur near the rivers in plain areas. Some part of the lake normally has aquatic vegetation (red/pink in colour) during pre-monsoon season.



Ox-bow lakes

1103 High Altitude lakes

These lakes occur in the Himalayan region. Landscapes around high lakes are characterized by hilly topography. Otherwise they resemble lakes in the plain areas. For keeping uniformity in the delineation of these lakes contour line of 3000 m above msl will be taken as reference and all lakes above this contour line will be classified as high altitude lakes.

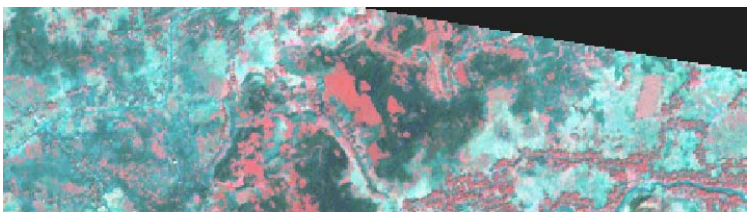


High altitude lakes

1104 **Riverine Wetlands**: Along the major rivers, especially in plains water accumulates leading to formation of marshes and swamp. **Swamps** are 'Wetland dominated by trees or shrubs' (U.S. Definition). In Europe, a forested fen (a peat accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly *Sphagnum*) could be called a swamp. In some areas reed grass - dominated wetlands are also called swamps). (Mitsch and Gosselink, 1986).

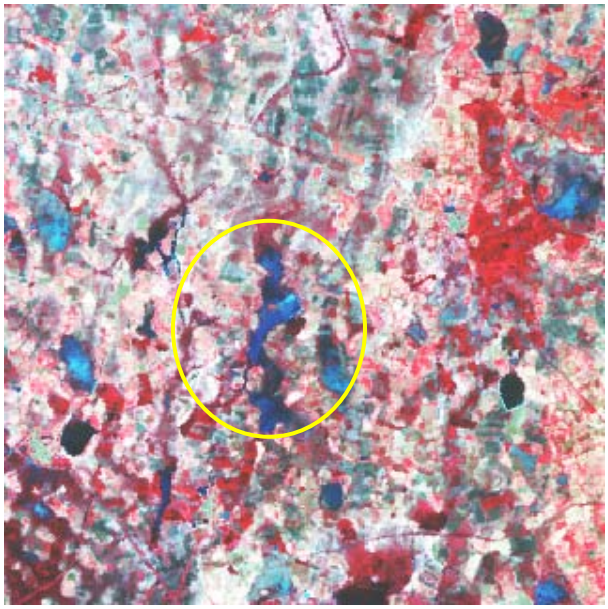
Marsh: A frequently or continually inundated wetland characterised by emergent herbaceous vegetation adapted to saturated soil conditions. In European terminology a marsh has a mineral soil substrate and does not accumulate peat (Mitsch and Gosselink, 1986). Tone is grey blue and texture is smooth.

Comment: Using satellite data it is difficult to differentiate between swamp and marsh. Hence, both have been clubbed together.



Riverine Marshes/Swamps

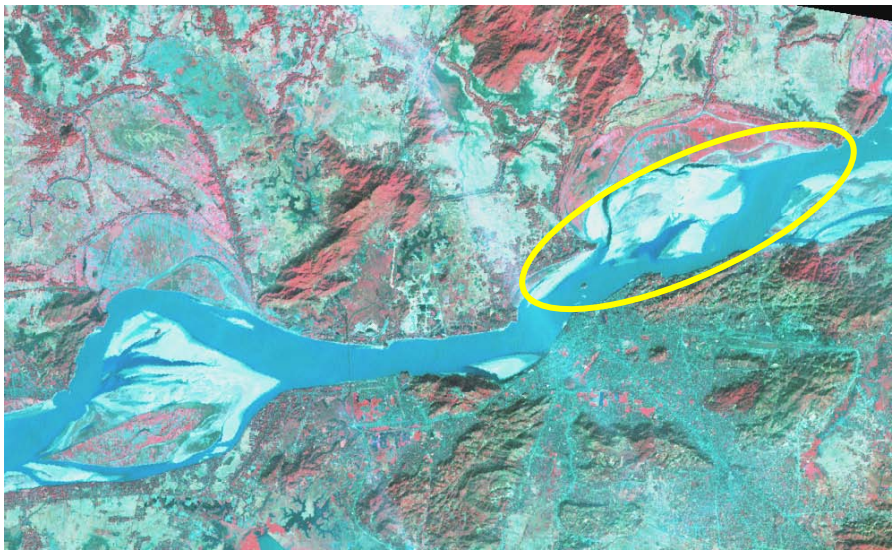
1105 **Waterlogged:** Said of an area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die (Margarate *et al*, 1974). Floods or unlined canal seepage and other irrigation network may cause waterlogging. Spectrally, during the period when surface water exists, waterlogged areas appear more or less similar to lakes/ponds. However, during dry season large or all parts of such areas dry up and give the appearance of mud/salt flats (grey bluish).



Waterlogged

ıat

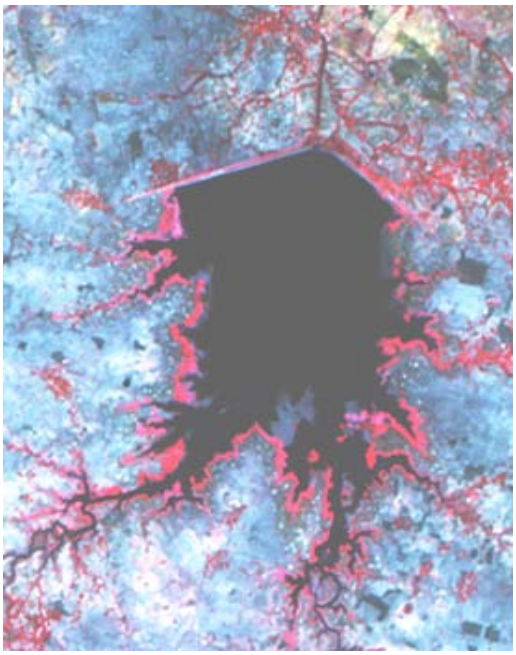
are wider than the mapping unit will be mapped as polygons. Its importance arises from the fact that many stretches of the rivers in Indo-Gangetic Plains and peninsular India are declared important national and international wetlands (Ex. The river Ganga between Brajghat and Garh Mukteshwar, is a Ramsar 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.



Rivers/Streams

1200 Man-made

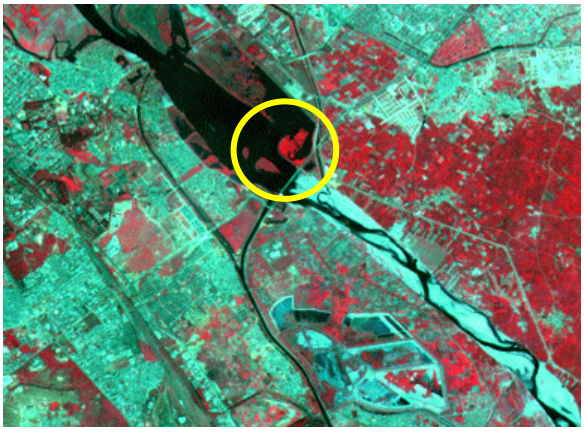
1201 Reservoir: A pond or lake built for the storage of water, usually by the construction of a dam across a river (Margarate et al, 1974). On RS images, reservoirs have irregular boundary behind a prominent dyke. Wetland boundary in case of reservoir incorporates water, aquatic vegetation and footprint of water as well. In the accompanying images aquatic vegetation in the reservoir is seen in bright pink tone. Tone is dark blue in deep reservoirs while it is ink blue in case of shallow reservoirs or reservoirs with high silt load. These will be annotated as Reservoirs/Dam.



Reservoir

October 2005 April 2006

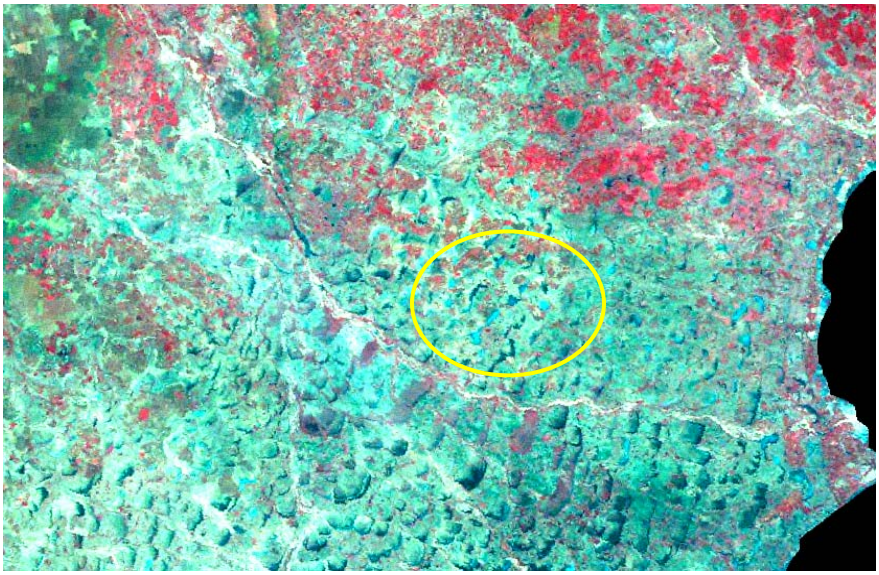
Barrage: Dykes are constructed in the plain areas over rivers for creating Irrigation/water facilities. Such water storage areas develop into wetlands (Harike Barrage on Satluj – a Ramsar site, Okhla barrage on the Yamuna etc. – a bird sanctuary). Water appears in dark blue tone with a smooth texture. Aquatic vegetation appears in pink colour, which is scattered, or contiguous depending on the density. Reservoirs formed by barrages will be annotated as reservoir/barrage.



Barrage

1202 Tanks/Ponds: A term used in Ceylon and the drier parts of Peninsular India for

an artificial pond, pool or lake formed by building a mud wall across the valley of a small stream to retain the monsoon (Margarate *et al*, 1974). **Ponds** Generally, suggest a small, quiet body of standing water, usually shallow enough to permit the growth of rooted plants from one shore to another (Reid *et al*, 1976). Tanks appear in light blue colour showing bottom reflectance.



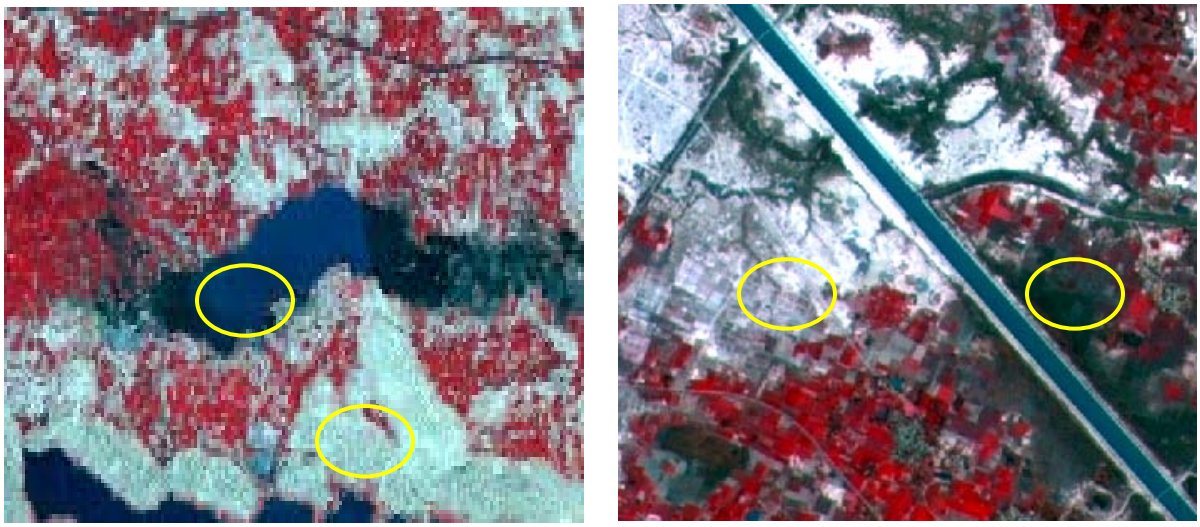
Tanks (Tamil Nadu)

In this category **Industrial ponds/mining pools mainly comprising Abandoned Quarries are also included (**Quarry is defined as "An open or surface working or excavation for the extraction of stone, ore, coal, gravel or minerals." In such pits water accumulate (McGraw Hill Encyclopaedia of Environmental Sciences, 1974), **Ash pond/Cooling pond** (The water body created for discharging effluents in industry, especially in thermal power plants (Encyclopaedic Directory of Environment, 1988) and **Cooling pond**: An artificial lake used for the natural cooling of condenser-cooling water serving a conventional power station (Encyclopaedic Directory of Environment, 1988). These ponds can be of any shape and size. Texture is rough and tonal appearance light (quarry) to blue shade (cooling pond).

Mine Quarries with water in Korba area (Chattishgarh)

1203 Waterlogged

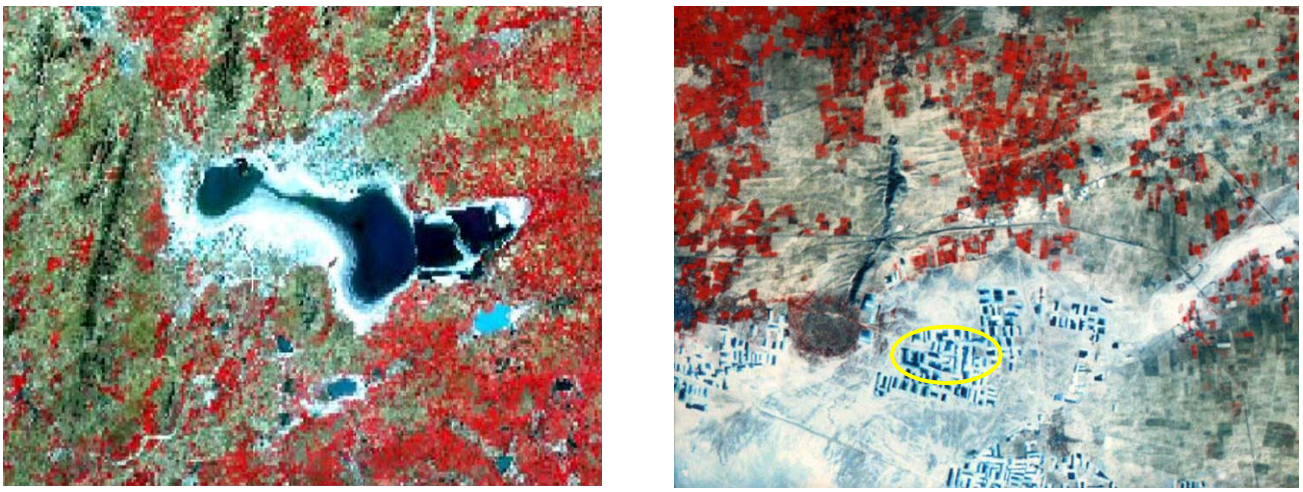
Man-made activities like canals cause waterlogging in adjacent areas due to seepage especially when canals are unlined. Such areas can be identified on the images along canal network. Tonal appearance is in various hues of blue. Sometimes, such waterlogged areas dry up and leave white scars on the land. Texture is smooth.



Waterlogging due to Canal Seepage

1204 Salt pans

Inland salt pans in India occur in Rajasthan (Sambhar lake). These are shallow rectangular man-made depressions in which saline water is accumulated for drying in the sun for making salt.



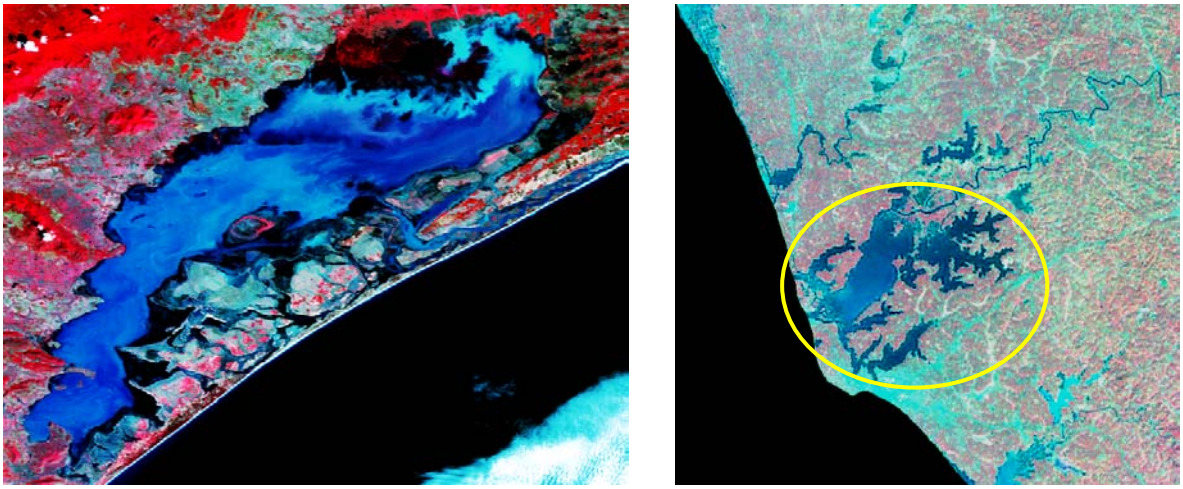
Sambhar lake and associated Salt pans

2000 Coastal Wetlands

2100 Natural

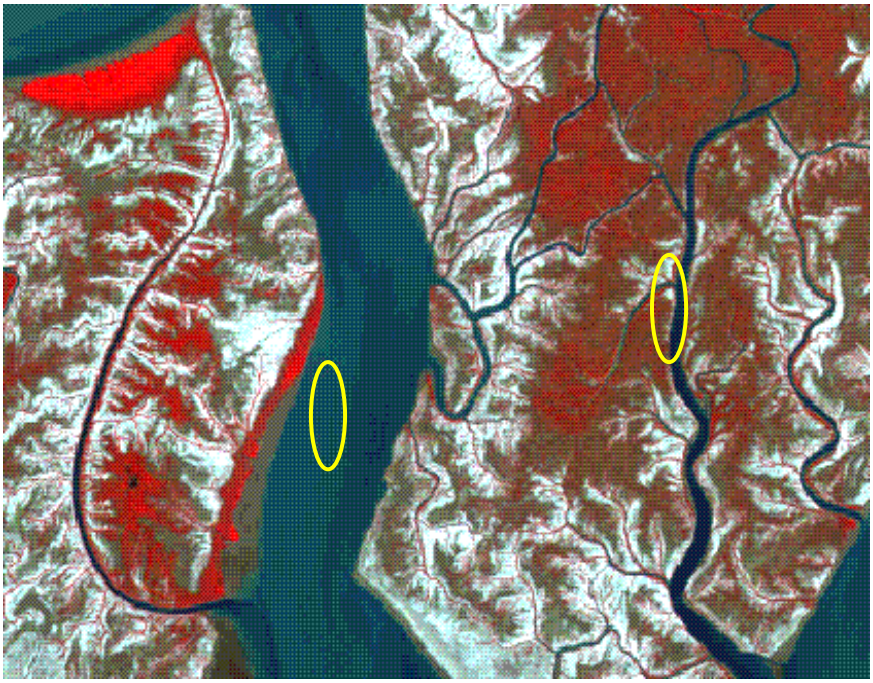
2101 Lagoons/Backwaters: Such coastal bodies of water, partly separated from the sea by barrier beaches or bass of marine origin, are more properly termed lagoons. As a rule, lagoons are elongate and lie parallel to the shoreline. They are usually characteristic of, but not restricted to, shores of emergence. 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).



Lagoons/Backwaters

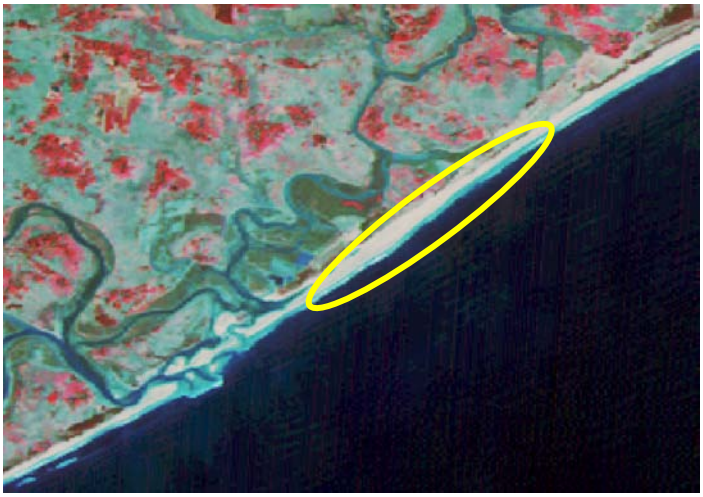
2102 Creek: A notable physiographic feature of salt marshes, especially low marshes. These creeks develop as do rivers "with minor irregularities sooner or later causing the water to be deflected into definite channels" (Mitsch and Gosselink, 1986). Creeks will be delineated, however, their area will not be estimated.



Creeks network and Mangroves

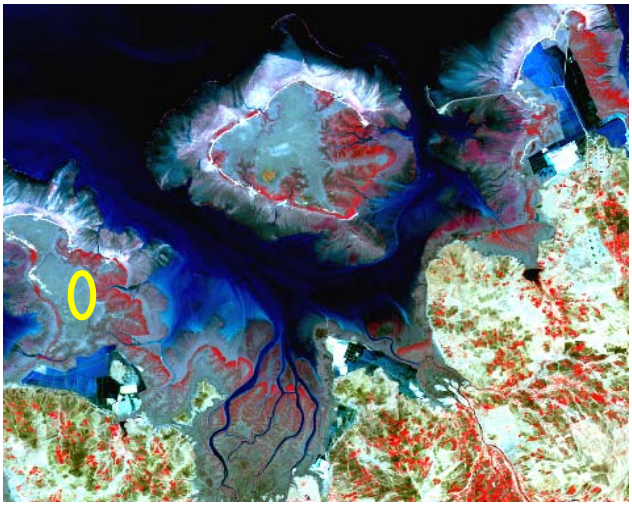
2103 Sand/Beach: Beach is an unvegetated part of the shoreline formed of loose

material, usually sand that extends from the upper berm (a ridge or ridges on the backshore of the beach, formed by the deposit of material by wave action, that marks the upper limit of ordinary high tides and wave wash) to low water mark (Clark, 1977). Beach comprising rocky material is called rocky beach.



Beach

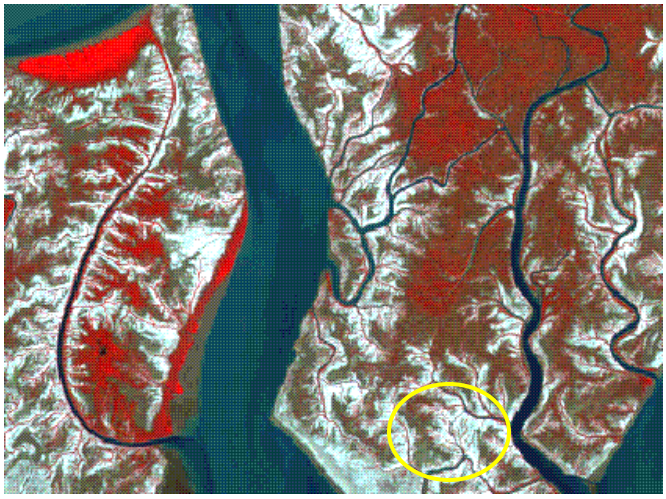
2104 **Intertidal mudflats**: Most unvegetated areas that are alternately exposed and inundated by the falling and rising of the tide. They may be mudflats or sand flats depending on the coarseness of the material of which they are made (Clark, 1977).



210 Intertidal mud flat/salt flat **Wood**

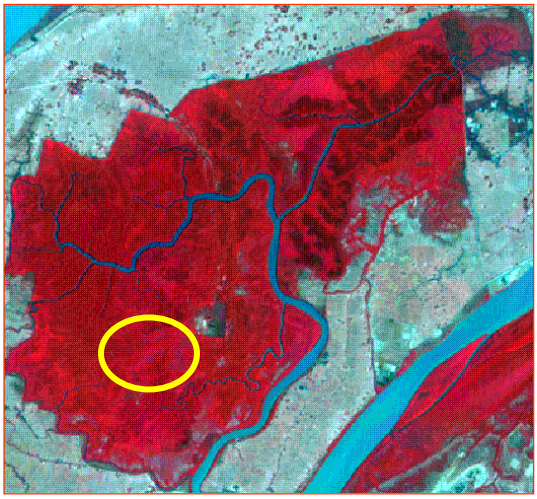
on the alluvial sediments bordering saline water bodies whose water level fluctuates either tidally or non- tidally (Mitsch and Gosselink, 1986). Salt marshes look in grey blue shade when wet and

Salt marshes



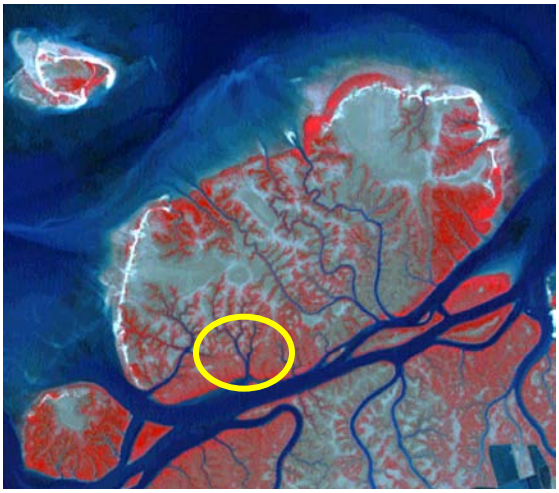
Salt marsh (white) near creeks

2106 **Mangroves**: The mangrove swamp is an association of halophytic trees, shrubs, and other plants growing in brackish to saline tidal waters of tropical and sub-tropical coastlines (Mitsch and Gosselink, 1986). On the satellite images mangroves occur in red colour if in contiguous patch. When mangrove associations are scattered or are degraded then instead of red colour, brick red colour may be seen.



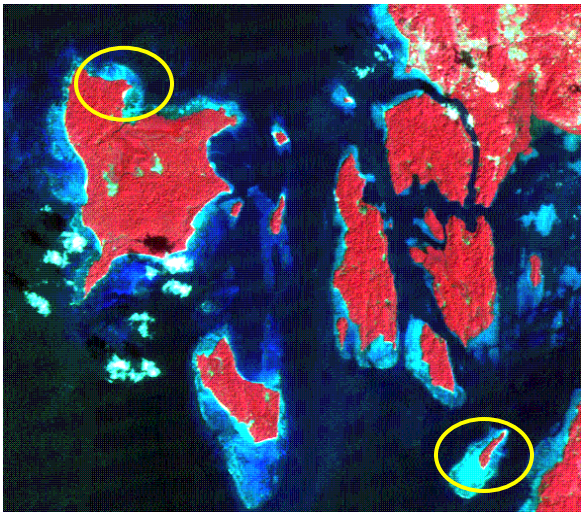
Mangroves

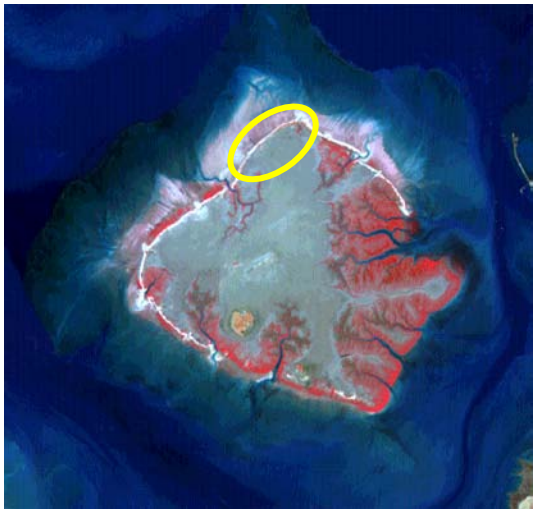
or



Mangroves interspersed with mud flats

warm tropical waters. The term coral reef, or organic reef is applied to the rock- like reefs built-up of living things, principally corals. They consist of accumulations of calcareous deposits of corals and corraline algae with the intervening space connected with sand, which consists largely of shells of foraminefera. Present reefs are living associations growing on this accumulation of past (Clark, 1977). Reefs appear in light blue shade.

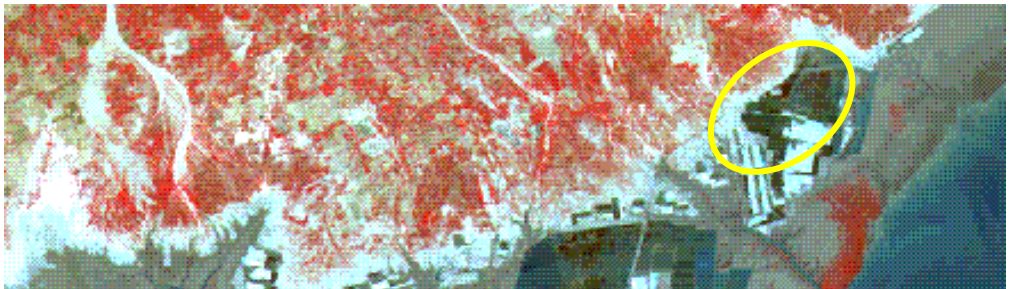




Coral Reefs

2200 Man-made

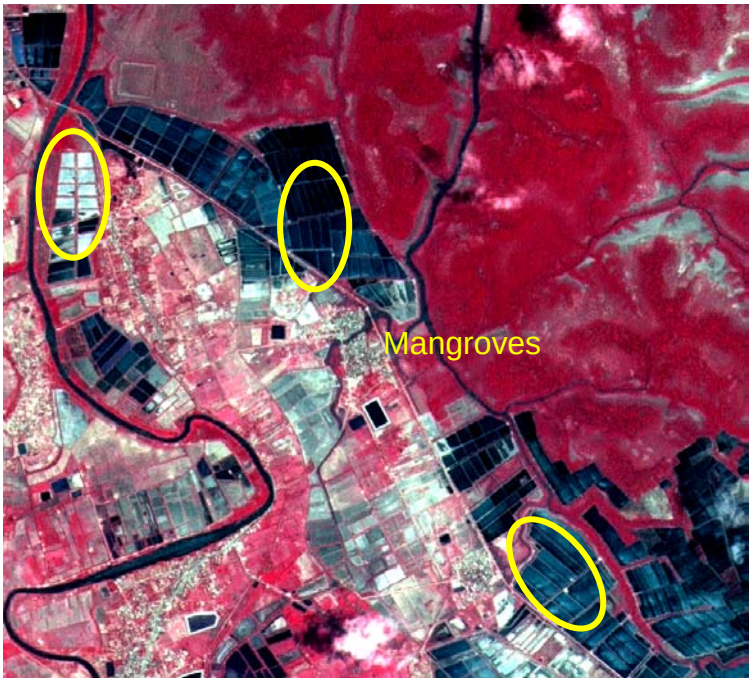
2201 Salt pans: An undrained usually small and shallow rectangular, man-made depression or hollow in which saline water accumulates and evaporates leaving a salt deposit (Margarate *et al*, 1974). Salt pans are square or rectangular in shape. When water is there appearance is blue while salt is formed tone is white.



Salt Pans. Mangroves. Gulf of Kachchh. Guiarat

Salt pans

2202 Aquaculture ponds: Aquaculture is defined as "The breeding and rearing of fresh-water or marine fish in captivity. Fish farming or ranching". The water bodies used for the above are called aquaculture ponds (Encyclopaedic Directory of Environment, 1988). Aquaculture ponds are geometrical in shape usually square or rectangular. Tone is blue.



Aquaculture Ponds

Chapter – 3

METHODOLOGY AND DATA REQUIREMENT

Chapter 3

METHODOLOGY AND DATA REQUIREMENT

Inventory of wetlands on 1:50 000 scale will involve analysis of Resourcesat LISS III post-monsoon and pre-monsoon) data of 2006/7 or 2005/6. All the existing maps prepared under Nation-wide Wetland Mapping Project will be used as reference while doing interpretation. Base maps on 1: 50 000 scale will be procured/prepared for all the states for which mapping on 1:250 000 scale was done in the first scientific inventory of wetlands in the country.

Salient features of overall methodology to be adopted are as under.

- Generation of spatial framework in GIS environment on the basis SOI graticule grids for database creation and organisation.
- Digital base map procurement/preparation
- Procurement/generation of base layers (rail, road network, settlements (including names), drainage, administrative boundaries)
- Geo-referencing of satellite data
- Wetland map preparation from digital satellite data
- Creation of a digital database for each layer as per the spatial framework.
- Mosaicing/edge matching of all these maps to create seamless database
- Design and development of query shell for information retrieval.
- Preparation of map compositions and Outputs on A0 Paper and A3 size atlases

3.1 SPATIAL FRAMEWORK AND GIS DATABASE DESCRIPTION

A seamless framework for India as defined under NSF (National Spatial Framework) GIS database standards will be followed in database creation (Anon, 1999, Anon. 2005a, 2005b, Anon. 2007)

Database contents

The database design and creation standards suggested by NRDB/NNRMS guidelines will be followed in wetland database creation (Table 3.1). List of data required and its naming conventions, sources etc. are given in Table 3.2.

Table 3.1: Database Design Specifications : Parameters and Values

Sl. No.	Contents	Specifications (1:50 000)
A.	**IMAGE STANDARDS**	
1.	Generic/Standard Resolution	25m XS or better
2.	IRS Images resolutions recommended for NNRMS activities	23.5m XS supported by 5.8m Pan / XS
3.	NSF	State
4.	Projection for image output	LCC/TM
5.	Datum for image products	WGS84
6.	Image Frames (geometrically corrected; important for seamlessness)	15' X 15'
7.	Image Position (Planimetric) Accuracy (0.5 mm of scale) in m	25
8.	Band-to-Band Registration for XS data (0.25 pixel) in m	~6
B.	**THEMATIC MAPPING STANDARDS**	
1.	NSF	State
2.	Minimum Map Frame size for incorporation to NRR	15' X 15'
3.	Image Registration accuracy @ 0.5 pixel (RMS)	12m
4.	Map Projection	LCC/TM
5.	Datum	WGS 84
6.	Position (Planimetric) Accuracy (1mm of scale) in m	50
7.	Minimum Mappable Unit (MMU) (3 x 3 mm of scale) in sq mts	22500
8.	Thematic Accuracy of Classification/Mapping	90/90
9.	Map Formats	- Digital GIS compliant - Paper
C.	**GIS DATABASE STANDARDS**	
1.	Spatial Framework	Seamless - National
2.	Tie-Point Intervals for Spatial Framework	5' X 5'
3.	Coordinate units for Precision	Decimal-Seconds
4.	Projection	Geographic
5.	Datum	WGS 84
6.	Coordinate Precision	Single
7.	Minimum Frame size for NRR	15' x 15'
8.	GIS DB Tic Registration Accuracy (0.25 mm of scale) (RMS) in m	12.5
9.	Position (Planimetric) Accuracy (1mm of scale) in m	50
10.	Coordinate Movement Tolerance(CMT)(0.125 mm of scale) in m*	6.25
11.	Weed Tolerance (WT) (0.125 mm of scale) in m*	6.25
12.	Sliver Polygon Tolerance (SPT) (LESS-THAN MMU) in m*	<22500
13.	Grid Size (for Image/Raster/DEM Layers) (0.5 mm of scale) in m	25

NOTE: * Depending upon thematic requirements, the range of these parameters may be made further stringent.

Table 3.2: List of data required and naming conventions

Sl. No.	**Theme**	***Theme name***	**Key field**	**Source**
1	Wetland boundary	WETBND	Wetcode Wettcode	RS data
2	Wetland pre-monsoon water spread	WETPRBND	Wetcode Wettcode	RS data
3	Wetland post-monsoon water spread	WETPOBND	Wetcode Wettcode	RS data
4.	Aquatic vegetation (post-monsoon)	AQVEGPOST	Wetcode	RS data
5.	Aquatic vegetation (pre-monsoon)	AQVEGPRE	Wetcode	RS data
6	Turbidity (post-monsoon)	TURBIDITYPO	Wetcode	RS data
7	Turbidity (pre-monsoon)	TURBIDITYPR	Wetcode	RS data
8	Wetlands (< 2.25 ha)	WETPNT	Wetcode Wettcode	RS data
9	Drainage lines	DRAINL	Key field codes will be as per NNRMS Standards	RS Data/SOI Maps/ NRIS/NRDB wherever available on 1:50000 scale
10	Drainage polygons	DRAINP		
11	Road network	ROADS		
12	Rail network	RAILS		
13	Settlements (points/area)	SETTLEP SETTLEA		
14	State boundary	STATE		
15	District boundary	DISTRICT		
16	Canal	CANAL		
17	Lat-Long grid	SOI		

Coding 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, which are self explanatory with short forms. This will have an attribute/look-up table and a key field (link-code), which links this look-up table and the database layer.

Attribute tables for wetland boundary layer*:* A wetland attribute table will be created for *WETBND* (Table 3.3). Two attribute tables will be created for references, namely *wetcode.dbf* and *wettcode.dbf*. Wetland boundary layer (*WETBND*) will be linked to these two tables; *wetcode.dbf* describes wetland codes and its description (Table 3.4). *Wettcode.dbf* contains wetland code, wetland type code and descriptions. (Table 3.5). *WETPRBND*, pre-monsoon wetland water spread coverage and *WETPOBND* – post-monsoon wetland water spread coverage will also be linked with *wetcode.dbf* and *wettcode.dbf*.

Table 3.3: Attribute Table of *WETBND*

Sl. No,	Field Name	Field Type	Key Field (Y/N)	Remarks
1	Wetcode	16, 16, C	Y	Unique identifier for each wetland
2.	Wettcode	4, 4, I	Y	Wetland type code based on wetland classification scheme
3.	Wetname	50,50,C	N	Wetland name if any
4.	Aqveg	2,2, C	N	Status of Aquatic vegetation (Y – Present, N – Absent)
5.	Turbidity	2,2,C	N	Status of Turbidity (H – High, M – Moderate, L – Low)

Table 3.4: Database structure of Wetcode.dbf

Field name	**Field type**	**Key field**	***Remarks***
Wetcode	16,16,C	Y	16 digit code (explained below) **
State	2,2,C	N	Coding scheme as per NNRMS/NRDB standards
District	2,2,C	N	Coding scheme as per NNRMS/NRDB standards
Taluka/Tehsil	2,2,C	N	Coding scheme as per NNRMS/NRDB standards
Toposheet	6,6,C	N	Ex. 46E/12 = 460512, 46A/16 = 460116
Wetnumber	4,4,C	N	Unique code for each wetland in a Map sheet Ex. Wetland no. 1 = 0001, wetland no. 2 = 0002…

**** Coding scheme for wetcode**:

Wetcode for each wetland is **'AABBCCDDDDDDEEEE'** (16 digits) map-sheet wise.

Where AA – State code
BB – District code
CC – Taluka code
DDDDDD – Map Sheet number
EEEE – Wetland number

Details of State codes, District codes and list of SOI topographic maps are given in Annexures IV, V, and VI .

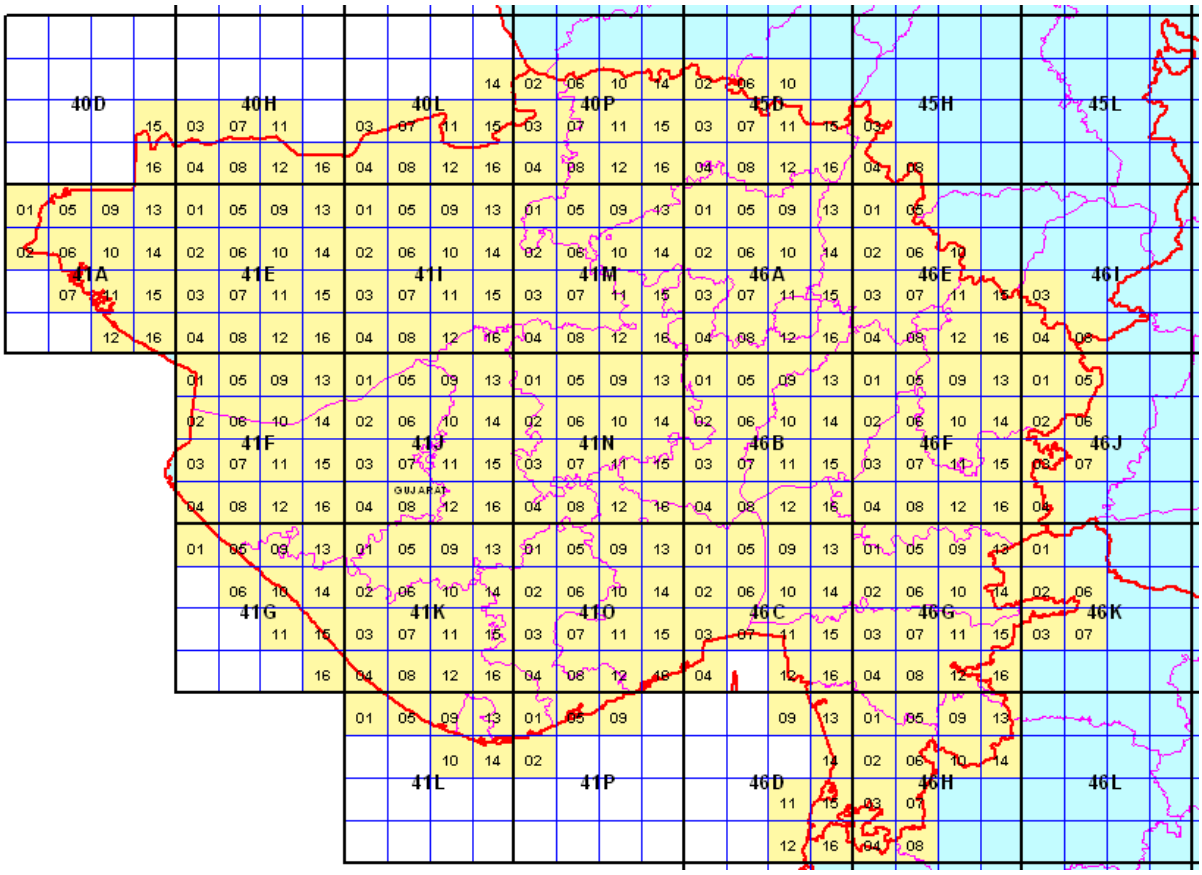
Structure of Wettcode.dbf

Field name	Field type	Key field	Remarks
Wettcode	4,4,I	Y	4 digit code (as per Table 2.1)
Wettdesc	50, 50 C	N	Description of wetland types (as per Table 2.1)

Creation of spatial framework

This is the most important task (prior to map digitisation) as the entire country is covered in multiple map sheets and the inputs are available on single map sheet basis. The geographic area of India is about 329 million ha covered in 5112 Survey of India topographical maps of 1:50,000 scale. Based on extent and map sheet graticules, the spatial framework for the GIS database has been/is being worked out. To create NWIA database, NNRMS/NRDB standards will be followed and four corners of the 1:50,000 (15' x 15') grid will be taken as the tics or registration points to create each map taking master grid as the reference. NSF details are given in Annexure I.

As an illustration spatial framework created for Gujarat state is shown in Figure 3.1. The tic marks are identified at 15 minutes interval.



Projection: **Lambert Conformal Conic (LCC)**
Units: **Meters**
Datum: **WGS84**
Parameters:
Standard Parallel 1 : 20.7916667
Standard Parallel 2: 23.958333
Central Meridian: 71.375, 22.37807121
False Origin (x, y): 1000000, 1000000

Fig. 3.1: Spatial framework of *NWIA (Gujarat State)*

Design considerations and database organisation

Any spatial information system requires systematic database design and organisation. Organisation of the database recognizes the fact that the system has to support information retrieval in terms of spatial units, which are generally at state/district level. These units are invariably the administrative units like state, district, taluka. Seamless geodatabase will be organised at state level. The wetland database and other references need to be designed in such a way that information retrieval and query at

various spatial units can be performed. In addition, wetland type/category wise information retrieval mechanism will be provided. Figure 3.2 shows four levels of database organization and Figure 3.3 shows GIS workspaces and file organisation.

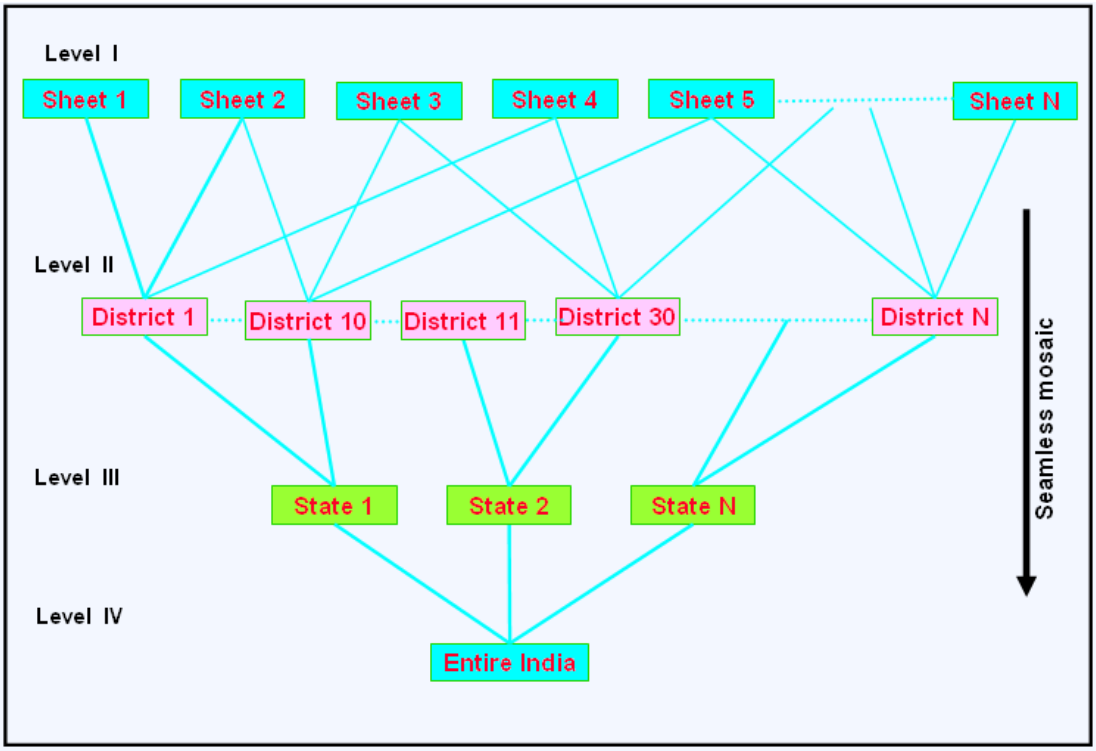


Fig. 3.2: NWIA levels of database organisation

3.2 SATELLITE DATA ANALYSIS

Wetland Inventory

Wetland maps (15' X 15') on 1: 50 000 scale will be prepared using Resourcesat-1 LISS III satellite data. LISS IV data will be used for 1:25000 scale wetlands mapping for the state of Sikkim. Mapping will be done state-wise and about 6057 wetland maps will be prepared. Latest LISS III digital data (pertaining to 2005/06 or 2006/07) will be analysed for delineation of boundary of wetlands, assessing water spread during post-monsoon and pre-monsoon seasons, assigning qualitative turbidity levels and distribution of vegetation (in wetlands).

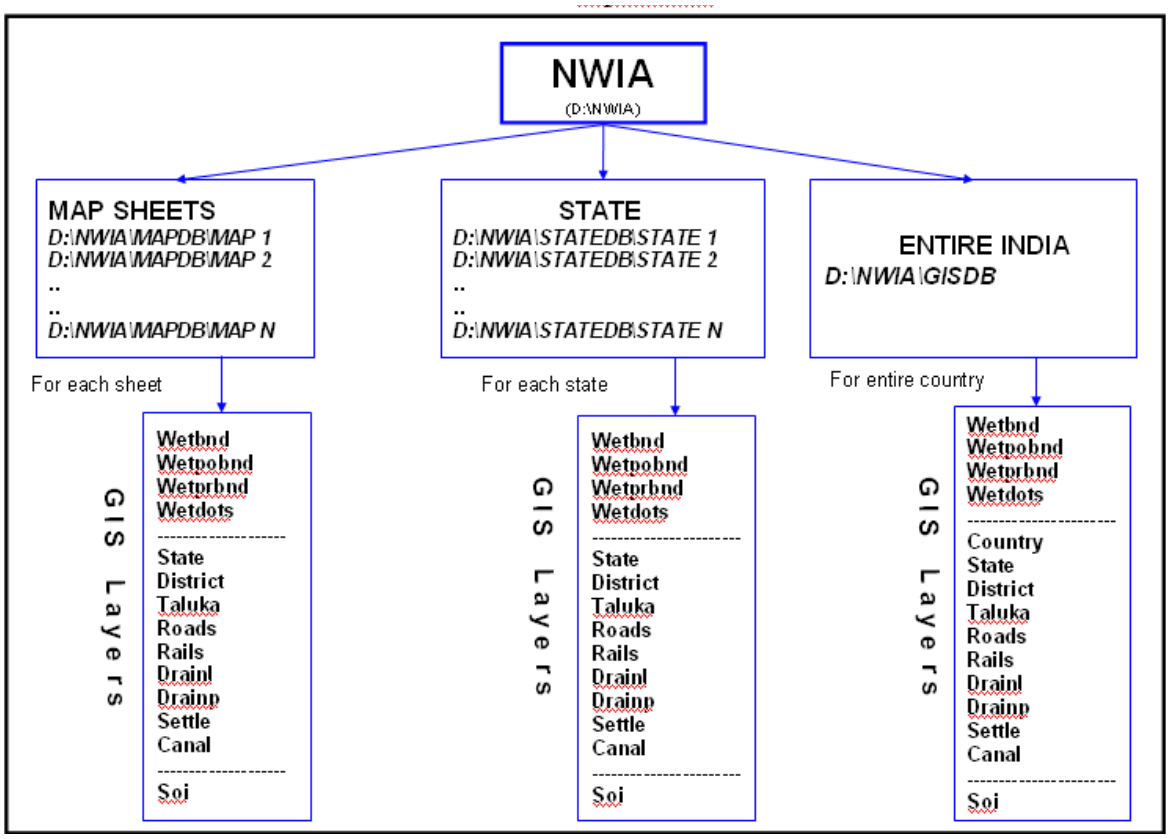


Fig 3.3: NWIA GIS workspaces and file organisation

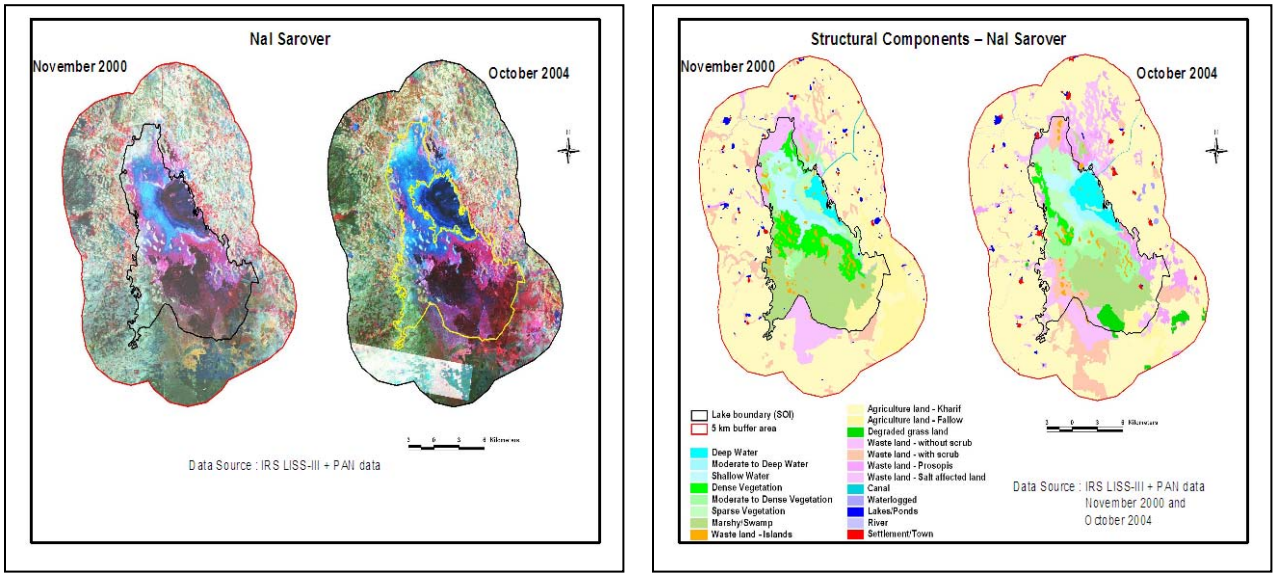
Besides satellite data, SOI topographical maps, ground truth information along with collateral data will also be used while delineating wetland categories. Following wetland layers will be generated for each inland wetland:

- Wetland extent
- Post-monsoon water spread
- Pre-monsoon water spread
- Aquatic vegetation as manifested on post-monsoon imagery
- Aquatic vegetation as manifested on pre-monsoon imagery
- Turbidity as manifested on post-monsoon imagery
- Turbidity as manifested on pre-monsoon imagery

In the case of coastal wetlands only wetland extent will be given.

Inland Wetlands – Extent, Structural Components and Turbidity

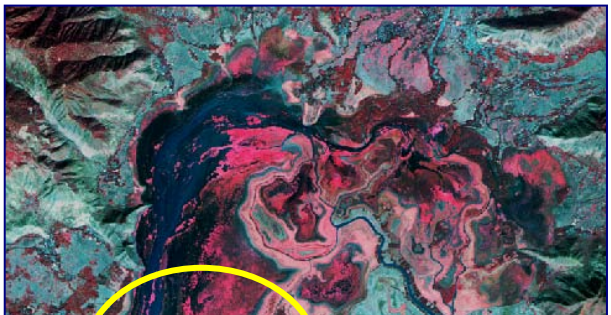
Setting of wetland boundary is a difficult task. As wetlands encompass water, marshy area, aquatic vegetation and mudflats (structural components), the wetland boundary should include all these. In the plain areas these can have separate polygons. However, in the hilly areas (especially the reservoirs and lakes) all these boundaries may coalesce. Structural components denote within wetland features such as open water, mud flats, islands etc. and vegetation (an indicator of trophic state). Remote sensing data is the best tool for depicting structural components in spatial domain. Such information will be generated for all Ramsar sites (19 in number).



Structural Components – Nal Sarovar

Vegetation

As is known, aquatic vegetation is of four types, viz. floating, emergent, submerged and benthic. It is possible to delineate first two types of vegetation through optical remote sensing. The presence of vegetation in wetlands provides information about its trophic condition. Typification of vegetation is not contemplated, however, it will be done for lakes, and reservoirs (> 1000 ha) as for smaller wetlands results may be erroneous.



Aquatic vegetation in Wular lake

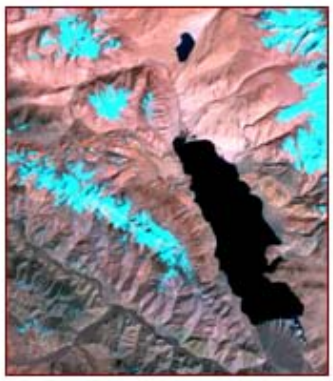
Turbidity

Qualitative turbidity ratings will be given to lakes, reservoirs, barrages and other large wetlands based on the hue as manifested on the False Colour Composite (FCC). The following interpretation key will be used for assigning qualitative turbidity rating to the water mass in the inland wetlands (lakes, reservoirs, barrages) (Table 3.6):

Table 3.6: Qualitative turbidity ratings as manifested on FCCs

Turbidity	**Hue on False Colour Composite (FCC)**
Low	Dark blue/blackish
Moderate	Medium blue
High/Bottom reflectance	Light blue/whitish blue

Following images indicate graphically qualitative turbidity rating as observed on the satellite imagery.



Low Turbidity

Moderate Turbidity

High Turbidity

3.3 GROUND TRUTH DATA COLLECTION

Ground truth data will be collected for preparation of Interpretation key and also accuracy assessment. Based on the information available from 1st scientific inventory of wetlands, ground truth data will be collected for all wetland categories available in a state. Minimum of 10 samples pertaining to each wetland type will be visited for field data collection. Information on structural components will also be collected during field data collection. Proforma for ground truth data collection is given in Annexure II.

3.4 OUTPUTS AND INFORMATION SYSTEM

Wetland database including base layers will be organised as per standards given earlier in Section 3.1. As mentioned earlier, as analysis of remote sensing data will be carried out using digital data, database of wetlands will also get generated while doing interpretation. This will lay foundation for periodic monitoring of wetlands in the country. Subsequently, a seamless digital database on 1: 50 000 scale wetland inventory at state level will be generated for the entire country. Query Shell/information system will be developed for facilitating data retrieval at the desired level. Outputs will be in the form of digital database, maps, atlases and information system.

Wetland maps (15' X 15')

India is covered in about 5112 Survey of India topographical maps. However, when each state is considered and interpreted separately then about 6057 maps covering fully or partly each state will be prepared (Table 3.7). State-wise digital database will be organised SOI topographical map sheet-wise. Wetland polygons smaller than the minimum mapping unit (3 mm x 3 mm or 2.25 ha) will be shown as 1 mm x 1mm squares since inclusion of wetland areas (of wetlands) smaller than mmu will lead to erroneous area estimates.

Output will be customized and stored as *.pdf* file for printing and output generation. Sample layout for map composition is given in Figure 3.4. Each map will depict legend, index map, name of participating agency, ISRO-SAC logo, data source, year and following information:

- Wetland boundary
- Post-monsoon water spread
- Pre-monsoon water spread
- Vegetation (aquatic or other) on post-monsoon image
- Vegetation (aquatic or other) on pre-monsoon image
- Base layers (road, rail network, settlement/village names etc)
- Turbidity status

Maps in the digital form and will be provided in *.pdf* form to the Ministry and to the users. Colour code for different wetland classes is given in Annexure III.

State-wise Atlases

Atlases (A3 size) will be prepared for each state and will contain district-wise wetland maps for each state. Mosaicing will be done for all the maps and clipping done for each district. A0 size maps (1:50 000 scale) will be reduced to fit in A3 size and printed for producing state-wise atlases for quick reference. Atlases will be available in digital format also.

Information System

Wetland information system will be developed (on the lines of WINSYS prepared for the pilot project on West Bengal will be modified and refined) for easy retrieval of information. Information System will also provide tools for overlay, query (spatial, tabular), map composition, output generation, charts (pie, bar) and statistics etc. It will also have facility of hot links (photographs, video clippings etc.). Subsequently, attempt will be made to develop tools for gap analysis and networking of wetlands for identifying areas for conservation at regional level. It is a fast developing wetland research area using spatial data.

Table 3.7: State-wise Wetland Maps to be prepared (SOI Maps)

Sr. No.	State	No. of maps	Sr. No.	State	No. of maps
1.	Andhra Pradesh	462	19.	Mizoram	47
2.	Arunachal Pradesh	172	20.	Nagaland	43
3.	Assam	171	21.	Maharashtra	503
4.	Bihar	180	22.	Orissa	270
5.	Chattisgarh	244	23.	Panjab	106
6.	Delhi	8	24.	Chandigarh	
7.	D.D. Nagar Haveli	335	25.	Rajasthan	583
8.	Gujarat		26.	Sikkim	19
9.	Goa	13	27.	Tamil Nadu	228
10.	Haryana	103	28.	Puducherry	
11.	Himachal Pradesh	116	29.	Tripura	29
12.	Jammu & Kashmir	420	30.	Uttar Pradesh	427
13.	Jharkhand	163	31.	Uttarakhand	111
14.	Karnataka	319	32.	W. Bengal	185
15.	Kerala	86	33.	A & N Islands	53
16.	Madhya Pradesh	536	34.	Lakshdweep	22
17.	Manipur	49		**TOTAL**	**6057**
18.	Meghalaya	54		**Entire Country**	**5112**

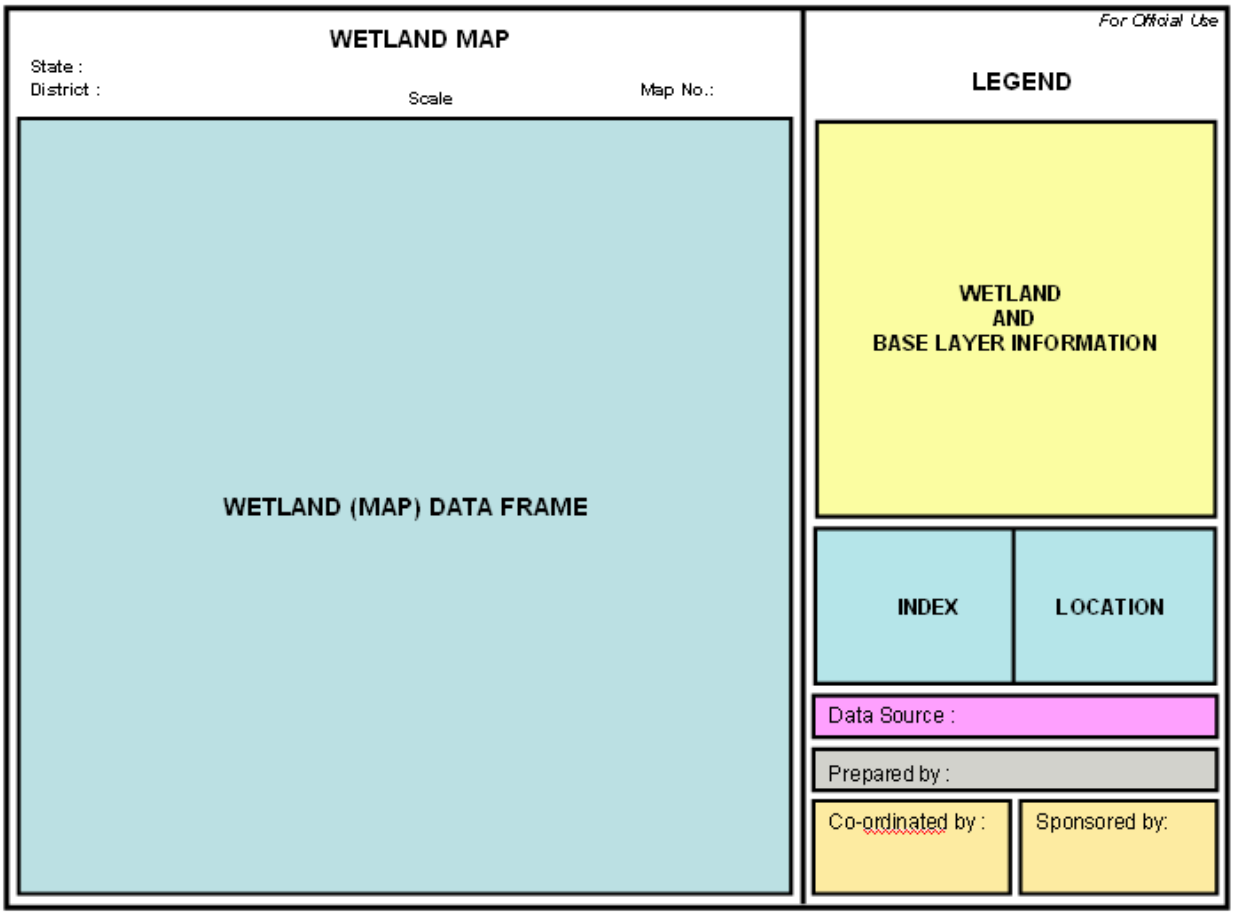


Figure 3.4 : Layout for Map Composition

3.5 INPUT DATA

Satellite Data

- Resourcesat (IRS P6) LISS III data of 2005/06 or 2006/07 pertaining to post-monsoon (October – November) and pre-monsoon (May-June) seasons. For the state of Sikkim Resourcesat –1 LISS IV data. India is covered in about 300 LISS III digital scenes. Since two season data will be used for wetland inventory and assessment a total of 600 scenes will be required in the execution of the project.

Legacy Data

- NWLM project Maps and GIS database (1:250,000 and 1:50,000 scale)

Reference/Collateral data

- Ground truth/other reference data
- SOI topographical maps

Chapter – 4

ACCURACY ASSESSMENT

Chapter 4

ACCURACY ASSESSMENT

A comprehensive accuracy assessment protocol will be 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 will also be evaluated for accuracy. Methodological details of accuracy assessment are given in the following sections.

4.1 Thematic Accuracy

Accuracy assessment will be done for each state. All the wetland categories will be numbered map-wise and sample chosen for field verification using the following equation (Jensen 1986):

i) Sample Size $N = \frac{4(p)(q)}{E^2}$

Where p is the expected percent accuracy (90 %), q = difference between 100 and p. E is the allowable error, and N the number of points to be sampled. It is planned to ensure $10\ \%$ sample for wetlands of each state and also all the wetland categories present in the state.

ii) Accuracy Estimation

Classification accuracy expected for various wetland categories is 90 percent at 90 percent confidence level. This will be tested on a sample basis assuming a binomial distribution. All the mapped wetland categories (including vegetation, turbidity) will be field tested and tabulated in contingency matrix in the following manner:

Table 4.1: Contingency table for assessment of Classification Accuracy

	Wetland Type determined from field/reference data				
Wetland Type identified and mapped		**Lake**	**Reservoir**	**Mud flat**	**Totals**
	Lake	**50**	5	2	57
	Reservoir	14	**13**	0	27
	Mud flats	3	5	**8**	16
	Totals	67	23	10	**100**

Total Accuracy: Number of correctly identified wetlands/total number of wetlands

$$Accuracy = \frac{50+13+8}{100} * 100$$

Similarly, accuracy for each wetland category will be determined.

4.2 Spatial/Location Accuracy

For assessment of positional accuracy, besides wetlands selected for classification accuracy assessment permanent features such as road intersections, railway line-road intersections will also be selected (about 20 per state). GPS readings of all these points will be taken and compared with lat/long estimated from wetland maps. Test for accuracy compliance will be done by comparing the planimetric (X and Y) coordinates of well defined ground points as well as points within/near to the wetlands with the coordinates of the same points determined by a survey of higher accuracy. A minimum of 20 well-defined and well-distributed wetland points will be used for location accuracy assessment.

RMS error in X direction = $\sqrt{(D^2/n)}$

Where $D^2 = d_1^{\,2} + d_2^{\,2} + d_3^{\,2} + ... + d_n^{\,2}$

D_1 = discrepancy in X-coordinate direction for i^{th} checkpoint

N = total number of points checked on the map in X coordinate direction

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ANNEXURE I
NATIONAL SPATIAL FRAMEWORK

(Reproduced from NNRMS Standards; ISRO:TR:112:2005 Committee Report)

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54. The definition of the National Spatial Framework (NSF) is the most critical aspect for the seamlessness of the multi-scale spatial database of the repository. The Framework has to be a combination of datum, projection and bounding limits definition (with assessment of accuracy) – that allows the most easy and accurate registration, transformation and visualization of the spatial information in the repository. In its simplest form, any spatial framework would be a frame of geographical coordinates with link points aimed at providing an invariant reference for all spatial data sets. However, with multi-scale and "seamless" geographical coverage, the NSF would have to be a combination of sub-frameworks that correspond to the nation, states (or regions) and lower units.

55. The NSF definition has been studied and the following design guidelines have driven a conceptual framework (Figure-1)

55.1 The GIS database of the repository can be in geographic coordinates so that the final delivery can be in a variety of formats or frameworks (even user definable). This will allow tremendous flexibility in design and outputs.

55.2. However, it is recognized that images and thematic maps would most probably comply with nationally-used frameworks (presently SOI framework) and thus this will continue.

55.3. Thus, maps generated would get transformed to geographic framework for archival.

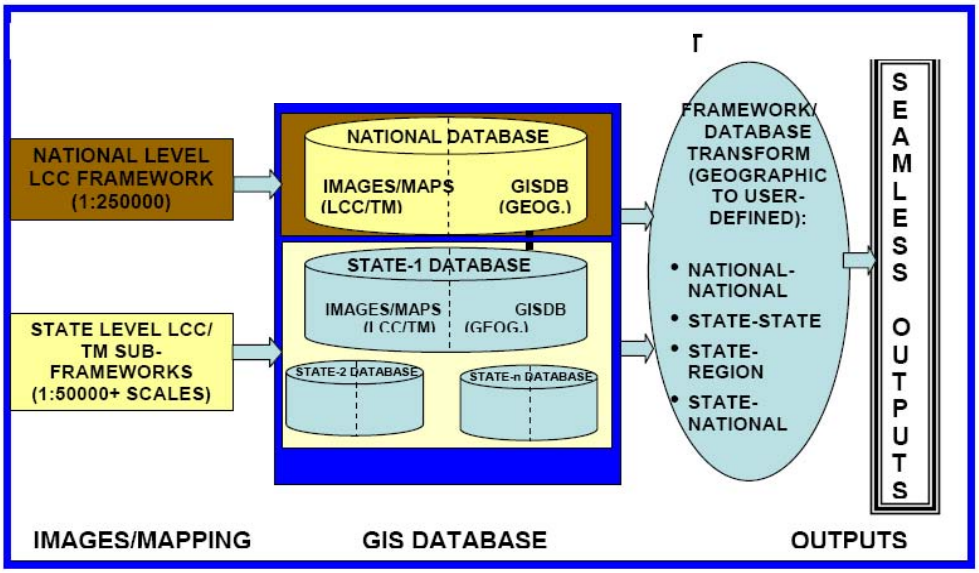

Fig. 1: NSF Design Concept

56. A 2-level framework would constitute the NSF, as follows (shown in Figures 2 and 3)

56.1. A small-scale nationally "seamless" framework for 1:250000 scale spatial information – conforming to a set of national parameters

56.2. Individual state-level frameworks for 1:50000 scale and larger (1:10000, 1:4000 and 1:2000)

57. As a starting point this implies that all the databases should have a common origin and coordinate system and calling for a Seamless system for entire country having same co-ordinate and projection system.

58. The NSF design is based on the policy guidelines of the National Map policy (NMP) (NMP, 2005) – which allows an Open Series Maps (OSM) for civilian use. The NMP OSM is characterized by WGS-84 datum for all scales of mapping.

59. The NSF is "tagged" to precise locations based on 2 important design schemes:

59.1. Adopting a standard boundary template for the 2 NSF. NNRMS Standard will adopt the boundary template as provided by SOI and will conform all its products – images, maps and GIS database to this template.

59.2. Defining standard framework parameters that are applicable to images, maps and GIS database.

59.3. Adopting a standard tie-point for the "anchoring" of each geographical lat/long coordinate to a "precise" location in the 2-dimensional space and referenced to the boundary template of the country and the states.

NSF – BOUNDARY TEMPLATE

60. The boundary template of India and the states for the NSF is of prime importance. The Boundary template will determine the "link" of the Repository to the administrative limits of the nation and also allow referencing to a large amount of administrative GIS databases that are available.

61. Choice of the template coverage has to be standardised so that all NNRMS users use the same template and "limit" their image, mapping, GIS activities within the boundaries defined – thus enabling a proper registration of the Repository across content.

62. NNRMS has decided to adopt Standard boundary "template" of India – obtained from SOI in digital format – a boundary template that would defined from SOI topographic maps on 1:250K scale. Similarly, NNRMS NSF would use a Standard boundary "template" for each state – obtained from SOI in digital format – a boundary template that would be defined from SOI topographic maps on 1:50K scale.

NSF Parameters For 1:50k & Larger Scale State Database

65. The second level of the NSF is the state-level "seamless" framework for the 1:50K and larger scales of Repository of the NNRMS. As has been mentioned earlier, all larger than 1:50K would use the 1:50K NSF so that a systematic correlation exists across scales at this level.

66. The 1:50K NSF will have the following characteristic:

66.1. Datum would be WGS-84 – keeping conformity of the NMP.

66.2. Projection for images and maps would be Lambert Conformal Conic (LCC) for most states where the latitudinal difference is low – which is the most suited for the individual states mapping activity and uniformly distributes position and area errors across latitudes. The LCC has also been recommended by the ISRO-level Committee on Map Projections and Datum for future IRS Data Products (IRS Data Products Committee Report, 2001).

66.2.1. 2 Standard Parallel defined with a K=6 factor for each state

66.2.2. A Central Meridian definition and a Latitude for Origin definition for each state – both together defining the origin of the coordinate system for the state

66.2.3. State-specific False Easting and false Northing to bring all coordinates for the state into positive real numbers.

66.2.4. NNRMS recommends 4 coordinate points of a "bounding box" that envelopes each state boundary – which mainly defines the boundling limits for the state framework and which is extended to cover a full 15' X 15' tile at the boundary.

66.3. Projection of Transverse Mercator (TM) for states where the latitudinal difference is high (greater than 6^{o}) – which is the most suited for the individual states mapping activity and uniformly distributes position and area errors across latitudes. The LCC has also been recommended by the ISRO-level Committee on Map Projections and Datum for future IRS Data Products (Map Projections Committee Report, 2001).

66.3.1. NNRMS recommends 4 coordinate points of a "bounding box" that envelopes each state boundary – which mainly defines the boundling limits for the state framework and which is extended to cover a full 15' X 15' tile at the boundary.

66.3.2. A Reference Meridian definition and Latitude for Origin definition for the state– both together defining the origin of the single coordinate system for the nation.

66.3.3. A Scale factor for the Projection

66.3.4. State-specific False Easting and false Northing to bring all coordinates for the state into positive real numbers.

66.4. Projection for GIS database would be Geographic.

67. Studies have been conducted on projection error estimation for 1:10,000 scale maps using 1:50K NSF parameters and projection errors are seen to be within tolerance limits. Hence, 1:50K NSF can be used for 1:10,000 scale.

68. It is to be noted that mapping at 1:4000 and 1:2000 scale are generally project specific and thus necessary correction factors may be determined and used on

project basis. In order to hold high precision of 1:4000 and 1:2000 scale database, it is recommended to used high precision storage unit as against what is used for 1:50K or 1:10K.

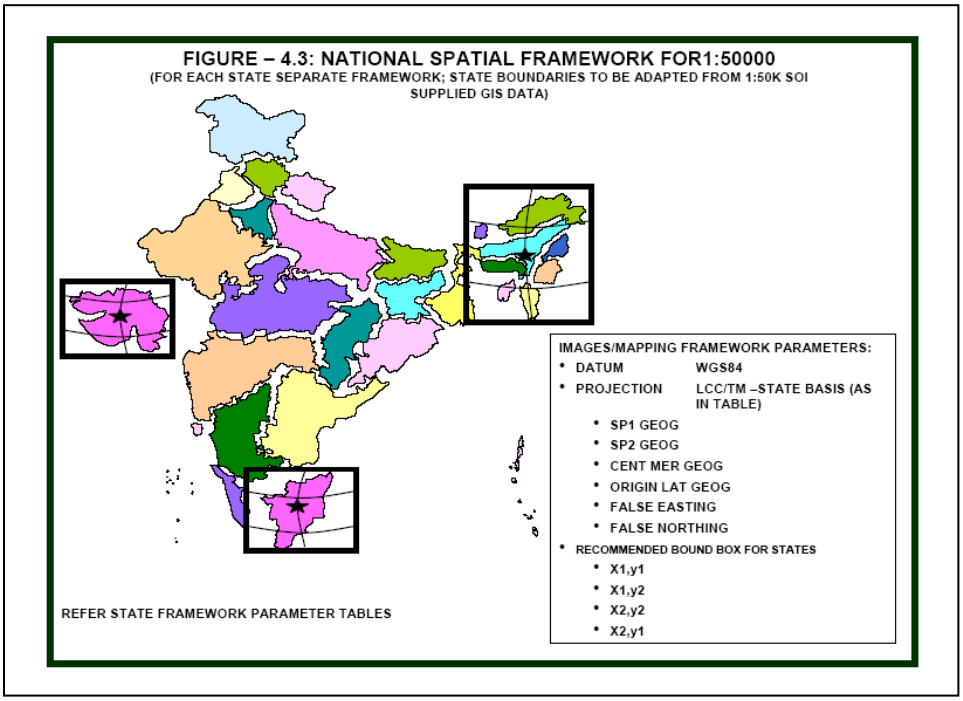

Fig. 2: National Spatial Framework for 1:50 000 scale

69. **FIGURE – 2** shows the details of the 1:50K NSF with the standard state boundary template and relevant LCC parameters.

70. The parameters for the 1:50K State-level LCC and TM framework are given in **TABLE – 1 and 2** respectively. Evaluation of the state NSF and its area figures needs to be taken upon the standard SOI state template of 1:50K OSM.

GEOGRAPHICAL TIE- POINTS FOR NSF

71. The requirement of tie-points is for selection of scheme, which facilitates unique identification number for every tie point all across Indian Territory. The suggested approach is on the basis of Latitude/ Longitude co-ordinates. The scheme proposes selection of multi-layer registration points as the Latitude-Longitude intersections as follows (**FIGURE – 3**):

71.1. Lat/Long Intersections up to 45 Second Interval, depending upon the level of details, as the Registration/ Tie points. This will take care of the map elements at a variety of scales ranging from 1:250,000 to 1:2000 as envisaged under NNRMS standards.

71.2. Unique assignment of ID for each point all over India. There will be 12- digit identification number for each registration point so as to make it unique. The 12-digit scheme would be as follows:

- DDMMSSddmmss, where DDMMSS = latitude values for the tie point coordinates in degree, minute and seconds and ddmmss = Longitude values for the tie point co-ordinates in degree, minute and seconds

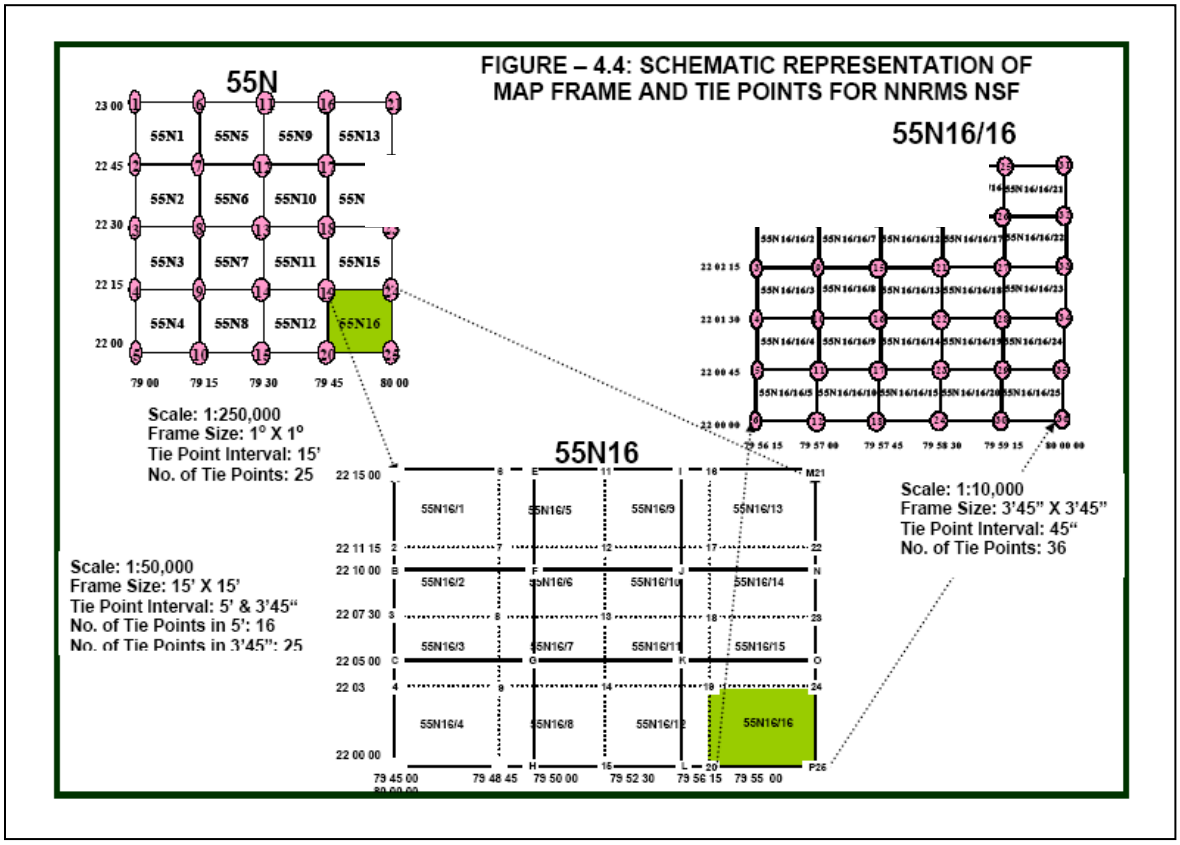

Fig. 3: Schematic representation of mapframe and tie points

Table 1: NSF Parameters of LCC Projection System for 1:50 K & Larger Scale

STATE	LATITUDE (IN DECIMAL DEGREE)		LONGITUDE (IN DECIMAL DEGREE)		REF LONG (IN DECIMAL DEGREE)	LCC PARAMETERS (IN DECIMAL DEGREE)				FALSE ORIGIN IN METRES)
						SP1	SP2	CEN. PARALLEL	SCALE FACTOR	(Both X & Y)
Andra Pradesh	12.5	20	76.75	85	80.875	13.75	18.75	16.25543298	0.999050399	1000000
Arunachal Pradesh	26.5	29.5	91.5	97.5	94.5	27	29	28.00157897	0.999799464	1000000
Assam	24	28	89.5	96	92.75	24.6666667	27.333333	26.00257703	0.999694921	1000000
Bihar	24	27.75	83.25	88.5	85.875	24.625	27.125	25.87725247	0.999728271	1000000
Delhi	28.25	29	76.5	77.5	77	28.375	28.875	28.62510126	0.999936773	1000000
Gujarat	20	24.75	68.25	74.5	71.375	20.7916667	23.958333	22.37807121	0.999601981	1000000
Haryana	27.5	31	74.25	77.75	76	28.0833333	30.416667	29.25226266	0.999734937	1000000
Himachal Pradesh	30.25	33.25	75.5	79.25	77.375	30.75	32.75	31.75183497	0.999766243	1000000
Jammu & Kashmir	32.25	37.25	72.5	80.5	76.5	33.0833333	36.416667	34.75570874	0.999461303	1000000
Jharkhand	22	25.25	83.25	88	85.625	22.5416667	24.708333	23.62652682	0.999798754	1000000
Madhya Pradesh	21	27	73.75	83	78.375	22	26	24.00529821	0.999368976	1000000
Maharashtra	15.5	22.25	72.5	81	76.75	16.625	21.125	18.88015774	0.999225467	1000000
Manipur	23.75	25.75	93	95	94	24.0833333	25.416667	24.75060911	0.99990381	1000000
Meghalaya	25	26.25	89.75	93	91.375	25.2083333	26.041667	25.62524747	0.999940111	1000000
Nagaland	25	27.25	93.25	95.5	94.375	25.375	26.875	26.12581974	0.999878274	1000000
North East	21.75	29.5	89.5	97.5	93.5	23.0416667	28.208333	25.63452135	0.998955546	1000000
Orissa	17.75	22.75	81.25	87.5	84.375	18.5833333	21.91666.7	20.25305174	0.999567913	1000000
Punjab	29.5	32.5	73.75	77	75.375	30	32	31.00178226	0.999773823	1000000
Rajasthan	23	30.75	69.25	78.5	73.875	24.2916667	29.458333	26.88505546	0.998947797	1000000
Uttar Pradesh	23.75	30.5	77	84.75	80.875	24.875	29.375	27.13270823	0.999190172	1000000
Uttaranchal	28.5	31.5	77.5	81.25	79.375	29	31	30.0017132	0.999783182	1000000

Table 2: NSF Parameters of TM Projection System For 1.50 K & Larger Scale

STATE	LATITUDE (IN DECIMAL DEGREE)		LONGITUDE (IN DECIMAL DEGREE)		REF LAT (IN DECIMAL DEGREE)	REF LONG (IN DECIMAL DEGREE)	TM	FALSE ORIGIN IN METRES)
							Scale Factor	(Both X & Y)
Andaman & Nicobar Island	6.75	13.75	92.00	94.50	10.25	93.25	0.9999428	1000000
Chhattisgarh	17.75	24.25	80	84.5	21	82.25	0.9998332	1000000
Goa	14.75	16	73.5	74.5	15.375	74	0.9999913	1000000
Karnataka	11.5	18.75	74	78.75	15.125	76.375	0.9998012	1000000
Kerala	8	13	74.5	77.5	10.5	76	0.9999177	1000000
Lakshadweep	8.25	11.75	72.00	74.25	10	73.125	0.9999536	1000000
Mizoram	21.75	24.5	92	93.5	23.125	92.75	0.9999821	1000000
Sikkam	27	28.25	88	89	27.625	88.5	0.9999926	1000000
Tamil Nadu	8	13.75	76	80.75	10.875	78.375	0.9997942	1000000
Tripura	22.75	24.75	91	92.5	23.75	91.75	0.9999822	1000000
West Bengal	21.5	27.25	85.75	90	24.375	87.875	0.9998584	1000000

ANNEXURE II

GROUND TRUTH DATA COLLECTION PROFORMA

NATIONAL WETLAND INVENTORY AND ASSESSMENT

Date:

State: District:

Taluka: Village:

Co-ordinates (GPS)

1. Wetland Type:
2. Wetland Characteristics on FCC:
   Shape:
   Size (approx. in ha):
   Tone:
   Texture:
   Association:

Field Sketch

3. Qualitative Turbidity (inland wetlands):
4. Vegetation
   a) Aquatic: Approximate area (per cent) covered
      List of important species
      - Emergent
      - Submerged
      - Floating

   b) Other (please specify)

5. Comments: Waterfowl, conservation measures etc.

Signatures

ANNEXURE III
Wetland Classification System and Colour code

Wettcode	Level I	Level II	Level III	Symbol

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	

Annexure IV
Nomenclature of sub districts in states and union territories of India

Sr. No	Name of State / UT*	Sub-district status
1	Jammu & Kashmir	Tehsil
2	Himachal Pradesh	Tehsil/Sub-Tehsil
3	Punjab	Tehsil
4	Chandigarh *	Tehsil
5	Uttaranchal	Tehsil
6	Haryana	Tehsil
7	Delhi *	Tehsil
8	Rajasthan	Tehsil
9	Uttar Pradesh	Tehsil
10	Bihar	Community Development Block
11	Sikkim	Sub-Division
12	Arunachal Pradesh	Circle
13	Nagaland	Circle
14	Manipur	Sub-Division
15	Mizoram	Rural Development Block
16	Tripura	Development Block
17	Meghalaya	Community Development Block
18	Assam	Circle
19	West Bengal	Community Development Block
20	Jharkhand	Community Development Block
21	Orissa	Police Station
22	Chhatisgarh	Tehsil
23	Madhya Pradesh	Tehsil
24	Gujarat	Taluk
25	Daman & Diu *	Taluk
26	Dadra & Nagar Haveli *	Taluk
27	Maharashtra	Tehsil
28	Andhra Pradesh	Mandal
29	Karnataka	Taluk
30	Goa	Taluk
31	Lakshadweep *	Sub-Division
32	Kerala	Taluk
33	Tamil Nadu	Taluk
34	Pondicherry *	Commune Panchayat
35	Andaman & Nicobar Islands *	Tehsil

Data Source : Census 2001

Note: * Signifies union territories

Annexure V
NWIA : State and District codes to be used for GIS database creation

ST_ CODE	STATE	DIST_ CODE	DISTRICT	STDIST_ CODE
01	JAMMU AND KASHMIR	01	Kupwara	0101
01	JAMMU AND KASHMIR	02	Baramula	0102
01	JAMMU AND KASHMIR	03	Srinagar	0103
01	JAMMU AND KASHMIR	04	Badgam	0104
01	JAMMU AND KASHMIR	05	Pulwama	0105
01	JAMMU AND KASHMIR	06	Anantnag	0106
01	JAMMU AND KASHMIR	07	Leh (Ladakh)	0107
01	JAMMU AND KASHMIR	08	Kargil	0108
01	JAMMU AND KASHMIR	09	Doda	0109
01	JAMMU AND KASHMIR	10	Udhampur	0110
01	JAMMU AND KASHMIR	11	Punch	0111
01	JAMMU AND KASHMIR	12	Rajauri	0112
01	JAMMU AND KASHMIR	13	Jammu	0113
01	JAMMU AND KASHMIR	14	Kathua	0114
02	HIMACHAL PRADESH	01	Chamba	0201
02	HIMACHAL PRADESH	02	Kangra	0202
02	HIMACHAL PRADESH	03	Lahul & Spiti	0203
02	HIMACHAL PRADESH	04	Kullu	0204
02	HIMACHAL PRADESH	05	Mandi	0205
02	HIMACHAL PRADESH	06	Hamirpur	0206
02	HIMACHAL PRADESH	07	Una	0207
02	HIMACHAL PRADESH	08	Bilaspur	0208
02	HIMACHAL PRADESH	09	Solan	0209
02	HIMACHAL PRADESH	10	Sirmaur	0210
02	HIMACHAL PRADESH	11	Shimla	0211
02	HIMACHAL PRADESH	12	Kinnaur	0212
03	PUNJAB	01	Gurdaspur	0301
03	PUNJAB	02	Amritsar	0302
03	PUNJAB	03	Kapurthala	0303
03	PUNJAB	04	Jalandhar	0304
03	PUNJAB	05	Hoshiarpur	0305
03	PUNJAB	06	Nawanshahr *	0306
03	PUNJAB	07	Rupnagar	0307
03	PUNJAB	08	Fatehgarh Sahib *	0308
03	PUNJAB	09	Ludhiana	0309
03	PUNJAB	10	Moga *	0310
03	PUNJAB	11	Firozpur	0311
03	PUNJAB	12	Muktsar *	0312
03	PUNJAB	13	Faridkot	0313
03	PUNJAB	14	Bathinda	0314
03	PUNJAB	15	Mansa *	0315
03	PUNJAB	16	Sangrur	0316
03	PUNJAB	17	Patiala	0317
04	CHANDIGARH	01	Chandigarh	0401

05	UTTARANCHAL	01	Uttarkashi	0501
05	UTTARANCHAL	02	Chamoli	0502
05	UTTARANCHAL	03	Rudraprayag *	0503
05	UTTARANCHAL	04	Tehri Garhwal	0504
05	UTTARANCHAL	05	Dehradun	0505
05	UTTARANCHAL	06	Garhwal	0506
05	UTTARANCHAL	07	Pithoragarh	0507
05	UTTARANCHAL	08	Bageshwar	0508
05	UTTARANCHAL	09	Almora	0509
05	UTTARANCHAL	10	Champawat	0510
05	UTTARANCHAL	11	Nainital	0511
05	UTTARANCHAL	12	Udham Singh Nagar *	0512
05	UTTARANCHAL	13	Hardwar	0513
06	HARYANA	01	Panchkula *	0601
06	HARYANA	02	Ambala	0602
06	HARYANA	03	Yamunanagar	0603
06	HARYANA	04	Kurukshetra	0604
06	HARYANA	05	Kaithal	0605
06	HARYANA	06	Karnal	0606
06	HARYANA	07	Panipat	0607
06	HARYANA	08	Sonipat	0608
06	HARYANA	09	Jind	0609
06	HARYANA	10	Fatehabad *	0610
06	HARYANA	11	Sirsa	0611
06	HARYANA	12	Hisar	0612
06	HARYANA	13	Bhiwani	0613
06	HARYANA	14	Rohtak	0614
06	HARYANA	15	Jhajjar *	0615
06	HARYANA	16	Mahendragarh	0616
06	HARYANA	17	Rewari	0617
06	HARYANA	18	Gurgaon	0618
06	HARYANA	19	Faridabad	0619
07	DELHI	01	North West *	0701
07	DELHI	02	North *	0702
07	DELHI	03	North East *	0703
07	DELHI	04	East *	0704
07	DELHI	05	New Delhi	0705
07	DELHI	06	Central *	0706
07	DELHI	07	West *	0707
07	DELHI	08	South West *	0708
07	DELHI	09	South *	0709
08	RAJASTHAN	01	Ganganagar	0801
08	RAJASTHAN	02	Hanumangarh *	0802
08	RAJASTHAN	03	Bikaner	0803
08	RAJASTHAN	04	Churu	0804
08	RAJASTHAN	05	Jhunjhunun	0805
08	RAJASTHAN	06	Alwar	0806
08	RAJASTHAN	07	Bharatpur	0807

08	RAJASTHAN	08	Dhaulpur	0808
08	RAJASTHAN	09	Karauli *	0809
08	RAJASTHAN	10	Sawai Madhopur	0810
08	RAJASTHAN	11	Dausa *	0811
08	RAJASTHAN	12	Jaipur	0812
08	RAJASTHAN	13	Sikar	0813
08	RAJASTHAN	14	Nagaur	0814
08	RAJASTHAN	15	Jodhpur	0815
08	RAJASTHAN	16	Jaisalmer	0816
08	RAJASTHAN	17	Barmer	0817
08	RAJASTHAN	18	Jalor	0818
08	RAJASTHAN	19	Sirohi	0819
08	RAJASTHAN	20	Pali	0820
08	RAJASTHAN	21	Ajmer	0821
08	RAJASTHAN	22	Tonk	0822
08	RAJASTHAN	23	Bundi	0823
08	RAJASTHAN	24	Bhilwara	0824
08	RAJASTHAN	25	Rajsamand *	0825
08	RAJASTHAN	26	Udaipur	0826
08	RAJASTHAN	27	Dungarpur	0827
08	RAJASTHAN	28	Banswara	0828
08	RAJASTHAN	29	Chittaurgarh	0829
08	RAJASTHAN	30	Kota	0830
08	RAJASTHAN	31	Baran *	0831
08	RAJASTHAN	32	Jhalawar	0832
09	UTTAR PRADESH	01	Saharanpur	0901
09	UTTAR PRADESH	02	Muzaffarnagar	0902
09	UTTAR PRADESH	03	Bijnor	0903
09	UTTAR PRADESH	04	Moradabad	0904
09	UTTAR PRADESH	05	Rampur	0905
09	UTTAR PRADESH	06	Jyotiba Phule Nagar *	0906
09	UTTAR PRADESH	07	Meerut	0907
09	UTTAR PRADESH	08	Baghpat *	0908
09	UTTAR PRADESH	09	Ghaziabad	0909
09	UTTAR PRADESH	10	Gautam Buddha Nagar *	0910
09	UTTAR PRADESH	11	Bulandshahar	0911
09	UTTAR PRADESH	12	Aligarh	0912
09	UTTAR PRADESH	13	Hathras *	0913
09	UTTAR PRADESH	14	Mathura	0914
09	UTTAR PRADESH	15	Agra	0915
09	UTTAR PRADESH	16	Firozabad	0916
09	UTTAR PRADESH	17	Etah	0917
09	UTTAR PRADESH	18	Mainpuri	0918
09	UTTAR PRADESH	19	Budaun	0919
09	UTTAR PRADESH	20	Bareilly	0920
09	UTTAR PRADESH	21	Pilibhit	0921
09	UTTAR PRADESH	22	Shahjahanpur	0922
09	UTTAR PRADESH	23	Kheri	0923

09	UTTAR PRADESH	24	Sitapur	0924
09	UTTAR PRADESH	25	Hardoi	0925
09	UTTAR PRADESH	26	Unnao	0926
09	UTTAR PRADESH	27	Lucknow	0927
09	UTTAR PRADESH	28	Rae Bareli	0928
09	UTTAR PRADESH	29	Farrukhabad	0929
09	UTTAR PRADESH	30	Kannauj *	0930
09	UTTAR PRADESH	31	Etawah	0931
09	UTTAR PRADESH	32	Auraiya *	0932
09	UTTAR PRADESH	33	Kanpur Dehat	0933
09	UTTAR PRADESH	34	Kanpur Nagar	0934
09	UTTAR PRADESH	35	Jalaun	0935
09	UTTAR PRADESH	36	Jhansi	0936
09	UTTAR PRADESH	37	Lalitpur	0937
09	UTTAR PRADESH	38	Hamirpur	0938
09	UTTAR PRADESH	39	Mahoba *	0939
09	UTTAR PRADESH	40	Banda	0940
09	UTTAR PRADESH	41	Chitrakoot *	0941
09	UTTAR PRADESH	42	Fatehpur	0942
09	UTTAR PRADESH	43	Pratapgarh	0943
09	UTTAR PRADESH	44	Kaushambi *	0944
09	UTTAR PRADESH	45	Allahabad	0945
09	UTTAR PRADESH	46	Barabanki	0946
09	UTTAR PRADESH	47	Faizabad	0947
09	UTTAR PRADESH	48	Ambedkar Nagar *	0948
09	UTTAR PRADESH	49	Sultanpur	0949
09	UTTAR PRADESH	50	Bahraich	0950
09	UTTAR PRADESH	51	Shrawasti *	0951
09	UTTAR PRADESH	52	Balrampur *	0952
09	UTTAR PRADESH	53	Gonda	0953
09	UTTAR PRADESH	54	Siddharthnagar	0954
09	UTTAR PRADESH	55	Basti	0955
09	UTTAR PRADESH	56	Sant Kabir Nagar *	0956
09	UTTAR PRADESH	57	Mahrajganj	0957
09	UTTAR PRADESH	58	Gorakhpur	0958
09	UTTAR PRADESH	59	Kushinagar *	0959
09	UTTAR PRADESH	60	Deoria	0960
09	UTTAR PRADESH	61	Azamgarh	0961
09	UTTAR PRADESH	62	Mau	0962
09	UTTAR PRADESH	63	Ballia	0963
09	UTTAR PRADESH	64	Jaunpur	0964
09	UTTAR PRADESH	65	Ghazipur	0965
09	UTTAR PRADESH	66	Chandauli *	0966
09	UTTAR PRADESH	67	Varanasi	0967
09	UTTAR PRADESH	68	Sant Ravidas Nagar Bhadohi *	0968
09	UTTAR PRADESH	69	Mirzapur	0969
09	UTTAR PRADESH	70	Sonbhadra	0970
10	BIHAR	01	Pashchim Champaran	1001

10	BIHAR	02	Purba Champaran	1002
10	BIHAR	03	Sheohar *	1003
10	BIHAR	04	Sitamarhi	1004
10	BIHAR	05	Madhubani	1005
10	BIHAR	06	Supaul *	1006
10	BIHAR	07	Araria	1007
10	BIHAR	08	Kishanganj	1008
10	BIHAR	09	Purnia	1009
10	BIHAR	10	Katihar	1010
10	BIHAR	11	Madhepura	1011
10	BIHAR	12	Saharsa	1012
10	BIHAR	13	Darbhanga	1013
10	BIHAR	14	Muzaffarpur	1014
10	BIHAR	15	Gopalganj	1015
10	BIHAR	16	Siwan	1016
10	BIHAR	17	Saran	1017
10	BIHAR	18	Vaishali	1018
10	BIHAR	19	Samastipur	1019
10	BIHAR	20	Begusarai	1020
10	BIHAR	21	Khagaria	1021
10	BIHAR	22	Bhagalpur	1022
10	BIHAR	23	Banka *	1023
10	BIHAR	24	Munger	1024
10	BIHAR	25	Lakhisarai *	1025
10	BIHAR	26	Sheikhpura *	1026
10	BIHAR	27	Nalanda	1027
10	BIHAR	28	Patna	1028
10	BIHAR	29	Bhojpur	1029
10	BIHAR	30	Buxar *	1030
10	BIHAR	31	Kaimur (Bhabua) *	1031
10	BIHAR	32	Rohtas	1032
10	BIHAR	33	Jehanabad	1033
10	BIHAR	34	Aurangabad	1034
10	BIHAR	35	Gaya	1035
10	BIHAR	36	Nawada	1036
10	BIHAR	37	Jamui *	1037
11	SIKKIM	01	North	1101
11	SIKKIM	02	West	1102
11	SIKKIM	03	South	1103
11	SIKKIM	04	East	1104
12	ARUNACHAL PRADESH	01	Tawang	1201
12	ARUNACHAL PRADESH	02	West Kameng	1202
12	ARUNACHAL PRADESH	03	East Kameng	1203
12	ARUNACHAL PRADESH	04	Papum Pare *	1204
12	ARUNACHAL PRADESH	05	Lower Subansiri	1205
12	ARUNACHAL PRADESH	06	Upper Subansiri	1206
12	ARUNACHAL PRADESH	07	West Siang	1207
12	ARUNACHAL PRADESH	08	East Siang	1208

12	ARUNACHAL PRADESH	09	Upper Siang *	1209
12	ARUNACHAL PRADESH	10	Dibang Valley	1210
12	ARUNACHAL PRADESH	11	Lohit	1211
12	ARUNACHAL PRADESH	12	Changlang	1212
12	ARUNACHAL PRADESH	13	Tirap	1213
13	NAGALAND	01	Mon	1301
13	NAGALAND	02	Tuensang	1302
13	NAGALAND	03	Mokokchung	1303
13	NAGALAND	04	Zunheboto	1304
13	NAGALAND	05	Wokha	1305
13	NAGALAND	06	Dimapur *	1306
13	NAGALAND	07	Kohima	1307
13	NAGALAND	08	Phek	1308
14	MANIPUR	01	Senapati (Excl. 3 sub-divisions)	1401
14	MANIPUR	02	Tamenglong	1402
14	MANIPUR	03	Churachandpur	1403
14	MANIPUR	04	Bishnupur	1404
14	MANIPUR	05	Thoubal	1405
14	MANIPUR	06	Imphal West	1406
14	MANIPUR	07	Imphal East *	1407
14	MANIPUR	08	Ukhrul	1408
14	MANIPUR	09	Chandel	1409
15	MIZORAM	01	Mamit *	1501
15	MIZORAM	02	Kolasib *	1502
15	MIZORAM	03	Aizawl	1503
15	MIZORAM	04	Champhai *	1504
15	MIZORAM	05	Serchhip *	1505
15	MIZORAM	06	Lunglei	1506
15	MIZORAM	07	Lawngtlai	1507
15	MIZORAM	08	Saiha *	1508
16	TRIPURA	01	West Tripura	1601
16	TRIPURA	02	South Tripura	1602
16	TRIPURA	03	Dhalai *	1603
16	TRIPURA	04	North Tripura	1604
17	MEGHALAYA	01	West Garo Hills	1701
17	MEGHALAYA	02	East Garo Hills	1702
17	MEGHALAYA	03	South Garo Hills *	1703
17	MEGHALAYA	04	West Khasi Hills	1704
17	MEGHALAYA	05	Ri Bhoi *	1705
17	MEGHALAYA	06	East Khasi Hills	1706
17	MEGHALAYA	07	Jaintia Hills	1707
18	ASSAM	01	Kokrajhar	1801
18	ASSAM	02	Dhubri	1802
18	ASSAM	03	Goalpara	1803
18	ASSAM	04	Bongaigaon	1804
18	ASSAM	05	Barpeta	1805
18	ASSAM	06	Kamrup	1806
18	ASSAM	07	Nalbari	1807

18	ASSAM	08	Darrang	1808
18	ASSAM	09	Marigaon	1809
18	ASSAM	10	Nagaon	1810
18	ASSAM	11	Sonitpur	1811
18	ASSAM	12	Lakhimpur	1812
18	ASSAM	13	Dhemaji	1813
18	ASSAM	14	Tinsukia	1814
18	ASSAM	15	Dibrugarh	1815
18	ASSAM	16	Sibsagar	1816
18	ASSAM	17	Jorhat	1817
18	ASSAM	18	Golaghat	1818
18	ASSAM	19	Karbi Anglong	1819
18	ASSAM	20	North Cachar Hills	1820
18	ASSAM	21	Cachar	1821
18	ASSAM	22	Karimganj	1822
18	ASSAM	23	Hailakandi	1823
19	WEST BENGAL	01	Darjiling	1901
19	WEST BENGAL	02	Jalpaiguri	1902
19	WEST BENGAL	03	Koch Bihar	1903
19	WEST BENGAL	04	Uttar Dinajpur	1904
19	WEST BENGAL	05	Dakshin Dinajpur *	1905
19	WEST BENGAL	06	Maldah	1906
19	WEST BENGAL	07	Murshidabad	1907
19	WEST BENGAL	08	Birbhum	1908
19	WEST BENGAL	09	Barddhaman	1909
19	WEST BENGAL	10	Nadia	1910
19	WEST BENGAL	11	North Twenty Four Parganas	1911
19	WEST BENGAL	12	Hugli	1912
19	WEST BENGAL	13	Bankura	1913
19	WEST BENGAL	14	Puruliya	1914
19	WEST BENGAL	15	Medinipur	1915
19	WEST BENGAL	16	Haora	1916
19	WEST BENGAL	17	Kolkata	1917
19	WEST BENGAL	18	South Twenty Four Parganas	1918
20	JHARKHAND	01	Garhwa *	2001
20	JHARKHAND	02	Palamu	2002
20	JHARKHAND	03	Chatra *	2003
20	JHARKHAND	04	Hazaribagh	2004
20	JHARKHAND	05	Kodarma *	2005
20	JHARKHAND	06	Giridih	2006
20	JHARKHAND	07	Deoghar	2007
20	JHARKHAND	08	Godda	2008
20	JHARKHAND	09	Sahibganj	2009
20	JHARKHAND	10	Pakaur *	2010
20	JHARKHAND	11	Dumka	2011
20	JHARKHAND	12	Dhanbad	2012
20	JHARKHAND	13	Bokaro *	2013
20	JHARKHAND	14	Ranchi	2014

20	JHARKHAND	15	Lohardaga	2015
20	JHARKHAND	16	Gumla	2016
20	JHARKHAND	17	Pashchimi Singhbhum	2017
20	JHARKHAND	18	Purbi Singhbhum	2018
21	ORISSA	01	Bargarh *	2101
21	ORISSA	02	Jharsuguda *	2102
21	ORISSA	03	Sambalpur	2103
21	ORISSA	04	Debagarh *	2104
21	ORISSA	05	Sundargarh	2105
21	ORISSA	06	Kendujhar	2106
21	ORISSA	07	Mayurbhanj	2107
21	ORISSA	08	Baleshwar	2108
21	ORISSA	09	Bhadrak *	2109
21	ORISSA	11	Jagatsinghapur *	2111
21	ORISSA	12	Cuttack	2112
21	ORISSA	13	Jajapur *	2113
21	ORISSA	14	Dhenkanal	2114
21	ORISSA	15	Anugul *	2115
21	ORISSA	16	Nayagarh *	2116
21	ORISSA	17	Khordha *	2117
21	ORISSA	18	Puri	2118
21	ORISSA	19	Ganjam	2119
21	ORISSA	20	Gajapati *	2120
21	ORISSA	21	Kandhamal	2121
21	ORISSA	22	Baudh *	2122
21	ORISSA	23	Sonapur *	2123
21	ORISSA	24	Balangir	2124
21	ORISSA	25	Nuapada *	2125
21	ORISSA	26	Kalahandi	2126
21	ORISSA	27	Rayagada *	2127
21	ORISSA	28	Nabarangapur *	2128
21	ORISSA	29	Koraput	2129
21	ORISSA	30	Malkangiri *	2130
22	CHHATISGARH	01	Koriya *	2201
22	CHHATISGARH	02	Surguja	2202
22	CHHATISGARH	03	Jashpur *	2203
22	CHHATISGARH	04	Raigarh	2204
22	CHHATISGARH	05	Korba *	2205
22	CHHATISGARH	06	Janjgir - Champa*	2206
22	CHHATISGARH	07	Bilaspur	2207
22	CHHATISGARH	08	Kawardha *	2208
22	CHHATISGARH	09	Rajnandgaon	2209
22	CHHATISGARH	10	Durg	2210
22	CHHATISGARH	11	Raipur	2211
22	CHHATISGARH	12	Mahasamund *	2212
22	CHHATISGARH	13	Dhamtari *	2213
22	CHHATISGARH	14	Kanker *	2214
22	CHHATISGARH	15	Bastar	2215

22	CHHATISGARH	16	Dantewada*	2216
23	MADHYA PRADESH	01	Sheopur *	2301
23	MADHYA PRADESH	02	Morena	2302
23	MADHYA PRADESH	03	Bhind	2303
23	MADHYA PRADESH	04	Gwalior	2304
23	MADHYA PRADESH	05	Datia	2305
23	MADHYA PRADESH	06	Shivpuri	2306
23	MADHYA PRADESH	07	Guna	2307
23	MADHYA PRADESH	08	Tikamgarh	2308
23	MADHYA PRADESH	09	Chhatarpur	2309
23	MADHYA PRADESH	10	Panna	2310
23	MADHYA PRADESH	11	Sagar	2311
23	MADHYA PRADESH	12	Damoh	2312
23	MADHYA PRADESH	13	Satna	2313
23	MADHYA PRADESH	14	Rewa	2314
23	MADHYA PRADESH	15	Umaria *	2315
23	MADHYA PRADESH	16	Shahdol	2316
23	MADHYA PRADESH	17	Sidhi	2317
23	MADHYA PRADESH	18	Neemuch *	2318
23	MADHYA PRADESH	19	Mandsaur	2319
23	MADHYA PRADESH	20	Ratlam	2320
23	MADHYA PRADESH	21	Ujjain	2321
23	MADHYA PRADESH	22	Shajapur	2322
23	MADHYA PRADESH	23	Dewas	2323
23	MADHYA PRADESH	24	Jhabua	2324
23	MADHYA PRADESH	25	Dhar	2325
23	MADHYA PRADESH	26	Indore	2326
23	MADHYA PRADESH	27	West Nimar	2327
23	MADHYA PRADESH	28	Barwani *	2328
23	MADHYA PRADESH	29	East Nimar	2329
23	MADHYA PRADESH	30	Rajgarh	2330
23	MADHYA PRADESH	31	Vidisha	2331
23	MADHYA PRADESH	32	Bhopal	2332
23	MADHYA PRADESH	33	Sehore	2333
23	MADHYA PRADESH	34	Raisen	2334
23	MADHYA PRADESH	35	Betul	2335
23	MADHYA PRADESH	36	Harda *	2336
23	MADHYA PRADESH	37	Hoshangabad	2337
23	MADHYA PRADESH	38	Katni *	2338
23	MADHYA PRADESH	39	Jabalpur	2339
23	MADHYA PRADESH	40	Narsimhapur	2340
23	MADHYA PRADESH	41	Dindori *	2341
23	MADHYA PRADESH	42	Mandla	2342
23	MADHYA PRADESH	43	Chhindwara	2343
23	MADHYA PRADESH	44	Seoni	2344
23	MADHYA PRADESH	45	Balaghat	2345
24	GUJARAT	01	Kachchh	2401
24	GUJARAT	02	Banas Kantha	2402

24	GUJARAT	03	Patan *	2403
24	GUJARAT	04	Mahesana	2404
24	GUJARAT	05	Sabar Kantha	2405
24	GUJARAT	06	Gandhinagar	2406
24	GUJARAT	07	Ahmadabad	2407
24	GUJARAT	08	Surendranagar	2408
24	GUJARAT	09	Rajkot	2409
24	GUJARAT	10	Jamnagar	2410
24	GUJARAT	11	Porbandar *	2411
24	GUJARAT	12	Junagadh	2412
24	GUJARAT	13	Amreli	2413
24	GUJARAT	14	Bhavnagar	2414
24	GUJARAT	15	Anand *	2415
24	GUJARAT	16	Kheda	2416
24	GUJARAT	17	Panch Mahals	2417
24	GUJARAT	18	Dohad *	2418
24	GUJARAT	19	Vadodara	2419
24	GUJARAT	20	Narmada *	2420
24	GUJARAT	21	Bharuch	2421
24	GUJARAT	22	Surat	2422
24	GUJARAT	23	The Dangs	2423
24	GUJARAT	24	Navsari *	2424
24	GUJARAT	25	Valsad	2425
25	DAMAN & DIU	01	Diu	2501
25	DAMAN & DIU	02	Daman	2502
26	DARDA & NAGAR HAVELI	01	Dadra & Nagar Haveli	2601
27	MAHARASHTRA	01	Nandurbar *	2701
27	MAHARASHTRA	02	Dhule	2702
27	MAHARASHTRA	03	Jalgaon	2703
27	MAHARASHTRA	04	Buldana	2704
27	MAHARASHTRA	05	Akola	2705
27	MAHARASHTRA	06	Washim *	2706
27	MAHARASHTRA	07	Amravati	2707
27	MAHARASHTRA	08	Wardha	2708
27	MAHARASHTRA	09	Nagpur	2709
27	MAHARASHTRA	10	Bhandara	2710
27	MAHARASHTRA	11	Gondiya *	2711
27	MAHARASHTRA	12	Gadchiroli	2712
27	MAHARASHTRA	13	Chandrapur	2713
27	MAHARASHTRA	14	Yavatmal	2714
27	MAHARASHTRA	15	Nanded	2715
27	MAHARASHTRA	16	Hingoli *	2716
27	MAHARASHTRA	17	Parbhani	2717
27	MAHARASHTRA	18	Jalna	2718
27	MAHARASHTRA	19	Aurangabad	2719
27	MAHARASHTRA	20	Nashik	2720
27	MAHARASHTRA	21	Thane	2721
27	MAHARASHTRA	22	Mumbai (Suburban) *	2722

27	MAHARASHTRA	23	Mumbai	2723
27	MAHARASHTRA	24	Raigarh	2724
27	MAHARASHTRA	25	Pune	2725
27	MAHARASHTRA	26	Ahmadnagar	2726
27	MAHARASHTRA	27	Bid	2727
27	MAHARASHTRA	28	Latur	2728
27	MAHARASHTRA	29	Osmanabad	2729
27	MAHARASHTRA	30	Solapur	2730
27	MAHARASHTRA	31	Satara	2731
27	MAHARASHTRA	32	Ratnagiri	2732
27	MAHARASHTRA	33	Sindhudurg	2733
27	MAHARASHTRA	34	Kolhapur	2734
27	MAHARASHTRA	35	Sangli	2735
28	ANDHRA PRADESH	01	Adilabad	2801
28	ANDHRA PRADESH	02	Nizamabad	2802
28	ANDHRA PRADESH	03	Karimnagar	2803
28	ANDHRA PRADESH	04	Medak	2804
28	ANDHRA PRADESH	05	Hyderabad	2805
28	ANDHRA PRADESH	06	Rangareddi	2806
28	ANDHRA PRADESH	07	Mahbubnagar	2807
28	ANDHRA PRADESH	08	Nalgonda	2808
28	ANDHRA PRADESH	09	Warangal	2809
28	ANDHRA PRADESH	10	Khammam	2810
28	ANDHRA PRADESH	11	Srikakulam	2811
28	ANDHRA PRADESH	12	Vizianagaram	2812
28	ANDHRA PRADESH	13	Visakhapatnam	2813
28	ANDHRA PRADESH	14	East Godavari	2814
28	ANDHRA PRADESH	15	West Godavari	2815
28	ANDHRA PRADESH	16	Krishna	2816
28	ANDHRA PRADESH	17	Guntur	2817
28	ANDHRA PRADESH	18	Prakasam	2818
28	ANDHRA PRADESH	19	Nellore	2819
28	ANDHRA PRADESH	20	Cuddapah	2820
28	ANDHRA PRADESH	21	Kurnool	2821
28	ANDHRA PRADESH	22	Anantapur	2822
28	ANDHRA PRADESH	23	Chittoor	2823
29	KARNATAKA	01	Belgaum	2901
29	KARNATAKA	02	Bagalkot *	2902
29	KARNATAKA	03	Bijapur	2903
29	KARNATAKA	04	Gulbarga	2904
29	KARNATAKA	05	Bidar	2905
29	KARNATAKA	06	Raichur	2906
29	KARNATAKA	07	Koppal	2907
29	KARNATAKA	08	Gadag *	2908
29	KARNATAKA	09	Dharwad	2909
29	KARNATAKA	10	Uttara Kannada	2910
29	KARNATAKA	11	Haveri *	2911
29	KARNATAKA	12	Bellary	2912

29	KARNATAKA	13	Chitradurga	2913
29	KARNATAKA	14	Davanagere	2914
29	KARNATAKA	15	Shimoga	2915
29	KARNATAKA	16	Udupi *	2916
29	KARNATAKA	17	Chikmagalur	2917
29	KARNATAKA	18	Tumkur	2918
29	KARNATAKA	19	Kolar	2919
29	KARNATAKA	20	Bangalore	2920
29	KARNATAKA	21	Bangalore Rural	2921
29	KARNATAKA	22	Mandya	2922
29	KARNATAKA	23	Hassan	2923
29	KARNATAKA	24	Dakshina Kannada	2924
29	KARNATAKA	25	Kodagu	2925
29	KARNATAKA	26	Mysore	2926
29	KARNATAKA	27	Chamarajanagar *	2927
30	GOA	01	North Goa	3001
30	GOA	02	South Goa	3002
31	LAKSHADWEEP	01	Lakshadweep	3101
32	KERALA	01	Kasaragod	3201
32	KERALA	02	Kannur	3202
32	KERALA	03	Wayanad	3203
32	KERALA	04	Kozhikode	3204
32	KERALA	05	Malappuram	3205
32	KERALA	06	Palakkad	3206
32	KERALA	07	Thrissur	3207
32	KERALA	08	Ernakulam	3208
32	KERALA	09	Idukki	3209
32	KERALA	10	Kottayam	3210
32	KERALA	11	Alappuzha	3211
32	KERALA	12	Pathanamthitta	3212
32	KERALA	13	Kollam	3213
32	KERALA	14	Thiruvananthapuram	3214
33	TAMIL NADU	01	Thiruvallur	3301
33	TAMIL NADU	02	Chennai	3302
33	TAMIL NADU	03	Kancheepuram	3303
33	TAMIL NADU	04	Vellore	3304
33	TAMIL NADU	05	Dharmapuri	3305
33	TAMIL NADU	06	Tiruvannamalai	3306
33	TAMIL NADU	07	Viluppuram	3307
33	TAMIL NADU	08	Salem	3308
33	TAMIL NADU	09	Namakkal *	3309
33	TAMIL NADU	10	Erode	3310
33	TAMIL NADU	11	The Nilgiris	3311
33	TAMIL NADU	12	Coimbatore	3312
33	TAMIL NADU	13	Dindigul	3313
33	TAMIL NADU	14	Karur *	3314
33	TAMIL NADU	15	Tiruchirappalli	3315
33	TAMIL NADU	16	Perambalur *	3316

33	TAMIL NADU	17	Ariyalur *	3317
33	TAMIL NADU	18	Cuddalore	3318
33	TAMIL NADU	19	Nagapattinam *	3319
33	TAMIL NADU	20	Thiruvarur	3320
33	TAMIL NADU	21	Thanjavur	3321
33	TAMIL NADU	22	Pudukkottai	3322
33	TAMIL NADU	23	Sivaganga	3323
33	TAMIL NADU	24	Madurai	3324
33	TAMIL NADU	25	Theni *	3325
33	TAMIL NADU	26	Virudhunagar	3326
33	TAMIL NADU	27	Ramanathapuram	3327
33	TAMIL NADU	28	Thoothukkudi	3328
33	TAMIL NADU	29	Tirunelveli	3329
33	TAMIL NADU	30	Kanniyakumari	3330
34	TAMIL NADU	01	Yanam	3401
34	TAMIL NADU	02	Pondicherry	3402
34	TAMIL NADU	03	Mahe	3403
34	TAMIL NADU	04	Karaikal	3404
35	ANDAMAN AND NICOBAR ISLANDS	01	Andamans	3501
35	ANDAMAN AND NICOBAR ISLANDS	02	Nicobars	3502

Data Source : Census 2001

* Districts formed during 2001 census

Annexure – VI : List of Survey of India Topographic Maps (1:50,000 scale)

Sr. No.	Sheet No.
Andhra Pradesh	
1	56E/15
2	56E/16
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Goa	
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Gujarat/Div/ Daman/Dadra NH	
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Jammu & Kashmir	
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47	84G/ 1
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114	78D/ 2
115	78D/ 3
116	78D/ 4
117	78D/ 5
118	78D/ 7
119	78D/ 8
120	78D/11
121	78D/12
122	78D/16
123	78F/ 1
124	78F/ 2
125	78F/ 3
126	78F/ 4

127	78F/ 5
128	78F/ 6
129	78F/ 7
130	78F/ 8
131	78F/ 9
132	78F/10
133	78F/11
134	78F/12
135	78F/14
136	78F/15
137	78G/ 3
138	78G/ 5
139	78G/ 9
140	79A/ 1
141	79A/ 2
142	79A/ 3
143	79A/ 4
144	79A/ 5
145	79A/ 6
146	79A/ 7
147	79A/ 8
148	79A/ 9
149	79A/10
150	79A/11
151	79A/12
152	79A/13
153	79A/14
154	79A/15
155	79A/16
156	79B/ 1
157	79B/ 2
158	79B/ 3
159	79B/ 4
160	79B/ 5
161	79B/ 6
162	79B/ 7
163	79B/ 8
164	79B/ 9
165	79B/10
166	79B/11
167	79B/12
168	79B/13
169	79B/14
170	79B/15
171	79B/16
172	79C/ 1
173	79C/ 2
174	79C/ 3
175	79C/ 5
176	79C/ 6
177	79C/ 7
178	79C/ 9
179	79C/10
180	79C/13
181	79C/14
182	79F/ 3
183	79F/ 4
184	79G/ 1
185	79G/ 2
Lakshadweep	
1	49A/ 2
2	49A/ 3
3	49A/ 4
4	49A/10
5	49A/12
6	49A/14
7	49A/15
8	49A/16
9	49B/ 1
10	49B/ 4
11	49B/ 5
12	49B/ 8
13	49B/ 9
14	49B/10
15	49E/ 2
16	49E/ 3
17	49E/15
18	49F/ 9
19	49F/12
20	49H/ 3
21	49I/ 3
22	49I/ 4
Andaman & Nicobar Islands	
1	86C/12
2	86C/14
3	86C/15
4	86C/16
5	86D/ 9
6	86D/10
7	86D/11
8	86D/12
9	86D/13
10	86D/14
11	86D/15
12	86D/16
13	86G/ 2
14	86G/ 3
15	86G/ 4
16	86H/ 1
17	86H/ 3
18	86H/ 4
19	86H/15
20	86K/ 3
21	86K/ 7
22	87A/ 2
23	87A/ 6
24	87A/ 9
25	87A/10
26	87A/11
27	87A/12
28	87A/13
29	87A/14
30	87B/ 1
31	87B/ 5
32	87B/ 6
33	87B/ 9
34	87B/10
35	87C/12
36	87C/16
37	87D/13
38	87E/ 1
39	87H/ 3
40	87H/ 4
41	87H/ 8
42	87H/10
43	87H/11
44	87H/12
45	88E/ 5
46	88E/ 9
47	88E/10
48	88E/11
49	88E/12
50	88E/15
51	88E/16
52	88F/ 9
53	88F/13