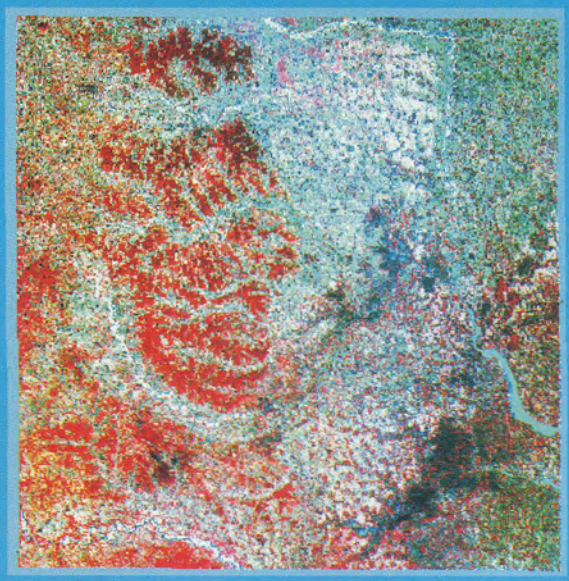
Policy Paper
No - 2

ASSESSING INLAND FISHERIES RESOURCES AND GIS



भाकृअनुप
ICAR

Central Inland Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore, West Bengal - 700 120

Edited by : Dr.K.K.Vass

Citation : Sahu, S. K., Karunakaran, D. and Mandal, S.K. 2007 - Assessing Inland Fisheries Resources and GIS.Policy paper No.-02, Central Inland Fisheries Research Institute.

ISSN. 0970-616X.

Published by : The Director, CIFRI, Barrackpore

Printed at : Florence Offset Process Pvt. Ltd.
6A, S. N. Banerjee Road
Kolkata 700 013

Policy Papar No. 2

Assessing Inland Fisheries Resources and GIS

By

Mr. S. K. Sahu

Mr. D. Karunakaran

and

Mr. S. K. Mandal

Central Inland Fisheries Research Institute
Barrackpore. Kolkata-120

CONTENTS

Importance of Resource Assessment and Mapping

Water is a basic human need. Having access to safe and sufficient water and sanitation are now recognized as basic human rights. In coming years the population in urban areas will increase tremendously and there will be competing demands for domestic, commercial, industrial and peri-urban agriculture on fresh water. In order to meet the soaring demand there will be enormous pressure on freshwater resources. The management of water resources is very important for the development of human society. For effective management of water resources there is need to understand how much water is available and where it is available. This is achieved by undertaking a resource assessment of water bodies. National authorities and resource managers need complete information on which to base their projections and decision-making. To meet the demand from various sectors like fisheries, agriculture, industry and domestic use an integrated approach may be devised including all the stakeholders for economic and social development.

The mapping of water bodies and a well designed information system such as Geographical Information System (GIS) may play an important role in building a sustainable future for mankind. The information system will immensely help the fisheries sector for comprehensive planning on regional basis. The resource availability status in an area with information on potentiality will definitely provide a basis for development planning for the fisheries sector.

Though there is a growing need of assessment of total resources under inland water bodies in India, the statistics available on the resource are based on old records. No effort has been taken to update them considering the cost and manpower involved.

River Basins in India

All ancient human civilizations dawned and flourished in river basins only. The man inhabited near the river to have water for drinking, domestic use, navigation and agriculture purposes. In India the major river basins supported the mankind for their prosperity and the people were intricately tied to the environment. Though there has been a decline in the availability of water in various rivers due to silting, water abstraction for irrigation and other purposes, damming for power generation, still these basins provide support for the livelihood of people. The major river basins in India are detailed below.

MAJOR RIVER BASINS OF THE COUNTRY

Sl. No.	Name of the River	Origin	Length (Km.)	Catchment Area (Sq. Km.)
1.	Indus	Mansarovar (Tibet)	1114 +	321289 +
2.	a) Ganga	Gangotri (Uttar Kashi)	2525 +	861452 +
	b) Brahmaputra	Kailash Range (Tibet)	916 +	194413 +
	c) Barak & other rivers flowing into Meghna, like Gomti, Muhari, Fenny etc.			41723 +
3.	Sabarmati	Aravalli Hills (Rajasthan)	371	21674
4.	Mahi	Dhar (Madhya Pradesh)	583	34842
5.	Narmada	Amarkantak (Madhya Pradesh)	1312	98796
6.	Tapi	Betul (Madhya Pradesh)	724	65145
7.	Brahmani	Ranchi (Bihar)	799	39033
8.	Mahanadi	Nazri Town (Madhya Pradesh)	851	141589
9.	Godavari	Nasik (Maharashtra)	1465	312812
10.	Krishna	Mahabaleshwar (Maharashtra)	1401	258948
11.	Pennar	Kolar (Karnataka)	597	55213
12.	Cauvery	Coorg (Karnataka)	800	81155
			Total	2528084

MEDIUM RIVER BASINS

S. No.	Name of the River	Village/Distt. (Origin)	State	Length (Km.)	Catchment Area (Sq. Km)
West Flowing Rivers					
1.	Ozat	Kathiawar	Gujarat	128	3189
2.	Shetrunji	Dalkania	Gujarat	182	5514
3.	Bhadar	Rajkot	Gujarat	198	7094
4.	Aji	Rajkot	Gujarat	106	2139

5.	Dhadhar	Panchmahal	Gujarat	135	2770
6.	Purna	Dhosa	Maharashtra	142	2431
7.	Ambika	Dangs	Maharashtra	142	2715
8.	Vaitarna	Nasik	Maharashtra	171	3637
9.	Dammanganga	Nasik	Maharashtra	143	2357
10.	Ulhas	Raigarh	Maharashtra	145	3864
11.	Savitri	Pune	Maharashtra	99	2899
12.	Sastri	Ratnagiri	Maharashtra	64	2174
13.	Washishthi	Ratnagiri	Maharashtra	48	2239
14.	Mandvi	Belgaum	Karnataka	87	2032
15.	Kalinadi	Belgaum	Karnataka	153	5179
16.	Gangavati or Bedti (in upper reaches)	Dharwar	Karnataka	152	3902
17.	Sharavati	Shimoga	Karnataka	122	2209
18.	Netravati	Dakshina Kannada	Karnataka	103	3657
19.	Chaliar or Baypore	Elamtalvi Hills	Kerala	169	2788
20.	Bharathapuzha (known as Ponnani)	Annamalai Hills	Tamil Nadu	209	6186
21.	Periyar	Sivajini Hills	Kerala	244	5398
22.	Pamba	Devarmalai	Kerala	176	2235
		East Flowing Rivers			
23.	Burhabalang	Mayurbahanj	Orissa	164	4837
24.	Baitarni	Keonjhar	Orissa	365	12789
25.	Rushikulya	Phulbani	Orissa	146	7753
26.	Bahuda	Ramgirivillage	Orissa	73	1248
27.	Vamsadhara	Kalahandi	Orissa	221	10830

28.	Nagavali	Kalahandi	Orissa	217	9410
29.	Sarda	Vishakhapatnam	Andhra Pradesh	104	2725
30.	Eleru	Vishakhapatnam	Andhra Pradesh	125	3809
31.	Vogarivagu	Guntur	Andhra Pradesh	102	1348
32.	Gundlakamma	Kurnool	Andhra Pradesh	220	8494
33.	Musi	Nellore	Andhra Pradesh	112	2219
34.	Paleru	Nellore	Andhra Pradesh	104	2483
35.	Muneru	Nellore	Andhra Pradesh	122	3734
36.	Swarnamukhi	Koraput	Orissa	130	3225
37.	Kandleru	Vinukonda	Andhra Pradesh	73	3534
38.	Kortalaiyar	Chinglepet	Tamil Nadu	131	3521
39.	Palar (including tributary Cheyyar)	Kolar	Karnataka	348	17871
40.	Varahandi	North Arcot	Tamil Nadu	94	3044
41.	Ponnaiyar	Kolar	Karnataka	396	14130
42.	Vellar	Chithri Hills	Tamil Nadu	193	8558
43.	Vaigai	Madurai	Tamil Nadu	258	7031
44.	Pambar	Madurai	Tamil Nadu	125	3104
45.	Gundar	Madurai	Tamil Nadu	146	5647
46.	Vaippar	Tirunolvolli	Tamil Nadu	130	5288
47.	Tambraparni	Tirunolvolli	Tamil Nadu	130	5969
48.	Subarnarekha	Nagri/Ranchi	Bihar	395	19296
				Total	248505

India is blessed with many rivers. As many as 12 of them are classifled as major rivers whose total catchment area is 252.8 million heactare (m.ha). Of the major rivers, the Ganga - Brahmaputra Meghana system is the biggest with catchment area of about 110 m.ha which is more than 43 percent of the catchment area of all the major rivers in the country. The other major rivers with catchment area more than 10 m.ha are Indus (32.1 m.ha.), Godavari (31.3 m.ha.), Krishna, (25.9 m.ha.) and Mahanadi (14.2 m.ha). The catchment area of medium rivers is about 25 m.ha and Subernarekha with 1.9 m.ha. catchment area is the largest river among the medium rivers in the country. Of the rivers and canals, Uttar Pradesh occupies the first place with the total length of rivers and canals as 31.2 thousand km, which is about 17 percent of the total length of rivers and canals in the country. Other states following Uttar Pradesh are Jammu & Kashmir and Madhya Pradesh.

Other than rivers and canals, total water bodies cover all area of about 7 m.ha. Among the various forms of the inland water resources, tanks and ponds have maximum area (2.4 m.ha.) followed by reservoirs (2.0 m.ha.).

Classification of Inland Fisheries Resources

Inland water resources of the country are classified as rivers and canals; reservoirs; tanks & ponds; beels, oxbow lakes, derelict water; and brackish water. The State-wise distribution of water resources is shown below in the table

State/Union Territory	Length of Rivers and Canals (Kms.)	Reservoirs (lakh ha)	Ponds and Tanks (Iakh ha)	Beels, Oxbow lakes & Derelict waterbodies (lakh ha)	Brackish water (lakh ha)
1. AndhraPradesh	11,514	2.24	5.17	--	0.79
2. Arunachal Pradesh	2,000	--	2.76	0.42	--

3. Assam	4,820	0.02	0.23	1.10	--
4. Bihar	3,200	0.60	0.95	0.05	--
5. Goa	250	0.03	0.03	--	--
6. Gujarat	3,865	2.43	0.71	0.12	3.76
7. Haryana	5,000	Neg.	0.10	0.10	--
8. Himachal Pradesh	3,000	0.42	0.01	--	--
9. Jammu & Kashmir	27,781	0.07	0.17	0.06	--
10. Karnataka	9,000	2.11	2.90	--	0.08
11. Kerala	3,092	0.30	0.30	2.43	2.43
12. Madhya Pradesh	20,661	2.94	1.19	--	--
13. Maharashtra	16,000	2.79	0.59	--	0.10
14. Manipur	3,360	0.01	0.05	0.04	--
15. Meghalaya	5,600	0.08	0.02	Neg.	--
16. Mizoram	1,395	--	0.02	--	--
17. Nagaland	1,600	0.17	0.50	Neg.	--
18. Orissa	4,500	2.56	1.14	1.80	4.17
19. Punjab	15,270	Neg.	0.07	--	--
20. Rajasthan	5,290	--	1 .80	--	--
21. Sikkim	900	1.20	--	0.03	--
22. Tamil Nadu	7,420	0.52	0.56	0.07	0.56
23. Tripura	1,200	0.05	0.13	--	--
24. Uttar Pradesh	31,200	1.50	1.62	1.33	--
25. West Bengal	2,526	0.17	2.76	0.42	2.10
26. Andaman & Nicobar Islands	115	0.01	0.03	--	0.37

27. Chandigarh	2	--	Neg.	Neg.	--
28. Dadra & Nagar Haveli	54	0.05	--	--	--
29. Daman & Diu	12	--	Neg.	--	Neg.
30. Delhi	150	0.04	--	--	--
31. Lakshadweep	--	--	--	--	--
32. Pondicherry	247	--	Neg.	0.01	0.01
INDIA	**191,024**	**20.31**	**23.81**	**7.98**	**14.37**

Source:- Handbook of Fisheries Statistics, Govt. of India.

Most of the area under tanks and ponds lies in Southern States of Andhra Pradesh, Karnataka and Tamil Nadu. These states along with West Bengal, Rajasthan and Uttar Pradesh, account for 62 percent of total area under tanks and ponds in the country. As far as reservoirs are concerned, major states like Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh account for larger portion of area under reservoirs. More than 77 percent of area under beels, oxbow, lakes and derelict water lies in the states of Orissa, Uttar Pradesh and Assam. Orissa ranks first as regards the total area of brackish water and is followed by Gujarat, Kerala and West Bengal. The total area of inland water resources is, thus, unevenly distributed over the country with five states namely Orissa, Andhra Pradesh, Gujarat, Karnataka and West Bengal accounting for more than half of the country's inland water bodies.

Resource Assessment Tools

The assessment of resource may be ground or remote sensing based. The ground based assessment needs actual surveying, which is elaborate, time consuming, expensive and involves huge manpower. The remote sensing based assessment is speedy and cost effective. The aerial photography or satellite data have nowadays offered new possibilities of assessment. The satellite data may be used for qualitative as well as quantitative assessment.

Indian Scenario in Remote Sensing

Over the past three and a half decades, India has achieved significant progress in space technology and applications for monitoring and management of natural resources. India has already launched twelve remote sensing satellites from IRS 1 A to CARTOSAT 2, of various spatial resolution, repetivity and spectral resolution. The IRS 1A, the first of the operational Indian Remote Sensing Satellites, was launched in March 17, 1988 and the CARTOSAT 2, latest remote sensing satellite, was launched recently on January 10, 2007. These satellites are capable to provide remote sensing imageries for application on natural resource management, disaster management, sustainable development of natural resources and cartographic application at cadastral level.

Space remote sensing in India has established its potential and important role in providing vital inputs towards monitoring agriculture crops, forests, water resource , minerals, wastelands, ocean and marine resources and drought and flood management. Remote sensing applications in the country under the umbrella of the National Natural Resources Management System (NNRMS) has worked in diverse themes, such as crop acreage/yield estimation, drought assessment, flood management, current agricultural landuse/landcover for agroclimatic zonal planning, wasteland development, water resources management, snow-melt-run-off prediction, fisheries potential, forecasting, coastal zone management, urban development, mineral prospecting and forest resources surveys. Several major projects have been completed with active involvement of the users at central, state and district level so as to ensure effective harnessing of this technology at grass root level. Mapping of ground water potential zones, land use / cover, wastelands, forests and coastal zones have been completed for the entire country. These concreted efforts have led to the development of a National (Natural) Resources Information System (NRIS) encompassing multidisciplinary themes. As part of the associated modeling efforts, several resource management models have been developed especially in the areas of urban development, wasteland management, mineral targeting and district level planning. Indigenous development of Geographic Information System (GIS) packages has been accomplished to support the NRIS efforts.

Several areas of application have been completed and under operation in different user departments of central and as well as state. Few of them are as following

- Landuse/land cover/wetlands mapping on 1:250,000 scale have been prepared for the whole country using IRS-1 multi data to help in the preparation of operational plans for 15 agroclimatic zones of India.
- Low resolution satellite data is providing advance information, at tehsil/ district level, on the extent and severity of agricultural drought conditions and fortnightly drought assessment
- Identification of crops, acreage estimation and forecasting their yield have been operationalized for all major corps such as wheat, rive, sorghum, cotton, groundnut, tobacco, tea etc
- Wasteland maps giving information on type and extend of wastelands at village level are being used in conjunction with geographical information system to generate comprehensive plans for reclamation of wastelands.
- Space Remote Sensing has been very effectively used in India for identifying prospective ground water potential zones for suitable exploitation with reduced time and efforts.
- Satellite data are contributing significantly for the forest management through biennial forest cover mapping and use of these maps for maintaining of ecological balance in critical areas.
- In the area of water resources management, remote sensing data are being used for prioritization of watersheds, surface water monitoring, rainfall run-off studies, snowmelt runoff forecasting and irrigation scheduling.
- Digital analysis of multi-date data has been used to prepare urban sprawl maps of major cities in the country with over 1 million population, as a baseline information for perspective planning of their growth. Geographical information system is being utilized for analyzing the multi-parameter data for providing guidelines to city planners to solve urban related problems.
- Study of the entire coastal line of the country for tidal wetlands, coastal landforms, potential aquacultures sites, mangroves, estuarine dynamics/ shoreline changes, and off-shore aspects like suspended sediment dynamics and coastal currents, near shore bathymetry, internal waves have been made.
- A preliminary map on coral reefs has been completed details of coral reef extent and related environmental aspects.

- A national programme on ocean remote sensing programme is in progress focusing (i) Sea Surface Temperature (SST) retrieval and applications, (ii) microwave applications, (iii) setting up of a national ocean information system and (iv) ocean modeling.
- Fisheries prospects charts based on location of thermal fronts derived from sea surface temperature charts are being generated from all Maritime States.

National Remote Sensing Agency (NRSA), an autonomous organization under the Department of Space (DOS), is responsible for acquisition, processing, supply of aerial and satellite remote sensing data and continuously exploring the practical uses of remote sensing technology for multilevel applications. It also involved various program based remote sensing application related to land use land cover, agriculture, soil, forest, geosciences, water, ocean environment management and disaster management.

National Natural Resources Management System (NNRMS) is a national level inter-agency system for integrated natural resources management in the country. NNRMS supports the optimal utilization of country's natural resources by providing for a proper and systematic inventory of natural resources available using remote sensing data in conjunction with conventional data/ techniques. The NNRMS activities are steered through nine NNRMS Standing Committees viz. (i) Agriculture & Soils, (ii) Bio-Resources, (iii) Geology and Mineral resources, (iv) Water Resources (v) Ocean Resources and Meteorology (vi) Cartography & Mapping, (vii) Urban Management (viii) Rural Development and (ix) Training & Technology. Each Standing Committee is chaired by Secretaries of the respective departments of the Government of India and consisting of experts from major user departments.

CIFRI's work in Remote Sensing.

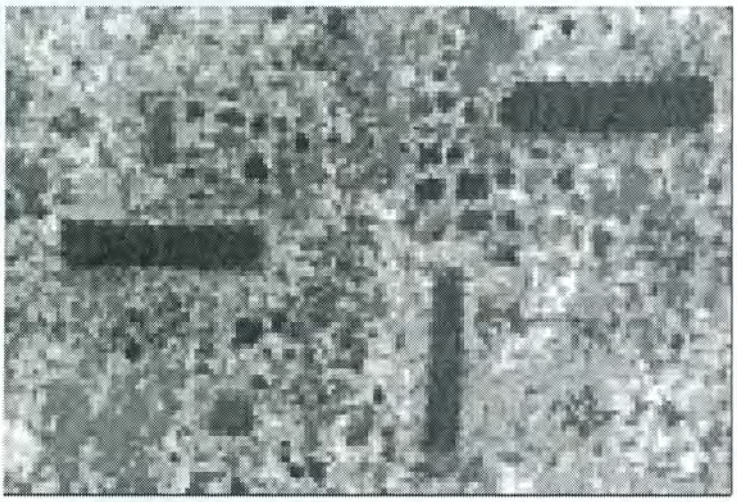
The estimates of resources under different categories of water bodies were worked out long back. Lot of changes has occurred in size, location and flow path of water bodies. There is an immediate need for assessment of such changes.

Natural resource management requires rapid and accurate methods for interpreting data for development and management. For the management of any natural resource, information on resource and their monitoring are two main factors. The production in inland water bodies are affected by many

biological and non-biological factors. The factors like location, soil, aquatic environment, socio-economic condition, crafts and gears, species composition, fishing practices are influencing the production. Modern techniques of remote sensing and Geographical Information System (GIS) may help in handling such data for improving management of resources.

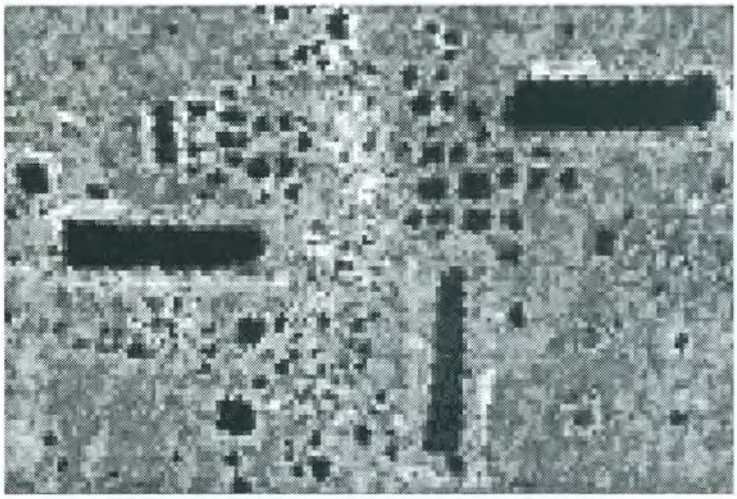
During recent years CIFRI is involved in using Remote Sensing and GIS techniques for the development fish and fisheries. The institute has already developed infrastructure and manpower for utilizing these modern tool for assessment water spread area and water quality. Presently CIFRI has been engaged in analysis of remote sensing imageries of different sensors for water coverage, land use and land coverage estimation.

Inland water bodies in India are distributed in various ecological regions. They are very scattered in nature and some of them are in inaccessible areas. The Institute is using satellite data for mapping of such water bodies. Post-monsoon and pre-monsoon cloud free LISS-III imageries have been procured for the purpose from National Remote Sensing Agency (NRSA), Hyderabad.. These imageries are being acquired by Indian Remote Sensing (IRS) satellite 1C and 1D using Linear Image Self Scanning (LISS)- III sensor.



FCC imageries of LISS III (Spatial resolution)

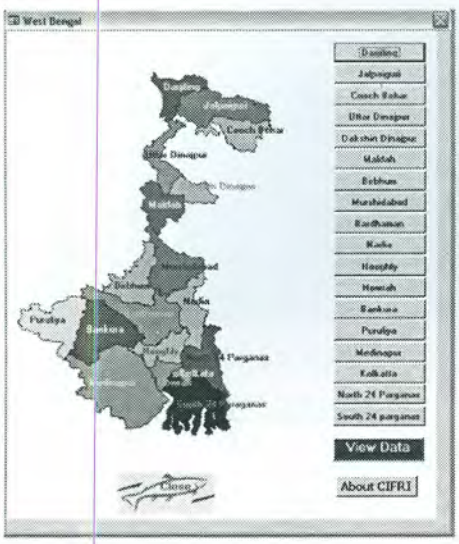
These satellites have revisit interval of 24 days and LISS III sensor has spatial resolution of 23.5 meters at Nadir. RS Imageries have been geo-referenced with Survey of India (SOI) topographical sheets of 1:50,000 scale with the help of digitizer. All the imageries have been geo-referenced and made mosaic for individual state. District images have been extracted from mosaic images of the state using district boundaries. Water area is being delineated using NDVI (Normalized Difference Vegetation Index) and near infrared band and feature mapping of three bands.



Normalized difference vegetation index of LISS III

Similarly, rivers and stream have also been delineated manually. Administrative boundaries have been created from District Planning Maps.

The Institute has delineated water bodies above 10 ha from LIS-III imageries for the state of West Bengal, Bihar, Orissa and Rajasthan. For viewing and retrieving the delineated information Institute has developed water body information system for West Bengal and electronic Atlas for Bihar, West Bengal and Rajasthan. The Electronic ATLAS is user friendly and can be handled easily even by a novice.

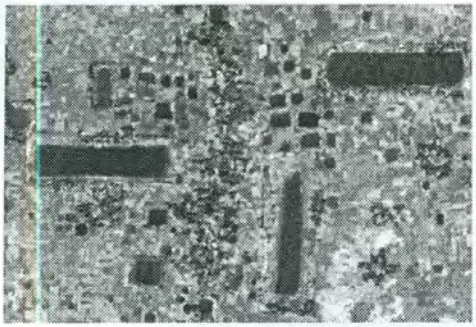


West Bengal

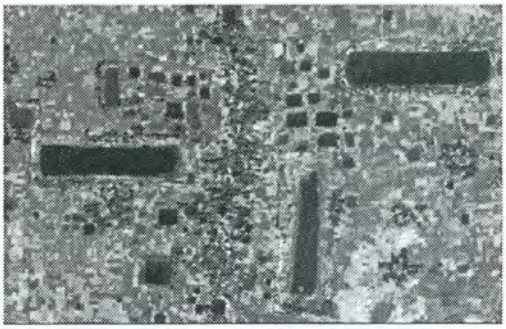
Bihar

Rajasthan

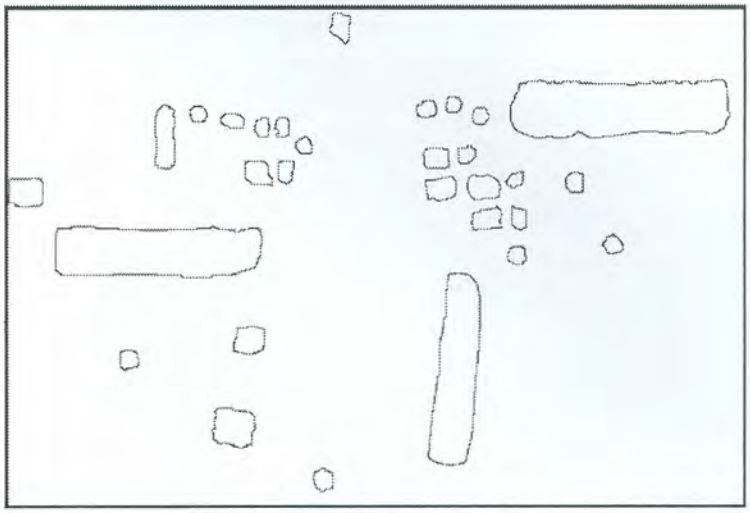
Considering the importance of small water bodies and their production potentiality, Institute had taken up externally funded project, for delineation of water bodies with area more than 0.5 ha water bodies. The edges of smaller water bodies are covered by plants or other vegetation. It may not be possible to go down below 0.5 ha for identification and mapping. False Colour Composite (FCC) of LISS-III with 23.5 m resolution fused with monochrome 5.8 m resolution satellite data is used for mapping purposes and subsequent development of GIS.



Panchromatic imageries
(Spatial resolution 5.8 m)



Fused FCC of LISS III+ PAN



Delineated water bodies

There is a growing pressure on water resources especially small tanks, ponds, wetland due to increasing human intervention in nature, need for human habitation, horizontal expansion of agricultural field etc. Keeping in view the rapid change in land use, mapping of water bodies may be repeated at an interval of ten years for detecting changes in the shapes and sizes and courses of the flow of water. The data in GIS will facilitate the decision in management. Census of fishers may also help in identifying the changes in fisheries. The multi-spectral satellite data may help in developing predictive model for assessment of the potentiality of water bodies. The satellite data along with soil, land use and land cover maps may be used for identifying potential area for fisheries development.

The production in inland water bodies is affected by many biological and non-biological factors. The factors like location, soil, aquatic environment, socio-economic condition, crafts and gears, species composition, fishing practices are influencing the production. Modern techniques of Geographical Information System (GIS) may help in handling such data for improving management of resources.

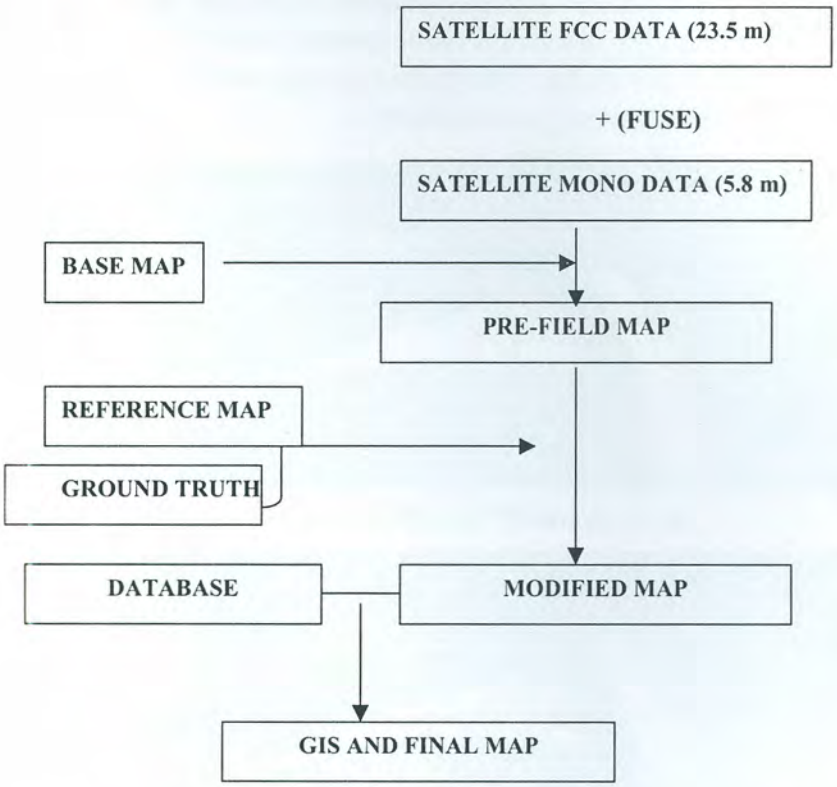
Most of the water bodies in India are weed chocked. Identification as well as mapping of these water bodies is very difficult. Ground truthing of these water bodies may help in proper identification and mapping. Non-availability of cloud-free data for a particular period and region some create hindrance in assessing the shape and size of the water body. Marked differences are in post-monsoon and pre-monsoon seasons (As seen in satellite images below marked as 1,2,3). Even high resolution multi spectral imagery is useful for mapping of weeds in water bodies. The generated information may become useful for advising suitable management practices.

Post-monsoon Satellite Image

Pre-monsoon Satellite Image

It's found that district level fish and fisheries information is not properly available at a single point. Modern web based information system have the capability to disseminate the information faster and in presentable manner. Mostly fisheries information are space specific, so web based geographical information system is most effective method for information dissemination. CFRI is also working in web enabled Geographical information System for fish catch at specific location.

A schematic diagram for mapping of water bodies is presented in Fig. below. There is also a need for ground truthing of water bodies for judging the misclassification and subsequent correction.



Schematic Diagram for Mapping and Development of GIS

Constraints in Mapping

Most of the water bodies in India are weed chocked. Identification as well as mapping of these water bodies is very difficult. Ground truthing of these water bodies may help in proper identification and mapping. Non-availability of cloud-free data for a particular period and region some create hindrance in assessing the shape and size of the water body. The National Remote Sensing Agency may be requested beforehand to acquire cloud free data for a specific period and region.

Recommendations

(1) Mapping of water bodies may be done at 10-year interval. Rapid growth of population and requirement of land for various purposes are causing fast changes in the availability of inland water resources.

(2) FCC satellite data with resolution of 5.8m may be used. Proper identification of water bodies needs multispectral data. The high resolution data help in accurately mapping the resources.

(3) To reduce the cost of images fusion of FCC of 23.5 m and monochrome data of 5.8 m may be thought of.

(4) Extensive ground truthing may be done. Confusion often arises with weed chocked water bodies, marshy lands and crop fields. The mapping in hilly areas also poses in identification. In order to avoid misclassification field visits are necessary.

(5) Village boundary maps, toposheets and district planning maps may be utilized for creating information on location of water bodies. Planners and decision makers may require the exact location of water bodies for development planning. This is possible only when the nearest village is known to them.

(6) Topo-sheet in the scale of 1:50,000 or lower may be utilized for georeferencing. For print out maps the scale should be proper according to the purpose of their utility.

(7) The data should be kept in GIS platform for easy storage of additional data and retrieval of existing information. The managers may utilize the data for development of management plans.

(8) Post-monsoon as well as pre-monsoon satellite data should be used for mapping. One time data may lead to wrong identification of water bodies.

(9) Information on hatchery, cold storage, fish landing and fish market may be kept in WEB enabled GIS platform for easy retrieval by user group.

Capacity Building and Training Facilities

(1) The infrastructure development for image analysis is of utmost importance for assessment of water bodies and development of GIS.

(2) In India National Remote Sensing Agency, Hyderabad conducts regular courses on remote sensing for application in various fields. Now-a-days many universities are also offering courses on remote sensing and GIS.

(3) With the launching of new satellites with improved sensors by different countries the analysis of acquired images needs training at regular interval. Organizations utilizing the satellite data for specific purposes should develop manpower by sending people to NRSA and universities.

GIS in Fisheries Sector

(1) GIS has become an important tool in management of huge data for decision making. It is widely applied in the fields of agriculture, forestry, coastal zone management, disaster management etc. The management of vast inland fisheries resources in India needs GIS tool also. Analysis of satellite data helps in assessing productivity of resources where as GIS may help in comprehensive development plan for fisheries.

(2) In order to apply GIS tools in fisheries sector a collaborative plan should be taken by central government, state governments through their remote sensing centres, universities, National Remote Sensing Agency and Space Application Centre. Planning Commission may come forward to approve and provide fund for such project.

(3) Facilities to be created for analysis of hyper-spectral satellite data. Ground truthing of water bodies to collect base line information on

fisheries for populating GIS must be taken by the participating organizations. This will not only help the fishers' community but also help in improving quality of environment.

(4) After the mapping and GIS being done the State Fisheries Departments may be entrusted to handle the information system under the control of a central organisation. They will be responsible for updating the information from time to time. However, a committee may be constituted for coordination of systematic implementation of GIS in fisheries sector.

References:-

1. Ministry of Water Resource website http://wrmin.nic.in
2. http://www.fao.org

   Handbook of Fisheries Statistics, Department of Animal Husbandry, Dairying and Fisheries, Govt.of India.