GEOINFORMATICS APPLICATION IN ASSESSMENT OF FISHERY RESOURCES OF UTTARAKHAND

Ashok K. Nayak
Prem Kumar
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FOREWORD

The vast and varied aquatic resources available in the hill regions provide opportunity for the culture and capture fishery. The most important need of the hour is the correct and valid assessment of the available resources. The use of Remote Sensing and Geographical Information System technology has opened the avenues for immense opportunities in large scale mapping, updating of existing resources, planning and decision making. Fisheries management is a multidisciplinary approach in which Geoinformatics plays a pivotal role in making decisions for the sustainable utilization of the available aquatic resources. In order to maximize fishery production, the applications of modern tools need to be introduced. Assessment of resources in hill region has become imperative due to natural and anthropogenic activities resulting in geomorphological changes over a period of time.

Resource inventory is one of the significant applications of Geoinformatics in fisheries management. Mapping of fishery resources and species distribution along with basic environmental or habitat parameters would result in accurate assessment of production potential. In present study, IRS LISS III data were used to assess the aquatic resources of the Uttarakhand state. The document contains comprehensive information on the fishery resources of Uttarakhand, which can be used by the stakeholder for fisheries management and planning.

CONTENTS

1. Introduction

Geoinformatics is an emerging technology, which has the capability of integrating the spatial and non-spatial data in order to maximize efficiency of planning and decision making. The tool provides efficient means of data handling, eliminating redundancy and for making efficient analyses/query of complex data involving geographical truths for generating new information. Application of Geographical Information Systems (GIS) could answer the generic questions like Location - what exists at a particular location; Condition - identify locations where certain condition exists; Trends - what has changed since; Patterns - what spatial parameters exists and Modeling - what if. These answers support in making authentic decisions, which are purely based on realities on the ground that can be used not only for scientific management of fisheries resources but also provide the opportunities of exploring the suitable sites for aquaculture in the hills. Geoinformatics has been described as the science and technology dealing with the structure and character of spatial information, its capture, classification, storage, processing and dissemination.

Coldwater fisheries distributed in different hilly regions occupy an important place amongst the freshwater fisheries resources of India. Its importance is even far greater in Himalayan uplands where the coldwater fish species have established themselves as an important candidate for sport and food. The country has significant aquatic resources in terms of upland rivers, streams, high and low altitudinal natural lakes, reservoirs that hold large population of indigenous and exotic, cultivable and non-cultivable fish species.

Uttarakhand, one of the hilly States of India has enormous freshwater fisheries resources that comprises of 2700 km of rivers, 24200 hectares of reservoirs, 297 hectares of lakes and about 2000 hectares of ponds. The state comprises two major regions namely, Kumaon and Garhwal. Both the regions are blessed with abundance of aquatic resources. A network of river systems, lakes and reservoirs, in addition to ponds, are the primary inland water resources for potential fish production and has greatly helped to improve the rural

these available natural resources and to bring them in the culture system to enhance the fish production, proper planning and management is required using modern tools of geoinformatics in developing spatial databases.

Fisheries sector occupies an important place in the socio-economic development of the country. It has been recognized as a powerful income and employment generator as it stimulates growth of a number of industries. It is a source of cheap and nutritious food besides being a foreign exchange earner. Most importantly, it is the source of livelihood for a large section of economically backward population of the country. Aquaculture is one of the fastest growing food production systems in the world. With stagnating yields from many capture fisheries and increasing demand for fish and fishery products, expectations for aquaculture to increase its contribution to the world's production of aquatic food are very high.

Most of the people inhabiting in the areas of coldwater sector are fish eater but fish production in the region is not self sufficient to meet the demand due to lack of development in fisheries sector of this particular region. Thus, fish is imported from other states, which drains out a big amount from the region instead of developing its own fisheries resources. Lack of database on the fisheries resources regard to planning and decision-making for long-term management is the major difficulty faced by many fishery managers. There are certain limitations to collect, analyse, store and retrieval of data manually. Therefore, the techniques develop in the recent past to exploit the individual water bodies are necessarily required to implement so that sufficient database can be obtained for management purposes. In the present study, an attempt is made to exploit fishery resources of various water bodies of the Uttarakhand State through Remote Sensing technique.

1.1. Remote Sensing Data

Multidated Remote Sensing Images, IRS-1C LISS III for the year 1997 and IRS P6 LISS III for the year 2004 of the study area were obtained from National Remote Sensing

Table 1: Description of the Satellite Data

Sl. No.	Resolution	Description
1.	Spatial Resolution	23.5 m
2.	Spectral Resolution	Green 0.52-0.59 microns Red 0.62-0.68 microns NIR 0.77-0.86 microns SWIR 1.55-1.70 microns
3.	Temporal Resolution	24 Days

Table 2: Data and their Satellite Pass

Path and Row	Satellite	Date
96/49	IRS LISS III 1C	02.11.1997
	IRS LISS III P6	23.02.2004
96/50	IRS LISS III 1C	02.11.1997
	IRS LISS III P6	23.02.2004
97/49	IRS LISS III 1C	07.11.1997
	IRS LISS III P6	28.02.2004
97/50	IRS LISS III 1C	07.11.1997
	IRS LISS III P6	28.02.2004
98/49	IRS LISS III 1C	06.12.1997
	IRS LISS III P6	04.03.2004
98/50	IRS LISS III 1C	06.12.1997
	IRS LISS III P6	04.03.2004
98/51	IRS LISS III 1C	19.10.1997
	IRS LISS III P6	04.03.2004
99/50	IRS LISS III 1C	09.01.1997
	IRS LISS III P6	22.12.2004

1.2 Geometric Correction

Toposheets of Survey of India (SOI) related to the specific areas are referred to geometric corrections of satellite data. Recent geo-coded data was used to demarcate the

segregate the real map of Uttarakhand. The images were processed for polyconic projection. Image rectification and restoration techniques were used for removing noise from the image. Subsets of the different water bodies such as lakes, reservoirs and rivers were prepared from the images. The required geomorphological parameters such as area, perimeter of the water bodies were analyzed through supervised classification technique and region growing tool in the software. Accuracy list is also performed in order to confirm the perfection of the classification.

1.3 Classification

To know the area covered by the water, temporal data are classified into land and water with assigning suitable signature. Image classification is the process of sorting pixels into finite number of individual classes or categories based on their digital number values. If a pixel satisfies set of certain criteria, then that pixel is assigned to the class corresponding to those criteria. There are two popular methods of classifications. They are unsupervised classification and supervised classification as described below.

1.3.1 Unsupervised classification

Unsupervised classification is more computer automated. It allows the user to specify parameters, which can be used as guidelines by the computer software to identify the statistical patterns in the data and group them without using any ground truth data. Performing an unsupervised classification is simpler than a supervised classification, because the signatures are automatically generated by a particular algorithm.

1.3.2 Supervised classification

Supervised classification is more closely controlled by the user than unsupervised classification. In this process, the user will select pixels that represent different classes in training sets based on ground truth data. Later, the computer software identifies the pixels with similar characteristics and classifies the entire image using the data set given by the user. If the classification is accurate, then each resulting class corresponds to a pattern that it

chemical characteristics. These are one of the important inland water resources for potential fish production and have greatly helped to improve the rural economy. However, these resources have not been fully assessed for their rational utilization.

2.1 Lakes in the Kumaon Region

Kumaon region is blessed with scenic beauty and a variety of natural resources. It is situated at the tri-junction of Nepal, Tibet and India, which constitutes a distinct geographical entity of great strategic significance and is spread over 21035 km^2 (Srivastava *et al.*, 2002). The altitudinal range varies from 200 to 7436 m asl resulting in varying climates in different parts of the region (Jalal, 1988). In the Nainital district of this region among other natural resources, there are number of natural freshwater lakes which are valuable resource for recreation and fisheries. The lakes viz. Nainital, Bhimtal, Naukuchiatal, Khurpatal, Sattal and Garudtal being situated at an altitude range of 1290 to 1937 m asl fall within a 25 km radius of the Nainital district. These lakes have multiple uses from tourism, potable water, irrigation and to fisheries in some cases. The habitation around the lakes varies significantly and is under different controlling authorities of each town. Kumaon region is known not only for the present day lakes but also for palaeo-lakes. Recent studies indicated that several palaeo-lakes were available in the Kumaon Himalaya (Kotlia *et al.*, 1997, 1998; Kotlia and Phartiyal, 1999) and Nainital Lake is considered to be a remnant of a former lake, covering an area from Khurpatal to Tallital. Further, different workers broadly group these into a number of basins e.g., Nainital-Sukhatal-Khurpatal basin; Bhimtal-Naukuchiatal basin and Sattal basin. The Nainital group of lakes includes Nainital, Sukhatal and Khurpatal while the Bhimtal-Naukuchiatal group consists of the Bhimtal and Naukuchiatal lakes.

The lakes have significant impact upon the economy of the region. Therefore, population is mainly concentrated around the lake on hills and their activities have direct bearing on it. As a result large quantities of organic and inorganic nutrients are added directly into the system. The lakes of this region are bestowed with valuable indigenous fish

et al., 2004). Moreover, most of these lakes are abode for sport fishes mainly of mahseer and angling is the common method of fishing (Mohan *et al.*, 1992). The recent years would not only be remembered for the civil development in the history that have made remarkable impact on the economy of the region but the anthropogenic activities and demographic pressure around the lakes may also be noted for their destruction resulting in rapid filling of the lakes that has changed the morphology. (Vass *et al.*, 2004). Kumar and Rai (2002) carried out a study on nutrients load added to Bhimtal and Nainital Lakes. They found that these lakes receive huge amount of domestic as well as organic load round the year. In order to draw long term policy for developing the aquaculture and sport fishery in these lakes depends on the accuracy of the available data regarding the type of the resource, way of change in the resources against time. In the present study, changes in the physical parameters of Kumaon lakes are depicted by techniques using multi-dated Remote Sensing data.

The satellite map showing different districts of Uttarakhand has been prepared from the NRSC imagery as given in fig. 1. In fig. 2 the major Kumaon lakes are depicted on the satellite imagery. Different physical parameters of various Kumaon lakes obtained for the year 1997 and 2004 are shown in Table 3. Further, the difference occurred in the shape and size of these lakes during the study period is shown in the fig. 3.

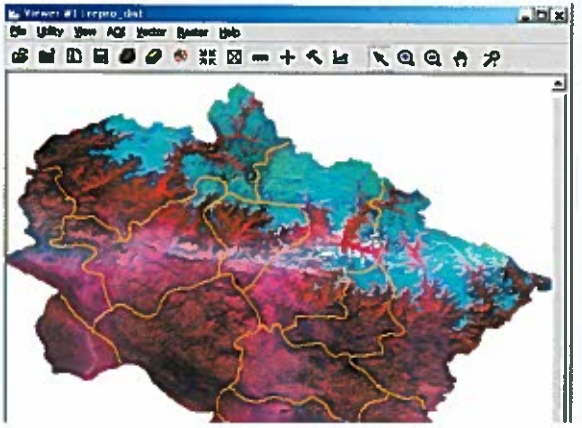


Figure 2: Major Kumaon Lakes in Satellite Imagery

Table 3: Perimeter and water spread area of various lakes of Kumaon region

S.No.	Name of Lake	Area (ha)		Perimeter (m)		Maximum Length (m)		Maximum Width (m)	
		Year							
		1997	2004	1997	2004	1997	2004	1997	2004
1.	Bhimtal	45.13	44.00	4300	4200	1703	1670	509	468
2.	Garudtal	5.70	4.80	1300	1200	560	418	316	243
3.	Khurpatal	4.92	4.62	920	800	300	262	205	136
4.	Nainital	54.29	52.90	4600	4400	1496	1432	434	412
5.	Naukuchiatal	29.30	29.80	3100	3100	931	920	779	753
6.	Sattal	48.90	47.60	6800	6400	1750	1740	459	409

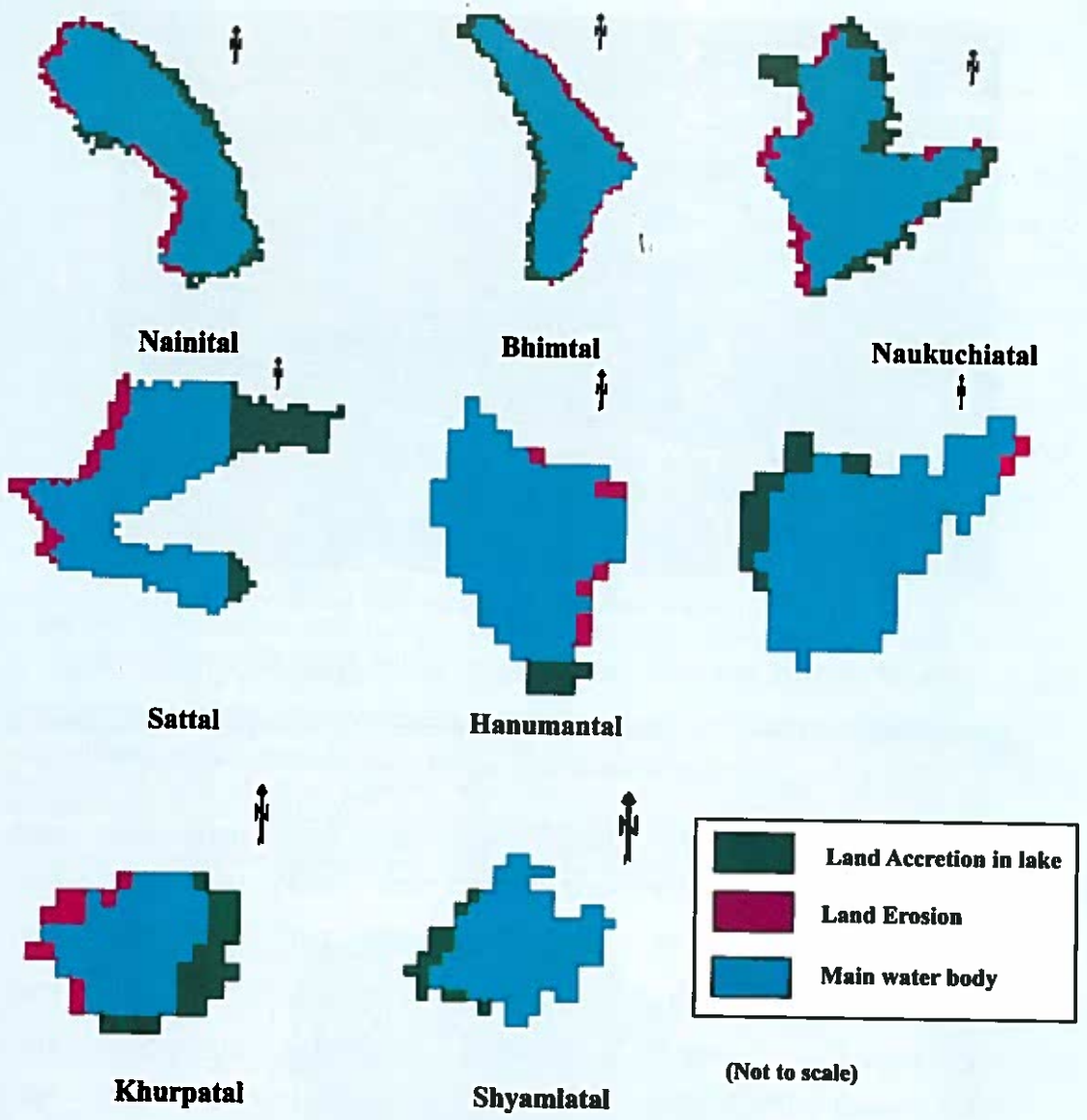


Figure 3: Changes in Water Spread area in Kumaon Lakes

It is observed that the maximum length and width of Bhimtal Lake are 1670 m and

geomorphology of the Bhimtal lake is not significantly changed during the last Century but whatsoever the changes happened in the last decade which may be due to rapid development of urban areas in the surrounding.

Similar trend is also observed in Nainital Lake. The above said parameters are slightly decreased from the year 1997 to 2004. Amesburg in 1871, measured the length and width of Nainital Lake as 1433 m and 463 m respectively a century back (Atkinson, 1996). It has also noted the circumference by the road and the superficial area as 3621 m and 49 hectares respectively. All the parameters as such observed by him are found very near to the figures obtained in our study for both the years. It seems that the major changes happened in this lake during the last decade. As compared to the figures reported by Amesburg, slightly reduced area of 46.9 hectares and increased circumference (or perimeter) of 3,700 m was obtained in the year 2004 of the same lake. This indicates that Nainital Lake is approaching to irregular shape in the subsequent years. A study on Nainital Lake has been carried out by Gupta and Pant (1983) that shows the surface sediments of the lakes is mainly comprised of organic and mineral matters. These changes in water-spread area of these lakes may appear slow but in the long run, this may be an alarming one.

In contrast to above, Naukuchiatal Lake is found almost in constant phenomena regarding the above parameters during the last decade. However, drastic changes is happened in the last century as evidence that the reported superficial area of this Lake was 45 hectares by Amesburg in 1871 (Atkinson, 1996) which is significantly higher than the approximate area observed in the year 1997 (29.3 hectares) and year 2004 (29.8 hectares). It is fed by streams from the neighboring hills. The volume or the number of responsible streams might have gone down in the last century due to extreme impact on the natural phenomena.

Analyses show a decreasing trend in area of the other lakes such as Garudtal, Khurpatal, Sattal, Shyamlatal and Hanumantal during the year 1997 to 2004. Similarly,

lakes of Kumaon region and it is therefore difficult to assess their depiction on the LISS III image. Thus, field truths have been collected for some of the lakes located in Garhwal region. The area of the lakes is either analyzed through GPS or digitization from the related toposheets which are as shown in fig. 4. The change in size and structure of these lakes are not possible to study with LISS III images. Area and perimeter of major lakes located in the Garhwal region are given in the Table 4. The total water spread area of the lakes is observed as 58 hectares.

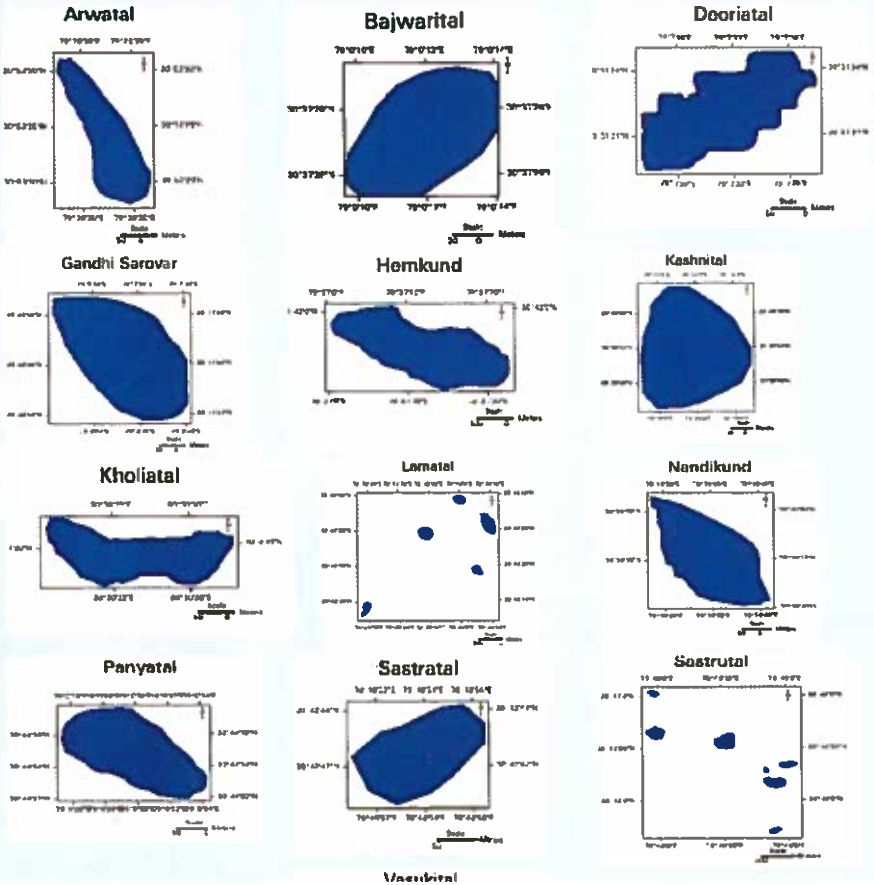


Table 4: The Perimeter and Water Spread Area of Various Lakes of Garhwal Region

Sl. No.	Name of the Lake	Area (ha)	Perimeter (km)
1	Arwatal	4.25	1.01
2	Bajwarital	1.06	0.39
3	Deoriatal	2.4	0.76
4	Gandhi Sarovar	1.61	0.49
5	Hemkund	9.30	1.42
6	Kashnital	2.51	0.60
7	Kholiyatal	2.32	0.79
8	Lamatal (comprises five small lakes)	0.56	0.28
		1.49	0.49
		1.05	0.38
		0.52	0.28
		0.63	0.35
	Sub-Total	4.25	1.78
9	Nandikund	6.63	1.10
10	Panyatal	2.53	0.65
11	Sastrutal (comprises seven small lakes)	0.47	0.27
		0.95	0.37
		0.99	0.39
		1.83	0.55
		3.68	0.74
		3.90	0.76
		5.34	0.88
	Sub-Total	17.16	3.96
12	Satratal	0.99	0.39
13	Vasukital	5.60	1.05

3. Mapping of Reservoirs of Uttarakhand

The important reservoirs available in the Uttarakhand State are Nanak Sagar, Baigul, Dhaura, Tumuria, Haripura, Baur, Sarda Sagar and Ramganga Sagar. The satellite imagery showing major reservoirs of Uttarakhand is depicted in fig. 5. The total reservoir along with their respective parameter and water spread area are given in Table 5. These reservoirs are

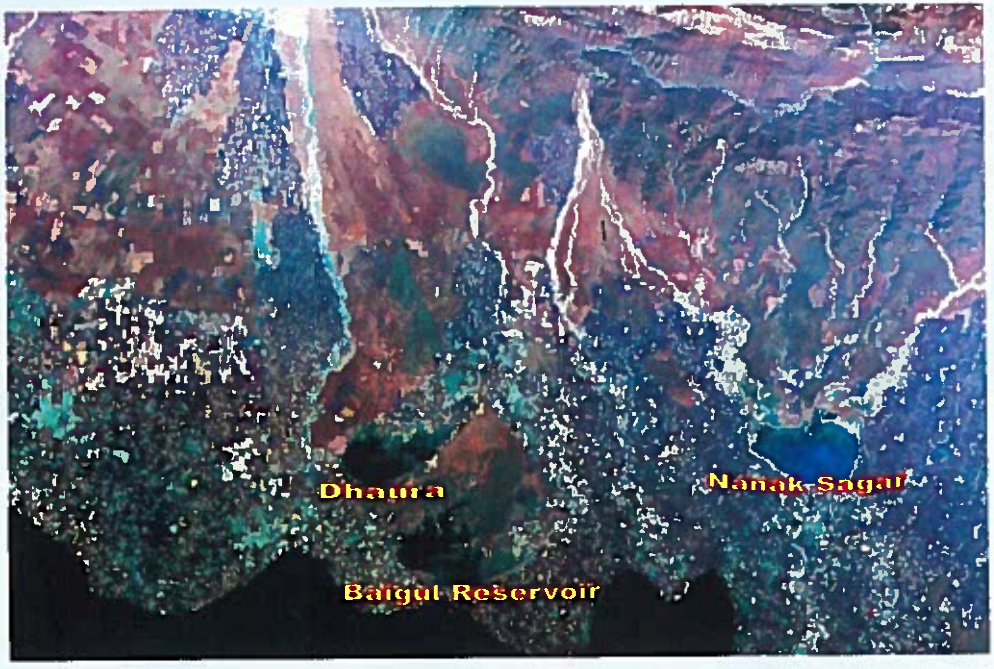


Figure 5: Satellite Imagery Showing Important Reservoirs of Uttarakhand

Table 5: Perimeter and water spread area of various reservoirs of Uttarakhand

Name of Reservoir	Date of Satellite Pass		Perimeter (in km)		Water Spread Area (in ha)	
	Year					
	1997	2004	1997	2004	1997	2004
Nanak Sagar	19.10.1997	04.03.2004	47.8	39.3	2495.0	1760.3
Baigul	19.10.1997	04.03.2004	57.4	59.3	1442.0	1677.8
Dhaura	19.10.1997	04.03.2004	28.1	31.6	845.0	1350.0
Baur	07.11.1997 & 06.12.1997	04.03.2004	29.5	21.7	978.0	1257.6
Haripura	06.12.1997	04.03.2004	15.8	16.4	672.0	883.0
Tumuria	07.11.1997	28.02.2004	42.0	57.2	1108.0	1604.0

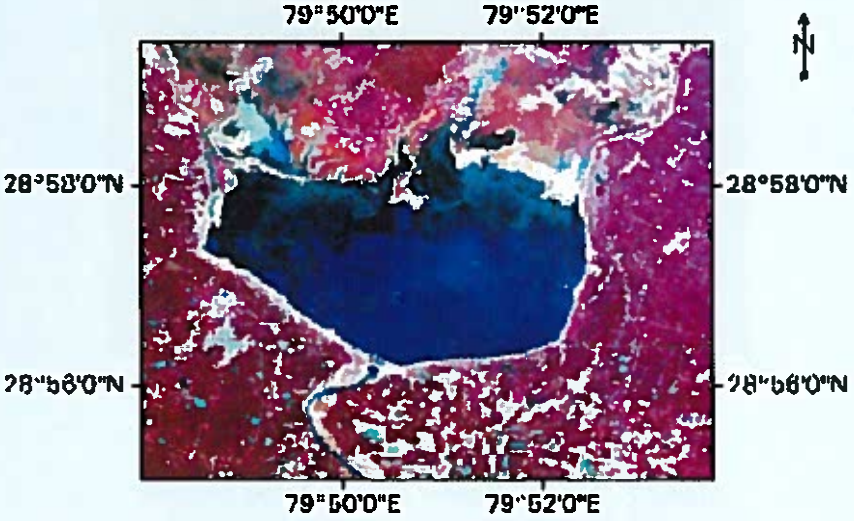


Figure 6: Analysis of Nanaksagar reservoir from satellite imagery

3.1 A Detailed Study of Sarda Sagar Reservoir

The Sarda Sagar reservoir is located between 28° 40' to 28° 50' N latitude and 80° 3' to 80° 12' E longitude. Geographically, the reservoir is situated in Udhamsingh Nagar district of Uttarakhand and Pilibhit district of Uttar Pradesh. The climate of the area is influenced with south-west monsoon or summer monsoon. The water fed to the reservoir is not by any river directly, but only some small drains join the Sagar. The main supply is from Sarda main canal through old and new Sarda Sagar feeders. The average rain fall in the area is 1488 mm per year. The south- west side of the reservoir is covered with thick and reserved forest. The climate surrounding the reservoirs is hot and moist.

A modeling was carried out based on criteria of optimum range of all physico-chemical properties of the reservoir water to obtain the productive zone of the Sarda Sagar. Based on selected criteria an area of 2481 hectares falls in medium productive and 2109 hectare of area was found to be high productive zone as shown in the fig 7. Based on the

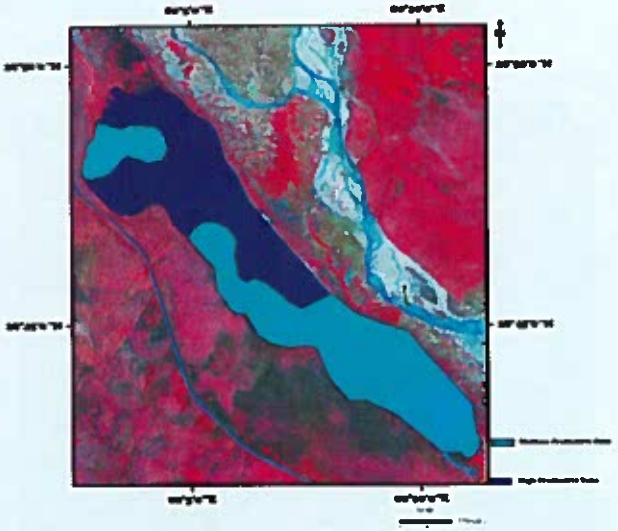
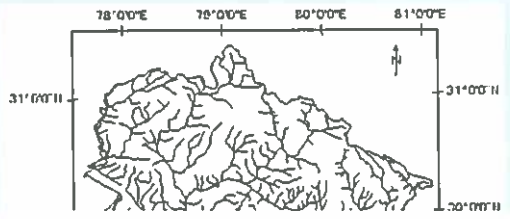


Figure 7: Productive zones of Sarda Sagar reservoir

4. Rivers in Uttarakhand

The major rivers of Uttarakhand State were digitized from the Survey of India Map as shown in fig. 8 and are enlisted in Table 6. The district-wise satellite imagery of various rivers has been demarcated and demonstrates for a particular Nainital district as shown in fig. 9. The Alaknanda river has the maximum total river length while Kali river has the maximum effective length among the available rivers in the state. The individual rivers were digitized and shown in fig. 10.

In total there are 22 major rivers, which have been identified from the toposheet and Remote Sensing data were digitized. Their total length is calculated as 6105 km. of which 2219 km are important from fishery point of view in the state.



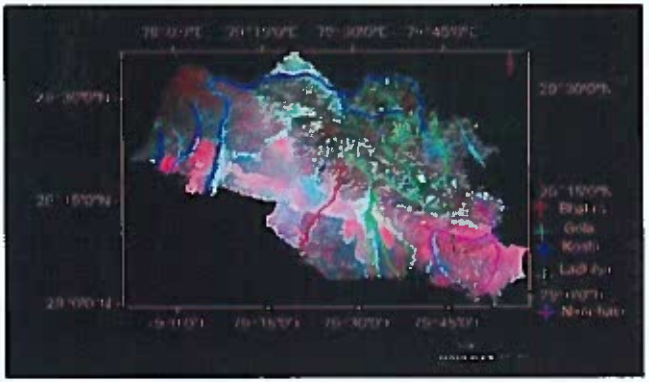
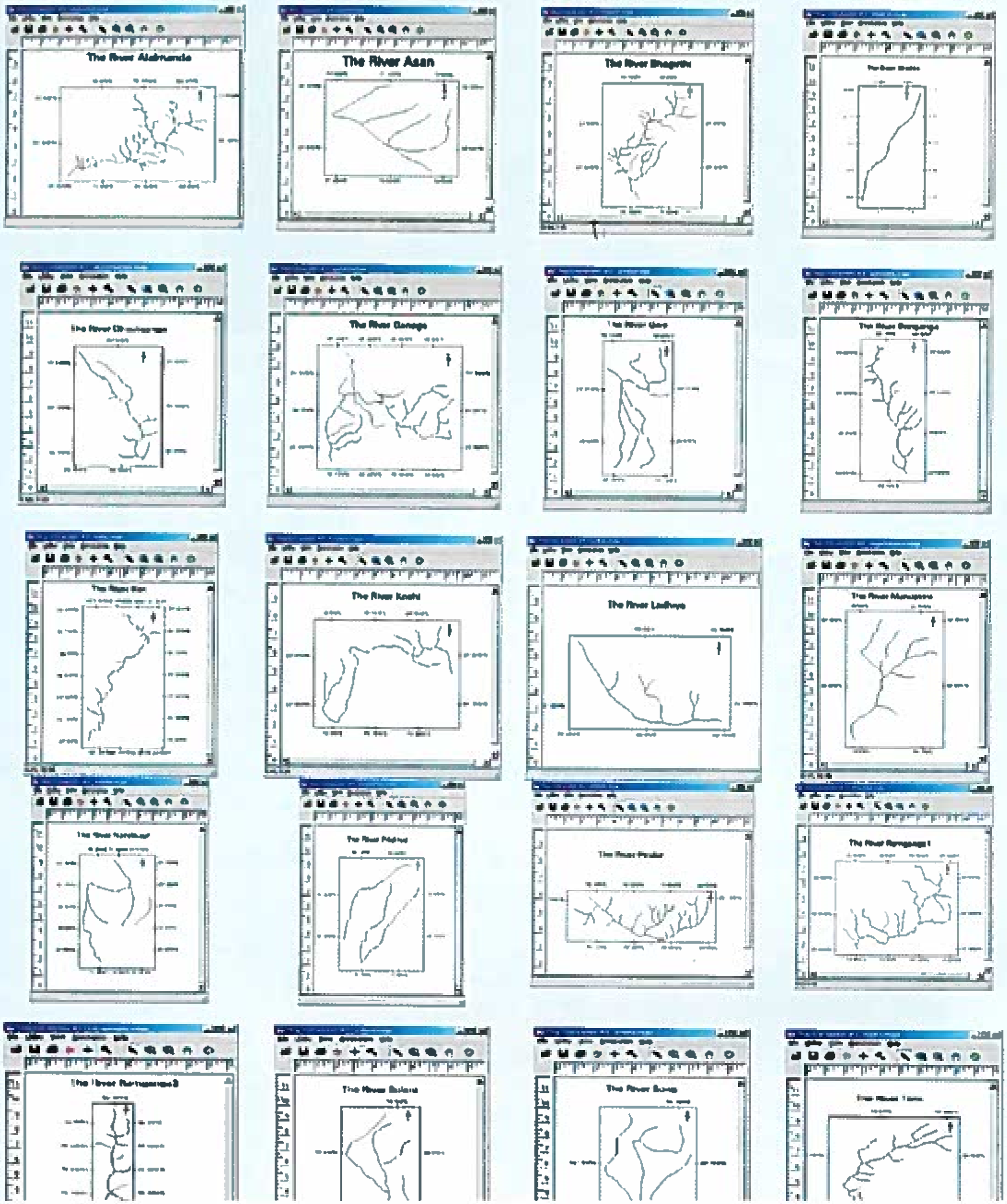


Figure 9: Distribution of various rivers in Nainital district

Table 6: Total river length and effective length of various rivers of Uttarakhand

Sl. No.	Name of the River	Total River Length (in km)	Effective Length (in km)
1.	Alaknanda	720	187
2.	Asan	116	35
3.	Bhagirthi	561	189
4.	Bhakra	429	43
5.	Dhauliganga	179	83
6.	Ganga	553	179
7.	Gola	225	91
8.	Goriganga	248	96
9.	Kali	343	235
10.	Koshi	247	121
11.	Ladhia	101	58
12.	Mandakini	142	62
13.	Nandhaur	114	67
14.	Pilakhar	133	41
15.	Pinder	305	104
16.	Ramganga West	375	111
17.	Ramganga East	176	85
18.	Solani	156	49


The River Asan

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