PLANNING FOR CONSERVATION OF WETLAND RESOURCES FOR SUSTAINABLE DEVELOPMENT OF BAGALKOT DISTRICT OF KARNATAKA: USING MULTISPECTRAL DATA

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ABSTRACT
Wetlands are one of the crucial natural resources. Wetlands are areas of land that are either temporarily or permanently covered by water. Wetlands support a large variety of plant and animal species adapted to fluctuating water levels, making the wetlands of critical ecological significance. However, the very existence of these unique resources is under threat due to developmental activities and population pressure. In this paper attempt is made to analyse the planning for preservation and conservation of wetland resources. To find out the wetlands in the study area used the multispectral data for accurate results. In the study area numerous small and important wetlands found and prepared a map at 1:50,000 scales. The multispectral data collected two time period of IRS: LISS- III data acquired during pre and post monsoon season are used for inventory to account for wet and dry season hydrology of wetlands. The map outputs include the status of water spread, aquatic vegetation and turbidity. Ancillary layers like road/rail, habitations are also created. The results are complied for prepare wetlands map of Bagalkot District. This map highlights the characteristics of the wetlands in the particular area within the district and hopes to improve our understanding of the dynamics and distribution of wetlands and their status in the study area. At present urgent need to take various conservation activities through the action plans by the concerned state government.

Key Words: *Planning, Resources, Wetlands, Diversity, Sustainable, Development.*

Introduction

It is increasingly realized that the planet earth is facing grave environmental problems with fast depleting natural resources and threatening the very existence of most of the ecosystems. Serious concerns are voiced among scientists, planners, geographers, sociologists, politicians and economists to conserve and preserve the natural resources of the world. One of the difficulties most frequently faced for decision making is lack of scientific data of our natural resources.

Wetlands are one of the crucial natural resources. Wetlands are areas of land that are either temporarily or permanently covered by water. This means that a wetland is neither truly aquatic nor terrestrial; it is possible that wetlands can be both at the same time depending on seasonal variability. Thus, wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics. Because of their transitional nature, the boundaries of wetlands are often difficult to define. Wetlands do, however, share a few attributes common to all forms. Of these, hydrological structure (the dynamics of water supply, throughput, storage and loss) is most fundamental to the nature of a wetland system.

It is the presence of water for a significant period of time which is principally responsible for the development of a wetland. One of the first widely used classifications systems, devised by Cowardin et.al., (1979), was associated to its hydrological, ecological and geological aspects, such as: marine (coastal wetlands including rock shores and coral reefs, estuarine (including deltas, tidal marshes, and mangrove swamps), lacustarine (lakes), riverine (along rivers and streams), palustarine (marshy - marshes, swamps and bogs). Given these characteristics, wetlands support a large variety of plant and animal species adapted to fluctuating water levels, making the wetlands of critical ecological significance. Utility wise, wetlands directly and indirectly support millions of people in providing services such as food, fiber and raw materials, storm and flood control, clean water supply, scenic beauty and educational and recreational benefits. The Millennium Ecosystem Assessment estimates conservatively that wetlands cover seven percent of the earth's surface and deliver 45% of the world's natural productivity and ecosystem services of which the benefits are estimated at $20 trillion a year (Source : www.MAweb.org). Wetlands are the first target of human interference and are among the most threatened of all natural resources. Around 50% of the earth's wetlands is estimated to already have disappeared worldwide over the last hundred years through conversion to industrial, agricultural and residential developments. Even in current scenario, when the ecosystem services provided by wetlands are better understood - degradation and conversion of wetlands continues. This is largely due to the fact that the 'full value' of ecosystem functions is often ignored in policy -making, plans and corporate evaluations of development projects.

One of the difficulties most frequently faced for decision making is lack of scientific data of our natural resources. Often the data are sparse or unconvincing, rarely in the form of geospatial database (map), thus open to challenges. Thus, the current thrust of researcher is to have an appropriate geospatial database of natural resources that is based on unambiguous scientific methods. The wetland areas of Bagalkot District are important among the wetlands of India. In this paper made an attempt to identify important wetlands for strengthening the ecological balance.

Study area

The area under study covers the whole geographical area of the Bagalkot District, lies between 15 ^{o} 49' to 16 ^{o} 46' northern latitude and 75 ^{o} 59' to 76^{o} 20' eastern longitude, covering an area of 6,593 Sq. Kms and located in the catchment areas of Krishna, Ghataprabha, Malaprabha and their tributaries. The district is located in the northern maidan/plain region is well situated in the interior of the Deccan plateau (see Fig. No:1). The district consists of Proterozoic sediments and basalts cover major part of the district and characterized by flat topography of basalts, undulating topography of granitoids and low lying linear plateau of sedimentary rocks.

The Bagalkot district generally comes under semi-arid climate, it has large variation in the amount and distribution of rainfall and faces the droughts at least thrice in a decade. The average rainfall over the last 100 years in the district is 554.13 mm. The rivers flow from West to East direction indicating that the district is elevated in the western part and sloping towards the eastern direction. The drainage area of the district is influenced by south-west monsoon. The district has population of 16,51,892 (2001 census) and it consists six revenue taluks namely Badami, Bagalkot, Bilagi, Hunagund, Jamkhandi and Mudhol. The total numbers of villages in the district are 623 and towns are 12. Out of the total geographical area (6,58,877 hectares) of the district 76.22 percent of area is used for the agriculture in 1990-91 but it decreases to 65.98 percent in 2000-01, due to the rehabilitation and resettlement of 1 urban and 168 rural settlement, which had affected and submerged by the Upper Krishna River Multipurpose project i.e. Alamatti Dam. In the last two decades the scenario of landuse pattern were changed drastically by the growing economic activities.

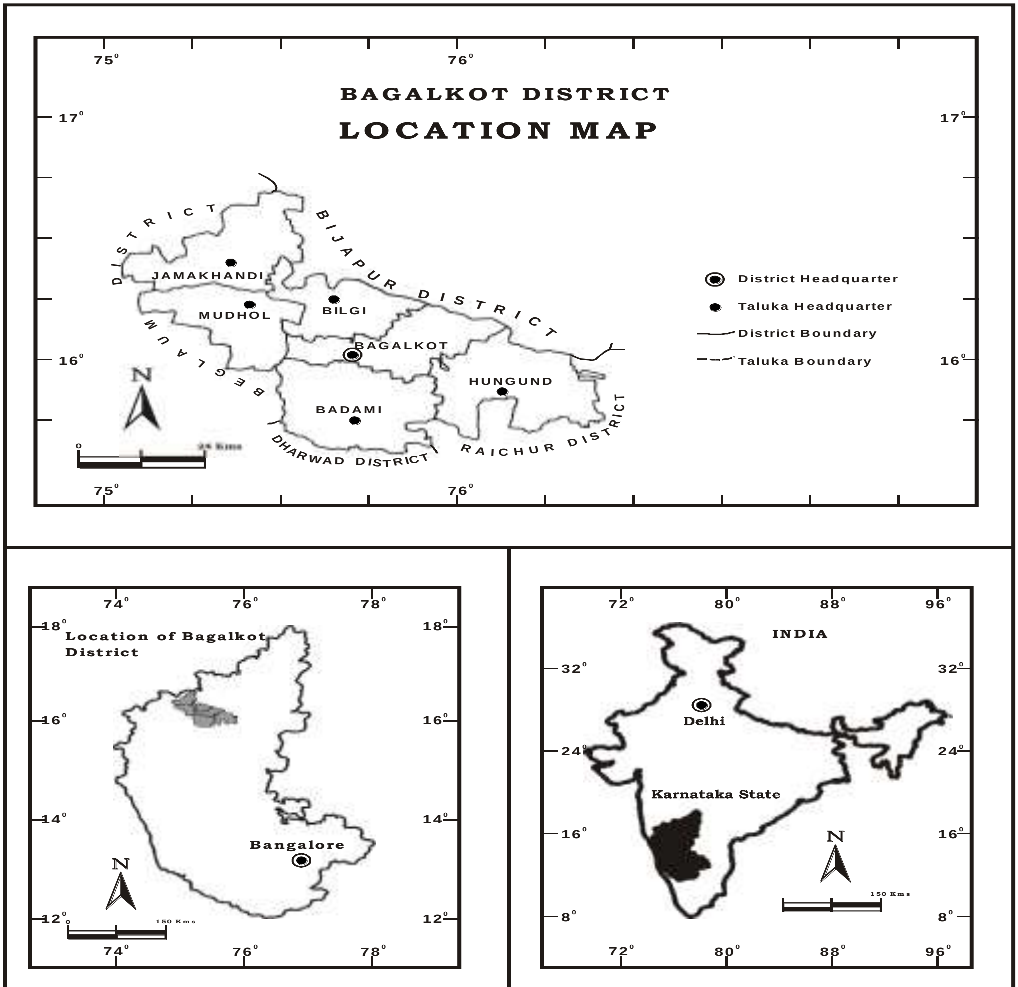

Fig. No:1

Source : National Atlas of India

OBJECTIVES

The main objectives of the present study are enunciated here under: To identify the wetlands of Bagalkot District by preparing map the wetlands on 1:50,000 scale using two date (pre and post monsoon) of IRS LISS -III digital data. To know about the present status of wetlands at macro as well as at micro levels. To prepare wetland map for easily identify the major ones for planning to preserve for maintain environment balance.

Data base

To conserve and manage wetland resources, it is important to have inventory of wetlands and their catchments. The ability to store and analyse the data is essential. Digital maps are very powerful tools to achieve this. Maps relating the feature to any given geographical location have a strong visual impact. Maps are thus essential for monitoring and quantifying

change over time scale, assist in decision making. The technique used in the preparation of map started with ground survey. The Survey of India (SOI) topographic
maps are the earliest true maps of India showing various land use/cover classes including wetlands. Recent years have seen advances in mapping technique to prepare maps with much more information. Of particular importance is the remote sensing and geographic information system (GIS) technique. Remote sensing is now recognized as an essential tool for viewing, analyzing, characterizing, and making decisions about land, water and atmospheric components.
The Bagalkot district has 6 taluks and is covered by 20 Survey of India (SOI)
Topographical maps on 1:50,000 scale that form the spatial frame work for mapping (see Fig. No: 2) prepared by using 15' x 15' grid.

BAGALKOT DISTRICT

COVERED BY 20 SURVEY OF INDIA (SOI) TOPOGRAPHICAL MAPS

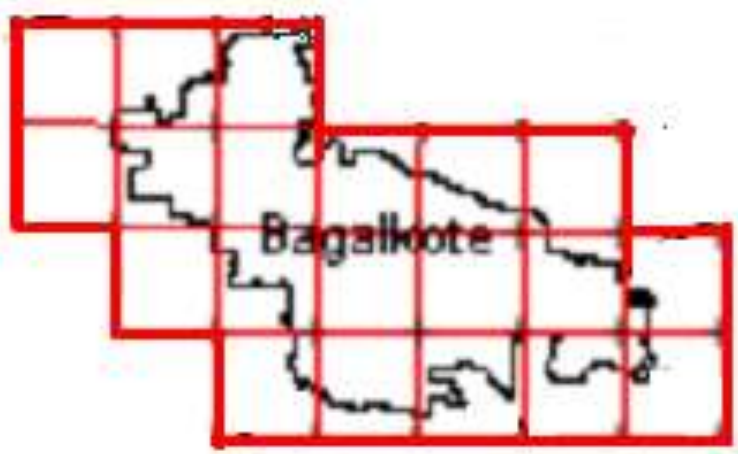

Fig. No: 2

Remote Sensing Data of IRS P6 LISS III data is used to prepare the Bagalkot District wetland map. The IRS P6 LISS III provides data in 4 spectral bands; green, red, Near Infra Red (NIR) and Short wave Infra Red (SWIR), with 23 .5 meter spatial resolution and 24 day repeat cycle. The spatial resolution is suitable for 1:50,000 scale mapping. The Bagalkot district is covered in 4 IRS LISS III scene (see Fig. No: 3). Two-time data is acquired, one acquired during October/November and another during April/May were used to capture the post -monsoon and pre -monsoon hydrological variability of the wetlands respectively (see Table No: 2) . The Fig.No: 6 & 6-a shows the overview of the part of Karnataka / Bagalkot as seen in the LISS III FCC of post - monsoon pre-monsoon data respectively.

Ground Truth Data: Remote sensing techniques require certain amount of field observation called "ground truth" in order to deduce meaningful information. Such work involves visiting a number of test sites, usually taking the satellite data. The location of the features is recorded using the GPS. The standard proforma as per the NWIA manual was used to record the field data. Field photographs are also taken to record the water quality (qualitative), status of aquatic vegetation and water spread. All field data collection work has been done during October and November 20010.

Other Data: Survey of India (SOI) topographical maps were used for reference purpose.

BAGALKOT DISTRICT

PATH / ROW INDEX OF LISS – III OVERLAID ON BAGALKOT DISTRICT BOUNDRY

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COVERED IN 4 IRS LISS III SCENE

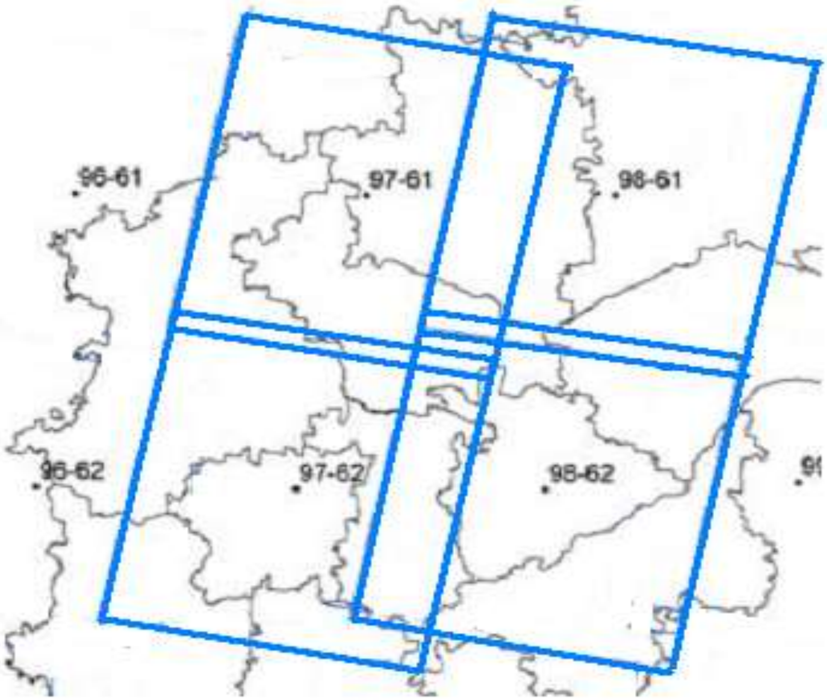


Fig.No:3

Methodology

The methodology to create the state level atlas of wetlands is adhered to NWIA technical guidelines and procedure manual (Garg and Patel, 2007). The overview of the steps used is shown in Fig.No: 4 & 5. Salient features of methodology given as under:

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

Preparation of map compositions and generation of statistics. Outputs on A4 size prints and charts for atlas.
Note: Work was carried out using Arc/Info and Arc-gis software's.

Table 1. Information of Satellite Data Used in the Present Study.

Sl . No.	Resourcesat LISS III	Post-monsoon	Pre-monsoon
1	97-61	December 02,2010	April 25,2010
2	98-61	December 07,2010	April 30,2010
3	97-62	January 19,2011	April 25,2010
4	98-62	December 07, 2010	April 30,2010

Creation of Spatial Framework: This is the most important task as the state forms a part of the national frame work and is covered in multiple map sheets. To create NWIA database, NNRMS/NRDB standards are followed and four corners of the 1:50,000 (15' x 15') grids are taken as the tics or registration points to create each map taking master grid as the reference. Spatial framework details are given in NWIA manual (Garg and Patel 2007). The spatial framework for Bagalkot District is shown in Fig. No: 4.

Geo -Referencing of Satellite Data: In this step the raw satellite images were converted to specific map projection using geometric correction. This is done using archived geometrically corrected LISS III data (ISRO-NRC-land use / land cover project). Standard image processing software was used for geo -referencing. First one date data was registered with the archived image. The second date data was then registered with the first date data.

Mapping of Wetlands: The delineation of wetlands through image analysis forms the foundation for deriving all wetland classes and results. Consequently, a great deal of emphasis has been placed on the quality of the image Interpretation. In the present study, the mapping of wetlands was done following digital classification and on-screen visual interpretation. Wetlands were identified based on vegetation, visible hydrology and geography. There are various methods for extraction of water information from remote sensing imagery, which according to the number of bands used, are generally divided into two categories, i.e. single-band and multi -band methods. Single -band method usually involves choosing a band from multi -spectral image to distinguish water from land by subjective threshold values. It may lead to over - or under -estimation of open water area. Multi-band method takes advantage of reflective differences of each band. In this paper, five indices known in literature that enhances various wetland characteristics were used as given below:
Normalized Difference Water Index (NDWI) = (Green-NIR) / (Green + NIR). Modified Normalized Difference Water Index (MNDWI) = (Green-MIR)/(Green + MIR). Normalized Difference Vegetation Index (NDVI) = (NIR - Red) / (NIR + Red). Normalized Difference Pond Index (NDPI) = (MIR – Green / MIR + Green). Normalized Difference Turbidity Index (NDTI) = (Red – Green) / (Red + Green).

The indices were generated using standard image processing software, stacked as layers. Various combinations of the indices/spectral bands were used to identify the wetland features as shown in Fig.No: 8. The following indices were used for various layer extractions: **Extraction of wetland extent:** MNDWI, NDPI and NDVI image was used to extract the wetland boundary through suitable hierarchical thresholds. **Extraction of open water:** MNDWI was used within the wetland mask to delineate the water and no -water areas. **Extraction of wetland vegetation:** NDPI and NDVI image was used to delineate the vegetation areas within a wetland using a suitable threshold. **Turbidity information extraction:** MNDWI image was used to generate qualitative turbidity level (high, moderate and low) based on signature statistics and standard deviations. In the False Colour Composite (FCC) these generally appear in different hues (Table 2.).

Table 2. Qualitative Turbidity Ratings.

Sl. No.	Qualitative Turbidity	Conditional criteria	Hue on FCC
1	Low	> +1σ	Dark blue/blackish
2	Moderate	> -1σ to <= +1σ	Medium blue
3	High/Bottom reflectance	<= µ - 1σ	Light blue / whitish blue

Conversion of the raster (indices) into a vector layer: The information on wetland extent, open water extent, vegetation extent and turbidity information was converted into vector lay ers using region growing properties or on-screen digitization.

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

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

Map composition and output: Map composition for atlas has been done at district and state level. A standard color scheme has been used for the wetland classes and other layers. The digital files are made at 1:50,000 scale. The hard copy outputs are taken on A4 size.

Accuracy assessment

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

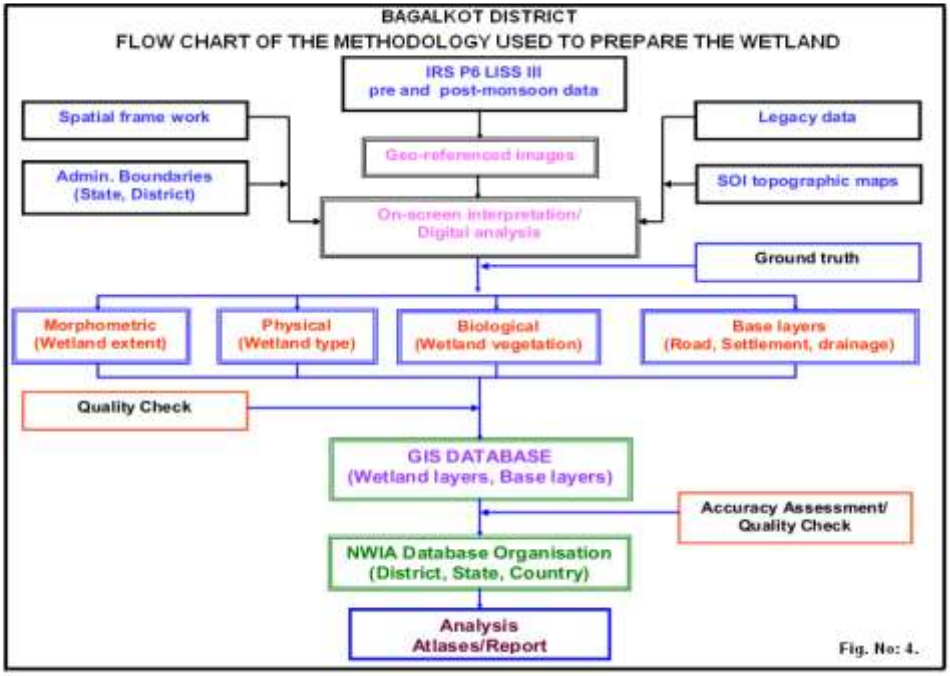


Fig. No: 4.

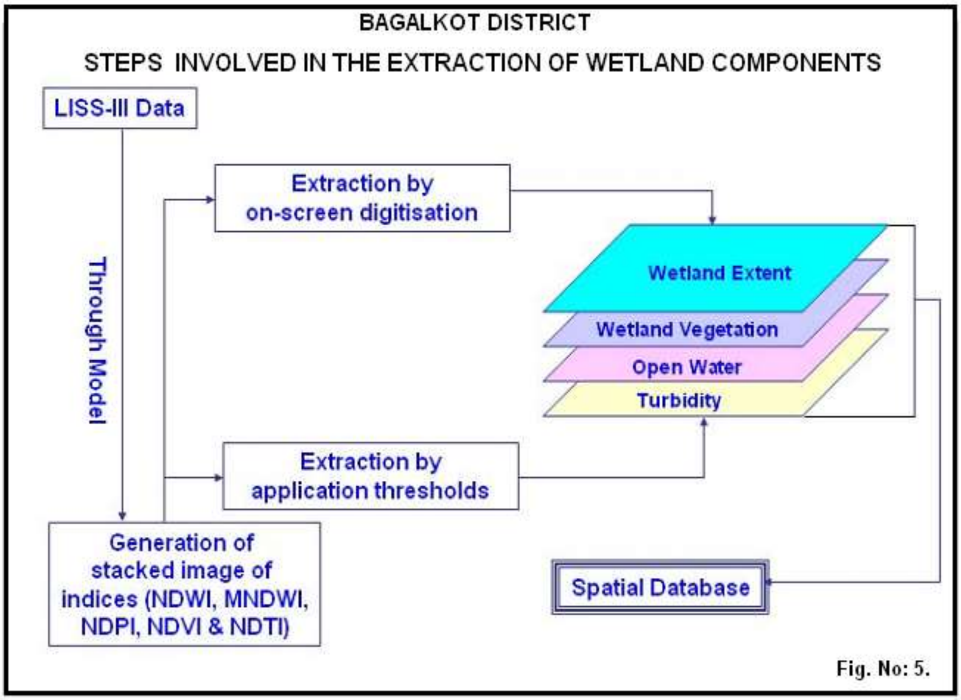


Fig. No: 5.

BAGALKOT DISTRICT
VARIOUS LAND FEATURES AS THEY APPEAR IN FOUR SPECTRAL BANDS AND IN A TYPICAL THREE BAND FCC

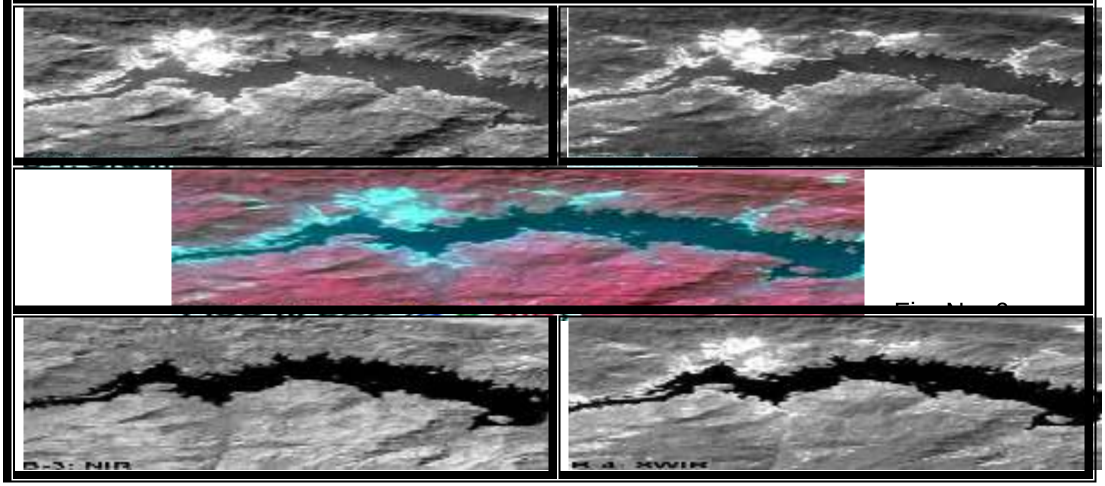


Table 3. Wetland Area of Bagalkot District compare to Karnataka State: 2010.

Sl. No.	Name	Area of (Sq.Kms)	Wetland area (hectares)	Percentage of total wetland area	Percentage of district area	Open water extent (hectares)		Seasonal change (in %)
						Post-monsoon	Pre-monsoon	
1	Bagalkot	6,594	37,470	5.80	0.20	34,770	14,577	- 58
2	Karnataka	1,91,791	6,43,576	100.00	3.40	4,27,921	2,62,991	- 39

The major rivers Ghataprabha, Malaprabha and Krishna that drain the Bagalkot district, the Almatti reservoir across the Krishna River and Muchakhandi tank are the major wetlands. In the Bagalkot district 127 wetlands have been delineated, besides detection of 128 wetlands smaller than 2.25 hectares. Total wetland area estimated to be 37,470 hectares (see Table No: 4 & Fig. No: 7 & 8), which accounts for about 6 per cent of total wetland area of the state. The major wetland types are Reservoir/Barrages (28,223 hectares) River/Stream (6,817 hectares), and Tanks /Ponds (1,719 hectares). Analysis of wetlands in terms of aquatic vegetation and open water has shown that 879 hectares and 1946 hectares of wetland area is under aquatic vegetation and 34,770 hectares and 14,577 hectares under open water category during post -monsoon and pre-monsoon respectively. Turbidity is dominated by moderate followed by low and high in both the seasons.

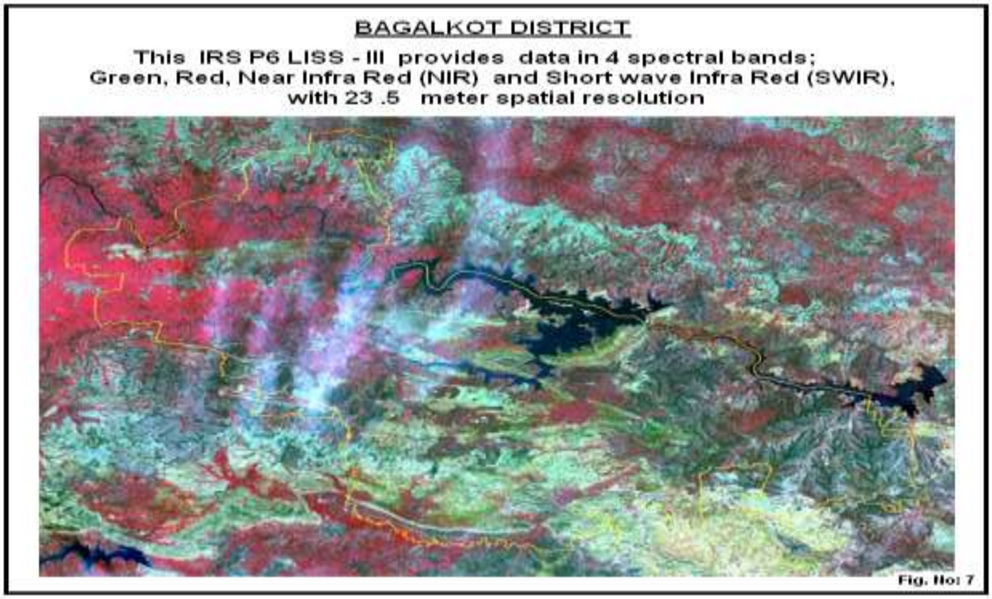
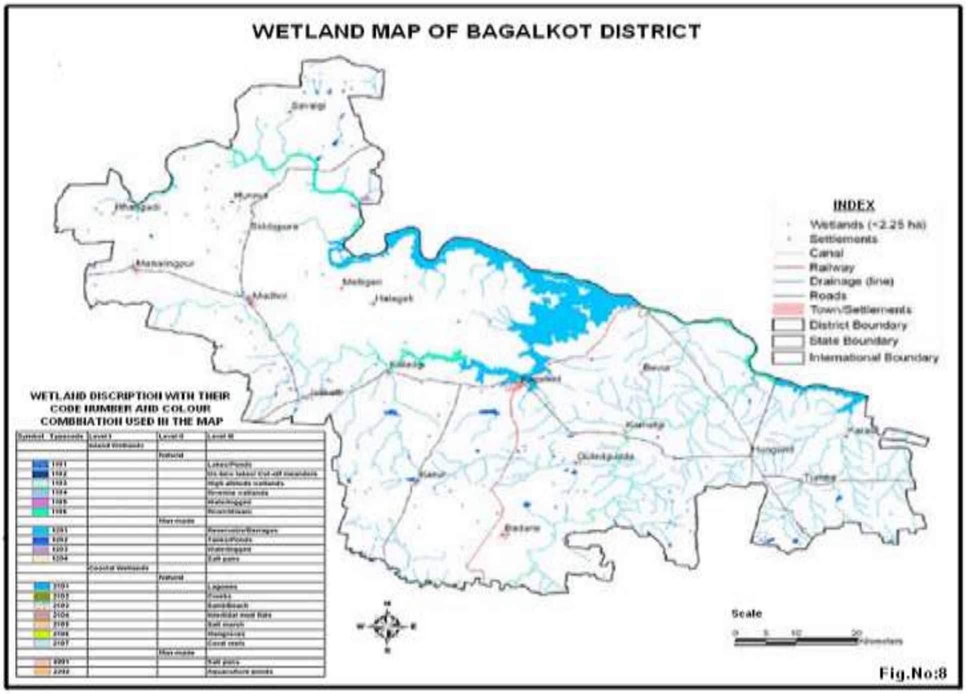
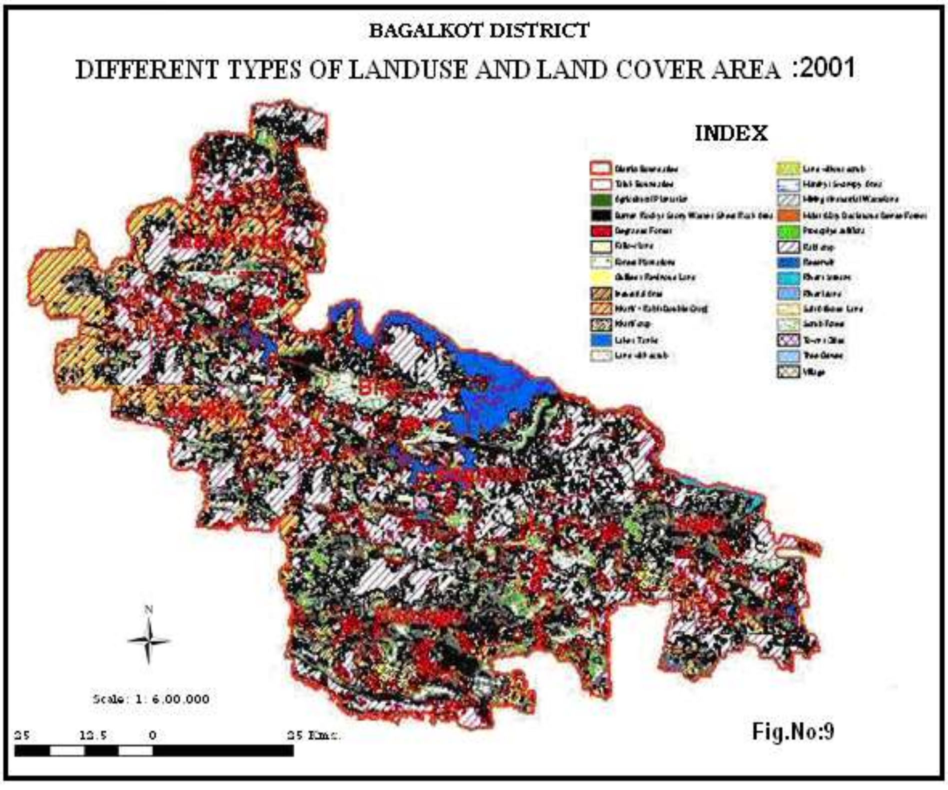


Table 4. Estimated Area Under Wetlands in Bagalkot District.

Sl. No.	Wet land Code	Wetland Category	Number of Wetlands	Total Wetland area (hectares)	Percentage of total wetland area	Open water extent (hectares)	
						Post-monsoo	Pre-monsoon
	1100	**Inland Wetlands - Natural**					
1	1101	Lakes/Ponds	-	-	-	-	-
2	1102	Ox-bow lakes/ Cut -off meanders	-	-	-	-	-
3	1103	High altitude wetlands	-	-	-	-	-
4	1104	Riverine wetlands	-	-	-	-	-
5	1105	Waterlogged	-	-	-	-	-
6	1106	River/Stream	15	6,817	18.19	6,484	5,273
	1200	**Inland Wetlands -Man - made**					
7	1201	Reservoirs/Barrages	2	28,223	75.32	26,890	8543
8	1202	Tanks/Ponds	94	1719	4.59	861	592
9	1203	Waterlogged	16	583	1.56	535	169
10	1204	Salt pans	-	-	-	-	-
		Total - Inland	**127**	**37,342**	**99.66**	**34,770**	**14,577**
		Wetlands (< 2.25 hectares), mainly Tanks	128	128	0.34	-	-
		Total	255	37,470	100.00	34,770	14,577
		Area under Aquatic Vegetation	-	-	-	879	1,946
		Area under Turbidity Levels					
		Low				11,950	2,133
		Moderate				22,590	12,339
		High				230	105


WETLAND MAP OF BAGALKOT DISTRICT
INDEX
Wetlands (<2.25 ha)
Settlements
Canal
Railway
Drainage (line)
Roads
Town/Settlements
District Boundary
State Boundary
International Boundary
WETLAND DISCRIPTION WITH THEIR CODE NUMBER AND COLOUR COMBINATION USED IN THE MAP
Scale
Fig.No:8


BAGALKOT DISTRICT
DIFFERENT TYPES OF LANDUSE AND LAND COVER AREA :2001
INDEX
N
Scale: 1: 6,00,000
25 12.5 0 25 Kms.
Fig.No:9

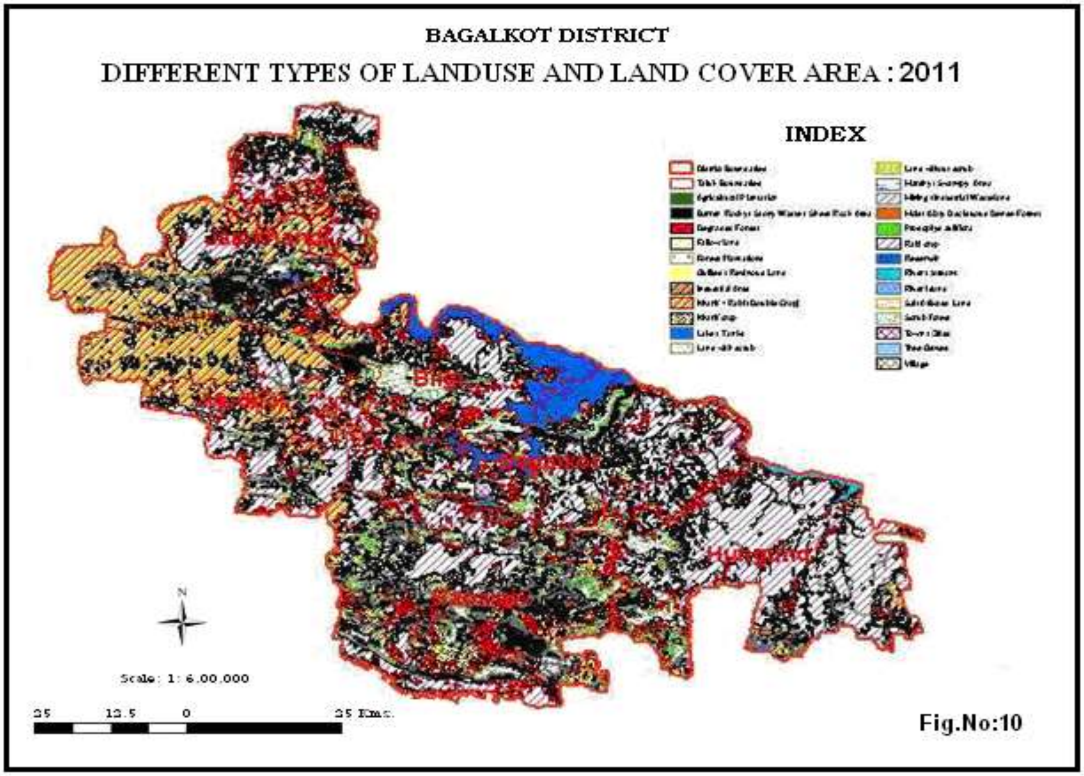


Fig.No:10

The assessment of results of landuse and land cover changes based on visual interpretation for two different years of satellite data (2001 and 2011 and see Fig. No: 9 & 10) reveals that, in 2001 out of the total geographical area of the Bagalkot district, 67.00 percent of area covered by cropland, 12.15 percent of area covered by fallow land, 12.31 percent of area covered by forest, while other(settlement, industry, transport lines, water body, etc.) landuse features occupied 7.55 percent and other uncultivable land kept as vacant area was 0.86 percent. The trend of the landuse and land cover continued with little change in subsequent years with the same order of importance. However in the period of 2011 the percentage of forest area is maintained in the same level, the cropland is slightly increased to 71.30 percent, there is more deviation towards reduction in fallow land (7.38%), the other cultivable land maintained its percentage, other landuse features area increased to 8.14 percent. In short the most common variable explaining the changes in landuse and land cover in Bagalkot district is due to population growth.

Conclusion

The above study has revealed that satellite data has the unique capability to detect the accurate place of each wetland and changes its characteristics. In some taluks of Bagalkot district, due to over irrigation the landuse and land cover area is changed drastically specially in Jamkhandi, Mudhol, Badami and Bilagi taluks. For the purpose of conceptual planning need to maintain the slow changes in landuse and land cover area for sustainable development of biodiversity in wetland on one hand. In other hand, need to control the areal extension of wetland areas of the study area for the better agriculture output. For fulfilling all these, need to implement the specific area planning in near future. This will help in maintaining the ecological balance and improving micro-environment of the study region.

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