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Research Article

Assessment of wetland dynamics in Sirohi district of Rajasthan, India using remote sensing and GIS techniques

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Abstract

Wetlands are very dynamic ecosystems in the world. The present study provides scenario of wetlands of Sirohi district of Rajasthan, India. Landsat TM data of October, 1992, IRS-P6 LISS-III data of October 2005 and IRS-P6 AWiFS data of January, February, March, April and May months (2005) have been used in the study. Visual interpretation technique was adopted to map the areal extent of wetlands on 1:50,000 scale. Wetlands were classified following the Ramsar classification. The total extent of wetlands for the Sirohi district as a whole is estimated to 11,961 ha with representation 189 wetlands during 1992 which later decreased 11,307 ha in 2005 with a loss of 654.2 ha during 13 years. Of the total wetland area of the district, rivers accounted for 61.9% area, followed by reservoirs (15.1%), seasonal lakes (15%), perennial lakes (5.6%), and ponds (2.5%). Further it is also observed that drastic reduction in the water spread area from February to May months. For conservation of wetlands it is necessary to assess the changes which take place in the water bodies from time to time.

Key words: GIS, Rajasthan, Remote sensing, Sirohi district, Wetlands

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INTRODUCTION

Wetlands are defined as lands transitional between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water (Mitsch and Gosselink, 1986). Wetlands compromise only three to six percent of the earth's land surface area, but they provide human populations with a host of goods and services, including water quality maintenance, agricultural production, fisheries, and recreation (Acreman and Hollis, 1996). Sustainable use and development of wetland resources has become a key issue for our own survival. A wide variety of wetlands like marshes, swamps, open water bodies, mangroves and tidal flats and salt marshes exist in India[1]. The interaction of man with wetlands during last few decades has been of concern largely due to the rapid population growth accompanied by intensified industrial, commercial and residential development further leading to pollution of wetlands by domestic, industrial sewage, and agricultural run-offs as fertilizers, insecticides and feedlot wastes (Rao et al., 1999; Prasad et al., 2002).

India, by virtue of its geographical extent, varied terrain and climatic conditions, supports a rich diversity of inland and coastal wetland ecosystems. Realizing the importance of wetlands in India, Ministry of Environment and Forests, Government of India, has published a directory of wetlands (1990) based on the survey carried out during 1972. However, the survey is not

comprehensive and many inland wetlands and most of the coastal wetlands have not been included in the compilation. Although the significance of wetlands has been known for a long time, their role in maintaining ecological balance is less understood.

As a prelude to their conservation, it is necessary to map wetlands, determine whether or not they have changed over specific time periods and quantify the changes, if any (Jensen et al., 1993). This task often may require timely and synoptic data collection and analysis. Remote Sensing (RS) in conjunction with Geographical Information System (GIS) and Global Positioning System (GPS) could play vital role in mapping and monitoring of existing land and water resources information at a particular period (Pattanaik and Reddy, 2007). Precise information of their nature, extent and spatial distribution is a prerequisite for the protection or optimal utilization of wetlands. The spectacular development in space technology, particularly, the repetitive satellite remote sensing across various spatial and temporal scale, offers the most economic means of assessing, planning, managing and monitoring the land and water resources now-a-days (Reddy et al., 2007; Reddy et al., 2008). The present study illustrates the use of multi-date satellite data for assessment and monitoring of wetlands of Sirohi district in semi-arid region of Rajasthan, India.

MATERIAL AND METHODS

Study area

Sirohi district is situated at the south-west part of Rajasthan between parallel of 24° 20' and 25° 17' North latitude and 72° 16' and 73° 10' East longitude. The geographical area of the district is 5136 km². It is surrounded by Jalore district on the west, Pali district on the north, Udaipur district on the east, and Banas Kantha district of Gujarat on the south. Sirohi district is much broken up by hills and rocky range. The maximum and minimum temperature is around 47 ºC during May and 10 ºC in December. Humidity is generally high in the south-west monsoon season and dry during the rest of the year (www.sirohi.nic.in). The rainfall in general was erratic and frequently below average. The period from mid-June to mid-September is the south-west monsoon season and mid-September to the end of November constitutes the post monsoon season. During the rainy season, all the wetlands are supplied both by stream inflow from the land of surrounding areas. Increase in anthropogenic pressures has led to loss of many wetlands now-a-days. Remote sensing appears to be the most practical option for assessing the wetland change.

Image processing

Landsat Thematic Mapper (TM) data acquired on 31st October, 1992 (path/row 149/43), Indian Remote Sensing satellite P6 Linear Imaging Self Scanner (LISS-III) data of 24th October, 2005 (path/row 93/54; 93/55) and IRS-P6 Advanced Wide Field Sensor (AWiFS) data (path/row 95/55) of January, February, March, April and May, 2005 have been used in the study. The ortho-rectified Landsat Enhanced Thematic Mapper (ETM+) satellite data (http://glcf.umiacs.umd.edu/) was used as reference for geo-rectification with proper ground control points (GCP) using ERDAS IMAGINE image processing software. The images were visually interpreted using image characteristics such as tone, texture, pattern, size, shape, shadow etc. which help in interpretation of earth features. Most of these image characteristics depend on the spectral, spatial, temporal and radiometric resolution of the sensor and the ability of an imaging system to record finer details in a distinguishable manner. False Colour Composite (FCC) images were developed for doing various analysis (Figs. 1 & 2). Visual interpretation technique was adopted to map areal extent of wetlands using IRS P6 LISS III and AWiFS data pertaining to the years 1992 and 2005. Wetlands were classified into six groups considering Ramsar classification *viz.* (1) Reservoirs (2) Seasonal lakes (above 8 ha) (3) Perennial lakes (above 8 ha) (4) Seasonal rivers (5) Seasonal ponds (below 8 ha) (6) Perennial ponds (below 8 ha). Also wetland areas were categorized into six classes based on the waterspread area as <50 ha, 50-100 ha, 101 -150 ha, 151 - 200 ha, 201 - 250 ha and > 250 ha. The classified satellite images were presented in Fig.3 to Fig.4.

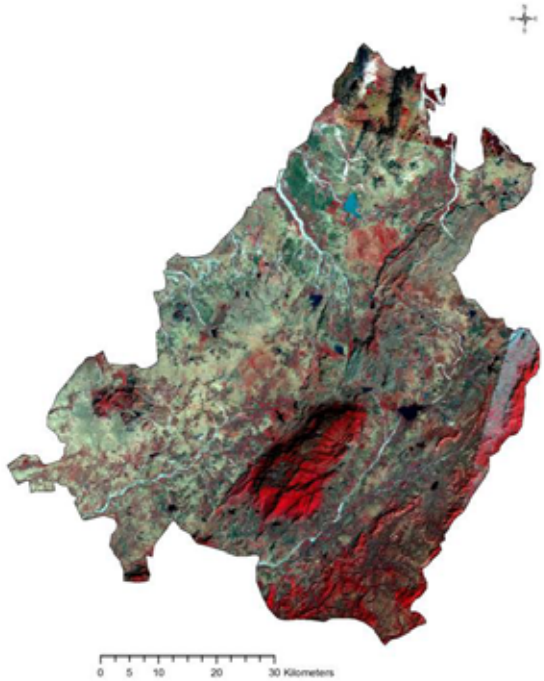

Fig. 1. Landsat TM FCC image of Sirohi district (October, 1992)

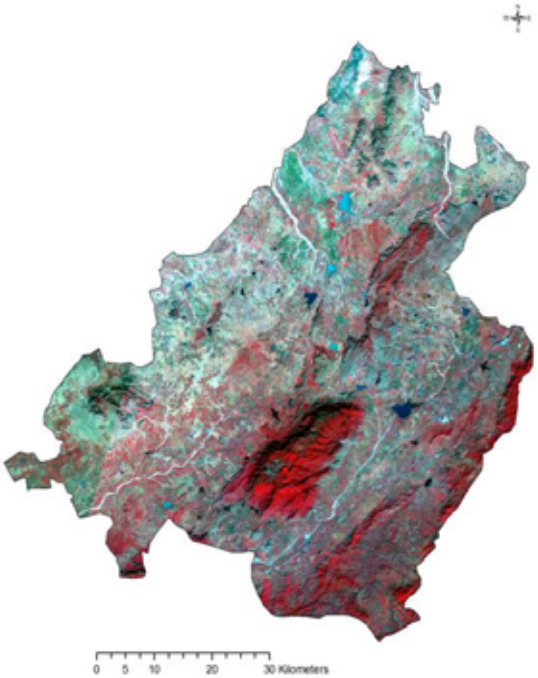

Fig. 2. IRS P6 LISS III FCC image of Sirohi district (October, 2005)

RESULTS AND DISCUSSION

Analysis of satellite data reveals wetlands occupy 2.2% of geographical area of the district. The Sirohi district characterizes 189 wetlands spreading 11,961 ha during 1992 (Table 1). The areal extent of rivers (seasonal) is 6,750.3 ha (56.4%) followed by seasonal lakes (20%) in 1992. There were three reservoirs in the district, which contributes to 1,783.5 ha (14.9%) of total wetland area. The number of wetlands were more (98) in seasonal ponds category followed by seasonal lakes (63). The total extent of wetlands in the Sirohi district was estimated 11,307 ha in 2005 (Table 2). The rivers accounted for 61.9% area, followed by reservoirs (15.1%), seasonal lakes (15%), perennial lakes (5.6%), and ponds (2.5%).

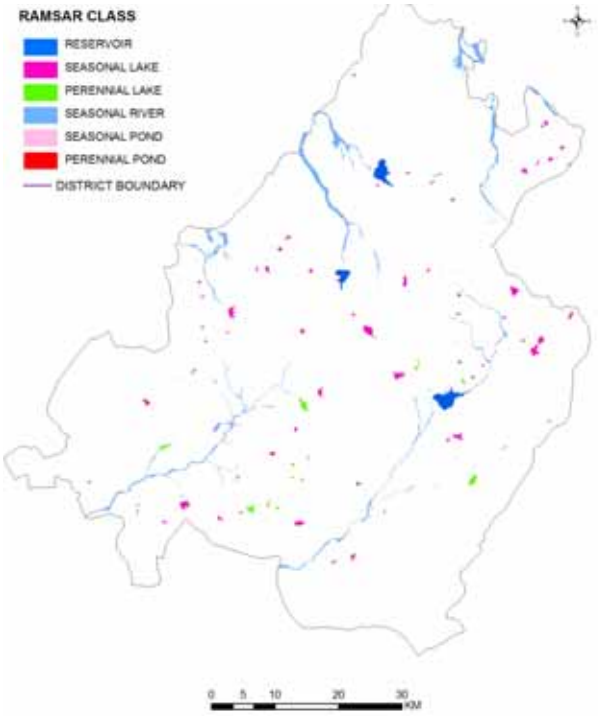

Fig. 3. Classified Wetland map of Sirohi district (1992)

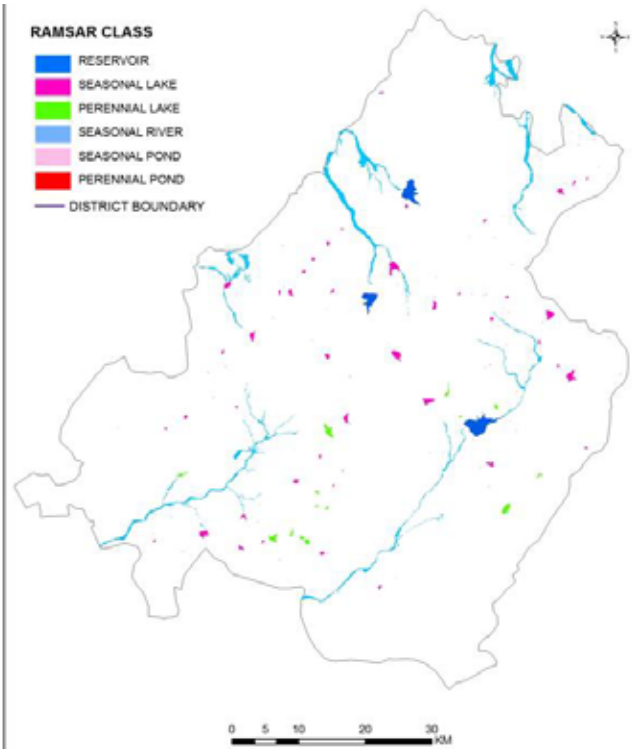

Fig. 4. Classified Wetland map of Sirohi district (October, 2005)

Table 1. Areal extent of Wetland categories: October, 1992

Sl.no.	Class	No. of Wetlands	Area (ha)	Percent of Area
1	Reservoir	3	1783.5	14.9
2	Seasonal lake (above 8 ha)	63	2387.7	20.0
3	Perennial lake (above 8 ha)	13	619.9	5.2
4	Seasonal rivers	10	6750.3	56.4
5	Seasonal ponds (below 8 ha)	98	402.7	3.4
6	Perennial ponds (below 8 ha)	2	17.0	0.1
	Grand total	189	11961.0	100

The maximum number of wetlands loss is observed in seasonal lakes (63 to 43) and seasonal ponds (98 to 61) respectively in a gap of 12 years. The areal extent of wetlands was analysed according to size distribution (Table 3). Maximum number of wetlands (105) are belongs to the class of <50 ha area. The wetland area class >250 ha occupies higher proportion (72.3%), followed by <50 ha class (10.1%).

Table 2. Areal extent of Wetland categories: October, 2005

Sl.no.	Class	No. of Wetlands	Area (ha)	Percent of Area
1	Reservoir	3	1711.4	15.1
2	Seasonal lake (above 8 ha)	43	1693.1	15.0
3	Perennial lake (above 8 ha)	14	630.0	5.6
4	Seasonal rivers	11	6994.3	61.9
5	Seasonal ponds (below 8 ha)	61	268.7	2.4
6	Perennial ponds (below 8 ha)	2	9.3	0.1
	Grand total	134	11307	100

Table 3. Areal extent of wetlands according to size distribution (area in ha)

Sl.no.	Class	October, 92	October, 05	January, 05	February, 05	March, 05	April, 05	May, 05
1	<50	1637.0	1146.6	201.4	214.1	165.7	147.9	156.1
2	51-100	669.4	541.2	124.4	74.4	142.0	149.6	0.0
3	101-150	871.2	1062.4	114.7	119.1	0.0	0.0	0.0
4	151-200	343.5	163.2	0.0	0.0	0.0	0.0	0.0
5	201-250	462.3	217.0	0.0	0.0	0.0	0.0	0.0
6	>250	7977.6	8176.4	0.0	0.0	0.0	0.0	0.0
	Grand total	11961.0	11306.8	440.5	407.6	307.7	297.5	156.1

The river Luni comprises maximum area under wetlands due to the fact that the district has longest river course. The study has revealed that the riverine wetlands are seasonal in nature and accounted for area of 6,994.3 ha. The analysis of AWiFS satellite data showed the surface area of non riverine wetlands were high in the month of October (4,312.6 ha) followed by January (440.5 ha), February (407.6 ha), March (307.7 ha), April (297.5 ha) and May (156.1 ha) (Table 4).

Table 4. Seasonal change in water spread area and number of wetlands in individual months

Sl.no.	Month	No. of wetlands	Area (ha)	Percent of total geographic area
1	October, 05	134	11306.8	2.20
2	January, 05	22	440.5	0.09
3	February, 05	16	407.6	0.08
4	March, 05	16	307.7	0.06
5	April, 05	16	297.5	0.05
6	May, 05	16	156.1	0.03

The number of wetlands in the months of October, January and February are 134, 22 and 16 respectively. The wetland area in October month is more because of post monsoon period. Then the water spread area is gradually decreased from January to May. The number of wetlands was only 16 in the months of February, March, April and May, but there is a drastic reduction in the water spread area from February to May.

The analysis shows interesting results. The number of wetlands was decreased from 189 to 134 during 1992 to 2005. It may be attributed due to anthropogenic pressure or deficit rainfall. The overall wetland area shown decrease with loss of an area of 654.2 ha. Seasonal ponds lost 134 ha area with in a period of 15 years. The wetlands above 250 ha areas are consistent and found to be 10 during 1992 to 2005. The loss of wetlands in Sirohi district is a great concern for future sustainability.

CONCLUSIONS

Remote sensing and GIS techniques allow natural resource inventories to be completed in a timely manner with greater accuracy and provide a database for storing, manipulating and displaying spatial data often missing in traditional inventories. The present study has developed wetland details on 1:50,000 scale. Spatially explicit database developed would stand as baseline for subsequent monitoring and assessment. One time inventory gives information of the wetlands at that time only which is of limited use. For continuous planning and management, it is necessary to assess the changes which take place in the water bodies from time to time. Hopefully, with further research into the use of satellite imagery for wetland resource planning and management, it will be possible to answer some of the questions arising from such studies and refine what amounts to a very useful and time saving method of monitoring wetland areas. The information generated is useful for establishing appropriate priority and effective plans for natural resources management.

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