Remote Sensing to Quantify Wetland loss

Sumit Anand[1], P.K Joshi[2]

[1] Student, Department of Natural Resources, TERI University

[2] Professor and Head, Department of Natural Resources, TERI University

10 Institutional Area, Vasant Kunj, New Delhi-110070

Abstract:

The Kanwar Lake in Begusarai district is one of the Asia's largest freshwater oxbow lake and eco-friendly natural lakes which attracts a variety of migratory birds. It has been shrinking at an abnormally high rate. Despite being designated as wildlife sanctuary, this wetland is under threat from anthropogenic pressures. An effort has been made in this study to conserve and manage wetland with remote sensing technology. Therefore multi-temporal satellite imagery used to quantify wetland dynamics and to estimate wetland loss. To carry out this work multi-temporal data is used and a comparison is made to assess the changes in the wetland area using ENVI software. From the study it is observed that a significant amount of wetland has been converted into agriculture land. The degradation of the ecosystem at Kanwar Lake is alarming. The situation is so severe that the population of birds at the wetland reduced from several lakhs in the 1970s to around 5000 in the 2012. The significant shrinking of the wetland area clearly indicates an imperative need for restoration of the landscape.

About the Author:

Mr. Sumit Anand

Bachelors in Geography from Delhi University and pursuing Master's in Geo-informatics from TERI University as a part of it, I have hands on experience for 10 weeks in a live project with USAID funded Global Center for Food Systems Innovation (GCFSI) at Michigan State University, USA.

E mail ID: sumitanand27@gmail.com

Contact No: +91 – 9650148484

Introduction

Wetland are areas that are seasonally or permanently inundated or saturated with water. Wetlands includes marshes, swamps, mangroves, rivers, lakes, flood plains, bogs, peat lands, shallow ponds and littoral zones of larger water bodies. The United States Geological Survey (USGS) defined wetland as a general term applied to land areas which are seasonally or permanently waterlogged, including lakes, rivers, estuaries, and freshwater marshes; an area of low-lying land submerged or inundated periodically by fresh or saline water (Mac et al., 1998). Remote sensing techniques provide important capabilities to map features and monitor the dynamics of wetland. Remotely sensed satellite data has been analyzed for delineating wetlands in the state. This study highlights the importance of monitoring the physical extent of Kanwar Lake wetland in Bihar state of India using multi-temporal satellite imagery, as the changes in wetland nature necessitate the use of satellite-based remote sensors and low-cost, affordable GIS tools for effective management and monitoring.

Study Area

Kanwar Lake or Khabar Tal located at 25° 37’ 00” N, 86° 08’ 00”E about 22 km northwest of Begusarai town in state of Bihar consider as Asia's largest freshwater oxbow lake. It is one of the most important wetlands for water fowl in the Gangetic plain supporting huge number of various species of migratory and resident avifauna. To check the rampant poaching of these birds, Khabar Tal has been declared as protected zone by the Bihar state government in 1986 followed by declaration as bird sanctuary in 1989 by the Government of India.

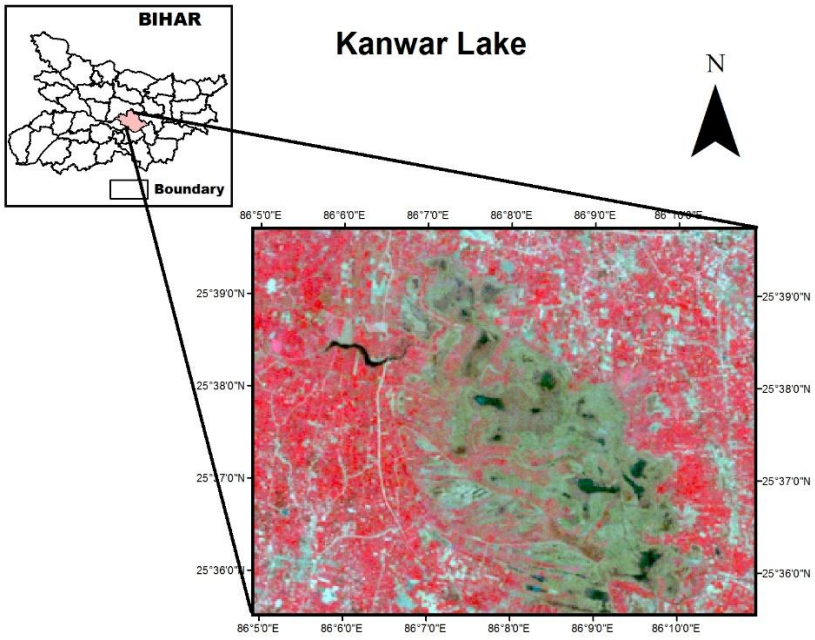

Fig: 1 Study Area

Datasets used and Methodology

(i) Satellite Datasets

Multi-temporal Landsat 5 Thematic Mapper (TM) imagery data were used as shown in Table1. The satellite data were used to delineate wetland boundary from 1988 to 2010. Landsat 5 TM data were used for quantifying the wetland dynamics of Kanwar Lake.

Table - 1

The sensor characteristics for different satellite data used for wetland ecosystem assessment

Satellite	Year of Data acquisition	Spatial Resolution (m)	Spectral Bands
Landsat 5 TM	08-02-1988	30	0.45 - 0.52 µm (Blue band) 0.52 - 0.60 µm (Green band) 0.63 - 0.69 µm (Red band) 0.77 - 0.90 µm (NIR band) 1.55 – 1.75 µm (MIR band) 2.08 – 2.35 µm (MIR band)
	20-02-2010		

(ii) Image Pre-Processing

The effects of the atmosphere upon remotely sensed data are part of the signal received by the sensing device. So it was important to remove atmospheric effects. For such correction in this study area Dark Pixel Subtraction technique used to remove haze from the top of satellite images.

(iii) Image Processing

The first method was subjected to Principal component analysis (PCA 1) and then to apply clustering to the first principal component to classify and enhance the wetland area. In the second method original remotely sensed satellite images were classified using unsupervised ISODATA algorithm. And these two methods compared and used to quantify wetland dynamics and to estimate wetland loss. Further two approaches were analyzed to choose best method.

(a) PCA based classification of wetland ecosystem

Principal component analysis is an approach that transforms the remotely sensed data into new data to interpret set of uncorrelated variables which captures the essential information. It aims to reduce number of bands to re-organize information. Then applied clustering to first Principal component using ENVI software to classify wetland which represents maximum information. The result obtained highlight wetness and able to distinguish wetland from other classes shown in Fig: 2.

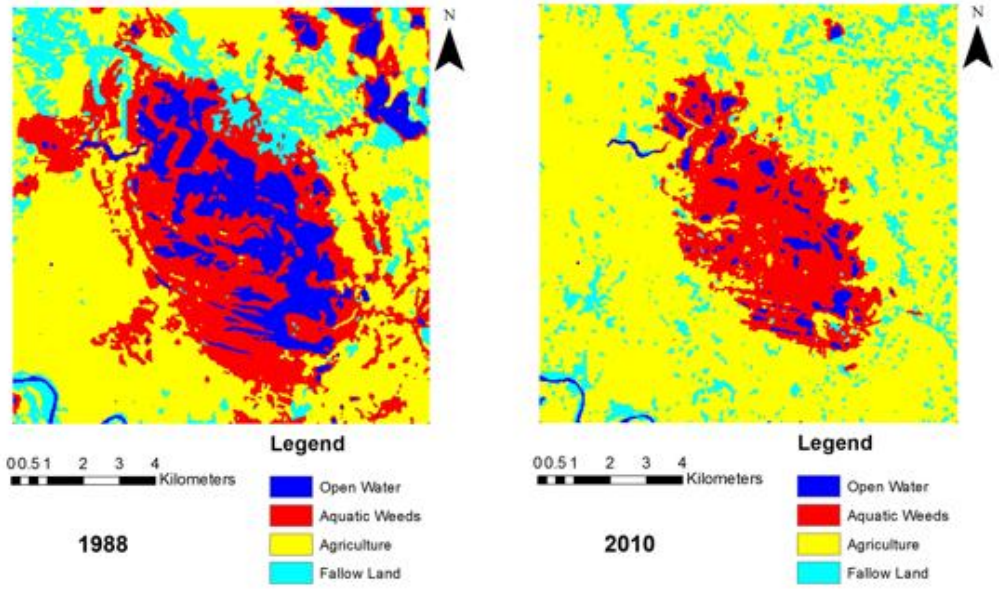

Fig: 2 – PCA based classification of wetland area for 1988 and 2010

(b) Unsupervised classification of wetland ecosystem

Unsupervised classification has been widely used for wetlands classification. Unsupervised classification (ISODATA algorithm) is an effective method of separating remotely sensed data for extracting land-cover information. Using ENVI software the change Threshold percentage was specified as 99% and the maximum iteration was specified at 10. Then 50 classes were generated to make four major classes and appropriate colours were assigned to new wetland classified map.

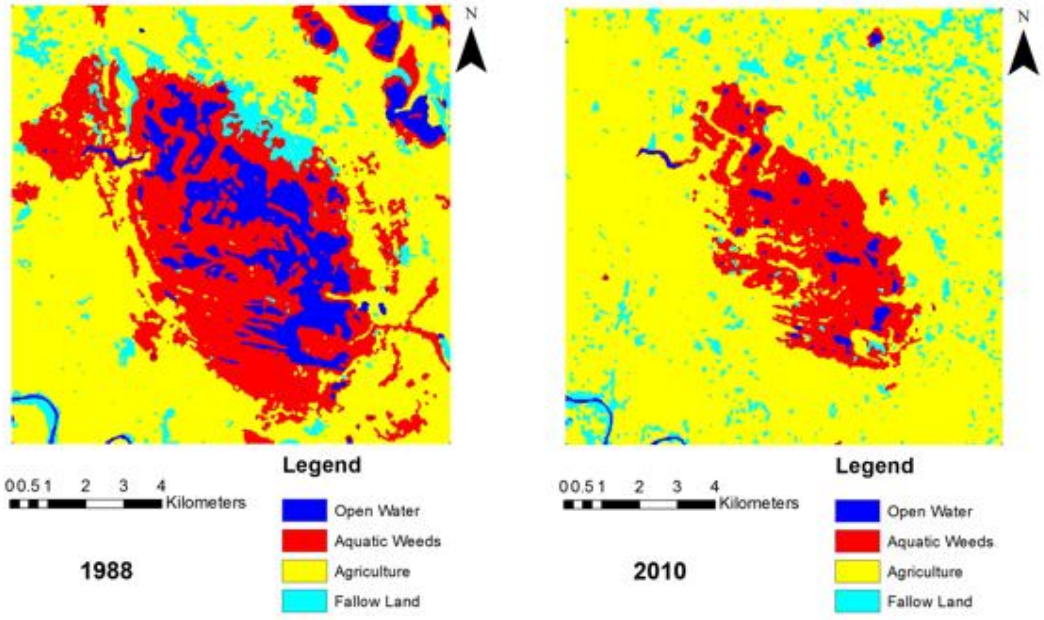

Fig: 3 – Unsupervised classification of wetland area for 1988 and 2010

Results and Discussion

Kanwar Lake wetland distribution

PCA based classification and unsupervised classification technique used for identification of four major classes: - Open water, Aquatic weeds, Agriculture and Fallow land. Here, in this study area wetland refers to the area covered with open water and aquatic weeds. Open water refers to the area that is covered within wetland area. While aquatic weeds are marshy land saturated with water. Remaining classes classified as agriculture and fallow land.

Accuracy Assessment

Final accuracy assessment was performed using ENVI software on all classified images and results show that the overall accuracy and Kappa coefficient of classified image as:-

PCA based classification overall accuracy is 84% and 90 % for 1988 and 2010 respectively. Kappa coefficient is 0.78 and 0.86 for 1988 and 2010 respectively.

Unsupervised classification overall accuracy is 80% and 90% for 1988 and 2010 respectively. Kappa coefficient is 0.73 and 0.86 for 1988 and 2010. Respectively.

Change Detection

It has been analyzed from satellite images that wetland area of Kanwar Lake has reduced. Kanwar Lake wetland has been shrinking at an abnormally higher rate, as revealed by remote sensing image taken in 1988 and 2010. It can be seen from the Table 1 and Table 2 that both methods provides almost same result with some or less variations in area statistics.
It can be noticed from the Table2 that open water has decreased from 13.39% of total area (1988) to 2.7% of total area (2010) and aquatic weeds has decreased from 27.76% of total area (1988) to 15.39% of total area (2010).

Table 2
PCA based area statistics of Wetland Area during 1988, 2010

Class Name	1988		2010		
	Area (ha)	Area (%)	Area (ha)	Area (%)	Change % 1988–2010
Open Water	1786.23	13.39	360.36	2.7	-10.69
Aquatic Weeds	3704.31	27.76	2053.35	15.39	-12.37
Agriculture	6376.95	47.8	9559.62	71.66	23.86
Fallow Land	1472.4	11.05	1366.56	10.25	-0.8
Total	13339.89	100%	13339.89	100%	0

While Table3 reveals that open water has decreased from 11.12% of total area (1988) to 1.35% of total area (2010) and aquatic weeds has decreased from 28.06% of total area (1988) to 14% of total area (2010).

Table 3
Unsupervised area statistics of Wetland Area during 1988, 2010

Class Name	1988		2010		
	Area (ha)	Area (%)	Area (ha)	Area (%)	Change % 1988–2010
Open Water	1484.01	11.12	179.82	1.35	-9.77
Aquatic Weeds	3741.21	28.06	1866.96	14	-14.06
Agriculture	7237.53	54.25	10339.47	77.5	23.25
Fallow Land	877.14	6.57	953.64	7.15	0.58
Total	13339.89	100%	13339.89	100%	0

Change Map

PCA based and unsupervised change map (Fig: 4) technique used for identification of wetland area that has been changed from 1988 to 2010. Indirect change showing the area that was present in 1988 as open water and now has dried up and converted into aquatic weeds (marshy land) saturated with water. Indirect change may be due to indirect effects of human interventions (reported by Tripathi P.K, Telegraph, and July 31 2012). Direct change reduced the aquatic weeds (marshy areas) due to anthropogenic factors which can be directly linked with the use of wetland for agricultural purposes, fishing and many other uses.

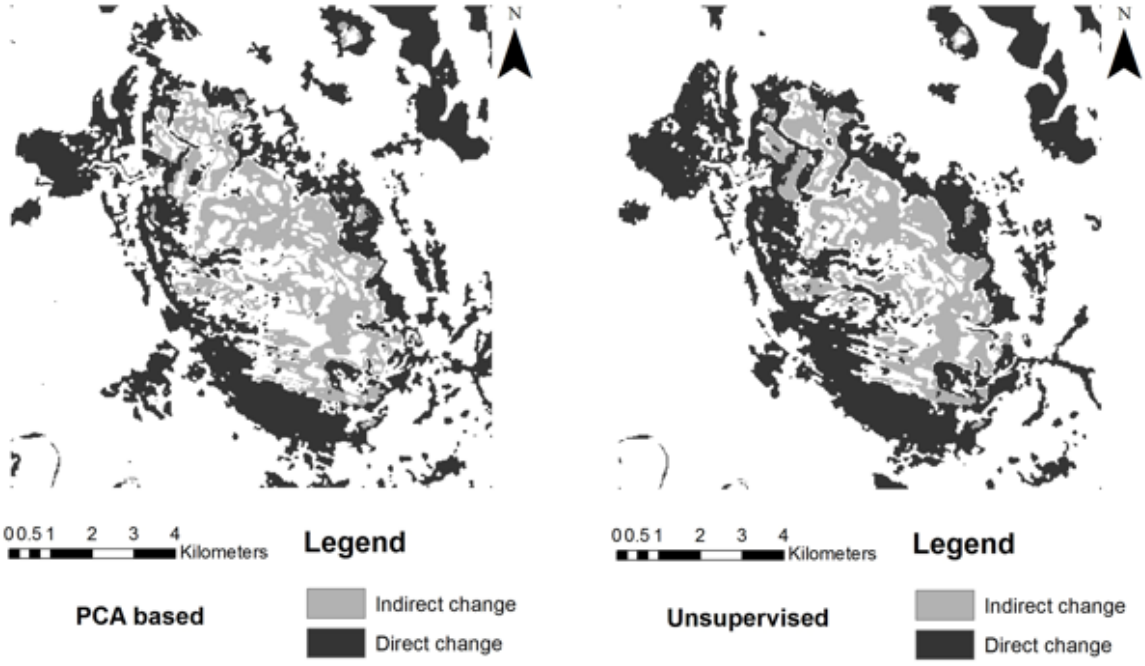

Fig: 4 – PCA based and Unsupervised Change Map of wetland area

Conclusion:

The results have revealed that classification of wetland is significantly useful in identification and quantification of wetland. PCA based classification study examined that total wetland area comprised of 5490 hectare of area under wetland in 1988 and which decreased to 2414 hectare of area under wetland in 2010. While the Unsupervised classification of wetland revealed that the total area under wetland was 5225 hectare in 1988 and that reduced to 2047 hectare in 2010. . It has been concluded that there is a slight difference between two methods but can be efficiently used to study Kanwar Lake wetland.

Kanwar Lake or Khabar Tal is considered as one of South Asia's largest freshwater lakes. Ecologically, it is one of the most important wetlands in the state, hosting 106 species of resident birds and providing a nesting ground for 59 species of migratory birds (Raksi et al., 1996). In 1986, Kanwar Lake was declared a protected area. The Kanwar Lake has been declared as an IBA (Important Bird Area) site of Bihar because of the large number of birds it harbors. Agriculture is the most important use of the wetland and the basic source of income in the area. The Union Government has notified Kanwar Lake as a wetland of national importance. The effective use of Remote Sensing and GIS techniques in wetland mapping reduces cost and enhances the accuracy. However, further research on specific wetland spots is needed for accurate inventories of wetlands and to explore the reasons why and how wetlands are changing.

References:

1. Sharma. N et al., 2012. Assessing wetland landscape dynamics in the Deepor Beel of Brahmaputra basin using geospatial tools, Asian Journal of Geoinformatics, 12:1
2. Sader, S.A., Ahl., D., and Wen-Shu, L. 1995. Accuracy of Landsat-TM and GIS Rule-BasedMethods for Forest Wetland Classification in Maine. Remote Sensing of the Environment, 53:133-144.
3. Townsend, P.A., 2001. Mapping seasonal flooding in forested wetlands using multitemporalRadarsat SAR. Photogrammetric Engineering and Remote Sensing, 67, 857–864.
4. Franke, J., Becker, M., Menz, G., Misana, S., Mwita, E. & P. Nienkemper (2009): Aerial imagery for monitoring land use in east African wetland ecosystems. IEEE- International Geosciences and Remote Sensing Symposium 2009, Cape Town, SA.
5. Saikia, P.K. and P.C. Bhattacharjee, 1987. A study of the Avifauna of DeeporBeel A Potential Bird Sanctuary in Assam. Parisah, D. and Prentice, R. C. (Eds) 1999. Wetland and Waterfowls Conservation in Asia. Asian Wetland Bureau/IWRB, Kuala Lumpur.
6. E. Teferi et al., 2010. Remote Sensing to quantify wetland loss in Ethiopia, 7, 6243–6284.
7. Bezbaruah, A., 2007. Environmental Management Fall 2007 Case Studies. http://www.ndsu.edu/pubweb/~bezbarua/em/casestudies.html#Other. (accessed on 16 Oct. 2010).
8. Singh, A., 1989, Digital change detection techniques using remotely-sensed data. International Journal of Remote Sensing, 6, 989- 1003.
9. Mulugeta, M.: Socio-economic determinants of wetland use in the Metu and Yayu-Hurumu Weredas of Illubabor Zone, in: Sustainable Management of Wetlands in Illubabor Zone, 13 December 1999, Addis Ababa, Ethiopia, 1999.
10. Ozesmi, S. L. and Bauer, M. E.: Satellite remote sensing of wetlands, Wetlands Ecol. Manage., 10, 381–402, 2002.