NDVI and NDWI based Change Detection Analysis of Bordoibam Beelmukh Wetlandscape, Assam using IRS LISS III data

Krishna Das

Department of Geography, Gauhati University
Guwahati, Assam, India- 781014
krishnageog@gauhati.ac.in

Abstract: ***This paper analyses per pixel change detection of Bordoibam Beelmukh wetlandscape located in Dhemaji district of Assam, India, which covers around 23 sq. km of geographical area. Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are the two remote sensing indices applied for change detection analysis in the study area. IRS LISS III satellite imageries with 23.5 meter spatial resolution have been used to conduct the analysis. These satellite imageries have been collected from NRSC Bhuvan portal with 5 years temporal interval (2008 to 2013). Image differencing technique has been applied to detect per pixel change using NDVI and NDWI difference image results of the wetlandscape. The study has observed per pixel change detection in five distinct categories for both NDVI and NDWI results of the study area. These are increased more than 5 percent, decreased more than 5 percent, some increase, some decrease and unchanged. In this regard, the study reveals that there is maximum change (79% to total change) in increased more than 5 percent category for NDVI, whereas for NDWI maximum change (96% to total change) is observed under decreased more than 5 percent category of the study area. It has been also observed that there are significant changes of both NDVI and NDWI values from 2008 to 2013 in the study area which in turn indicate changes of vegetation and water cover areas of the same.***

Keywords: Water use efficiency, conveyance efficiency, on farm application efficiency, CROPWAT.

1. Introduction

Change detection using satellite data is an important application of remote sensing science [18]. Remote sensing change detection involves the application of temporal satellite datasets for any region to detect changes of pixels values quantitatively [1]. Many researchers have adopted change detection analysis using IRS LISSS III data products in land use and land cover change monitoring, wetland change monitoring, agriculture and natural resources management studies, etc. [4,5,8,11,14,15]. Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are two important and most widely used remote sensing indices which involves spectral bands of multi-spectral and multi-temporal satellite datasets for vegetation, water resource, wetland studies [3,7,13,17,20].

Wetlands are important sources of natural resources [13]. Scientific monitoring of wetland resources involves wide application of remote sensing technology. In this study, an attempt has been made to adopt remote sensing methodology for pixel based change detection analysis of Bordoibam Beelmukh wetlandscape located in Dhemaji district of Assam using multispectral IRS LISS III data. The study area covers a geographical area of 23.04 sq. km. The extension of the wetlandscape is from 27°17´24´´ N to 27° 21' 36" N latitudes and from 94° 19' 12" E to 94° 20' 60" E longitudes.

2. Objectives

The main objectives of this study are-

a) to generate NDVI and NDWI maps of the study area from LISS III data of 2008 and 2013; and

b) to analyse change detection of the study area using generated NDVI and NDWI indices.

3. Database and methodology

The study is carried out using IRS LISS III geo-rectified data collected from National Remote Sensing Centre (NRSC) Bhuvan geo-portal. Bhuvan provides LISS III data into tile format with 23.5 meter spatial resolution and 4 spectral bands. From two sets of satellite data tiles (2008 & 2013), the study area has been subsetted and reprojected into

WGS84UTM 46 north projection system for further analysis.

NDVI and NDWI are the two remote sensing indices used in the study. Both these indices involve spectral bands of multispectral satellite data to map out earth's surface landscape in terms of green vegetation cover and surface water cover [13].

NDVI and NDWI have been applied to deal with the first objective of the study and also to get raster inputs for change detection analysis. The intensity of both NDVI and NDWI are categorised into three classes, viz. low, moderate and high using mean, standard deviation (S. D.) and value ranges observed from NDVI and NDWI results [19]. To deal with the second and final objective of the study, image difference technique has been applied for change detection of the wetlandscape based on NDVI and NDWI inputs of 2008 and 2013. The remote sensing analysis and statistical calculations have been carried out using ArcGIS and Erdas Imagine software packages.

I. **TABLE I**. IRS LISS III DATA SPECIFICATION

IRS LISS III tiles, year: 2008 & 2013, season: post-monsoon, resolution: 23.5 meter, projection: WGS84UTM46N.	
Band	**Wavelength (micrometer)**
B2 (green)	0.52-0.59
B3 (red)	0.62-0.68
B4 (near infrared)	0.77-0.86
B5 (mid infrared)	1.55-1.70

II. **TABLE II.** METHODS USED IN THE STUDY

NDVI= (NIR-RED)/NIR+RED), the values of NDVI range between 0 and ± 1, and negative values or values close to 0 represent surface water areas, whereas positive values or close to 1 represent healthy vegetation [6].
NDWI= (GREEN-NIR)/GREEN+NIR), the values of NDWI range between 0 and ± 1, and negative values or values close to 0 represent vegetation, whereas positive values or close to 1 represent surface water/deep water bodies [9].
Image differencing change detection technique is performed by subtracting the digital number (DN) value of a pixel in one date for a given band from the DN value of the same pixel for the same band of another date [1].

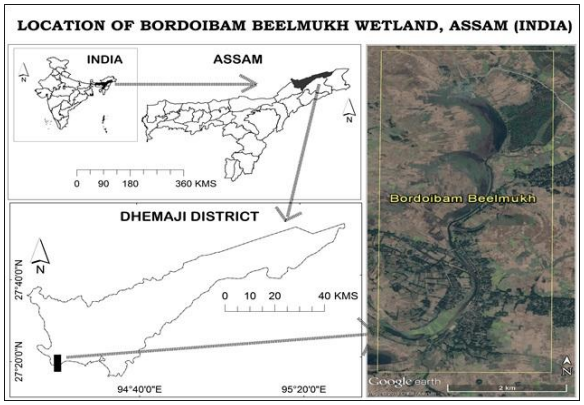

Figure.1. Location of the study area

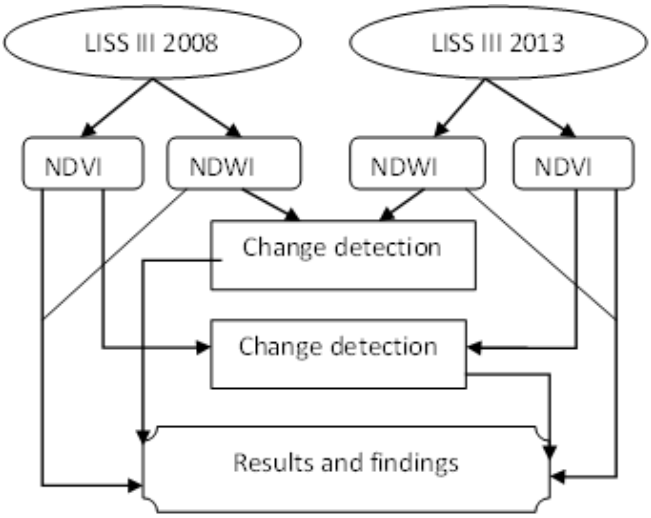

Figure. 2. IRS LISS III data of the study area

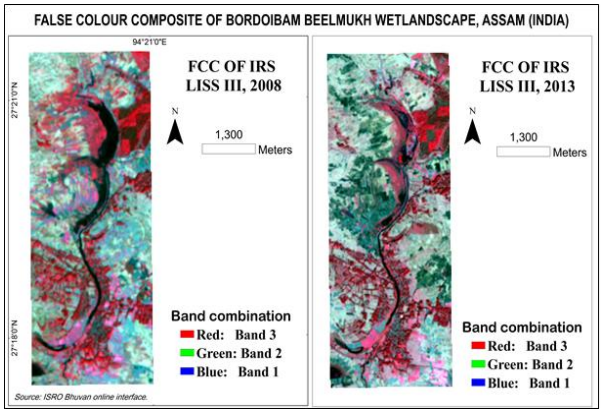

Figure. 3. Methodological procedure as adopted in the study

4. Analysis and findings

NDVI and NDWI are the two normalized indices used to depict surface landscape of the study area in gray-scale maps. Both these indices have been generated from 2008 and 2013 LISS III data of the study area. For NDVI maps of both years, white colour are assigned to depict green vegetation cover, whereas dark black colour depicts no vegetation or water pixels. On the contrary, NDWI maps depict clear open water cover in white colour, whereas no water pixels are depicted in dark black colour. The intensity of NDVI and NDWI maps are again reclassified into low (mean-S.D.), moderate (between low & high) and high (mean+S.D.) classes using the mean, standard deviation and range values (Figure 3 & 4). The NDVI value range was between -0.209 to 0.518 during 2008 in the study area, which was changed between -0.088 to 0.669 in 2013. Similarly, NDWI value range was between -0.195 to 0.521 during 2008, which was changed between -0.487 to 0.189 in 2013 (Table III). For both the indices results, highest percentage share to the total area of the study area has been observed in moderate category.

III. **TABLE III.** NDVI & NDWI STATISTICS OF THE STUDY AREA, 2008-2013

NDVI	**2008**	**2013**
Range	-0.209 to 0.518	-0.088 to 0.669
Mean	0.188	0.304
S. D.	0.119	0.113
NDWI	**2008**	**2013**
Range	-0.195 to 0.521	-0.487 to 0.189
Mean	0.058	0.226
S. D.	0.089	0.088

Change detection analyses have been done using image difference technique from generated NDVI and NDWI maps. Change detection includes five distinct categories of changes that occur per pixel wise in the changed images of NDVI (2008-2013) and NDWI (2008-2013) of the study area. These change categories include increase more than 5 % to the total mean change, decrease more than 5 % to the total mean change, some increase, some decrease and unchanged pixels (Figure 5).

IV. **TABLE IV.** NDVI & NDWI INTENSITY STATISTICS, 2008-2013

NDVI, 2008				
Class	**Pixels**	**Pixel size**	**Area (sq. km)**	**% share**
Low	4676	23.5 m x 23.5 m	2.58	11.21
Moderate	29000		16.02	69.50
High	8052		4.45	19.30
Total	41728		23.04	100
NDVI, 2013				
Class	**Pixels**	**Pixel size**	**Area (sq. km)**	**% share**
Low	3854	23.5 m x 23.5 m	2.13	9.24
Moderate	30035		16.59	71.98
High	7839		4.33	18.79
Total	41728		23.04	100
NDWI, 2008				
Class	**Pixels**	**Pixel size**	**Area (sq. km)**	**% share**
Low	5429	23.5 m x 23.5 m	3.00	13.01
Moderate	31443		17.36	75.35
High	4856		2.68	11.64
Total	41728		23.04	100
NDWI, 2013				
Class	**Pixels**	**Pixel size**	**Area (sq. km)**	**% share**
Low	5108	23.5 m x 23.5 m	2.82	12.24
Moderate	31115		17.18	74.57
High	5505		3.04	13.19
Total	41728		23.04	100

In NDVI based change detection, maximum change is observed under increased more than five percent category (79.39%) and minimum change is observed under some decrease category. On the contrary, in NDWI change detection maximum change (96.29%) has been found under decreased more than 5 percent category and minimum is observed under some increase category (Table V).

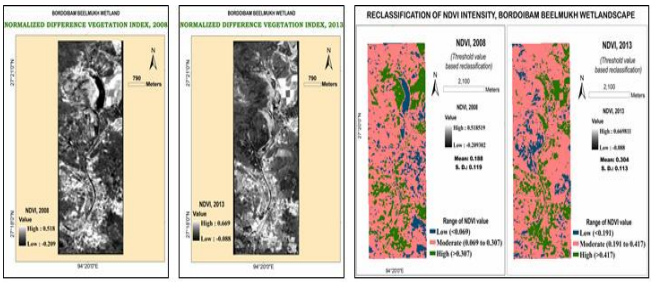

Figure. 3. NDVI maps of the study area, 2008-2013

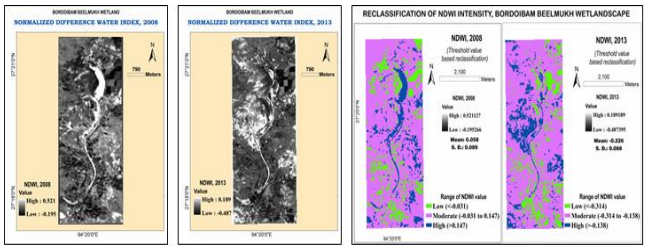

Fig. 4. NDWI maps of the study area, 2008-2013

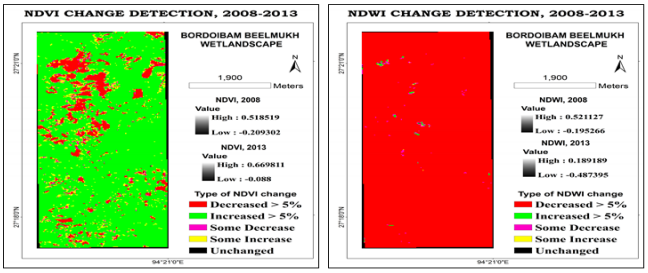

Fig. 5. NDVI & NDWI based change detection of the study area, 2008-2013

V. TABLEV. CHANGE DETECTION STATISTICS OF THE STUDY AREA, 2008-2013

NDVI based change (2008-13)				
Category	**Pixels**	**Area (sq. km)**	**Area (hectare)**	**% share**
Decreased	3803	2.1	210.02	9.11
Some Decrease	783	0.43	43.24	1.88
Some Increase	2737	1.51	151.15	6.56
Increased	33127	18.29	1829.44	79.39
Unchanged	1278	0.71	70.58	3.06
Total	41728	23.04	2304.43	100

NDWI based change (2008-13)				
Category	**Pixels**	**Area (sq. km)**	**Area (hectare)**	**% share**
Decreased	40178	22.19	2218.83	96.29
Some Decrease	177	0.1	9.77	0.42
Some Increase	16	0.01	0.88	0.04
Increased	82	0.05	4.53	0.2
Unchanged	1275	0.7	70.41	3.06
Total	41728	23.04	2304.43	100

5. Conclusion

The study has observed NDVI and NDWI based change detection of Bordoibam Beelmukh wetlandscape, Assam using LISS III data from 2008 to 2013. NDVI and NDWI are the two normalized remote sensing indices applied in this study. These indices are opposite to each other in terms of map-results they provide. It has been observed that there are significant vegetation and water cover areas changes from 2008 to 2013. The NDVI and NDWI maps depict the same. Another important observation from change detection analysis results is that NDVI change has showed maximum pixels under increased change category in the study area and the same category of change has minimum pixels in case of NDWI change detection results. In this regard, it is found that both the indices have provided accurate results of change detection of the study area. Finally, the entire study has been found very effective using remote sensing technology.

References

[1] Afify, Hafez A. "Evaluation of change detection techniques for monitoring land-cover changes: a case study in new Burg El-Arab area." Alexandria Engineering Journal 50.2 (2011): 187-195.

[2] Al-doski, J., Mansor, S., & Shafri, H. "Change Detection Process and Techniques." Civil and Environmental Research, 3.10 (2013): 37–46.

[3] Ashraf, Mohammad, and Rabeya Nawaz. "A Comparison of Change Detection Analyses Using Different Band Algebras for Baraila Wetland with Nasa's Multi-Temporal Landsat Dataset." Journal of Geographic Information System 7.01 (2015): 1.

[4] Chatterjee, Chandranath, Rakesh Kumar, and Pankaj Mani. "Delineation of surface waterlogged areas in parts of Bihar using IRS-1C LISS-III data." Journal of the Indian Society of Remote Sensing 31.1 (2003): 57-65.

[5] Das, S. "Urban Landuse / Land-Cover Change Detection Analysis of Aurangabad City Using Geoinformatics Techniques." International Journal of Scientific and Research Publications, 2.9 (2012): 1–5.

[6] Fuller, D. O. "Trends in NDVI time series and their relation to rangeland and crop production in Senegal, 1987-1993." International Journal of Remote Sensing 19.10 (1998): 2013-2018.

[7] Ji, Lei, Li Zhang, and Bruce Wylie. "Analysis of dynamic thresholds for the normalized difference water index." Photogrammetric Engineering & Remote Sensing 75.11 (2009): 1307-1317.

[8] Kavyashree, M. P., and H. Ramesh. "Wetland Mapping and Change Detection Using Remote Sensing and GIS." International Journal of Engineering Science 2356 (2016).

[9] McFeeters, Stuart K. "The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features."

International journal of remote sensing 17.7 (1996): 1425-1432.
[10] Macleod, Robb D., and Russell G. Congalton. "A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data." Photogrammetric engineering and remote sensing 64.3 (1998): 207-216.
[11] Mallupattu, Praveen Kumar, and Jayarama Reddy Sreenivasula Reddy. "Analysis of land use/land cover changes using remote sensing data and GIS at an Urban Area, Tirupati, India." The Scientific World Journal 2013 (2013).
[12] Melorose, J., Perroy, R., & Careas, S. "Unsupervised change detection." Statewide Agricultural Land Use Baseline. 1.3 (2015): 1863–1866.
[13] Ministry of Environment and Forests (2011). National Wetland Atlas. Indian Space Research Organization, Government of India.
[14] Nandy, S., and S. P. S. Kushwaha. "Study on the utility of IRS 1D LISS-III data and the classification techniques for mapping of Sunderban mangroves." Journal of Coastal Conservation 15.1 (2011): 123-137.
[15] Panhalkar, S. S., & Pawar, C. T. "Change Detection Analysis of Hiranyakeshi Basin Using Multi- Temporal Remote Sensing Data and Geoinformatic Technique." International Journal of Research Studies in Science, Engineering and Technology, 1.2 (2014): 1–6.
[16] Panigrahy, Rabindra K., et al. "Forest cover change detection of Western Ghats of Maharashtra using satellite remote sensing based visual interpretation technique." Current Science 98.5 (2010): 657-664.
[17] Rokni, K., et al. "Water Feature Extraction and Change Detection Using Multitemporal Landsat Imagery. Remote Sensing, 6, 4173-4189." (2014).
[18] Xu, Lu, et al. "The comparative study of three methods of remote sensing image change detection." 2009 17th International Conference on Geoinformatics. IEEE, 2009.
[19] Somvanshi, S., et al. "Water turbidity assessment in part of Gomti River using high resolution Google Earth's Quickbird satellite data." Geospatial World Forum. 2011.
[20] Veettil, B. K. "A Comparative study of urban change detection techniques using high spatial resolution images." Proceedings of the 4th GEOBIA, Rio de Janeiro, SP, Brazil (2012): 7-9.
[21] http://bhuvan.nrsc.gov.in/data/download/index.php