ISSN 2250-3153

Characterization and Mapping of Inland Wetland: A Case Study on Selected Bils on Nadia District

Ratnadeep Ray*, Sakti Mandal, Arijit Dhara*****

* Lecturer, Department of Remote Sensing and GIS, Vidyasagar University, Midnapore (west), West Bengal, India
** PhD Research Scholar, Department of Geography, University of Calcutta, West Bengal, India,
Email Id: tomblo.sakti@gmail.com
***Ex Student, Department of Architecture, Town and Regional Planning Bengal Engineering and Science University, Shibpur, West Bengal

Abstract: Sustainable management of wetland ecosystem is necessary as it serves the important functions such as food storage, water quality maintenance and providing habitat for different species of wildlife. Hence an inventory of wetlands in any given area is a pre-requisite for their conservation and management. Here a study has been carried out to delineate the characteristics of inland-wetland of Nadia district of West Bengal using LANDSAT ETM+ and LANDSAT TM data for the year of 2000 and 2010.The data have been analyzed and qualitatively characterized based on the turbidity and aquatic vegetation status. Two kinds of wetlands have been delineated like ponds and ox-bow lakes. From the analysis it has been observed that inland wetlands constitute 5.7% of the study area and here the ox-bow lakes are locally named as 'Bils'. Thus this study highlights the usefulness of Remote Sensing data and DIP techniques for wetland mapping and characterization.

Index Terms: Wetlands, Turbidity Status, Aquatic Vegetation

I. 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, sociologists, politicians, and economists to conserve and preserve the natural resources of the world. One of the constraints most frequently faced for decision making is lack of scientific data of our natural resources. Often the data are sparse or unauthentic, rarely in the form of geospatial database (map), thus open to challenges. Hence, the current emphasis of every country is to have an appropriate geospatial database of natural resources based on unambiguous scientific methods.

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.

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 relate the feature to any given geographical location has 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) topographical 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 recognised as an essential tool for viewing, analyzing, characterizing, and making decisions about land, water and atmospheric components. From a general perspective, remote sensing is the science of acquiring and analyzing information about objects or phenomena from a distance (Jensen, 1986; Lillesand and Keifer, 1987).

Today, satellite remote sensing can be defined as the use of satellite borne sensors to observe, measure, and record the electromagnetic radiation (EMR) reflected or emitted by the earth and its environment for subsequent analysis and extraction of information. EMR sensors includes visible light, near-, mid- and far-infrared (thermal), microwave, and long-wave radio energy. The capability of multiple sources of information is unique to remote sensing. Of specific advantage is the spectral, temporal, and spatial resolution. Spectral resolution refers to the width or range of each spectral band being recorded. Since each target affects different wavelengths of incident energy differently, they are absorbed, reflected or transmitted in different proportions.

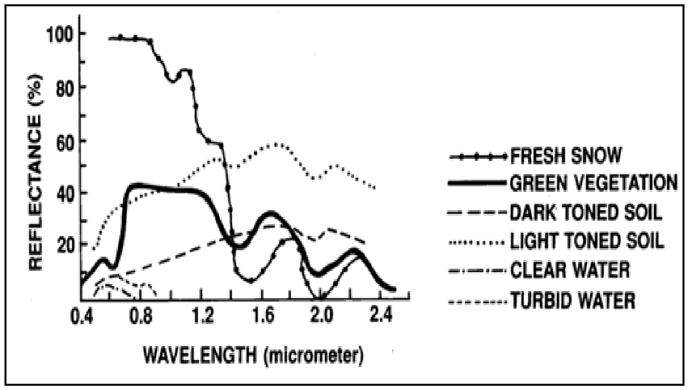
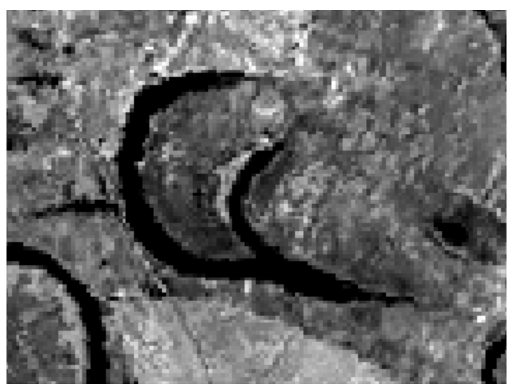


Figure 1: Spectral Signatures of various targets

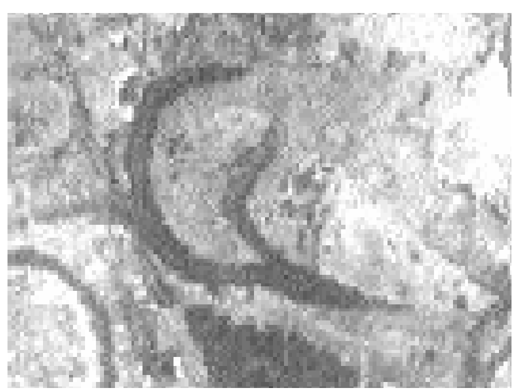
Currently, there are many land resource remote sensing satellites that have sensors operating in the green, red, near infrared and short wave Infrared regions of the electromagnetic spectrum giving a definite spectral signature of various targets due to difference in radiation absorption and reflectance of targets. These sensors are of common use for land cover studies, including wetlands**.** Figure 1 shows typical spectral signature of few targets from green to SWIR region. Converted to image, in a typical false color composite (FCC) created using NIR, red and green bands assigned as red, green and blue color, the features become very distinct as shown in Figure 2. In FCC, the vegetation thus appears invariably red (due to high reflection in NIR from green leaves).

FCC (4-3-2)



Band - 4

Band -3



Band -2

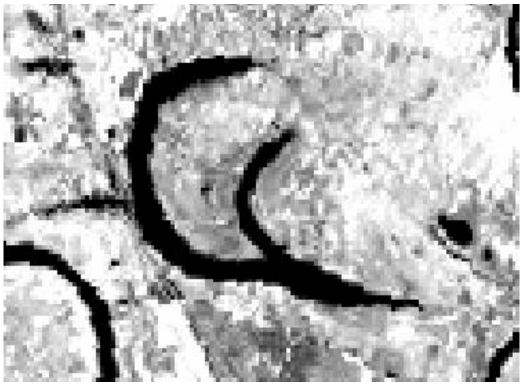


Figure 2: various land features as they appear in four spectral bands and in a typical three band FCC.

Band - 5

II. Objective of the Study:

To make an inventory of wetlands in an area this will enable us to monitor the changes that are occurring due to human interference over a period of time. In some of the earlier studies remote sensing techniques were used for deriving information on the quantitative and qualitative status of wetlands(Carpenter & Carpenter,1983; Munity.et.al,1988;Polria.et.al,1994;Wani.et.al,1996;Chopra.et.al,1999). Most of these studies have focused on individual wetlands. Here four ox-bow lakes have been considered like HansadangaBil, BhalukaBil, AlokanandaBil, and NoaparaBil. Thus an overall estimate off the condition of the wetlands over large area is useful for conservation of wetlands. Garg.et.al (1998) has carried out the study to delineate wetlands of a number of districts across India using IRS-1A LISS III data. This study was carried on a large scale. Only the wetlands of the area greater than 65 hectare were mapped on 1:25000 scales. However an overall estimate off the condition of wetlands over a large area at higher resolution is useful for wetland management. Conservation of wetland is essential because of its productive and retentive uses such as supplementing human dietary requirements, ecological significance in terms of flood control, water purification, aquatic productivity and micro-climate regulation. Realizing the importance of wetlands the present study was taken up with the specific objective of delineation and characterization of wetlands in terms of turbidity and aquatic vegetation using digital image processing techniques. The seasonal variation of the water spread for the mapped wetlands was also carried out. These are extremely important habitats for many species of migratory birds.

1. Material Used:

I. Digital Data	LANDSAT TM(path/row: 138 / 44 Date: 15/03/2011)
III. Software Used	• ERDAS Imagine 2011 • Arc GIS 9.3 • TNT Mips Pro

III. Study Area

Nadia is situated between 22º53’ and 24º11’ North latitude and 88º09’ and 88º48’ East longitude and about 390027 Sq.k.ms. in Area, this District is linear in shape with orientation of North-South. The District is Approximately 46 ft. above the mean sea level. The Tropic of cancer divides the district in two parts. The geographical boundary of Nadia district comprises Bangladesh in the East, Bardhaman and Hugli district on the West, Murshidabad district on the North and North West and North 24 Parganas towards South and South East. We have taken Krishnanagar block, Krishnanagar block2, Nabadwip as our study area in the Nadia district of West Bengal. Taken the 4 bils namely-Bhalukabil, Hansadangabil, Noaparabil, and Alokanandabil and acquired them from the satellite imageries using IRS-1A LISS II data. Situated on the main rail route connecting Howrah/Kolkata and New Jalpaiguri (NJP) including parts of North Eastern states, the Nadia district can easily be accessed by rail. The major railway stations are NabadwipDham, Ranaghat and others with regular trains to Kolkata/Howrah/NJP/Guwahati. The proposed International Rail Link connecting India and Bangladesh will pass through Nadia District with Gende as the last railway station at Indian Border. Bifurcated by National Highway-34 on the North and East, the district can also be accessed by road from other parts of the country.

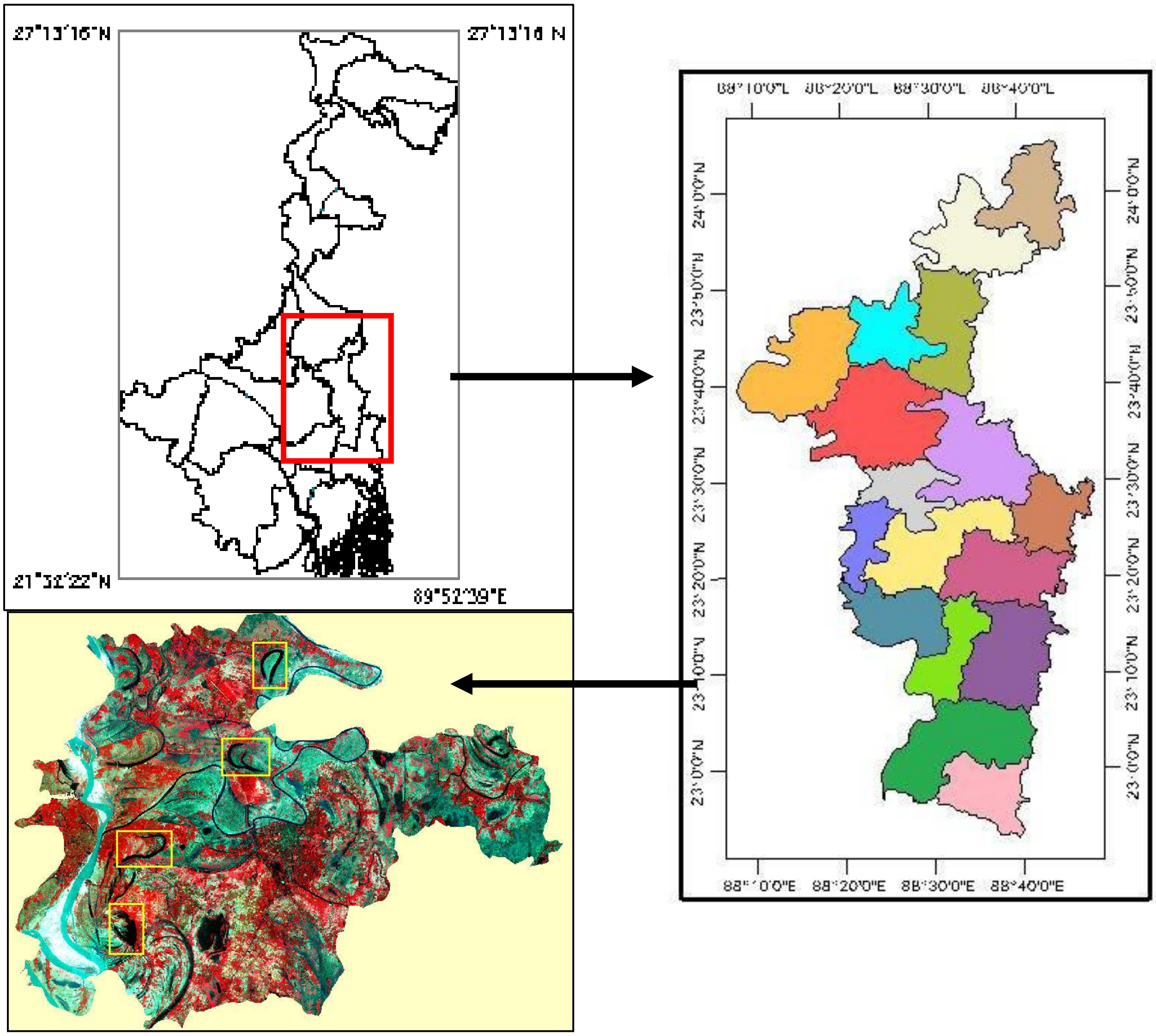


Figure 3: Location map of the study area

IV. METHODOLOGY:

The methodology for inland wetland characterization the NWIA Technical Guidelines and the Procedure Manual has been followed.

The overview of the steps and the salient features of the methodology adopted are:

1. Generation of spatial framework in GIS environment for database creation and organization.
2. Geo referencing of satellite data and required pre-processing.
3. Identification of wetland classes as per the NRSC LULC and NWIA Manual and mapping of the classes using an object-based digital classification process.
4. Coding of the wetlands following the standard system and codification as per NWIA Manual.
5. Preparation of Thematic layers and generation of statistics.

All of these works have been carried out using ERDAS Imagine & TNT Mips software's.

For mapping and delineating the inland wetlands some image analysis techniques vis-à-vis band algebra techniques like Image Transformation, Band Combination, Digital Indexing etc. have been used.

The delineation of wetlands through image processing forms the foundation for deriving all wetland classes and results Consequently, a great deal of emphasis have been placed on the quality of image interpretation. There are various methods for extraction of water information from remote sensing imagery which according to number of bands used are generally divided into two categories that means single band and multiband methods. Single band methods usually involve choosing a band from multispectral image to distinguish the water from land by subjective threshold values and multiband method takes advantage of reflective differences of each band. Besides these, different kinds of the digital indices can also be used for this purpose like MNDWI, NDPI, NDTI, NDVI etc.

1. Normalized Difference Water Index (NDWI) = (Green-NIR) / (Green + NIR)

2. Modified Normalized Difference Water Index (MNDWI) = (Green-MIR) / (Green + MIR)

3. Normalized Difference Vegetation Index (NDVI) = (NIR - Red) / (NIR + Red)

4. Normalized Difference Pond Index (NDPI) = (MIR – Green / MIR + Green)

5. Normalized Difference Turbidity Index (NDTI) = (Red – Green) / (Red + Green)

These indices have been combined to identify the wetland features like characteristics and extensions. Besides these the spectral curve analysis also helps us to delineate the wetland nature. And last of all, the digital statistics will be extracted and analyzed for the partial fulfillment of the study. Various digital image processing techniques such as thresh holding, spectral indices analysis, classification etc. are available for delineating the water bodies (Nagarjan.et.al,1993 ; Sharma.et.al,1996).In the present study thresh holding technique was adopted. This thresh hold is a technique were the entire grey value were occurring in the image are divided into a series of analyst specified intervals. All the grey values falling within a range are grouped in one grey value which is displayed in output. The process divides the image into water and land pixels. From the study of histogram peaks minimum and maximum value for water pixels is identified and image is density sliced. Thresh holding can be performed on single or combination of bands. The near infrared band of the concerned digital data is used for delineating the water bodies in the study as the spectral signature of the water are clearly separable from other signatures. Hence the NIR band is used and is density sliced interactively with study area FCC such that the pixels having grey values corresponding only to the water bodies are identified. From this water body mask of the wetlands corresponding FCC have been extracted using the routine function of DIP software for further digital analysis.

These different kinds of indices approaches are basically used for qualitative assessment of the wetlands in terms of turbidity status and aquatic vegetation concentration. The wetland water quality has to be maintained in order to sustain the wetland ecosystem. Often the turbidity level in any wetland is indicative of the quality of the water in it. In the present study the inland wetlands are characterized in terms of their turbidity level as it is important for wetland conservation. The red band of the concerned digital data is found to be very useful for turbidity classification as the spectral reflectance characteristics of the pure and turbid water are clearly separable in this wavelength range. The NDTI is useful for this kind of mapping which is analyzed over here.

The aquatic vegetation in the wetland is an indicator of the trophic status of the wetland which has a bearing on the water quality. Thus the excessive presence of aquatic vegetation viz. the eutrophication not only deteriorates the water quality but also affects the stability of the ecosystem. Therefore it is also essential to monitor the level of aquatic vegetations in a wetland at regular intervals and for this kind of study the NDVI technique has been adopted over here to assess the qualitative status of aquatic vegetation in the wetlands.

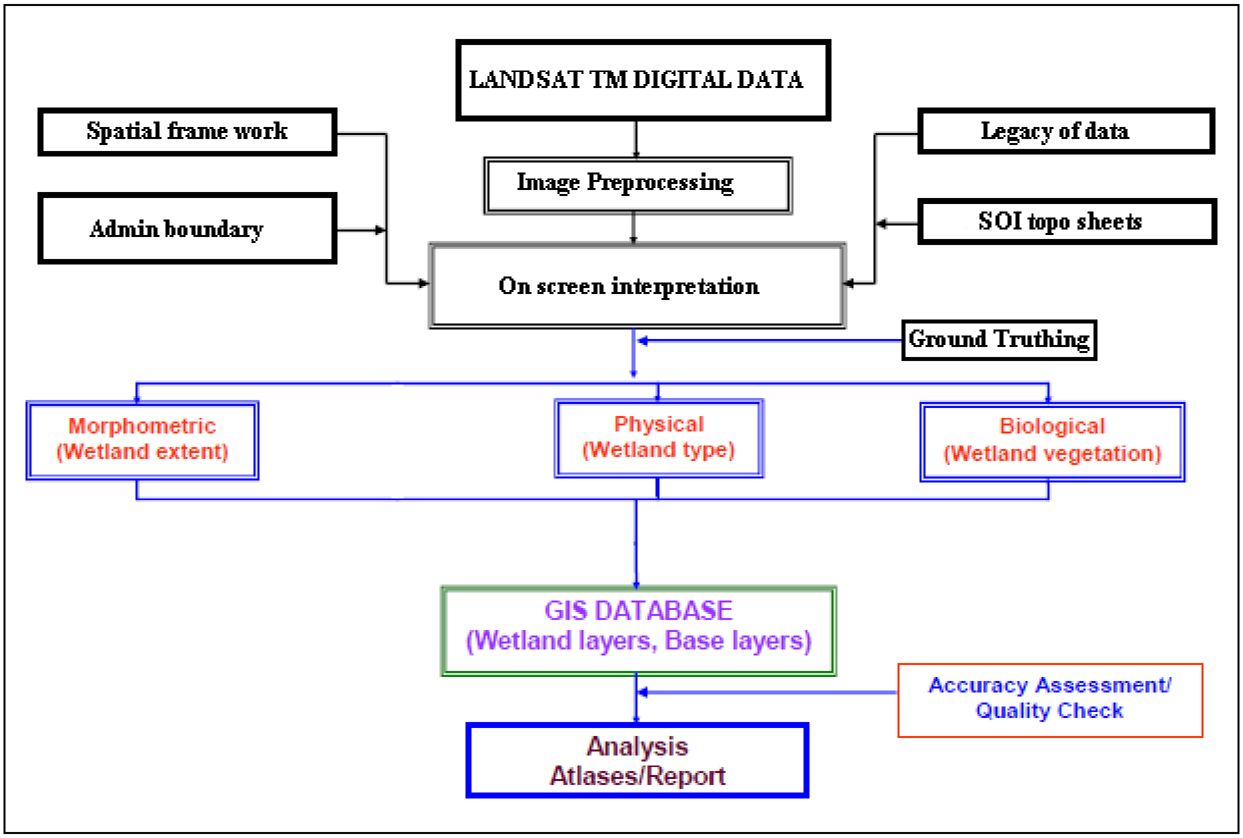


Figure 4: Flow chart of methodology used

V. Result and Discussion:

5.1. Turbidity Status for different Wetlands:

Multispectral satellite data provides invaluable synoptic data on the dynamics of wetlands such as turbidity and aquatic vegetation. The turbidity levels for the different wetlands of Nadia district have been qualitatively characterized into three levels namely, low, medium and high. It is observed that as much as 93.79% of the area is under moderate to high turbidity. The post-monsoon turbidity patterns for the different wetlands is shown in the turbidity levels are found to be tower for the oxbow lakes as compared to the other wetlands. The turbidity levels are found to be higher in the post monsoon data. The percentage of area under medium and high turbidity has gone up significantly, while that under low turbidity has reduced to 6%. The increased turbidity level in the post monsoon data is attributed to the sediments and silt that have been transported into the wetlands along with runoff water. Here using Transect Extraction Technique Reflectance curves are generated for each of these four water body FCCs. After that the Reflectance curves are analyzed for the gradation of bils according to its turbidity level. The turbidity natures of the bils are discussed underneath-

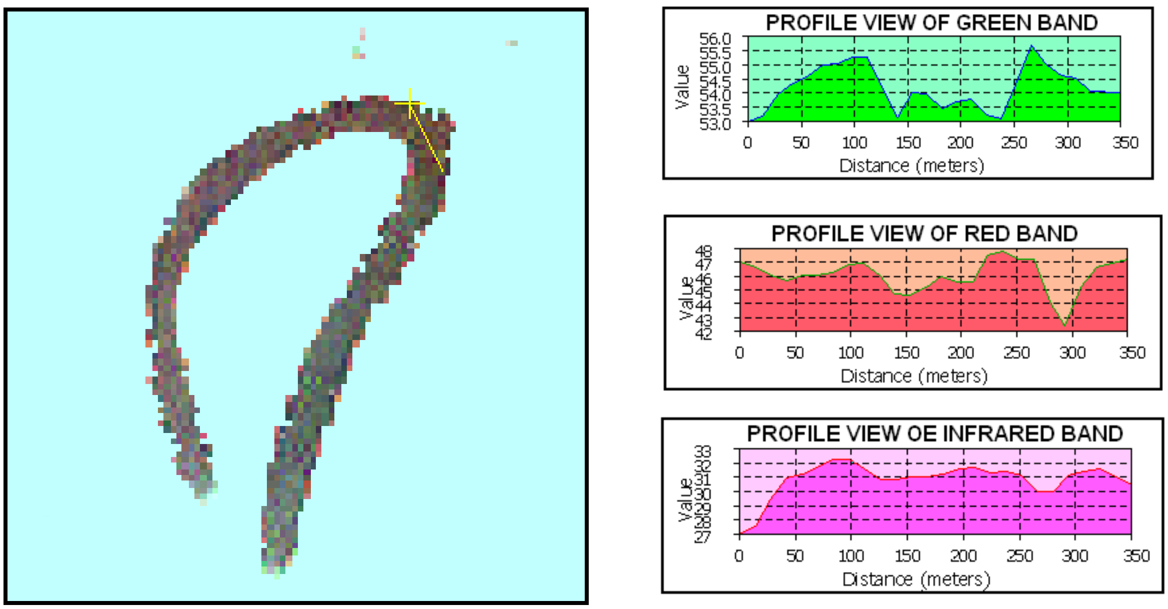


Figure 5: Profile view of NoaparaBil

In case of Noaparabil at krishnanagar II the profile view shows this reflectance curve. So we can state that where red reflectance is so less than the infrared reflectance and the green reflectance is so high than the others. On the basis of these we can say that the turbidity level as well as the eutrophication rate is high over here.

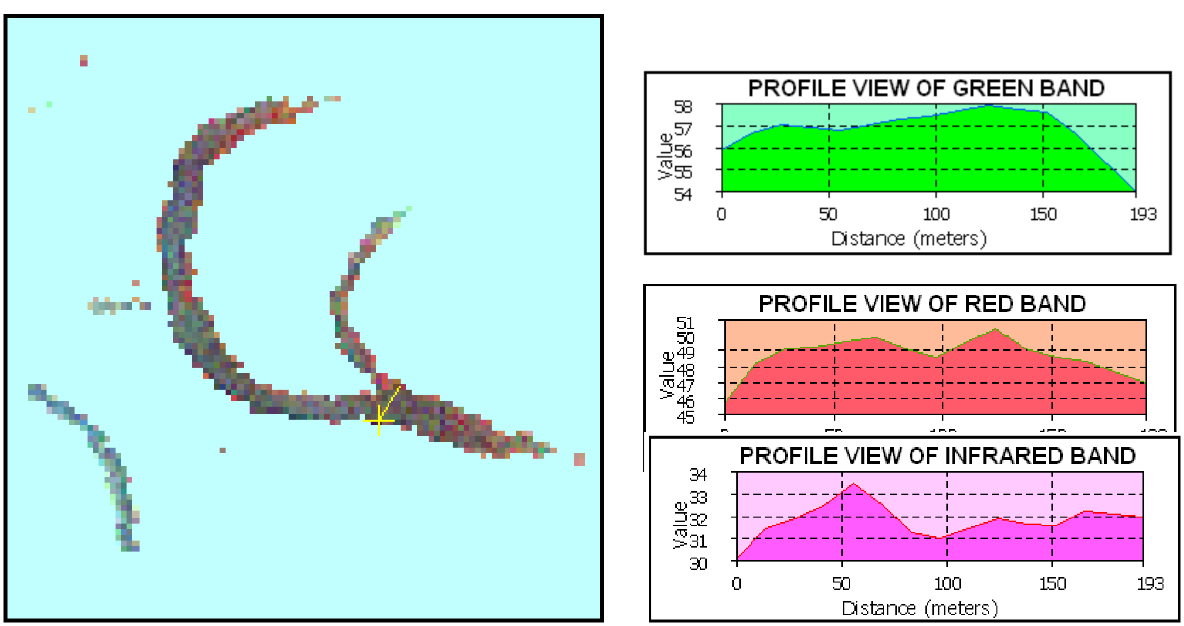


Figure 6: Profile view of HansadangaBil

But in case of Hansadangabil at krishnanagar –II the profile shows that the green, red and infrared reflectance are so high in a part and on the another part infrared is low than the otters two, so we can state that here the concentration of aquatic flora is high but the chlorophyll concentration is low, cause of insufficient oxygen.

In case of Alokanandabil at Krishnanagar –I the profile view shows the infrared reflectance is high than the red and green reflectance curve. So we can state that the turbidity level and eutrophication rate is high in this area.

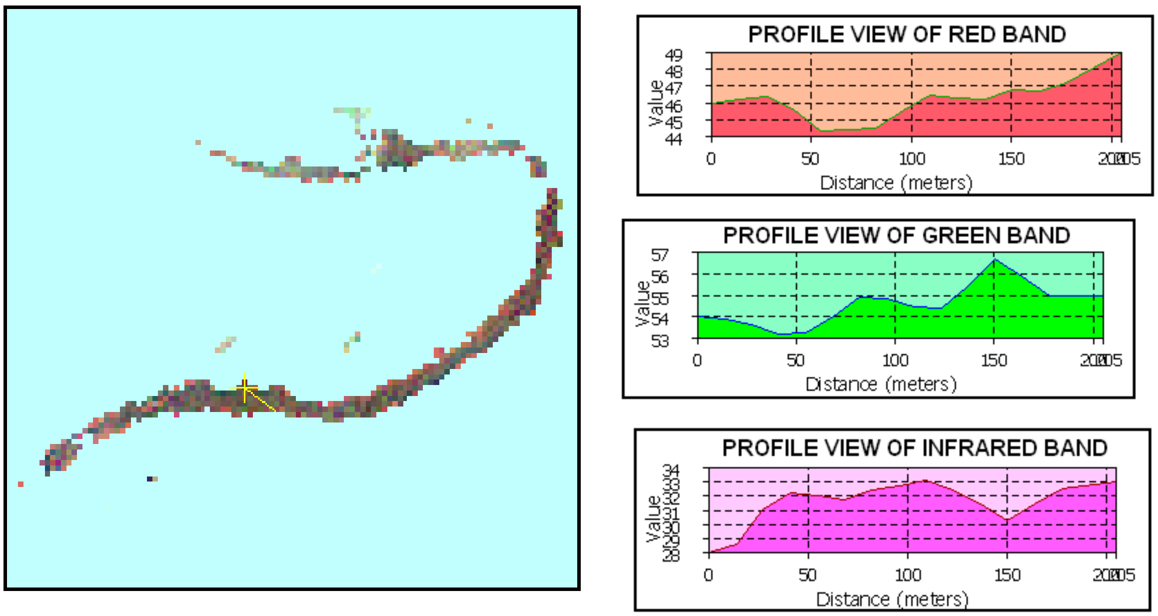


Figure 7: Profile view of AlokanandaBil

But in case of bhalukabil at Nabadwip the profile view shows that at the beginning the high reflectance of infrared shows clear type of water but just after that high red reflectance shows the medium turbidity level of water.

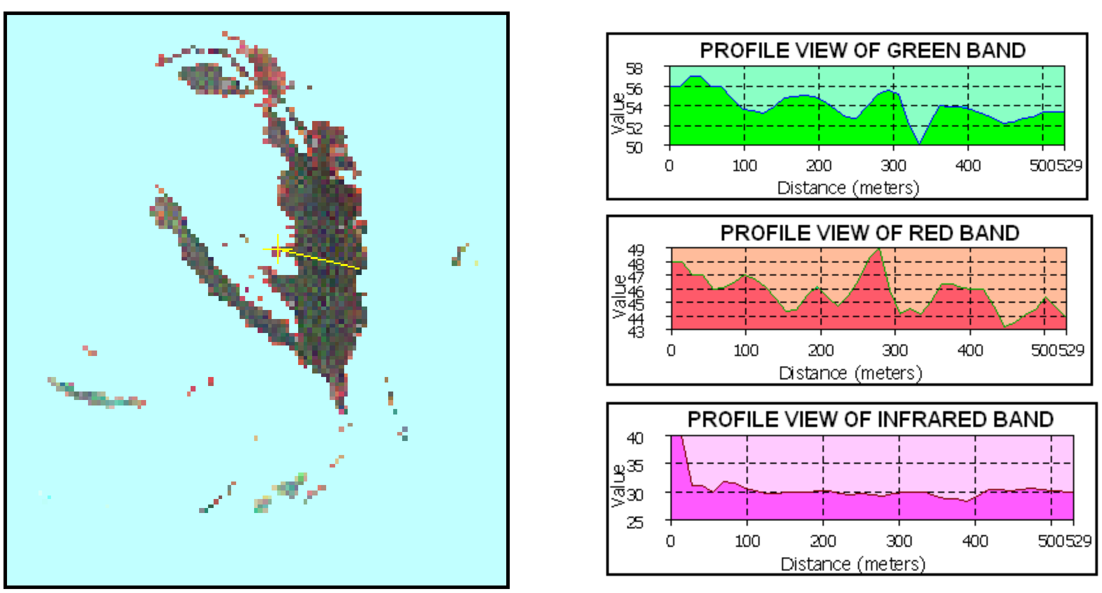
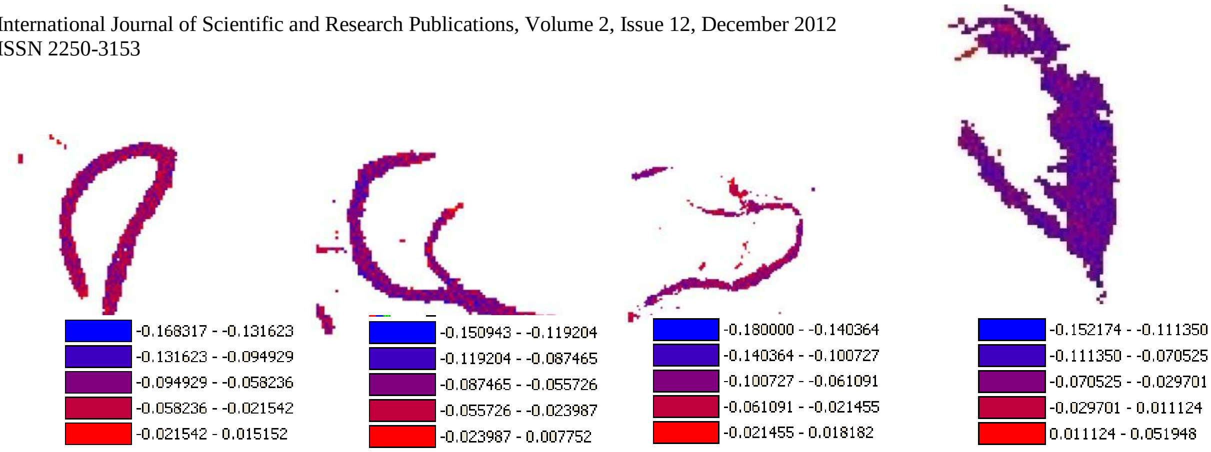


Figure 8: Profile view of BhalukaBil

Except the investigation of spectral characteristics the NDTI can also helps us to characterize the wetlands according to the turbidity level. Higher the index value, higher will be the turbidity level and if the NDTI raster is compared with the spectral profile, at the spectral trough the higher value will be seen.

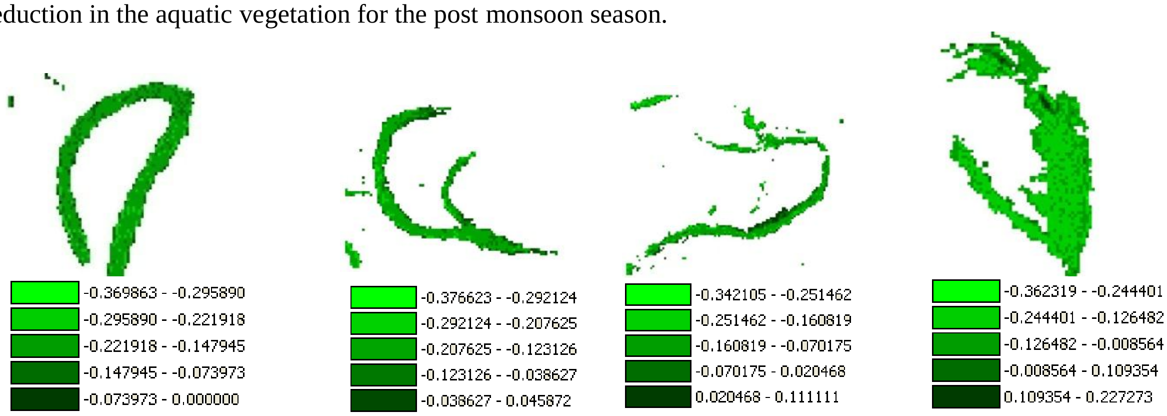


Noaparabil **Hansadangabil** **Alokanandabil** **Bhalukabil**

Figure 9: NDTI of selected bils

6.2. Qualitative Status of Aquatic Vegetation:

The post - monsoon aquatic vegetation distribution for different wetlands which clearly shows that nearly 87% of the area of wetland corresponding to low vegetation density category. High vegetation density coverage is found to be around only about 5% of the wetland area. It is seen that the level of aquatic vegetation is higher for the oxbow lakes as compared to other wetland types. Thus, a high level of aquatic vegetation density would indicate the possibility of the water being eutrophic. This may be attributed to the excessive growth of aquatic vegetation caused by excess input of organic and inorganic nutrients into a wetland. The percentage of area under low vegetation has gone up substantially in the post monsoon season. The percentage of area under medium vegetation has reduced by more than half and that under high vegetation has marginally gone up. Thus, the overall picture seems to indicate a reduction in the aquatic vegetation for the post monsoon season.



NoaparabilHansadangabil AlokanandabilBhalukabil

Figure 10: NDVI of selected bils

In the present study (AlakanandaBil, HansadangaBil, Bhalukabil, NoaparaBil) are selected as sample site and on the basis of the NDVI values the aquatic vegetation. The NDVI value is ranging from 0-1 and which is segregated in 5 categories. Among which the clear water is demarcated by the volume of 0.0, the moderately turbid (having the concentration of aquatic vegetation) water is demarcated by the value of -0.36, and as it is tending towards 1, the vegetative content is getting high, as per the output 0 for both of Noaparabil and Hansadangabil, 0.1 for Alokanandabil and 0.22 for Bhalukabil.

Besides if we use the indices like MNDWI, NDPI and NDTI as different band and follow the band combination technique we can also qualitatively assess the bils.

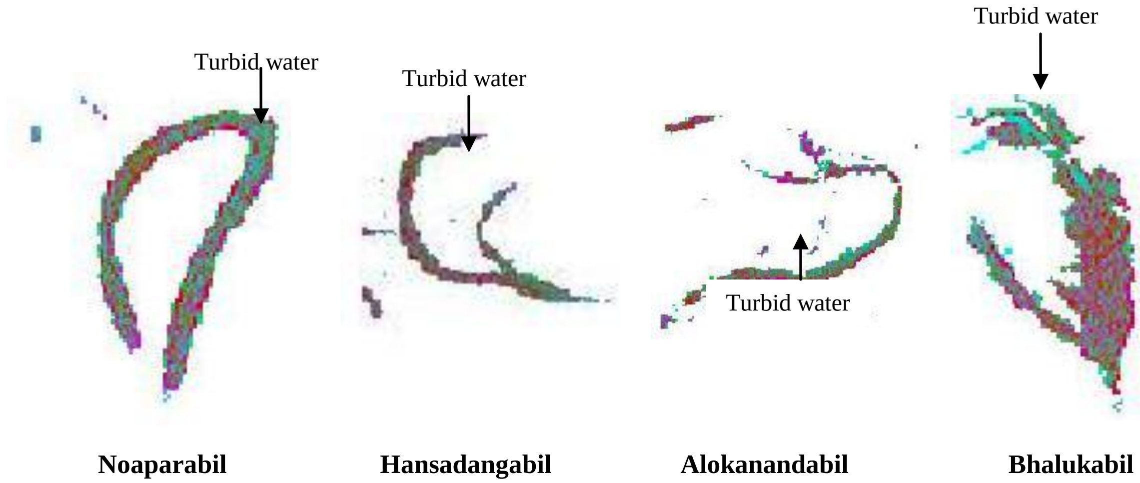


Figure 11: Combination of different indices (MNDWI-NDPI-NDTI) to characterize the selected bils

VI. CONCLUSION:

In the present study, delineation and characterization of wetlands was carried out using digital image processing techniques. The spatial and temporal characteristics of wetlands in terms of turbidity and aquatic vegetation could serve as guiding tool, in conservation prioritization of wetlands. Specifically, the spatial distribution of aquatic vegetation in terms of different density levels gives an indication of the trophic status of the area concerned. Thus, periodic monitoring of wetlands for large administrative units like districts will efficiently bring out the changes in water spread and quality parameters for adopting necessary conservation measures. Moreover it could pave the way for a detailed assignment of the problem in a relatively shorter duration.

References:

1. Carpenter, D.J. and Caipemer. S.M. (9SJ|. Modelling inland water quality using Landsat data. Remote Sensing Environment.". 13; 345-352.
2. Chopra, R, Verma, V.K. and Sharma.PK. (1999). Mapping, monitoring and conservation of Harike ecosystem, Punjab. India, through remote sensing. Int. J Remote Sensing;-18: I637-1651.
3. Wetlands of India. Scientific Note: RSAM/SAC/ RESA/PR/01/98. Space Applications Centre, Ahmedabad, India.
4. Hollis, G E. and Acreman, M. C. (1994). The functions of wetlands with inintegrated river basin development: international perspectives. In: integrated River
5. Basin Development (Eds.: C. Kirby and W. R. White) Wiley, Chichcster pp. 351-365.
6. Loveland, T.R., Merchant, J.W. Ohlen, D.O. and Brown, J.R (1991).
7. Development of a land cover characteristics database for the conterminous U.S. Photogrammetric Engg. & Remote Sensing, 57:! 453-1463.
8. Murthy, T.V.R, Muley, M.V., Chakraborty, M., Tarnilarasan, V. Amminedu,
9. E., Mehar Baba, .G, krishnan, A. and Rama Krishna, S. (1988). Water quality studies .in the Chilka Lake using LANDSAT data. .Workshop of "remote sensing applications in water resources management. Bhubaneswar.
10. Nagarajan, R., Marathe, G.T and Collins, WG (1993). Identification of flood prone regions of Tapti river using temporal remotely sensed data. Int. J. Remote Sensing,14 (7): 1297-1303.
11. Palria, S., Singh, T. C., Chakraborty, M., Tamilarasan. V and Chaws, MA. (1994). Mapping of turbidity levels and aquatic vegetation in the Wular Lake using IRS-1A data.Proc. ISRS Silver Jubilee Symposium, 1994-95.
12. Perry. C. and Lautcnschlager, L. {1984) Functional equivalence of spectral vegetation indices. Remote Sensing Environ.. 14. 169-182.
13. RRSSC (2000).Manual for mapping of inland wetlands. RRSSC. Dehradun, India
14. Sharma; P.K., Chopra, R., Verma. V.K. and Thomas, A, (1996). Flood management using remote sensing technology: !he Punjab (India) experience. Inf. J. Remote Sensing,17{17): 3511-3521.
15. Tucker, C.J. and Sellers, P.J. (1986).Satellite remote-sensing of primary production, int. J. Remote Sensing. 7: 1395-1416.
16. Tucker, C. (1979). Red and photographic near infra-red linear combination for monitoring green vegetation. Remote Sensing Environ, 8: 127-150.
17. Wani MM - Choubey, V.K. and Joshi, H. (1996). Quantification of suspended sediments in Dal Lake, Srinagar using Remote Sensing Technology. J. Indian Soc. Remote Sensing, 24; 25-32.

Author

First Author:
Ratnadeep Ray , M.sc in Remote Sensing and GIS, Lecturer, Department of Remote Sensing and GIS, Vidyasagar University, Midnapore (west), West Bengal, India, Email Id: ratnadiprsgis@gmail.com

Second Author:

Sakti Mandal, M.sc in Geography, PhD Research Scholar, Department of Geography, University of Calcutta, West Bengal, India, Email Id: tomblo.sakti@gmail.com

Third Author:
Arijit Dhara, M.sc in Geography and M.sc in Town and Regional Planning, Email Id: arijit.dhara27@gmail.com

Corresponding Author:
Name: Sakti Mandal,
Email Id: tomblo.sakti@gmail.com
Phone Number: 09804302153