International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 7 No. 1 July 2014, pp. 353-365

http://www.ijias.issr-journals.org/

Assessment of Chalan *beel* Ecosystem Diversity through Remote Sensing and Geographical Information Systems

Md. Abu Sayeed[1], Shaharior Hashem[2], M. A. Salam[2], Mostafa Ali Reza Hossain[3], and M. A. Wahab[4]

[1]Department of Fisheries Technology and Quality Control, Sylhet Agricultural University, Sylhet-3100, Bangladesh

[2]Department of Aquaculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[3]Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[4]Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ABSTRACT: Chalan *beel,* the largest natural depression in Bangladesh is under threat due to population pressure, over exploitation, change of water courses, pollution and siltation. Therefore, a study was conducted to assess the habitat and biodiversity status in dry and wet seasons through MODIS AQUA 250 m images and Geographical Information Systems supported by field data from July 2010 to June 2012. The MODIS data of 2002 and 2008 were collected and analyzed to perceive the water availability, extend of water area and variety of fishes found round the year. The False Colour Composite images of blue, near infra-red and mid infra-red bands and Normalized Difference Vegetation Index of 2002 and 2008 were prepared to perform the land use and land cover changes. The data interpretation showed the trend of water receding tendency from wet to dry season in 2002 and 2008 images respectively. The occurrence of moderate and high vegetation was comparatively higher in 2002 images than in 2008. Moreover, very small water area was observed in March and April in both year images due to over use of surface and underground water for irrigation that is the threat to the natural resources in the region. Hence, steps need to be taken by the Government and stakeholders to stop fishing via dewatering and maintain the minimum water level in the Chalan *beel* for safe guard the aquatic biodiversity.

KEYWORDS: MODIS AQUA image, biodiversity, natural depression, land use change, irrigation.

1 INTRODUCTION

Fisheries sector plays a vital role in the agro-based economy of Bangladesh through its contribution to employment, income generation, foreign exchange earnings and providing food and nutrition security to the country. The sector presently contributes 4.43% of gross domestic product (GDP) and about 2.73% of total export earnings. The production of fish was 3.06 million MT in 2012 [4].

The inland water bodies have been supporting rich and diversified aquatic biodiversity and thus are important to the people Bangladesh for their food security and livelihood [7]. However, due to sharp decline the natural fish production and consumption over the last years and reached protein deficiency.

For centuries, a fragile cycle of flooding, fish migration between rivers and floodplains, spawning and grazing has been maintained in the wetlands of the country. The country's vast river networks, ponds, ditches and canals have been serving for the natural cycle of fish migration and wetlands regeneration. Floodplains inundated during monsoons are nutrient rich and play a significant role as nurseries for the larvae and juvenile of fish species [3], [9], [16]. Large areas of permanent, semi-permanent or seasonal wetlands are found in floodplains of lowland rivers with tranquil hydrology. The magnitude of flood and flooded areas greatly influences the population dynamics of fish species [2].

Corresponding Author: Shaharior Hashem

The *Beels* are one of the important sources of fish supply in Bangladesh. Natural depressions comprise about 2.49% of total aquatic resources which supplied 30.06 million MT in 2011--12. Collectively, floodplain and wetlands occupy an area of 28.33 million ha constituting 61.91% of total inland water resources and provided more than 7, 68,830 tons production of inland capture fisheries. It also offered tremendous scope for both capture and culture fisheries potential by adopting enhancement technique [5].

The Chalan *beel* is the largest and most important watershed in Northern part of Bangladesh. It comprises a series of depressions interconnected by various channels to form a continuous vast water body in the rainy season (July-November) when it covers an area of about 400 km^2. During the dry winter and summer, the water area decreases down to 52-78 km^2 and looks like a cluster of *beels* of different sizes [14] and offers an excellent alluvial crop land in the post monsoon season. Presently the Chalan *beel* like many other *beels* are at the risk of partial or total degradation due to manifold reasons like agricultural encroachment including pesticide usage, siltation along with other anthropogenic activities. However, it is very difficult to say how much degradation has been occurred for sure and how these problems can be solved. The present study is aimed to provide an overview on the present status of ecosystem diversity through Remote Sensing (RS) images and Geographical Information Systems (GIS) tools to investigate the real scenario of water area and depth in different seasons for the aquatic organisms. It is also aimed to identify the scope and opportunities to develop fisheries management strategies with a focus on biodiversity conservation. Hence, the present study would be a significant development to the planners and policy makers to take initiatives to save the natural resources through proper recommendations and suggestions.

2 MATERIALS AND METHODS

2.1 THE STUDY AREA

The Chalan *beel* is situated between 24.35^o and 24.70^o North latitude and 89.10^o and 89.35^o East longitudes. Historically Chalan *beel* was spread over the districts of Rajshahi, Pabna, Sirajgang, Natore, Naogoan and Bogra (Figure 1). At present, the *beel* has been compressed in the districts of Pabna, Sirajgonj and Natore due to crisscross roads, embankments and other infrastructural expansion. Therefore, the research was conducted in three representative cluster sites under the above districts. For data collection, ten upazilas such as Singra, Gurudaspur and Boraigram of Natore district, Chatmohar, Bhangura and Faridpur of Pabna and Shahjadpur, Ullapara, Tarash and Raygonj of Sirajganj district were selected.

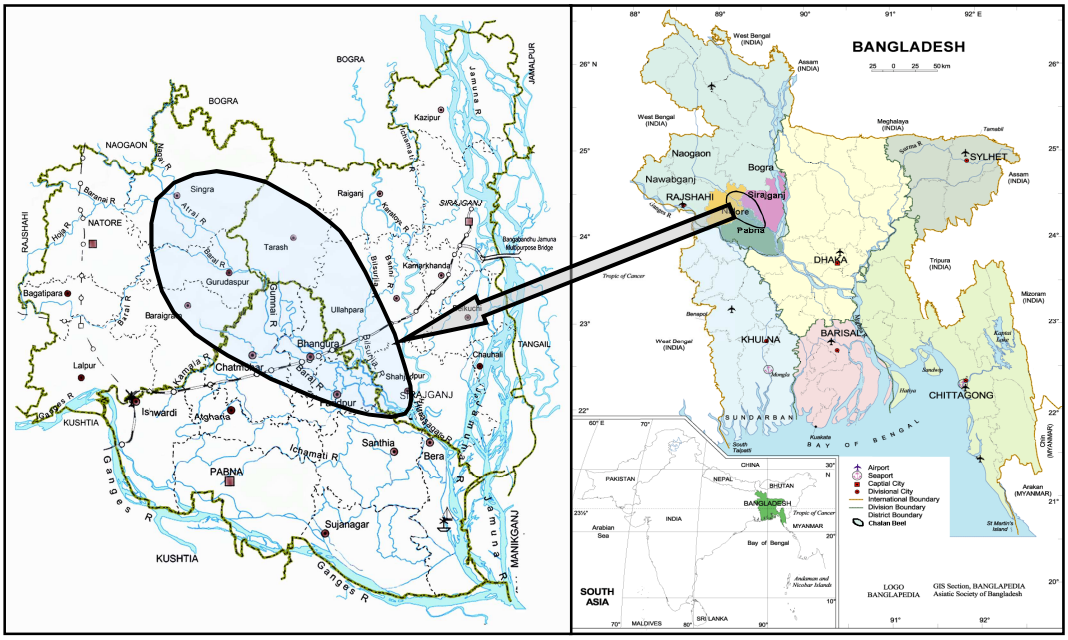

Fig. 1. "Chalan beel"

Figure 1 shows the study site "Chalan *beel*" in the map of Bangladesh

2.2 DATA SOURCES

The MODIS AQUA images were collected from the University of Stirling, Scotland, UK. (Table 1). The images of different dates of dry and wet seasons were collected and analyzed to see the land use changes if any of the ecosystems in the *beels* which caused the biodiversity degradation in the *beel*. The methodology of the study was based on Remote Sensing (RS) image interpretation which is supported by the secondary data collected from a range of sources like field visit, literature review, internet search and consultation with the relevant reports.

Table 1. MODIS AQUA image information used in the study

Name of Image data	Months and year	MODIS Product	Resolution	Season	Temporal Granularity
MYD13Q1	June-November 2002	Vegetation Indices	250 m	Wet season	16 Day
MYD13Q1	January-May 2002	Vegetation Indices	250 m	Dry season	16 Day
MYD13Q1	June-November 2002	Vegetation Indices	250 m	Wet season	16 Day
MYD13Q1	January-May 2008	Vegetation Indices	250 m	Dry season	16 Day

2.3 IMAGE ANALYSIS TECHNIQUE

MODIS AQUA data range from the bands Red, NIR, MIR and Blue were used in this study. The spatial resolution of image was 250 m x 250 m which used in the study. Image enhancement False colour composite (FCC) for visual interpretation, NDVI (Normalized Dense Vegetation Index) preparation, unsupervised image classification, etc. were also done.

2.4 IMAGE ENHANCEMENTS

The images were subjected to preliminary digital enhancements in order to enable their visual interpretation. The FCC images provided a clear visual discrimination of vegetation, water and water-bare land boundaries [6], [15]. The image processing methodology is presented in Figure 2. An associated contrast stretch of 5% was applied to have better visual discrimination among the features.

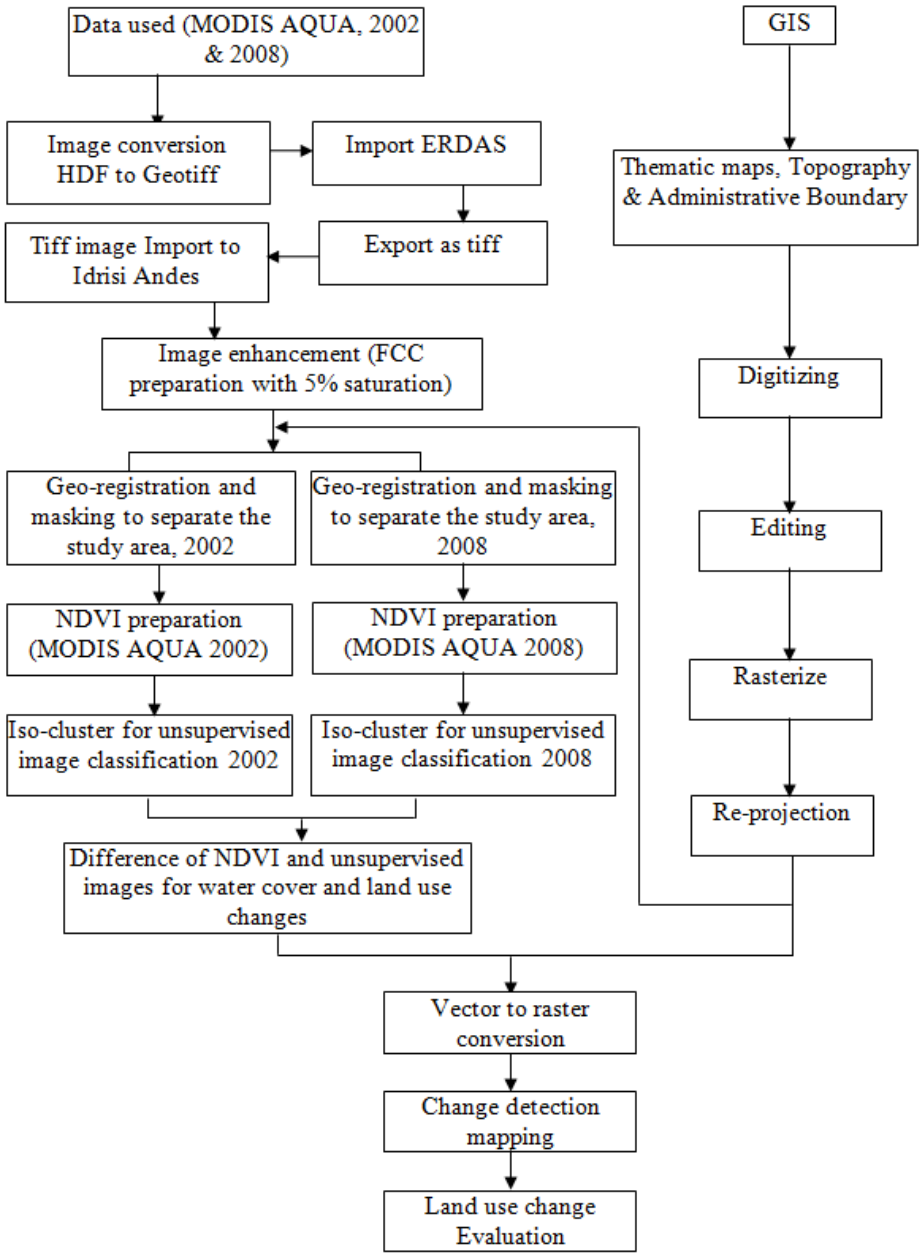

Figure 2 shows the schematic diagram of the major steps of RS and GIS methodology adopted in the study

2.5 NORMALIZED DIFFERENCE VEGETATION INDEX

The Normalized Difference Vegetation Index (NDVI) [13] was applied to calculate the state of vegetation on the land surface for each image from the RED and MIR bands of the satellite data using equation 1. The NDVI expresses the vegetated ground and the vegetation condition and is closely related to the leaf area index (LAI). The land use changes between the years were studied by NDVI images. The dense vegetation showed up very strongly in the imagery and the areas with little or no vegetation were also clearly identified. It also identified the water and the bare lands clearly. The NDVI took values between -1 to +1 where the value of 0.5 indicating dense vegetation and value <0 indicating no vegetation. Produced NDVI maps were reclassified into six land use categories depending on the digital number (DN) as deep water, shallow water, bare land, very low vegetation, moderate vegetation and high vegetation etc.

$$NDVI = \frac{MIR - Red}{MIR + Red} \quad \text{---------- (1)}$$

Where, MIR is the digital number in the mid infrared band and RED is the digital number in the red band in MODIS AQUA images.

2.6 UNSUPERVISED IMAGE CLASSIFICATION

The logic by which unsupervised classification works is known as cluster analysis and this was done by IDRISI Andes through ISOCLUSTER module. This module groups the features together with similar reflectance patterns. The unsupervised classification was done using the image bands of infrared, mid infrared and near infrared, and which provided the number of spectral classes in the raw data. This was conducted in several steps. First of all, the ISOCLUSTER module was used with the option of user selecting number of classes for the final image. The module then classified the image into discrete categories. This process was conducted using 15 fine clusters. Following the cluster, a 3 x 3 mode FILTER was applied out to eliminate minor clusters less than 9 pixels. The clusters were then identified and further reclassified into five land use and land cover classes based on the colour composite images and field visit data.

2.7 STATISTICAL ANALYSIS

Land use type data was evolved through ISOCLUSTER and NDVI analysis. Land and water were compared by two-way ANOVA considering years and seasons as fixed factors. The percentage data were arc-sine transformed. If the means were significantly different, then the differences among the treatments were tested with Duncan's Multiple Range Test (DMRT). All statistical tests were carried out at 5% significance level using SPSS (version 12.0).

3 RESULTS

3.1 FALSE COLOUR COMPOSITE ANALYSIS

The FCC images of blue, near infra-red and mid infra-red bands of dry and wet season for the year 2002 and 2008 were used to guide the land use and land cover classification and NDVI image interpretation (Figures 3-6). In the FCC images of dry and wet seasons of 2002 and 2008, blue, blackish and purple colour represented the water in the land. Meanwhile, the blackish, blue and purple colour in the FCC images indicated the turbid/shallow water and green colour represented the vegetation in both the images as land use phenomenon. Comparatively more water area was observed on the FCC images in 2002 than 2008 images may be due to long monsoon in the year or immediate rainfall before the satellite passed over.

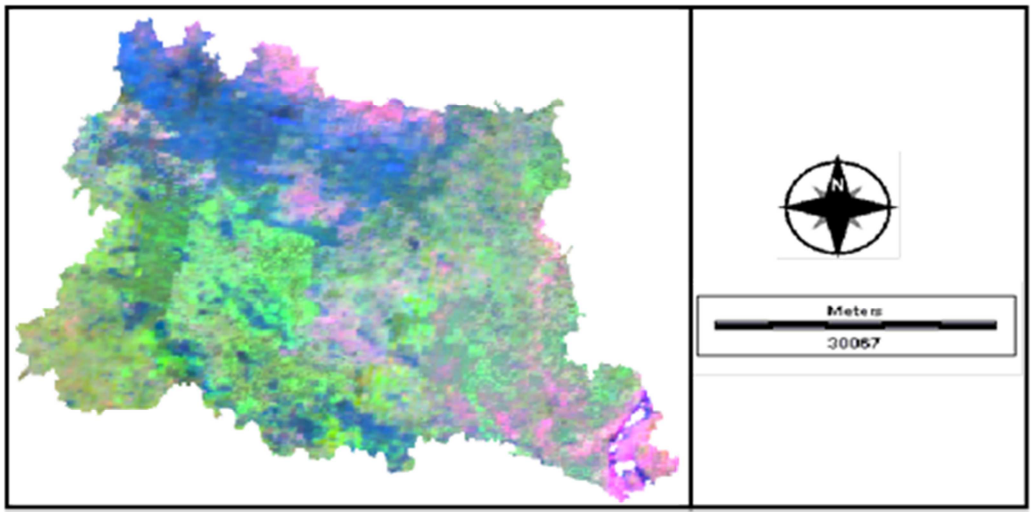

Fig. 3. FCC of Chalan beel of MODIS (250 m) image in dry season of 2002

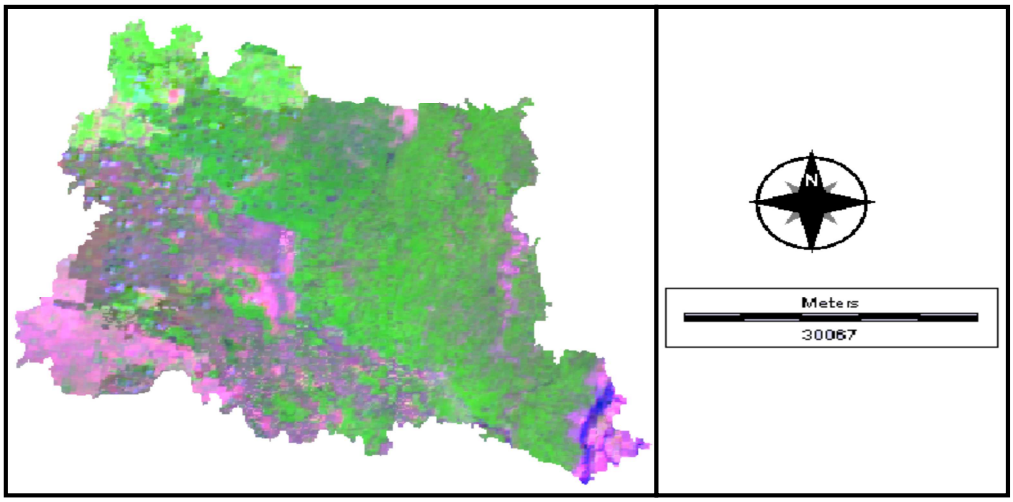

Fig. 4. FCC of Chalan beel of MODIS (250 m) image in dry season of 2008

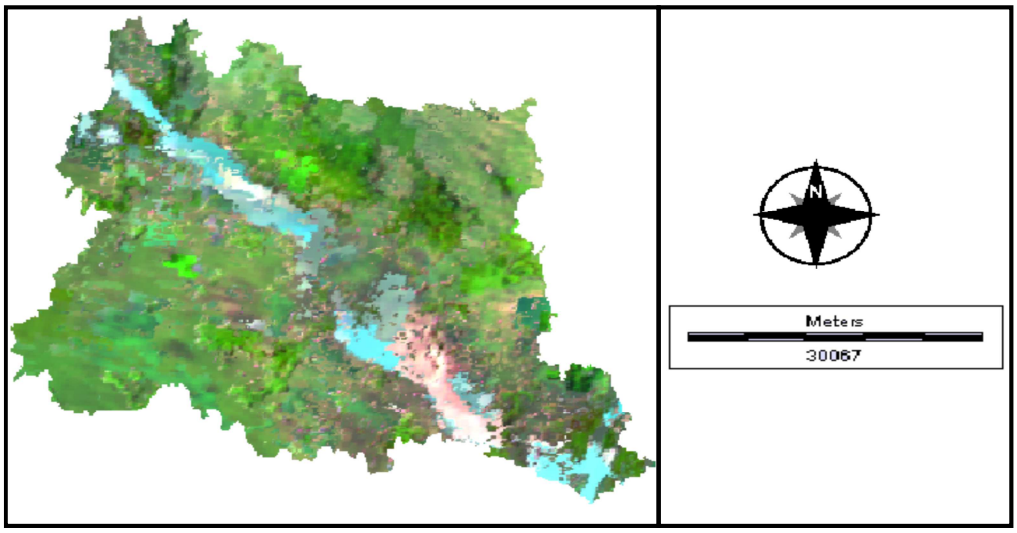

Fig. 5. FCC of Chalan beel of MODIS (250 m) image in wet season of 2002

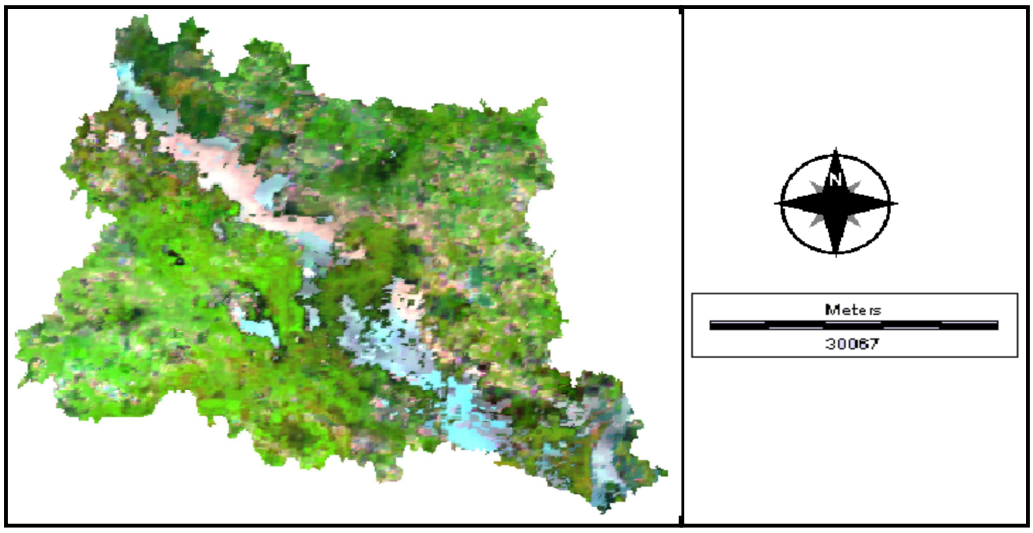

Fig. 6. FCC of Chalan beel of MODIS (250 m) image in wet season of 2008

3.2 NORMALIZED DIFFERENCE VEGETATION INDEX

Normalized difference vegetation index maps of Chalan *beel* were produced (Figures 7-8) where the red, yellow and green colour indicated the vegetation, bare land and water area respectively on the ground. The NDVI images interpretation showed that the water and vegetation areas were higher in 2002 image than in 2008. It is observed that comparatively more vegetative and water area in dry season images in 2002 when compared to 2008 due to late water receding from the *beel* area in 2002.

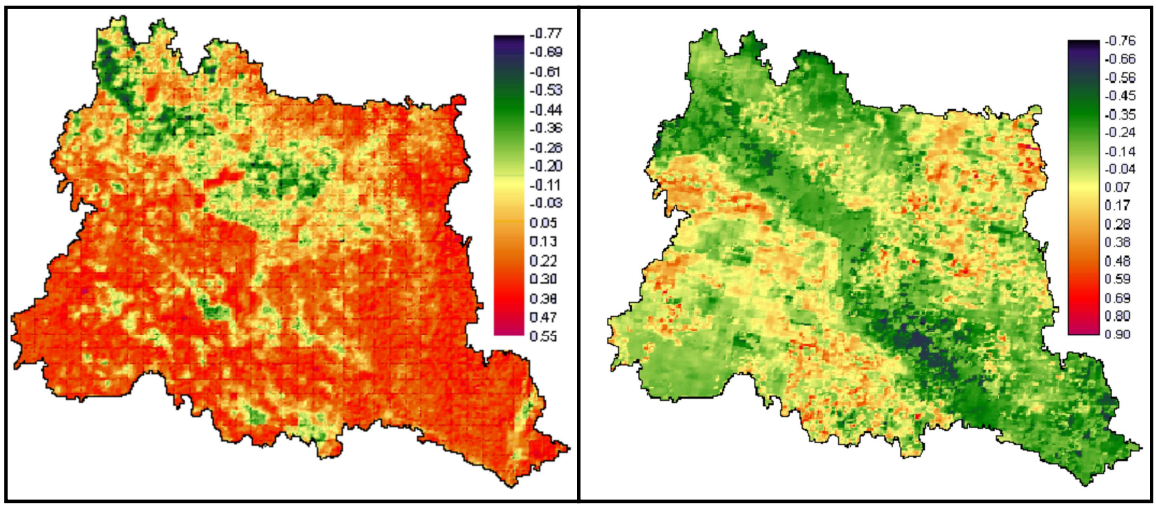

Fig. 7. NDVI of MODIS (250 m) image of Chalan beel in dry and wet season of 2002

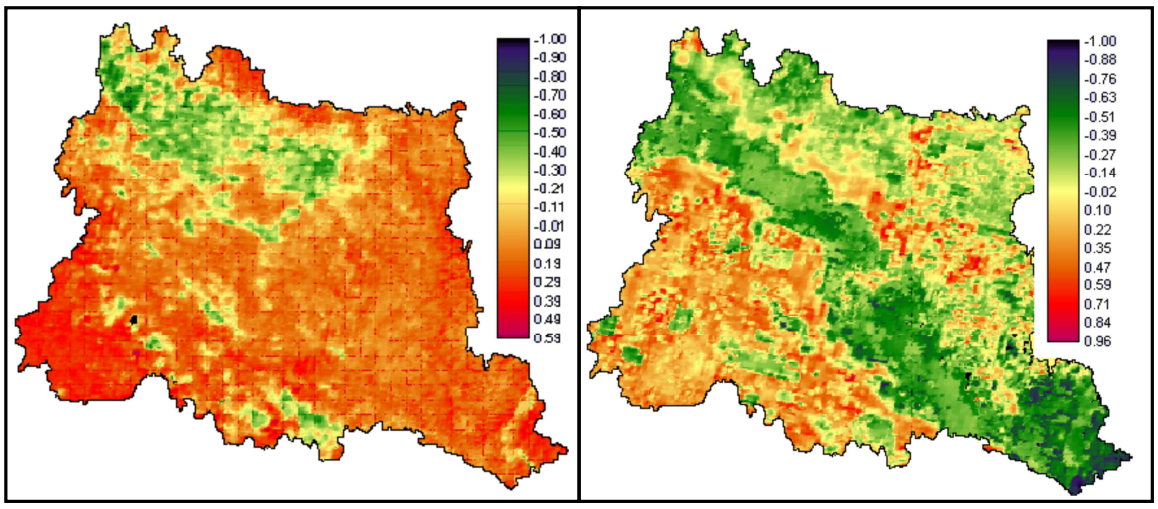

Fig. 8. NDVI of MODIS (250 m) image of Chalan beel in dry and wet season of 2008

Table 2. Percentages (%) of land under different NDVI-groups during 2002 and 2008 in Chalan beel area

Month	Water		Bare land		Low vegetation		Medium vegetation		High vegetation	
	2002	2008	2002	2008	2002	2008	2002	2008	2002	2008
January	28.25	20.63	37.35	0.94	6.87	66.30	27.10	11.96	0.43	0.17
March	6.61	6.50	45.19	0.03	0.28	49.09	45.70	43.73	2.22	0.65
April	0.57	0.50	2.68	0.05	83.54	79.70	13.16	19.71	0.05	0.04
June	20.62	10.32	19.11	1.90	56.48	79.09	3.69	8.01	0.10	0.68
August	17.85	21.58	70.45	0.86	9.02	65.10	2.39	8.65	0.29	3.81
September	16.49	10.73	3.24	1.61	56.60	53.04	23.09	27.28	0.58	7.34

The NDVI images were reclassified in to five land use categories (Table 2). The NDVI values were between -0.77 to +0.55 and -1.0 to +0.53 in dry season in 2002 and 2008 images respectively, that means the state of vegetation were comparatively higher in 2002 images than in the images of 2008. On the other hand, these values were between -0.76 to 0.90 and -1.0 to 0.96, respectively in wet season images for the same years.

3.3 ISOCLUSTER IMAGE ANALYSIS

The isocluster images of Chalan *beel* were produced (Figures 9-12), where the red, yellow and green colours indicated the vegetation, bare land and water area, respectively. Comparatively more water area were observed in dry season images of 2002 than in 2008 images. The land use types differed significantly (P<0.05) in different land types but not in seasons and years except homestead vegetation and bare land in seasons because of crops growth patterns and duration. The water area was more in 2002 images than in 2008 images.

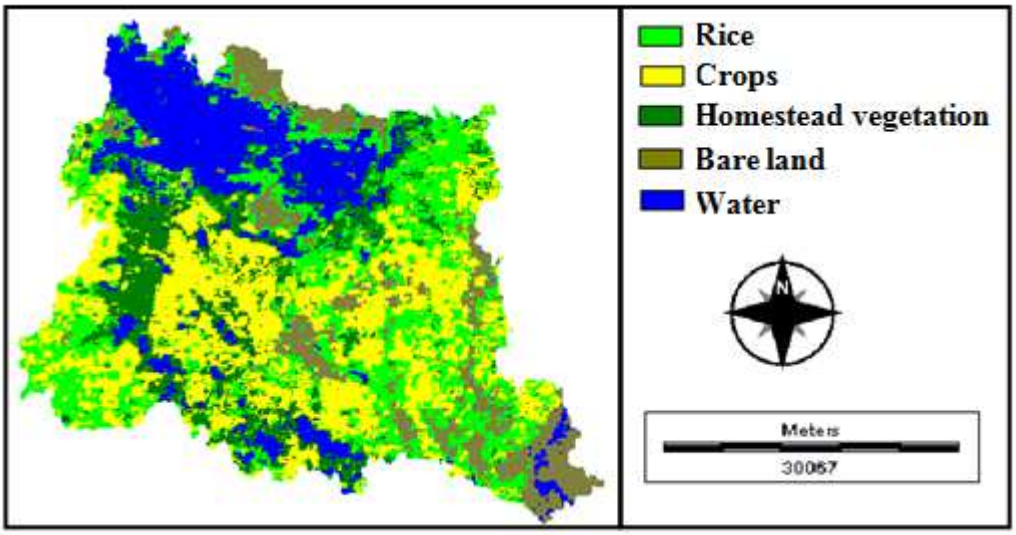

Fig. 9. Isocluster image of Chalan beel MODIS (250 m) in dry season of 2002

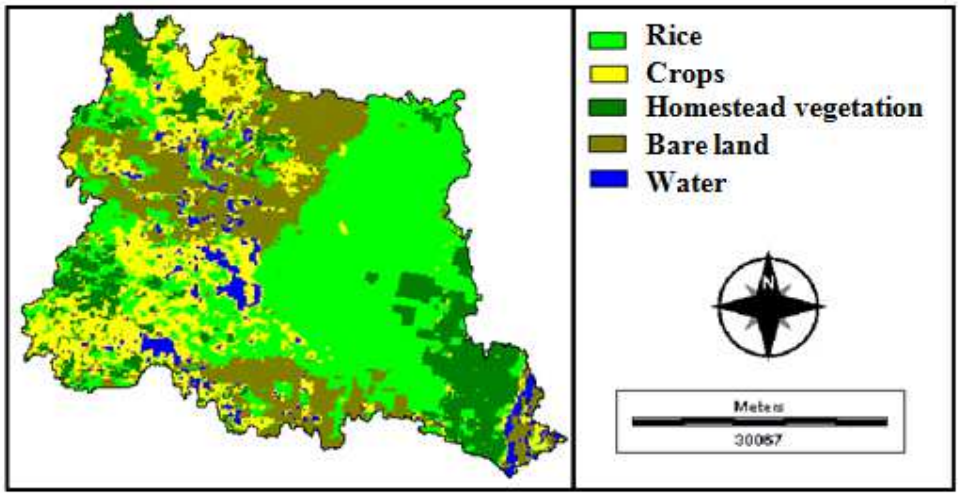

Fig. 10. Isocluster image of Chalan beel MODIS (250 m) in dry season of 2008

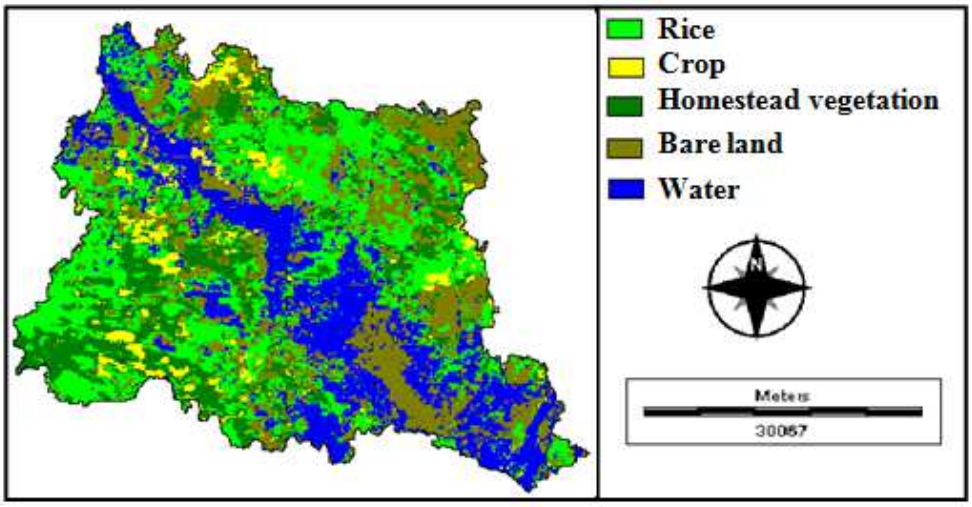

Fig. 11. Isocluster image of Chalan beel MODIS (250 m) in wet season of 2002

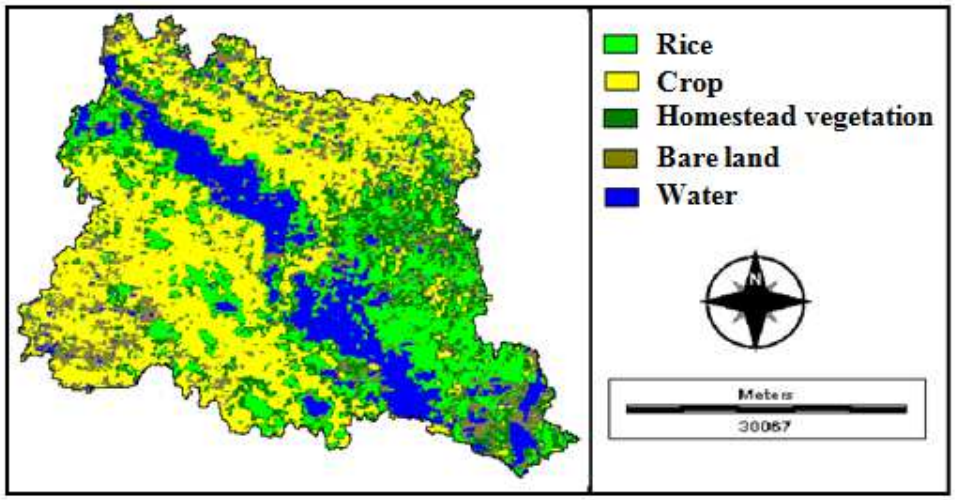

Fig. 12. Isocluster image of Chalan beel MODIS (250 m) in wet season of 2008

A decreasing tendency of crop lands area was observed in 2008 images than in 2002 images. Similarly, the bare land area is increasing while the water area is decreasing in the area (Table 3). The average land use pattern (Figure 13) showed that the higher cropping areas in 2002 images than in 2008 images.

Table 3. Percentages (%) of land under different iso-groups during 2002 and 2008 in Chalan beel

Month	Rice		Crop		Homestead vegetation		Bare land		Water	
	2002	2008	2002	2008	2002	2008	2002	2008	2002	2008
January	42.60	11.13	6.55	35.10	21.75	18.36	8.78	22.90	20.30	12.45
March	56.97	47.89	14.52	15.20	14.98	9.86	12.19	25.70	1.34	1.33
April	41.04	38.59	20.38	19.70	14.10	21.29	20.55	19.40	3.93	1.09
June	40.54	24.81	11.67	24.60	22.13	27.98	13.84	9.42	11.80	13.22
August	39.50	25.66	27.54	26.80	16.67	29.21	2.61	5.94	13.70	12.36
September	41.29	38.33	20.24	17.30	18.39	25.90	4.90	9.29	15.20	9.23

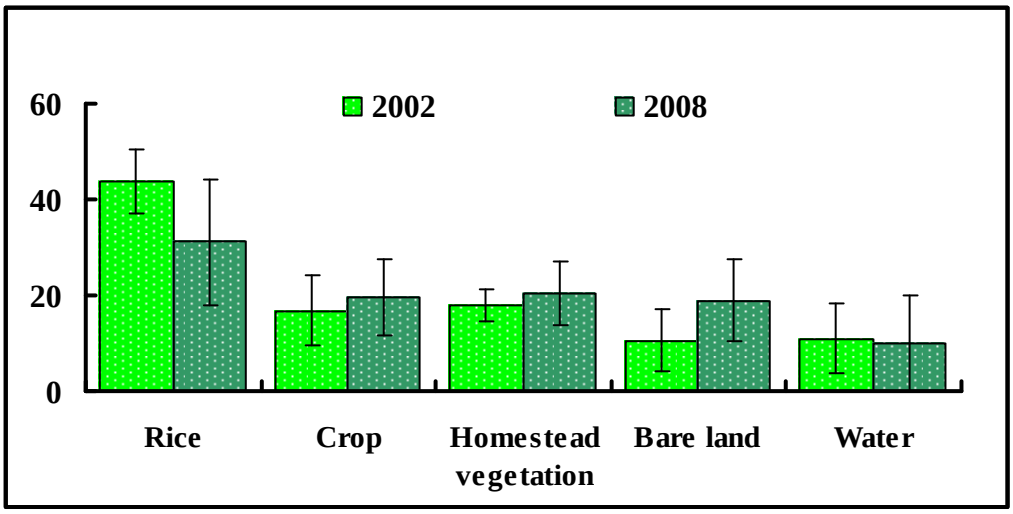

Fig. 13. Comparison of land use pattern as per isocluster analysis during 2002 and 2008 in Chalan beel

3.4 NDVI IMAGE RECLASSIFICATION

The Chalan *beel* NDVI images were reclassified in to two land use categories (Figs. 3.15-3.18) and the total area was calculated. The NDVI images interpretation showed that the water area was higher in 2002 images than in the 2008 images. On the other hand, it was observed from the calculation that more water area in the wet season images of 2008 than in 2002. Abnormally higher water aresa were observed in the northern part in dry season in 2002 images than in 2008 image which might be due to relatively longer monsoon in the year or immediate rainfall before the satellite passed over.

3.5 ISOCLUSTER IMAGE RECLASSIFICATION

Isocluster images were reclassified in to land and water areas, where comparatively higher water area were observed in 2002 images than in 2008 images might be due to low level of water in the distributaries due to the dam created on the trans boundary rivers.

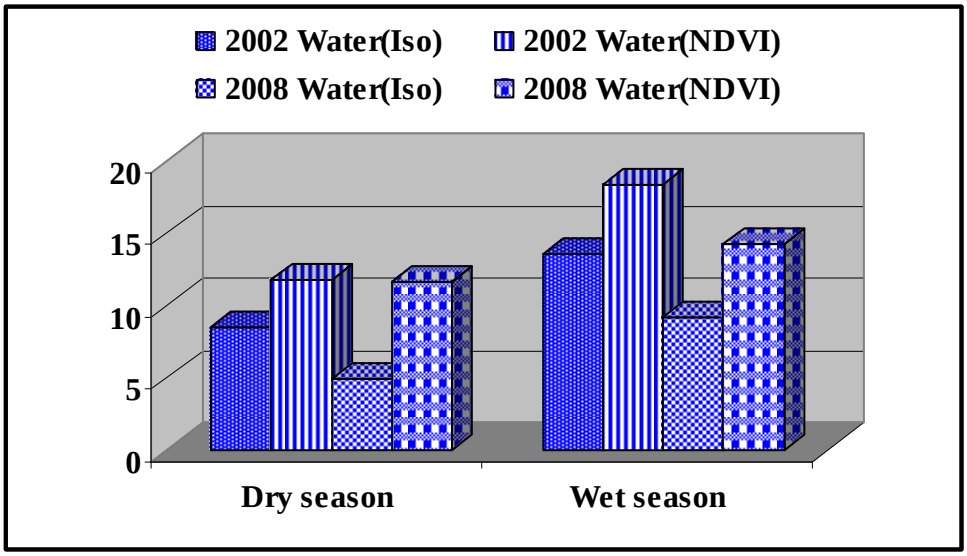

Fig. 14. Comparison of water area during dry and wet seasons of 2002 and 2008 in Chalan beel

3.6 CALCULATION OF WATER AREA

The trend of water areas in different season month in both the years images were analyzed and calculated. The water area differed significantly (P<0.05) in different months and seasons but not in the years in both the images. However, a decreasing trends were observed in 2002 images to 2008 images .The water area was comparatively lower in the wet season images of 2008 than in 202 image which might be due decreasing of water flow in the trans-boundary rivers.

The calculated water area as per NDVI and Isocluster images are presented in Figure 14. The water area as per NDVI images was higher than the Isocluster image because the NDVI image included the moist land within the water category.

4 DISCUSSION

The MODIS AQUA images are very successful in detecting surface water, crop land, irrigated rice fields or natural water body [11]. The higher water area was observed in the FCC image in the month of January of 2002 images in the northern and southern part of study area, however, not in the eastern part i.e., in the river area which might be due to heavy rain fall immediately before satellite pass over or might be due to irrigation in rice field. Again, in 2002, wet season image showed a big water area in the south west portion, which may be the irrigated rice field on that particular year. Therefore, more water area was observed in the FCC images of dry season in 2002. The FCC images of rainy season in both the years showed a large water area in this area. Bangladesh experienced water shortages in the dry season, which significantly disrupted the agricultural practices and socio-economic activities of the country which reflected well in the present findings [1].

The NDVI and Isocluster images interpretation of Chalan *beel* showed that the water area and vegetation were higher in 2002 than that in 2008 but did not differ significantly (P>0.05) which is the indication of water decreasing trend in this area. A study on remote sensing and GIS approach showed that the Nana Kosi watershed at Jammu Himaalaya of India had a period of moisture surplus from June to August and the remaining months are deficit which supports the present finding [8].

In the dry season of 2002, the rivers were observed in the image like thin lines but in 2008 which almost disappeared from the NDVI image. This indicated that the rivers are becoming narrower day by day due to siltation and encroachment. The construction of the Farakka Barrage in 1973 on the Ganges River by neighbouring country has silted up most of its distributaries in Bangladesh leading to huge impact on the ecosystem and biodiversity of those rivers [10]. In dry season, the flow of the rivers in Chalan *beel* are either cut off or substantially reduced the flow and lowering the surface water as well as ground water level causing ecological devastation. In wet season, higher water area in Chalan *beel* were observed compared to the dry season in 2002 and 2008 due to the rain fall. On the other hand, comparatively higher vegetation observed in the dry season of 2002 than that in 2008, might be due to the extend boro rice and short duration winter crops.

The NDVI images of wet season in 2002 showed relatively high water which might be the local flood just before satellite passed overthe area. The lower observed that the water, bare land and vegetation was observed in wet season images of

2008. On the contrary, higher percentage of bare land observed in August, and low vegetation in April and June in both in the years. The significant changes of water and vegetation in different (P<0.05) seasons were observed but not in years images. This might be due to inter-crop gaps and various growing stages of crops [12]. Furthermore, significantly (P<0.05) higher dense vegetation areas were observed in 2008 images than in 2002 images which might be due to social forestation activities in the areas by social forestry programme of Government..

Again, higher water area was observed in NDVI images than that of Isocluster images because the moist lands were included in water category. The moist lands were classified as water in that were included in the water category, as a result, more water area observed in NDVI images than in the Isocluster images [11].

5 CONCLUSION

The land and water area did not differ significantly in the year and seasons but differed significantly among the months. The higher water area observed in the month of January in 2002 image which might be presence of surface water by rain before the satellite pass over, which increased the mean value of dry season. However, the actual situation is that very low amount of water was observed in the month of March and April in both the years images, which is the real threat to the fish and aquatic diversity of the Chalan *beel*. The situation was deteriorated further through the over use of surface and underground water for irrigation. Therefore, the authority should take necessary steps for maintaining aquatic biodiversity with special emphasis on fish biodiversity to have a sustainable fish production from this renowned *beel* in Northwestern Bangladesh.

REFERENCES

[1] A.M.M.M Ahmed and K. Roy, “Utilization and conservation of water resources in Bangladesh," *Development of Sustainable Agriculture*, Vol. 2, pp. 35-44, 2007.

[2] A.H. Arthington, S.R. Balcombe, G.A. Wilson, M.C. Thoms and J. Marshall, “Spatial and temporal variation in fish assemblage structure in isolated waterholes during the 2001 dry season of an arid-zone river, Cooper Creek, Australia,” *Marine and Freshwater Resources*, Vol. 56, pp. 1-11, 2005.

[3] P.B. Bayley, “Factors affecting growth rates of young tropical floodplain fishes: seasonality and density-dependence,” *Environmental Biology of Fishes*, Vol. 21, pp 127-142, 1988.

[4] DoF (Department of Fisheries) , *Jateyo Matshya Soptaho Sangkolon*, Department of Fisheries, Ministry of Fisheries and Livestock, People republic of Bangladesh, 2012.

[5] FRSS (Fisheries Resource Survey System), *Fisheries Statistical Year Book of Bangladesh, 2007- 08*. Twenty Fifth Edition, Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, 2008.

[6] D. Gray, S. Zisman and C. Corves, *Mapping of the mangroves in Belize: Technical Report,* University of Edinburgh, Scotland, 1990.

[7] M.R. Hasan, *Oxbow lakes and floodplain fisheries sustainable livelihoods: A lesson from the wetland country, Bangladesh, Book of abstracts,* Seventh INTECOL Interventional wetlands conference, Utrecht, The Netherlands, 2004.

[8] A.S. Jasrotia, A. Majhi and S. Singh, *“Water Balance Approach for Rainwater Harvesting using Remote Sensing and GIS Techniques, Jammu Himalaya, India,”* Water Resource Management, Vol.23, pp 3035-3055, 2004.

[9] Junk, W.B., Bayley, P.B., and Sparks R.E., *The flood pulse in river floodplain systems*, In: D.P. Dodge (ed.), Proc. International Large River Symposium Canadian Special Publications, pp. 110–127, 1989,

[10] Mirza, “The Ganges water sharing treaty, risk analysis of the negotiated discharge,” *International Journal of Water*, Vol. 2, pp. 57-74, 2002.

[11] H. Neil, M.A. Salam and G.R. Lindsay, *Use of Landsat ETM+ and MODIS data for Investigation Land use surface water distribution in Bangladesh as part of a wider GIS based Assessment of Aquaculture potential under a changing climate*, A book of abstracts of workshop jointly organized by Bangladesh Agricultural University, Mymensingh and Institute of Aquaculture, University of Stirling, UK, 2009.

[12] D.P. Rao, V. Raghavswamy, N.C. Gautam, G. Ravi Shankar, L.S. Suresh and M. Mustaba, *“Land use Pattern in Deltas of East Coast with Special Reference to Godavari and Krishna River Deltas,”* The Geological Society, India, pp. 277-285, 1998.

[13] Rouse, J.W. Haas, R.H. Schell and D.W. Deering, *“Monitoring vegetation systems in the Great Plains with ERTS,”* Proceeding of 3rd Earth Resources Technology satellite-1 Symposium Greenbelt, NASA SP-351, 1974.

[14] K. Shahnaz, *Drastic fall in Chalan Beel fish production*, 2005. [Online] Available: http://www.weeklyholiday.net/env.html (September 9, 2005)

[15] L. J Trolier and W. R. Philipson, *"Visual analysis of Landsat Thematic Mapper images for hydrologic land use and cover,"* Photogrammetric Engineering and Remote Sensing, Vol. 52, pp.1531 – 1538, 1986.
[16] R. L. Welcomme, *"River Fisheries. FAO Fisheries"* Technical Paper No. 202, Rome, FAO, 1985.