Asian Journal of Conservation Biology, December 2020. Vol. 9 No. 2, pp. 335-340 AJCB: SC0048
ISSN 2278-7666 ©TCRP Foundation 2020

Short Communication

Conservation of wetlands of Nalbari district of Assam: An ecological assessment

Upen Deka[1*], Tapan Dutta[2], Sarada Kanta Sarma[3], Santa Paul[3]

[1] *Department of Botany, Silapathar College, Silapathar,Dhemaji-787059 Assam, India*
[2] *Department of Botany, Jawaharlal Nehru College, Boko, Kamrup, Assam, India*
[3] *Department of Botany, Gauhati University, Guwahati-781014, Assam, India*

(Received: July 03, 2020; Revised: October 07, 2020; Accepted: October 16, 2020)

ABSTRACT

The present study has been carried out in four perennial wetlands of Nalbari district of Asam, India to investigate the current scenario of the wetlands. During the study periods different land use classes have been found due to changing the morphology of the wetlands that leads to massive loss of wetland areas i.e. 44.65%, 23.78%, 22.71%, 13.88% in Ghoga beel, Borali beel, Batua kamakhya beel and Borbilla beel respectively during 1987 to 2013. These lose of water spread areas of the wetlands are due to several natural and anthropogenic activities. Plant community structure was calculated by using diversity indices. Shannon - Weaver diversity index was found to be highest in Batua kamakhya beel (H = 3.45) and Borbilla beel (H = 3.31) during the summer season whereas less diversity indices were observed in Ghoga beel (H = 2.03 and 1.77) both in summer and winter seasons due to high anthropogenic pressure in this wetland. Such very resourceful wetlands of the district which are sheltering of various aquatic resources are now gradually degrading over the last few decades. Therefore proper restoration and conservation measures should be taken for existence of these wetlands at the earliest.

Key words: Wetlands, Nalbari district, Anthropogenic activities, Land use and land cover change, Restoration and Conservation measures.

INTRODUCTION

Wetlands are defined as 'lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water (Mitsch & Gosselink, 1986). Aquatic and wetland plants are mostly confined to the marshes and wetland habitats. These waterlogged or wet soils form the diverse habitats for specific aquatic plant communities, which in a broader sense are known as wetland (Ghosh, 2005). They are ecologically characterized by the presence of water i.e. fresh, brakish, saline or euthropic; hydric soil; at least a few hydrophytic vegetation and also by the absence of flood intolerant vegetation. "Wetland" is the collective term for marshes, swamps, bogs and similar areas and is a source of many valuable aquatic flora and fauna and endangered species (Cowardian *et al.,* 1979). Although wetlands cover only six percent of the earth's surface (Mitsch and Gosselink, 1993), they provide habitats for about 20 percent of the earth's total biological diversity.

Beel the term used to represent the wetlands in Assam is very unique in nature. They play a significant role in conserving the earth's fragile ecosystem and are regarded as direct and indirect life supporting system for millions of people having immense socioeconomic and cultural values associated with them and the aquatic macrophytes present in wetlands are the important source of food, fodder, vegetables, medicines, biofertilizers, small scale industries, religious and cultural activities for the people residing in its vicinities.

Landscapes are not static, there are numerous exogenetic and endogenetic forces continuously operating over the landscapes and because of this landscapes are dynamic in nature. All over the world ecosystems have been rapidly transformed in the post-2000 period by human populations through increasingly permanent uses of land (Ellis *et al.,* 2010). Land-use/land-cover (LULC) much interest in environmental analyses (Bradley and Mustard, 2005; Geist and Lambin, 2001 and Turmer, 2001). Since land use change may contribute to ecological degradation (Hunsaker *et al.,* 1994) and is considered one of the most important variables of global ecological change (Houet *et al*., 2010; Sivrikaya, 2007; Vitousek, 1994).

Around the world, regional level wetland mapping has been done by several workers using Landsat-1 Multispectral Scanner (MSS) imagery (Work and Gilmer, 1976; Butera, 1983; Jensen *et al*., 1986). But due to the low resolution of Landsat MSS imagery, the thematic mapper (TM) multispectral instrument was launched on Landsat-5 in 1984, which brings increased spatial resolution (30 m) and increased spectral resolution (6 bands) to bear on the problem of wetland remote sensing. Landsat TM bands 4 (near infrared), 5 (mid-infrared), and 3 (red) were most optimal for discriminating between land-water interface (Dattavia and Dottavia, 1984; Ozesmi and Baver, 2002). Since then Landsat TM has been used for change detection of wetlands by several worker (Dewidar, 2004; Kiage, 2007; Roeck *et al*., 2008; Ibharim, 2009).

The studies of the degradation of the wetlands of Assam using RS/GIS tool have made easy to determine the current ecological status of the wetlands. Some contribution like Deka *et al*. (2011) studied a multi-temporal remote sensing approach for monitoring changes in spatial extent of freshwater lake of Deepor Beel Ramsar Site, a major wetland of Assam. Deka *et al*. (2015) studied monitoring of land use and land cover changes of Kapla beel, a major wetland of Barpeta district, Assam using multi temporal satellite data. Though the wetlands are unique and invaluable category of land important from various points of view but they are facing a threat to their existence all over the world. The chief causes of their degradation are mainly due to encroachment and pollution. The blockage of the inlet and outlet channels and

*Corresponding Author's E-mail: upen_deka@yahoo.in

pollution by the sewages from the surrounding areas of the wetlands has contributed greatly to their degradation.

The study reveals that the wetlands of North East India particularly Assam is facing serious threats of degradation due to the increasing anthropogenic pressure on them. Therefore the present study has been carried out to investigate the current ecological status of the wetlands, the change of the wetland ecosystem of the district and their affect on the plant community structure. The review attempts to provide a glimpse of the use of modern spatial technology tools, viz. Remote Sensing / GIS for obtaining an assessment, description and monitoring of the wetlands of the district.

Study area

The study was carried out in Nalbari district of Western Assam, India located at global position between 26^0 10′ N to 26^0 47′N latitude and 90^0 15′E to $91^0$10′E longitude. Four parrenial wetlands of the district namely Batua kamakhya beel, Borbilla beel, Borali beel and Ghoga beel were taken into consideration for the present investigation as shown in Figure 1.

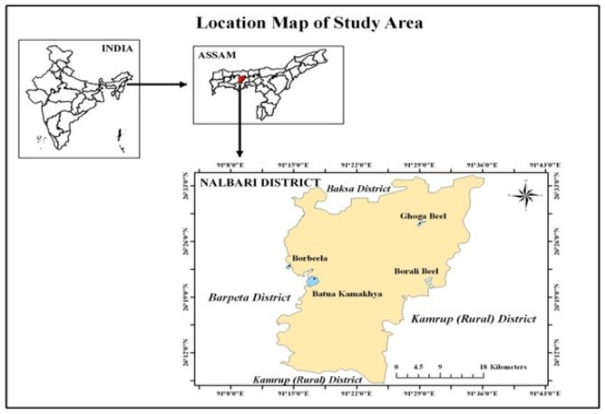

Figure 1. Map showing the location of the study site

Data Source

To analyze the land use changes of the wetlands of Nalbari district of Assam multi dated, multi season satellite imageries were used. Besides this, the Survey of India topographical sheet at 1:50,000 scales were used for delineation the wetland boundary and to generate baseline information for the study area. The details of the datasets used in this study are shown in Table 1.

Diversity indices like Shannon-Weaver Diversity Index (Shannon and Weaver, 1963), Simpson Dominance Index (Simpson, 1949), and Species evenness index (Pielou, 1966) and Species richness (Margalef, 1964), were used to get analytical data of the plant communities by using the following formulas:

1. Shannon–Weaver index of diversity (H): $H = -\sum pi \ln pi$ Where, pi = the proportion of Importance Value of the ith species (pi = ni / N, ni is the Importance Value of ith species and N is the Importance Value of all the species).
2. Simpson's index of Dominance (D): $D = \sum (pi)^2$, Where, pi = the proportion of Important Value of the ith species (pi =ni / N, ni is the Importance Value of ith species and N is the Importance Value of all the species).
3. Evenness index (E): E= H /logs, Where H = Shannon–Weaver diversity, and log S= Natural log of the total number of species recorded.
4. Species richness (d): $d = S/\sqrt{N}$ where, S=Total number of species, and N =Total number of individuals of all the species.

RESULTS AND DISCUSSION

The study of present investigation reveals that most of the wetlands of Nalbari district are on the verge of degradation due to various anthropogenic and natural activities. Encroachment inside the wetland areas due to construction of houses by the local villagers, agricultural practices, construction of roads throughout the centre of the wetlands, development of commercial fisheries, lack of efficient inlet and outlet channels of the wetlands, overgrazing by domestic cows and buffaloes, excessive collection of resources by local villagers for getting food, fodder, vegetables, medicines, biofertilizers, raw materials for small scale industries and also for religious and cultural activities, application of chemical fertilizers and pesticides in the nearby agricultural and crop fields by the local farmers are the prime cause for the substantial economic and ecological losses from the wetlands of the study sites. All these unplanned anthropogenic activities have resulted in rendering the ecosystem integrity of all the wetlands of Nalbari dist. Besides, siltation as a result of flood, excessive growth of exotic weed *Eichhornia crassipes* and the starting of the process of eutrophication due to the decay of aquatic weed are the major factors for the degradation of the wetlands of the study sites. While Borbilla beel and Batua kamakhya beel are facing disturbances of both natural as well as of man induced, the other two wetlands i.e. Borali beel and Ghoga beel confront mainly natural disturbances of very high intensity in the form of floods during the summer of every year caused by the overflowing of the river Pagladia with which it is connected. The flood caused by the river Pagladia during the year 1984, 2000, 2004 and 2012 was of devastating form when the flood water caused heavy siltation in the wetland areas of both Borali beel and Ghoga beel. This recurring flood has resulted in the noticeable change in the macrophytic community structure of Borali beel by converting the once purely aquatic vegetation to alluvial grassland patches composing of species like *Arundo donax, Phragmites karka, Saccharum spontaneum* and

Table1. Datasets used for monitoring the LU/LC

Data type	Path/Row	Date of acquisition
Landsat TM	136/42	26th December
Landsat TM	136/42	19th December
IRS LISS III	109/52	8th December
Survey of India Toposheets	78N/6, 78N/8, 78N/10, 78N/11 (1: 50,000 scale)	1974

Source: Satellite imagery of Landsat TM of 1987 and IIRS P6 III of 1999 and 2013, NASA's Global Land Cover Facilittator & National Remote Sensing Centre, Hyderabad.

Vettiveria zanioides in the midst of the wetland in small pockets during the last 10-15 years. Simultaneously, the western part of Ghoga beel along with its aquatic vegetation was also completely submerged during this unprecedented flood. On the other hand, heavy grazing by domestic buffaloes during certain periods of the year also seasonally affects the aquatic plant community structure of Borbilla beel and Batua kamakhya beel as well (Deka, 2014).

The satellite data showed that the wetlands of the study sites are gradually shrinking from year to year from 1987, 1999 and 2013 (Figure 2). It is due to several natural as well as anthropogenic activities occurring in the wetlands during the last few decades. In Batua kamakhya beel water spread areas has been declined by 46.74% due to encroachment, agricultural practices and development of commercial fisheries inside the wetland areas. Similarly, in Borbilla beel, water spread areas has been decreased by 74.31% due to mainly encroachment inside the wetland areas. In Borali beel 43.63% water spread areas have been reduced due to siltation and conversion into agricultural fields and also encroached by the local villagers for various purposes. In Ghoga beel water spread areas has been reduced by 64.24 %. It is due to conversion of the wetland areas into fishery and agricultural practices inside the wetland areas.

Nalbari district has many unique natural wetlands that act as a source of livelihood for the people living in its vicinities. People collect resources from the wetlands for different purposes like for getting food, fodder, fuel, vegetables, medicine, biofertilizers, raw materials for small scale industries and also for the purpose of religious and cultural activities.

Fishing in the wetlands is the main primary activity of the people living adjacent to the wetlands of the study sites. It has been found that 42% and 48% people of the surrounding villages of Batua kamakhya beel and Borbilla beel have been found to be engaged in fishing activities in the wetlands. On the other hand, agriculture is the primary occupation of the people living in the vicinities of Borali beel and Ghoga beel which were found to be 28.5% and 34.4% respectively during the study period .

Rooted with floating leaved hydrophytes *Euryale ferox, Trapa natans,* and *Nelumbo nucifera* are becoming very rare in the wetlands of the study site. It is due to the aggressive growth of *Eichhornia crassipes* and luxuriant growth of *Leersia hexandra* in the wetlands that suppressed the growth of those macrophytes. Significantly, heavy siltation after flood caused by the overflowing of the river Pagladia in Ghoga beel and Pagladia and Boralia river in Borali beel is causing shrinkage of the population sizes of *Nelumbo nucifera, Trapa natans* and *Euryale ferox* in both the wetlands.

The results of the present investigation show that Batua kamakhya beel and Borbilla beel have less natural as well as anthropogenic disturbances during the study period. For this reason these two wetlands showed high species composition as compared to other two wetlands of the study sites. Shannon - Weaver diversity index was found to be highest in Batua kamakhya beel (H = 3.45) and Borbilla beel (H = 3.31) during the summer season of the study period (Table: 2). Significantly, Borbilla beel is now worsely degrading due to the construction of dykes to facilitate fisheries surrounding the beel, in the strictly stagnant water enhances the growth of invasive exotic aquatic weed *Eichhornia crassipes* in the wetland. Moreover, there is no ecotone region in Borbilla beel at present during the summer season as this wetland is bounded by dykes to prevent Borbilla village during the rainy period. This recent construction of dykes in 2012 surrounding the beel will influence not only the hydroperiod of the wetland but also the species distribution in this wetland as well.

On the other hand Shannon- Weaver diversity index shows less value in Borali beel (H = 3.01) and Ghoga beel (H = 2.03) during the summer season as compared to the former two wetlands of the study sites (Table 2). It is because of the fact that Borali beel and Ghoga beel confronts mainly natural disturbances in the form of flood caused by the overflowing of the river Pagladia and Boralia and the degraded ecotone region or excessive biotic interferences in these two wetlands. The floodwater carried silt and clay and gets deposited in the wetland areas of both the wetlands. As a result most of the aquatic macrophytes along with their rhizomes and tubers became submerged during this heavy silt load. Besides the excessive cultivation in the ecotone regions in both the wetlands might also be a cause for the poor species composition in these two wetlands.

The fluctuation of species diversity among the wetlands of the study site shows that ecotone region has contributed a significant role for their species composition. During the summer season the ecotone regions of the wetlands have been found to be extended where the plant species like *Monochoria hastata, Sagittaria sagitifolia, Eichhornia crassipes, Ipomoea aquatica, Ipomoea carnea*, species of Cyperus as well as wet grassland patches were more frequently observed during the study periods.

In wetland ecosystem, water is the prime medium for the existence of the wetlands and its biodiversity. Besides, soil of the wetlands also plays an important role that exchange nutrients to the aquatic plant communities. The nutrients present in the soil are dissolved into water which ultimately utilize by the aquatic macrophytes for their growth and development. Obviously, the physicochemical characteristics of water and soil of the wetlands of the study sites show a direct relationship with productivity of the wetland's macrophytes of the study sites.

It is also clear from the different diversity indices of plant communities that summer season showed greater species diversity in comparison to winter season of the study periods. It is due to the availability of sufficient water during the season which is the prime medium for the growth of the macrophytes.

Conservation approaches

Wetlands are the most fragile ecosystem in the earth. Each of the wetland is facing natural death all over the world and will be vanished shortly if we don't take proper conservation measures for their sustainable existence. Wetlands are not only considered as a suitable habitat of aquatic flora and fauna, moreover they also influence the socioeconomic conditions of the people living in its vicinities and also the overall environment of the wetland ecosystem as well. Considering the present status of the wetlands of the study sites, ongoing various anthropogenic and natural activities on the wetlands and their influence on the socioeconomic conditions of the people living in the surrounding areas, following recommendations have been given for -

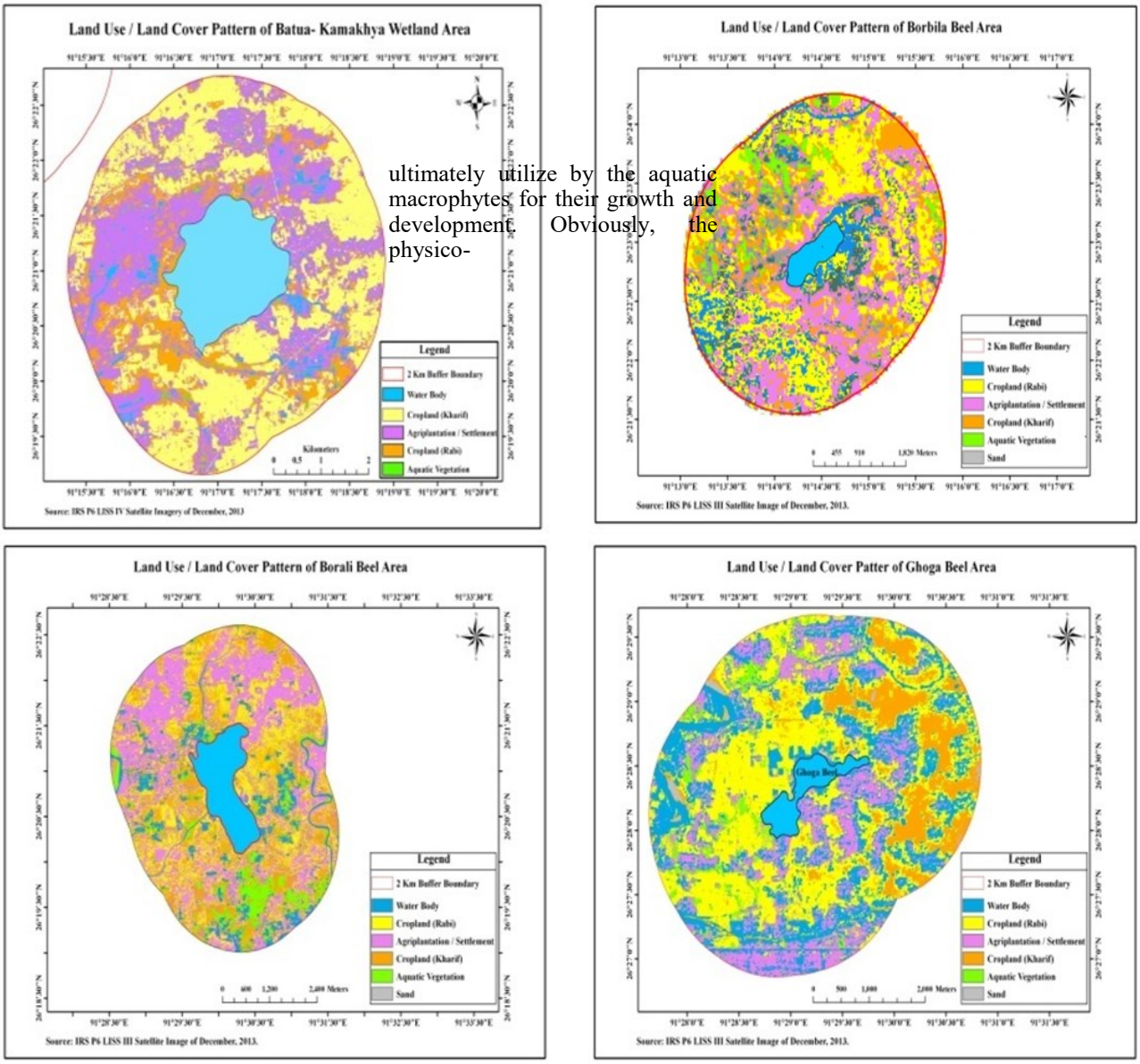

Figure 2. Land use and land cover pattern of the wetlands during the study periods. A= Batua Kamakhya beel B= Borbilla beel C=Borali beel D= Ghoga beel Source: Satellite imagery of Landsat TM of 1987 and IIRS P6 III of 1999 and 2013, NASA's Global Land Cover Facilittator & National Remote Sensing Centre, Hyderabad.

ultimately utilize by the aquatic macrophytes for their growth and development. Obviously, the physico-

Table 2. Different diversity indices of aquatic macrophytes during summer as well as in winter season

Diversity indices	Batua kamakhya beel		Borbilla beel		Borali beel		Ghoga beel	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Shannon- Weiver Diversity Index	3.45	2.70	3.31	2.80	3.01	2.37	2.03	1.77
Simpson Index of Dominance	0.05	0.11	0.01	0.06	0.04	0.16	0.08	0.02
Evenness Index	0.92	0.81	0.99	0.87	0.89	0.73	0.61	0.58
Species Richness	21.44	12.31	24.02	11.52	19.98	11.15	17.74	10.44

1. Encroachment inside the wetland areas is a major problem for most of the wetlands of the study sites. Land use and land cover changes data shown by satellite imagery reveals that the water spread areas of Borbilla beel is reduced by 74% from the year 1987 to 2013. It is mainly due to encroachment by the local villagers for residential purposes. Therefore encroachment of any kind inside the wetland areas should be stopped.
2. During the present study periods, Batua kamakhya beel and Borbilla beel were found to be leased out to some private parties for the purpose of fisheries for a specific period of time and thus depriving the local people losing their right, access and ownership of the wetlands and their resources. Therefore leasing of the beel should be rationalized if cannot be stopped completely.
3. The construction of road through the centre of Borbilla beel, construction of boundaries surrounding the Borbilla beel and construction of a temple inside the Borbilla beel are the major threats to the beels for their degradation and also shrinkage of the wetland areas. Any kind of such developmental activities inside the wetland areas which may affect the normal functioning of the wetland ecosystem should be stopped.
4. Harmfull aquatic weeds mainly the fast growing species like water hyacinth (*Eichhornia crassipes*) which have increased the rate of eutrophication in all the wetlands and also which checks the growth of the native macrophytes of the wetlands of the study sites should be eradicated completely.
5. During the present study periods the inlet and outlet channels of water of most of the wetlands of the study sites are found to becoming very narrow or even in some wetlands they are completely blocked. It is mainly due to encroachment for construction of houses by the local villagers, development of commercial fisheries inside or near the inlet or outlet channels of the wetlands, construction of boundaries surrounding the wetlands , the rapid growth of water hyacinth in the inlet and outlet channel of the wetland and heavy siltation by the overflowing of the river Pagladia and Boralia which caused the damage to the inlet and outlet channels of water of Borali and Ghoga beel. All these factors have not only reduced the water flow of the wetlands but also influence the whole wetland ecosystem as well. Therefore the inlet and outlet channels of the wetlands of the district should be cleared for the normal inflow and outflow of water into the wetlands.
6. Excessive harvesting of resources by the local villagers for getting food, fodder, fuel, vegetables, medicine, biofertilizers, raw materials for small scale industries and also for the purpose of religious and cultural activities from the wetlands of the study sites should be reduced to protect the wetlands ecosystem.
7. Excessive application of chemical fertilizers and pesticides by the local farmers in the nearby agricultural fields of the wetlands should be minimized.
8. It has been observed that some parts of Borali beel have become very shallow due to siltation caused by the overflowing of the river Pagladia and simultaneously people began to cultivate in those raised or shallow bed of the wetland for agricultural purposes both in summer as well as in winter season. Such kind of agricultural activities inside the wetland areas which may affect the overall wetland ecosystem should be stopped
9. Harvesting of fishes from the wetlands of the study sites during its breeding season should be totally prevented.
10. Abundantly growing invasive aquatic weed i.e. *Eichhornia crassipes* found in the wetlands of the study sites can be used as organic fertilizers and also in other small scale industries. Scientific training programme of proper utilization of such aquatic macrophytes should be adopted among the local villagers. This will help not only the economic support to the people living in the surrounding areas of the wetlands but also the overall environment of the wetland ecosystem as well.
11. District level awareness generation programmed towards the conservation of biodiversity of wetlands should be implemented. The concerned government authorities should show sincere attitudes towards the conservation of the wetlands and follow their management rules. Proper conservation strategies of the wetlands should be taken through necessary government and nongovernment framework.

CONCLUSION

Most changes of the Land use and land cover has been observed in the wetlands as well as their surrounding areas during the present study periods. The increasing population of the surrounding villages of the wetlands of the study sites is a major anthropogenic cause of degradation of most of the wetlands of Nalbari district. These threats have resulted not only in shrinking of the wetland area but also deteriorated the natural environment for the survival of different flora and fauna within the wetland ecosystem as well. If such activities continue for few years, the wetlands will disappear very soon. Therefore proper conservation measure is the need of hour for the sustainable existence of the wetlands of the district and also the livelihood of the poor people living in its adjacent areas.

ACKNOWLEDGEMENT

Authors gratefully acknowledge Advanced Level Institutional Biotech Hub, J. N. Collge, Boko, for the carry out the work. Authors also gratefully acknowledged National Remote Sensing Centre, Hyderabad for providing the satellite imageries of the respective wetlands. of the study site.

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