Assessment of wetlands to evaluate aquatic environment: a case study in Floodplain of Himalayan foothill region

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Abstract

In floodplain wetland the evaluation of aquatic environment has been implemented as an effective tool for the rapid assessment. Ox-bow lakes i.e. natural wetlands are the abandoned part of the former meander are common features developed in floodplain. The northern portion of Coochbehar district is under the Tarai belt and the southern portion lies under the alluvial plain physiographic region. The Tarai zone is composed of alternate layers of clay and sand, with a high water table that creates many wetlands. Many natural wetlands in the form of ox-bow lakes have been formed in Tufanganj C.D. Blocks which are locally known as *beel* or *baor*. These *beels* are the abandoned channels of Raidak I, Gadadhar, Kaljani, and Mora Raidak River. Due to the geological and geomorphological set up of this region the rivers mentioned above frequently change their course. Topographical, Geomorphological and Geohydrological maps have been used to know the spatial distribution of wetlands and physiographic set up of the region. Many *beels* have evolved which are ecologically very much productive. With the help of the Oakton multi parameter and WTW DO meter wetland index has been prepared in some of the *beels* to analyze the physico-chemical properties of wetlands and to assess the ecological importance as well as human intervention. Thermal bands of Landsat image (OLI/TIRS) have also been used to assess the temperature distribution of the land and wetlands. This paper investigates the role of wetland hydrology to evaluate aquatic environment for the wetland assessment in the floodplain regime.

Keywords Floodplain wetland · Northern plain · Wetland index · Habitat integrity

1 Introduction

Wetlands are the most lucrative resource having environmental and ecological values on the earth [1]. Wetlands provide ecological as well as hydrological functions such as flood mitigation, stabilization of local climate, nutrient retention, ground water recharge and support biodiversity [1–5]. Wetlands also provide wide range of ecosystem services like food, fiber, fuel and greenhouse gas regulation through carbon sequestration [6, 7]. Due to prerequisite hydrological and meteorological condition associated with high water table, high productivity and low decomposition rate wetlands act like carbon sinks which is helpful for mitigation of global warming [6, 8, 9]. Like ecosystem

services wetlands support non- market goods and services such as landscape maintenance and sustenance of rural people [7]. But in recent few decades this productive ecosystem [1, 10, 11] have been facing alterations which leads to wetland degradation [12]. Wetlands are important on earth supporting diverse and unique habitat for organisms as well as providing fresh water, fisheries, agriculture, irrigation, industrial activities, and recreation on which many humans largely depend [11, 13]. Economic development of any region results into the increasing pressure on wetland hydrology and affect wetland aquatic environment. Water surface temperature is an influential parameter to examine the existing wetland processes such as evaporation, water quality and oxygen concentration in water [14,

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15]. In this connection a complete study requires to plan strategies for their protection and preservation.

The study of aquatic environment of wetlands reveals ecological importance of floodplain [16–19] which is mainly the outcome of geomorphology and hydrology [19]. Floodplain, complex and diverse ecosystem [20] stores huge amount of sediments [21]. Shifting of river courses, ox-bow lakes, scrolls are the common features associated with the floodplain [21] and the frequency of these features depend on many factors like flood occurrence, soil, channel pattern, precipitation over catchment area, sediment transportation etc. [21, 22]. These natural wetlands which are locally known as *beel* or *baor* in Assam, West Bengal are ecologically very productive [23, 24]. Floodplain wetlands providing enormous growth of fish food organisms are very much potential for capture fisheries as well as culture based fishery [25]. These natural landscapes with strategic importance to human society [25, 26] have been facing threats from anthropogenic modifications [27], often leading to unbalanced floodplain conditions such as increased sedimentation and siltation processes; eutrophication through various anthropogenic sources [28, 29]. Wetland hydrology plays very significant role to define its nature whether seasonal, dry or perennial [3]. To assess the physico-chemical and biological properties of the wetlands, routine monitoring of Dissolved oxygen, total dissolved solids, conductivity, salinity, temperature, pH are the important parameters [30–33]. Monitoring wetland hydrology also allows for the detection of local climate change [5]. Wetlands though act like a ‘kidney of landscape’ [34] but contaminated water can negatively affect wetland biota and ecosystem [10, 35]. Thus, surface water quality of floodplain wetland can be determined by both the natural processes (precipitation rate, soil erosion, weathering processes) and the anthropogenic influences such as agricultural and industrial activities, urbanization and over exploitation of water resources [28, 36]. High amount of sediments from the catchment area increases turbidity which affects wetland biota negatively [20, 37]. But these nutrients amplify the growth of some aquatic weeds like water hyacinth and cause hindrance for the light penetration into the wetland and affect wetland ecosystem [38]. In recent few decades the siltation and various anthropogenic activities are to be found as a major reason behind the gradual depletion of ecological productivity in floodplain wetland [28, 39].

The Sikkim-Bhutan Himalayan foothill region is the geomorphological hotspot over which processes of alterations are occurring in gradual rates. To the south of the Sikkim-Bhutan Himalaya, the northern plain has been divided into three distinctive parts Bhabar, Tarai and Alluvial plain [40]. In the Bhabar, due to the coarser sediments the rivers disappear and get reemerged into the Tarai. This Tarai region

consists of alternative layer of sand, silt and clay which results into marshy land and luxurious growth of vegetation. The study area encompasses 127 villages of Tufanganj I and Tufanganj II C.D. Blocks in Coochbehar District [41], situated on the eastern border of West Bengal with a latitudinal and longitudinal extension of 26° 9' 22" N to 26° 27' 36" N and 89° 31' 55" E to 89° 52' 48" E bordered by Assam in East, Alipurduar district of West Bengal in the north, Dinhata block of the Coochbehar district in the south and Coochbehar I and Coochbehar II in west (Fig. 1).

The northern portion of the study area lies under Tarai whereas the rest of the portion is under alluvial plain. The main rivers Raidak I, Raidak II, Gadadhar, Kaljani have frequently shifted their courses and formed ox-bow lakes, scrolls, paleo-channel. The total area of Tufanganj I and Tufanganj II is 582.69 km² out of which 579.48 km² constitute urban whereas 3.21 km² is rural. Total water area of Tufanganj I and Tufanganj II Blocks are 6.19% and 8.62% of Coochbehar district out of the total water area *beels* have been found in maximum portion i.e. 261.81 ha. and 178.52 ha. respectively [58]. The main objectives of the study is to (1) find out the ecological importance of wetlands in Tufanganj C.D. Blocks (2) find out the deviation of temperature from wetland to the surroundings (3) identify anthropogenic sources of toxic elements in the wetland of Tufanganj C.D. Blocks.

2 Materials and methods

2.1 Elevation and geomorphological set up

ASTER DEM (Digital Elevation Model) of the study area has been downloaded from <https://earthexplorer.usgs.gov/> and reprojected in Universal Transverse Mercator (UTM), Zone 45 N from Geographic Coordinate system (WGS 1984) to get the actual ground elevation. The Dem consist of pixels having 90 m spatial resolution. Using spatial analysis tool, elevation has been extracted automatically and geomorphological and geohydrological map of Coochbehar District have been collected from Geological survey of India and the study area has been extracted to know the slope and physiographic settings of the region (Fig. 2) as geomorphology and hydrology act like a driving processes for the formation and maintenance of floodplain wetlands [18]. All maps are prepared using Arc GIS 10.6 software.

2.2 Water sample test

Water samples (Fig. 3) in the study area have been collected from different *beels*. The total number of water samples for this assessment study is seventeen in

Fig. 1 Study area

number. Only those *beels* have been selected which are wet throughout the year. Using multi-parameter (Oakton 35425-00, 35425-05, 35425-10; Eutech instruments) pH, total dissolved solids (ppm), temperature in °C, conductivity (μ S), salinity (ppm) have been measured on the spot to know the physico-chemical properties of wetlands. With the help of DO meter (WTW DO meter model 3310, Xylem Germany) dissolved oxygen in mg/ltr has also been measured on the spot to determine the oxygen level for the aquatic life (Fig. 4). All water samples are measured during post monsoon season. Correlation of the parameters has been calculated in Table 1 to study the interrelationship among parameters. Garmin GPS Etrex 30x instrument has also been used to locate the sample *beels* of the study area (Fig. 3).

2.3 Wetland index

Wetland index developed by National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), previously known as River Health programme (RHP) is an effective tool to examine the ecological and environmental assessment of the floodplain wetland system [18, 42–44].

Wetland index is designed for the rapid assessment of floodplain wetlands to understand the present ecological status [18, 43]. This index is also easy to use for any non-wetland specialists. For this purpose, six water quality parameters with the standard score [45] prepared by Fishery Department, WHO and BIS [46] have been selected which are Temperature, pH, DO, TDS, Conductivity and salinity. These various components of water quality have great influence on productivity of floodplain wetland as a result of variety of impacts/activities in the catchment [18, 45]. The principal component analysis has been used to evaluate the ecological importance of wetlands as well as identification of the sources of anthropogenic interventions. The PC result reveals what parameter is in better position and what are lagging behind for the assessment of wetlands (Table 2). The calculation and formulation of wetland index [42, 47] involved the following steps:

1. In the first step, each of the six water quality parameters has been assigned to a rank and weightage value on the basis of productivity as well as human interferences of the *beels* depending on the previous studies [18, 42, 47]. All these parameters do not

Fig. 2 Geomorphology and geohydrology of the study area

have the same capacity to influence aquatic environment. On the basis of importance and sensitivity to change aquatic environment the weightage has been assigned (Table 2).

2. In the second step, the each variable has been awarded numerical score to a maximum of 10 and its score has been distributed proportionately among the components of each variable on the basis of impact factor of the parameter on biological productivity of the *beels* (Table 2).
3. After given weightage to each component of all the parameters the overall score index (SI_i) for each component has been obtained by multiplying the original score by assigned score (Table 2).
4. Finally, after calculation of overall score index (SI_i) of each component of six parameters the wetland index has been calculated by following equation:

$$WI = \sum_{i=1}^n SI_i$$

where WI = wetland index, n = number of parameters, SI_i = score of individual parameter.

The output scores from Wetland index model are categorized to understand the present ecological state of productivity and suitability for aquatic life form as well as to identify the anthropogenic sources of toxic elements within wetland.

2.4 Land surface temperature

The measurement of surface temperature if done manually is quite cost effective and time consuming. To avoid such barriers remote sensing is an eminent tool to understand

Fig. 3 Location of water sample sites

Table 1 Correlation study of the parameters

	DO	Temperature	pH	TDS	Conductivity	Salinity
DO	1.00					
Temperature	−0.01	1.00				
pH	0.56	0.55	1.00			
TDS	−0.21	−0.25	−0.54	1.00		
Conductivity	−0.15	0.16	−0.17	0.79	1.00	
Salinity	−0.20	0.15	−0.18	0.80	0.99	1.00

the ecological as well as environmental assessment of wetland [48, 49]. Landsat imageries having the thermal bands are useful for surface temperature measurement [50]. Thermal bands of Landsat imagery i.e. Band 10 and 11 of Landsat 8 OLI/TIRS (wavelength 10.60–12.51 μm .) for Jan, 2019 (post monsoon season) have been used for surface temperature measurement (USGS 2019). It includes three step procedures [51, 52]. After calculating LST of band 10 and 11, cell statistics from spatial analysis tool on Arc GIS 10.6 software has been incorporated to get the mean temperature of two bands.

1. Conversion to Top Of Atmospheric (TOA) radiance:

$$L_{\lambda} = M_L Q_{\text{cal}} + A_L$$

where L_{λ} = TOA spectral radiance (Watts/($\text{m}^2 \cdot \text{srad} \cdot \mu\text{m}$)), M_L = Band specific multiplicative rescaling factor from the metadata (Radiance multiple band x, where x is the band number), A_L = Band specific additive rescaling factor from metadata (Radiance add band x, where x is the band number), Q_{cal} = quantized and calibrated standard product pixel values (DN)

2. Conversion to top of atmosphere brightness temperature in $^{\circ}\text{C}$:

Fig. 4 Photo plates of some beels during water sample test **a** 26°18'46.61"N, 89°41'13.97"E, **b** 26°15'48.02"N, 89°38'09.78"E, **c** 26°19'57.26"N, 89°37'4.23"E

$$TB = [K2/Ln(K1/L_{\lambda} + 1)] - 272.15$$

where T = top of atmosphere brightness temperature (in °C), L_{λ} = TOA spectral radiance (Watts/(m²*srad*μm)), K1 = Band specific thermal conversion constant from the metadata (K1 constant band x, where x is the thermal band number), K2 = Band specific thermal conversion constant from the metadata (K2 constant band x, where x is the thermal band number).

3. Conversion from Atmospheric Satellite temperature to Land surface temperature:

$$T = T_B / [1 + (\lambda * T_B / C2) * Ln(e)]$$

where λ = wavelength of emitted radiance, $c2 = h * c / s = 1.4388 * 10^{-2} \text{ m k} = 14,388 \text{ μm}$, h = Planck's constant = $6.626 * 10^{-34} \text{ Jsk}$, s = Boltzmann constant = $1.38 * 10^{-23} \text{ J/K}$, c = velocity of light $2.988 * 10^1 \text{ ms}$.

3 Results and discussion

3.1 Physiographic settings for the formation of wetland

The study area consists of the alluvial fan deposit (Fig. 2) with alternative layer of sand, silt and clay. The direction of

groundwater flow from the north-west to the south-east direction towards Bangladesh (Fig. 2) indicates the slope of the study area. The average annual rainfall is 3500 mm [53]. These physiographic settings and climatic condition lead to the occurrence of flash flood every year. It results into the alteration in channel planform and movement of sediments. The region is fluvio-hydrologically dynamic area. These physiographic settings are resulting into the formation of large number of meander scrolls, paleo channels, neck and chute cut-offs due to the lateral oscillation of Kaljani, Gadadhar, Raidak I, Raidak II river which are collectively known as *Beel* or *Baor*.

3.2 Role of temperature for the assessment of wetland

Land surface temperature map (Fig. 5) has been prepared to know the deviation of temperature from wetland to the land area. The maximum temperature is 26.5 °C whereas minimum temperature is 16.5 °C. The pixel values show that the wetland area shows the lowest temperature whereas the land area shows the highest temperature in different pockets of Tufanganj I and Tufanganj II blocks of Coochbehar District. The deviation of temperature from wetland to surrounding region is almost 10 °C. The surface temperature derived from satellite images reveals that the wetlands reduce temperature of its own as well as its surrounding areas by 9 °C–10 °C. This temperature plays

Table 2 Score calculation for wetland Index

Variable	Symbol	Score assigned on the basis of quality	Weightage assigned according to rank	Total scores awarded
<i>Temperature(°C): Rank 1</i>				
< 25 °C	Temp1	1.67	5.00	8.35
25–35 °C	Temp4	6.67	5.00	33.35
> 35 °C	Temp1	1.67	5.00	8.35
		10.00		50.05
<i>Dissolved oxygen (mg/l): Rank-2</i>				
0–2.0 bad	DO1	1.00	5.00	5.00
2.0–4.0 moderate	DO2	2.00	5.00	10.00
4.0–7.0 good	DO3	3.00	5.00	15.00
7.0–11.0 very good	DO4	4.00	5.00	20.00
		10.00		50.00
<i>pH: Rank 3</i>				
< 4.5	pH 1	0.67	4.00	2.68
4.5–5.5	pH 2	1.33	4.00	5.32
5.5–6.5	pH 3	2.00	4.00	8.00
6.5–7.5	pH 4	2.67	4.00	10.68
7.5–8.5	pH 5	3.33	4.00	13.32
> 8.5	pH 1	0.67	4.00	2.68
		10.00		42.68
<i>Conductivity (μs): Rank 4</i>				
< 200	Con1	0.67	3.00	2.68
120–200	Con2	1.33	3.00	5.32
80–120	Con3	2.00	3.00	8.00
40–80	Con4	2.67	3.00	10.68
> 40	Con5	3.33	3.00	13.32
		10.00		40.00
<i>Total dissolved solids (ppm): Rank 5</i>				
< 120	TDS1	0.67	3.00	2.01
90–120	TDS2	1.33	3.00	3.99
60–90	TDS3	2.00	3.00	6.00
30–60	TDS4	2.67	3.00	8.01
> 30	TDS5	3.33	3.00	6.70
		10.00		26.71
<i>Salinity(ppm): Rank 6</i>				
< 30	Saln1	1.00	1.00	1.00
30–60	Saln2	2.00	1.00	2.00
60–90	Saln3	3.00	1.00	3.00
> 90	Saln4	4.00	1.00	4.00
		10.00		10.00

a significant role for the distribution of aquatic life [54] as there is a symbiotic relation with temperature and all parameters.

3.3 Wetland assessment through wetland index

Wetland index (Table 3) has been prepared on the basis of ecological productivity of the *beels*. This index is very much efficient to study the ecological importance as

well as the identification of anthropogenic sources on the *beels* in the study area. After calculation the score of the sample *beels* (Table 3) reveals that the Masankura *beel* has the lowest score i.e. 46.03 whereas the highest score has been found in Rasikbeel and Bamnir Chara i.e. 87.69 (Table 3). The higher the score the higher the productivity and suitability for the aquatic environment (Table 4). The wetland index score having more than 75 indicates that the *beels* are suitable for fish and aquatic

Fig. 5 Land surface temperature

life with less human intervention. Rasikbeel wetland complex with highest index score is one of the promising biodiversity reserves in this region. Every year Rasikbeel wetland complex witnesses a large population of residential as well as migratory birds such as cormorants, egrets, herons, snipes, kingfishers, Lesser-whistling teals, Poachard etc. Total 51 species of avifauna are recorded in this wetland. On the contrary, the *beels* having lowest index score (< 55) are facing threats from human intervention. The lowest wetland indexed *beels*, surrounded by agricultural land have no such fish production and are also harmful for other aquatic life due to the mixing of inorganic fertilizers through agricultural run-off profusely used in paddy cultivation in this region. The pH of the sample *beels* ranges from 7.1 to 10 indicating slightly alkaline nature. The optimal range of pH for aquatic life is 6.5–9.0 [55] for irrigation; it is 7.0–8.5 [46, 56]. The value of pH is associated with the photosynthetic activities on *beels* [57]. The permissible limit of pH, temperature

and DO for fish production is 6.5–7.5, 25 °C–32 °C and 4–5 mg/ltr [58]. The pH of Jaigir Chilakhana Beel 1 and Jaigir Chilakhana Beel 3 is 9.1 and 10 respectively indicating these two beels are unsuitable for the growth and production of fish and other aquatic life. The variation in pH has occurred probably due to the effluents from the adjacent catchment area. Though the temperature of the *beels* is within the permissible limit but the other parameters show some variability in some of the *beels*. Fluctuation of temperature from the optimal range may become a threat for the aquatic life as oxygen level decreases and pollutants become toxic in higher temperature. Low water temperature and better transparency may result into the DO level slightly rising high during post-monsoon than monsoon and pre-monsoon. However, it can rapidly decrease due to the discharge of oxygen demanding wastes like ammonia, nitrate, iron etc. from agricultural land. Low DO content results into the heavy contamination of organic matters and adversely affects

Table 3 Wetland assessment through wetland index

Sl. no.	Name of the Beel	Temp	Dis-solved Oxygen	pH	Conductivity	TDS	Salinity	Total Score
1.	Santoshpur Beel	8.35	20.00	13.32	10.68	6.00	2.00	60.35
2.	Titbahar Beel	33.35	15.00	13.32	10.68	8.01	2.00	82.36
3.	Bhutanir Beel	8.35	15.00	13.32	5.32	3.99	3.00	48.98
4.	Uttar Balabhut Beel	33.35	15.00	13.32	2.68	2.01	4.00	70.36
5.	Haripur Beel	8.35	20.00	13.32	8.00	6.00	2.00	57.67
6.	Kamat Phulbari Beel	33.35	20.00	13.32	5.32	2.01	4.00	78.00
7.	Jaigir Chilakhana Beel 1	33.35	20.00	2.68	8.00	6.00	3.00	73.03
8.	Jaigir Chilakhana Beel 2	33.35	10.00	13.32	5.32	3.99	3.00	68.98
9.	Jaigir Chilakhana Beel 3	33.35	15.00	2.68	5.32	3.99	3.00	63.34
10.	Bangmari beel	33.35	20.00	2.68	10.68	6.70	2.00	75.41
11.	Masankura Beel	8.35	10.00	10.68	8.00	6.00	3.00	46.03
12.	Nayacharra	33.35	15.00	10.68	8.00	6.00	3.00	76.03
13.	Ghunghundanga Beel	33.35	20.00	13.32	8.00	6.00	2.00	82.67
14.	Janakir Chara	8.35	15.00	10.68	5.32	3.99	3.00	46.34
15.	Bamnir Chara	33.35	20.00	13.32	13.32	6.70	1.00	87.69
16.	Rasikbeel	33.35	20.00	13.32	13.32	6.00	1.00	87.69
17.	Rasikbeel	8.35	20.00	13.32	5.32	3.99	3.00	53.98

Table 4 Productivity according to wetland index

Class	Productivity	Name of the Beel
< 55	Low	Bhutanir Beel, Masankura Beel, Janakir Chara, Rasikbeel
55–75	Medium	Santoshpur Beel, Uttar Balabhut Beel, Haripur Beel, Jaigir Chilakhana Beel 1, Jaigir Chilakhana Beel 2, Jaigir Chilakhana Beel 3
> 75	High	Titbahar Beel, Kamat Phulbari Beel, Ghunghundanga Beel, Bamnir Chara, Bangmari Beel, Nayachara, RasikBeel

fish and other aquatic life. The DO level in the study area ranges from 4 to 8.5 mg/ltr indicating healthy aquatic environment for fish and other aquatic life. Conductivity is the parameter which determines the total dissolved ions in the *beels*. The desirable limit for conductivity and TDS for aquatic life is 1000 μ s and 500 ppm respectively [46, 55]. It has been observed from the study that none of the *beels* has crossed the desirable limit for the growth of aquatic life. In present study lower TDS has been recorded in Jaigir Chilakhana *beel* 3 i.e. 10 ppm whereas the highest is in Uttat Balabhut *beel* i.e. 161 ppm. The increase of TDS value indicates the higher amount of nutrients present in water. The increase of TDS in *beel* is not good for the health of aquatic life. Agriculture is the prime focus of both the blocks and the *beels* are mostly used for boro cultivation due to the higher amount of water requirement. The use of fertilizers in the fields is also very common. Through the agriculture run-off these toxic elements enter into the *beels* and affect the wetland biota negatively. The recorded value of the physico-chemical parameters in limnological studies [4, 30, 42]

in some parts of the *beels* reveal the favorable aquatic environment for the fish production and provide livelihood to rural poor.

PCA of the *beels* ($n = 17$) explaining 40.3% of total variance in respective water quality datasets reveals that most of the variations in water quality are explained by the anthropogenic pollution sources. Correlation coefficient study of the different parameters reveals that there is a strong relationship between salinity and conductivity ($r = 0.99$), salinity and TDS ($r = 0.89$), conductivity and TDS ($r = 0.79$) (Fig. 6). Conductivity determines the concentration of dissolved salts i.e. the higher the salinity the higher is the conductivity [55]. Highest concentration of TDS has been found in those *beels* which have been surrounded by agricultural practices. And there is no such fish production. However, PCA results may be convincingly presumed that the *beels* in this floodplain regime, the aquatic environment is mainly affected through the agricultural run-off, idol immersion and different recreational activities like bathing, washing clothes etc. All the water quality parameters for the floodplain wetland ($n = 17$) assessment

Fig. 6 Correlation between different parameters **a** total dissolved solids and Conductivity, **b** total dissolved solids and Salinity **c**

through wetland index show significant relationship with the ecological productivity ($p < 0.05$, t test).

4 Conclusion

The study reveals that the physiographic set up of the region and the climatic condition have resulted in the formation of many wetlands within meander belt due to the lateral oscillation of the River Kaljani, Gadadhar, Raidak I and Raidak II. While the Land surface temperature reveals that the presence of *beels* is effective to

temperature from wetland to land area, the wetland Index shows that the *beels* are ecologically very much productive for fish culture and are excellent habitat for migratory birds. Rasikbeel wetland complex has been declared as Wetlands of National Importance and is under the National Wetlands Conservation Programme. Wetland assessment through wetland index provides a composite score of individual *beel* to determine the present ecological state as well as identify the anthropogenic sources hampering the ecological productivity of the *beels* at a glance [18]. PCA helped in identifying sources responsible for the variation in growth and production of fish and aquatic life in the *beels*. Of all the six water quality parameters in wetland index -TDS; conductivity and salinity have the greater influence on the aquatic environment indicating the anthropogenic interferences of the *beels*. Not only the anthropogenic interferences but also natural short term processes like rainfall, temperature, frequency of flooding and regional set up affect wetland habitat. Except rainy season; these *beels* have been excessively used by the villagers for boro crop cultivation thereby posing a threat to the ecological balance of the *beels*. Floodplain wetlands have been altered with the intensification of agricultural modernization. Any economic pressure may hamper the biological productivity *i.e.* influenced by temperature and morphometric features. The planned exploration of these floodplain wetland resources which provide favorable aquatic environment for the growth of fish and fishery may support livelihood for society. Therefore, development of this resource will generate suitable rural economic environment and employment. Thus, this study presents usefulness of wetland index model through water quality parameters, RS GIS techniques and statistical techniques in ecological assessment, environmental assessment and identification of anthropogenic sources with a view to get better aquatic environment as well as productivity in the floodplain wetland and proper monitoring strategies for the sustainable use of wetlands.

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Compliance with ethical standards

Conflict of interest Author state that there is no conflict of interests.

Ethical approval Author state that the research was conducted according to ethical standards.

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