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Assessment of Spatio- Temporal changes of Beel Area in Rajshahi District using Multi-Temporal Satellite Images

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Abstract

Wetlands are important natural resources in Bangladesh that provide vital homes for distinct, dynamic ecosystems with enormous economic and ecological importance. Rajshahi is one of the drought-prone districts of the northwest region, which covers approximately 179 beels, among which 16 beels having area larger than 200 acres were included as our study area. This study used Landsat images for a period of 31 years (1990–2020) at five-year intervals to assess the spatiotemporal changes of the beels in Rajshahi District using remote sensing technique for Wet and Dry seasons. Throughout the last 31 years, 63.7% to 97.9% of the wet season area shrank in the dry seasons. The changes of beel area didn't show any trend and the beel area was the largest in 1995, 55% of the beel area emerged from the time interval of 1990 to1995, while in the next 15 years (1996–2020), overall 16.2% of the beel area has been reduced. Moreover, the research illustrated strong relation between beel area and water level of the nearby station and found out that among the 16 beels, only 12 were perennial. This study can help the concerned authority take decisions for irrigation practices and biodiversity conservation.

Keywords: *Spatio- Temporal Change***,** *Remote Sensing, Landsat Images, Beels*

1 Introduction

Wetlands are priceless gifts from the nature. According to the RAMSAR Convention's criteria, a majority of two thirds of Bangladesh may be categorized as wetland areas(Huq and Shoaib 2013). In the rainy season, 7-8 million hectares, or nearly 50% of Bangladesh's total land area, are thought to be covered by wetlands(Khan 1993).They are extremely important from an ecological, hydro-biological, geomorphological, commercial, and socio-economic perspectives. They also play a significant part in preserving the ecological balance of ecosystems. Among the different wetlands,enormous haor,baor,beels,etc are scattered throught the country. A beel is a moderately large surface, stationary water body that collects surface run-off water through an internal drainage channel.Beel area in Bangladesh has been estimated to cover 114,161 acres, or 27.0% of the country's inland freshwater(Ahmed, Ahamed et al. 2007).

The beel water is rich in nutrients and is very fertile. It is also full of organic detritus and flora, which gives numerous larval, juvenile, and adult fishes and other aquatic animals food and a place to live(De Graaf 2003).However, an study on the ecosystem of chalan beel showed that, during the dry season, 68% of the beels that were at their maximum (monsoon) water-spread area during the lean season were reduced to 0-5% of that size, which is crucial for the survival of many fish species(Hossain, Nahiduzzaman et al. 2009). Moreover, The northwestern region of Bangladesh which is enriched with numerous beels is facing drought problem(Habiba, Shaw et al. 2012) and Due to considerable rainfall variability, the north-western region is mostly prone to drought(Shahid and Behrawan 2008) as this region receives far less rainfall than the rest of the country(Paul 1998). This area receives 1329 mm of rainfall on average each year, compared to 4338 mm in the north-east(West, Roncoli et al. 2008). Due to their capacity to retain moisture and high rates of infiltration, the Bangladeshi districts of Rajshahi, Chapai Nawabganj, Naogaon, Rangpur, Bogura, Pabna, Dinajpur, and Kustia are experiencing an increase in reports of it. Due to the reduction of water the aquatic habitats,fisheries and agricultural sector are facing severe problem. Again, the monsoon high rainfall causes flood at monsoon period frequently. The monsoon climate in this area significantly affects how people live, particularly in the social and economic context of countries like Bangladesh that are heavily dependent on agriculture(Rahman, Kamal et al. 2016).Rajshahi district is situated in this region and faces both drought and flood during dry and rainy season respectavely. 179 beels is scattered is this district and their surface water area varies in different season which affects the bio-diversity and agricutural sector of this area. Despite the fact that only limited research has been done on Bangladesh's wetlands(Mobassher, Safiullah et al. 1996),The beels in Rajshahi district have not been the subject of any research. As a result, it has been deemed necessary to create an inventory of the chosen beels in Rajshahi district and examine the beel area changes seasonally in different years which may be helpful for irrigation practices, fisheries and biodiversity conservation. Nowadays, land cover studies utilizing remote sensing data have attracted a lot of interest on a global scale due to its importance in global change research(Cihlar 2000).This study performs a remote sensing strategy to analyze the beel area changes for different times.

2 Methodology

2.1 Study Area

Rajshahi is located in the northern part of Bangladesh between latitudes 24°12′ to 24°42′ N and longitudes 88°15′ to 88°50′ E, covering an area of 2407 sq. km. It is enclosed to the north by Naogaon District, to the east by Natore District, to the west by Chapai Nawabgong District, and to the south by the Padma River. Rajshahi district is enriched with 179 beels having an area of approximately 51.2 sq. km. among which 16 beels have an area greater than 200 acres, and they altogether cover almost 41.9% of the total beel area in this region. This study selected these 16 beels as a large-scale representative of the Rajshahi district region's beel and analyzed the spatio-temporal changes of these beels seasonally and yearly. To identify the location of each beel in the study area map, each beel was given an ID number based on the thana name.

Table 3. Information on beels

ID NO	NAME	Thana	Area (Acres)
M1	Mograr Beel	Mohanpur	289.96
B1	Nimay Beel	Baghmara	357.57
B2	Joka Beel	Baghmara	361.29
B3		Baghmara	453.35
D1	Anulia Beel	Durgapur	351.63
M2	Hina Beel	Mohanpur	615.70
B4	Kolar Beel	Baghmara	219.79
M3	Dobci Beel	Mohanpur	441.80
M4		Mohanpur	208.76
B5	Kalay Beel	Baghmara	222.30
B6	Josoy Beel	Baghmara	472.59
B7		Baghmara	235.30
M5	Mograr Beel	Mohanpur	445.71
B8	Kaligram Beel	Baghmara	520.14
T1	Jaonlal Beel	Tahore	528.13
D2		Durgapur	353.26

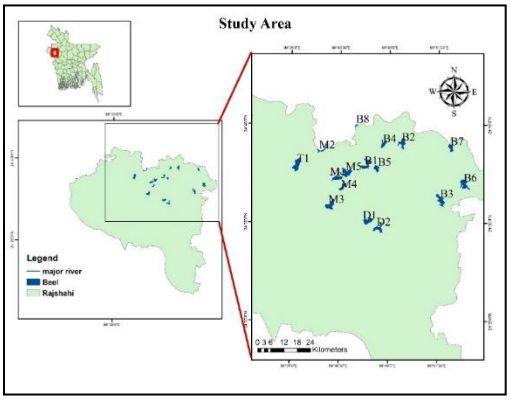

Fig. 1 Study area (Rajshahi District)

2.2 Data Collection

Landsat LT 04, 05, and LC 08 images from the United States Geological Survey (USGS) and sentinel-1 images were obtained as secondary data. USGS Images from 1990-2014 were used for the analysis and Sentinal-1 images were used for the analysis of 2015-2022. These images were collected at 5-year intervals from 1990 to 2020 for long-term study and each year from 2016 to 2020 for short-term analysis. Seasonal fluctuation of beel area changes was calculated in two seasons- Dry Season (November to April) and Wet Season (May to October). Shapefiles of beels were collected from the Center for Environmental and Geographic Information Services (CEGIS) and rainfall data from Bangladesh Meteorological Department (BMD). Water level and discharge data were collected from Bangladesh Water Development Board.

Table 2. Summary of required satellite data

Satellite	Sensor	Resolution
Landsat 04- 05	LT- TM	30m
Landsat 08	LC	30m
Sentinel-1		10m

2.3 Area change detection

The analysis was done in Arc GIS software. After the removal of haze and noise from the study area, the CEGIS beel shapefiles were used to identify the beels and after the digitization of the beels, changes of area were computed for different seasons and years.
A self-explanatory flowchart depicting the working method is presented below:

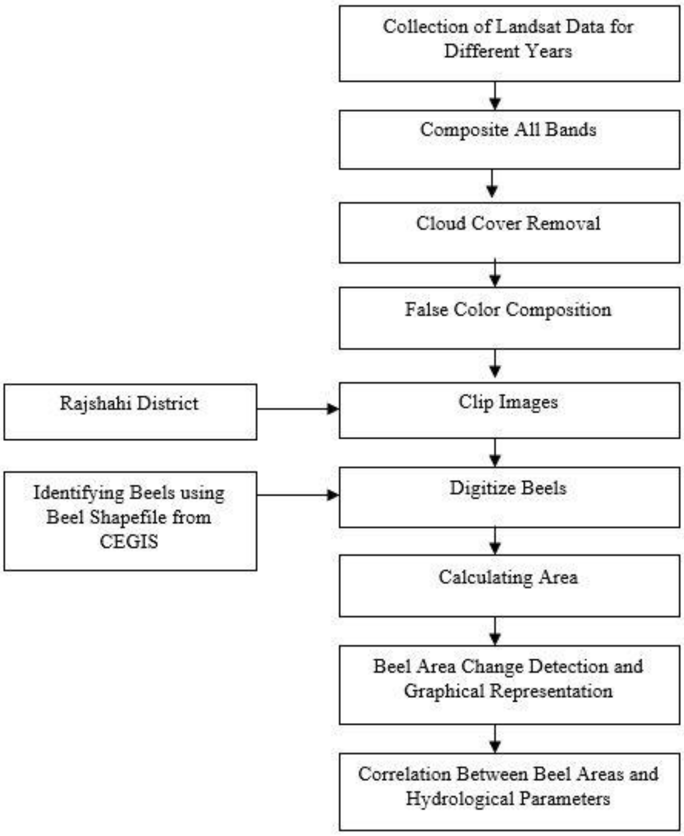

Fig. 2 Steps and Processes of the study.

3 Results and Discussions

3.1 Changes of beel Area in five-years interval from 1990 to 2020

Figures 3,4 and 5 demonstrate the beel area changes for the study region during the dry and wet seasons between the years 1990-2020 at a 5-year interval. Analysis revealed that in the dry season, most of the wetland area disappeared, even some of the beels were completely dried out. From the analysis, Joka Beel, Jasoy beel, Kaligram beel and an unnamed beel completely dried out in the dry season from 1990 to 2020; they can be termed as temporary beel. Other beels retained a smaller amount of water than in the wet season, so these are perennial beels.

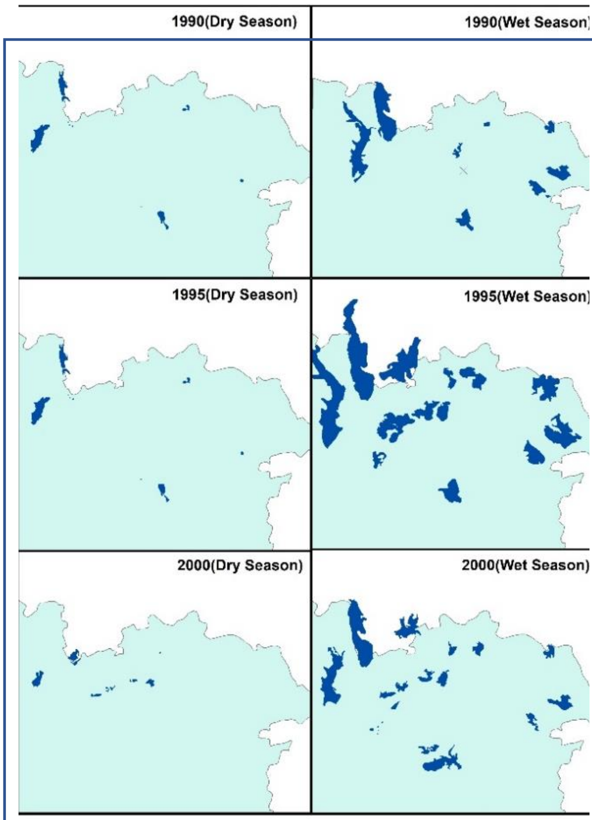

Fig. 3 Beel area during Dry season and Wet Season (1990 to 2000)

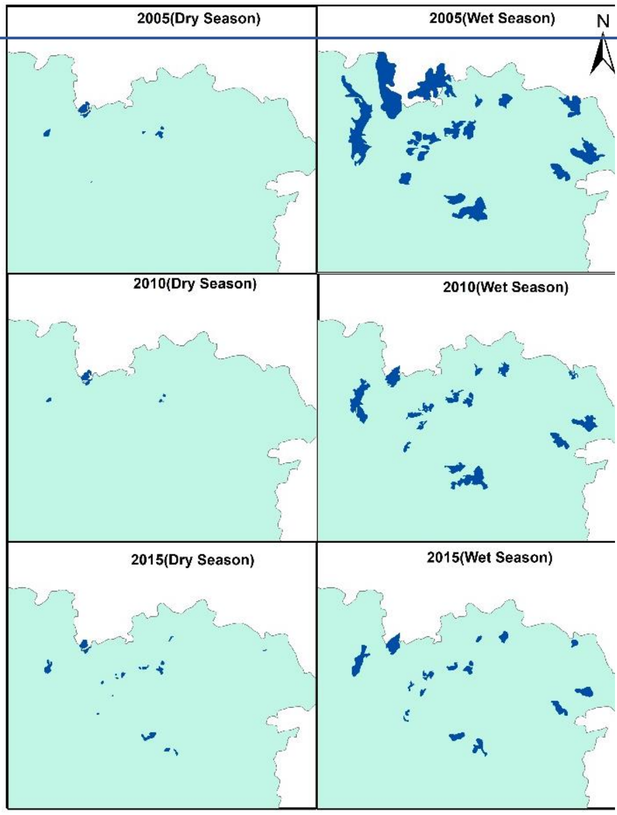

Fig. 4 Beel area during Dry season and Wet Season (2005 to 2015)

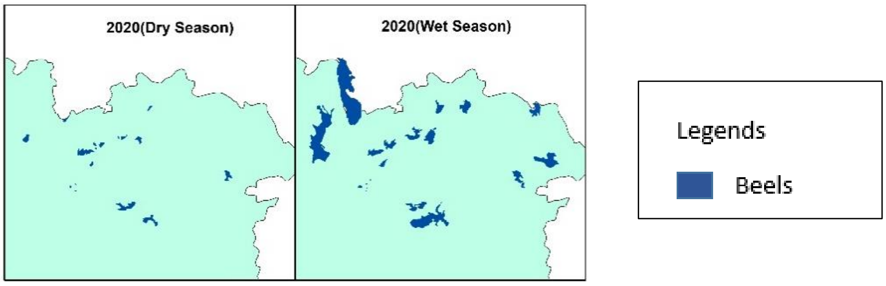

Fig. 5 Beel area during Dry season and Wet Season in 2020

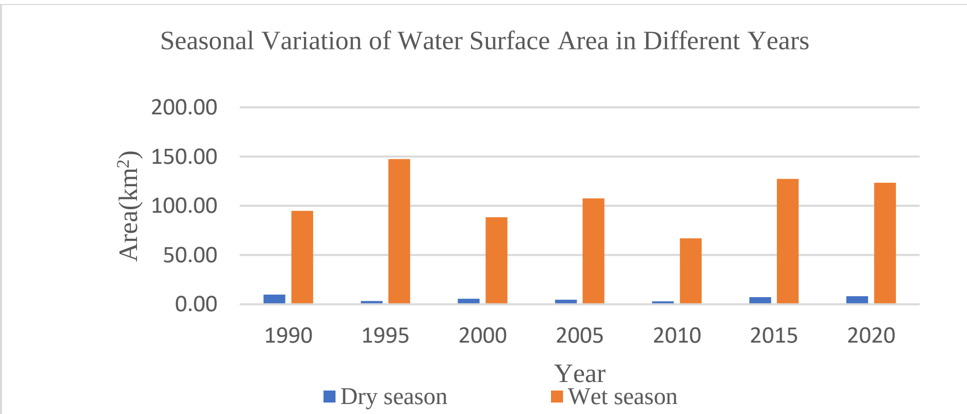

Fig. 6 Seasonal Variation of Water Surface Area in Different Year

From the water surface area vs. year graph, during the wet season, the wetlands area rose around 55% in 1995, from 94.9 sq. km in 1990 to 147.4 sq. km in 1995, which covered the largest area among these 31-year periods. The water surface area was the lowest in 2010, which was reduced by approximately 29.6%, covering an area of 66.8 km^2. In 2020, wetlands covered an area of 123.5 sq. km, which was approximately 30.2% higher than that of 1990. During the dry season, the water surface area was 3.15 sq. km in 1995, which was the lowest in this time interval and 67.2% lower than that of 1990. Beels covered 9.56 sq. km of area in 1990, which was the largest area during the dry period.

In respect of seasonal variation, the largest variation can be seen in 1995, when almost 144.2 sq. km of water area was gained in the wet season, and the shrunken area of the dry season was almost 97.9% less than the wet season. However, in 2010, the reduction was 63.7%.

3.2 Changes of Area in One-Year Interval from 2016-2020:

No significant pattern is found in the beel area changes. During the wet season, wetlands gained area from 2016 to 2017, lost again up to 2018, and finally gained some area again in 2019 and 2020.

The study didn't observe any discernible changes in the dry season.

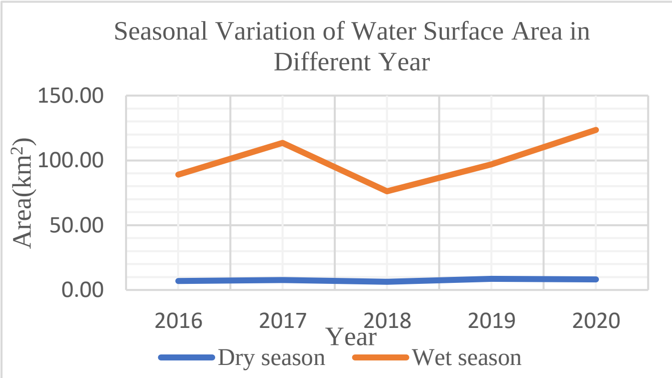

Fig. 7 Seasonal Variation of Water Surface Area in Different Year

3.3 Hydrological parameter analysis

Figure 8 shows how beel area changed with rainfall in 2020. It is observed that heavy rainfall occurred from the month of June to October. Due to the heavy rainfall, beel area gained water in these months and again gradually area was reduced in the post monsoon season. From January to April, monthly rainfall was very low and the beel area occupied the lowest amount of water in these months, some beels completely dried out.

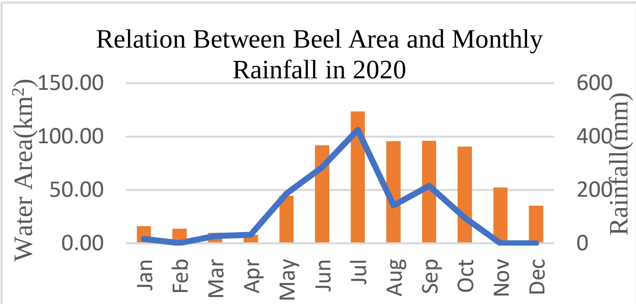

Fig. 8 Beel Area Changes with Rainfall in 2020

From Figure 9, the relationship between the water areas and discharge of the nearby station (SW261) was obtained by plotting water areas against observed monthly discharge data for the year of 2016,2020 and 2022. The correlation co-efficient (R^2) value for these three years is 0.6055 which shows a good relationship between beel area and discharge value.

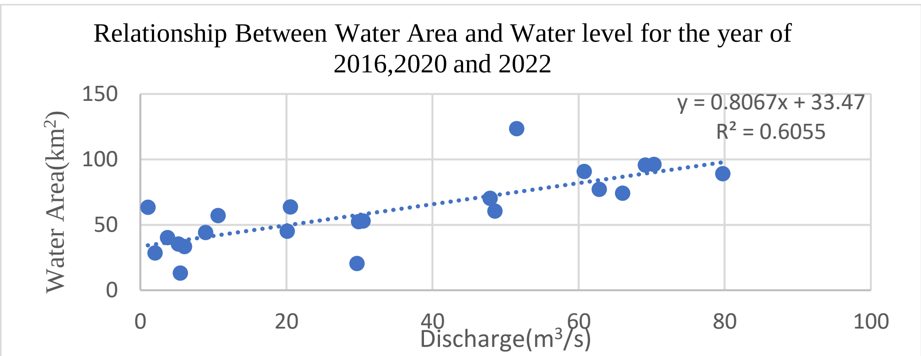

Fig.9 Relationship Between Water Area and discharge for the year of 2016,2020 and 2022

The correlation co-efficient value between water area and water level of the nearby station for the year of 2016,2020 and 2022 is 0.8056 representing a strong relationship between beel area and water level.

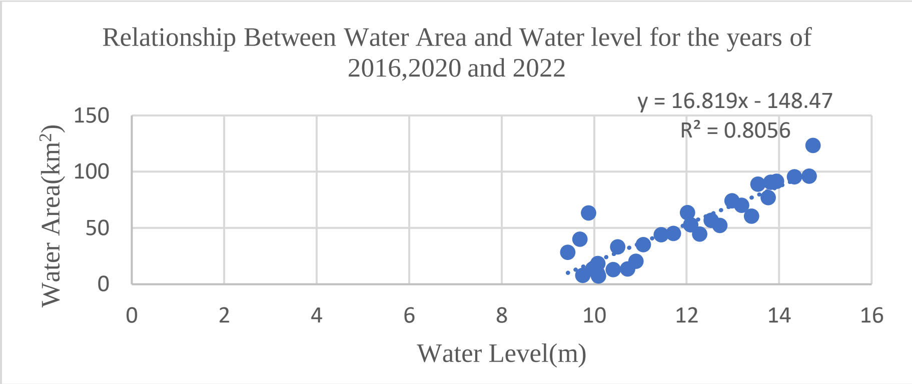

Fig. 10 Relationship Between Water Area and Water level for the year of 2016,2020 and 2022

4 Conclusions

The wetland area changes didn't follow any trend over the years. Nearly 63.7% to 97.9% of wet season area shrank in the dry season. Among the 16 beels, 4 beels completely dried out in the dry season during all study years. These are temporary beels. Approximately 30.2% of beel area was regained in 2020 from 1990, and in 1995, beels covered the largest area. Water area showed a strong relation with water level of the nearby station than discharge. The changes of beel area have an impact on marine resources, agriculture, and groundwater level. The competent authority might use this report to help with managerial decisions for irrigation techniques and biodiversity preservation. However, this study considered the largest 16 beels among the 179 beels of the Rajshahi district as a representative, further study can be done considering all the beels. Beel depth can be incorporated with the area change. Ground truthing wasn't done in this study.

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