# CLIMATIC FACTORS ON WETLAND DYNAMICS OF DEEPOR BEEL IN INDIA: A REMOTE SENSING AND GIS BASED APPROACH

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**ABSTRACT:** In recent years, climate change is a leading issue in various changes on the earth. In this study an attempt has been made to understand the affect of climate change on Deepor Beel, a Ramsar convention wetland in North East India. At first step, topographic maps, Landsat (MSS, TM and ETM) and SRTM DEM have been used for identification and detection of changes in the wetland. Approximately 57% downfall in the wetland water area was estimated over the last 38 years (from 1972 to 2010). However, in contrast to the wetland water area downfall, the area of high moisture content land was observed to be increased up to 140% beyond the wetland during the same time frame. Deepor Beel is mainly rain fed and hence, in the second step, rainfall data is analysed to understand its affect on the wetland. The rainfall data is obtained from Indian meteorological department. This study is an initiative for assessing different issues for changes in the wetland and its upland for several factors including the climate change.

## 1. INTRODUCTION

In the recent world, climate change is a major issue which may intensify the global hydrological cycle and can have large impacts on regional water resources (Immerzeel, 2008). Wetlands are transition zones between aquatic and terrestrial environment and hence, need particular attention in the context of climate change due to their vulnerability to the hydrological changes (Hongjuan Liu et al., 2011; Ventelä et al., 2010; Wen, Rogers, Saintilan, & Ling, 2011). The changes in wetland levels due to climate change primarily depend on the volume and timing of the precipitation and this may have diverse effects on moisture availability, ranging from alterations in the timing and volume of streamflow to the lowering of water levels in many wetlands (Bates et al., 2008).

Deepor Beel, located about 10 km southwest of Guwahati city, Assam, India is considered as one of the large and important riverine wetlands in the Brahmaputra valley of lower Assam (figure 1). It is surrounded by the Bharalu basin in the east, the Kalamani in the west, Jalukbari in the north and Rani and Garbhanga reserve forests in the south. It lies between 91º35′ to 91 º 43′ E longitudes and 26º05′ to 26º11′N latitude. It is recognized as one of the most significant wetland systems (10,000 acres) in the world under the Ramsar International Convention on Wetlands.

This study aims in accounting the affect of climate change, especially rainfall in the change in extent and areal dimension of Deepor Beel and its upland areas in last 50 years or more. This demanded the use of multi temporal remote sensing data and techniques suitable for wetlands. There are several innovative approaches for identification, delineation and classification of the wetland systems (Baker et al. 2007; De Roeck et al. 2008; Ozesmi & Bauer 2002; Williams 1997).

## 2. DATA AND METHODS

### 2.1 Data

The Landsat (MSS, TM, ETM+) multi temporal data from 1972 to 2010 were the spectral data sources used for the study. Multi seasonal imageries were used for easy identification of the extent of the wetland. Other data used for this study includes the 90 m SRTM DEM (Digital Elevation Model) for topographic information delineation. Also, topographical map from Texas Library (1940's) are used as the base maps.

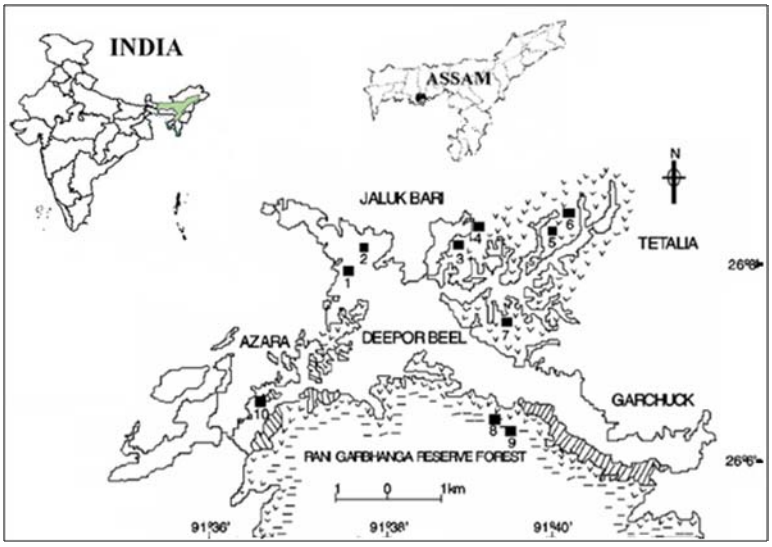


Figure 1: Location map of the study area Deepor Beel, Assam, India

The rainfall data from 1978 to 2010 was obtained from Indian Meteorological Department and NOAA (National Oceanic and Atmospheric Administration) World climatic data (http://www7.ncdc.noaa.gov/IPS/mcdw/mcdw.html).

### 2.2 Image Pre processing

The topographical maps and images are georeferenced to the same coordinate system and projection (UTM). This was done by image to image rectification method to avoid mismatching of features. The DEM which was initially in geographic projection is transformed to UTM. The satellite images are processed digitally to prepare them for visual and digital interpretation. The extent of image enhancement depends on the quality of the images. However, emphasis was given to enhance the water and moist lands to detect the wetland boundary. For this purpose, Normalised Difference Vegetation Index (NDVI) images and Normalised Difference Water Index (NDWI) images were prepared (figure 2 (b)). These can be obtained by a simple band ratioing as follows:

$$NDVI = \frac{NIR-R}{NIR+R} \tag{1}$$

$$NDWI = \frac{NIR-SWIR}{NIR+SWIR} \tag{2}$$

The next step was to classify the wetland as well as its upland using a hybrid classification technique which is a combination of supervised and unsupervised classification technique. The principal component analysis (PCA) was applied to the images prior to classification. However it was difficult to differentiate between the wetland and grasslands of the upland due to thick vegetation cover of the wetland. Hence, a layerwise classification technique was adopted where the wetland was digitized from using the NDWI image and subset. This subset was separately classified and superimposed on the previous layer for the final classification map (figure 2(a).

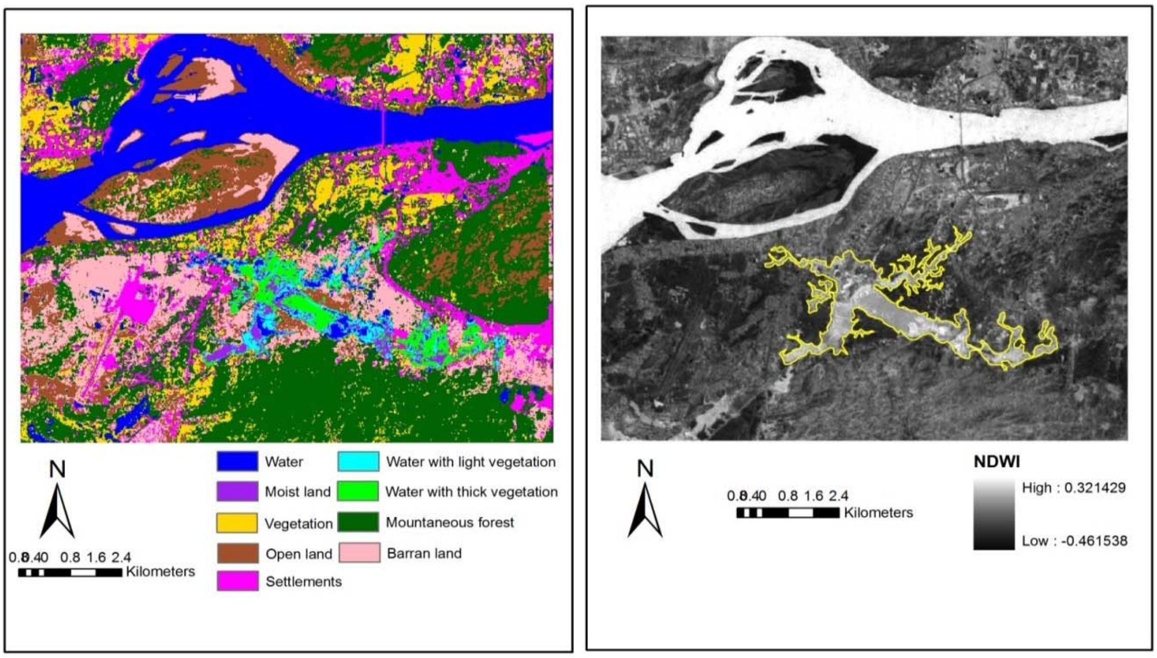
### 2.3 Change Detection Procedure

The change detection has been done in both qualitative and quantitative manner. For quantitative analysis, a model has been prepared in ERDAS which was used to detect the changes in the NDWI images of the input images. The thresholds of NDWI for each image are determined on a trial and error basis. For example, if in the NDWI image, the DN values greater than 0.1 are observed to be water, then in the model, the water areas are separated. Similar has been done for the second time series data, and finally in the output layer, only 3 values are kept where (a) there is no change, (b) water changed to land and (c) land changed to water in the wetland area.

Another way of quantifying the change was to use GIS techniques to obtain the areal extents of the wetland classes from the time series classified images. These were then compared and analyzed in tabular and graphical form.

### 2.4 Influence of Climatic Factors

As it has been mentioned before that this study is an initiative for finding the influence of different factors on the wetland, a statistical analysis has been done to compare rainfall time series with the changes in the wetland. Since it is important to analyse temporal pattern of the rainfall to determine its affect on the changes in the wetland, 42 years rainfall data is used. At first, only the pattern of the rainfall trend is observed after which NDVI values are used to analyse the affect of the rainfall on the wetland.




(a) (b)

Figure 2: April 2010 Landsat Image with (a) Layerwise classification map with four classes inside and six classes outside the wetland (b) NDWI image with mapped boundary

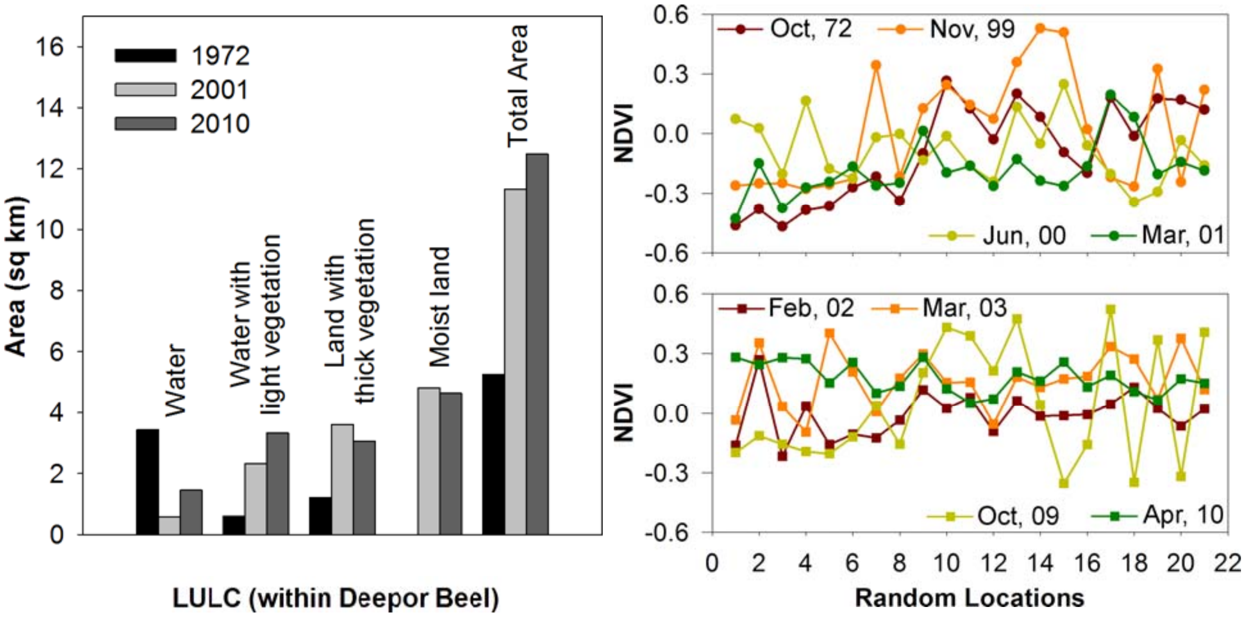
## 3. RESULTS AND DISCUSSIONS

### 3.1 Historical Trends

Figure 3 shows the graphical representation of the change observed in the wetland from 1972 to 2010. Using the threshold of NDWI, the total area of the wetland in 1972 was found to be 5.2 sq km (2.4 % of the whole study area) changed to 12.4 sq km (5.5% of study area). This makes an increase of 138% in the wetland. However, if individual classes are noticed, the area of water has tremendously decreased from 1972 to 2010 (figure 3(a)). In 1972, the area of water was 3.4 sq km which decreased to 1.4 sq km in 2010 by decreasing an amount of approximately 57%. In 1972 the wetland with vegetation was very less as compare to 2001 and 2010. This vegetation is supposed to be mostly the agricultural fields which are the activities of the local people due to fertile nature of the wetland. Hence, it is critical to say whether the wetland has expanded or due to anthropogenic activities the real wetland is shrinking.

Twenty one random locations were selected within the wetland boundary of 2010 to see the changes of NDVI from 1972 (figure 3 (b)). These points fall in both water and vegetated areas. Although there is no definite trend in the NDVI values, for different years, same season NDVI data shows drastic difference in their values. The pre monsoon (Feb-Apr) plot infers a gradual increase in NDVI from 2001 to 2003. However, there is no much difference in the average NDVI of 2003 and 2010 for all points, although there are some changes in each location. For post monsoon plot (Oct-Nov), there are few locations (1 to 8), where the NDVI was less in 1972 which increased in 2009, however in June 2000 the NDVI of these 8 locations are observed to be the highest. For the rest of the locations of the plot in this season, the pattern is random. But, in June 2000 the average of all the points can be assumed to be a constant horizontal line.

Figure 4 shows the monthly climate normal from 1978 to 2010 for rainfall in a boxwhisker plot. The boundary of the box closest to zero indicates the 25th percentile, a line within the box marks the median (red dash line indicates the mean), and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers (error bars) above and below the box indicate the 90th and 10th percentiles. The black dots are the maximum and minimum rainfall value. In 42 years (1978-2010) least variation in the rainfall data can be observed in the months of January, February, November and December. The highest variation in rainfall during the Monsoon season (June-August) indicates a huge change in climate in the area. The highest rainfall in this region is observed to be in the month of July after which it tends to decrease and in October the rainfall almost stops till February/March.




(a) (b)

Figure 3: (a) Change in the area of the LULC classes within the Deepor Beel (b)

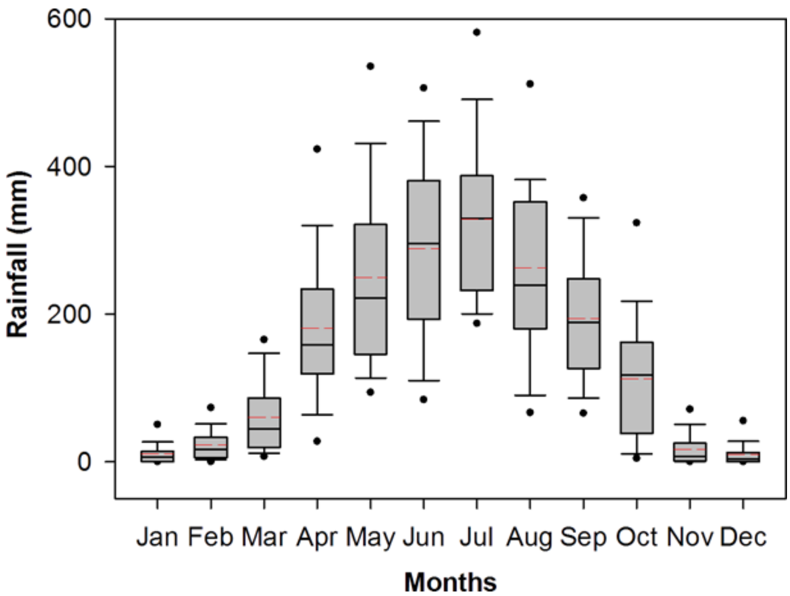
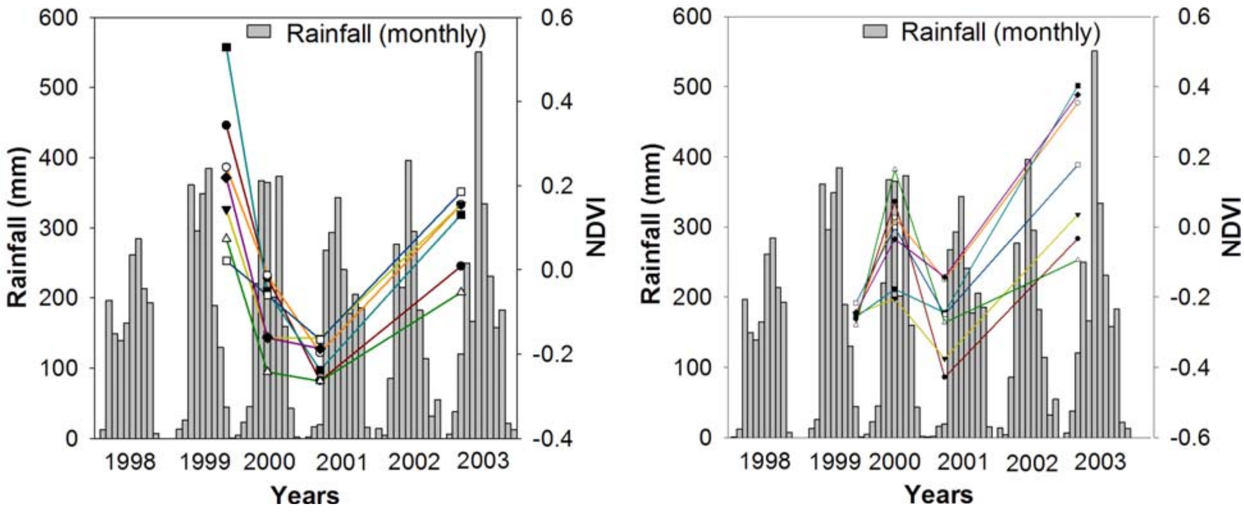



Figure 4: Box-whisker plot with monthly climate normals (1978-2010) of rainfall

### 3.2 Climate Impacts

For climate related studies, it is important to analyze the present data with the previous temporal pattern of the precipitation (or other climatic) data. To analyze this, the NDVI values from 21 locations are plotted against the rainfall data and 2 definite patterns are observed as shown in figure 5. However, the sharp changes in the NDVI are due to the limited number of values and more number of values will be tried to incorporate. These graphs are plotted to understand affect of the variation in the rainfall on different locations of the wetland. Figure 5 (a) refers to locations which fall in the water areas of the wetland. Hence, in November 1999, the water level decreases and the NDVI (may be due to chlorophyll) starts increasing. In June 2000, when the rain starts, it is filled with water. In March 2003 NDVI shows higher values inferring some chlorophyll content in the wetland. Figure 5(b) may refer to locations with agriculture fields or other vegetation which showed better NDVI in the Monsoon season. The low NDVI values in 2001 March for both graphs is crucial and may need some more analysis with some other factors than rainfall alone. It is clear that the changes in the wetland are not only due to rainfall although the basin is mainly rain fed.




(a) (b)

Figure 5: Patterns of NDVI values in 21 random locations in and around Deepor beel with respect to rainfall

## 4. CONCLUSION

In this study, an initial attempt has been made to understand the changes and the affect of rainfall on Deepor beel. The historical analysis of the wetland revealed that there is a vast change in the wetland where the water area decreased up to 57%, but the extent of the wetland increased approximately for 140% in the last 50 years. No distinct drying or wetting trends were observed in the climatic data and the rainfall is primarily controlled by the dynamics of Monsoon. However the large variation in the rainfall in the Monsoon season indicated the change in climate in the area. From the analysis of NDVI with rainfall it is clear that although there are 2 definite trends out of 21 random locations in and around Deepor beel, rainfall is not the standalone factor which affected the changes in the wetland in the last 50 years. However, from the limited points, it is evident that precipitation is one of the major factors. The study needs consideration of few more year data which is in progress and also inclusion of some other climatic factors such as humidity, temperature and some crucial factors from anthropogenic activities.

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