IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⵣ Peer-reviewed & Refereed journal ⵣ Vol. 12, Issue 3, March 2025
DOI: 10.17148/IARJSET.2025.12323

POTENTIAL IMPACT OF URBAN WETLAND USING LANDSAT DATA AND MAPPING IN DEEPOR BEEL, ASSAM

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Abstract*:* Deepor Beel is a wetland of great biodiversity, situated in the southwest part of the Guwahati city of Assam. The Rani and Garbhanga Reserved Forests are adjacent to the wetland, which altogether stands as a complete ecosystem providing environmental solutions, food security and different types of biodiversity to the city. With the rapid advancement of urban development in the city of Guwahati, the wetland is under constant threat of diminishing area of the wetland, extinction of biodiversity, as well as transformation of land use pattern of the entire area and its surroundings. The study aims to assess the changes in the lake water area from the surface area using the Modified Normalized Difference Water Index(MNDWI) and the changes in the vegetation and human habitation area using the Land Use Land Cover(LULC) classification with the help of the Arc GIS software. Time- series Landsat 8 images of the years of 2014, 2016, 2018, 2020 and 2021 were used to extract the MNDWI in GIS domain.

The analysis showed a declining nature of the area of the wetland with the years and an increase in the built-up area near the wetland. The decline in the lake water area is a serious concern in the age of rapid urbanization of big cities like Guwahati. The study reveals the potential of Landsat data and GIS study in mapping the change in the wetland ecosystem. It is hoped that the study will have its utility in the preparation of proper management plan for the conservation of the ecosystem of the Deepor Beel wetland.

Keywords*:* Surface area, Modified Normalized Difference Water Index, Land Use Land Cover, Landsat.

I. INTRODUCTION

1. General:

Wetlands are area that are covered by water, seasonally or perennially. The diverse nature of the wetland has made it difficult for the scientists to come up with single unifying definition of wetlands. The Ramsar Convention (2006) embraced this diversity in grouping a wide variety of landscape whose ecosystems share the wetland characteristics of being strongly influenced by water. Wetlands form a transition zone between water bodies and dry lands [2]. Wetlands can act as carbon sink, depending on the wetland, so wetlands have the potential to help with climate change mitigation [2]. Wetlands harvest rainwater and are the source of water supply to many big cities. Wetlands are seen to contribute in services like water purification, storm protection and flood control [2]. Wetlands that are in the vicinity of rivers act as buffers and helps to control flood and river flow.

According to the Ramsar Convention, the economic worth of the ecosystem services provided to society by intact, naturally functioning wetlands is frequently much greater than the perceived benefits of converting them to ‘more valuable’ intensive land use- particularly as the profits from unsustainable use often go to relatively few individuals or corporations, rather than being shared by society as a whole.

Extensive loss of wetland has occurred in several places throughout the world. Thus, to conserve these wetland resources, it is important to monitor and map them [13]. Remote sensing offers a cost effective method to make this happen over a large area at different points of time [13]. Usage of this method provide useful information on wetland characteristics.

Remote sensing of wetlands using satellite data started in 1972 with the launch of Lansdat1 MSS. Many regional level wetland mapping has been done by several people across the world, using Landsat-1 Multispectral Scanner (MSS) imagery [13].

Satellite data have increasingly been used for mapping wetlands and are relatively easy to integrate into a Geographic Information System (GIS). The method of satellite remote sensing can be useful in investigation and monitoring of wetlands when the funds are limited and little information is available on the wetland areas [8].

2. Objectives of the Study:

- The study attempts to study the changes in the covered area of the wetland deeporbeel in the last ten years using Geographic Information System (GIS) based approach.

- It attempts to prepare Land Use Land Cover (LULC) maps using the ArcGIS software to assess the changes in the covered area for five LULC groups. The classes viz. water body, open land, range land, vegetation and built-up area used in the study based are on the classes of National Remote Sensing Centre, India LULC classification scheme (NRSA, 1995).

- The analyse the accuracy assessment of the LULC classification in the prepared maps using the Kappa Coefficient in the ArcGIS software.

II. LITERATURE REVIEW

1. **Ahmed et.al., (2021)** The study conducted by Ahmed et.al. clearly showed that the LULC changes around the Deepor Beel was significant during the period from 2001 to 2019. Also, from 2001 to 2019, the lake lost about one-fourth of its surface area and from 2011 to 2019, the lake lost about one-tenth of its surface area.

2. **Mitra and Bezbaruah (2014)** demonstrated that GIS techniques can be effectively used in modelling impacts of transportation infrastructure on microenvironments. This is, so far, the first time the tool has been used for analysing the impacts of a railroad project on a natural wetland with specific emphasis on an endangered animal.

3. **Sarma et al. (2021*)*** demonstrated that the drainage basin is often selected as a unit of morph metric investigation because of its topographic and hydrological unity. GIS software has resulted to be of immense utility in the quantitative analysis of the geo-morph metric aspects of the drainage basins.

4. **Bhuyan and Bhattacharya (2014**) analysed the satellite imageries over different time periods since 1977 till 2006 for cloud free seasons of the study area and prepared detailed LULC maps using the ArcGIS software.

5. **Mandal et.al., (2024)** assessed the rapid land-use/land-cover change (LULCC) and its impact on ecosystem service value (ESV), affecting the socioeconomic and climatic stabilization of wetlands. In this study, a multi-resolution image segmentation and k-nearest neighbours algorithm were used for the thematic classification of satellite images of 2003 and 2018 in the Deepor Beel wetland, a lake of international significance.

6. **Talukdar et.al., (2018*)*** depicted that change in ratio of total population and settlement area are real indicator of urbanisation. Satellite remote sensing and GIS was found to be a very effective tool for spatial change detection analysis and inventory of urban areas.

III. STUDY AREA

Deepor Beel is a permanent freshwater lake which is to the south of the main river and to the south-west of Guwahati city and it covers an entire area of 40.1 km^2. It was declared as a Ramsar Site on November 19, 2002. Deepor Beel is recognized internationally for its ecological importance [23]. It is located within the coordinates of $91^0$35’ to $91^0$43’E and $26^0$05’ to $26^0$11’N and lies on 165-186 feet above MSL [19].

It is situated on the Southern bank of the river Brahmaputra and surrounded by Maj Jalukbari, Pachim Jalukbari, Dharapur and NH37 in the North; Dakhin Jalukbari, Tetelia and Pachim Boragaon in the East; Gorbhanga Reserve Forest, Chakardew Hill and Chilla Hill in the South West and Village Azara and Kahikuchi in the West [19].

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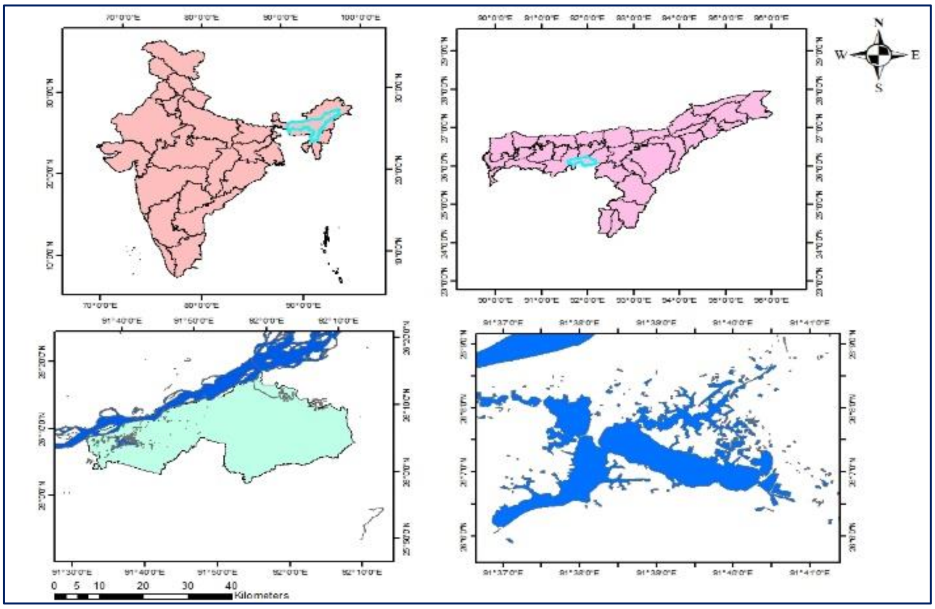

Fig. 3.1 Study Area Map of Deepor Beel

The Basistha River is the main inlet of the Beel. Morabharalu acts as a link channel joining the Bharalu river with the Basistha which discharges the waters of the Bharalu into Deepor Beel through the Basistha Bahini River when the Brahmaputra flows above the level of the Bharalu [19].

Deepor Beel has a meso-thermal climate, characterized by high humidity. The annual average precipitation is 3000 to 4000 mm. Most rainfall occurs from May to September [19].

The Basistha and Kalmani rivers and local monsoon run-off are the main sources of water to the lake. Khonajan channel drains the Beel into the Brahmaputra river, 5km to the north. It acts as a natural storm water reservoir during the monsoon season for the Guwahati city. The Beel has a perennial water spread area of about 10.1 km^2, which extends up to 40.1 km^2 [7].

Deepor Beel is one of the richest biodiversity areas within the wetland ecosystem of Assam. It supports various flora and fauna. However, the lake is degenerated at present. The major cause is the construction of the Northeast Frontier Railway track undertaken in 2001 across the Deepor Beel [21]. Meanwhile, many factories and industries developed their base in the surrounding areas and disposed off garbage and wastes into the Beel. These activities began to pollute the wetland and threatened its biodiversity [7].

IV. METHODOLOGY

The data of the study area for the years of study were collected from USGS earth explorer site. The Landsat data were download from https://earthexplorer.usgs.gov by creating polygons along the boundaries of respective districts and setting data in Landsat 8 OLI/TIRS C2 L1. The files were downloaded in FGDC format. The shape files of administrative data base were downloaded from https://onlinemaps.surveyofindia.gov.in for computing the digital elevation model.
The study involved the analysis of Landsat images of the years 2014, 2016, 2018, 2020 and 2021.

1.Spatial Temporal Variation of Surface Water in Deepor Beel:
The Spatial Temporal variation of surface water in Deepor Beel was studied using the ArcGIS software. The surface area mapping was performed to correctly extract the water features using Modified Normalized Difference Water Index (MNDWI) in ArcGIS.

2.Land Use Land Cover (LULC) Classification:
In LULC (land use land cover) classification, the areas were classified into five categories: water body, vegetation, range land, open land and built up areas. The LULC maps; considering those categories were then prepared using the ArcGIS software to assess the changes in the covered area of the wetland over the period of seven years from 2014 to 2021.

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3.Accuracy Assessment in LULC:

The accuracy of the LULC classification data were checked by the help of kappa coefficient in ArcGIS, which helped in comparing the LULC data with the reference data. The value of Kappa Index provided information about the overall accuracy of the assessment.

V. RESULTS AND DISCUSSIONS

Satellite images from different years (e.g.2014,2016,2018,2020,2021) were analyzed to track changes in Deepor Beel's surface area. It has been observed that the area of Deepor Beel has decreased over each selected period. In 2014, Deepor Beel covered approximately 6.34sq km. By 2021, this had reduced to 4.4sq km, showing a contraction of nearly 30 percent over 7 years. The area reduction from 2014 to 2016 was nearly 1 percent. Similarly, the area reduction from 2016 to 2018 was about 19%. The reduction from 2018 to 2020 was approximately 0.3% and the reduction from 2020 to 2021 was 12.8%.

1.Increase in Surrounding Built- Up Area:

Using GIS, we quantified the increase in built up area around Deepor Beel. The encroachment of built up areas near Deepor Beel directly limits the beel's natural boundary in several ways, primarily by occupying land that was once part of the wetland ecosystem.

- In our analysis, it had been observed that the built up area around Deepor Beel has increased over each selected period.
- In 2014, built up area covered approximately 16.49sq km. By 2021, this had increased to 21.57sq km, showing an expansion of nearly 30.8percent over 7 years.
- The increase in built up area from 2014 to 2016 was 0.72%. Similarly, the increase from 2016 to 2018 was observed to be around 13.1%. The increase from 2018 to 2020 was nearly 1% and the increase in built up area from 2020 to 2021 was observed to be approximately 14%.

2.Spatial Temporal Variation of Surface Water in Deepor Beel:

Table.5.1 Spatial temporal variation of surface water

YEAR	SURFACE AREA (km2)	PERCENTAGE CHANGE (%)
2014	6.46	
2016	6.34	1.8
2018	5.37	10
2020	5.26	2
2021	4.63	12

In Table 5.1, we can observe that the surface area of Deepor Beel has been decreasing year by year it depicts the contraction of the water body by around 30% which can be attributed to many reasons like urbanization, deposition of sediments, etc. [10].

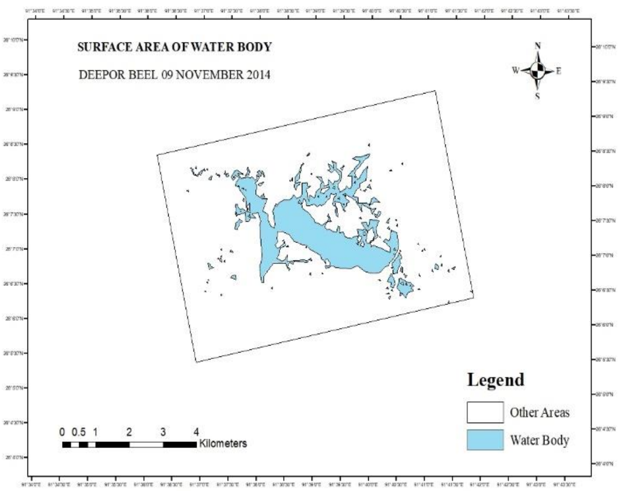

Fig. 5.1 Spatial Temporal Variation of surface water map of 2014

ISSN (O) 2393-8021, ISSN (P) 2394-1588

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Fig. 5.1 shows the spatial temporal variation of surface water map for the year 2014.

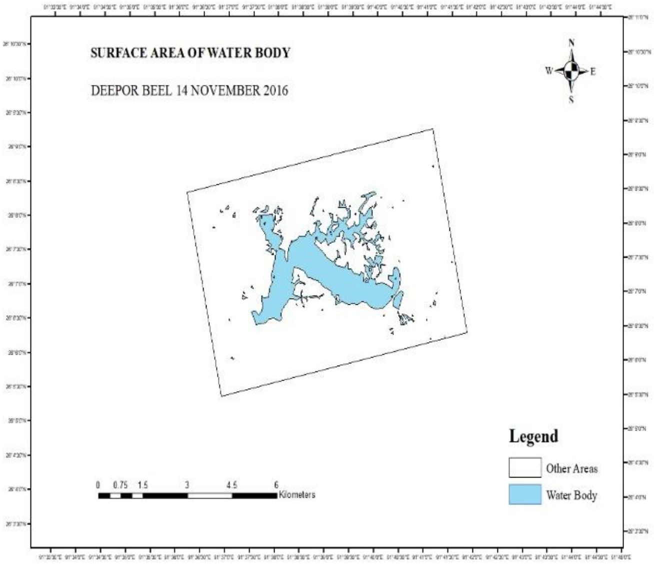

Fig. 5.2 Spatial Temporal Variation of surface water map of 2016

Fig. 5.2 shows the spatial temporal variation of surface water map for the year 2016.

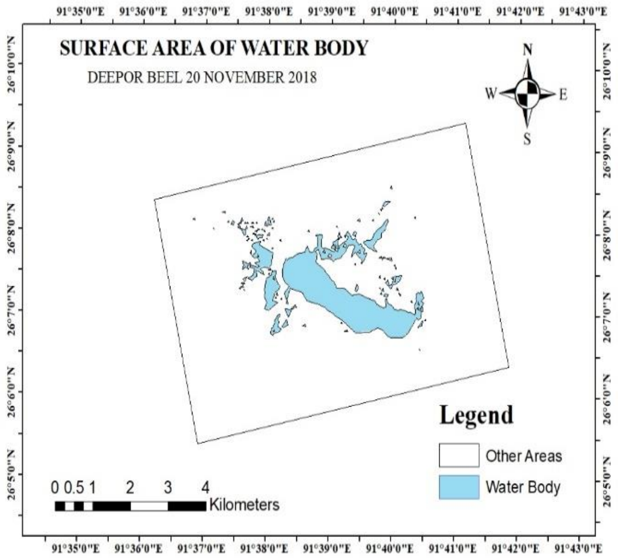

Fig. 5.3 Spatial Temporal Variation of surface water map of 2018

Fig. 5.3 shows the spatial temporal variation of surface water map for the year 2018.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

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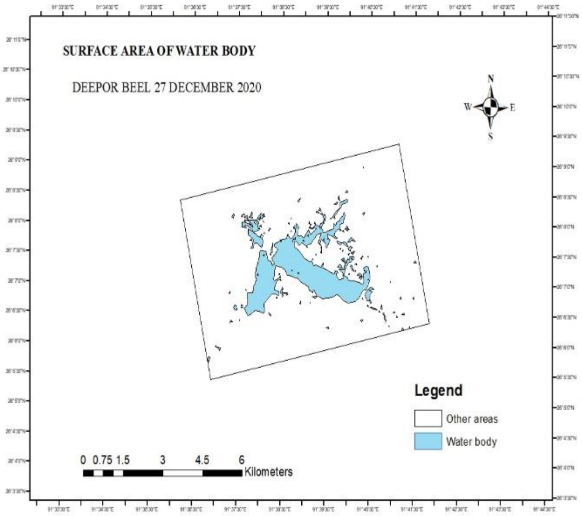

Fig. 5.4 Spatial Temporal Variation of surface water map of 2020

Fig. 5.4 shows the spatial temporal variation of surface water map for the year 2020.

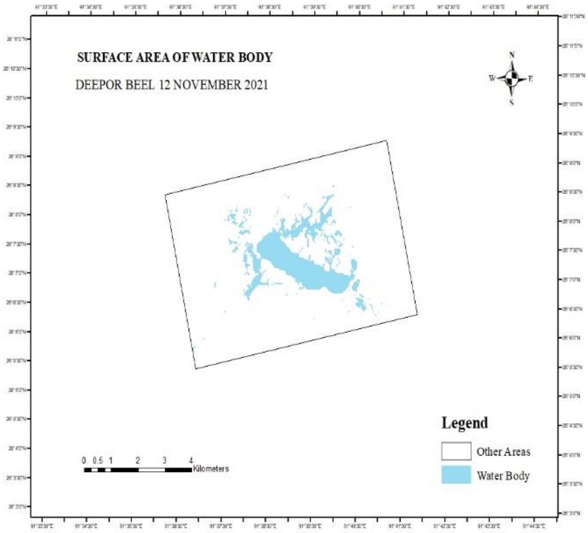

Fig. 5.5 Spatial Temporal Variation of surface water map of 2021

Fig. 5.5 shows the spatial temporal variation of surface water map for the year 2021.

3.Land Use Land Cover(LULC) Classification:

From our study on the Deeporbeel wetland, we inferred that the surface area of the water body has seen a decline of around 30% for a span of 7 years (2014-2021). The decline in the area of water body was around 1.2% for the time span of 2014 to 2016. While it was around 19% from 2016 to 2018. The decline in the water body was around 13% from 2018 to 2021.

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Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 3, March 2025

Table 5.2 LULC Table

YEAR	WATER BODY (km2)	VEGETATION (km2)	RANGE LAND (km2)	OPEN LAND (km2)	BUILTUP AREA (km2)
2014	6.34	11.23	10.46	2.34	16.49
2016	6.26	9.14	10.39	4.15	16.61
2018	5.07	6.1	10.34	6.57	18.81
2020	5.05	3.82	10.3	7.01	18.96
2021	4.4	1.99	9.9	8.94	21.57

The overall vegetation decrease in our study was around 80% from 2014 to 2021. This accounts for the increasing population and its impact on the vegetation of the wetland. Vegetation present in wetlands help retain the water by slowing down the surface runoff and encouraging water infiltration into the soil. Their roots create spaces in the soil that enhance water storage capacity. Without vegetation, water drains more quickly, reducing the amount of water retained in the wetland and leading to a decline in surface water levels. Thus, the decline in the vegetation of the area can also account for the reduction in the effective surface area of the water body of the wetland.

The open land was seen to increase by around 73% from 2014 to 2021. Open land lacks the vegetation cover that slows water runoff and promotes infiltration. As a result, rainwater flows more rapidly over the surface, carrying sediments and reducing the amount of water entering the wetland through natural infiltration processes. Faster runoff can lead to less water being retained in the wetland, reducing the surface area of water bodies.

Fig. 5.6 shows the LULC map comprising of the five groups of classification namely, water body, vegetation, range land, vegetation and built up area for the year 2014.

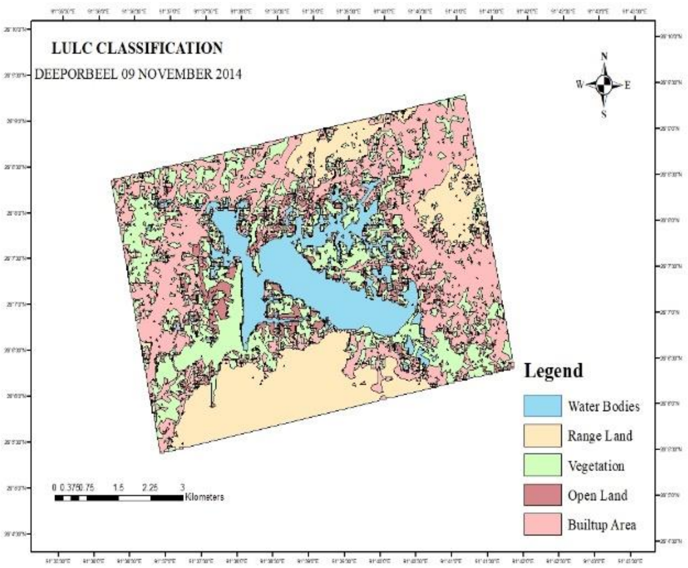

Fig. 5.6 Land Use Land Cover(LULC) map of 2014

Fig. 5.7 shows the LULC map comprising of the five groups of classification namely, water body, vegetation, range land, vegetation and built up area for the year 2016.

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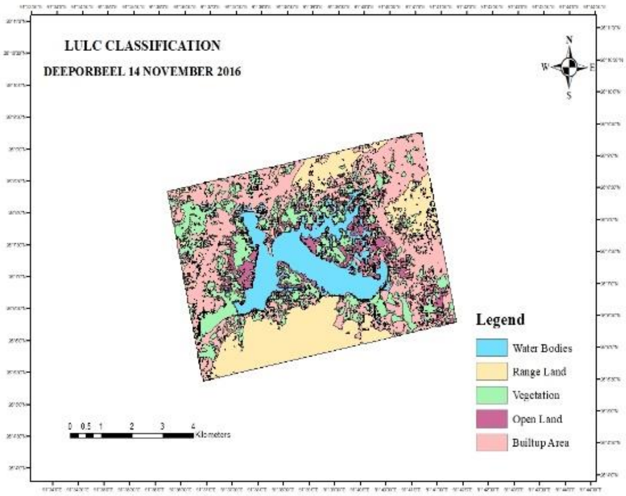

Fig. 5.7 Land Use Land Cover(LULC) map of 2016

Fig. 5.8 shows the LULC map comprising of the five groups of classification namely, water body, vegetation, range land, vegetation and built up area for the year 2018.

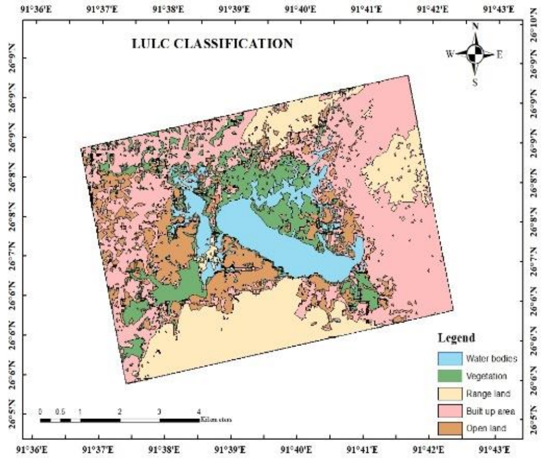

Fig. 5.8 Land Use Land Cover(LULC) map of 2018

Fig. 5.9 shows the LULC map comprising of the five groups of classification namely, water body, vegetation, range land, vegetation and built up area for the year 2020.

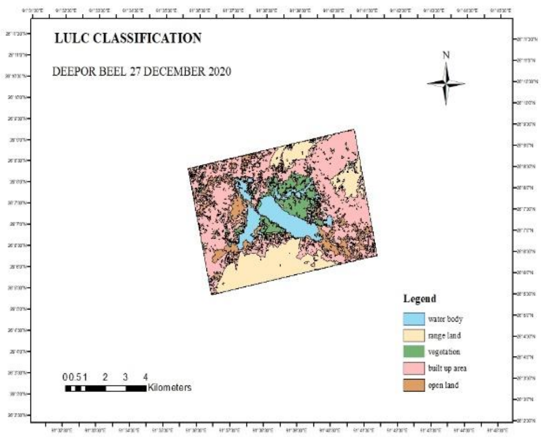

Fig. 5.9 Land Use Land Cover(LULC) map of 2020

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Fig. 5.10 shows the LULC map comprising of the five groups of classification namely, water body, vegetation, range land, vegetation and built up area for the year 2021.

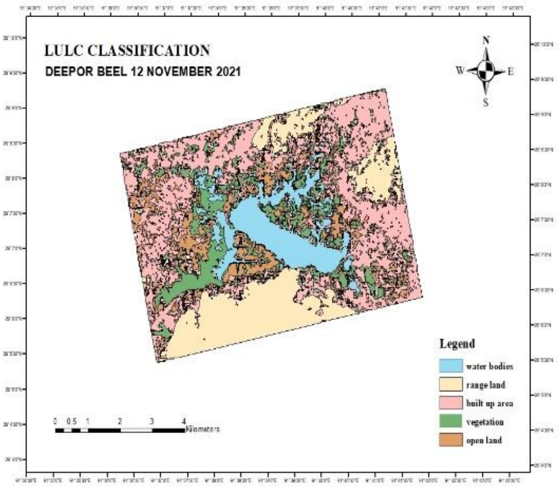

Fig. 5.10 Land use land cover(LULC) map of 2021

4.Accuracy Assessment in LULC:

Accuracy assessment is a critical step in evaluating the reliability and precision of Land Use and Land Cover (LULC) classifications derived from remote sensing data. It ensures that the LULC map accurately represents the real-world conditions by comparing the classified data with reference (ground-truth) data.

4.1.Kappa Coefficient:

A statistical measure of agreement between classified and reference data, accounting for chance agreement as shown in Table 5.3.

Table. 5.3 Kappa index value (Source: [9])

LEVEL OF AGREEMENT	KAPPA INDEX VALUE
Poor	<20%
Fair	20.1%- 40%
Moderate	40.1%- 60%
Good	60%- 80%
Very Good	>80%

4.2.Accuracy Assessment in LULC Table:

Table. 5.4 Accuracy Assessment in LULC

YEAR	ACCURACY (%)
2014	87
2016	83
2018	89.5
2020	92.1
2021	96.2

In Table 5.4, all accuracies are more than 80%, thus we can interpret the level of agreement to be very good according to the level of agreement mentioned in Table 5.3.

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VI. CONCLUSION

The GIS based study conducted on our study area of Deepor Beel wetland reveals a scenario of declining water body surface area over the span of seven years from 2014 to 2021. The overall declination of water body surface area was observed to be around 30%, with an area of 6.34 sq.km in 2014 to 4.4 sq.km in 2021. This change can be attributed to the changes in other class of study such as built-up areas, open land, vegetation which significantly affects the natural flow of the water body. The built-up areas increased significantly over the years with a whooping increase by around 30.8% between 2014 and 2021. The decrease in vegetation of the area was seen to be around 80% and the increase in the open land was around 73%. The disagreement in the percentage decrease in the vegetation area and the percentage increase in the open area can be attributed to the encroachment of the vegetation area for various human activities like construction of buildings, roads, etc. The recent increase in urbanization and encroachment has degraded the ecological balance to a large extent. The other possible factors that contributes to the wetland's degradation includes pollution and recreational activities.

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