A PROJECT REPORT

ON

Deepor Beel Wetland: Exploring Socio-Economic Dependencies and Sustainable Restoration Practices

Partial fulfilment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY IN CIVIL ENGINEERING

(With specialization in Water Resources Engineering)

Under

ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY

SESSION: 2023-2025

Submitted

by

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STATEMENT

The work contained on the report "Deepor Beel wetland: Exploring Socio Economic dependencies and Sustainable Restoration Practices" has been carried out by me under the supervision of Dr. Bipul Talukdar, Professor, Department of Civil Engineering, Assam Engineering College, Guwahati.

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SESSION (2023-2025)

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This is to certify that the work contained in the report entitled "Deepor Beel wetland: Exploring Socio Economic dependencies and Sustainable Restoration Practices" has been carried out by Prerona Bhuyan, Roll No PG/C/23/32, a student of 3rd semester in the Department of Civil Engineering with specialization in Water Resources Engineering, Assam Engineering College, Guwahati for the award of degree of Masters of Technology under my supervision.

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ABSTRACT

Deepor Beel, the lone Ramsar site, is located southwest of Guwahati, Assam. The Deepor Beel is the only stormwater holding basin in Guwahati. The city holds significant environmental and biological importance. However, wetlands are decreasing owing to many anthropogenic factors. The restoration and conservation of the wetland became the need of the hour due to growing frequent flooding in the Guwahati city. An extensive literature review was carried out to establish the theoretical framework and identify research gaps followed by field surveys to gather primary data on community demographics. Landsat satellite imagery from 2004 to 2024 with the 5-year interval was utilized for the Land Use land Cover mapping to observed the changes happened in the wetland over the two decades. The study also highlights the water quality of the wetland over the last 5 years. The data gathered comprises with the IS:2296 which is a surface water quality standard and making the trendlines of the parameters according to the classifications. A complete data structure of all the been developed to understand the current situation of the Deepor Beel, and its implication on ecosystem services and its possible responses were drafted in this work.

CHAPTER 1

INTRODUCTION

1.1 PROLOGUE

Wetland is defined as transition zones between terrestrial and aquatic ecosystems whose formation, processes, and characteristics are determined by water (Davis and Clarides 1993). According to Ramsar Convection (2002), the wetland is defined as 'areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary water that is static or flowing". It is considered the most productive ecosystem in the world which provide resources and different kind of services to the concerned human society. Wetlands play a vital role to human well-being because they promote economic growth, mitigate climate change, and facilitate adaptation. They support several species of plants and animals that rely on wetlands for survival.

1.1.1 IMPORTANCE OF WETLANDS ON LIVELIHOODS

1.*Source of food*

a) Fisheries and aquaculture: Wetlands provide breeding and feeding sites for a variety of fish and shellfish species. These provide protein-rich nourishment for millions of people and help the commercial fishing industry.

b) Wild Edibles: Wetlands provide a variety of edible plants, including wild rice, water chestnuts, and fruits, which are essential to local diets.

c) Hunting and foraging: They benefit wildlife such as waterfowl, which are hunted for food in some areas.

2. Agricultural support

a) Fertile Soil: Wetlands frequently feature nutrient-rich soils, making them ideal for agricultural activities such as rice growing.

b) Irrigation: Wetlands provide water for irrigating agricultural area, resulting in consistent crop production

3. Economic Opportunities.

a) Fisheries and aquaculture: Coastal and interior wetlands support both commercial and subsistence fishing.

b) Tourism: Wetlands attract ecotourism, which creates jobs in guiding, hospitality, and conservation.

c) Handicrafts and trade: Wetland plants are used by local communities to make mats, baskets, and ropes for sale.

4. Disaster Management and Resilience

a) Flood Protection: Wetlands minimize flood danger by protecting homes, agricultural lands, and infrastructure.

b) Drought Mitigation: Wetlands serve as natural water reserves, assisting communities during the dry season.

c) Storm Buffers: Coastal wetlands, such as mangroves, protect settlements from storm surge and erosion.

5. Cultural and social livelihoods.

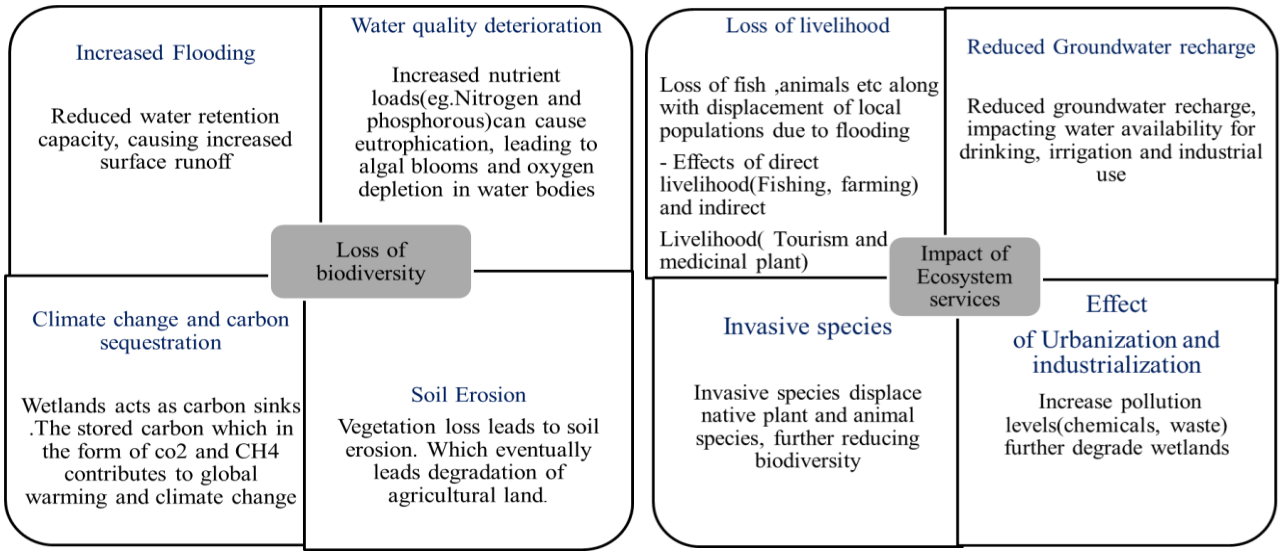
a) Traditional Practices: Many people have long-standing cultural and spiritual ties to wetlands, which they have used responsibly.

b) Health and Well-being: Wetlands produce therapeutic plants and pure water, which benefits public health.

6. Challenges to Livelihoods

Wetlands face threats like pollution, urbanization, and climate change. The degradation of wetlands directly impacts livelihoods, especially for vulnerable populations who rely on them for daily needs.

1.1.2 General problems associated with wetland degradation



1.2 MOTIVATION FOR THE WORK

This study aims to highlight problems associated with the livelihoods near the Deepor beel wetland by doing field survey, group discussions. The changing pattern observed in the beel has a significant impact on this research. It is also observed that the previous studies also offer some suggestions regarding the restoration, conservation and management of the beel. So, it is thought that to implement my interest of research in this work correspondence with the present scenario of the wetland due to rapid changes observed in the beel such as anthropogenic activity, water quality parameter changes over the decades. The objective is to frame a structure related to impact of livelihoods due to changes observed in the beel and mentioned some restoration techniques which will help for betterment of the water source “wetland” for the future generation.

1.3 STUDY AREA

Deepor Beel is a low-lying region in western Guwahati, on the southern bank of the Brahmaputra River. It is the sole Ramsar site in Assam, the third Ramsar site in the north-east area of India is located approximately 18 kilometres from Guwahati city centre. The beel and surrounding marshes occupy around 10.1 sq. km (2500 acres). The beel is bounded by Maz Jalukbari, Paschim Jalukbari, Dharapur villages, and NH37 in the north, Dakshin Jalukbari, Tetelia, and Paschim Boragaon in the east, Garbhanga Reserve Forest, Chakordew Hill, and Chilla Hill in the south, and Azara and Kahikuchi villages in the west. The beel is confined by the hill.

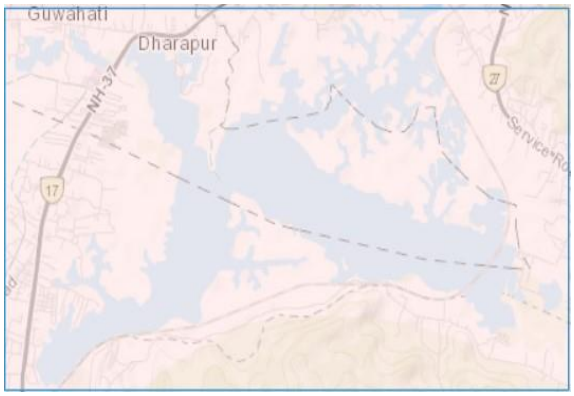


Fig 1: Deepor Beel from Survey of India

Fig 2: Deepor Beel Captured in GPS camera

1.4 OBJECTIVE OF THE STUDY

1. To identify different problems and issues associated with the wetland.
2. To assess spatial-temporal changes of the wetland.
3. To suggest remedial measures for Deepor beel restoration.

1.5 METHODOLOGY

A questionnaire is prepared on the basis of livelihood strategy, socio-economic-environmental impact on the beel and surveyed is done through four villages in four regions i.e. Keotpara (North), Garchuk (East), Tetelia-Boragaon (West), and Chakordew (South). The surveying involves localities near the wetland specially farmers and fisherman to examine the factors behind their intended willingness to participate in or support conservation of the beel. The field observation was carried out and validated with the GPS camera.

The Land use Land cover (LULC) for the last 20 years data collected from ArcGIS. The time spanning involved the years 2004,2009,2015,2019 and 2024 which shows the changing pattern of the wetland.

1.6 SOCIETAL IMPACT OF THE RESEARCH

The research focused around the challenges faced by the communities living near the wetland, particularly regarding the impacts of deterioration of water quality in previous years and various anthropogenic factors on their livelihood and overall well-being. These challenges are multifaceted, encompassing economic, social and environmental dimensions, and have profound societal implications. By addressing these issues, the research has significantly contributed to society in ways as mentioned below.

Firstly, by involving local communities in this research process, their perspectives and experiences are integrated into the formulation of the adaptive strategy, ensuring that interventions are contextually relevant and culturally sensitive.

Secondly, by providing the deeper understanding of the factors contributing to socio-economic conditions, the research has observed the fishing practices, agricultural practices. By integrating geo-spatial technology and socio-economic data, it gives us a clear vision of the present scenario of the community reside near the wetland. The dissemination of the findings and recommendations from the research has the potential to raise awareness and foster community participation in resilience-building initiatives and strengthening social networks.

Moreover, the research offered a platform to a further discussion on topics such as policy and advocacy efforts in restoring the wetland. This can inform policy interventions at the local, regional and national levels promoting better solutions that prioritize the well-being of the marginalized communities and the conservation of natural resources. Though, community engagement, the findings from the research have the potential to objectify the changes and covered more regions and paved the way for a stable, sustainable future.

1.7 CHAPTERWISE SCHEME OF THE STUDY

The dissertation contains the following chapters: -

Chapter 1: This study deals with a brief description on the topic of the study. Furthermore, this chapter includes study area, objective, methodology and societal impact of the research.

Chapter 2: This chapter depicts the literature review.

Chapter 3: This Chapter deals with the Methodology which includes LULC Mapping, Water Quality Trends, Socio-Economic Impact of the Livelihoods.

Chapter 4: This chapter deals with the results and discussions.

Chapter 5: This Chapter deals with the conclusion and future scope of the work

CHAPTER 2

LITERATURE REVIEW

2.1 PROLOGUE

The literature review for this study encompasses a diverse range of research examining fluvial dynamics, geomorphological processes and socio-economic sources of water, particularly focusing on Deepor Beels in Guwahati, Assam. Numerous studies have investigated the impact of urbanization and their livelihood strategies, highlighting the role of restoration techniques involved in the Beel, Peoples participation in restoring the Beel, land use changes, and anthropogenic interventions in shaping fluvial characteristics. Additionally, research has explored the testing of water quality parameters in the Beel throughout a definite span of time. By synthesizing findings from these diverse bodies of literature, this study aims to contribute to our understanding of the complex interactions between the water quality standards and how its effecting the livelihood, ecological and morphological changes happened in the Beel, providing insights that can inform adaptive management strategies and promotes sustainable development in the region.

2.2 LITERATURE REVIEW RELATED TO WATER QUALITY, MORPHOMETRIC CHARACTERISTICS OF BEEL

Acharjee and Sharma (2012) categorized 5 different years of changes in area, land use pattern etc. in wetland of Bhogdoi basin. Their study shows the rapid changes occurred in wetland and its surrounding areas in respect of agricultural activities, human settlement and industrialization which impact in the wetland ecosystem within the entire Bhogdoi river basin. By using GIS tools, it reveals that there have been significant changes in the areas of natural lakes and ponds between the years 1974 (16.698 sq km.) and 1998 (8.554 sq km). Similarly, the length of the river during 1974, 1998 and 2005 were 184 km, 186 km and 191 km respectively.

Dutta and Konwar et al. (2013) highlight an imperative need for restoration of wetlands and need for satellite remote sensing for monitoring and dynamic assessment of fluvial ecosystem changes which facilitates planning for ecosystem conservation, management and restoration. The study area, Panidihing natural wetland located in Sivasagar district, comprises between three river system, south by Disang, east by Demou and west by Brahmaputra is of fluvial origin which shows that the wetland lies within the contour height of 300 meter by using toposheets. The present size, shape and areas have been measured from

satellite imagery and maps collected from Divisional Forest Office, Sivasagar district. The result obtained from toposheets and field observations come into a conclusion that the change of total area from 1972 to 2000 is 17%, but from 2000 to 2010 is 21% and human encroachment has become prominent as they have expanded their economic activities in the form of paddy cultivation, Dairy farming, Dairy Fishing, mustard seed cultivation, removal of top soil layers by contractors for construction etc. The physio-chemical parameters also tested which resulted that the pH of the water was very alkaline during the pre-monsoon when compared to the monsoon and post monsoon seasons. Thus, the morphological aspects were analyzed to meet the future monitoring of the wetland.

Kapil and Bhattacharjee (2013) analyzed on monitoring of pH and 10 trace metals (As, Cd, Cr, Co, Cu, Ni, Mn, Pb, Hg, Zn) in the Deepor Beel water at 13 sites for three different depths consisting of surface layer, middle layer or euphotic zone, and bottom layer or euphotic zone x 1.5. The assessment was done bimonthly for a year. The Deepor Beel wetland system has intensive cultivation in its surroundings which may be described as a vast floodplain and is therefore a high-risk area for contamination by metals. Various chemical formulations containing these toxic metals have been in use for pest management and may be considered as the single most 67 www.ccsenet.org/ep Environment and Pollution Vol. 2, No. 1; 2013 68 important contributor to wetland water. In addition, these metals may have increased over time through natural accumulation processes involving sediment transport, soil weathering, and atmospheric deposition. pH of water is seen to have large temporal and spatial variations, and therefore, trace metals shift between water and sediment in a pattern which is dependent on time, depth of the water column and also location.

Singh et al. (2019) suggested a novel framework which prioritized the wetland restoration at a regional scale. The framework uses an ecosystem service model and an optimization algorithm that maximizes P reduction for given levels of restoration cost. The framework enables to quantify P retention services for 3606 wetlands and the potential efficacy of wetlands as nature-based solutions to improve water quality in agricultural landscapes. The tradeoffs curves obtained on optimizations represent a powerful tool to help regulatory agencies, non-profits and landowners explore benefits from a range of restoration scenarios.

Ahmed et al. (2021) aims to calculate the lake water volume from the water surface area and the underwater terrain data using a triangulated irregular network (TIN) volume model. Using ArcGIS, time series Landsat images of 2001,2011,2019 were used to extract the

modified normalized difference water index (MNDWI). The results obtained of MNDWI in 2011 was 0.462, which reduces to 0.240 in 2019. The outcome shows that the lake water storage capacity shrank in the last 2 decades. Which indicates a major problem i.e. the storage capacity of the lake has been declining gradually from 20.95 million m^3 in 2001 to 16.73 million m^3 in 2011 and further declined to 15.35 million m^3 in 2019. The last decline in lake water volume is a serious concern in the age of rapid urbanization of big cities like Guwahati.

Sharma and Sarma (2021) investigate the morphometry of the Deepor Beel basin which reflect a better understanding of basin characteristics and helps for better planning and management of the basin. With the help of ArcGIS 10.4.1 the DEM of the basin generated and categorized the Basin morphometry under linear, aerial and relief aspects. From the study, it is found that Deepor Beel catchment consists of 4th order stream covering an area of about 256 km^2. Besides, a total no of 108 streams having total stream length of 185.98 Km distributed throughout the basin in a dendrite pattern. The whole study is valuable for erosion control, watershed management, land and water resources planning and future prospective related to runoff study.

2.3 LITERATURE REVIEW RELATED TO THREATS TO ECOSYSTEM SERVICES AND LIVELIHOOD IMPACT

Bhatta et al. (2016) done some household surveys and collected quantitative and qualitative data, focus group discussions, key informant interviews and community workshops in Maguri-Motapung Beel, Assam, India to analyzed a total of 29 ecosystem services in which five out of seven livelihood strategies sourced from ecosystem services. Over exploitation of wetland resources and siltation were reported as the major direct drivers of change with impacts on both ecosystem services and people's livelihoods. By analyzing the wetland system, authors suggested that there is an urgent need for a comprehensive participatory management plan to restored the extinct fish stocks, fodder and tourism and sustain people's participation in the area.

Saikia (2019) reviewed the ecosystem services of the Deepor Beel using DPSIR (Drivers-Pressure-State-Impact-Response) framework to the local community which are discussed by focusing on the practices of two indigenous communities who have been dependent on wetland for centuries. These communities are Karbi and Koibortra community. It discusses the reasons for the shift of two communities from indigenous practices. From two different community perspectives, ecosystem services to the local community and its linkages

to poverty were discussed. The findings help us to understand the importance of key services related to provincial and regulatory services which are deteriorating such as wood fuel, transportation and social relation in the area. The main threats observed in the wetland are water pollution, decline in fish population, land use pattern and decrease in the number of plant and animal species.

Tamuli and Bora (2021) focuses on the Silsako beel, an urban wetland of Guwahati city, Assam with the effect of urbanization over the decades on the wetland. The landcover map of the study area has been prepared using NDWI approach. It is observed that the total wetland area is getting reduced from 124.15 ha in 2000 to 71.10 ha in 2010 over a period of 10 years. Again in 2020, it was reduced in area by 32.31 ha. It is interesting to note that some people have even converted the wetland areas under their occupancy into land class under permanent occupancy. The geo-environmental problems such as areal shrinking, choking of drainage, streams, urban encroachment, flash flood, pollution also contributes to the wetland. The results obtained from collection of data from secondary sources like journals, research papers and field survey are that expansion of the developmental activities has put tremendous ecological stress and strain on the wetland system. Growing urban sprawl combined with rapid pace of urbanization in the region has led to high rate of wetland degradation.

Feng et al. (2024) showed that policy opted for Poyang Lake in Jiangxi province wetland restoration has a negative impact on the changed livelihood strategies farmers family, choosing other types of agricultural production and off farm employment are currently the main choices for farmers. The examination performs i.e. the regression results help to understand the impact of wetland restoration on farmers' incomes and non-agricultural employment.

2.4 CONCLUSION

Despite the existing literature, there are inconsistences and shortcomings in our understanding. Existing study often focus on isolated aspects of morphological characteristics, variation in water quality parameters and its effect on the wetlands, necessitating a more integrated approach of restoration techniques involved in wetlands. The present study aims to contribute to providing livelihood impacts and landcover pattern changes over the decades to contribute to the understanding of wetland dynamics and community well-being in the face of environmental changes.

CHAPTER 3

METHODOLOGY

1.8 PROLOGUE

The research methodology employed in this study adopts a multi-disciplinary approach, integrating field surveys, remote sensing analysis, water quality variation during pre-monsoon and post-monsoon seasons in the Deepor Beel. Subsequently, field surveys were conducted to collect primary data on socio-demographic profile, main source of income through Deepor Beel and the adaption and coping strategies of the community. GIS and remote sensing techniques were employed to analyze satellite imagery and hence changes in landcover over the duration of time. The remedial measures for wetland restoration are also discussed. So, in this section all these aspects explored to investigate their significance offering vital prospective to better understand the dynamic environmental and social processes at work.

1.9 SATELLITE DATA

In this research the use of satellite data particularly the Landsat is important to understand the land use land cover pattern over the years.

Table 1: Satellite images acquisition details

Sl No.	Year	Satellite	Bands	True Color Composite Bands
1	2004	Landsat 4-5 Liss II	1 to 7	4,3,2
2	2009	Landsat 4-5 Liss II	1 to 7	4,3,2
3	2014	Landsat 8	1 to 7	5,4,3
4	2019	Landsat 8	1 to 7	5,4,3
5	2024	Landsat 9	1 to 7	5,4,3

Landsat 4-5 Thematic Mapper (TM), Landsat 8-9 Operational Land Imager (OLI)/TIRS Collection 2 Level 2 data were obtained from the United States Geological Survey (USGS)for the year 2004,2009, 2014, 2019 and 2024 with a 5-year interval having the 20-year study period duration. These satellite images were processed within a GIS environment to the following steps.

Download Landsat Images

Composite Bands

Extraction by mask

Create training Samples and Signature Files

Maximum Likelihood Classification

1.10 WATER QUALITY DATA

Deepor Beel is subjected to adverse human activities like encroachment, cutting the sides of wetlands, pollution, fishing, killing of migratory birds, excessive fodder practices degrade the environment value. The industrial sewage comes to the dumping site without any treatment that create high chances of water pollution. Picnic parties are also be need to blame for creating disturbance ad polluting the water. Encroachment leads to blockage the natural drainage pattern of the Deepor Beel that creates the water level imbalance in the Beel. In the monsoon season, the mud water coming from high level which leads to siltation and decrease of the Beel.

The water quality data of Deepor Beel collected from Pollution Control Board (PCB), Guwahati, Assam. From 2020 to 2024 (up to September month) several parameters of water quality of Dharapur, Boragaon, Near Bird watching tower, Near Picnic Spot, At Howrapara Khanamukh before mixing with Khanamukhjan, Chakardoi, Near Assam Engineering College, Centre of Deepor Beel regions are given. Out of which on my work, Dharapur and Boragaon area is taken. DO, BOD, Electrical Conductivity (EC), pH, Nitrate, Total Hardness, Total Dissolved solids (TDS) parameter are selected for showing the difference in the two seasons i.e. Pre monsoon and Post monsoon in MS Excel by bar charts and setting the standards as per IS:2296 (Water quality standards).

1.11 SOCIAL-ECONOMIC IMPACT AND LIVELIHOOD STRATEGIES OF THE DEEPOR BEEL

3.4.1 Socio-Economic Impact of Deepor Beel

1. **Livelihood Provider for local Communities**

- **Fishing:** It is a critical source of livelihood for many fishermen. It supports a variety of

fish species, which local communities depend on for both subsidence and income

- **Agriculture:** The fertile lands around the wetland are used for paddy cultivation and other agricultural activities, which are integral to the local economy.
- **Livestock Rearing:** The wetlands provide grazing grounds for livestock, especially cattle, which is another source of income for the local population.

2. **Economic Importance**

- **Market supply:** The fish and aquatic resources from Deepor Beel are sold in local markets such as Azara fish market, Garchuk Chariali etc.
- **Tourism:** The wetland is a popular spot for bird watching and eco-tourism, attracting visitors from around the world. Deepor Beel is home for almost 232 bird species belonging to 42 families, the majority of which are migratory birds. Fifteen endangered species of avian fauna were found in the Deepor Beel This generates revenue for local businesses, including small shops, guides and transport services**.**

3. **Ecosystem services**

- **Water Supply:** The wetland serves as a freshwater source for surrounding areas.
- **Flood Mitigation:** Deepor Beel acts as a natural flood reservoir, reducing the severity of floods in the region.
- **Biodiversity Conservation:** It is home to several endangered species, such as the greater adjutant stork (Bird), which holds ecological and cultural significance.

4. **Challenges and Negative Impacts**

- **Pollution and Encroachment:** Industrial and municipal waste from Boragaon area has degraded the quality of water, affecting fish populations and other aquatic life.
- **Loss of livelihoods:** Pollution, reduced fish stock, and encroachment have directly impacted the livelihoods of fisherman and other dependent communities.
- **Infrastructure Development:** Construction of a Railroad along the southern boundary of the Beel by the Northeast Frontier Railway, in 2001 has highly affected the environment and ecosystem of this wetland. The railroad divided the wetland into parts and it disturbed the ecosystem of the wetland in a greatly high extend.

3.4.2 Livelihood Strategies of Communities Around Deepor Beel

- **Fishing Based Livelihoods**: Fishing is the primary livelihood for many households around Deepor Beel. Fisherman often use traditional methods, such as nets and traps, to catch fish. To cope with declining fish stocks, some fishermen are diversifying into aquaculture or

migrating to other regions for work.

- **Agriculture and Allied Activities:** Many families practice agriculture in the fertile lands surrounding the wetland. Crops like rice are cultivated, with some household using organic farming technique. Livestock rearing, including cattle and poultry farming, is another common livelihood strategy.
- **Eco-Tourism and Conservation Jobs:** Some locals have shifted to eco-tourism activities, working as guides, boat operators, or small business owners catering to tourist visiting the wetland. Employment opportunities are also created through conservation projects and activities by NGOs and government agencies.
- **Alternative Livelihoods:** Due to degradation of the wetland, some households have resorted to alternative livelihoods, such as daily-wage labor, handicrafts, or small-scale trading. Migration to urban areas for employment has become a coping strategy for many families.
- **Community-Based Resource Management**: Local communities have formed groups and cooperatives to manage and protect the wetlands resources. Participatory approaches to conservation have helped balance livelihood needs with ecological sustainability in some cases.

On the basis of that a questionnaire is provided to localities and surveying is done in the four locations. The area covered for surveying are Keotpara village, Chakardoi, Pamohi and Boragaon to examine the factors behind their intended willingness to participate in or support conservation. The field observation was carried out and validated with a Google Earth image. The questionnaire provided is as follows: -

Questionnaire on social-Economic impact and their livelihood strategies in the Deepor Beel:

1. Socio-Demographic Profile

- Name:
- Age:
- Gender:
- Educational Level:
- Occupation:
- Duration of residence near Deepor Beel:

2. Livelihood Strategy

- What is your primary source of income?
- Do you depend on Deepor Beel for your livelihood? Yes/No (If yes, how?)
- How many hours per day/week do you spend on livelihood activities related to the wetland?
- What other non-wetland related activities contribute to your household income?
- Do you have own land for cultivation? (Yes/No)
- Does your income solely dependent on agriculture? (Yes/No)
- Do you borrow land from others? (Yes/no)

3. Natural Resources Use

- Which Resources do you extract from Deepor Beel?
  (E.g. Fish, aquatic plants, Firewood)
- How has the availability of these resources changed over the past 10 years?
- Do you use any traditional methods to extract resources sustainably?
- Are there restrictions on resource use in the area? If yes, what are they? And how do you impact your livelihood?

4. Main Source of Income through Deepor Beel

A. Agricultural Practices

- Do you engage in farming activities near Deepor Beel? If yes:
  - What crops do you grow?
  - In which area cultivation production is optimum?
  - How frequently do you cultivate?
  - In which season production is high?
  - Do you use water from the wetland for irrigation? (Yes/no)
  - Have there been changes in agricultural yields in recent years?

B. Fishing Practices

- Do you engage in fishing activities near Deepor Beel? If yes:
  - How the fishing pattern changes over the years?
  - In which time of the year fishing is high?
  - In which area different quality of fishes appears?

- Fishes Obtained in different locations over the years.
- How much fishing is done on and average over the years?

5. Environmental Challenges

- Have you observed changes in wetlands size, water quality or biodiversity?
- What do you think are the causes of these changes?
- Do you experience conflicts with over community members over wetland resources?

6. Social and Cultural Importance

- Does the wetland hold cultural or religious significance for your community?
- Are there specific festivals, rituals or tradition associated with Deepor Beel?

7. Adaption and coping strategies

- What strategies do you use to cope with livelihood challenges (E.g., Reduced fish stock, water pollution)?
- Have you received any external support or training to improve your livelihood? (E.g. NGO's, government program)
- Are you open to shifting alternative livelihoods if resources from the wetland continue to decline?

8. Awareness and Conservation

- Are you aware of conservation programs or policies for Deepor Beel?
- Do you participate in any community or government led conservation activities?
- What suggestions do you have for the sustainable management of Deepor Beel?

9. Miscellaneous

- What are key challenges you face in maintaining your livelihood?
- How do you envision the future of Deepor Beel and its role in your community livelihood?

The field survey involves 30 responders from all the four regions. During the field survey it exhibits the traditional dependent communities suffered greatly as a result of the strain placed on the beel. Peasant communities in adjacent villages, including Pamohi, Mikirpara, Kalitapara, and Deosotol, primarily cultivate rice. "Boro Dhan" "Bou Dhan" and "Hali Saul"

which are cultivated during the month of December April and in Monsoon season. The group synchronized their cultivation based on the availability of water from the wetlands. The wetland's water is becoming polluted, forcing these communities to pursue alternative livelihoods. Fishing populations have inhabited Keotpara, Matiya, Barbari, and Hirapara for generations.

1.12 WETLAND RESTORATION PROCESS

There are several ways to restore wetland. Few of them are discussed below.

- **Eutrophication Process**: Eutrophication is a process driven by nutrient enrichment, particularly nitrogen (N) and phosphorus (P), that leads to excessive growth of algae and aquatic plants, followed by oxygen depletion. While eutrophication is typically viewed as a negative process in natural wetlands, it can also occur during the restoration of degraded wetlands, especially when nutrient-rich sediments or water sources are involved. The positive side of Eutrophication in restoration process includes stimulation of the establishment of plant biomass and organic soils, which are essential for wetland function. However, this requires careful monitoring to prevent excessive nutrient accumulation.
- **Dilution/Flushing:** Dilution involves the addition of low-nutrient water to reduce lake nutrient concentration and can be effective where external or internal sources are not controlled. Flushing simply removes algal biomass, although that may require large volumes of water if nutrient concentration is high and not limiting. While effective, employment of these treatments has limited application due to the availability of water, especially low-nutrient water.
- **Artificial Circulation:** This approach prevents heat stratification by mixing rising air bubbles. It improves oxygen levels, reduces iron and manganese, and limits algal development in unpredictable nutrient environments and can counterbalance the elements promoting domination by blue-green algae. The examples of Artificial Circulation include shalow lakes, constructed wetlands etc.
- Sediment Removal: This approach can be used for a variety of purposes, including controlling algae and macrophytes. Deepening shallow lakes can effectively regulate macrophytes, reduce nutrient loading by removing enriched sediment layers, and remove hazardous sediments. This method has a considerable long-term advantage over nutritional inactivation since it removes the source, unlike P inactivation, which leaves

it bound in place. Dredging has limits, including high costs and the need for proper disposal sites. Innovative disposal methods, such as using dredged material to create structures, make dredging more appealing.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 LAND USE LAND COVER ASSSESSMENT

The analyzation of land use and land cover identifies patterns such as urbanization, agricultural growth and wetland ecosystem degradation. Studies conducted in the area over timeframes of 20-year analysis with 5-year interval such as 2004,2009,2014,2019 and 2024 is done and shown significant changes, often attributed to human activities.

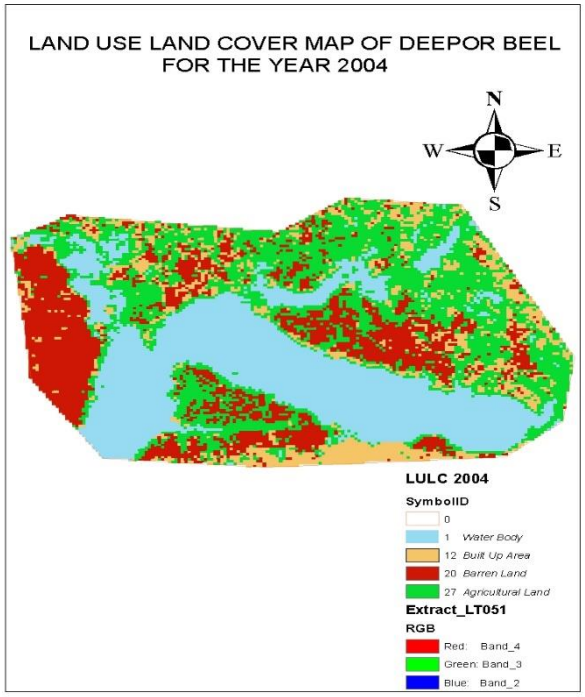


Fig 3: LULC of Deepor Beel for 2004

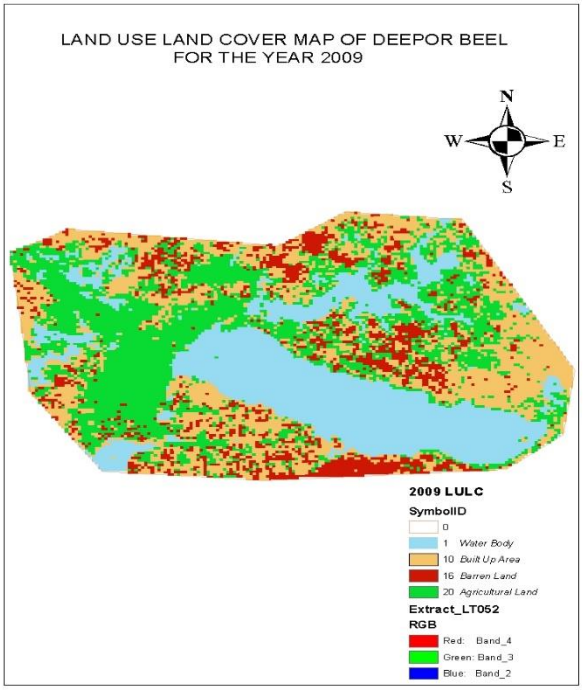


Fig 4: LULC of Deepor Beel for 2009

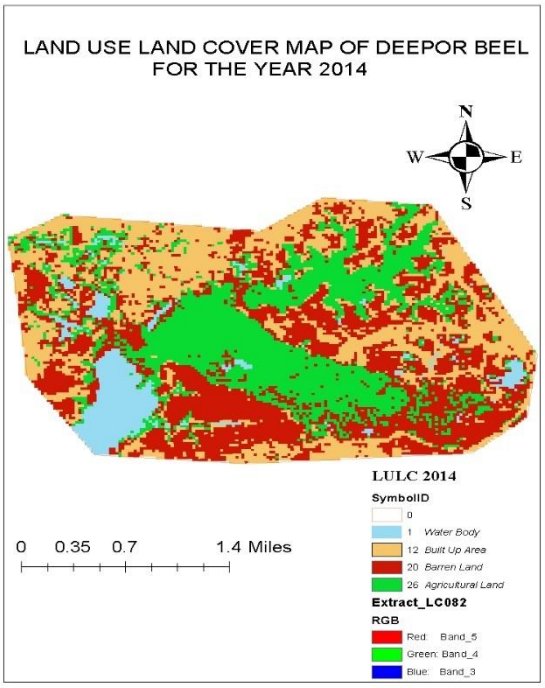


Fig 5: LULC of Deepor Beel for 2014

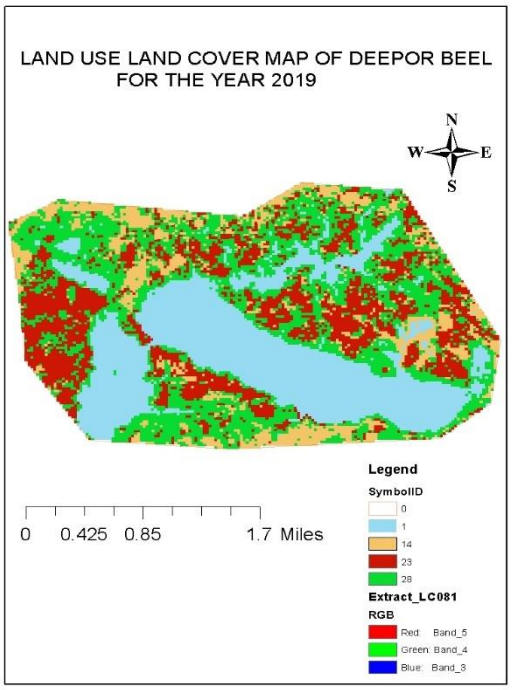


Fig 6: LULC of Deepor Beel for 2024

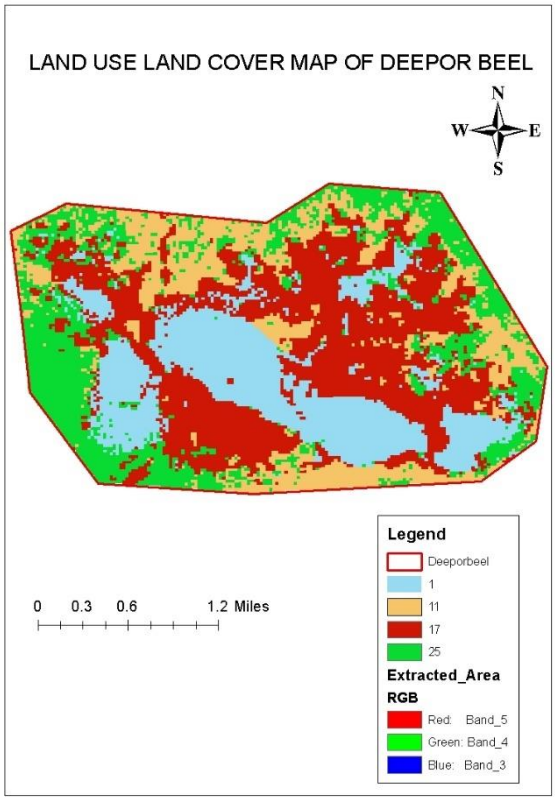


Fig 7: LULC of Deepor Beel for 2024

4.1.1 Results Obtained from the LULC Assessment

Table 2: Results of Classification of LULC for 2004

Classification	Sum of Area (km^2)	%
Water Body	4.507	33
Agricultural Land	4.511	33
Built Up Area	1.709	12
Barren Land	3.043	22
Grand Total	13.772	100

Table 3: Results of Classification of LULC for 2009

Classification	Sum of Area (km^2)	%
Water Body	3.750	27
Agricultural Land	4.344	32
Built Up Area	4.005	29
Barren Land	3.750	12
Grand Total	13.774	100

Table 4: Results of Classification of LULC for 2014

Classification	Sum of Area (km^2)	%
Water Body	0.994	7
Agricultural Land	3.825	28
Built Up Area	4.125	30
Barren Land	4.872	35
Grand Total	13.767	100

Table 5: Results of Classification of LULC for 2019

Classification	Sum of Area (km^2)	%
Water Body	4.227	31
Agricultural Land	4.654	34
Built Up Area	1.738	13
Barren Land	3.155	23
Grand Total	13.775	100

Table 6: Results of Classification of LULC for 2024

Classification	Sum of Area (km^2)	%
Water Body	3.201	23
Agricultural Land	3.041	22
Built Up Area	2.601	19
Barren Land	4.922	36
Grand Total	13.766	100

4.2 WATER QUALITY DATA ASSESSMENT WITH SURFACE WATER QUALITY STANDARDS

Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Electrical Conductivity (EC), pH, Nitrate, Total Hardness, Total Dissolved solids (TDS) parameter are selected for showing the variance in the two seasons i.e. Pre monsoon and Post monsoon in MS Excel by bar charts and making the trendlines for respective classes throughout the years with the standards as per IS:2296 (Surface Water Quality Standards) for the site locations Dharapur Chariali and Boragaon Near Institute of Advanced Study in Science and Technology (IASST). The Representation showing mainly the Pre-Monsoon season of (2020,2021,2022,2023,2024) against Post monsoon season (2020,2021,2022,2023). The classes represent in the IS Codes are: Class A- Drinking water without conventional treatment but after disinfection

Class B- Water for Outdoor Bathing

Class C- Drinking water with conventional treatment followed by disinfection

Class D- Water for fish culture and wild-life propagation

Class E- Water for irrigation, industrial cooling and controlled waste disposal.

DO:

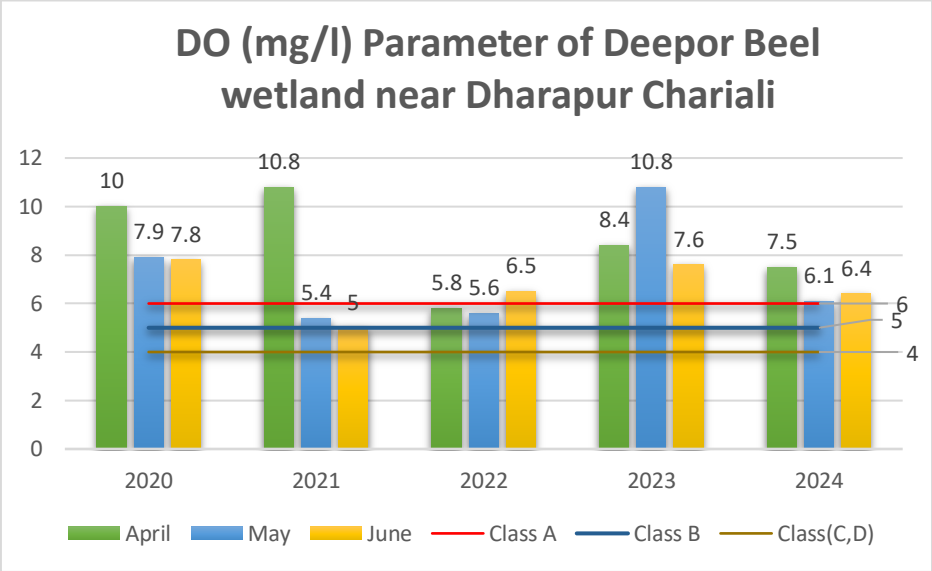


Fig 8: DO (mg/l) parameter in the Pre-Monsoon Period Period

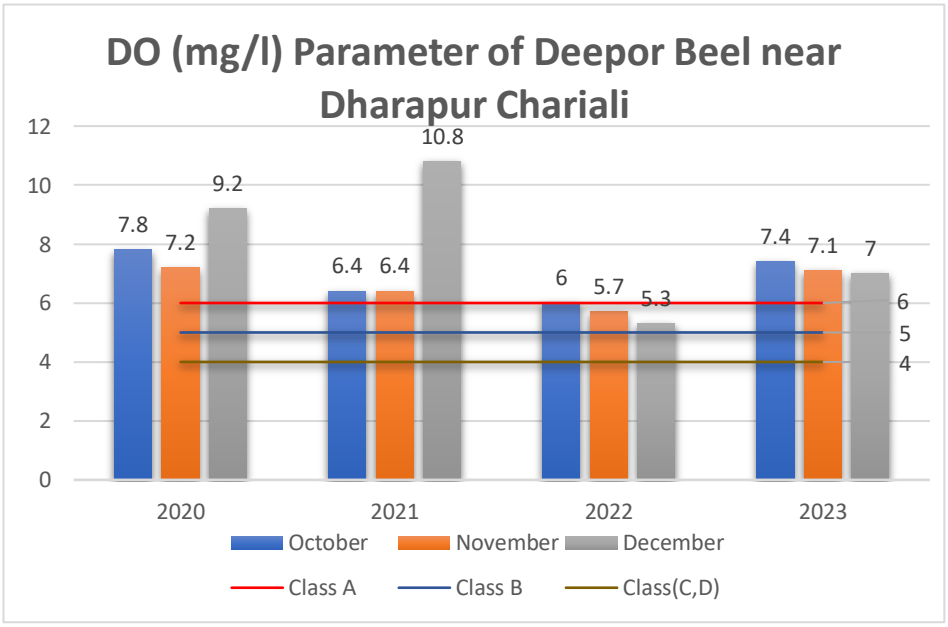


Fig 9: DO (mg/l) parameter in the post-monsoon period

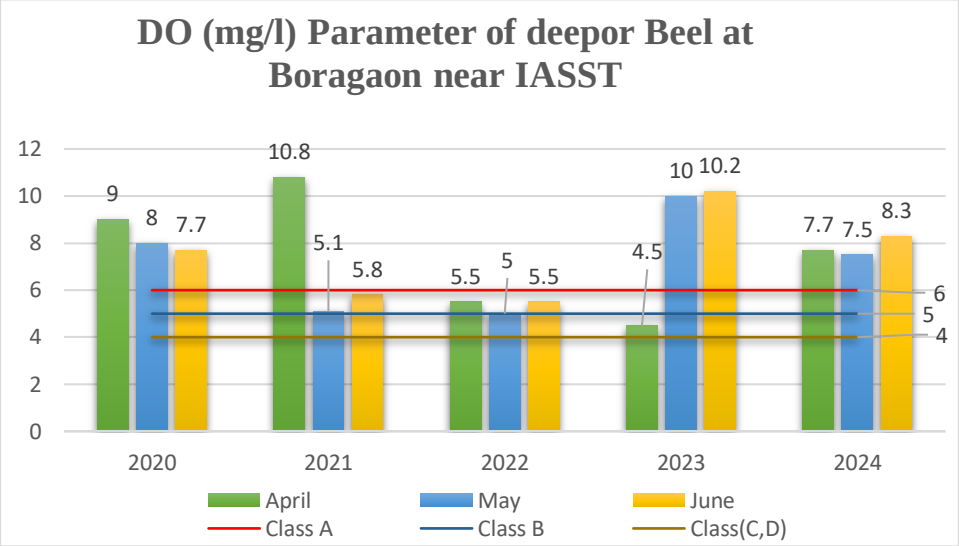


Fig 10: DO (mg/l) parameter in the Pre-Monsoon Period

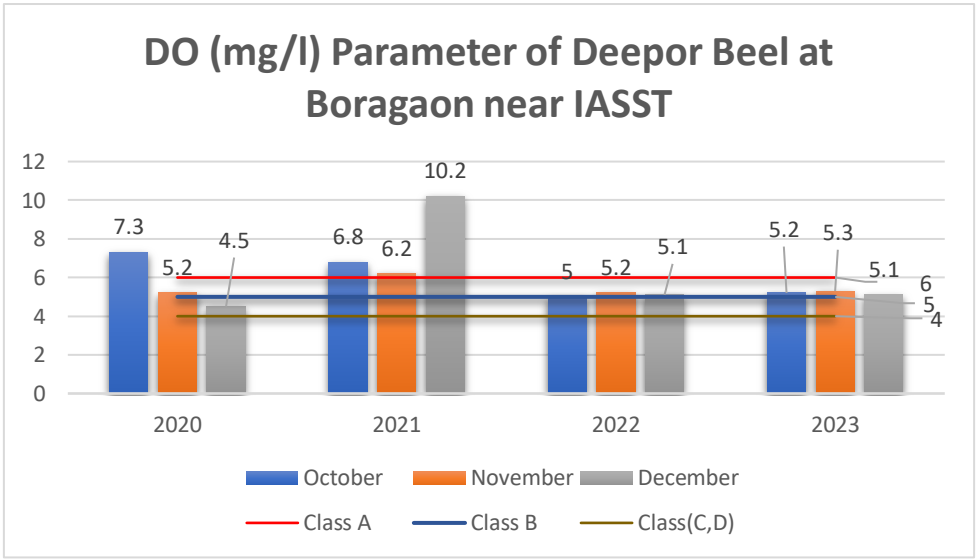


Fig 11: DO (mg/l) parameter in the post-monsoon period

BOD:

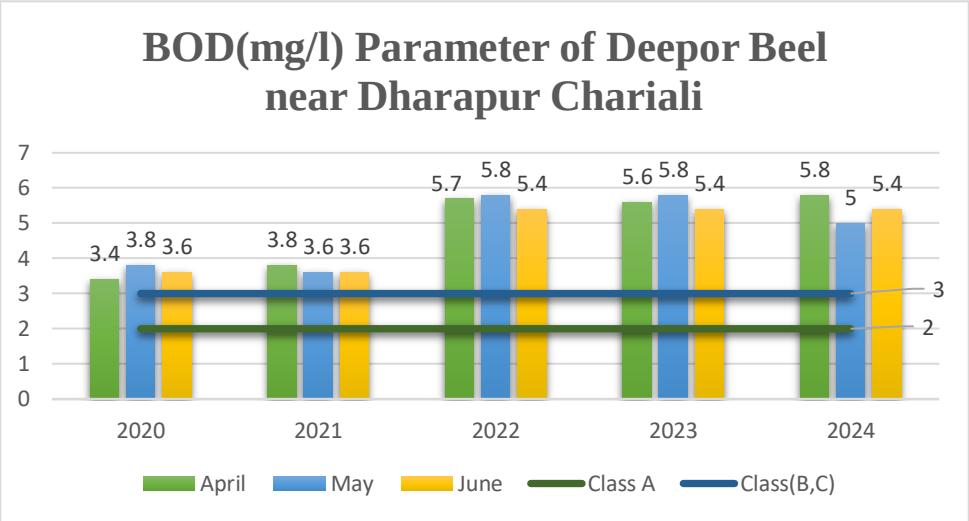


Fig 12: BOD parameter in the Pre-Monsoon Period

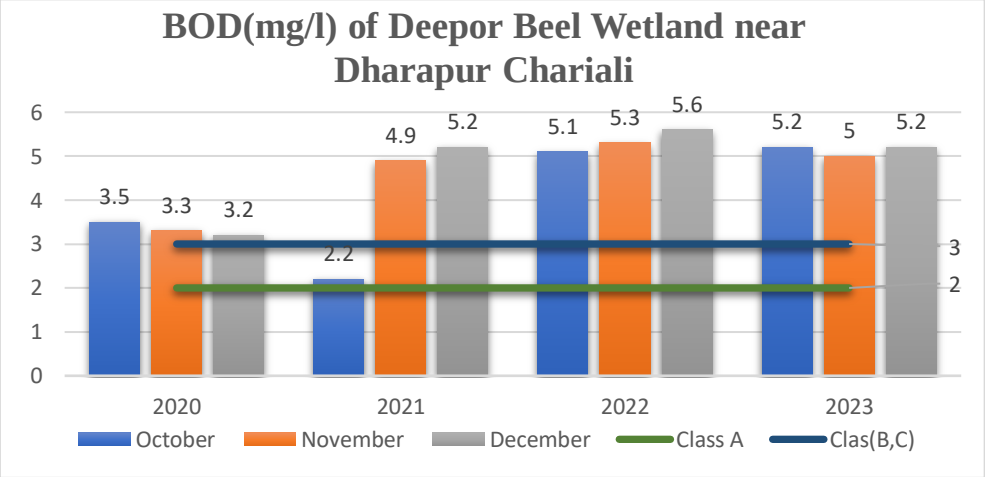


Fig 13: BOD Parameter in the Post-Monsoon Period

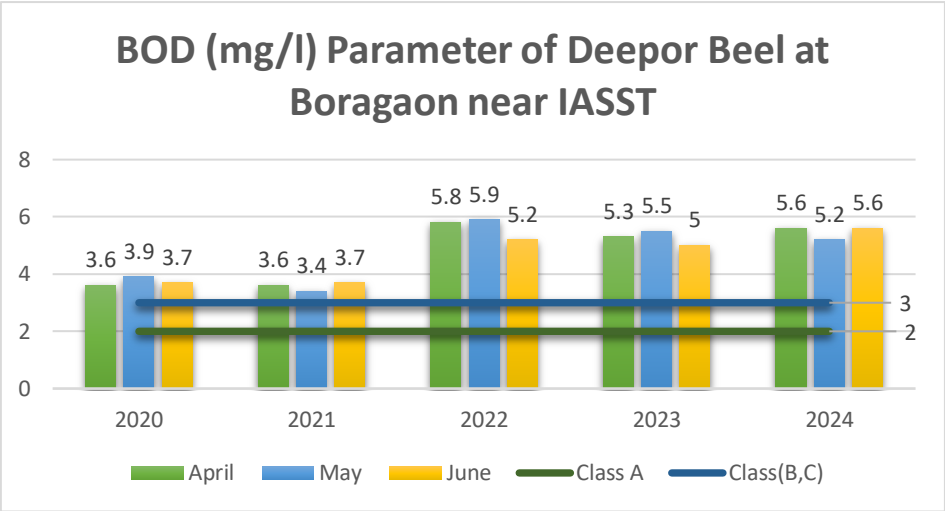


Fig 14: BOD (mg/l) Parameter in the Pre-Monsoon Period

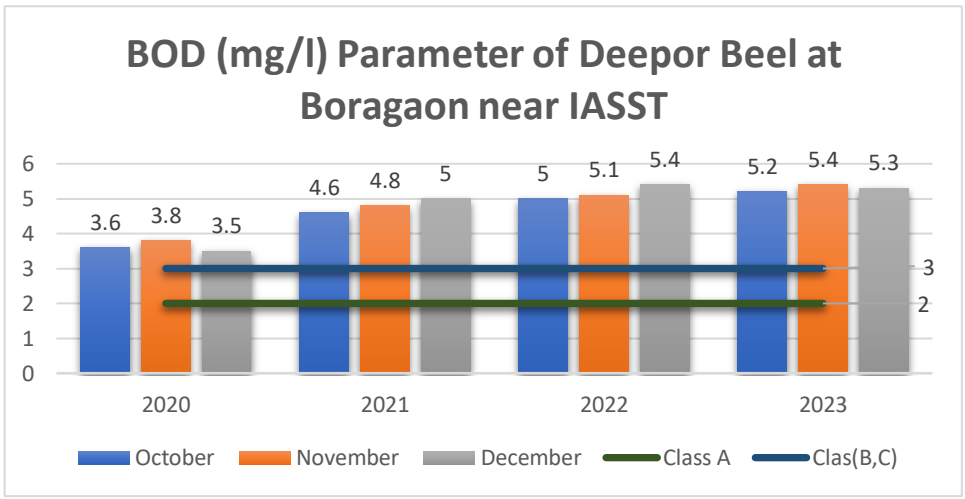


Fig 15: BOD (mg/l) Parameter in the Post-Monsoon Period

EC:

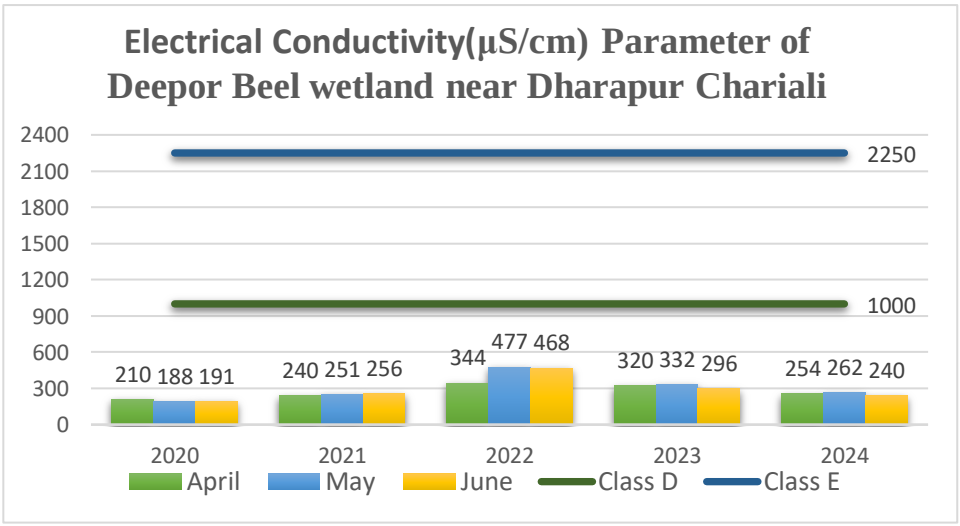


Fig 16: EC (µS/cm) Parameter in the Pre-Monsoon Period

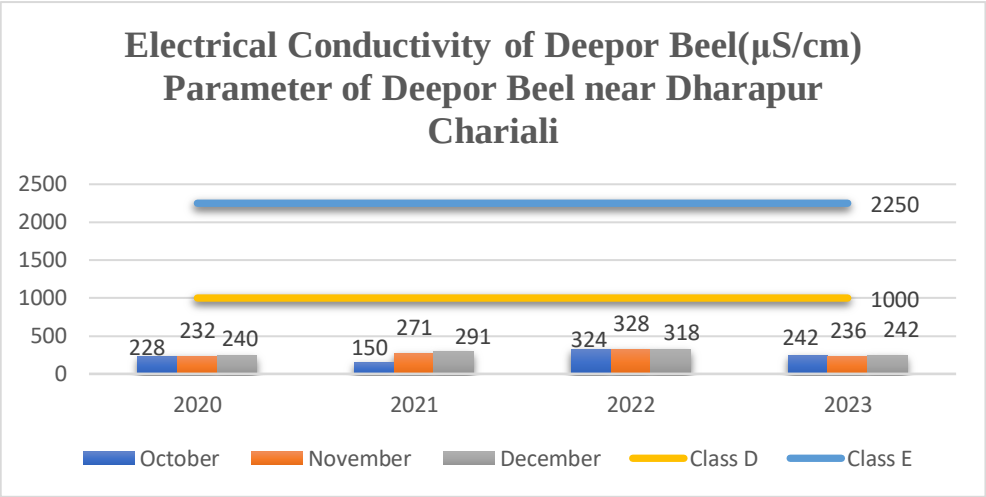


Fig 17: EC (µS/cm) Parameter in the Post-Monsoon Period

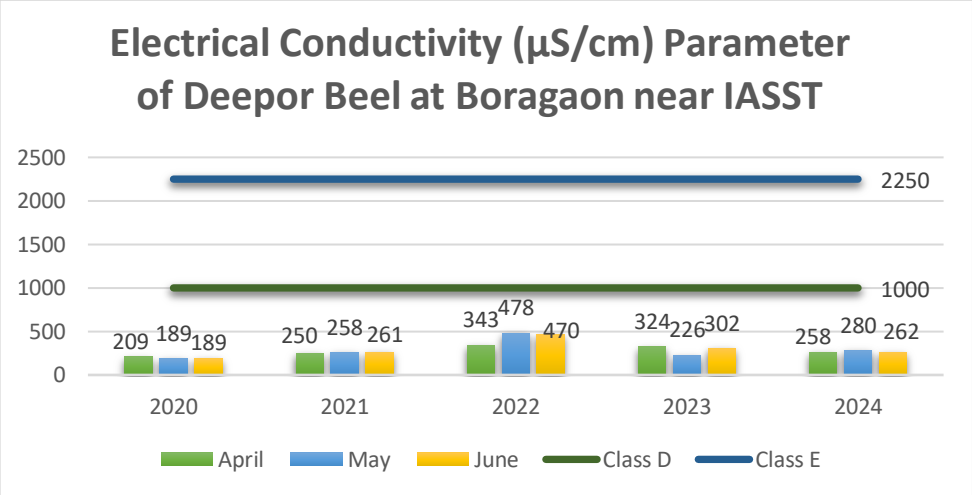


Fig 18: EC (µS/cm) Parameter in the Pre-Monsoon Period

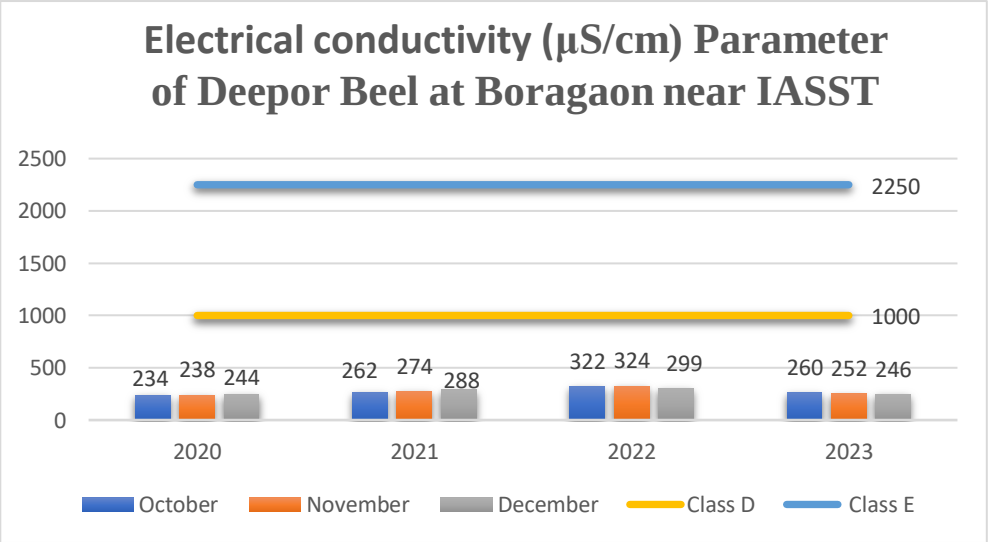


Fig 19: EC (µS/cm) Parameter in the Post-Monsoon Period

pH:

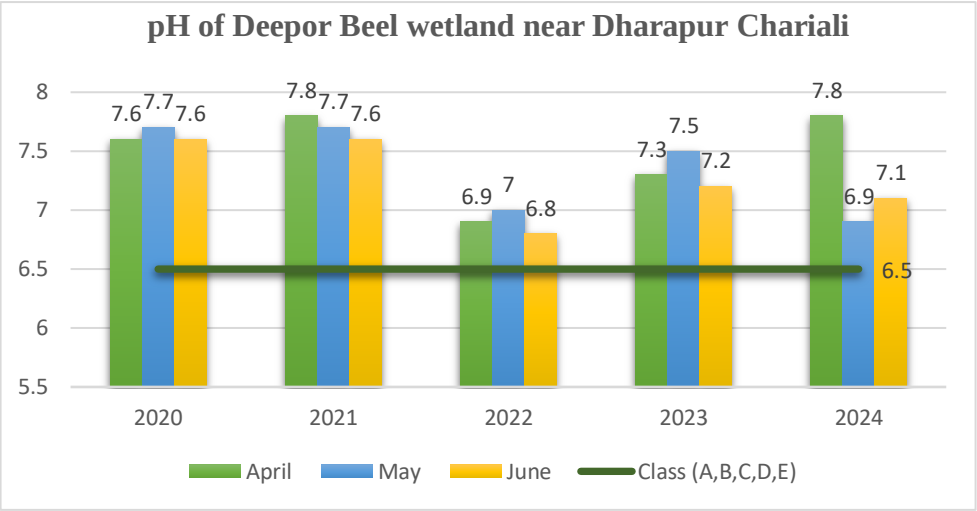


Fig 20: pH parameter in the Pre-Monsoon Period

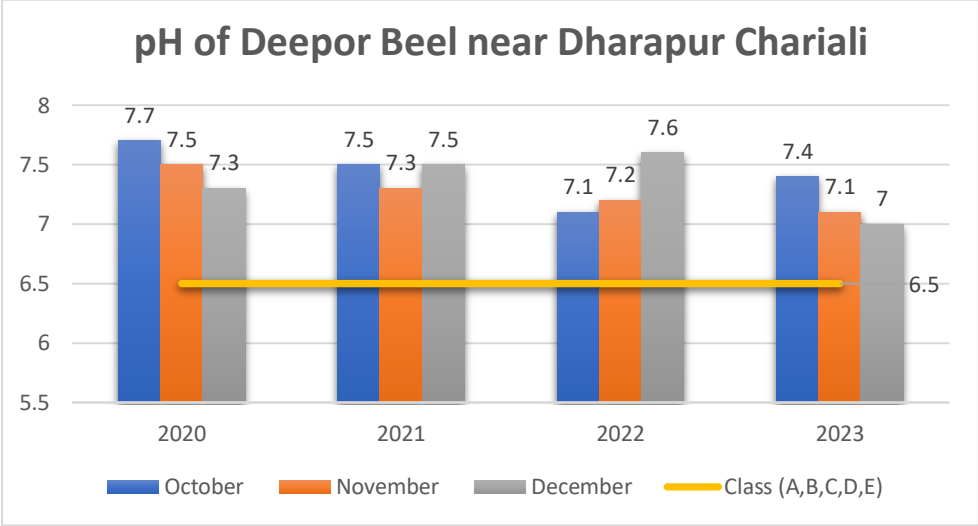


Fig 21: pH Parameter in the post-Monsoon Period

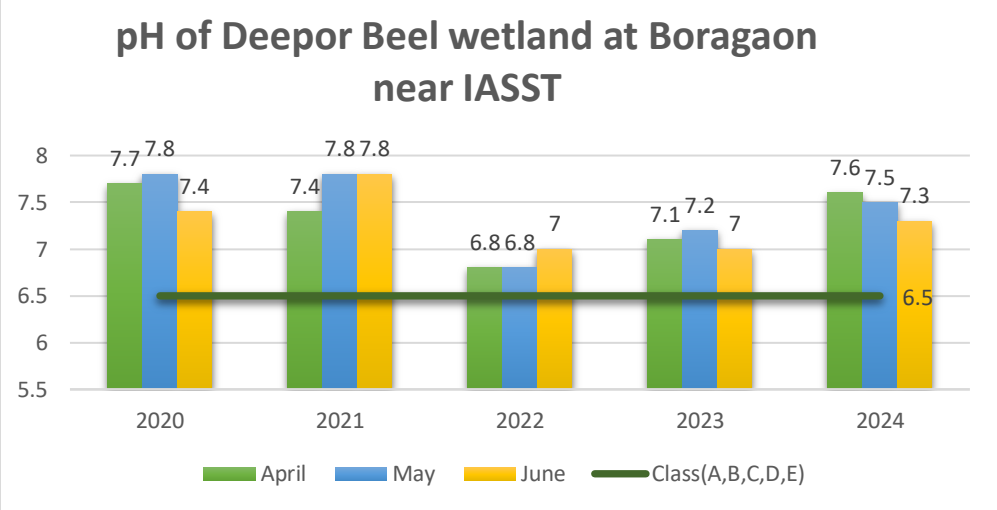


Fig 22: pH Parameter in the Pre-Monsoon Period

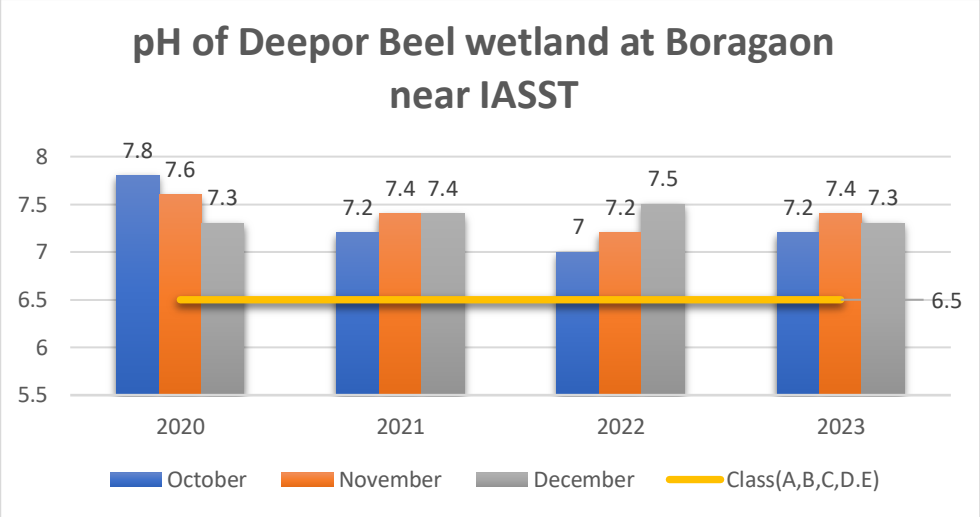


Fig 23: pH Parameter in the post-Monsoon Period

Nitrate:

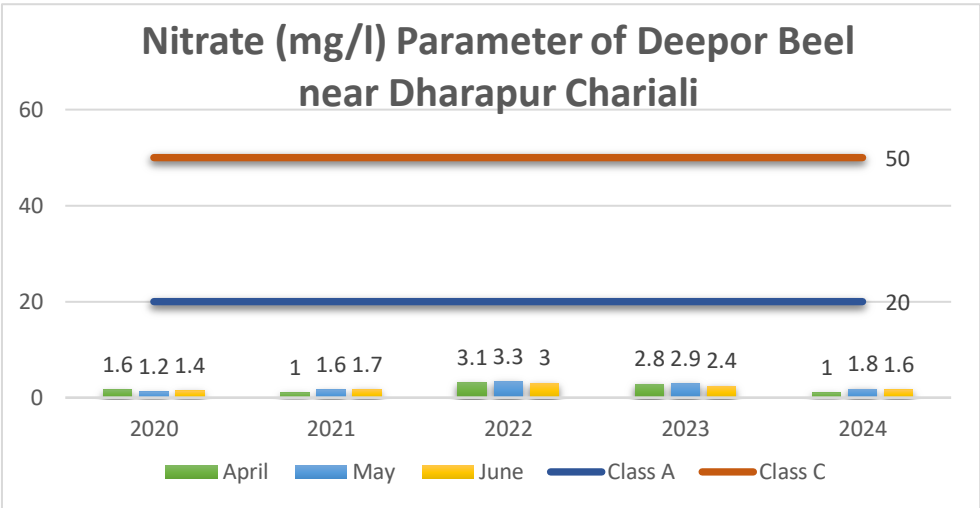


Fig 24: Nitrate Parameter in the Pre-Monsoon Period

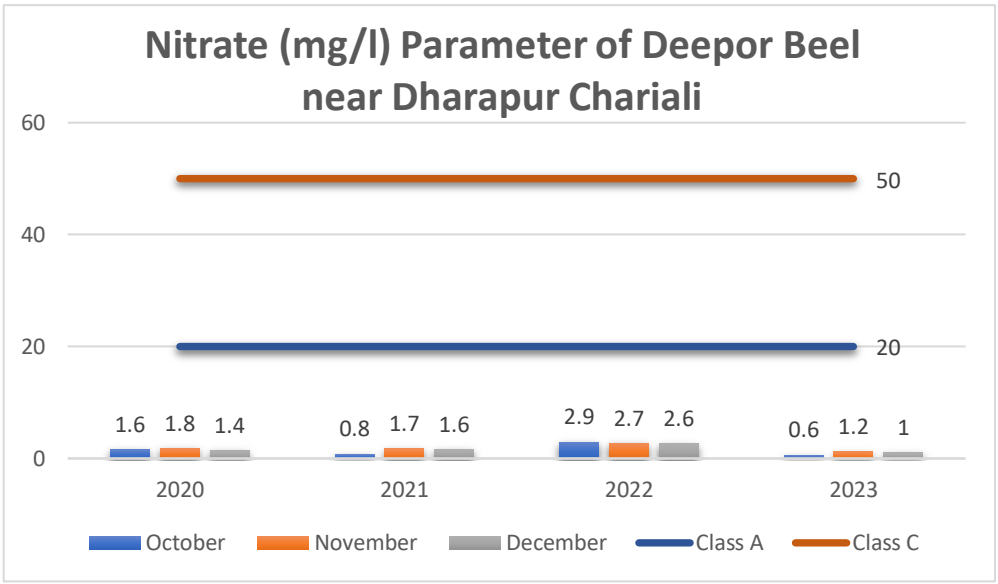


Fig 25: Nitrate Parameter in the Post-Monsoon Period

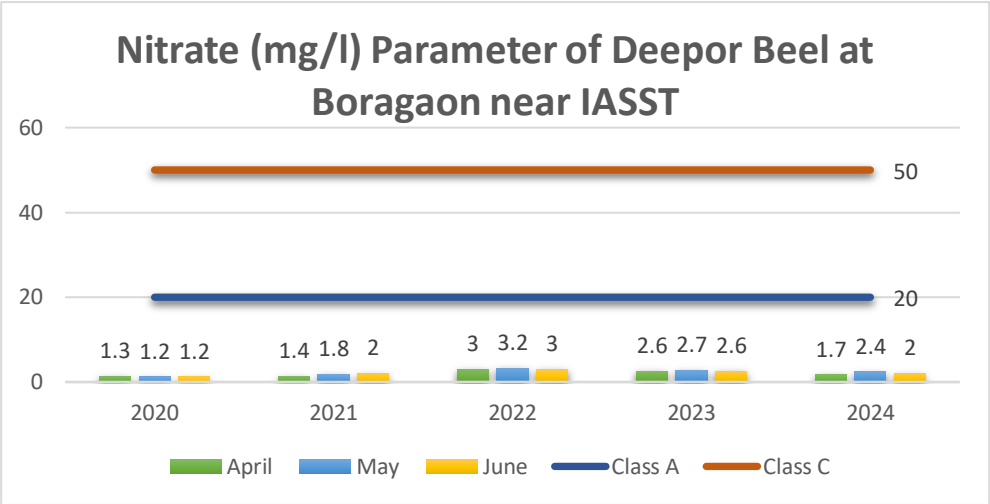


Fig 26: Nitrate Parameter in the Pre-Monsoon Period

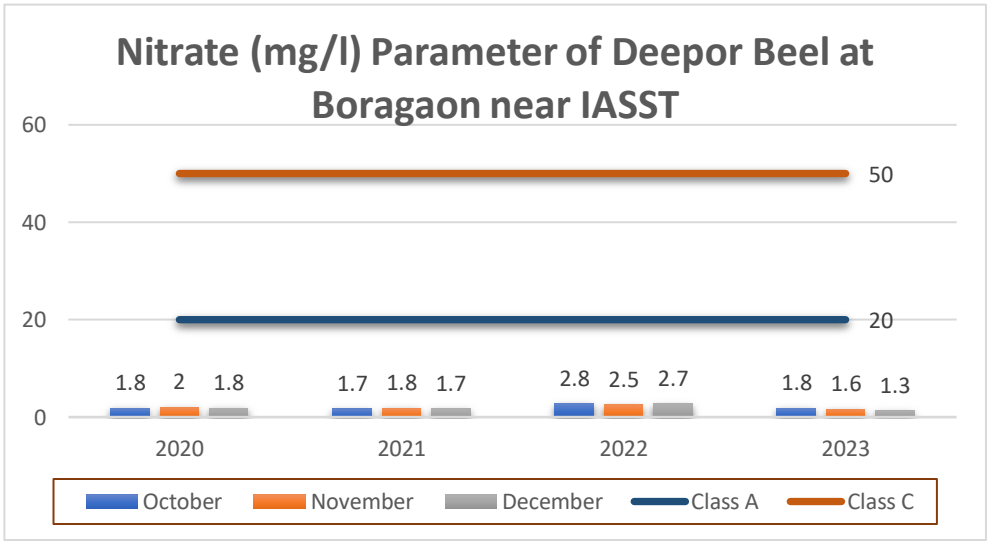


Fig 27: Nitrate Parameter in the Post-Monsoon Period

TH:

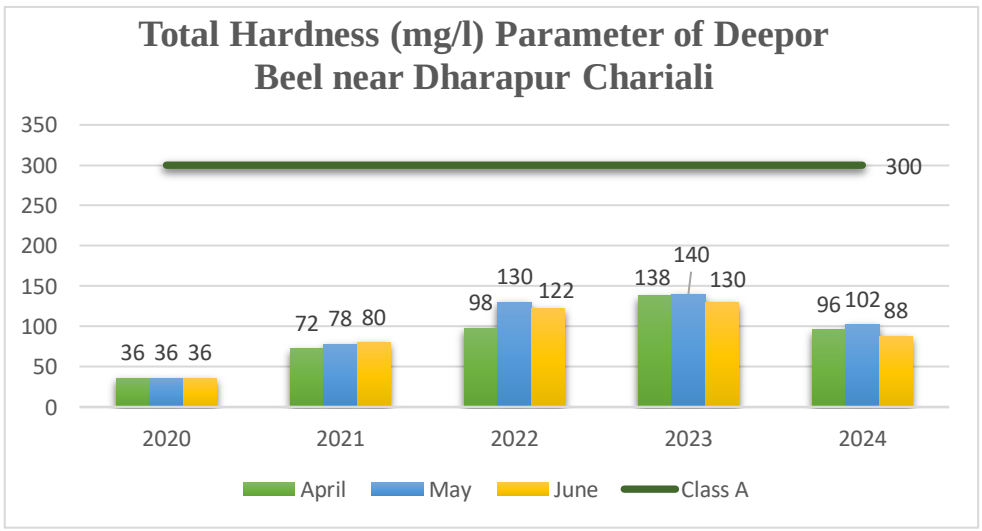


Fig 28: Total Hardness Parameter in the Pre-Monsoon Period

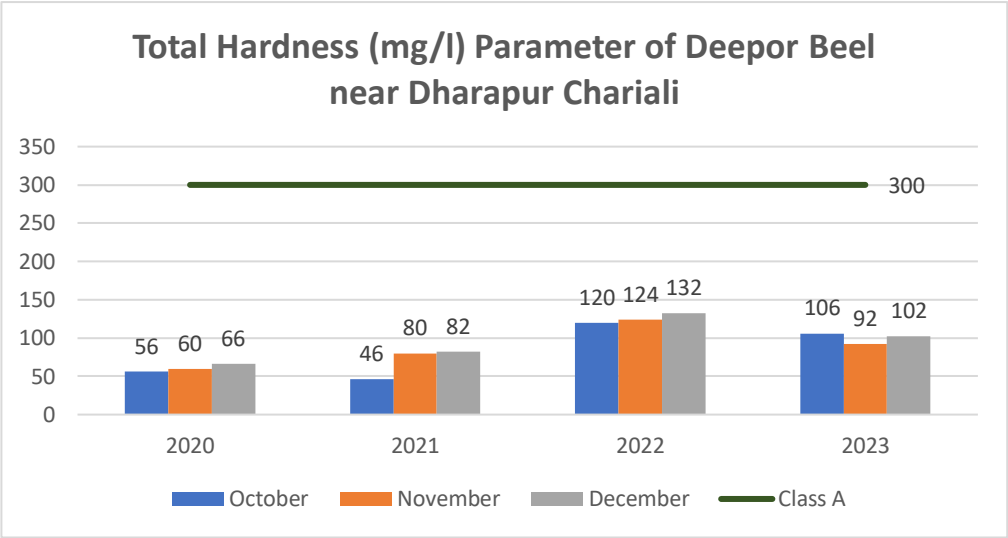


Fig 29: Total Hardness Parameter in the Post-Monsoon Period

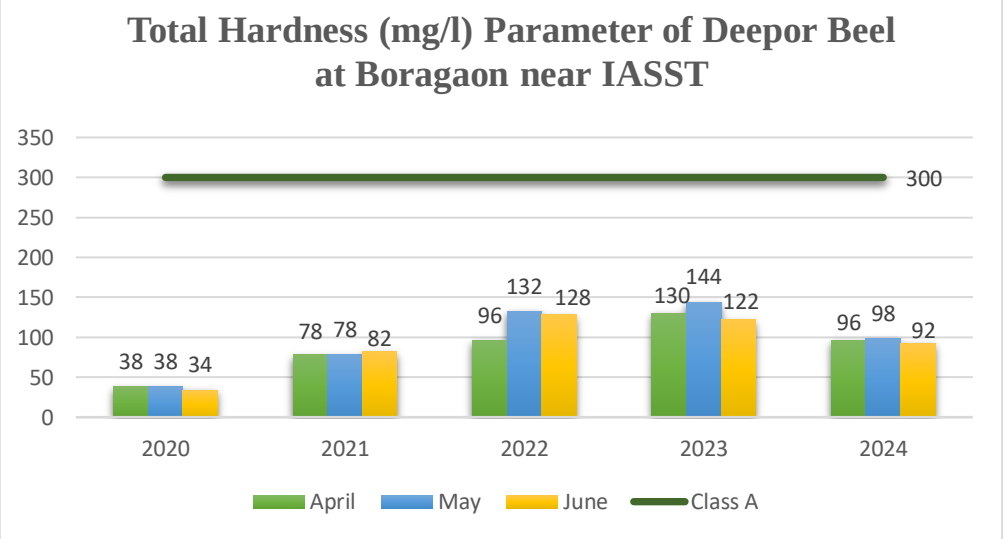


Fig 30: Total Hardness Parameter in the Pre-Monsoon Period

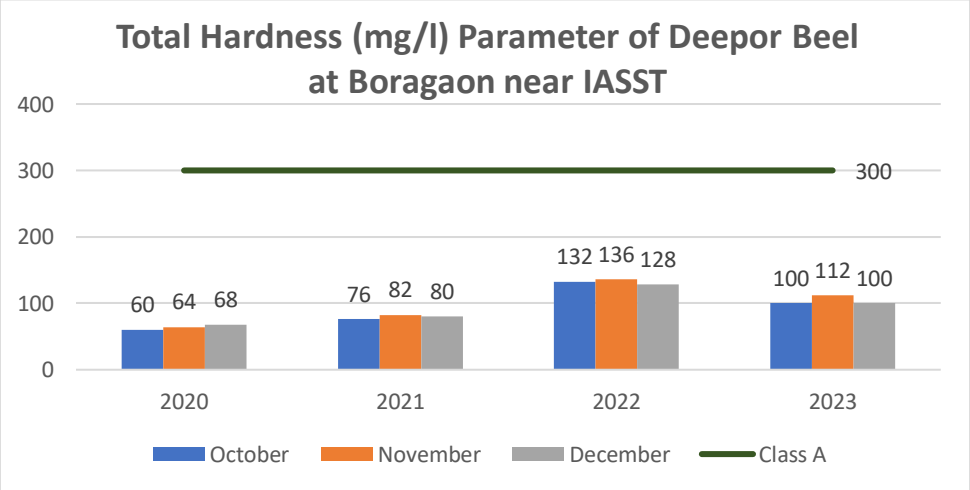


Fig 31: Total hardness in the Post-Monsoon Period

TDS:

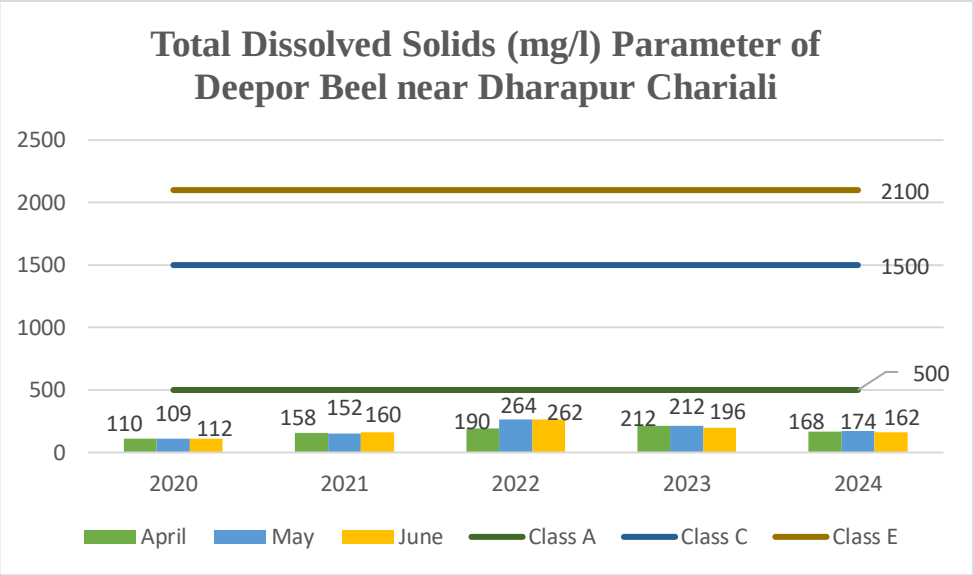


Fig 32: TDS Parameter in the Pre-monsoon Period

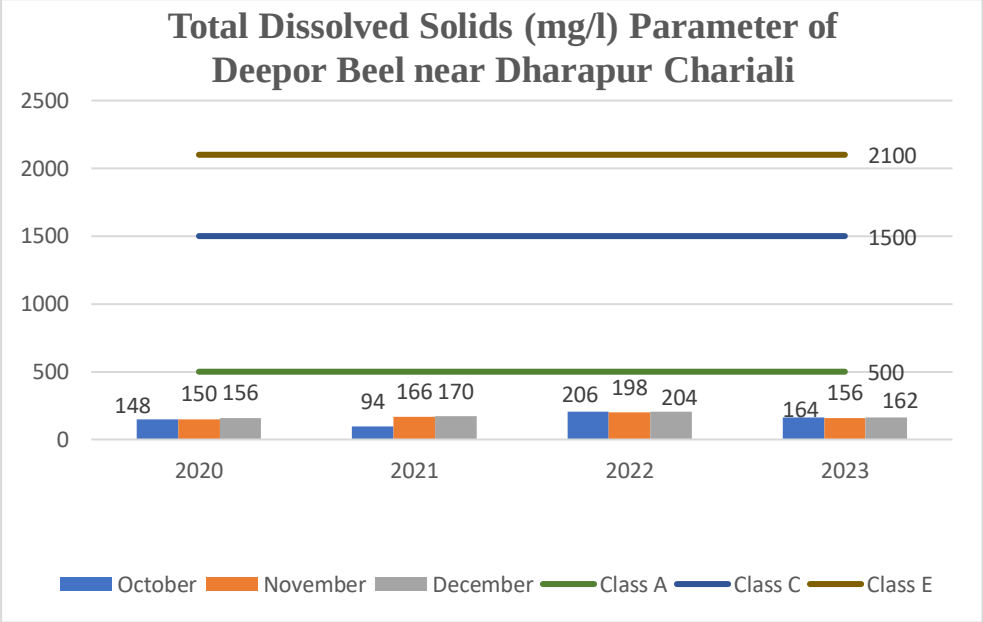


Fig 33: TDS Parameter in the Post-Monsoon Period

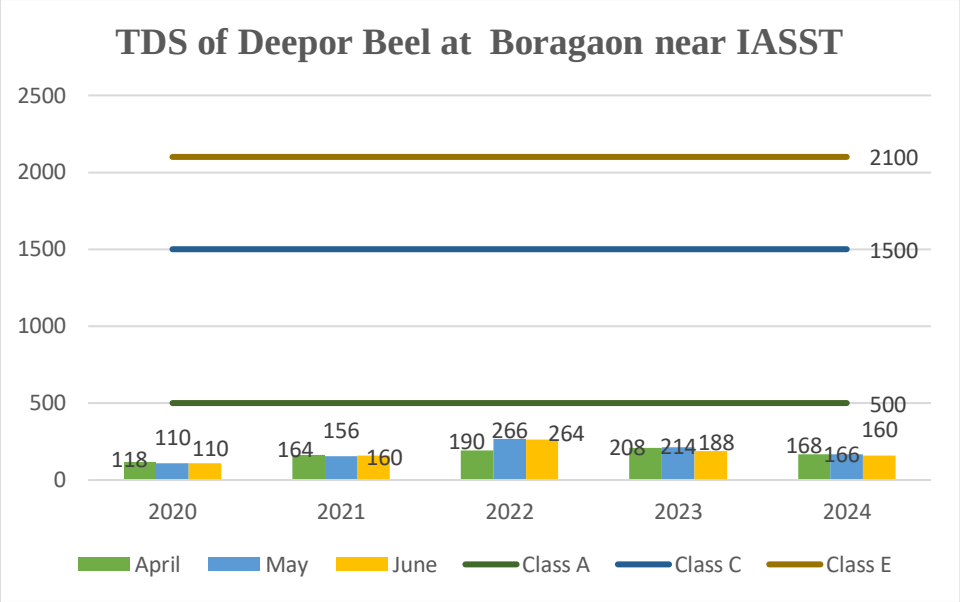


Fig 34: TDS Parameter in the period of Pre-Monsoon Period

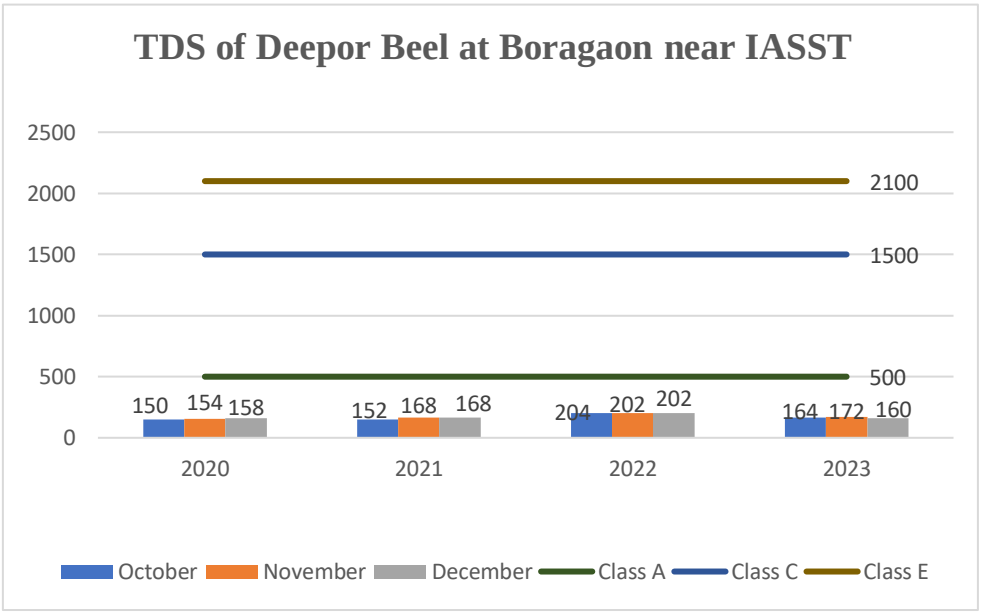


Fig 35: TDS Parameter in the period of Post-Monsoon Period

4.2.1 Results Obtained:

DO: The highest DO observe in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 10.8 which is not in a limit of classes (A, B, C and D).

The highest DO observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observe is 10.8 and 10.2 which is not in a limit of classes (A, B, C and D)

BOD: The highest BOD observes in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 5.8 and 5.6 which is not in a limit of classes (A, B and C)

The highest BOD observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observes is 5.9 and 5.4 which is not in a limit of classes (A, B, C)

Electrical Conductivity (EC): The highest EC observes in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 477 and 328 which is in a limit of classes D and E.

The highest EC observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observes is 477 and 324 which is in a limit of classes (A, B, C).

pH: The highest pH observes in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 7.8 and 7.7 which is not in a limit of classes (A, B, C, D, E)

The highest pH observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observes is 7.8 which is not in a limit of classes (A, B, C, D, E).

Nitrate: The highest Nitrate observes in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 3.3 and 2.9 which is in a limit of classes A and C.

The highest Nitrate observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observes is 3.2 and 2.8 which is in a limit of classes A and C.

Total Hardness (TH): The highest TH observes in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 140 and 132 which is in a limit of class A.

The highest TH observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observes is 144 and 136 which is in a limit of class A.

Total Dissolved Solids (TDS): The highest TDS observes in Deepor Beel near Dharapur Chariali during Pre-monsoon and post-monsoon season observe is 264 and 198 which is in a limit of class (A, C and E)

The highest TDS observe in Deepor Beel at Boragaon near IASST during Pre-monsoon and post-monsoon season observes is 266 and 202 which is in a limit of class (A, C and E).

4.3 SOCIO-ECONOMIC SURVEY DATA RESULTS

Table 7: Socio-Demographic Profile of the communities

Response Type	Total Responders	Results
➢ % of male member in the family	30 (100%)	60%
➢ % of female member in the family	30 (100 %)	40%
➢ % of highest educational level in household	30 (100%)	43.33 %
➢ Average age above 60 years	30 (100%)	70%
➢ Average below 10 years	30 (100%)	46.67
➢ Highest duration of residence in years	30 (100%)	65 years

Table 8: Livelihood Strategies of the communities

Response Type	Total Responders	Results
➢ Hours Spent on livelihood activities	30 100%	Max 8-10 hours
a. Fishing b. Farming c. Livestock rearing d. Eco Tourism e. Handicrafts f. Govt and NGO initiatives	17 5 2 2 2 2	Max 8-10 hr Max 4-5 hr Max 5 hr Max 10-12 hr Max 6-7 hr Max 7-8 hr
➢ Own Land for Cultivation (Yes/No)	30 100%	Yes
➢ Income Solely dependent on agriculture (Yes/No)	30 100%	25(83.33%) Responders-Yes 5 (16.66%) Responders-No
➢ Borrow land from others (Yes/No)	30 100%	30 Responders-No

Table 9: Agricultural Practices of the communities

Response Type	Total Responders	Results
➢ Area of optimum cultivation	30 (100%)	✢ Peripheral Margins of the wetland (Specially Bodo paddy variety) during dry season ✢ Higher lands for (vegetables, mustard) production.
➢ Season of High Production	30 (100%)	✢ Monsoon Season (Fish Production) ✢ Winter season (High Agricultural Productivity)
➢ Use of wetland water for irrigation (Yes/No)	30 (100%)	✢ Yes
➢ Changes in agricultural yields	30 (100%)	✢ Encroachment and Urbanization ✢ Flooding and waterlogging ✢ Decline in aquatic crop cultivation

Table 10: Fishing Practices of the communities

Response Type	Total Responders	Results
➢ In which time of the year fishing is high	30 (100%)	✢ Post-monsoon season (October to February).
➢ How much fishing is done on and average over the years	30 (100%)	✢ Produces approximately 600 to 1,000 metric tons of fishes
➢ How the fishing pattern changes over the years	30 (100 %)	✢ Mostly Traditional Practices such as nets, bamboo traps, and lines.

Table 11: Miscellaneous:

Response Type	Responded	Not responded	Results
➢ Key challenges in maintain livelihood	20 66.67%	10 33.33%	✚ Climate change and environmental Degradation ✚ Economic Instability ✚ Social Inequality ✚ Urbanization
➢ Vision for the future of Deepor Beel	20 66.67%	10 33.33%	✚ Sustainable Use

The Deepor Beel provides a means of livelihood to a number of local families. Nine villages in the vicinity of the beel and around 850 households are involved in fishing. From the study, out of 30 responders 17 are fisherman, 5 responders are farmers while as for responders involved in livestock rearing, handicrafts, eco-tourism and Govt and NGO operators are 2. The results indicated that wetlands contribute significantly to the livelihood and nutritional security of the fisher households. Moreover, it was also found that these wetlands provide a major source of animal protein to the fisher population.

4.3.1 Fishing Ecosystem of Deepor Beel

Fig 36: Fish Rohu

Fig 37: Fish Kanduli

Fig 38: Fish Sona

Fig 39: Fish Kothi

Fig 40: Collection of Fish Puthi

Fig 41: Collection of Fish Goroi, Kawoi

Fig 42: Fish Shol

These fish collection is from Azara Fish Market. From the survey it concludes that the major source of revenue is collected by the government by selling fish and a seed of giant water lily. The wetland has a cultural connection with the communities. In the month of January, in Bihu Festival, community fishing is practiced by neighboring villages using their different indigenous fishing methods. They mostly use traditional methods of practices to collect fish like nets, traps etc.

Deepor Beel provides benefits both directly and indirectly for fourteen villages around the wetland. Almost 500 families of scheduled caste people are directly dependent on fishing and collection of herbaceous plants.

The current conservation status of wetlands in India is vulnerable which threatens the livelihood of fishing dependent communities. Fisher households with little resources and capital will continue to depend on the wetlands for income and food security. Therefore, there effective management practices are necessary to safeguard and conserve fishing resources, ensuring their long-term use for livelihood and nutrition security.

4.3.2 Sustainable Measures to protect the overexploitation of Wetland Resources

The study found a link between wetlands and anthropogenic activity, with local communities engaging in both agriculture and fish culture. These activities promote wetland protection and need long-term practice to enhance wetland management with widespread community involvement. Some suggestions include with respect to the findings obtained from the survey:

1. Strengthening Regulations and Enforcement:
   - Wetland Protection Laws**:** Enforce strict implementation of the Wetlands (Conservation and Management) Rules, 2017, and other relevant environmental laws to regulate activities in and around Deepor Beel.
   - Fishing Limits: Impose seasonal fishing bans during breeding periods to allow fish

populations to replenish.

2. Community Participation and Awareness:
   - Development of local participation in wetland conservation.
   - Local participation would increase due to economic gain.
   - Raise awareness about the ecological and economic importance of Deepor Beel among locals and visitors.
   - Integrate traditional sustainable fishing practices into modern conservation strategies.

3. Promoting Eco-Tourism:
   - Eco-Friendly Tourism**:** Develop sustainable tourism initiatives that respect the ecological sensitivity of the wetland while generating revenue for conservation.
   - Visitor Guidelines: Educate tourists on minimizing their ecological footprint, such as avoiding littering and adhering to designated pathways.

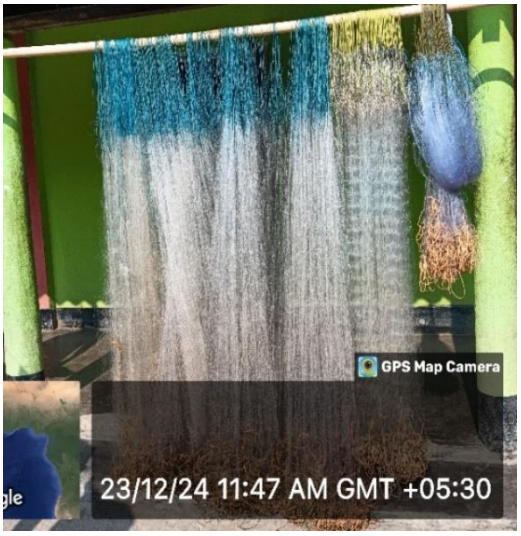
4. Monitoring and Research
   - Resource Assessment**:** Conduct regular scientific studies to monitor fish stocks, water quality, and biodiversity health.
   - Early Warning Systems**:** Develop mechanisms to identify and address emerging threats, such as pollution or illegal activities.
   - Citizen Involvement**:** Engage local stakeholders in data collection and monitoring efforts.

A multifaceted approach will be appreciated that includes rules, community interaction, and scientific management which required to prevent overexploitation and preserve the long-term viability of Deepor Beels resources. Deepor Beel, a key wetland habitat, may survive as long as ecological health and community well-being are prioritized.

4.4 PHOTOGRAPHS OF THE FIELD SURVEY RELATED TO COMMUNITIES OF DEEPOR BEEL

(a)

(b)

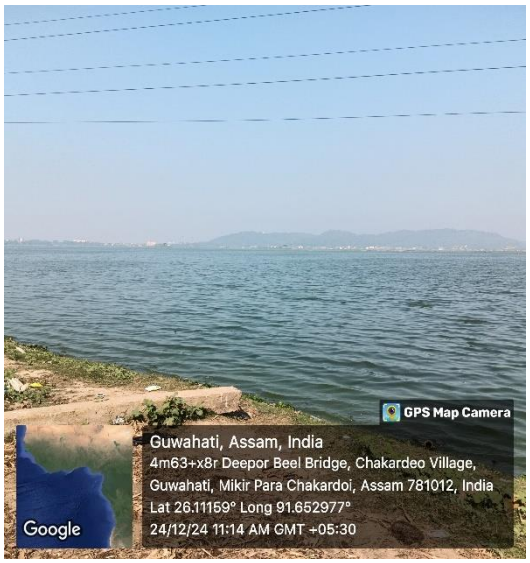


(C)

Fig 43(a, b, c): Fishing Techniques of Deepor Beel in the community

(a) (b)

Fig 44 (a, b): Community Survey of the localities



(a) (b)

Fig 45 (a, b): Deepor Beel image

CHAPTER 5

CONCLUSION

The work on the LULC mapping helps to improve our understanding of Deepor Beel's spatial organization, ecological health, and anthropogenic activities. It is a crucial tool for environmental monitoring, resource management, and sustainable development planning.

The study reveals the water quality trends of Deepor Beel throughout the 5-year interval in the Pre-Monsoon and Post-monsoon season of the two locations which shows the variability in the parameters with the IS code classifications. The water quality of Deepor Beel is critical for a variety of biological, socioeconomic, and environmental reasons. As one of Assam's most important wetlands, its health has a direct impact on biodiversity, livelihoods, and ecosystem services. Therefore, water quality monitoring is important.

The socio-economic survey leads us to understand the traditional dependent communities which suffered greatly as a result of the strain placed on beel. Peasant communities in adjacent villages, including Pamohi, Mikirpara, Kalitapara, and Deosotol, primarily cultivate rice. "Boro Dhan" "Bou Dhan" and "Hali Saul" which are cultivated during the month of December, April and in Monsoon season. The group synchronized their cultivation based on the availability of water from the wetlands. The wetland's water is becoming polluted, forcing these communities to pursue alternative livelihoods. Fishing populations have inhabited Keotpara, Matiya, Barbari, and Hirapara for generations which are mass communities totally dependent on the wetland.

5.1FUTURE SCOPE OF THE STUDY

The relationship of the community with the wetland can be expressed by Livelihood Vulnerability index which comprehensively addresses the exposure, adaption capacity, and sensitivity of smallholder maize farming households to natural hazards and climate change. The term vulnerability is employed with variability across intellectual communities, including analysts of poverty, food security and natural hazards researchers, each offering unique conceptualizations (Bryan 2009).

While considering the livelihood vulnerability analysis, the changing pattern of water quality for different sampling locations over the years with the classifications mentioned in WHO make the findings more interesting.

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