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Sustainable Wetland Management: A Case Study on Panidihing Bird Sanctuary Wetland Areas

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ABSTRACT

Wetlands are the most important feature in the earth's surface and it is one of the integral parts of our ecosystem. It is responsible for maintaining the ecological balance in the ecosystem. The wetlands of Assam are facing serious challenges from both nature as well as from men. Climate change and the rapid increase of human activities causing threats to the wetland of Assam. Panidihing Bird Sanctuary wetland areas face several challenges and its rich heritage is degrading over the years. This degradation of natural wetlands impacts one the number of total inhabitant flora and fauna. The conservation and management of Panidihing wetland areas will be a major task for the government as well as for the concerned management authorities. The sustainable management of wetlands is in high demand. More suitable legislative actions are needed for the conservation of wetlands and their residing wildlife. There must be a reduction in human activities that harm the wetland areas. The government must pay attention to investigating the issue of seasonal drought in the Panidihing wetland areas. This paper is an attempt to study the seasonal variations, sustainable management strategies, conservation and mitigation, and prospect for policy formulation and implementation for the Panidihing wetland region.

Key words: Wetland, Ecological balance, Sustainable management, Tourism

Introduction

Wetland plays an important eco-hydrological duty in environmental management and provides various environmental as well as socio-economic benefits to the people of nearby areas (Dixon, 2005). Wetlands are among the most fruitful ecosystems. Besides the home of most flora-fauna, the wetlands are known for playing an important role in carbon sequestration (Sarkar, 2011). Wetlands are the source of goods and services and have a significant role in human societies having direct, indirect, and potential uses (Lannas and Turpie, 2009). The depletion of wetlands cause damages the health and yield of individual well-being as well as the local commu-

nity and it will impact their developmental process (Lamsal *et al.*, 2015).

Wetlands are the most important fluvial features of Assam (Mili and Acharjee, 2014). There are more than 3500 identified wetlands in Assam and these have wide economic and scientific value to the local communities. The Wetlands of Assam provide a well ground for fishery and agriculture, which will be helping them by providing occupational support. Wetlands supply aquatic resources and also reflect the over-exploitation in recent years. This impacts the morphology and qualities of wetlands and demands protection and restorations. This is caused mainly by the extensive pressure from anthropogenic activities since colonization (Wardrop *et al.*,

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2011). As Assam is one of the global biodiversity hotspots, there is a potential growth of eco-tourism activities. This may bring awareness to the conservation of biodiversity in the long term. This will help in mitigating environmental issues and cause economic benefits to the people (Deori and Das, 2013).

Statement of the problem

The wetlands of the world are facing threats and challenges from both climate change and human-induced activities. The pressure from the growing population and other developmental activities leaving their negative impacts on the wetlands over the years (Sarkar, 2011). Sometimes, wetlands are infected by acidic contamination from nearby factories and industries (Treacy and Timpson, 1999). The untreated wastewater leads to pollution in the wetlands and it causes harmful effects on marine life (Adewumi and Oguntuase, 2016). There is a lack of understanding of the socio-economic and ecological values of wetlands. This led to the lack of suitable policy and decision-making processes (Lannas and Turpie, 2009).

Panidihing Bird Sanctuary Wetland region needs urgent eco-friendly legislation to reduce human activities. The seasonal drought and reduction in the availability of water cause a serious threat to the sustainability of the wetland in coming years. The government must allocate research activities to investigate seasonal variations and their changing trend. There is a need for urgent actions from International agencies, governmental authorities, and NGOs to reduce the depletion process.

Study Objectives

1. The changing pattern and availability of water bodies in the Panidihing wetland areas over the years.
2. The assessment of the anthropogenic activities on wetland region and its future prospects on wetland conservation and sustainability.

3. The future prospects for the tourism industry in the Panidihing area.

Study Area

Panidihing Bird Sanctuary is located on the northern boundary of the Sivasagar district and the southern bank of the River Brahmaputra. Panidihing was recognized as Bird Sanctuary by the Government of Assam in the year 1996. This place is known for its important ornithological site and this place consists of grasslands and several wetlands. Panidihing Bird Sanctuary is located geographically from 27°6'22" N to 27°3'48" N latitude and from 94°34'30" E to 94°38'54" E longitude covering almost 34 square km of the total area in the district of Sivasagar.

Materials and Methodology

The temporal data are acquired from the USGS Earth Explorer archive. The satellite image of Landsat 4TM, Landsat 7ETM+, and Landsat 8OLI has been acquired for the years 1995, 2009, and 2022 respectively with 30 meters of spatial resolution. These data will help in studying the changing pattern of water bodies in respect of both seasons in the study area. This will help in detecting the water bod-

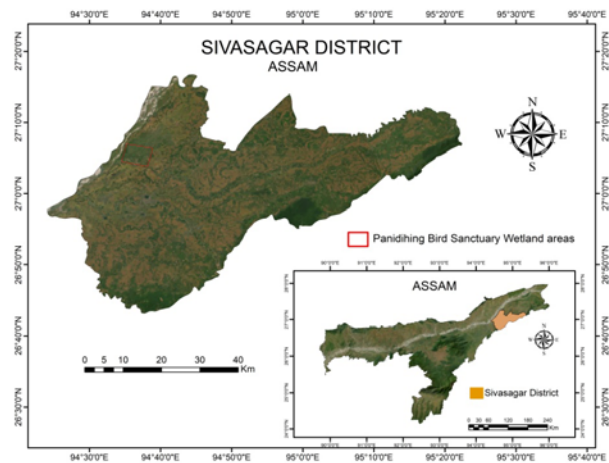


Fig. 1. Showing study area of Panidihing Bird Sanctuary Wetland areas, Sivasagar, Assam

Table 1. Collection of Satellite Image, Resolution, and Bands

Year	Satellite	Bands	Spatial Resolution	Date of images
1995	Landsat 4 TM	B1, B2, B3, B4	30 m	13/04/1995
	Landsat 4 TM	B1, B2, B3, B4	30 m	05/12/1995
2009	Landsat 7 ETM+	B1, B2, B3, B4	30 m	26/09/2009
	Landsat 7 ETM+	B1, B2, B3, B4	30 m	28/12/2009
2022	Landsat 8 OLI	B2, B3, B4, B5	30 m	30/01/2022
	Landsat 8 OLI	B2, B3, B4, B5	30 m	16/11/2022

ies' land use over time.

To fulfill the other objectives of the study, the general survey has been conducted in the local villages nearby wetland areas. Some of the aspects are pointed out by the personal interview as well as my author's observation techniques.

The acquired satellite images will be further processed in Erdas Imagine software to produce the wetland's waterbody landuse data. These images will be compared according to the rainy or dry months. The impacts will be analyzed to find the prospects for tourism development. It helps to find appropriate measures and suggestions for state policy formulation.

Results and Discussion

Changing pattern through the years

Natural resources and habitats serve multiple purposes and constitute large reservoirs of economic value, which is a fundamental tenet of sustainable economics (Turner, 1991; Barbier, 1993). Wetland change processes can assist in exposing and comprehending the reasons for degradation, which is helpful for improving the restoration of ecological functions and fostering wetland ecological health (Wei, *et al.*, 2022). Regional sustainable development depends on tracking wetland change patterns and

identifying the main driving forces behind them (Davidson, 2014).

The changes in the land cover of the Panidihiing Bird Sanctuary wetland region are shown in the aforementioned Figure 2 and Table 2. From 28.81 sq. km in 1995 to 25.492 sq. km in 2022, the flood area and water bodies are decreasing, according to categorized satellite photos of monsoon seasons. Wetland sustainability is mostly dependent on water availability, which has long-term effects on the local flora and wildlife. It demonstrates the effects on grassland areas, which decreased to about 8 sq km over a period of 27 years. Recent satellite photos indicate wide areas and a reduction in dense plant

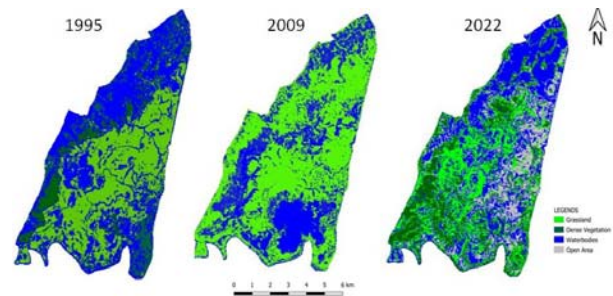


Fig. 2. Showing the land-use change of Panidihiing wetland areas in the rainy season in the years 1995, 2009, and 2022.

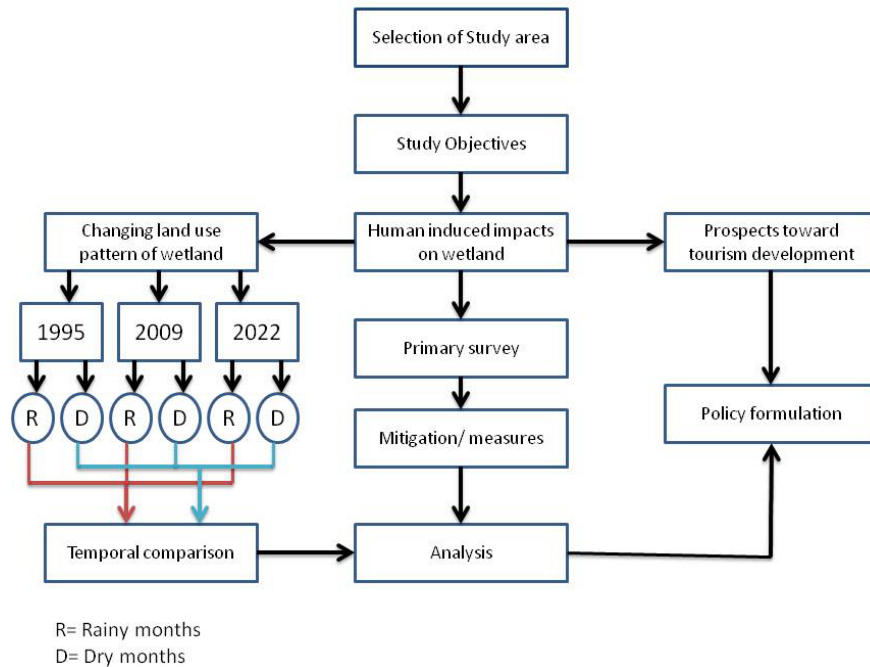


Fig. 2. Methodology flow chart

Table 2. Showing the land-use area of Panidihing wetland and buffer region in the years 1995, 2009, and 2022 (rainy season).

Legends/Year	Area in 1995 (Sq. km)	Area in 2009 (Sq. km)	Area in 2022 (Sq. km)
Grassland	25.328	34.051	17.3
Dense Vegetation	12.008	6.603	5.19
Waterbodies	28.81	25.492	25.492
Open Area	0	0	9.887
Total Area	66.146	66.146	66.146

Table 3. Showing the land-use area of Panidihing wetland and buffer region in the years 1995, 2009, and 2022 (winter season).

Legends/Year	Area in 1995 (Sq. km)	Area in 2009 (Sq. km)	Area in 2022 (Sq. km)
Grassland	26.566	24.963	25.129
Dense Vegetation	14.717	14.987	12.634
Waterbodies	12.189	8.52	9.731
Open Area	12.674	17.676	18.652
Total Area	66.146	66.146	66.146

cover. Which is not encouraging for the sustainability of wetlands.

The changes in the land cover of the Panidihing wetland regions throughout the winters of 1995, 2009, and 2022 are shown in Figure 4 and Table 3 above. The grouped maps make the reduction in aquatic bodies quite evident. Along with the expansion of open space, dense vegetation is also disappearing. The open spaces that make up the majority of the northern Panidihing wetlands sections are periodically turned into agricultural lands by the locals. The entire wetland area experienced seasonal flooding in the winter due to the lack of water bodies. It might be brought on by man-made obstructions built on the banks of the River Brahmaputra.

Anthropogenic impacts on the wetland

Wetlands are sensitive and adaptive ecosystem of the earth’s surface. Most of the freshwater wetlands are converted to agricultural lands in recent years (Goodwin *et al.*, 2001). Most of the freshwater marine species are going extinct or threatened by the rising pressure from urbanization (Bassi, N. *et al.*, 2014). Allowing contaminated effluent from urban, agricultural, and industrial sources to enter and stay there, reduces and degrades them (Foote *et al.*, 1996). Wetlands lose several of their functions, including providing habitat for wildlife, supporting the food chain, and providing opportunities for human enjoyment, due to overfishing and overhunting (Paul,

et al., 2011). There are various challenges faced by the Panidihing wetland areas in recent times as follows;

- Growing population in nearby areas: Wetland

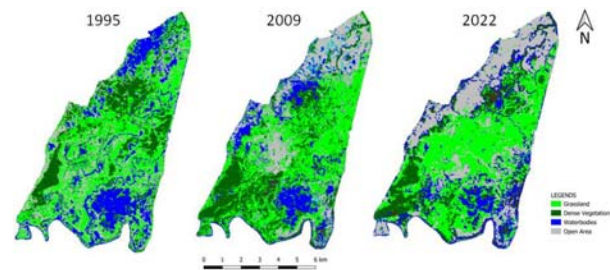


Fig. 3. Showing the land-use change of Panidihing wetland areas in the winter season in the years 1995, 2009, and 2022.

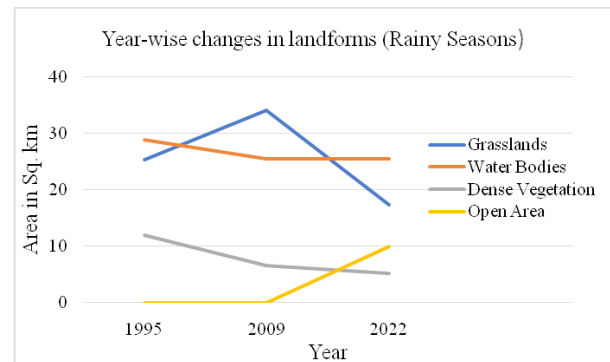


Fig. 4. Showing year-wise changes in the landforms of Panidihing and its buffer areas.

ecosystems can become fragmented as a result of rapid infrastructure development and urbanization, isolating populations of both plants and animals. Fragmentation restricts species migration and lowers gene flow, which can result in a decline in biodiversity and the extinction of wetland-dependent species. The Panidihing wetland areas are experiencing fast population growth over the past few decades have led to the emergence of unhygienic conditions for the local species.

- Conversion to agricultural land: The process of converting naturally occurring wetland ecosystems into locations suitable for farming, animal grazing, or aquaculture. In order to make the area suitable for agriculture, this conversion often entails draining the wetlands by changing the water flow or eliminating vegetation.
- Illegal poaching of birds: Locals in the region occasionally indulge in unlawful wild bird poaching for meat. It poses a major hazard to migratory and wild birds.
- Commercial fishing in wetland areas: On wetlands, commercial fishing is completely prohibited. However, fishing is the principal occupation for the locals. It causes a fish population decline in that area, which is crucial for migratory birds since it reduces their access to food.
- Dumping of household wastes: The use of various items, such as household waste, damages wetland habitats by polluting them. Locals in the surrounding areas discard household waste in an unhygienic manner, thus disrupting the natural balance of the wetland areas.
- Illegal digging of soil for commercial purposes: The primary element in habitats is soil. However, residents in Panidihing areas sell their soil for use in construction. It affects the local vegeta-

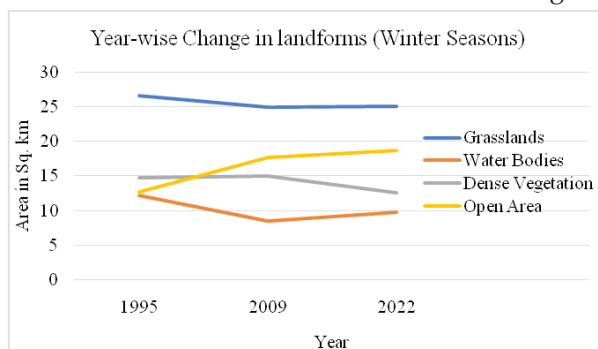


Fig. 5. Showing year-wise changes in the landforms of Panidihing and its buffer areas.

tion and plant growth.

- Air pollution: Air quality and air pollution are a result of the brick industry and the unrestrained burning of plastic-made products in the Panidihing area.

Prospects on wetland conservation and sustainability

In the policy-making process, numerous other wetlands that serve potentially significant purposes continue to be disregarded. As a result of urbanization, population expansion, and increased economic activity, many freshwater wetlands habitats are threatened and many have already been lost (Central Pollution Control Board, 2008). To accommodate the demands of an expanding population, the majority of India's major river basins increased their land area to serve agricultural and other purposes at the expense of converting flood plains, primary forests, grasslands, and related freshwater habitats (Zhao *et al.*, 2006). To maintain complete sustainability, the following essential steps need to be implemented;

- There must be a complete ban on the poaching of migrating birds as well as other species that nest in wetland regions. Certain laws do exist, but rigorous application is required.
- Fishing ought to be effectively prohibited in Panidihing wetland areas. The sources of food for wildlife were affected by commercial fishing. It affects the viability of species and has long-term effects on the ecosystem of wetlands. Therefore, now is the time to consider an effective ban on all fishing.
- It is best to avoid commercial and residential soil excavation because it has long-term effects on soil fertility and plant growth.
- For the management of residential waste and other community waste, there should be a well-established waste management system. The wetland ecosystem's sustainability is effectively protected by its proper management and disposal.
- Plastic is the element that harms the ecosystem the most. An unsafe scenario developed all around the Panidihing wetland areas as a result of its misuse and inappropriate disposal. It should be severely forbidden to burn plastic products because it significantly worsens local air pollution.
- The wetland and bird sanctuary management authority must concentrate on maintaining strict

security in certain Panidihing regions and have a quick response team ready to deal with any unforeseen instances of illegal activity. The management of wildlife, flora, and fauna will benefit from this.

- The government initiative is one of the most important measures for managing the Panidihing natural heritage site sustainably. Effective personnel must be used to accomplish conservative principles. The best use of financial and other resources is required for the policies in order to better achieve the conservation of the species in the Panidihing area.

Prospects for Tourism Industry

The eco-tourism defines ecologically important and naturally beautiful places with probable tourist attractions (Das *et al.*, 2019). The tourism sector mainly focuses on the development and displaying the resourceful areas of natural beauty and the shreds of evidence from the past. The tourism sector is one of the major emerging sectors in recent years and focuses on generating income and livelihood by displaying naturally and culturally rich areas. The eco-tourism is a word generally used for the governance of tourism and the conservation of nature. It shows a fine balance between tourism activities and the ecological harmony of nature (Deori and Das, 2009). A wetland ecosystem is very much important for the aquatic organism by supplying water and nutrients to the residing organisms. And, these landscapes are also known for their own unique characteristics and natural beauty. This thing shows a suitable landscape for the development of a tourist spot (Das *et al.*, 2019).

Panidihing Bird Sanctuary wetland areas have lacked behind in terms of tourism activities and management. There is an urgent need for governmental focus and actions to promote tourism in the wetland area. The promotion and advertising of the rich biodiversity and natural beauty will attract the tourist to enjoy the beautiful view of nature. This will bring the development of a tourist spot in the Panidihing area. The challenges are to be mitigated with the help of finding appropriate measures. These are as follows,

- Transport and communication facilities: Panidihing Bird Sanctuary wetland areas lack of good transport and communication facilities. Tourism development relies on accessibility to the spot. The government must focus on the de-

velopment of roads and networks and other services to the incoming tourist to the wetland site.

- Advertising and promotion of tourist sites: Panidihing areas have potential tourist sites of beautiful natural beauty and are home to many migratory birds. These criteria attract tourists from nearby people. The people as well as government must promote the rich heritage by advertising orally or with the help of print and digital mediums.
- Availability of tourism infrastructures: Panidihing wetland areas lack tourism infrastructures like; resorts, hotels, well-set guide personnel, etc. Tourist from distant places needs accommodation facilities. The travel guide plays a great role in the development and promotion of tourist spots. The wetland areas have potential boat safaris in the monsoonal season. This will encourage and invites the adventurer tourists to the spot.
- Awareness of the local communities: The government effort is incomplete without the awareness of the local communities. The local communities play an important role in policy implementation and help in the conservation of wetland areas. The local communities may help by opening some resorts, hotels, etc. The people may facilitate the tourist as a travel agent and guide. The people may start boating and other facilities to attract tourists.
- The need of governmental effort in terms of tourism development strategies by legislative actions: The role of government is very significant in managing and developing a tourist spot. There must be some state policies that have some strategies to facilitate tourism activities. It may help the government to generate income and revenue from the tourism activities. And, it also generates occupational service to the local communities. There must be some active management and security officials with quick response bodies to look after the matters related to the safety and security of flora-fauna species of the wetland areas. Government policies need the complete implementation to achieve conservative goals and environmental sustainability.

Conclusion

Create and uphold wetlands' legal protection, including setting aside areas as designated conserva-

tion areas and implementing laws against wetland deterioration or degradation. Encourage the public's understanding of the value of wetlands and their contribution to environmental sustainability. Use sustainable land-use techniques, such as thoughtful agriculture, forestry, and urban design, to reduce the adverse effects on wetland ecosystems. Using revegetation, water management, and exotic species management, repair and restore damaged wetlands. Encourage global wetland conservation efforts by fostering international collaboration and partnerships to solve transboundary wetland challenges. To maintain and restore wetlands, it is crucial to address these human-caused problems and implement sustainable practices. This entails putting into practice efficient wetland conservation plans, encouraging sustainable land-use methods, upholding laws, spreading knowledge of the importance of wetlands, and encouraging international cooperation for wetland management and preservation.

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