

Change Detection in Aerial Beel



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Executive Summary

Arial Beel is one of the most ecologically significant floodplain wetlands in central Bangladesh, providing critical ecosystem services including flood regulation, fisheries production, agricultural support, biodiversity conservation, and livelihood security for surrounding communities. In recent decades, however, increasing anthropogenic pressure has altered its natural hydrological and ecological functioning. This study examines the spatial and temporal dynamics of land use and land cover (LULC) change in the Arial Beel watershed over a 20-year period (2005–2025) and assesses the associated impacts on hydrology, biodiversity, and community livelihoods.

A mixed-methods approach was employed, integrating multi-temporal satellite imagery analysis using Remote Sensing (RS) and Geographic Information Systems (GIS), field-based biodiversity surveys, and socio-economic assessments of wetland-dependent communities. Landsat and Sentinel-2 imagery were analyzed to quantify changes in major land-use categories, while ecological surveys documented species composition and habitat condition. Socio-economic surveys and stakeholder consultations were conducted to understand livelihood dependence and community perceptions of environmental change.

The results reveal a persistent transformation of the Arial Beel landscape, characterized by a gradual reduction of open waterbodies and natural vegetation and a corresponding expansion of agricultural land, flooded agricultural areas, and built-up development. These land-use changes have disrupted natural drainage pathways, reduced hydrological connectivity with surrounding river systems, and weakened the beel's capacity for seasonal water retention and flood moderation. Biodiversity assessments indicate that, although the wetland still supports diverse flora and fauna, habitat fragmentation, shrinking perennial water refuges (denga), pollution, and overexploitation are contributing to declining species abundance and increased ecological stress. Socio-economic findings demonstrate continued heavy dependence of local communities on the beel for fisheries, agriculture, and seasonal employment, alongside rising livelihood vulnerability due to declining natural resources and drainage congestion.

The study concludes that land-use change, hydrological alteration, biodiversity degradation, and livelihood stress in Arial Beel are closely interconnected processes. Without coordinated management, continued degradation will increase flood risk, undermine ecosystem services, and exacerbate socio-economic vulnerability. The findings provide a robust evidence base for policy intervention, emphasizing the need for wetland-sensitive land-use planning, restoration of hydrological connectivity, strengthened legal protection, and community-based co-management. Implementing these measures can help restore the ecological integrity of Arial Beel and enhance its role in sustainable development and climate resilience in central Bangladesh.

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Chapter 01: Introduction

1.1 Introduction:

Wetlands are the most valuable ecological systems in Bangladesh and act as the critical environmental and socio-economic functions such as flood reduction, groundwater recharge, nutrient cycling, carbon sequestration, biodiversity conservation, and livelihood support for surrounding communities. Within this dynamic network of wetlands, Arial Beel stands out as one of the largest and most ecologically significant wetlands in central Bangladesh. Its seasonal inundation patterns, productive fisheries, fertile agricultural lands, and rich biodiversity contribute substantially to regional ecological balance and community well-being.

However, like many wetlands across the country, Arial Beel is experiencing increasing pressure from rapid land use transformations. Over the past several decades, natural hydrological processes have been progressively changed by anthropogenic activities such as agricultural encroachment, settlement expansion, road and embankment construction, and water-control interventions. These changes are reshaping the landscape, modifying drainage pathways, reducing water retention capacity, and threatening the ecological functionality of the watershed.

1.2 Background of the Study

Arial Beel is situated within the central floodplain of Bangladesh is an area shaped by monsoon-driven hydrology, low-lying topography, and alluvial soil fertility. Historically, the beel functioned as a natural retention basin, supporting extensive fish habitats, seasonal agriculture, and diverse wetland-dependent flora and fauna. Its hydrological regime is characterized by widespread inundation during the monsoon and gradual water recession during the dry season, which is creating a dynamic ecosystem that sustains both ecological processes and local livelihoods.

However, in recent decades this balance has been increasingly disrupted. Population growth, intensification of agriculture, proliferation of road networks, expansion of settlements, and modification of waterways have significantly altered the natural flow regime of the beel. These interventions have reduced flood retention capacity, increased sedimentation, fragmented habitats, and intensified pressure on wetland resources. Despite the ecological and socio-economic importance of



*Figure-1.1: Arial Beel in Wet Season
(Source: Research Team, UDD, 2025)*



*Figure-1.2: Arial Beel in Dry Season
(Source: Research Team, UDD, 2025)*

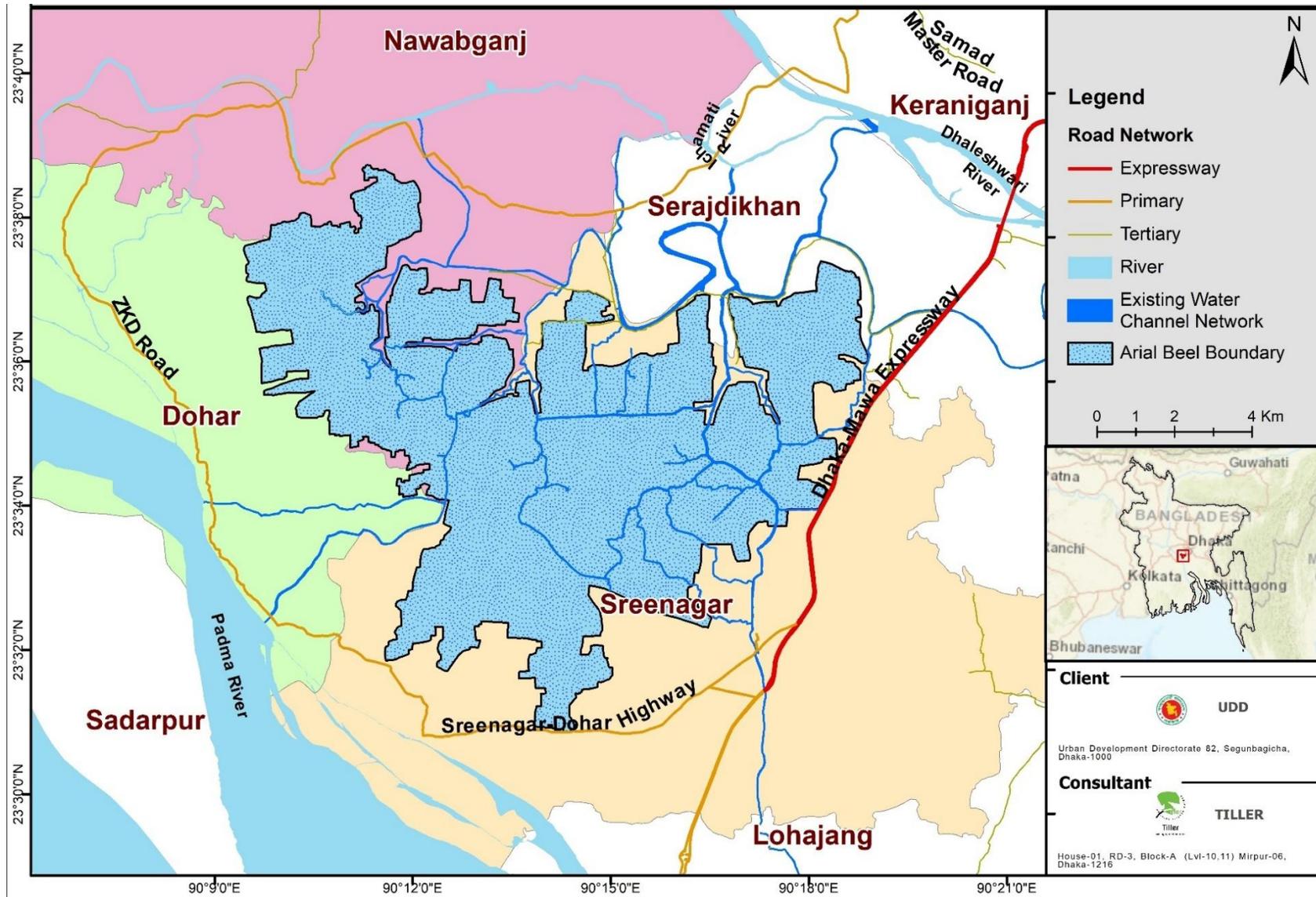
Arial Beel, there is limited scientific documentation that captures the extent, pattern, and drivers of these changes across time.

Remote sensing-based change detection has been applied in this study to systematically document how the Arial Beel landscape has transformed over time. By using multi-temporal satellite imagery, the study is able to map shifts in land use, identify areas of wetland loss, and detect changes in hydrological patterns with greater accuracy than conventional field-based methods alone. The use of this tool enables the study to generate clear, evidence-based insights that support better decision-making for wetland management, restoration planning, and sustainable use of natural resources. The findings are expected to assist policymakers, planners, and local authorities in understanding both the extent of change and the emerging environmental challenges within the watershed.

1.3 Overview of the Study Area

Arial Beel is one of the largest and most ecologically significant freshwater wetlands in central Bangladesh, located primarily within Srinagar Upazila of Munshiganj District, with hydrological influence extending into parts of Dohar and Nawabganj upazilas of Dhaka District and Sirajdikhan Upazila of Munshiganj. Geographically, the beel lies between 23°30'-23°39' N latitude and 90°09'-90°19' E longitude, situated between the Padma River to the south and the Dhaleshwari River system to the north. It is a seasonally inundated floodplain wetland (beel) that remains extensively flooded during the monsoon and partially dries out in the dry season, except for deeper perennial depressions locally known as 'denga'. These deeper perennial pockets retain water year-round, serving as critical refuges for aquatic life and reconnecting with the wider beel during the monsoon to support fish breeding and nutrient exchange. Together with surrounding open water, marshes, agricultural land, canals, and raised banks, Arial Beel sustains rich biodiversity and supports local livelihoods dependent on fisheries, agriculture, and water-based activities.

The Arial Beel watershed forms part of the lower central floodplain of Bangladesh and functions as an integrated hydrological system connected to major regional rivers. The total contributing watershed area of Arial Beel extends well beyond the core wetland and encompasses approximately 136 km², including surrounding agricultural lands, canals, and low-lying floodplains that drain into the beel during monsoon rainfall events. Hydrologically, the watershed is bounded and influenced by the Padma River system to the south and southwest, while to the north and northeast it is connected through a network of khals (canals) and distributaries linked to the Dhaleshwari–Ichhamati–Kaliganga river systems. These connections enable seasonal inflow and outflow of floodwaters, sediment, and aquatic organisms, making Arial Beel an important natural retention and flood moderation basin within the regional river network.



Map-1.1: Location Map of Arial Beel (Source: Research Team, UDD, 2025)

Within the watershed, several sub-catchment units drain into the beel through both natural and man-made channels. These sub-catchments collect runoff from surrounding settlements, agricultural fields, and road networks, gradually conveying water into the beel during rainfall events. The hydrological connectivity of these channels determines the extent, duration, and depth of seasonal inundation across the wetland. Any obstruction or encroachment within these drainage paths directly affects water retention, flooding dynamics, and ecological health of the beel. In brief, the Arial Beel watershed functions as a linked river–floodplain–wetland system, where upstream rainfall, canal connectivity, and river water levels jointly control inundation patterns, sedimentation processes, and ecosystem productivity. Protection of watershed boundaries and maintenance of hydrological connectivity are therefore critical for sustaining the ecological integrity and livelihood functions of Arial Beel.

1.4 Problem Statement and Rationale

Over the past two decades, Arial Beel has undergone significant land use and land cover changes driven by rapid human-induced transformations. Expansion of settlements, road construction, agricultural intensification, and hydrological modifications have disrupted the natural functioning of this wetland ecosystem. These changes have reduced seasonal inundation, degraded aquatic habitats, intensified drainage congestion, and compromised the ecological services that support fisheries, agriculture, biodiversity, and community livelihoods. Despite these emerging challenges, there is a notable absence of comprehensive, spatially explicit research documenting the magnitude, pattern, and causes of landscape transformation within the Arial Beel watershed. Without updated data, planning and conservation efforts remain limited, and unregulated land conversion continues to threaten the ecological resilience of the beel.

Remote sensing-based change detection has been employed in this study to overcome the lack of consistent historical data and to generate a clear, objective picture of how the Arial Beel landscape has changed over time. By analyzing satellite imagery from multiple periods, the study is able to quantify shifts in wetland extent, track the conversion of natural areas into agriculture or settlements, and detect modifications in hydrological patterns that are not easily captured through field observations alone. The insights produced through this geospatial assessment provide a reliable evidence base to understand the scale and direction of environmental change within the watershed. This scientific foundation is essential for informing conservation strategies, strengthening policy decisions, and supporting sustainable management of the wetland. Ultimately, the study aims to contribute to better protection of biodiversity, enhanced community resilience, and more climate-responsive planning for the Arial Beel region.

1.5 Research Objectives

The main aim of this study is to examine the spatial and temporal dynamics of land use and land cover change in the Arial Beel watershed over the past twenty years, in order to develop a comprehensive understanding of how land use transitions, hydrological modifications, and human activities have shaped its ecological and socio-economic landscape. The specific objectives are:

- a) To analyze multi-temporal land use and land cover changes in the Arial Beel watershed between 2005 and 2025 using satellite imagery and GIS to identify key landscape transformation trends, patterns of wetland shrinkage, and changes in hydrological characteristics.
- b) To examine the livelihood patterns and socio-economic dependence of local communities on wetland resources (such as fisheries, agriculture, and ecosystem services) and to evaluate how these livelihoods are being affected by land use changes and environmental transformations of the beel.
- c) To Conduct a biodiversity assessment and document the current ecological status of Arial Beel and explains how these ecological dynamics relate to observed land use transitions.
- d) To evaluate how land use changes, hydrological alterations, biodiversity impacts, and community livelihoods interact to shape ecosystem vulnerability and resilience.
- e) To formulate strategies that support sustainable wetland conservation, habitat restoration, ecological protection, and climate-resilient spatial planning for the Arial Beel watershed.

1.6 Scope and Structure of the Report

This research focuses on the environmental, socio-economic, and ecological dimensions of the Arial Beel watershed over the past two decades. It examines the interactions between land use changes, hydrological modifications, community livelihoods, and biodiversity dynamics. By integrating remote sensing analysis, field observations, and socio-economic assessment, the study provides a multi-dimensional understanding of how land use transitions, hydrological modifications, and human activities influence the sustainability of the wetland ecosystem. The scope of the study encompasses three interconnected components:

- (a) Land Use and Land Cover Changes:** The research has analysed multi-temporal spatial data to identify trends of landscape transformations within the catchment area of Arial beel.
- (b) Livelihood Patterns:** The study investigates the socio-economic dependence of local communities on wetland resources, like fisheries, agriculture, and ecosystem services and explores how these livelihoods are responding to transformation.
- (c) Biodiversity Assessment:** A field-based inventory and assessment of flora and fauna are conducted to evaluate the current ecological status of the beel. The study has also identified habitat characteristics, and determine key threats affecting biodiversity. At the end, the study proposes recommendations for policy development, conservation planning, and sustainable management of Arial Beel.

Chapter-02: Literature Review

2.1 Introduction:

Wetland ecosystems are globally recognized for their ecological richness, hydrological functions, and socioeconomic significance. Bangladesh, being part of the largest deltaic region in the world, hosts a diverse array of wetlands that sustain both natural ecosystems and human livelihoods. Despite their importance, these ecosystems face increasing environmental pressures due to rapid land use changes, population growth, and climate variability. Remote sensing and GIS-based studies have emerged as essential tools for quantifying such transformations and assessing their implications for ecological sustainability. This chapter synthesizes the existing body of literature on wetlands and watersheds in Bangladesh, their ecological and socioeconomic importance, the threats they face, and the methodological advances in change detection. Additionally, it explores prior research on Arial Beel and similar wetland systems, concluding with an overview of the policy and regulatory frameworks governing wetland management in Bangladesh.

2.2 Wetlands and Watersheds in Bangladesh:

Wetlands are one of the most valuable natural ecosystems and supporting exceptionally rich biodiversity and sustaining the lives and livelihoods of millions of people worldwide. The Ramsar Convention defines wetlands as areas saturated or inundated with water, either permanently or seasonally, including marshes, floodplains, beaches, and shallow coastal zones (Ramsar Convention Secretariat, 2016). Although wetlands cover only about 6% of the Earth's land surface, they support nearly 40% of all plant and animal species (United Nations, 2025). Despite their ecological significance, wetland systems are experiencing environmental degradation at faster rate than any other ecosystem globally (Millennium Ecosystem Assessment, 2005).

Traditionally, wetlands have provided vital support to rural economies through agriculture, fisheries, navigation, forestry, and recreation. They also supply fuelwood, timber, and construction materials (Mitsch & Gosselink, 2015). As transitional environments between terrestrial and aquatic systems, wetlands host many threatened and endemic species and play crucial roles in water purification, groundwater recharge, and flood mitigation (Turner et al., 2000; Costanza et al., 1997). Their ecological and socio-economic value is manifested through several key functions:

(a) Biodiversity protection:

Wetlands are globally recognized as biodiversity hotspots, supporting a remarkable array of species across multiple trophic levels. Many wetland organisms such as amphibians, migratory birds, aquatic plants, and fish are highly specialized and cannot survive outside these unique hydrological conditions (Junk et al., 2013). Although freshwater ecosystems occupy only about

1% of the Earth's surface, they harbor more than 40% of the world's species and 12% of all known animal species (WWF, 2020). Coral reefs, despite covering a mere 0.2% of the ocean floor, may support up to 25% of global marine life (Matthew et al., 1987). This extraordinary species richness underscores the ecological importance of wetlands and the urgent need to protect them from degradation and fragmentation.

(b) Ecosystem Services and Human Dependence:

Wetlands bring a broad spectrum of ecosystem services that are critical to human well-being. Their provisioning services including fish, rice, fodder, aquatic vegetation, and fuelwood are essential for food security and rural livelihoods (FAO, 2011). Regulating services such as flood reduction, water purification, aquifer recharge, and carbon sequestration help maintain environmental stability (MEA, 2005; Mitsch & Gosselink, 2015). Cultural services, including recreation, heritage values, and traditional practices, contribute to community identity and social cohesion. In Bangladesh, wetland-based fisheries alone provide millions of people with income and protein sources (DoF, 2019). However, these benefits diminish rapidly when wetlands become degraded, fragmented, or converted for agriculture, infrastructure development, or settlement expansion (Hassan et al., 2018).

(c) Water storage:

Wetlands function as natural water reservoirs, storing water within soil pores and surface depressions such as beels, marshes, ponds, and river channels. This storage capacity moderates seasonal water availability, reduces drought impacts, and maintains base flows during dry periods (Mitsch & Gosselink, 2015).

(d) Groundwater replenishment:

A significant portion of water stored in wetlands gradually infiltrates into underlying aquifers, contributing to groundwater recharge (Winter, 1999). This process is crucial for sustaining irrigation and domestic water supply, especially in groundwater-dependent regions like Bangladesh.

(e) Sediment retention:

Wetlands reduce the speed of flowing water, allowing sediments to settle. This sediment-trapping mechanism prevents downstream siltation, improves water clarity, and enriches soil fertility within floodplain ecosystems (Kadlec & Wallace, 2009). It also helps maintain river morphology and agricultural productivity.

(f) Retention of nutrients and other substances:

Wetland vegetation and microbial communities act as natural filters that remove nutrients, particularly nitrogen and phosphorus, from agricultural runoff, domestic wastewater, and industrial effluents (Vymazal, 2011). This nutrient cycling process enhances water quality and maintains ecological balance across aquatic systems.

(g) Carbon Sink:

Wetlands are significant carbon sinks due to their ability to store organic carbon in waterlogged soils. Peatlands, mangroves, and marshes are particularly effective in sequestering carbon and regulating greenhouse gas emissions (S. E., Rieley, J. O., & Banks, C. J., 2011). Wetlands also mitigate climate-related hazards by buffering storm surges, reducing flood peaks, moderating microclimates, and stabilizing coastlines (Bergkamp, 2001). These climate regulatory functions make wetlands crucial for both climate mitigation and adaptation strategies.

Bangladesh's geographical identity as a deltaic nation results in the formation of extensive wetland systems that are hydrologically linked to the Ganges, Brahmaputra, and Meghna rivers (Mitsch & Gosselink, 2015). Wetlands in Bangladesh include beels, haors, baors, estuaries, mangroves, rivers, floodplains, marshes, and numerous manmade water bodies. These ecosystems provide habitats for diverse flora and fauna, including endemic and migratory species (Rahman et al., 2019).

Seasonal wetlands such as beels expand during the monsoon and shrink during the dry season, creating a dynamic environment suitable for fish breeding, aquatic vegetation, amphibians, waterbirds, and invertebrates. Wetland-associated watersheds regulate water flow, store monsoon runoff, and recharge groundwater. The ecological integrity of these watersheds is vital for biodiversity conservation, hydrological stability, and climate resilience. However, many wetlands in Bangladesh remain under-documented and insufficiently managed, highlighting the need for scientific monitoring and conservation interventions.

Bangladesh is predominantly a wetland country, with more than two-thirds of its land area classified as wetland environments (Ramsar Convention Bureau, 2000). Wetlands include rivers, floodplains, haors, baors, beels, jheels, ponds, and low-lying tidal areas (Bangladesh Haor and Wetlands Development, 2005). Their ecological and economic contributions underscore their importance for local communities and the national economy (Kabir & Amin, 2006).

2.3 Types of Wetlands in Bangladesh

Wetlands in Bangladesh exhibit diverse geomorphological and hydrological characteristics shaped by the country's deltaic landscape. Several national documents including the Bangladesh Haor Master Plan (Bangladesh Haor and Wetland Development Board, 2012) and the Wetland Classification Framework of Bangladesh (The Wetland Classification Framework developed by the Bangladesh Haor and Wetland Development Board, 2016) formally categorize wetlands into distinct types such as haors, beels, baors, rivers and floodplains, and coastal wetlands.

2.3.1 Haors:

Haors are large, bowl-shaped floodplain depressions located primarily in the northeastern region of Bangladesh, including Sunamganj, Kishoreganj, Habiganj, and Netrakona. During

the monsoon, these depressions become gigantic water bodies, often merging into a single inland sea-like expanse. In the dry season, water recedes, exposing fertile land that is cultivated for boro rice (BHWD, 2012; MoWR, 2014). Haors are hydrologically unique because they receive both local rainfall and upstream flash floods originating from the Meghalaya Hills. Their dual character, deep flooding in monsoon and complete exposure in winter, supports rich fisheries, migratory birds, and floodplain agriculture.

2.3.2 Beels:

Beels are natural depressions or low-lying areas within floodplains that retain water during the monsoon and may partially or completely dry up during the dry season. They may be perennial or seasonal depending on depth, geomorphology, and hydrological connectivity (Ramsar Convention Bureau, 2000). Examples of important beels of Bangladesh are Arial Beel, Chalan Beel, and Gopalganj-Khulna beel systems. Beels play an important ecological role by supporting freshwater fisheries, aquatic vegetation, and local agricultural practices. Their hydrological and ecological dynamics are strongly influenced by river flooding, sedimentation, and rainfall patterns.

2.3.3 Baors:

Baors, also known as oxbow lakes, are crescent-shaped water bodies formed when curved sections of a river become detached from the main channel due to natural river shifting. These wetlands are typically perennial, with limited inflow and outflow, and are found predominantly in Gopalganj, Narail, and Jessore (Bangladesh Water Development Board, 2010). Baors serve as productive fisheries and provide critical habitat for aquatic flora and fauna. Their geomorphological evolution reflects long-term river dynamics and sediment behavior.

2.3.4 Rivers and Floodplains:

Riverine wetlands encompass all rivers, distributaries, streams, and associated floodplains that remain seasonally or permanently inundated. These systems are dynamic, shaped by river flow, seasonal flooding, sedimentation, and channel migration (Mitsch & Gosselink, 2015). Major examples are the Padma, Jamuna, Meghna, and Brahmaputra rivers and their extensive floodplains. Floodplain wetlands function as natural reservoirs during monsoon, recharge groundwater, support fisheries, and maintain ecological connectivity across the landscape.

2.3.5 Coastal Wetlands:

Coastal wetlands in Bangladesh include tidal flats, estuaries, salt marshes, and the Sundarbans mangrove forest, located along the country's southern coast. These wetlands are influenced by tidal action, saline water intrusion, cyclonic storm surges, and sediment deposition (Iftekhar & Saenger, 2008). The Sundarbans of Bangladesh (a UNESCO World Heritage Site) is the

world's largest contiguous mangrove ecosystem and provides critical habitat for numerous species, including the Royal Bengal Tiger, estuarine crocodile, and diverse fish communities. Coastal wetlands function as natural coastal defenses, carbon sinks, breeding grounds, and nutrient cycling zones.

2.4 Environment and Socioeconomic Importance of Wetlands

Wetlands provide a vast array of ecosystem services essential for environmental stability and human well-being. Environmentally, wetlands serve as natural buffers against flooding by absorbing excess water during the monsoon and slowly releasing it into the surrounding landscape (Ramsar Convention Secretariat, 2016). They also promote groundwater recharge, maintain base flows in rivers, and contribute to water purification through the natural filtration of sediments and pollutants. From a climate perspective, wetlands are key contributors to carbon storage and play a vital role in mitigating greenhouse gas emissions. Wetland vegetation, especially mangroves and marsh plants, absorbs carbon dioxide and stores it in biomass and soil, positioning wetlands among the most effective carbon sinks globally (MEA, 2005).



*Figure-2.1: Livelihoods Dependent on Wetlands
(Source: Research Team, UDD, 2025)*

Socioeconomically, wetlands are vital sources of livelihood in rural Bangladesh. Fisheries remain a major contributor, with more than a million people directly or indirectly dependent on open-water fishing (Islam & Gnauck, 2009). Agriculture in wetland areas benefits from nutrient-rich alluvial soils deposited annually by floodwaters. Wetlands also support aquatic vegetation harvesting, livestock grazing, transportation, and small-scale cottage industries. In addition, many wetlands hold cultural and traditional significance, contributing to social cohesion and indigenous knowledge systems (Chowdhury & Ahmed, 2020).



*Figure-2.2 and 2.3 Livelihoods Dependent on Wetlands in Bangladesh
(Source: Research Team, UDD, 2025)*

Given this wide range of services, any degradation of wetlands has immediate consequences for ecosystem stability, food security, and community livelihoods. Understanding these dependencies is therefore essential for formulating sustainable management strategies.

2.5 Change Detection Studies in Wetland Systems

Monitoring environmental transformations in wetland ecosystems requires methods capable of detecting subtle spatial and temporal changes. Remote sensing (RS) based change detection has emerged as one of the most effective tools for this purpose due to its ability to generate multi-temporal, synoptic, and spatially consistent datasets across large and often inaccessible landscapes (Lu et al., 2004). These techniques make it possible to measure changes in land use and land cover, identify shifts in wetland hydrology, assess vegetation health, and evaluate the extent of human disturbance. A wide array of methods has been applied in wetland change detection, including:

- 1) Post-classification comparison, considered one of the most reliable techniques for temporal change assessment, where classified images from different periods are compared pixel-by-pixel (Jensen, 2015).
- 2) Spectral indices, such as the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI), which help detect vegetation health and surface water changes.
- 3) Machine learning-based classifications, including Random Forest and Support Vector Machines, which have improved classification accuracy in heterogeneous landscapes (Hassan et al., 2018).

In Bangladesh, multiple studies have applied RS and GIS methodologies to haor basins, riverine wetlands, and mangrove ecosystems. For example, Haque and Basak (2017) observed substantial wetland shrinkage in northern floodplain areas due to agricultural expansion and infrastructural development. Similar findings in coastal wetlands documented erosion, salinity intrusion, and aquaculture-induced land conversion. Despite these advancements, there remains a significant research gap for wetlands like Arial Beel, particularly regarding long-term landscape changes and their socio-ecological implications. This underscores the need for a detailed RS and GIS based change detection study to support scientific decision-making and policy formulation.

2.6 Threats to Wetlands and Watershed Areas

Wetlands in Bangladesh are increasingly threatened by a combination of natural processes and anthropogenic pressures. Rapid population growth and escalating demand for land have resulted in widespread conversion of wetlands into agricultural land, settlements, and commercial developments (Biswas et al., 2018). Infrastructure development, including roads, embankments, and drainage canals, has further disrupted natural hydrological connectivity by obstructing seasonal water flow and inundation processes that are essential for wetland functioning. A study conducted by the Bangladesh Institute of Planners (2023) reported that

approximately 0.44 km² of wetland area was filled between 2015 and 2023, indicating a significant acceleration of land conversion in recent years. Additional pressures include sedimentation that gradually infills wetland depressions, pollution from agricultural chemicals, industrial discharges, and domestic wastewater, as well as overfishing, which alters aquatic food webs and reduces ecological resilience.

Arial Beel, one of the largest wetlands in Bangladesh is one of the crucial examples of these broader national trends of wetland degradation. Historically, the beel has been subject to development pressure, most notably during the early 2010s when a proposed airport project triggered strong local resistance. Community protests ultimately led to the cancellation of the project, reflecting the social and ecological importance of the wetland to local livelihoods. However, in recent years, Arial Beel has faced renewed and more diffuse threats in the form of gradual encroachment and land filling driven by real estate development (The Daily Star, 22 July, 2023). Field observations and secondary sources further indicate that sections of the beel have been acquired by private real estate entities and filled with sand for prospective residential development. Investigations across several villages including Hasara, Kewatkhali, Gaidighat, Baroikhali, Srinagar, Rairkhal, and Alampur revealed the presence of unregistered real estate developments, installation of advertising hoardings, and construction activities within former wetland and cropland areas (The Daily Star, 22 July, 2023).



Beyond direct land conversion, a range of additional ecological pressures is undermining the long-term sustainability of Arial Beel. As a monsoon-dependent wetland system, Arial Beel is particularly sensitive to climate-induced changes in temperature and rainfall regimes. Rising temperatures, irregular precipitation patterns, and the increasing frequency of extreme weather events have facilitated the spread of invasive species, altered habitat structure and displaced native flora and fauna (MEA, 2005). These climate-driven stresses further disrupt hydrological regimes and reduce the predictability and extent of seasonal flooding, which is critical for maintaining wetland productivity, biodiversity, and ecosystem functions (Islam et al., 2019).



Figure-2.4: Private Real Estate in Arial Beel (The Daily Star, 2023)

Collectively, these interacting pressures have resulted in wetland shrinkage, habitat degradation, biodiversity loss, reduced water retention capacity, and declining ecosystem services, thereby increasing livelihood vulnerabilities for dependent communities.

2.7 Prior Research on Arial Beel and Similar Wetlands

Although wetlands such as the haor basins and coastal mangrove ecosystems have received considerable academic and policy attention in Bangladesh, relatively fewer studies have focused specifically on Arial Beel. The limited existing research highlights issues such as seasonal waterlogging, heavy agricultural dependency, declining water quality, and the gradual shrinkage of open-water habitats (Rahman & Akter, 2020). However, these studies are often constrained by short temporal scales and frequently overlook the integration of socio-economic dimensions with environmental dynamics. Consequently, a comprehensive understanding of how ecological processes and livelihood systems interact within the Arial Beel watershed remains inadequate.

Research conducted on comparable beel systems such as Chalan Beel, the Gopalganj beel complexes, and the Pabna floodplain offers valuable insights into the broader trajectory of wetland degradation in Bangladesh. Studies have demonstrated that extensive hydrological fragmentation in central beel systems has occurred due to embankments, expanding road networks, and unplanned drainage structures, all of which disrupt natural water flow and intensify wetland degradation (Khan et al., 2021). Furthermore, persistent wetland loss across northern districts has been documented, primarily driven by the expansion of irrigated agriculture and rapid settlement growth, which increasingly encroach upon natural aquatic habitats (Haque & Basak, 2017).

These findings collectively indicate that wetland ecosystems throughout Bangladesh are experiencing significant environmental transformations driven by anthropogenic pressures and hydrological modifications. Given this context, it is highly probable that Arial Beel is undergoing similar or even more pronounced changes. This underscores the need for a systematic, long-term assessment using robust RS–GIS techniques to evaluate spatial patterns of land use change and to understand their ecological and socio-economic implications for the Arial Beel watershed.

2.8 Policy and Regulatory Framework:

Wetland management in Bangladesh is governed by a range of national policies, legal instruments, and international commitments that collectively aim to promote sustainable resource use, ecological conservation, and climate resilience. These frameworks provide the institutional foundation for regulating wetland protection, monitoring environmental change, and guiding development activities within sensitive ecosystems such as beels, haors, and floodplains. Key policy instruments relevant to wetland management and environmental change studies include:

2.8.1 Bangladesh Water Act, 2013:

This is the key water law in Bangladesh which constitutes the principal legal framework governing the integrated development, management, protection, and conservation of the

country's water resources, including surface water, groundwater, seawater, rainwater, and wetlands. The Act provides a comprehensive statutory basis for regulating water use, preventing pollution, managing sewage disposal, and identifying and protecting water-stress and ecologically critical water areas such as Arial Beel. A key institutional feature of the Act is the establishment of the National Water Resources Council (NWRC), chaired by the Honorable Prime Minister. The Council is mandated to provide strategic policy direction, ensure inter-ministerial coordination, and oversee integrated water resources management (IWRM) across sectors. This high-level governance structure reinforces the national importance of wetlands and floodplain systems and legitimizes coordinated action among water, land, agriculture, fisheries, environment and concern development organizations.

The Act is particularly significant as it formally recognizes the natural flow regimes, storage capacity, and ecological functions of water bodies, and explicitly restricts unauthorized encroachment, land filling, diversion, or obstruction of natural watercourses. These provisions are directly relevant to the observed patterns of wetland shrinkage, conversion to agricultural or built-up land, and hydrological fragmentation identified through remote sensing (RS) and GIS based analysis in the Arial Beel area. Consequently, the Act provides a clear legal benchmark against which detected land-use changes can be assessed to determine their compliance or non-compliance with national water legislation.

The Act supports fisheries, agriculture, and local livelihoods that depend on natural water bodies. Therefore, land-use changes that increase turbidity, vegetation stress, and sedimentation directly contribute to ecological degradation and declining water quality, as recognized by the law. The Act also provides a legal basis for declaring and protecting water-stress and environmentally sensitive areas, such as Arial Beel. In this context, multi-temporal land-use and land-cover analysis can inform evidence-based zoning, buffer zone designation, and wetland restoration measures consistent with the Act's conservation objectives.

2.8.2 Playground, Open Space, Park and Natural Water Reservoir Conservation Act, 2000:

The Playground, Open Space, Park and Natural Water Reservoir Conservation Act, 2000 provides an important statutory framework for protecting water bodies and natural lowlands in Bangladesh from illegal encroachment, land filling, and unplanned development. Section 5 of the Act explicitly prohibits any change in the character, classification, or designated use of natural water reservoirs, including wetlands, beels, and low-lying retention areas. This provision is particularly relevant to floodplain wetlands such as Arial Beel, where land filling and reclassification for urban development directly contradict the legal mandate of conservation. Moreover, Section 6 restricts the leasing, transfer, or allocation of protected water bodies and open spaces for purposes other than their original natural function and Section 7 further empowers the government to undertake protection, conservation, and restoration

measures, establishing a legal basis for wetland rehabilitation, buffer zone enforcement, and reversal of illegal encroachment identified through spatial analysis.

Despite the strong statutory safeguards provided by the Act, multiple studies and judicial observations highlight persistent implementation and enforcement gaps. Section 8 enables legal action and penalties against illegal encroachment, and this clause has been repeatedly invoked by the judiciary particularly through High Court interventions to issue stay orders against unauthorized wetland development in and around Arial Beel. However, the continued reduction of open water areas and expansion of built-up land along the beel's periphery reveal a significant disconnect between legislative intent and ground-level land-use practices.

2.8.3 Bangladesh Environment Conservation Act, 1995:

The Bangladesh Environment Conservation Act (ECA), 1995, amended in 2010, serves as the core legal framework for environmental protection and sustainable natural resource management in Bangladesh. The Act empowers the government to prevent environmental degradation, regulate environmentally harmful activities, and conserve ecologically sensitive areas, including wetlands and floodplain ecosystems. Its provisions are particularly relevant for wetlands, which perform critical ecological functions related to flood regulation, water storage, biodiversity conservation, and livelihood support.

A key feature of the Act is the authority vested in the government to declare Ecologically Critical Areas (ECAs) and impose restrictions on land use and development activities that threaten environmental quality. The Act prohibits activities that cause pollution, unplanned land conversion, land filling, and disruption of natural hydrological regimes processes that are commonly associated with wetland degradation in rapidly urbanizing floodplain regions. These provisions provide a strong legal basis for regulating development in and around environmentally sensitive wetlands like Arial Beel.

The 2010 amendment further strengthened the Act by enhancing enforcement mechanisms, increasing penalties for environmental offences, and expanding regulatory oversight over environmentally harmful land-use practices. Despite these strengthened provisions, practical evidence shows that enforcement challenges persist, particularly in peri-urban wetlands where competing development pressures are high. The continued expansion of built-up areas and reduction of wetland extent around Arial Beel indicate a gap between statutory intent and on-the-ground implementation.

2.8.3 National Land Use Policy, 2001:

The National Land Use Policy provides a strategic policy framework for the planned and sustainable use of land resources in Bangladesh, with particular emphasis on preventing unplanned land conversion and protecting environmentally sensitive areas. The policy recognizes wetlands, floodplains, and low-lying agricultural lands as critical ecological assets

and explicitly discourages their conversion to non-agricultural and urban uses. A key objective of the policy is to ensure land-use compatibility by guiding the allocation of land for agriculture, settlement, industry, infrastructure, and conservation based on environmental suitability. The policy stresses the protection of natural drainage systems, water retention areas, and flood flow zones to reduce flood hazards and maintain ecological balance. It also emphasizes the need for zoning regulations, land classification, and coordinated planning across sectors to minimize land-use conflicts and environmental degradation, specially where rapid urban expansion and land filling pose significant environmental risk.

2.9 Judicial Directives, Legal Actions and Strategic Plan:

2.9.1 High Court Directives (2023–2025):

In response to reports of large-scale illegal real estate expansion and wetland encroachment, the High Court of Bangladesh issued an immediate directive in August 2023 ordering the cessation of all unauthorized earth-filling and construction activities within Arial Beel. Recognizing the necessity of objective spatial evidence, the Court further instructed the concerned authorities to submit multi-temporal satellite imagery of Arial Beel covering the period from 2010 to 2022 in order to detect, verify, and assess land-use changes over time. Subsequently, the High Court imposed additional regulatory measures to safeguard the wetland's legal and ecological status. As of 2025, any reclassification, transfer, or sale of land within the officially designated boundary of Arial Beel (covering approximately 530 hectares) must be formally reported to the Deputy Commissioner. This measure aims to ensure that the reservoir status and natural function of the beel are not altered through administrative or commercial actions.

2.9.2 Haor Master Plan:

The Haor Master Plan represents a strategic planning framework for the integrated management, conservation, and sustainable development of wetland ecosystems in Bangladesh. Although it primarily addresses large haor basins, its planning principles are equally applicable to floodplain wetlands such as Arial Beel. The Plan emphasizes the protection of natural water retention areas, preservation of seasonal flooding regimes, and regulation of land use in flood-prone and environmentally sensitive areas to prevent unplanned land conversion. These priorities directly reflect the challenges facing Arial Beel, where land-use change has disrupted natural drainage, reduced wetland extent, and threatened ecological functions and local livelihoods.

2.9.3 Bangladesh Delta Plan 2100

The Bangladesh Delta Plan 2100 (BDP 2100) provides a long-term strategic framework for sustainable development, climate resilience, and water resources management in Bangladesh's deltaic landscape. It recognizes wetlands, floodplains, and natural water retention areas as key components of delta resilience and promotes an integrated water resources management (IWRM) approach to protect natural drainage corridors, seasonal inundation zones, and flood

flow areas. The Plan also highlights the growing risks of rapid urbanization, land-use change, and climate variability, particularly in low-lying and peri-urban areas, where disruption of natural hydrological regimes intensifies flooding, waterlogging, and ecological degradation. Despite these frameworks, challenges persist in enforcement due to institutional fragmentation, limited monitoring capacity, and conflicts between conservation priorities and development pressures (Ahmed, 2019). Strengthening coordination among agencies, integrating geospatial monitoring tools, and involving local communities in decision-making processes are essential for effective wetland governance.

Chapter-03: Methodology of the Study

3.1 Research Design and Overall Approach

This study adopts a mixed-methods and spatially integrated research design to examine the interrelationships among land-use change, biodiversity status, hydrological connectivity, and livelihood patterns within the Arial Beel wetland system. The approach integrates remote sensing and GIS-based spatial analysis, ecological field surveys, and socio-economic assessments to generate a comprehensive understanding of environmental change and human–ecosystem interactions. The mixed-methods design enables triangulation of quantitative spatial data with qualitative and field-based observations, thereby enhancing the robustness, validity, and policy relevance of the findings. This integrative framework is particularly appropriate for complex wetland systems like Arial Beel, where ecological processes and human activities are closely interconnected.

3.2 Methodological Framework

The methodological framework of this study is designed as a sequential and integrative process, combining spatial analysis, ecological investigation, and socio-economic assessment to comprehensively examine the dynamics of Arial Beel. The approach recognizes the wetland as a coupled human–natural system, where land-use change, biodiversity condition, and livelihood patterns are closely interrelated. Accordingly, the framework consists of four interlinked components, each informing and reinforcing the others.

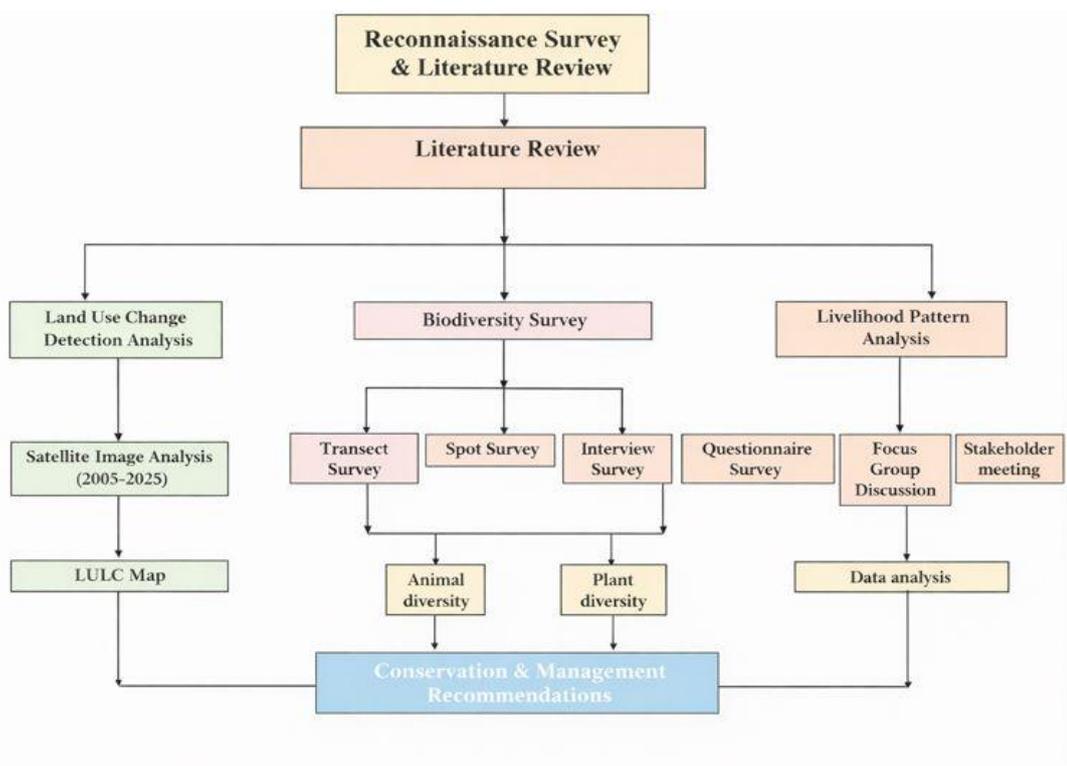


Figure-3.1: Flow chart of the methodology for the Research

3.2.1 Reconnaissance Survey and Literature Review:

The study commenced with a reconnaissance survey to obtain a preliminary understanding of the physical setting, hydrological characteristics, habitat types, and ongoing human activities within and around Arial Beel. This initial field observation helped refine the study boundary, identify key ecological features, and guide the design of subsequent surveys. In parallel, an extensive review of relevant national and international literature, policy documents, and previous research was undertaken to establish the ecological and socio-economic context of wetlands in Bangladesh, identify historical trends in Arial Beel, and define research gaps. The combined insights from field reconnaissance and literature review provided the conceptual foundation for the overall research design.

3.2.2 Land Use and Land Cover Change Analysis:

Land Use and Land Cover (LULC) change detection was carried out to analyze the spatial and temporal dynamics of land transformation within the Arial Beel catchment over a 20-year period (2005–2025). This analysis aimed to quantify changes in wetland extent, agricultural expansion, built-up growth, vegetation cover, and other land-use categories, and to understand their implications for ecosystem integrity and human activities.

The methodological workflow for historical LULC change detection is illustrated in Figure-3.1, which outlines the sequential steps from satellite data acquisition to final map generation and statistical analysis.

(a) Lands Use Classification:

Multi-temporal satellite imagery was used to generate LULC maps for the years 2005, 2010, 2015, 2020, and 2025. For the earlier periods (2005 and 2010), Landsat 5 Thematic Mapper (TM) imagery with a spatial resolution of 30 m was employed, ensuring long-term temporal consistency. For the later years (2015, 2020, and 2025), higher-resolution Sentinel-2 Multi-Spectral Instrument (MSI) imagery with 10–20 m resolution was utilized to capture finer spatial details of recent land-use changes.

All satellite image preprocessing, band selection, and classification were conducted in Google Earth Engine (GEE), a cloud-based geospatial analysis platform. Images with less than 10% cloud cover were selected to ensure data quality and reliability. Dry-season imagery (January–February) was prioritized to minimize seasonal variability associated with monsoon flooding and to maintain inter-temporal comparability across all study years.

LULC mapping for 2005 and 2010 relied on Landsat 5 TM data, while Sentinel-2 MSI imagery was used for 2015, 2020, and 2025. This combination ensured both historical continuity and improved spatial accuracy in recent years, facilitating robust multi-year LULC classification and change detection. The spectral bands used for each satellite sensor, along with their

corresponding wavelengths, spatial resolution, and acquisition details, are summarized in Annexure-01.

(b) Supervised Classification

LULC classification was performed using a supervised classification approach, which relies on predefined reference and validation datasets to assign land-use classes. Reference samples were developed using a combination of field observations, high-resolution imagery, and expert visual interpretation. Approximately 70% of the reference samples were used for classifier calibration, while the remaining 30% were reserved for independent validation to assess classification reliability.

Up to 100 reference points per land-use class were used to ensure representative sampling and to enhance classification robustness across diverse landscape features. Individual land-use zones were carefully delineated to improve discrimination among spectrally similar classes, particularly flooded agricultural land, open waterbodies, and vegetated areas common in deltaic wetland environments.

(c) Post-Classification Processing

Post-classification refinement was carried out using ArcGIS to improve the spatial accuracy and visual coherence of the classified outputs. This process included filtering and smoothing techniques to reduce classification noise, remove isolated pixels, and refine class boundaries. The classified raster datasets were then clipped to the defined study area boundary of the Arial Beel catchment. The refined LULC maps were symbolized using consistent cartographic elements to support comparison across different years and to facilitate interpretation of spatial patterns and trends.

(d) Reclassification

For analytical clarity and policy relevance, the classified outputs were reclassified into six major Land-use categories, which are (i) Waterbody, (ii) Built-up area, (iii) Agricultural land, (iv) Flooded agricultural land, (v) Vegetation and (vi) Barren land. These classes were coded numerically (0–5) to support spatial analysis and statistical computation. Following reclassification, raster-to-polygon conversion was applied to enable precise area calculation and spatial statistics.

(e) Prepare Land Use Change Analysis Map

Final LULC maps were produced for each reference year (2005–2025), and corresponding area statistics were calculated in absolute terms (acres) and relative proportions (%). Year-to-year comparisons were conducted to identify trends, transitions, and rates of change among different land-use categories. The resulting maps, tables, and graphs collectively illustrate the temporal evolution of land-use patterns in Arial Beel over two decades, providing a clear basis for

interpreting wetland transformation processes and their ecological and socio-economic implications.

3.2.3 Biodiversity Assessment:

Biodiversity surveys were conducted between April and June 2025 through multiple field visits covering representative habitats across the study area. The survey design followed internationally accepted ecological field methods to ensure repeatability and comparability with similar wetland studies. However, due to time and resource constraints multiple data were collected during the same field visit to streamline the sampling effort. The data were recorded on pre-designed data sheets and notebooks, which were ultimately processed and analyzed to draw the conclusion. All methods were replicable, so the findings will serve as the baseline for future monitoring.

For fauna, the relative abundance of different species was identified on the basis of its level of chance of identification in the light of its detectability in the field (Khan *et al.* 2016). Four categories were used to express the relative abundance of different species. These are – (i) Very Common (76%-100% percent chance of being identified in its habitats at the time when it is most active); (ii) Common Species (51%-75% chance of being identified in its habitats at the time when it is most active); (iii) Uncommon Species (26%-50% chance of being identified in its habitats at the time when it is most active); and (iv) Rare Species (25%t or less chance of being identified in its habitats at the time when it is most active).



Figure-3.2: Sample Collection from Water
(Biodiversity Survey, 2025)

For flora, plant species within the project area were recorded and collected following standard procedures (Gillison, 2006). Collected samples were processed using established techniques, and supplementary information was gathered through field experience, local interviews, and relevant literature. Species identification was carried out by taxonomic experts and verified through comparison with herbarium specimens and standard taxonomic descriptions, keys, and illustrations. Species abundance and relative abundance were assessed through following formula:

Abundance (A) = Total no. of individual of a species/Total area in where the species found.

Relative Abundance (RA) % = (Abundance of a species/Total Abundance of all species) × 100

Based on the Relative Abundance (RA) value, the existing status of the plant species were categorized according to DAFOR scale (Hearnshaw and Hughy 2010) as mentioned below:

Table-3.1: Plant Species Category using DAFOR Scale

DAFOR category	RA value
D for Dominant	>75%
A for Abundant	51-75%
F for Frequent	26-50%
O for Occasional	11-25%
R for Rare	1-10%

Source: Biodiversity Survey, UDD, 2025

The threatened species of fauna and flora were identified on the basis of published status following IUCN Red List Categories and Criteria (IUCN-Bangladesh 2015). Field data collection primarily employed three complementary methods: (i) transect surveys, (ii) spot surveys, and (iii) interview surveys, enabling systematic observation, site-specific assessment, and incorporation of local knowledge.

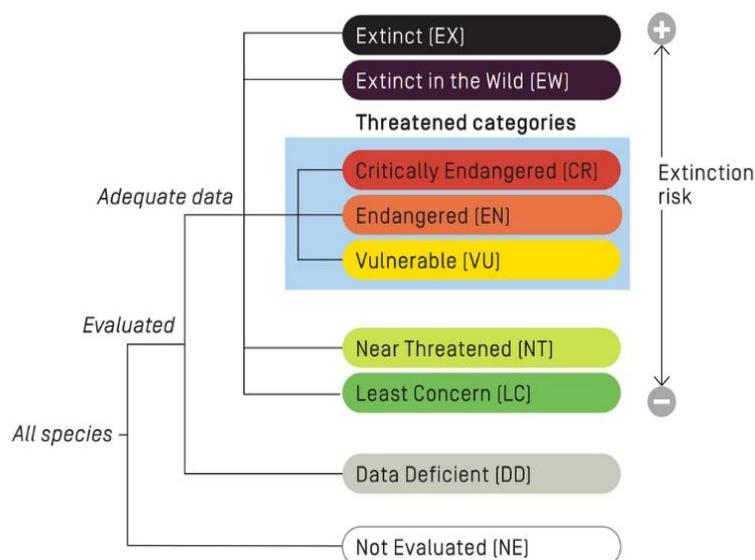


Figure-3.3: Red List categories (Regional/National Level) (IUCN-Bangladesh 2015)

(a) Transect Survey: Transect surveys were conducted following the standard line transect methodology described by Buckland et al. (2001). Surveys were carried out on foot during the dry season and by boat during the wet season to ensure comprehensive coverage of both terrestrial and inundated habitats within the study area. Each transect followed a predefined route along which observers systematically recorded the occurrence of target objects, including animal and plant species. Observations were recorded within an approximate 50-m buffer on either side of each transect, with survey speed maintained at around 1.5 km/hour to ensure accurate species detection. Surveys were carried out during morning and afternoon periods when wildlife activity was highest. Transects were designed to pass

through all major habitat types present in the study area, including open water, flooded agricultural land, vegetated wetlands, and raised banks, to ensure representative sampling and maximize species detection. Finally, photographic documentation was carried out for key fauna and flora that requires detailed examination for accurate identification or conservation assessment.

(b) Spot Survey: Spot surveys complemented transect surveys by targeting ecologically important micro-habitats and areas likely to support rare or cryptic species. This method involved intensive searches of selected locations, including vegetation patches, pond banks, and leaf litter, and was particularly effective for documenting amphibians, reptiles, and understory plant species.

(c) Interview and Key Informant Survey:

Semi-structured interviews and key informant surveys were conducted with local residents, fishers, farmers, and community leaders to document species occurrence, seasonal patterns, resource use, and perceived ecological changes. Structured interview protocols were applied to minimize respondent and interviewer bias.



*Figure-3.4: Consultation Meeting
(Research Team UDD, 2025)*

(d) Species Identification and Abundance Assessment: Species identification followed standard taxonomic references and expert verification. Relative abundance of fauna was categorized into four classes (Very Common, Common, Uncommon, Rare) based on detection probability. For flora, abundance and relative abundance were calculated and classified using the DAFOR scale, consistent with international ecological assessment practices. Threatened species were identified following the IUCN Red List Categories and Criteria (national and global levels).

3.2.4 Socio-Economic Survey:

Structured household surveys, FGDs, and stakeholder consultations were used to analyze livelihood patterns, resource dependency, infrastructure access, and socio-economic vulnerabilities of local communities.

(a) Study Area and Sampling Strategy

The socio-economic survey was conducted across four upazilas surrounding the Arial Beel wetland, namely Sreenagar, Dohar, Nawabganj, and Sirajdikhan, covering a total of 270 respondents. The selection of upazilas and unions was based on their proximity to the wetland, degree of livelihood dependence on beel resources, and representation of diverse socio-economic and land-use settings.

Table-3.2: Socio-Economic Survey in the Peripheral Areas of Arial Beel

Srl. No.	Upazila	Types and Locations of Survey			
		Reconnaissance Survey	Questionnaire Survey	FGD	Stakeholder meeting
01.	Sreenagar	Sreenagar Upazila	Barikhali Union (60) Hansara Union (60)	Gadighat Village	Sreenagar Upazila
	Munshiganj Sadar	-	Munshir Hat	-	-
02.	Dohar	-	Sutarpara Union (30) Narisha Union (30) Muksudpur Union (10)	-	-
03.	Nawabganj	-	Churain Union (30) Galimpur Union (10)	-	-
04.	Sirajdikhan	-	Shekharnagar Union (20) Rajanagar Union (20)	Rajanagar Union	-

Source: Field Survey conducted by Research Team, UDD (2025)

(b) Data Collection

The socio-economic assessment was based on both primary and secondary data sources. Primary data were collected through household questionnaire surveys, focus group discussions (FGDs), reconnaissance surveys, and stakeholder meetings. Secondary data were obtained from published literature, journals, books, government reports, and relevant online sources to contextualize field findings. Households were selected using a random sampling approach within villages adjacent to Arial Beel to minimize selection bias. Respondents included local residents, farmers, fishers, and other wetland-dependent groups. Interviews with village residents provided critical insights into historical changes, livelihood transitions, and community perceptions regarding the wetland. In addition, a significant number of farming households were surveyed to better understand agricultural practices and vulnerability.

The questionnaire covered key socio-economic indicators, including household income sources, daily income patterns, housing conditions, sanitation facilities, access to drinking water, healthcare services, and agricultural activities. These variables collectively helped develop a comprehensive socio-economic profile and provided a “pen picture” of the livelihoods and living conditions of wetland-dependent communities. Collected data were processed and analyzed using Microsoft Excel and Microsoft Word. Quantitative data were summarized using descriptive statistics, while qualitative information from FGDs and stakeholder consultations was synthesized thematically. Selected results were presented through tables, pie charts, bar diagrams, and graphs to support clear interpretation and comparative analysis.

3.3 Data Processing and Analysis

Quantitative data were analyzed using spreadsheet-based statistical tools, while qualitative responses were thematically coded to support interpretation of livelihood–ecosystem linkages. Results were presented through tables, graphs, and thematic summaries.

3.4 Data Integration and Synthesis

Results from spatial analysis, biodiversity assessments, and socio-economic surveys were systematically integrated to develop a holistic understanding of the Arial Beel system. This cross-disciplinary synthesis enabled the identification of causal relationships between land-use and land-cover change, ecological degradation, and livelihood vulnerability. The integrated findings provided a robust evidence base for formulating context-specific conservation strategies, land-use management options, and policy-relevant recommendations to support sustainable wetland management and community resilience.

3.5 Limitations of the Study

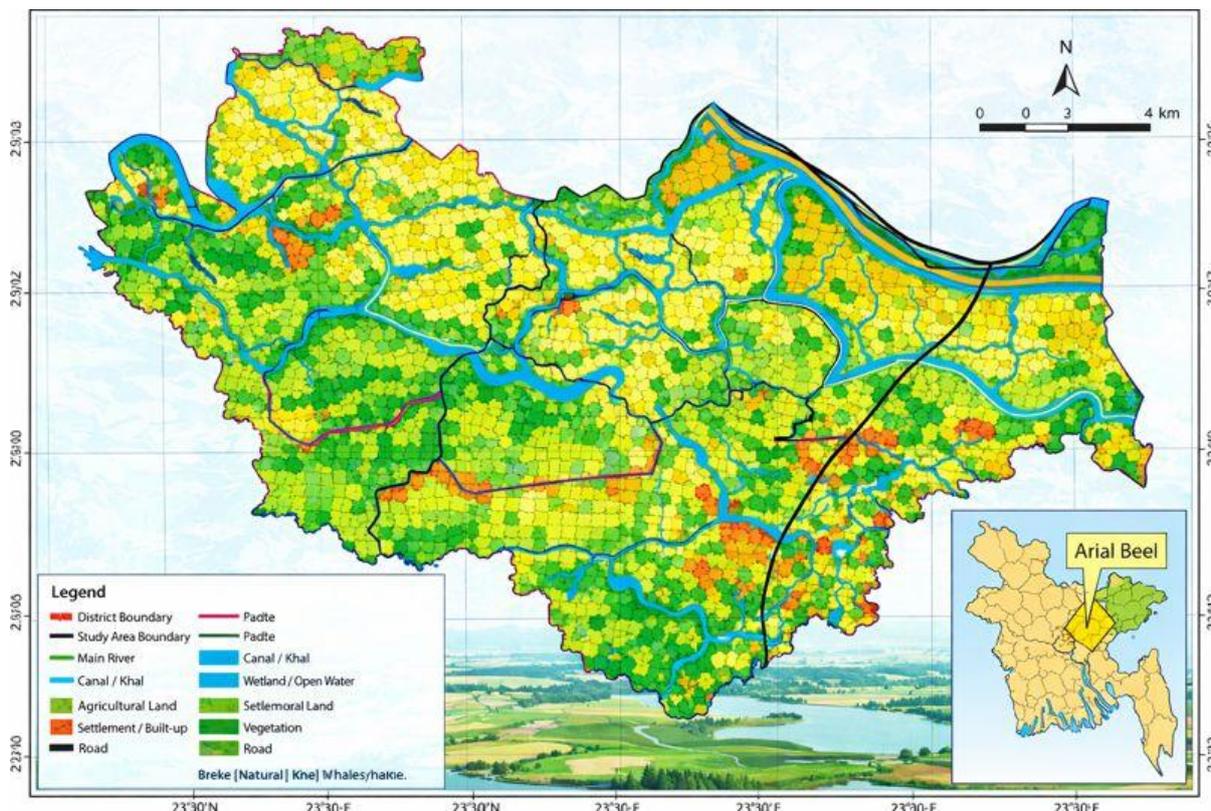
This study come across several limitations during the research process, which are outlined below:

- 1) Reliable and consistent long-term data on hydrology, biodiversity, and socio-ecological conditions of Arial Beel were limited. In particular, detailed historical records on species abundance, water depth, seasonal hydrologic connectivity, and overall ecological health were unavailable, restricting precise comparison between past and present conditions.
- 2) The Land Use and Land Cover (LULC) analysis was based on multi-temporal satellite imagery with different spatial resolutions (Landsat at 30 m and Sentinel-2 at 10–20 m). Although standardized classification methods and Google Earth Engine were applied, differences in sensor resolution, spectral characteristics, and image acquisition dates may have introduced classification uncertainties, especially for small water channels, narrow vegetation patches, and fragmented built-up areas.
- 3) Biodiversity field surveys were conducted over a limited period (May-July 2025) and did not cover all seasons. Consequently, some seasonal, migratory, nocturnal, cryptic, or rare species may not have been fully documented. Therefore, the biodiversity inventory should be considered indicative rather than exhaustive.
- 4) Socio-economic information was primarily collected through questionnaire surveys, focus group discussions, and interviews, which are inherently subject to respondent bias, recall errors, and perception-based responses. Despite efforts to reduce bias through structured questionnaires and data triangulation, a certain degree of subjectivity remains unavoidable.
- 5) Limitations related to time, manpower, and logistics constrained the intensity of field sampling and the extent of hydrological analysis. As a result, detailed water quality assessments, long-term ecological monitoring, and climate-change-driven hydrological modeling were beyond the scope of this study.

Chapter-4: Environmental and Geographic Profile

4.1. Physical Geography, Climate, and Hydrology

Arial Beel is one of the largest and most ecologically significant freshwater wetland systems in central Bangladesh covering an area of approximately 136 km². The landscape is characterized by a low-lying floodplain morphology typical of the Ganges-Brahmaputra-Meghna delta, shaped by fluvial deposition, periodic flooding, and sediment redistribution. The terrain exhibits very gentle slopes and shallow depressions, making the area highly susceptible to seasonal inundation and waterlogging.



Map-4.1: Land-Cover Map of Arial Beel (Siddiqui, 2011 & Research Team, UDD, 2025)

Climatically, the area experiences a humid subtropical monsoon climate, marked by three distinct seasons: pre-monsoon (March-May), monsoon (June-October), and dry winter (November-February). The monsoon season accounts for the majority of annual rainfall, leading to extensive flooding across the beel basin. During this period, Arial Beel functions as a natural flood retention and storage system, absorbing excess runoff from upstream catchments, attenuating flood peaks, and contributing to regional flood regulation. The seasonal flooding also plays a crucial role in nutrient replenishment and soil fertility, supporting agricultural productivity and aquatic ecosystems.

Hydrologically, Arial Beel maintains dynamic connectivity with the Padma River and adjacent water systems through a network of natural canals (khals) and distributaries. This connectivity

facilitates seasonal water exchange, sediment transport, and fish migration, sustaining the beel's high ecological productivity. During the dry season, surface water coverage shrinks considerably, and much of the wetland converts into agricultural and fallow land. Only deeper perennial depressions, locally known as denga, retain water year-round. These denga areas serve as critical refugia for fish and other aquatic organisms during periods



*Figure-4.1: Flooding Across Arial Beel
(Nusrat, 2020)*

of low water availability and act as source habitats from which aquatic life disperses during the monsoon. Together, these geographic, climatic, and hydrological characteristics form the foundation of Arial Beel's ecological resilience and underpin its vital role in supporting biodiversity, livelihoods, and regional hydrological stability.

4.2. Soil Types, Land Cover, and Water Quality

The soils of Arial Beel are primarily recent alluvial deposits, consisting of silty clay, clay loam, and fine sandy loam, shaped by periodic flooding and sedimentation from adjacent rivers. These fertile soils support intensive seasonal agriculture, particularly boro rice cultivation and winter vegetable farming once floodwaters recede. However, excessive soil extraction and unregulated land filling in some areas have altered soil structure and micro-topography.

Land cover within the beel reflects strong seasonal variability. During the monsoon, extensive areas are submerged and function as open wetlands and flooded agricultural land. In the dry season, large portions convert into agricultural fields, fallow land, and grazing areas. Over the past two decades, satellite-based analysis indicates a gradual increase in agricultural and built-up land at the expense of waterbodies, vegetation, and flooded agricultural zones, reflecting growing human pressure and land transformation trends.



*Figure-4.2: Arial Beel in Dry Season
(Research Team, UDD, 2025)*

Water quality in Arial Beel is influenced by hydrological seasonality, agricultural runoff, and sediment inputs. During monsoon flooding, water quality improves through dilution and flushing processes. Conversely, in the dry season, reduced flow and water stagnation in denga areas may lead to increased turbidity, nutrient concentration, and localized eutrophication.

Runoff containing fertilizers and pesticides from surrounding agricultural lands poses additional risks to aquatic ecosystems and fish habitats.

4.3. Landscape Features and Habitat Types

Arial Beel comprises a mosaic of interconnected landscape features that support diverse ecological functions. Key habitat types include open seasonal wetlands, permanent ponds, agricultural fields, marginal lands, canal networks, and elevated pond banks (denga). These denga areas are particularly important, as they remain unflooded during monsoon and provide refuge for terrestrial vegetation, mammals, reptiles, and nesting birds.



*Figure-4.3: Denga in Arial Beel
(Research Team, UDD, 2025)*

The core wetland zones, identified based on frequent use by migratory birds and fish breeding activity, represent high-value ecological areas within the beel. These zones contain relatively undisturbed water bodies and dense aquatic vegetation that support spawning, feeding, and shelter functions. Canal corridors serve as ecological linkages, facilitating fish migration and maintaining hydrological connectivity between the beel and adjacent river systems. This diversity of habitat types allows Arial Beel to function simultaneously as an aquatic ecosystem during the wet season and a terrestrial-agricultural landscape during the dry season, making it one of the most ecologically dynamic wetlands in Bangladesh.

4.4. Seasonal Variability and Hydrological Dynamics

Seasonal variation is a defining characteristic of Arial Beel and governs its environmental, ecological, and socio-economic processes. During the monsoon season, the beel transforms into an extensive water body, supporting fisheries, aquatic vegetation, and migratory waterbirds. Floodwaters spread across agricultural lands, replenishing soil fertility and sustaining wetland productivity. In contrast, the dry season brings significant contraction of surface water coverage. Only deeper depressions and perennial ponds retain water, while exposed lands are cultivated or used for grazing. This seasonal drying place pressure on aquatic habitats and concentrates fish populations within limited water refuges, increasing vulnerability to overfishing and habitat disturbance.

Hydrological modeling and watershed analysis indicate that changes in rainfall patterns, canal blockages, and upstream land-use alterations have gradually reduced hydrological connectivity and altered inundation dynamics. These changes have implications for flood regulation, biodiversity conservation, and livelihood sustainability, highlighting the importance of maintaining natural water flow pathways and seasonal flood regimes.

Chapter-5: Land Use and Land Cover Change

5.1 Introduction:

Land Use and Land Cover (LULC) change analysis provides a critical understanding of how natural wetland landscapes of Arial Beel have been transformed under increasing anthropogenic and environmental pressures. Using multi-temporal satellite imagery (2005–2025) and Google Earth Engine based classification, this chapter examines historical land use patterns, temporal dynamics, quantitative transformations, and the key drivers responsible for observed changes. The analysis highlights a gradual shift from wetland-dominated landscapes toward more intensive agricultural and built-up land uses, with significant implications for hydrological connectivity, biodiversity, and livelihoods.

5.2 Historical Land Use Patterns

Historically, Arial Beel functioned as a large, seasonally inundated freshwater wetland system characterized by extensive waterbodies, flooded agricultural lands, natural vegetation, and scattered settlements. Prior to large-scale land transformation, the beel landscape was dominated by:

- a) Agricultural land, primarily seasonal rice cultivation adapted to monsoon flooding
- b) Flooded agricultural areas, supporting fisheries and aquatic vegetation during the wet season
- c) Permanent and seasonal waterbodies, maintaining hydrological connectivity with surrounding rivers
- d) Sparse built-up areas, limited to village homesteads and small rural infrastructure
- e) Natural vegetation and barren land, mainly along embankments, denga areas, and wetland margins

In 2005, agriculture and flooded agriculture together accounted for more than three-quarters of the total land area, while built-up land occupied a negligible share (0.04%). This pattern reflects a wetland-dependent land-use system shaped by seasonal flooding, traditional farming, fishing, and low population density. However, subsequent years reveal progressive deviation from this historical equilibrium as land reclamation, infrastructure development, and agricultural intensification expanded.

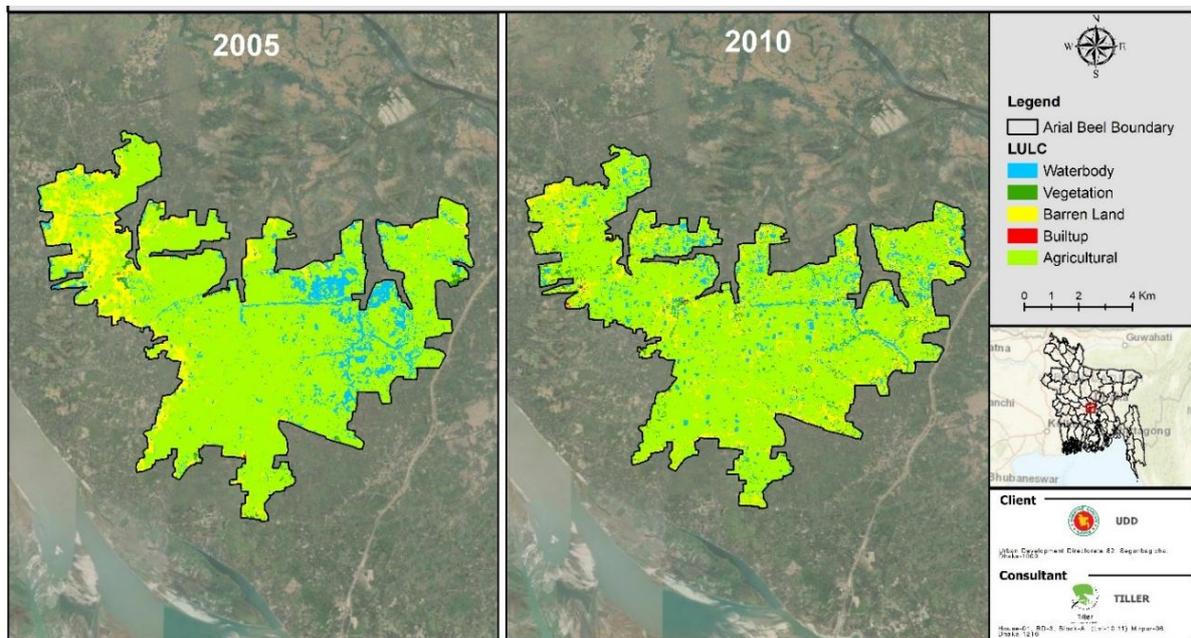
5.2.1 Temporal Land Use Change Analysis (2005-2025)

Temporal analysis of land use and land cover changes in Arial Beel from 2005 to 2025 reveals a gradual yet persistent transformation of the landscape, characterized by uneven rates of change across different time periods. While the overall direction of change remains consistent, shifting from wetland-dominated land uses toward more permanent agricultural and built-up areas, the pace and intensity of transformation vary over time. Distinct phases of change can be identified, reflecting periods of accelerated agricultural expansion, settlement growth, and

reduction of waterbodies and natural vegetation. These temporal variations highlight the growing influence of human activities and underscore the cumulative nature of land conversion processes affecting the wetland system.

5.2.2 Land Use Analysis between 2005–2010

The Land Use analysis for the period 2005–2010 was conducted using dry-season (January) satellite imagery to ensure consistency in seasonal hydrological conditions and to minimize classification uncertainty caused by monsoonal inundation. This period represents an early phase of land-use transition within the Arial Beel catchment, reflecting both environmental modification and emerging anthropogenic pressures. The classification identified five major land-use categories: Agricultural land, Barren land, Built-up area, Vegetation, and Waterbody. Comparative analysis between 2005 and 2010 reveals a gradual yet discernible reconfiguration of land use across the beel landscape, reflecting emerging shifts in land management practices and spatial development patterns.



*Map-5.1: Map of Land-use and Land cover change between 2005 and 2010
(Research Team, UDD, 2025)*

Agricultural land remained the dominant land-use category throughout the study period; however, a measurable decline is evident, particularly in low-lying and flood-prone areas surrounding the core wetland. As shown in Table-5.1, agricultural land decreased by 488.09 acres (–1.98%) between 2005 and 2010. Spatial patterns illustrated in Figure-5.1 indicate that this reduction occurred mainly along the periphery of Arial Beel and adjacent to drainage channels, suggesting increasing seasonal inundation, reduced drainage efficiency, and declining suitability of certain areas for dry-season cultivation. From a planning perspective, this trend highlights growing spatial mismatch between existing agricultural land use and evolving hydrological conditions.

Vegetation cover experienced a marginal decline of 46.51 acres (-0.19%), with losses concentrated along wetland margins and homestead vegetation zones. Although limited in extent, the spatial distribution of vegetation loss indicates early degradation of wetland buffer zones. These buffers are critical for maintaining ecological stability, mitigating erosion, and supporting biodiversity; their gradual erosion has implications for long-term environmental sustainability and land-use compatibility within the catchment.

Waterbody area decreased by 390.93 acres (-1.59%) over the study period. As illustrated in Figure-5.1, the contraction of open water surfaces during the dry season is most evident in shallow and peripheral wetland areas. This reduction reflects declining water retention capacity and altered hydrological regimes, with direct implications for flood regulation, fisheries productivity, and the overall ecological functioning of Arial Beel. From a spatial planning standpoint, this trend underscores the need to protect core wetland zones and hydrological corridors from encroachment and modification.

Table-5.1: Land-Use and Land Cover Change of 2005 and 2010

Land-use Category	Year 2005		Year 2010		Land-use Change	
	Acre	%	Acre	%	Acre	%
Agricultural	18903.99	76.81%	18415.9	74.82%	-488.0	-1.98%
Barren Land	3186.95	12.95%	4105.35	16.68%	+918.4	+3.73%
Built-up	10.54	0.04%	17.68	0.07%	+7.14	+0.03%
Vegetation	140.31	0.57%	93.8	0.38%	-46.51	-0.19%
Waterbody	2370.23	63%	1979.3	8.04%	-390.93	-1.59%

Source: Land Use analysis using satellite image (Research Team, UDD, 2025)

In contrast, barren land recorded the most significant increase, expanding by 918.40 acres (+3.73%) between 2005 and 2010. These areas are spatially concentrated in transitional zones between agricultural land and wetland areas. The expansion of barren land reflects land clearing, exposure of wetland beds during the dry season, and preparatory land conditions for potential agricultural intensification or future infrastructural development. This pattern indicates increasing disturbance of the wetland–agriculture interface and signals areas where unregulated land conversion may occur without appropriate planning controls.

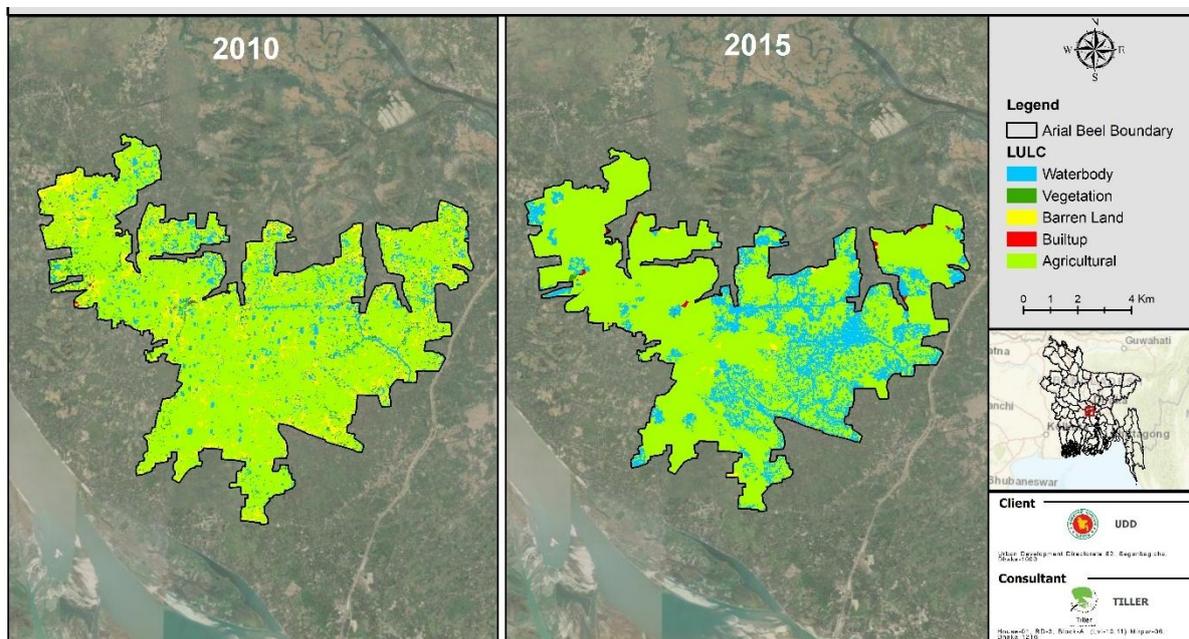
Built-up land increased marginally by 7.14 acres (+0.03%) during this period. Although built-up areas accounted for a very small proportion of total land use, their spatial concentration along road corridors and relatively elevated land suggests the early stages of settlement and infrastructure expansion within the catchment. While limited at this stage, this pattern marks the onset of permanent development that may accelerate in the absence of clear land-use zoning and development control mechanisms.

Overall, the land-use changes observed between 2005 and 2010 reflect a transitional phase in the Arial Beel landscape characterized by gradual reduction of agricultural and waterbody

areas, expansion of barren land, and the initial emergence of built-up development. From an urban planning perspective, these trends indicate increasing hydrological stress, declining wetland resilience, and early anthropogenic transformation of the beel environment. Although development pressure remained relatively limited during this period, the observed spatial patterns underscore the importance of proactive, wetland-sensitive land-use planning, zoning regulation, and development control to safeguard the ecological integrity, productive functions, and long-term sustainability of the Arial Beel catchment.

5.2.3 Land Use Analysis between 2010–2015

For the 2010-2015 period, Land Use and Land Cover classification was conducted using dry-season (January) satellite imagery to maintain comparability with earlier datasets and minimize seasonal variability. Unlike the preceding period, this phase reflects a more pronounced and spatially extensive transformation of the Arial Beel catchment, indicating a shift from transitional land states toward more defined and intensive land uses. Between 2010 and 2015, the Arial Beel catchment underwent a pronounced phase of land-use transformation, marked by rapid agricultural expansion, near elimination of barren land, and the accelerated emergence of built-up development. The spatial patterns illustrated in Figure-5.2, together with the quantitative changes presented in Table-5.2, indicate a decisive shift toward more intensive land utilization across the beel landscape.



*Map-5.2: Map of Land-use and Land cover change between 2010 and 2015
(Research Team, UDD, 2025)*

During the period agricultural land expanded substantially by 3,648.96 acres [from 18,415.90 acres (74.82%) to 22,064.86 acres (89.85%)], while barren land declined sharply by 3,797.63 acres, from 4,105.35 acres (16.68%) to only 307.72 acres (1.25%). The land cover change map (Figure-5.2) indicates a strong spatial correspondence between these two trends, showing that

the expansion of agriculture occurred predominantly through the conversion of previously barren, seasonally exposed, and low-lying lands, particularly along the peripheral and shallow zones of the wetland. This inverse relationship reflects increasing pressure to maximize productive land within the catchment due to land scarcity and livelihood dependence. However, while this conversion may offer short-term economic benefits, the near disappearance of intermediate land-use categories that previously absorbed seasonal inundation reduces the landscape's capacity to accommodate hydrological fluctuation, thereby increasing vulnerability to waterlogging and flood impacts.

Along with the barren land other natural land-cover classes continued to show a declining trend during this period. Vegetation cover decreased by 18.16 acres (−0.07%), reflecting gradual loss of wetland fringe vegetation and homestead green cover. Similarly, waterbody area declined by 85.21 acres (−0.35%), from 1,979.30 acres (8.04%) to 1,894.09 acres (7.70%). This reduction is concentrated in shallow and peripheral wetland zones, suggesting contraction of dry-season open water surfaces and reduced water retention capacity. This trend has implications for flood regulation, fisheries productivity, and ecosystem services that support local livelihoods. At the same time, built-up land increased evidently, from 17.68 acres (0.07%) in 2010 to 269.73 acres (1.10%) in 2015, representing a net increase of 252.05 acres. Although built-up areas still cover a small share of the total land, the map (Figure-5.2) shows that new development is mainly concentrated along roads, market areas, and higher ground. This indicates the early growth of settlements and infrastructure within the beel area. If this development continues without proper planning and control, it may gradually spread into environmentally sensitive wetland areas and increase pressure on the beel ecosystem.

Table-5.2: Land-Use and Land Cover Change of 2010 and 2015.

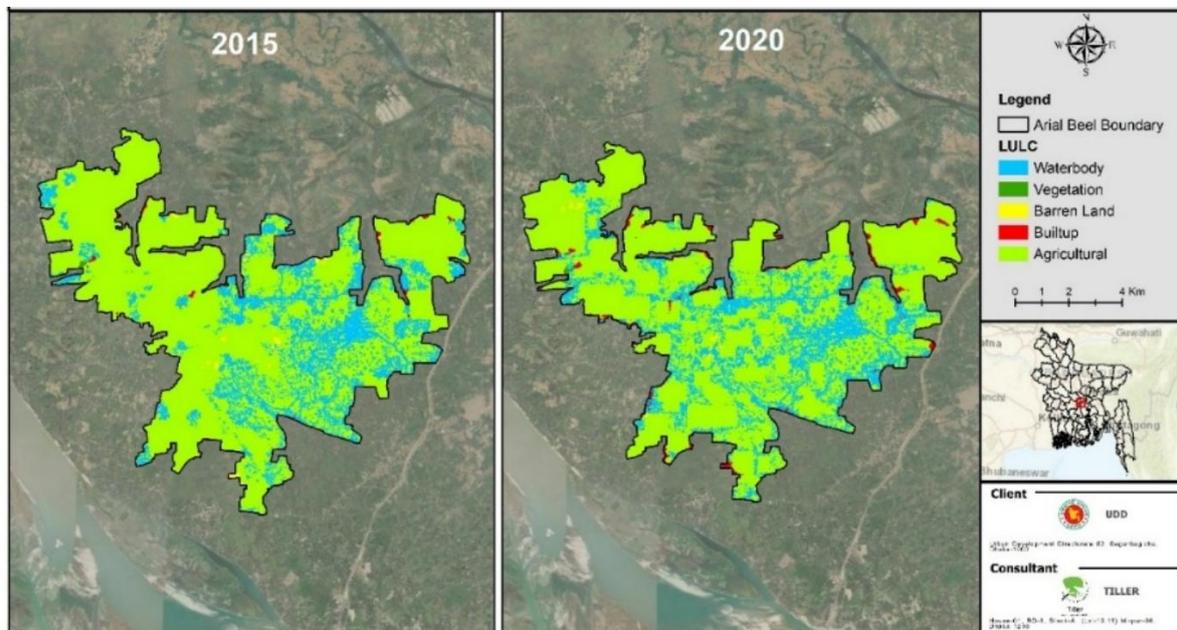
Land-use Category	Year 2010		Year 2015		Land-use Change	
	Acre	%	Acre	%	Acre	%
Agricultural	18,415.90	74.82%	22,064.86	89.85%	+3,648.96	+15.03%
Barren Land	4,105.35	16.68%	307.72	1.25%	−3,797.63	−15.43%
Built-up	17.68	0.07%	269.73	1.10%	+252.05	−1.02%
Vegetation	93.80	0.38%	75.64	0.31%	−18.16	−0.07%
Waterbody	1,979.30	8.04%	1,894.09	7.70%	−85.21	−0.35%

Source: Land Use analysis using satellite image (Research Team, UDD, 2025)

This phase reflects a major land-use transition phase in the Arial Beel landscape. This phase is characterized by the near elimination of seasonally exposed and low-lying lands, aggressive expansion of agricultural use, accelerated growth of built-up areas, and continued decline of vegetation and waterbodies. From an urban planning perspective, these changes reflect increasing anthropogenic pressure and hydrological stress within the wetland system.

5.2.4 Land Use Analysis between 2015–2020

Land-use classification for 2015–2020, based on dry-season imagery, captures a phase of consolidation and intensification of land use within the Arial Beel catchment. During this period, agricultural expansion and urban growth became more pronounced, while seasonally flooded areas and natural land-cover classes continued to decline.



*Map -5.3: Map of Land-use and Land cover change between 2015 and 2020
(Research Team, UDD, 2025)*

Between 2015 and 2020, agricultural land experienced a moderate decline of 331.70 acres, decreasing from 22,064.86 acres (89.85%) to 21,733.16 acres (88.30%). Although agriculture remained the dominant land-use category, this reduction reflects a gradual shift toward non-agricultural uses, particularly the expansion of built-up areas, indicating growing competition between agricultural activities and settlement growth within the beel catchment. During the same period, barren land declined by 112.83 acres, from 307.72 acres (1.25%) to 194.89 acres (0.79%), suggesting continued absorption of previously exposed or fallow lands into other land-use categories. The diminishing extent of barren land implies a reduction in open and buffer areas that historically accommodated seasonal hydrological variation, thereby increasing the landscape’s vulnerability to flooding and waterlogging.

Natural land-cover classes continued to decline, although at a slower rate compared to earlier periods. Vegetation cover decreased marginally by 0.69 acres (–0.01%), while waterbody area declined by 52.92 acres (–0.22%), from 1,894.09 acres (7.70%) to 1,841.17 acres (7.48%). The contraction of waterbody areas is primarily concentrated in shallow and peripheral wetland zones, indicating reduced dry-season open water extent and declining water retention capacity, with implications for flood regulation, fisheries, and wetland ecosystem services.

Table-5.3: Land-Use and Land Cover Change of 2015 and 2020

Land-use Category	Year 2015		Year 2020		Land-use Change	
	Acre	%	Acre	%	Acre	%
Agricultural	22,064.86	89.85%	21,733.16	(88.30%)	-331.70	-1.55%
Barren Land	307.72	1.25%	194.89	0.79%	-112.83	-0.46%
Built-up	269.73	1.10%	767.87	3.12%	+498.14	+2.02%
Vegetation	75.64	0.31%	74.95	0.30%	- 0.69	-0.00%
Waterbody	1,894.09	7.70%	1,841.1	7.48%	-52.92	-0.22%

Source: Land Use analysis using satellite image (Research Team, UDD, 2025)

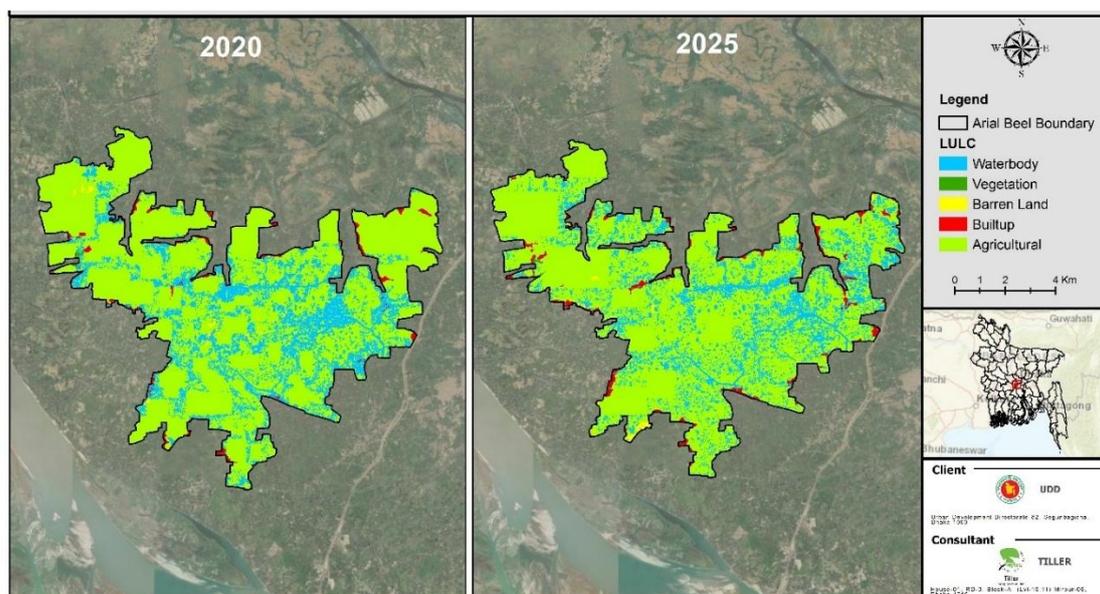
Built-up land increased rapidly between 2015 and 2020, rising by 498.14 acres from 269.73 acres (1.10%) to 767.87 acres (3.12%). This shows fast growth of settlements, roads, and other infrastructure within the Arial Beel area. The map (Figure-5.3) indicates that most new development is happening along roads, near growth centres, and on higher land, where access is easier. This means that land once influenced by wetland conditions is gradually being converted into permanent built-up areas. Although built-up land still covers a small share of the total area, the speed and location of this growth increase the risk of unplanned development spreading into sensitive wetland zones, highlighting the need for stronger land-use control and planned development measures.

5.2.5 Land Use Analysis between 2020–2025

The 2020–2025 period reflects a continuation of established land-use trends within the Arial Beel catchment, characterized by steady urban expansion, relative stabilization of agricultural land, and continued contraction of wetland-related land-cover types. Agricultural land experienced a slight decline of 143.46 acres, decreasing from 21,733.16 acres (88.30%) in 2020 to 21,589.70 acres (87.72%) in 2025. Although agriculture remained the dominant land-use category, this marginal reduction indicates increasing pressure from non-agricultural uses, particularly expanding built-up development, rather than further agricultural expansion.

Wetland-related and natural land-cover classes continued to decline during this period. Waterbody area decreased by 94.98 acres, from 1,841.17 acres (7.48%) to 1,746.19 acres (7.09%), indicating ongoing contraction of dry-season open water surfaces and reduced water retention capacity. Vegetation cover declined by 17.21 acres, while barren land decreased by 22.59 acres, reflecting the near disappearance of open and buffer lands that historically accommodated seasonal hydrological variation.

Built-up land continued to increase at a notable pace, expanding by 278.23 acres, from 767.87 acres (3.12%) to 1,046.10 acres (4.25%) during the five-year period. The spatial pattern of development indicates that growth remains concentrated along transport corridors, growth centres, and relatively elevated land. This trend reflects sustained settlement and infrastructure growth and a further shift toward permanent land conversion within the wetland-influenced landscape.



Map-5.4: Map of Land-use and Land cover change between 2020 and 2025
(Research Team, UDD, 2025)

These patterns confirm a consolidation toward permanent agricultural and urban land uses, accompanied by a sustained decline in wetland-dependent land-cover classes. From an urban and regional planning perspective, the observed changes indicate increasing risks to wetland biodiversity, hydrological regulation, and traditional livelihood systems, underscoring the urgent need for integrated land-use planning, strengthened development control, and targeted wetland conservation interventions to safeguard the long-term ecological and functional integrity of the Arial Beel catchment.

Table-5.4: Land-Use and Land Cover Change of 2020 and 2025.

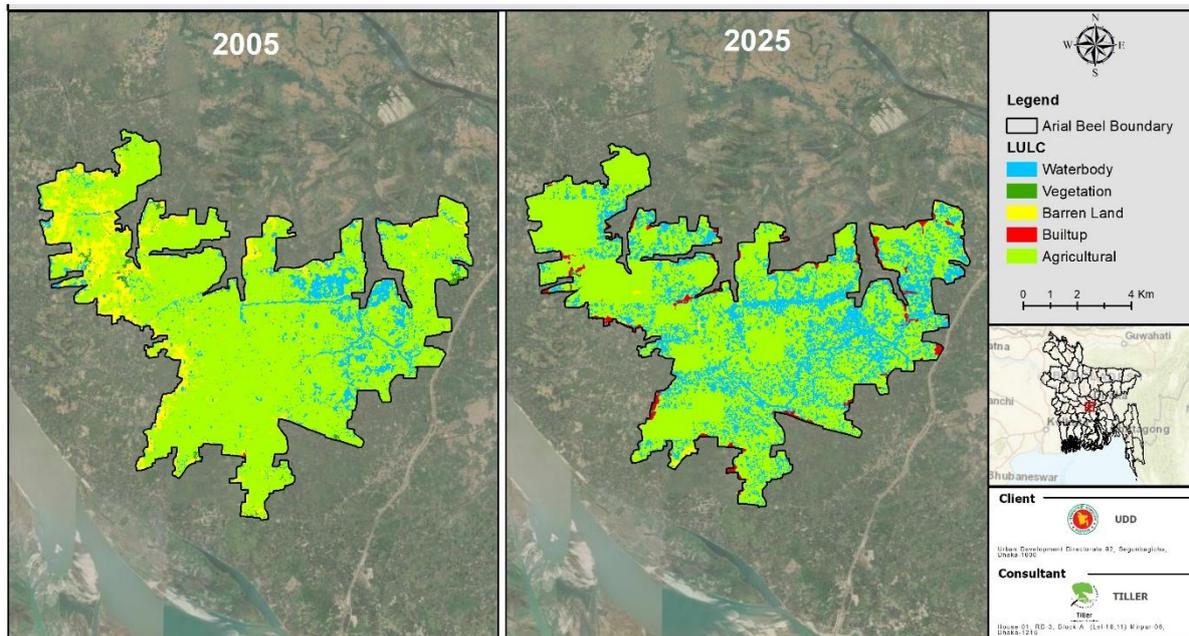
Land-use Category	Year 2020		Year 2025		Land-use Change	
	Acre	%	Acre	%	Acre	%
Agricultural	21,733.16	88.30%	21,589.70	87.72%	-143.46	-0.58%
Barren Land	194.89	0.79%	172.30	0.70%	-22.59	-0.09%
Built-up	767.87	3.12%	1,046.10	4.25%	+278.23	+1.13%
Vegetation	74.95	0.30%	57.74	0.23%	-17.21	-0.07%
Waterbody	1,841.17	7.48%	1,746.19	7.09%	-94.98	-0.39%

Source: Land Use analysis using satellite image (Research Team, UDD, 2025)

5.2.6 Land Use Transformation Trends (2005–2025)

The 20-year land-use transformation (2005–2025) of the Arial Beel catchment reveals a clear and sustained shift toward permanent agricultural and urban land uses, accompanied by a continuous decline in wetland-dependent land-cover types. Analysis based on five-year interval dry-season satellite imagery provides a robust basis for understanding long-term spatial trends and their implications for land management, development control, and wetland sustainability. The observed changes reflect cumulative impacts of population growth,

livelihood pressure, infrastructure expansion, hydrological modification, and limited enforcement of land-use regulations within the beel environment.



Map -5.5: Map of Land-use and Land cover change between 2005 and 2025
(Research Team, UDD, 2025)

Over the study period, agricultural land expanded significantly, increasing from 76.81% in 2005 to 87.72% in 2025, resulting in a net gain of 2,685.71 acres. This expansion has occurred largely through the conversion of barren and shallow wetland areas into permanent cultivation, supported by improved drainage, embankments, and dry-season land management practices. From a planning perspective, this trend indicates increasing agricultural consolidation within the beel, reducing the availability of land that can naturally accommodate seasonal flooding and hydrological variability. At the same time, barren land declined sharply, from 12.95% to only 0.70% over the 20-year period. While this reflects improved land utilization and reduced idle land, it also signifies the near disappearance of buffer and transition zones that historically absorbed floodwaters and reduced pressure on agricultural and settlement areas. The loss of these zones increases exposure to flooding, waterlogging, and climate-related risks, particularly under changing rainfall patterns.

The most rapid relative change was observed in built-up land, which expanded from 0.04% in 2005 to 4.25% in 2025. Although built-up areas still occupy a smaller proportion of the landscape compared to agriculture, the rate of growth is significant and spatially concentrated along transport corridors, growth centres, and higher ground. This pattern reflects the gradual transformation of the beel from a predominantly rural-wetland system into a mixed agricultural–urban landscape. This trend signals the urgent need for development control mechanisms, including land-use zoning, building regulation, and infrastructure planning that are sensitive to wetland dynamics. Without such controls, settlement expansion risks encroaching further into ecologically fragile areas, increasing long-term costs related to flood damage, service provision, and environmental degradation.

Table-5.5: Land-use Transformation between 2005 and 2025.

Land-use Category	Lan-use of 2005 (Acre, %)	Lan-use of 2010 (Acre, %)	Lan-use of 2010 (Acre, %)	Lan-use of 2020 (Acre, %)	Lan-use of 2025 (Acre, %)	Net change 2005–2025 (Acre, %)
Agricultural	18903.99 (76.81%)	18415.90 (74.82%)	22064.86 (89.65%)	21733.16 (88.30%)	21589.70 (87.72%)	2685.71 (10.91%)
Barren Land	3186.95 (12.95%)	4105.35 (16.68%)	307.72 (1.25%)	194.89 (0.79%)	172.30 (0.70%)	-3014.65 (-12.25%)
Built-up	10.54 (0.04%)	17.68 (0.07%)	269.73 (1.10%)	767.87 (3.12%)	1046.10 (4.25%)	1035.56 (4.21%)
Vegetation	140.31 (0.57%)	93.80 (0.38%)	75.64 (0.31%)	74.95 (0.30%)	57.74 (0.23%)	-82.57 (-0.34%)
Waterbody	2370.23 (9.63%)	1979.30 (8.04%)	1894.09 (7.70%)	1841.17 (7.48%)	1746.19 (7.09%)	-624.04 (-2.54%)

Source: Land Use analysis using satellite image (Research Team, UDD, 2025)

Natural land-cover classes have shown a consistent downward trend throughout the study period. Waterbody area declined from 9.63% to 7.09%, while vegetation cover decreased from 0.57% to 0.23%. These changes indicate a progressive loss of open water habitats, aquatic vegetation, and wetland fringe cover that are essential for flood regulation, fisheries, biodiversity conservation, and water quality maintenance. The contraction of waterbodies and vegetation reduces the wetland’s ability to function as a natural flood buffer and ecological support system. This has direct implications for disaster risk management, food security, and the livelihoods of communities dependent on fisheries and wetland resources.

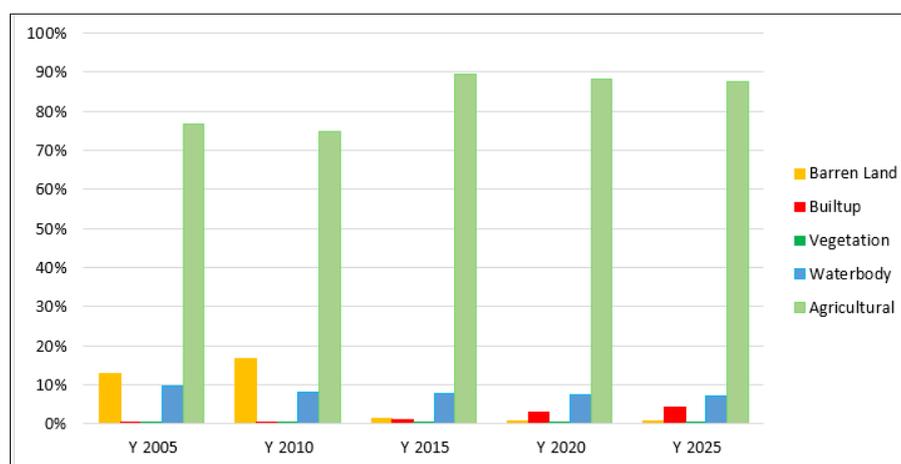


Figure-5.1: Land-use and Land cover Transformation Trend (2005 and 2025)
(Research Team, UDD, 2025)

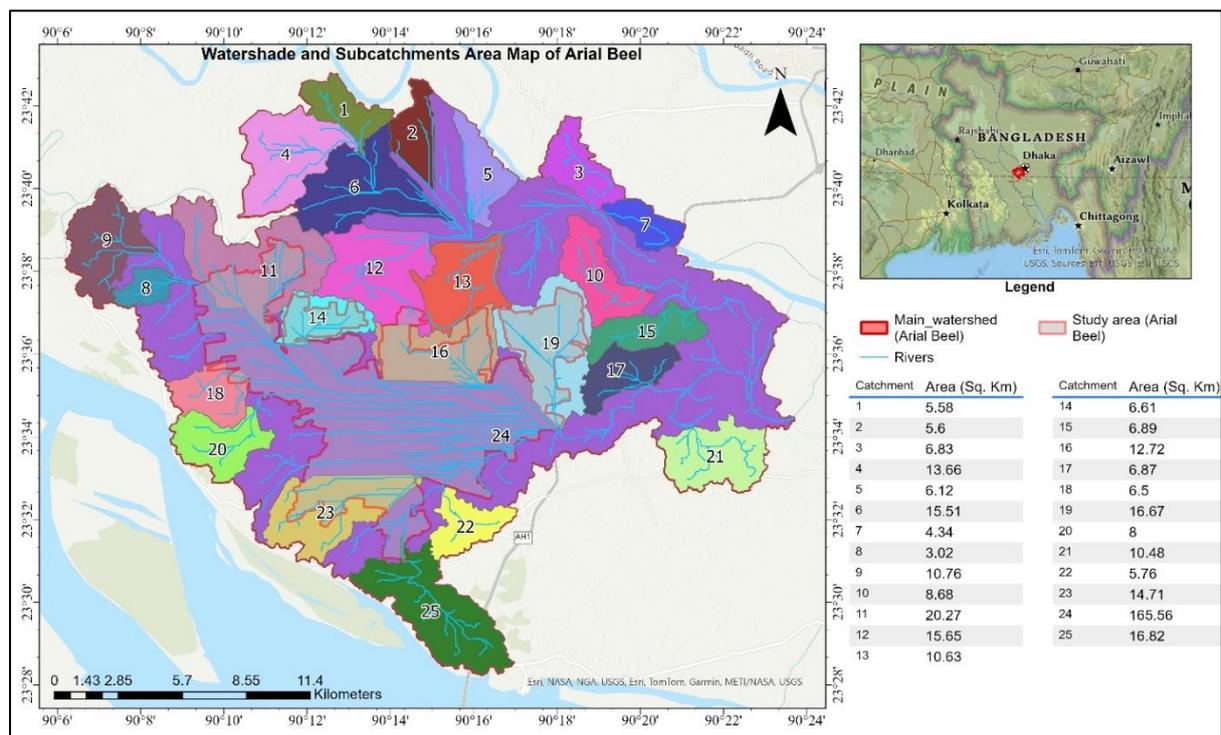
The evidence from this 20-year analysis provides a clear basis for strategic intervention in the Arial Beel catchment. If timely planning and regulatory measures are not adopted, continued land-use intensification will further weaken the ecological resilience of the beel and reduce its long-term economic productivity. The sustained expansion of agriculture and rapid growth of built-up areas indicate that current land-use changes are occurring faster than existing planning

and regulatory frameworks can manage. This situation highlights the need to shift from reactive land conversion toward proactive and planned spatial management of the beel.

Priority actions should focus on establishing wetland-sensitive land-use zoning, protecting core waterbody and flood-retention areas, regulating settlement expansion—particularly along transport corridors—and integrating hydrological considerations into agricultural and infrastructure planning. Strengthened coordination among planning, water, agriculture, and local government institutions will be essential to ensure that development objectives remain aligned with wetland conservation and disaster risk reduction.

5.3 Watershed and Catchment Area

The spatial distribution of surface runoff responsible for seasonal water accumulation and flooding within the Arial Beel wetland system has been systematically delineated through watershed and its catchment analysis. This delineation was carried out using a Digital Elevation Model (DEM) combined with standard hydrological modelling techniques to identify topographic flow boundaries, drainage divides, and natural convergence points and clearly define the hydrological zones that govern runoff generation, flow direction, and drainage behavior across the study area.



Map-5.6: Map of Watershed and Sub-Catchment Area of Arial Beel (Research Team, UDD, 2025)

The main watershed, highlighted in red on the map (Figure-5.7), represents the entire hydrologically connected area from which precipitation and surface runoff ultimately drain into Arial Beel. This watershed boundary functions as the primary spatial unit for understanding the wetland’s hydrological response and provides a critical framework for integrated flood

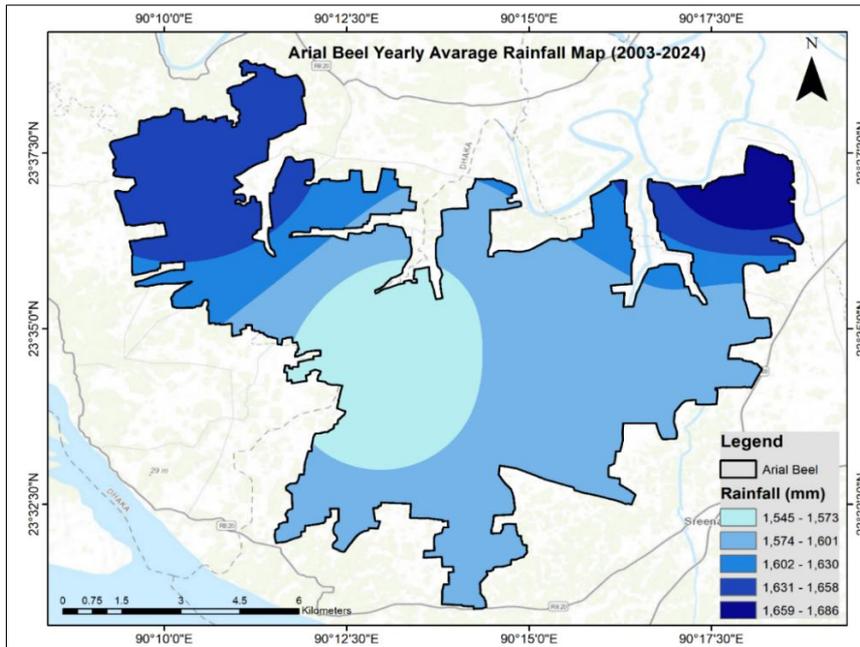
management, land-use regulation, drainage planning, and ecological protection. Since all upstream runoff within this boundary eventually converges toward the beel, land-use changes anywhere within the watershed directly influence flooding patterns and water retention in the core wetland area.

Within the main watershed, the drainage system has been further divided into 25 distinct sub-catchments, each delineated based on local topography and natural flow direction, which has been represented in distinct colours and identification numbers to facilitate visual interpretation and spatial differentiation (Figure-5.7). Each sub-catchment function as an independent local drainage unit, which is collecting surface runoff and conveying it through tributaries, khals, and low-lying flow paths before discharging into the main body of the beel. To enhance understanding of hydrological processes, river and channel lines (shown in light blue) are superimposed on the sub-catchment map to illustrate how surface water moves through the natural landscape through a network of tributaries and streams. This visualization assists in identifying areas susceptible to backwater effects, flash flooding, flow convergence, and potential hydraulic bottlenecks.

Analysis of the sub-catchment configuration indicates notable spatial variation in runoff contribution. The largest sub-catchment is centrally located and directly feeds the core wetland area, making it a critical contributor to floodwater accumulation within Arial Beel. In contrast, the smallest sub-catchment is situated along the western edge of the watershed and contributes comparatively limited runoff. The relatively large spatial extent of the southern and central sub-catchments (e.g., Nos. 23, 24, and 25) suggests that these areas supply a substantial volume of runoff during periods of heavy rainfall. Meanwhile, the northern and northeastern sub-catchments (such as Nos. 1, 2, 3, 5, and 6) act as the primary upstream collection zones and play an important role in regulating upstream-to-downstream flow dynamics. This watershed and sub-catchment framework provide a robust hydrological basis for identifying flood-prone areas, prioritizing drainage interventions, and guiding watershed-based land-use planning and wetland management strategies for the Arial Beel system.

5.4 Rainfall Distribution (2003–2024)

The long-term spatial pattern of rainfall over the Arial Beel region provides important insight into the hydrometeorological dynamics that influence flooding behavior and water retention within the wetland system. Analysis of mean annual rainfall over a 22-year period (2003–2024) highlights notable spatial variations that directly affect runoff generation, flood intensity, and seasonal inundation patterns. This assessment is based on interpolated rainfall data derived from a combination of satellite-based datasets and ground-based meteorological stations, ensuring a consistent representation of long-term rainfall trends across the study area.



Map-5.7: Yearly Average Rainfall Map of Arial Beel (2003–2024) (Research Team, UDD, 2025)

Rainfall intensity across the study area has been classified into five distinct zones, ranging from approximately 1,545 mm to 1,686 mm per year. The central part of the beel receives comparatively lower average rainfall (1,545-1,573 mm) (Figure-5.8: represented by lighter blue shades in Figure-5.8). Rainfall intensity increases gradually toward the periphery of the watershed, particularly in the northeastern and northwestern zones, where average annual rainfall exceeds 1,659 mm. The eastern and western flanks of the watershed also experience relatively higher rainfall (1,602–1,658 mm), indicating localized microclimatic variation influenced by topography, drainage patterns, and land-use characteristics. These rainfall variations play a significant role in shaping runoff contribution from different sub-catchments and partially explain the observed differences in flood response across the beel system.

Table-5.6: Maximum Flood Depth Level

No	Inundation Area/km ²	Max. Flood Depth/m
1	86.70	3
2	96.44	4
3	99.56	5

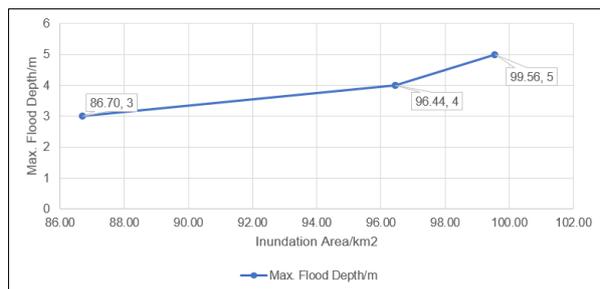
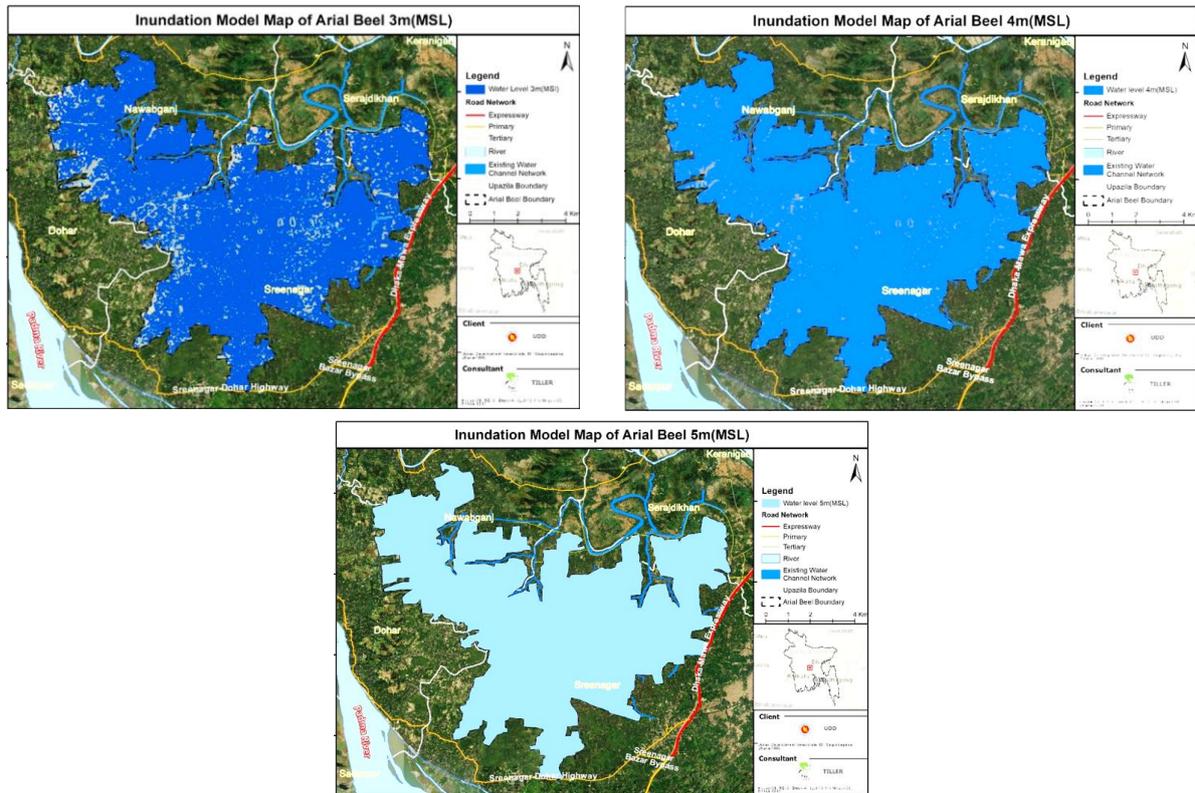


Figure-5.2: Inundation Model of Three Sub-Scenarios (Research Team, UDD, 2025)

Further to assess flood vulnerability under varying hydrological conditions, an inundation model was developed for the Arial Beel area using multiple water-level scenarios. The model simulates the spatial extent of flooding under incremental water levels of 3 m, 4 m, and 5 m above mean sea level (MSL), representing different degrees of seasonal flooding and extreme

hydrological events. These scenarios provide a practical framework for evaluating flood severity, frequency, and spatial impact.



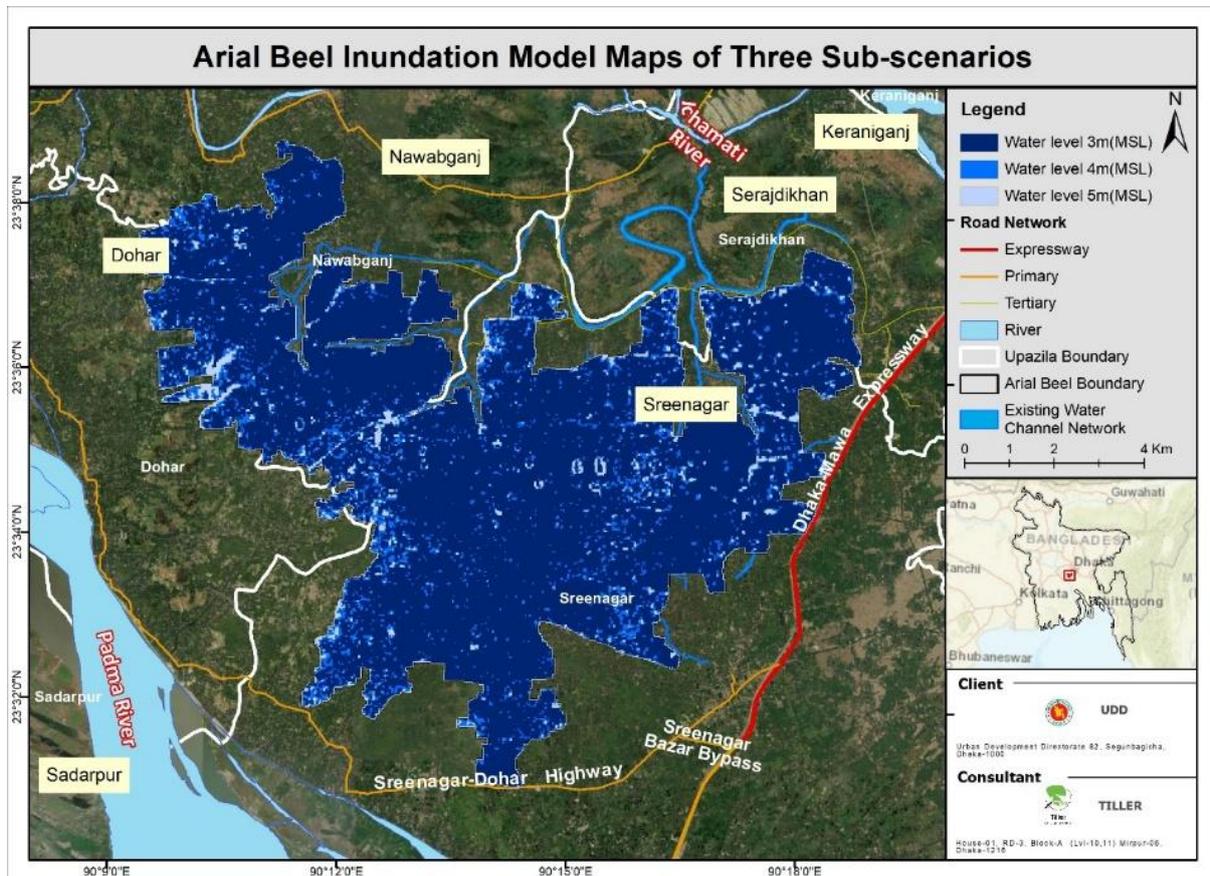
Map-5.8: Inundation Model Map of Three Sub-Scenarios - 3m, 4m, 5m MSL [Source: *Recorded Highest Water Level: 5.92 m MSL (BWDB, 2025)*]

The model results indicate a progressive increase in inundated area as water levels rise (Figure-5.10). At 3 m MSL, approximately 86.70 km² of land is inundated, primarily affecting low-lying agricultural fields and peripheral wetland zones. At 4 m MSL, the inundated area expands to 96.44 km², reflecting conditions close to the annually observed high-water level. Under this scenario, extensive croplands become submerged, hydrological connectivity between channels improves, and several rural roads and embankments begin to experience structural stress, although major transportation routes may remain functional.

At 5 m MSL, inundation increases further to approximately 99.56 km², approaching the official danger level of 4.75 m MSL. Under this scenario, floodwaters spread into residential areas, local roads, and critical infrastructure corridors, including sections near the Dhaka-Mawa Motorway. This level represents a high-return flood event, likely to occur once every 25-30 years, and results in widespread disruption to settlements, agriculture, and transport systems. Water levels approaching the historical maximum of 5.92 m MSL would nearly submerge the entire beel and its surrounding areas, corresponding to an extreme flood event with an estimated return period of approximately 50 years.

The integrated model demonstrates that even relatively small increases in water level can result in substantial expansion of inundated areas, emphasizing the high sensitivity of the Arial Beel

system to hydrological change. These results provide a valuable decision-support tool for identifying flood-prone zones, assessing infrastructure vulnerability, and guiding flood-resilient land-use planning and wetland management.



Map-5.9: Inundation Model Map [Recorded Highest Water Level: 5.92 m MSL (BWDB, 2025)]

5.5 Expansion of Build-up Area:

The most prominent driver of land-use transformation in Aerial Beel is the rapid expansion of built-up areas, which increased substantially from 0.04% in 2005 to 4.25% in 2025. Although built-up land still occupies a relatively small proportion of the total landscape, its rate of growth is exceptionally high, indicating accelerating settlement expansion, infrastructure development, and increasing urban encroachment along the wetland periphery. Conversion pathway analysis reveals that built-up expansion has occurred primarily through the transformation of multiple land-use categories. Approximately 34.83% of built-up land originated from barren land, followed by 32.22% from agricultural land, 19.03% from waterbodies, and 1.21% from vegetation.

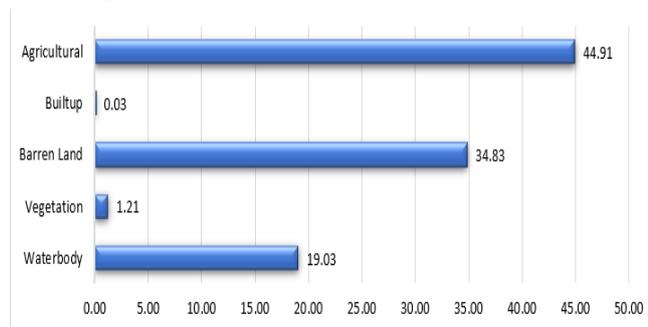
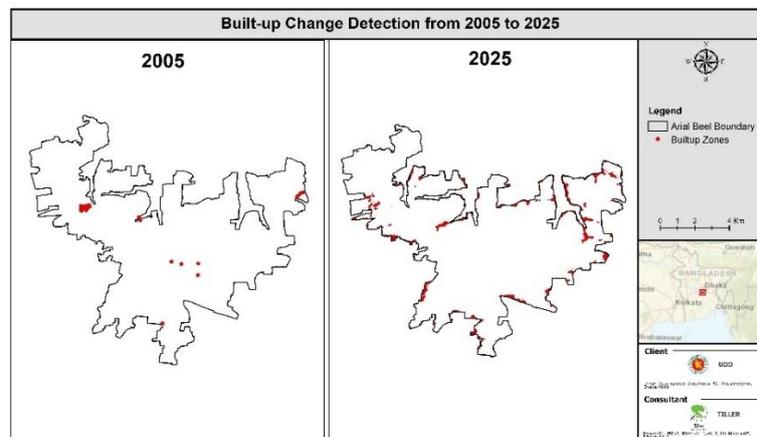


Figure-5.3: Built up Transformation Rate of Aerial Beel, 2005 and 2025 (Research Team, UDD, 2025)

12.69% from flooded agricultural areas, while only 0.03% remained unchanged. This explains that both natural and productive land uses have been systematically converted into permanent built structures and increasing human intervention within the wetland system.

Spatial analysis shows that most land-use conversions are concentrated in the seasonally variable zones along the territorial boundary of Arial Beel. These peripheral areas remain inundated during the monsoon and supported fishing in the wet season while become cultivable or exposed in the dry season and are used for agricultural activities. As these lands appear dry and usable for part of the year, they are often considered suitable for permanent development, even though they play an essential role in seasonal water storage, flood buffering, and hydrological connectivity. Absence of land-use zoning, weak regulatory enforcement, and inadequate monitoring have therefore stimulated gradual and largely unplanned construction in these hydrologically sensitive areas.



Map-5.10a: Conversion pathway of Built-up Area, 2005 and 2025 (Research Team, UDD, 2025)



Map-5.10b: Conversion pathway of Built-up Area 2005 and 2025 (Research Team, UDD, 2025)

In addition, rapid population growth and the expanding influence of nearby urban centers, particularly Dhaka and Munshiganj have significantly intensified development pressure in and around Arial Beel. Improved physical connectivity through new roads, embankments, and transport corridors has increased land accessibility, accelerating urban sprawl into previously marginal and hydrologically sensitive wetland zones. Collectively, these drivers have contributed to a steady reduction in open-water areas, with waterbody coverage declining from 9.71% to 7.09% over the study period.

This trend reflects ongoing wetland shrinkage and encroachment, with important implications for flood regulation, ecological integrity, and long-term resilience of the beel system. However, in recent years, Arial Beel has faced renewed and more diffuse threats in the form of gradual encroachment and land filling driven by real estate entities and filled with sand for prospective residential development. Several villages including Hasara, Kewatkhali, Gaidighat, Baroikhali, Srinagar, Rairkhal, and Alampur revealed the presence of unregistered real estate developments, installation of advertising hoardings, and construction activities within former wetland and cropland areas.

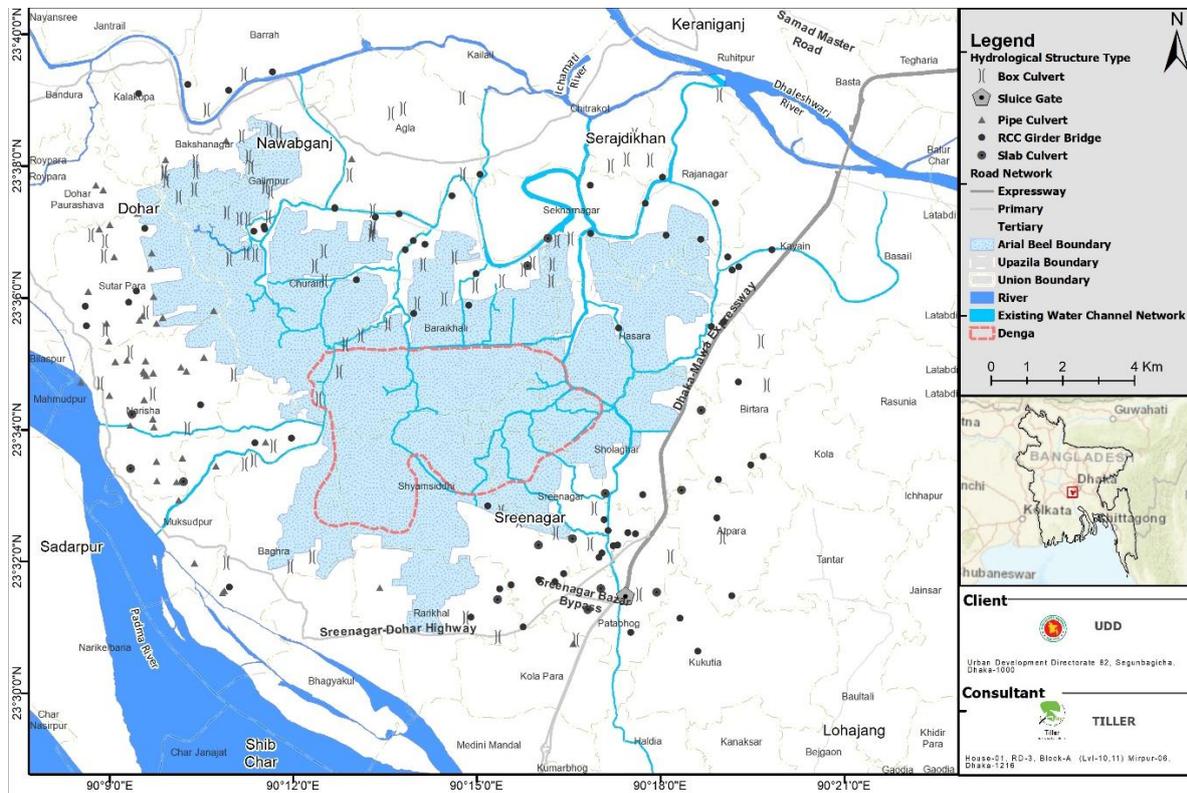
Another critical factor contributing to built-up expansion is the lack of strict land-use policies and effective regulatory oversight. In many cases, agricultural lands were sold for residential or commercial development due to higher short-term economic returns. Over time, this process converted large areas of natural and productive land into impervious surfaces, reducing the wetland's water retention capacity, disrupting natural flow paths, and increasing flood risk in surrounding areas. If unregulated development continues, these changes may become irreversible. Therefore, future planning and management must prioritize wetland-sensitive land-use zoning, restoration of hydrological connectivity, and community-based governance approaches to balance development needs with the long-term resilience and protection of this ecologically critical wetland system.

5.6 Hydrological Connectivity

Arial Beel is part of a complex river–wetland system that historically maintained strong hydrological connectivity with surrounding major rivers through seasonal water exchange. The massive Padma River flows along the western boundary of the study area, separating it from Sadarpur and Dohar, while the Dhaleshwari River borders the northern and northeastern margins near Serajdikhan and Keraniganj. To the northwest, the Ichamati River flows near Nawabganj. Together, these river systems historically sustained the hydrological dynamics of Arial Beel and supported its ecological productivity. Along with that Arial Beel also upheld a robust hydrological connection with the Padma River through several major khals, including Bhagyakul, Kamargaon, Meghula, Moksedpur, and Dhapari, which enabled seasonal inflow and outflow of water. These channels facilitated monsoon flooding, sediment transport, fish migration, and gradual drainage during the dry season, thereby maintaining the natural flood pulse essential for wetland functioning.

Over the time, hydrological connectivity has declined significantly due to extensive human interventions. The construction of embankments in the Srinagar–Dohar area, along with road infrastructure development and land reclamation activities, has obstructed many of the traditional khals. In addition, undersized culverts at Noyabari and Kharia have further restricted natural water movement. As a result, the influence of the Padma River on the natural hydrological regime of Arial Beel has been substantially reduced. At present, some open channel networks still exist that connect Arial Beel to the Padma River through Joypara,

Rishibari, Kathalbari, and Sadar Bepari khals, along with additional channels linking the Beel to the Ichamati and Dhaleshwari rivers. These remaining channels constitute the functional hydrological system of Arial Beel. However, their effectiveness is severely weakened by road crossings, bamboo bridges, fish-farming embankments, and settlement encroachments that obstruct flow.



Map-5.11: Hydrological Connectivity of Arial Beel (Research Team, UDD, 2025)

Furthermore, water quality within these channels has deteriorated due to pollution from household waste disposal, septic system discharge, and poultry farm runoff along khal banks. This degradation not only reduces hydraulic efficiency but also impairs ecological processes within the wetland. Consequently, Arial Beel has transitioned from a dynamic, river-fed wetland system into a fragmented and semi-stagnant hydrological environment. The natural flood pulse that once sustained wetland productivity, biodiversity, and water regulation functions has been significantly weakened. This decline in hydrological connectivity has contributed to prolonged waterlogging in some areas, reduced dry-season water availability in others, and an overall loss of hydrological vitality, increasing the wetland's vulnerability to both flooding and ecological degradation.

Chapter-06: Biodiversity and Socio-Economic Assessment

6.1 Biodiversity of Arial Beel:

Despite increasing anthropogenic pressures and emerging environmental stresses, Arial Beel remains one of the most biologically rich wetland ecosystems in central Bangladesh. Despite increasing anthropogenic pressures and emerging environmental stresses, the beel continues to support a diverse assemblage of flora and fauna, including several nationally threatened species. This ecological richness is largely attributed to its seasonal inundation regime, sustained hydrological connectivity with surrounding rivers and canals, and the presence of elevated perennial pond banks locally known as *denga*, which provide stable refugia during peak monsoon flooding.

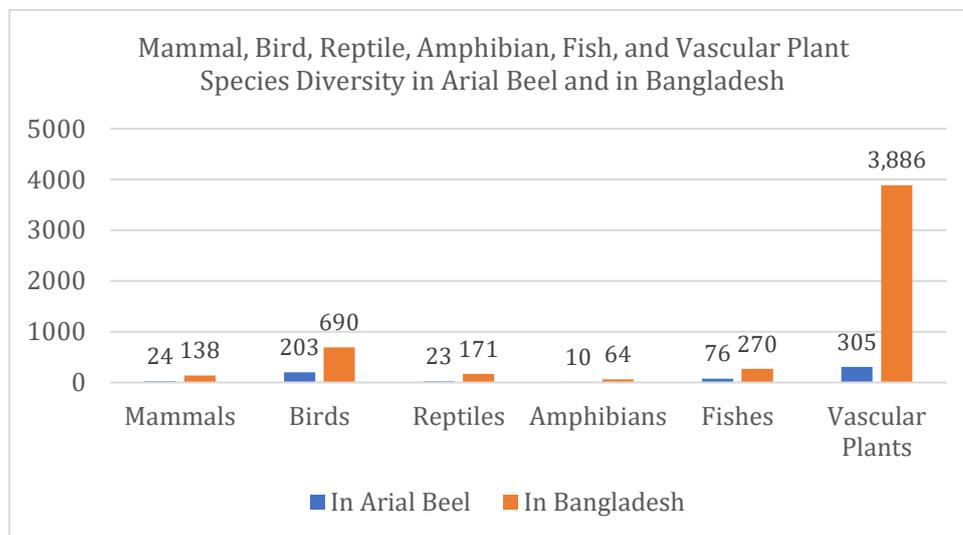


Figure-6.1: Comparison of total species of vertebrates and vascular plants in Arial Beel (Khan 2018, IUCN-Bangladesh 2015, Hossain et al. 2022).

Field-based biodiversity surveys conducted between May and July 2025, complemented by key informant interviews (KII) and secondary literature review, documented a total of 24 mammal species, 203 bird species (including 71 winter migratory species), 23 reptile species, 10 amphibian species, and 76 fish species within the Arial Beel ecosystem (Appendix I). Comparative assessment indicates that a substantial proportion of Bangladesh's national species pool of vertebrates and vascular plants is represented within this wetland, underscoring its ecological importance at the national scale.

6.1.1 Faunal Biodiversity

The faunal biodiversity of Arial Beel reflects the ecological complexity and functional integrity of this large seasonal wetland system. The combination of permanent and seasonal waterbodies, hydrological connectivity, and elevated *denga* habitats supports diverse faunal assemblages

across multiple trophic levels. The relative abundance¹ patterns further provide insight into habitat suitability, ecological stability, and emerging conservation concerns.

(a) Mammals:

Relative abundance analysis indicates that the mammalian community of Arial Beel is moderately diverse and structurally balanced. Of the recorded mammal species, 10 species (42%) were classified as Very Common, 8 species (33%) as Common, 4 species (17%) as Uncommon, and 2 species (8%) as Rare. This distribution suggests that the wetland and its surrounding habitats continue to provide suitable foraging, shelter, and movement corridors for terrestrial mammals. Notably, the presence of the Fishing Cat (*Prionailurus viverrine*), a nationally threatened species, underscores the ecological functionality of Arial Beel. As a wetland-dependent carnivore, the Fishing Cat requires intact aquatic habitats with adequate prey availability and minimal disturbance. Its occurrence indicates that key ecological processes, such as fish availability and wetland connectivity, remain partially intact despite increasing anthropogenic pressures.



Figure-6.2: Prionailurus viverrine (Mahadi Al Hasnat, 25 Apr 2024).

(b) Avifauna:

Arial Beel supports a highly diverse avifaunal community, reflecting its importance as both a resident habitat and a seasonal refuge for migratory birds. Among the recorded bird species, 62 species (30%) were categorized as Very Common, 63 species (31%) as Common, 50 species (25%) as Uncommon, and 28 species (14%) as Rare. This wide distribution across abundance classes highlights the availability of diverse feeding and nesting niches within the wetland landscape. During the study seven nationally threatened bird species were documented, including Common Pochard, Black Stork, Black-headed Ibis, Steppe Eagle, Greater Spotted Eagle, Indian Spotted Eagle, and Yellow-breasted Bunting. Seasonal flooding creates extensive shallow



Figure-6.3: Black-shoulder Kite (Biodiversity Survey UDD, 2025)

¹ *Relative abundance analysis is a qualitative–semiquantitative method used to evaluate the distribution, frequency of occurrence, and ecological status of faunal species within a given area. In the Arial Beel study, species were classified as Very Common, Common, Uncommon, or Rare based on field observations, encounter frequency, and corroborated local ecological knowledge.*

water areas, mudflats, and flooded agricultural lands that provide critical feeding grounds, while denga banks and riparian vegetation offer roosting and nesting sites. Consequently, Arial Beel functions as an important wintering and stopover site within regional migratory bird flyways.

(c) Reptiles, Amphibians and Insects:

The herpetofauna survey recorded 23 reptile species and 10 amphibian species, indicating the availability of suitable aquatic and semi-terrestrial habitats. Relative diversity among reptiles reflects the presence of permanent waterbodies, vegetated banks, and comparatively less interrupted micro-habitats. Among all three reptile species, such as Yellow Turtle, Peacock Softshell Turtle, and Water Monitor, are nationally threatened, highlighting growing conservation concerns related to habitat loss, hunting, and hydrological alteration. Although no amphibian species recorded during the survey are currently listed as threatened but as they are highly sensitive to environmental change due to their dependence on shallow breeding habitats and vulnerability to pollution, pesticide runoff, and altered hydrological regimes.

In addition to vertebrate fauna, Arial Beel supports a variety of insects and pollinators, including butterflies and dragonflies, which play important roles in pollination, trophic interactions, and as indicators of wetland health.



Figure-6.4: Common Garden Lizard



Figure-6.5: Yellow-striped Frog
(Biodiversity Survey UDD, 2025)



Figure-6.6: Grey Pansy (Butterfly)

(d) Fishes:

Fish diversity represents a cornerstone of both the ecological integrity and livelihood systems of Arial Beel. A total of 76 fish species were recorded, of which 15 are nationally threatened, including Indian River Shad, Giant Snakehead, Freshwater Shark, and several species of catfish and featherback fishes. This diversity highlights the wetland's importance as a major spawning, nursery, and feeding area for indigenous fish populations.

The denga ponds play an essential role by acting as dry-season water retention areas, allowing fish to survive during dry and low water period. During the monsoon season, these areas support the spread of fish larvae and adults across the flooded landscape. This seasonal connection emphasizes the need to maintain natural water flow and prevent channel blockages to ensure long-term fisheries sustainability and biodiversity conservation.



Figure-6.7: Mixed Fish Species

Table 6.1: Nationally Threatened Faunal Species Recorded in Arial Beel

Taxonomic Group	Name	Conservation Significance
Mammal	Fishing Cat (<i>Prionailurus viverrinus</i>)	Wetland-dependent carnivore; indicator of intact aquatic habitats
Reptile	Yellow Turtle (<i>Indotestudo elongata</i>)	Sensitive to habitat loss (Interruption)
	Peacock Softshell Turtle (<i>Nilssonia hurum</i>)	Dependent on permanent waterbodies and threatened by overharvesting
	Water Monitor (<i>Varanus salvator</i>)	A top predator of the food chain and vulnerable to habitat degradation
Bird	Common Pochard (<i>Aythya ferina</i>)	Migratory waterfowl; declining globally
	Black Stork (<i>Ciconia nigra</i>)	Requires undisturbed wetlands and riparian habitats
	Black-headed Ibis (<i>Threskiornis melanocephalus</i>)	Dependent on shallow wetlands for feeding
	Steppe Eagle (<i>Aquila nipalensis</i>)	Migratory raptor; sensitive to habitat change
	Greater Spotted Eagle (<i>Clanga clanga</i>)	Wetland-associated raptor; declining populations
	Indian Spotted Eagle (<i>Clanga hastata</i>)	Requires mosaic of wetland and open habitats
	Yellow-breasted Bunting (<i>Emberiza aureola</i>)	Rapidly declining migratory species
Fish	Indian River Shad (<i>Tenualosa ilisha</i>)	Economically important; sensitive to hydrological disruption
	Silver Hatchlet Barb (<i>Chela cachius</i>)	Dependent on clean, flowing waters
	Mrigel Carp (<i>Cirrhinus cirrhosus</i>)	Indigenous carp; affected by habitat modification
	Giant Snakehead (<i>Channa micropeltes</i>)	Top predator; requires connected waterbodies
	Dwarf Catfish (<i>Mystus cavasius</i>)	Vulnerable to overfishing and pollution
	Long-whiskered Catfish (<i>Sperata aor</i>)	Indicator of river–wetland connectivity
	Necktie Loach (<i>Botia dario</i>)	Sensitive to substrate and flow changes
	Butter Catfish (<i>Ompok bimaculatus</i>)	Declining due to habitat degradation
	Pabda Catfish (<i>Ompok pabda</i>)	Requires floodplain connectivity

Taxonomic Group	Name	Conservation Significance
	Humped Featherback (<i>Chitala chitala</i>)	Floodplain-dependent breeding species
	Grey Featherback (<i>Notopterus notopterus</i>)	Sensitive to flow alteration
	Squarehead Catfish (<i>Clupisoma garua</i>)	Affected by river modification
	Freshwater Shark (<i>Glyphis gangeticus</i>)	Critically dependent on river–estuary systems
	Gangetic Mudeel (<i>Anguilla bengalensis</i>)	Migratory species; threatened by barriers

Source: Biodiversity Assessment of Arial Beel by UDD 2024.

6.1.2 Floral Biodiversity:

The floristic survey of the project area documented a total of 305 vascular plant species, representing 231 genera and 78 families, distributed across a range of aquatic, semi-aquatic, and terrestrial habitats (Appendix III). This species richness accounts for approximately 7.85% of the total vascular plant species recorded in Bangladesh, indicating the significant contribution of Arial Beel to national floristic diversity.



Figure-6.8: *Cardiospermum halicacabum* (Lota Futki)



Figure-6.9: *Boletus sp. fungus* (Banger Chhata)



Figure-6.10 *Ficus heterophylla* (Lata Dumur)



Figure-6.11: *Crateva magna* (Barun)



Figure-6.12: *Abutilon indicum* (Potari)



Figure-6.13: Floral diversity under water in Arial Beel. (Biodiversity Survey, UDD, 2025)

Taxonomic analysis shows a clear dominance of dicotyledonous plants, which comprise 217 species (71%), followed by monocotyledons with 79 species (26%) and pteridophytes with 9 species (3%) (Figure-6.8). This pattern reflects the prevalence of terrestrial and marginal wetland vegetation associated with seasonally exposed floodplain areas and elevated banks. Habitat-wise distribution further reveals that terrestrial environments support 254 species (83%), while aquatic habitats contain 51 species (17%), underscoring the ecological importance of wetland margins and higher grounds within the beel.

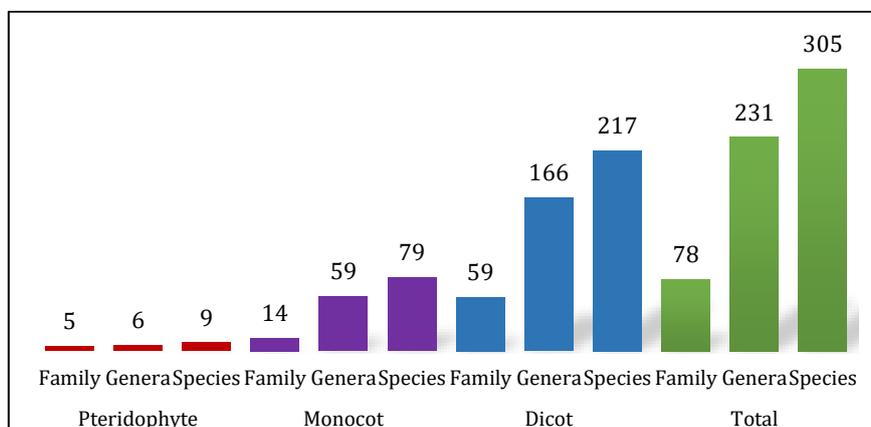


Figure-6.14: Floristic composition under different plant groups in Arial Beel (Biodiversity Survey, UDD, 2025)

The recorded plant species were classified into six major life-form categories, trees, shrubs, herbs, climbers, palms, and bamboos. Herbaceous species form the dominant group with 110 species, followed by trees (53 species), shrubs (29 species), and climbers (26 species), while palms and bamboos occur in limited numbers (Figure-6.9). The dominance of herbs reflects the dynamic hydrological regime of Arial Beel, characterized by seasonal flooding, sediment deposition, and periodic disturbance, which favor fast-growing and adaptable plant forms.

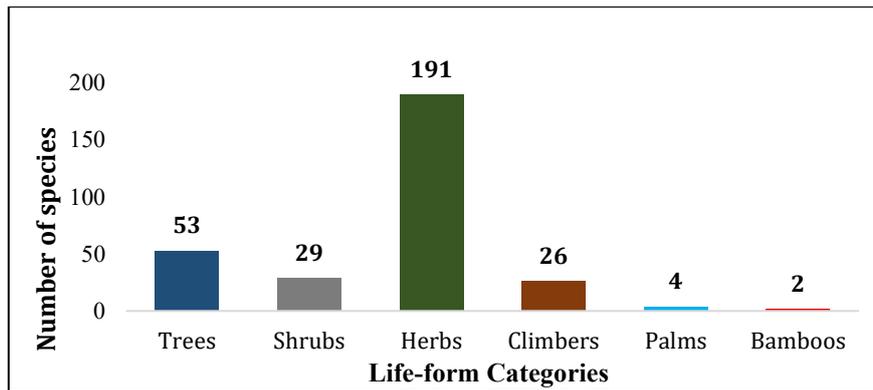


Figure-6.15: Life-form categories of plants in Arial Beel (Biodiversity Survey, UDD, 2025)

Relative abundance assessment using the DAFOR scale indicates that Frequent (102 species) and Occasional (103 species) categories together account for the majority of the flora, followed by Abundant (48 species) and Dominant (22 species) classes, with 30 species classified as Rare (Figure-6.10). This distribution suggests a structurally balanced and resilient plant community with limited dominance by a few taxa. Importantly, no plant species listed under the national IUCN Red List were recorded during the survey, indicating that, despite increasing pressures, the floristic composition of Arial Beel remains relatively intact at present.

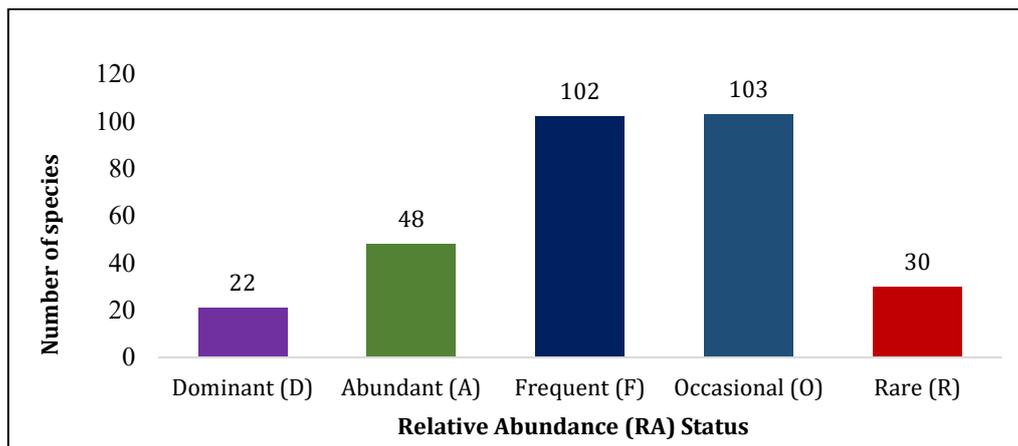
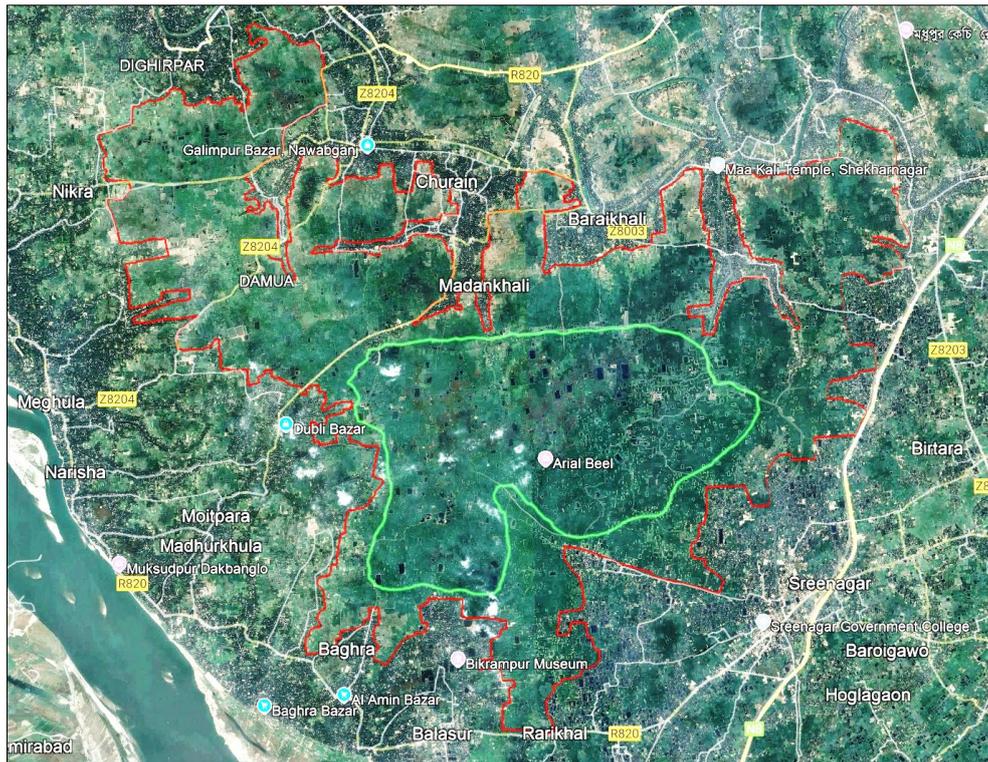


Figure-6.16: DAFOR categories of plants in Arial Beel. (Biodiversity Survey, UDD, 2025)

6.1.3 Key Ecological Areas and Important Habitats

A core ecological area of Arial Beel has been identified based on its importance for migratory birds, fish breeding, and overall biodiversity (Figure-6.17). This core area includes most of the perennial ponds (denga- high earthen banks) used for fish culture, which play a vital role in sustaining fisheries throughout the year. These dengas remain above water during the monsoon season and are covered with natural and planted vegetation. As a result, they provide safe shelter and habitat for a wide range of terrestrial plants and animals, including wildlife, especially during periods of flooding. In this way, denga function as critical high-ground habitats within the wetland system. Some denga banks with limited vegetation have also been identified as suitable locations for tree plantation and afforestation, offering opportunities to further strengthen habitat quality.



Map-6.1: The core area for migratory birds, fish breeding and vegetation of Arial Beel (UDD Research Team, 2025)

Local communities recognize the importance of Arial Beel, as it supports fisheries, agriculture, and other livelihood activities. To enhance conservation and sustainable use, the Institute of Water Modelling (IWM, 2025) has identified 10 sites covering a total area of 7.78 hectares for the establishment of fish sanctuaries and tree plantation. In addition, Shekharnagar and Alampur areas along the Srinagar Khal have been proposed as fish sanctuaries. These sites were selected based on simple and practical criteria, including low-lying location, connection with rivers or canals, ecological importance, and availability of government (khas) land. Together, these core areas and associated habitats form the ecological backbone of Arial Beel, supporting biodiversity, sustaining fisheries, and providing a strong foundation for future conservation and management interventions.

6.2 Socio-Economic Framework:

Arial Beel plays a critical role in sustaining the livelihoods, economy, and socio-cultural fabric of surrounding communities across Sreenagar, Sirajdikhan, Dohar, and Nawabganj upazilas. The wetland functions not only as an ecological system but also as a productive socio-economic landscape where natural resources directly support household income, food security, transportation, and cultural practices. The socio-economic survey, supported by questionnaire interviews, focus group discussions (FGDs), and community consultations, highlights the strong interdependence between local livelihoods and the health of the wetland ecosystem.

6.2.1 Livelihood Dependence:

Livelihoods around Arial Beel are predominantly wetland-dependent. Agriculture and fisheries constitute the principal sources of income, with a large proportion of households engaged either directly or indirectly in these activities.

(a) Fishing and Fish Biodiversity:

Fishing is one of the most traditional and culturally significant livelihood activities associated with Arial Beel and remains a critical source of income and food security for local communities, particularly during the monsoon season when the wetland becomes fully inundated and fish availability increases. The deeper perennial waterbodies (denga) retain water throughout the year and function as natural fish holding and breeding areas, supporting fisheries during both wet and dry seasons. Historically, these dengas supported a rich diversity of indigenous fish species and ensured relatively stable income for fishing households.

However, findings from field surveys and secondary sources indicate a gradual decline in fish abundance and species diversity, with several native fish species now categorized as nationally threatened. Reduced hydrological connectivity, habitat modification, unsustainable fishing practices, and increasing environmental pressures have collectively contributed to this decline. As a result, fishing-dependent households are experiencing reduced catch volumes, increased income uncertainty, and declining availability of fish for household consumption, thereby heightening livelihood vulnerability and food insecurity.

(b) Water-Lily Collection:

During the monsoon season, water lilies in Arial Beel are harvested by local households as an important seasonal, wetland-based livelihood. Both the flowers and edible roots are collected and sold as vegetable and food items. As the plants grow naturally in the inundated wetland, the activity requires little to no financial investment, making it especially accessible to lower-income and marginal farming households with limited livelihood opportunities during the monsoon period. Water-lily collection provides a critical source of seasonal income and food security, particularly for land-poor households. The collected water lilies are usually sold to local traders or wholesalers and transported to nearby wholesale markets, connecting small-scale collectors to wider market systems.

(c) Agriculture and Cropping on Seasonal Wetlands:

Seasonal agriculture is practiced extensively, with rice cultivation during the dry season and vegetable farming on exposed floodplain lands and elevated areas. These floodplain agricultural practices are closely linked to hydrological conditions and soil fertility. While agriculture remains a major livelihood activity, changes in water availability, sedimentation, and land conversion are increasingly affecting crop productivity and long-term viability.

(d) Navigation:

In addition to production activities, Arial Beel serves as an important navigation route during the monsoon season. Boats are widely used for transportation of people, agricultural produce, fish, and daily necessities. It reduces travel time and cost for communities with limited road connectivity. This multifunctional use of the wetland underscores its importance as both a natural resource base and a local transport network.

6.2.2 Economic Contribution of Wetland and Watershed Resources

Arial Beel plays a significant role in the local economy by supporting a wide range of wetland- and watershed-based livelihood activities that contribute directly to household income, food security, and local and regional market supply. Through fisheries, floodplain agriculture, navigation, and the collection of aquatic resources, the wetland functions as a productive economic system that sustains both subsistence needs and cash-based livelihoods for surrounding communities.

(a) Livelihood Structure of Respondents:

The occupational distribution of respondents in the Arial Beel area reflects a predominantly rural and resource-dependent economy (Figure 6.18). The occupational structure reveals an economy dominated by agriculture and fisheries, with moderate engagement in business activities, limited participation in the service sector, and a sizeable informal economy.

Agriculture is the primary source of livelihood, accounting for approximately 34% of respondents, indicating a strong dependence on crop cultivation and farming-related activities. The fisheries sector also plays a significant economic role, highlighting the importance of wetland resources in supporting local livelihoods. The business and small trade sector represents a moderate share of employment, suggesting the presence of local commercial activities such as retail, trading, and small enterprises. A smaller proportion of households depend on emigrant, reflecting income contributions from overseas work.

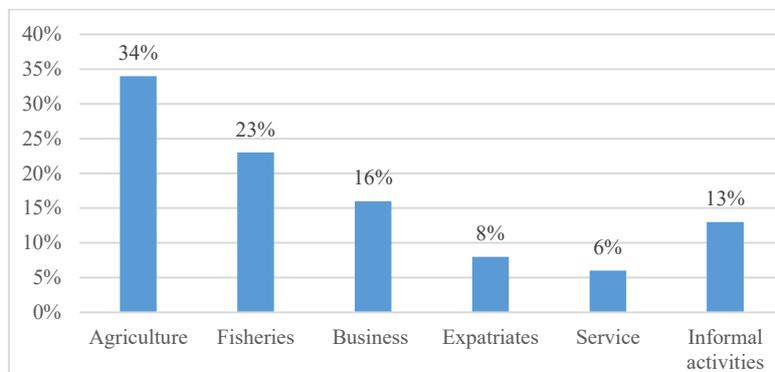


Figure-6.17: Occupation of the Respondent of the Study Area (Research Team, UDD, 2025)

The service sector, comprising about 6% of respondents, is the least represented among formal employment categories, indicating limited access to jobs in education, healthcare, and public services. In contrast, informal economic activities including casual labor, street vending, and micro-trading, constitute a substantial share of livelihoods, underscoring both economic vulnerability and adaptive livelihood strategies. This pattern highlights both structural constraints and opportunities for livelihood diversification and local economic development.

(b) Household Income Profile

Household income levels provide important insight into the socio-economic condition of the study area (Figure 6.19). The largest share of respondents (37%) falls within the BDT 21,000-30,000 income range, while 32% report incomes above BDT 40,000, indicating the presence of a relatively higher-income segment. Approximately 17% of households earn between BDT 11,000-20,000, and 10% fall within the BDT 31,000-40,000 range. Only 5% of respondents belong to the lowest income category (BDT 5,000-10,000). The income distribution suggests that the majority of households earn above BDT 20,000, reflecting a moderate to relatively stable economic profile, though income disparities remain among different occupational groups.

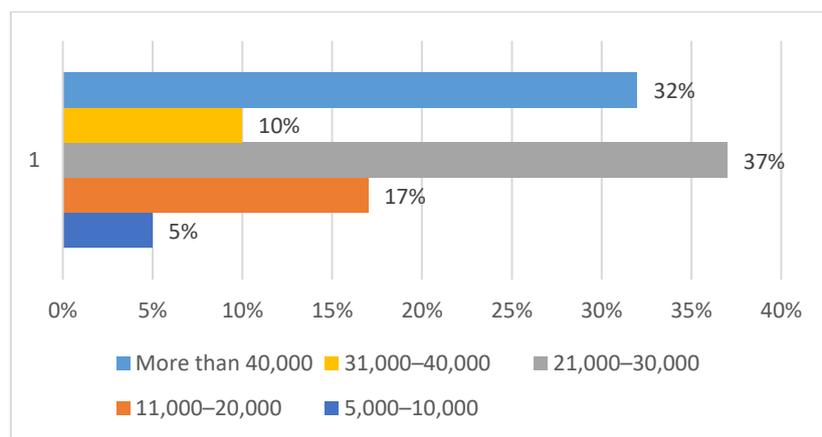


Figure-6.18: Income of the Respondent of the Study Area (Research Team, UDD, 2025)

(c) Household Expenditure Pattern

Household expenditure patterns indicate moderate to high levels of spending among respondents (Figure 6.20). A substantial proportion of households report monthly expenditures exceeding BDT 20,000, which may reflect higher living costs, improved living standards, or increased financial commitments related to food, education, healthcare, housing, and livelihood

activities. These expenditure trends underscore the importance of stable and sustainable income sources, particularly those derived from wetland and watershed resources.

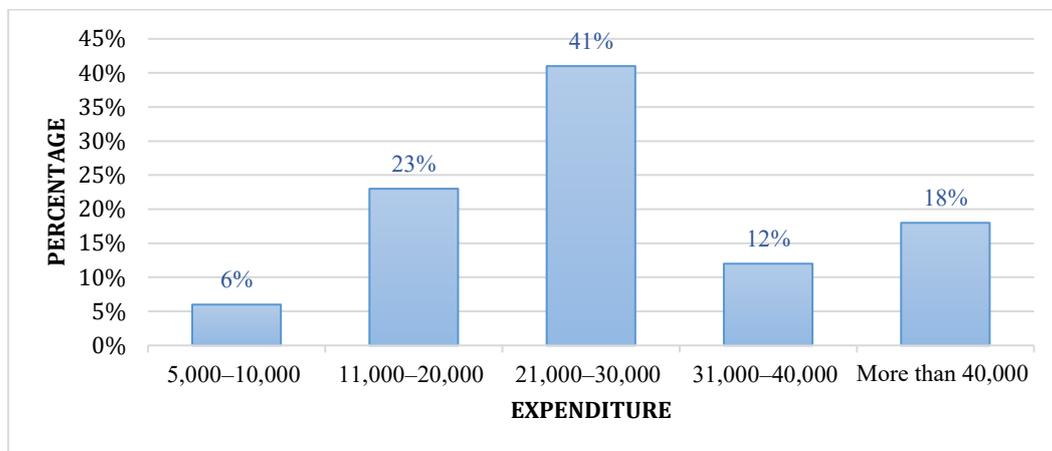


Figure-6.19: Expenditure of the Respondent of the Study Area (Research Team, UDD, 2025)

In brief, the socio-economic assessment shows that livelihoods in the Arial Beel area are highly dependent on wetland and watershed resources and agriculture and fisheries forming the main sources of income and employment, supported by small businesses and a large informal sector. Although most households report moderate and relatively stable incomes but income inequality, limited access to formal service-sector jobs, and continued reliance on informal and seasonal activities indicate underlying livelihood vulnerability. Rising household expenditure further emphasizes the need for reliable and diversified income sources. These findings highlight the importance of protecting wetland resources while promoting integrated planning, livelihood diversification, and expanded access to formal employment to strengthen long-term socio-economic resilience and sustainable development in the Arial Beel region.

6.2.3 Housing Structure:

The study area exhibits three dominant housing typologies: katcha, semi-pucca, and pucca, which together reflect the socio-economic conditions and vulnerability profile of local households. Housing structure is closely linked with income level, livelihood security, access to services, and resilience to environmental and climate-related hazards. Semi-pucca houses constitute the largest share (47%) of total households, indicating that nearly half of the population belongs to a transitional socio-economic group. These dwellings typically combine partial brick construction with temporary roofing materials such as tin or wood, reflecting moderate and improving economic conditions. While households in this category have begun upgrading their living standards, they remain vulnerable to shocks such as flooding, cyclones, and economic stress. The dominance of semi-pucca structures highlights strong potential for targeted housing improvement programmes, micro-finance support, and incremental upgrading initiatives.

Katcha houses account for 24% of the housing stock and represent the most economically vulnerable segment of the population. Constructed mainly from bamboo, mud, and tree leaves, these structures provide minimal protection against climatic extremes and environmental hazards, increasing risks related to health, housing insecurity, and livelihood instability. In contrast, pucca houses make up 29% of total dwellings and signify the most stable and economically secure group within the community. These permanent brick-built houses indicate higher income levels, better access to resources, and greater resilience to natural hazards. While pucca households require less immediate housing support, they can play an important role in community-based development, co-financing mechanisms, and local governance initiatives.

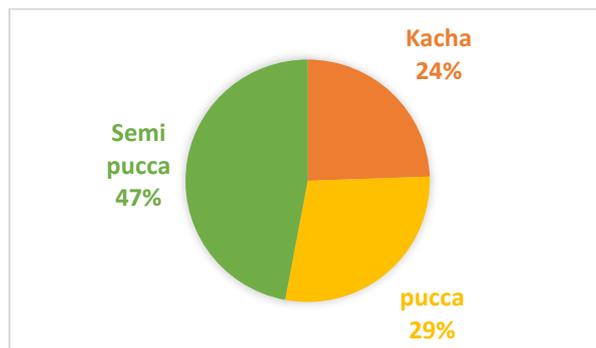


Figure-6.20: House structure of the Study Area (Research Team, UDD, 2025)

6.2.4 Education

Figure 72 illustrates household perceptions of the adequacy of the education system in the study area. A majority of respondents (57%) reported that the existing education system is sufficient to meet their needs, indicating generally adequate availability and accessibility of educational facilities. However, a significant proportion (42%) perceived the system as insufficient, mainly due to financial constraints, highlighting affordability as a key barrier rather than physical access. Only 1% cited distance to educational institutions as a concern. Overall, the findings suggest that while educational infrastructure is largely in place, targeted financial and social support measures are needed to ensure inclusive and equitable access to education.

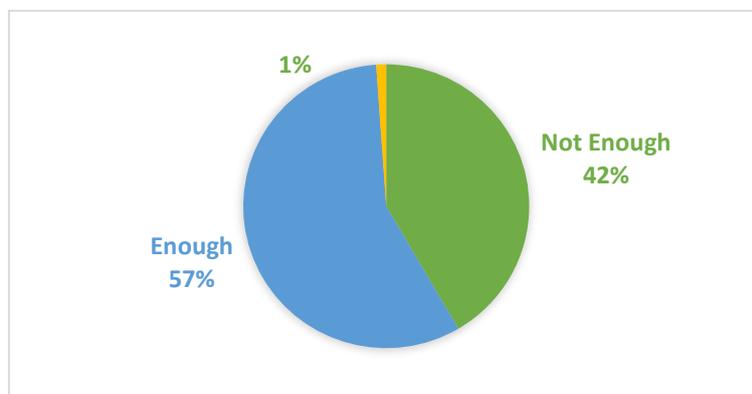


Figure-6.21: Education System of the Study Area (Research Team, UDD, 2025)

6.2.5 Health

Health services in the study area are severely inadequate, particularly in terms of government healthcare provision. Public health facilities are limited in number and poorly equipped, restricting access to essential medical care for a large segment of the population. As shown in Figure 73, 62% of respondents reported that existing health care facilities are insufficient, indicating widespread dissatisfaction with service availability and quality. Only 25% considered the facilities to be adequate, while 13% stated that health services are located far from their homes, highlighting geographical access constraints. Overall, the findings reveal significant gaps in both the availability and accessibility of health care services, emphasizing the urgent need to strengthen public health infrastructure and service delivery in the study area.

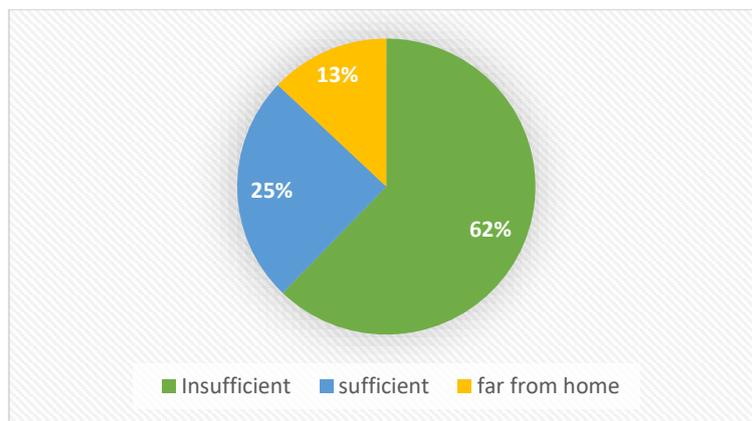


Figure-6.22: Health Care Facilities of the Study Area (Research Team, UDD, 2025)

6.2.7 Service Facilities:

Despite having full electricity coverage, the area remains underserved in terms of basic infrastructure. Narrow roads, inadequate transportation facilities, and the absence of designated waste disposal sites have led to indiscriminate dumping of solid waste into canals, beels, and ponds, accelerating siltation, drainage congestion, and environmental degradation.

6.2.8 Community Perception

The study indicates that most respondents are long-term residents of the study area, with others originating from nearby upazilas and unions, representing a broad cross-section of the local population across all age groups from college-going youth to elderly community members. A notable proportion of households have expatriate family members, and several migrants visiting during vacation periods were also interviewed, reflecting the strong linkage between local livelihoods and migration-based income. Respondents consistently reported declining agricultural land, reduced fish availability, and falling crop yields, identifying decreasing water levels and canal filling as the most critical local challenges.

Although communities surrounding Arial Beel face increasing pressures from pollution, fisheries decline, agricultural land loss, and climate-related impacts, their dependence on the wetland remains substantial. Limited alternative livelihood opportunities compel households

to rely on the beel for food, water, transportation, and seasonal employment. Respondents also emphasized the need for improved road connectivity, dredging of canals and rivers, strengthened waste management systems, and better access to education and alternative income opportunities. Strengthening wetland governance through coordinated, multi-sectoral planning and inclusive institutional arrangements is essential to enhance long-term socio-economic resilience and environmental sustainability for beel-dependent communities.

Community perceptions further demonstrate a strong awareness of the ecological, economic, and social importance of Arial Beel. Many respondents observed noticeable declines in fish stocks, worsening water quality, and increased waterlogging compared to previous decades. While traditional practices such as seasonal fishing, crop rotation, and adaptive use of land and water, continue to shape local livelihoods, these practices are increasingly constrained by encroachment, drainage disruption, and pollution. Participation in formal conservation and management initiatives remains limited due to weak institutional presence and the lack of structured mechanisms for community engagement. Nevertheless, survey findings indicate strong potential for community-based management approaches, particularly when traditional knowledge, local priorities, and livelihood needs are meaningfully integrated into wetland conservation and fisheries management.

Beyond its economic role, Arial Beel holds deep cultural and social significance for surrounding communities. Traditional fishing activities, seasonal festivals, waterlily harvesting, and collective fishing events are closely intertwined with local identity and social cohesion. Indigenous knowledge, developed over generations, regarding seasonal flooding patterns, fish migration, crop calendars, and resource management continues to guide daily livelihood decisions. The wetland also influences settlement patterns, housing forms, and everyday routines, fostering a strong sense of place and cultural attachment. Integrating cultural values, indigenous knowledge, and active community participation into wetland conservation and development planning is therefore crucial for ensuring both ecological sustainability and community well-being.

Chapter-07: Sustainable Ecosystem Management Framework of Arial Beel

7.1 Discussion and Synthesis

The findings from land-use and land-cover change analysis, biodiversity assessment, hydrological evaluation, and socio-economic surveys are synthesized to develop an integrated understanding of the Arial Beel watershed as a coupled socio-ecological system. Rather than restating quantitative results presented earlier, the discussion interprets observed transformation processes and examines their consequences for ecosystem functioning, biodiversity conservation, and wetland-dependent livelihoods. The synthesis highlights how interactions among land-use change, hydrological modification, and human activities are reshaping the ecological character of Arial Beel.

7.1.1 Interpretation of Change Detection and Biodiversity Findings

Long-term change detection indicates a clear transformation path within the Arial Beel landscape, marked by the increasing dominance of permanent land uses and a gradual decline of seasonally inundated and natural wetland features. These patterns are consistent with broader processes of wetland modification driven by demographic pressure, infrastructure expansion, agricultural intensification, and weak enforcement of land-use regulations. Despite these pressures, biodiversity assessments demonstrate that Arial Beel continues to support substantial species richness across multiple taxonomic groups, including mammals, birds, reptiles, amphibians, fishes, and vascular plants. The presence of nationally threatened species confirms the wetland's conservation importance at the national scale and indicates that key ecological functions remain partially intact.

The persistence of biodiversity can be attributed to several interacting ecological features. Perennial ponds (denga) provide essential dry-season refugia for aquatic and semi-aquatic species, while remaining canal networks maintain a degree of hydrological connectivity that supports seasonal fish migration, nutrient exchange, and habitat linkage with surrounding river systems. In addition, the heterogeneous mosaic of habitats comprising open water, flooded agricultural land, canal corridors, vegetated banks, and elevated denga areas continues to support diverse ecological niches and trophic interactions.

However, field observations and community perceptions reveal increasing signs of ecological stress. A growing proportion of species are classified as uncommon or rare, particularly among wetland-dependent taxa such as fish, waterbirds, and aquatic vegetation. Declining fish abundance, reduced occurrence of migratory birds, and loss of aquatic plant communities suggest that core ecological processes are weakening. Continued reduction of waterbodies and

natural vegetation, combined with declining hydrological connectivity and increasing pollution, indicates a progressive reduction in the ecological carrying capacity of the wetland.

Overall, the evidence suggests that Arial Beel retains significant ecological value and functional importance but is approaching a critical threshold. Current biodiversity levels largely reflect ecological capital accumulated under historical hydrological regimes and traditional wetland use practices. Ongoing land-use conversion, hydrological fragmentation, and habitat degradation are steadily eroding this capital. Without timely, coordinated, and integrated management interventions, the wetland risks crossing ecological tipping points beyond which biodiversity loss, ecosystem degradation, and livelihood decline may become difficult to reverse.

7.1.2 Comparison with Other Wetland Systems in Bangladesh

Like other floodplain wetlands, Arial Beel exhibits strong seasonal hydrological variability, supports productive inland fisheries, hosts migratory waterbirds, and sustains agriculture-based livelihoods. The ecological dynamics of monsoon flooding, dry-season water recession, and seasonal habitat transformation are common features shared across Bangladesh's beel and haor systems. Similarly, livelihood patterns characterized by combined dependence on fishing, floodplain agriculture, and seasonal resource harvesting reflect broader socio-economic structures typical of deltaic wetland regions.

However, Arial Beel is subject to considerably stronger peri-urban development pressures due to its proximity to Dhaka, Bangladesh's capital and largest metropolitan area. Unlike more remote haor systems in Sunamganj and Kishoreganj, which remain relatively isolated from major urban centers, Arial Beel is increasingly influenced by urban expansion, improved road connectivity, real estate development, and peri-urban settlement growth. This proximity has accelerated rates of land conversion, infrastructure encroachment, and hydrological modification, creating a pattern of change distinct from more remote wetland systems.

At the same time, Arial Beel demonstrates higher levels of institutional attention and legal intervention compared to many smaller, less-documented wetlands. The High Court directives issued in 2023–2025, the formal declaration of wetland boundaries, and ongoing monitoring efforts reflect growing recognition of the beel's importance. This level of legal and policy engagement is comparable to nationally recognized wetlands such as Tanguar Haor (designated as a Ramsar site) and Hakaluki Haor, though Arial Beel has not yet received formal protected status under national or international conservation frameworks.

The continued presence of diverse flora and fauna, including nationally threatened species, indicates that Arial Beel retains greater ecological integrity than many heavily degraded urban and peri-urban wetlands in the Dhaka region. For example, wetlands such as Balu River

floodplains, Turag riverbanks, and portions of the Buriganga system have experienced near-complete loss of natural habitats and biodiversity. In this context, Arial Beel represents a critical transitional stage neither fully protected nor completely degraded where timely management interventions can prevent irreversible ecological loss while accommodating sustainable development needs.

7.2 Frameworks for Sustainable Management of Arial Beel

To support sustainable ecosystem management of Arial Beel the study applied conceptual and analytical frameworks based on the findings of land-use and land-cover change analysis, biodiversity assessment, hydrological evaluation, and socio-economic surveys to interpret human-environment interactions and to guide strategic decision-making. The study employed two internationally recognized frameworks:

- i) DPSIR (Driving Forces–Pressures–State–Impact–Response) framework and
- ii) TEEB (The Economics of Ecosystems and Biodiversity) framework.

7.2.1 DPSIR (Driving Forces, Pressures, State, Impact, Response) Framework:

The DPSIR framework is a conceptual model used to understand environmental issues and their management. Applying the DPSIR framework to the Arial Beel can help to identify key factors that impact the wetland ecosystem and provide insights into the necessary responses for sustainable management. An explanation of the DPSIR framework on ARIAL Beel is provided below:

(a) Driving Forces:

Driving forces are the underlying socio-economic and environmental processes that initiate change within the wetland system. In the context of Arial Beel, the principal driving forces include:

i) Demographic Pressure and Unplanned Settlement Expansion

Population growth in the surrounding upazilas of Arial Beel (Sreenagar, Dohar, Nawabganj, and Sirajdikhan) has increased the demand for housing, infrastructure, and community facilities. As a result, settlement expansion has become a major cause of land-use change within and around the Arial Beel watershed. Development pressure in this peri-urban floodplain has led to faster growth of built-up areas than other land uses. Urban and semi-urban expansion has often taken place without proper land-use planning. The lack of wetland-sensitive zoning and development control has further allowed construction in low-lying and flood-prone areas. This has disrupted natural drainage and reduced the water storage capacity of the wetland.

Most settlement expansion has occurred by converting open land, agricultural fields, and seasonally flooded wetland areas. Development is mainly concentrated along the edges of the

wetland and in areas that appear dry during the dry season. However, these areas are important during the monsoon. They store floodwater, reduce flood intensity, and maintain natural water flow. Weak enforcement of land-use regulations has allowed gradual encroachment to continue. Small and short-term actions such as land filling and plot-level construction have added up over time. This has caused widespread changes in the landscape. As a result, wetland functions have declined, natural water flow has been disturbed, and the risk of flooding and waterlogging has increased.

ii) Infrastructure Development and Hydrological Fragmentation

Construction of road, embankment and installation of undersized culverts have systematically disrupted natural hydrological connectivity between Arial Beel and surrounding river systems. For example, historical connections with the Padma River through major khals (Bhagyakul, Kamargaon, Meghula, Moksedpur, and Dhapari) have been substantially reduced by embankments in the Srinagar–Dohar area and road infrastructure development. While some open channel networks remain through Joypara, Rishibari, Kathalbari, and Sadar Bepari khals, their effectiveness is severely weakened by road crossings, bamboo bridges, fish-farming embankments, and settlement encroachments that obstruct flow.

iii) Agricultural Intensification and Land Conversion

Agricultural expansion in the Arial Beel area reflects both the spread of cultivation into former wetland spaces and the intensification of land use through increased water control. Farmers have modified the landscape by constructing earthen embankments around plots, installing low-lift pumps, and filling natural depressions to support dry-season cultivation of boro rice and vegetables. These practices allow year-round farming and provide short-term gains in agricultural production and household income. However, in the long run it reduces key ecosystem services such as fish breeding habitat, nutrient cycling, and natural flood regulation, increasing long-term ecological and livelihood vulnerability.

iv) Economic Incentives and Land Market Dynamics

Rising land values driven by proximity to Dhaka and improved accessibility through new roads have created strong economic incentives for land conversion. Agricultural lands have been sold for residential or commercial development due to higher short-term returns, with limited consideration of long-term ecological costs. Real estate development, including unregistered housing schemes documented in Hasara, Kewatkhal, Gaidighat, Baroikhali, Srinagar, Rairkhal, and Alampur, reflects speculative investment patterns typical of peri-urban areas. These market-driven conversion processes are reinforced by weak institutional capacity for monitoring, limited public awareness of wetland values, and absence of effective mechanisms to internalize environmental costs into land-use decisions. As a result, private economic calculations favor development over conservation, driving cumulative wetland degradation.

v) Climate Change

Changes in rainfall patterns, rising temperatures, and increased frequency of extreme weather events are influencing the hydrology and ecology of Arial Beel. Altered timing and intensity of rainfall affect seasonal flooding, water availability, and habitat conditions, increasing stress on wetland ecosystems and the livelihoods that depend on them.

vi) Governance Gaps and Institutional Fragmentation

Despite the presence of comprehensive legal frameworks, including the Bangladesh Water Act (2013), Bangladesh Environment Conservation Act (1995), the Playground, Open Space, Park and Natural Water Reservoir Conservation Act (2000), effective implementation remains limited. Institutional fragmentation, unclear jurisdictional responsibilities, weak coordination among agencies, and limited enforcement capacity continue to constrain wetland governance. Multiple government institutions including the Ministry of Land, Ministry of Water Resources, Department of Environment, Department of Fisheries, and local government bodies have overlapping roles in wetland management, which creates coordination challenges, delays decision-making, and allows regulatory gaps that enable unauthorized land conversion. The absence of formal protected status for Arial Beel, delayed and unclear boundary delineation prior to recent High Court interventions, and limited involvement of local communities in management processes have further reduced the overall effectiveness of governance and wetland protection.

(b) Pressures

Pressures refer to the direct human activities that arise from underlying driving forces and place stress on the wetland environment. In Arial Beel, these pressures include the conversion and encroachment of wetland areas for agriculture, settlements, and infrastructure development. Construction of roads and embankments has obstructed natural water flow and increased siltation, further disrupting wetland hydrology. Over-exploitation of natural resources, particularly excessive fishing and harvesting of aquatic vegetation, has reduced ecological productivity. In addition, increased extraction of water for irrigation and domestic use has lowered dry-season water availability, affecting aquatic habitats. Pollution from agricultural runoff, domestic waste disposal, and localized industrial activities has degraded water quality. Together, these pressures have directly altered the physical, chemical, and biological conditions of the Arial Beel wetland system.

(c) State

The ecological state of Arial Beel has been affected by multiple human pressures. These pressures have altered the ecological state of Arial Beel in several ways. Habitat loss and water pollution have led to a gradual decline in biodiversity, including reductions in bird populations, aquatic plants, and reptiles. Water quality has deteriorated due to pollution from agricultural runoff and domestic waste, affecting both ecological health and resource use. Excessive

extraction of water has reduced water levels, particularly during the dry season, which has negatively affected aquatic life and wetland productivity. In addition, conversion of wetland areas into agricultural and urban land, along with land grabbing and encroachment, has reduced the overall size of the wetland and weakened its ecological and hydrological functions.

(d) Impact

The degradation of Arial Beel has significant impacts on both the environment and human well-being. Declining wetland health has reduced essential ecosystem services such as water filtration, flood control, groundwater recharge, and habitat support for biodiversity. Deterioration of water quality and reduced water availability have affected access to clean water for local communities, particularly during the dry season. Loss of wetland habitat has led to a decline in plant and animal species that depend on this ecosystem. At the same time, reduced fish stocks and depletion of natural resources have negatively affected local livelihoods, especially those dependent on fishing and agriculture, increasing economic vulnerability among wetland-dependent households.

(e) Responses

Responses refer to coordinated actions taken to reduce environmental pressures, improve current ecological conditions, and ensure the long-term sustainability of the wetland system. For Arial Beel, priority responses include preventing further encroachment through effective land-use control and restoring degraded wetland areas using nature-based and ecosystem-friendly approaches. Raising awareness among local communities, landowners, and resource users is essential to improve understanding of the ecological and economic importance of the wetland and to promote responsible use of natural resources.

Adoption of sustainable agricultural practices can significantly reduce pollution and pressure on the wetland. Measures such as limiting chemical fertilizers and pesticides, improving drainage management, and promoting environmentally friendly farming techniques can help reduce runoff and protect water quality. Strengthening pollution control through improved waste management systems and stricter regulation of domestic and agricultural discharges is also necessary. In addition, water management policies should be designed to balance human water demand with the ecological requirements of the wetland, particularly during the dry season. Effective implementation and enforcement of existing national and local laws are critical to protect biodiversity, maintain water quality, and preserve the overall ecological integrity and resilience of Arial Beel.

Application of the DPSIR framework provides a structured understanding of how socio-economic drivers, human pressures, and governance limitations are collectively influencing the ecological condition of Arial Beel. Moreover, this analysis highlights that sustainable management of Arial Beel cannot be achieved through isolated interventions, but requires coordinated land-use planning, protection of hydrological connectivity, effective enforcement

of existing laws, and active involvement of local communities. By using the DPSIR framework as a guiding tool, decision-makers and planners can better align development needs with wetland conservation objectives and move toward long-term ecological sustainability and resilience of the Arial Beel system.

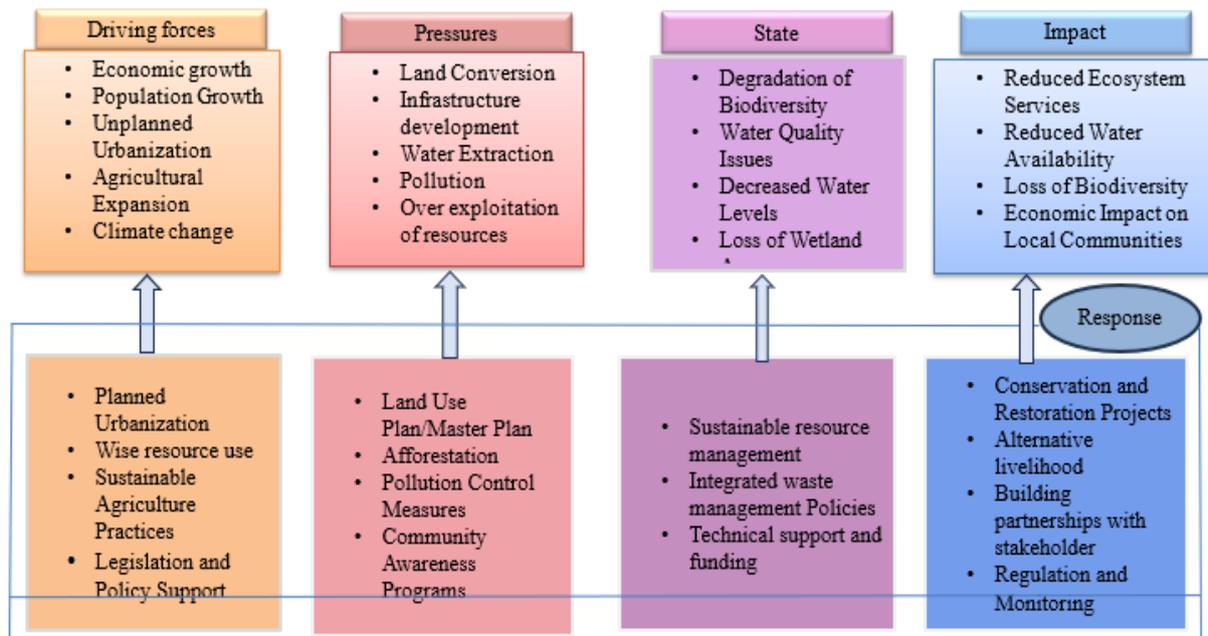


Figure-7.1: DPSIR Framework for Sustainable Management of Arial Beel (Research Team, UDD, 2025)

7.2.2 The Economics of Ecosystems and Biodiversity (TEEB)

The Economics of Ecosystems and Biodiversity (TEEB) framework emphasizes recognizing, demonstrating, and capturing the economic value of ecosystem services in decision-making. Applying the TEEB framework to Arial Beel highlights that wetland conservation is not solely an environmental concern, but also an economic and social necessity. Arial Beel provides a wide range of ecosystem services, including fisheries production, flood mitigation, water purification, agricultural support, biodiversity conservation, and cultural and recreational values. Degradation of the wetland therefore entails not only ecological loss but also substantial economic costs to local communities and society at large.

The TEEB perspective underscores that failure to protect Arial Beel will impose long-term economic burdens on future generations through increased flood damage, reduced food security, loss of livelihoods, and higher infrastructure and water management costs. Conversely, sustainable wetland management represents an investment that yields continuous economic and social returns over time. Incorporating ecosystem service valuation into planning and policy decisions can strengthen the justification for wetland protection, guide allocation of resources, and promote development pathways that internalize environmental costs and benefits.

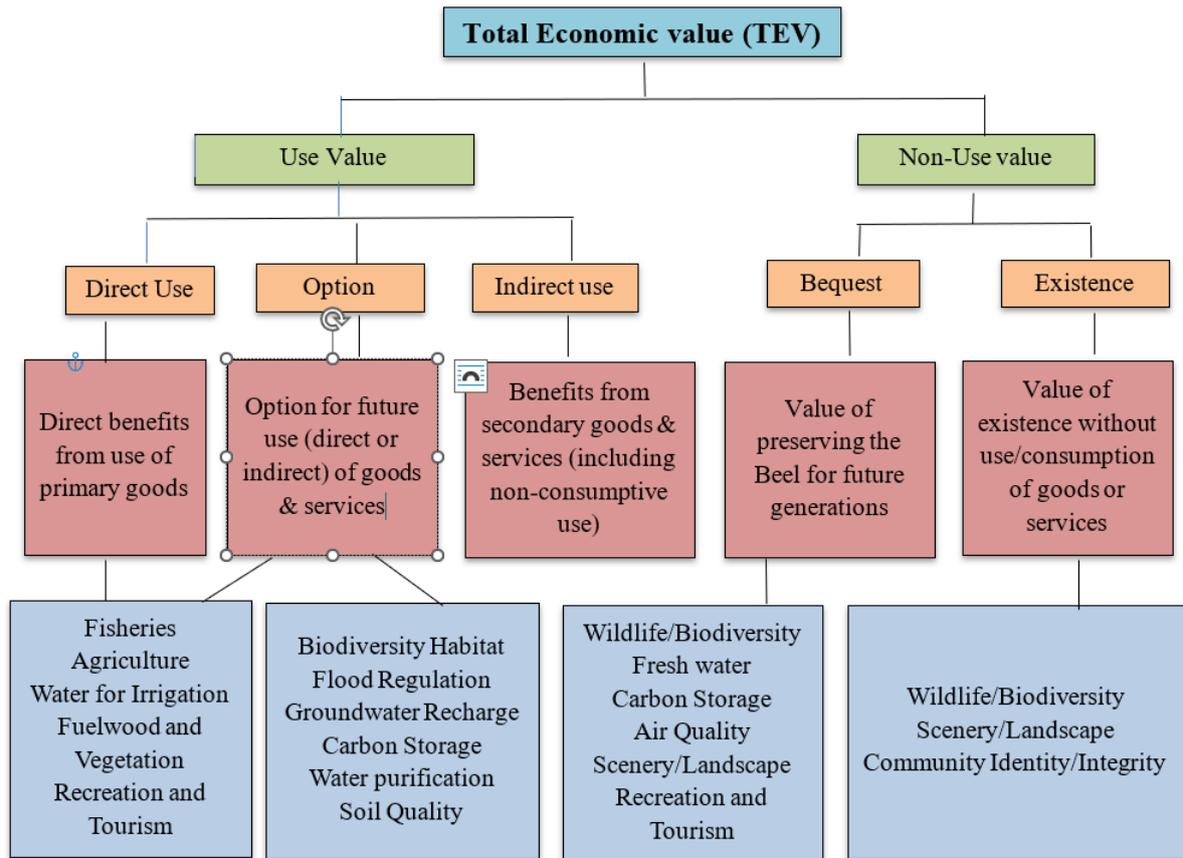


Figure-7.2: The Economics of Ecosystems and Biodiversity (TEEB) framework on Aerial Beel (Research Team, UDD, 2025)

Chapter 08: Conclusions and Policy Directions for the Sustainable Management of Arial Beel

8.1 Basis for Strategic Recommendations

Arial Beel is a critical floodplain wetland system that supports biodiversity, fisheries, agriculture, water regulation, and the livelihoods of surrounding communities. The findings of this study demonstrate that the wetland's ecological functions and socio-economic benefits are increasingly threatened by unplanned land-use change, infrastructure expansion, agricultural intensification, hydrological disruption, and weak institutional coordination. At the same time, the wetland retains significant ecological value and community support, indicating strong potential for recovery if timely and coordinated management actions are taken. The recommendations presented in this chapter translate these findings into strategic, implementable actions aimed at safeguarding ecosystem functions while supporting sustainable livelihoods and resilient regional development.

8.2 Policy Directions for Integrated Conservation and Management of Arial Beel

Effective conservation of Arial Beel requires an integrated management approach that recognizes the interdependence between ecological processes, hydrological functions, land use, and human livelihoods. As a natural flood retention basin, the wetland plays a vital role in regulating seasonal floods, storing excess monsoon water, and supporting groundwater recharge. Degradation of these functions has increased flood vulnerability, waterlogging, and pressure on infrastructure and agriculture. Conservation strategies must therefore prioritize protection of remaining wetland areas, restoration of degraded habitats, and maintenance of natural drainage and water flow patterns. These measures are essential not only for environmental protection but also for long-term disaster risk reduction and water security.

8.2.1 Legal and Policy Framework for Protection

Existing national laws and policy instruments provide a strong foundation for protecting and managing Arial Beel. Formal legal recognition of Arial Beel as a protected or specially managed area would significantly strengthen regulatory control, clarify management objectives, and enable coordinated action among government agencies. Relevant legislations are:

- i) Bangladesh Biodiversity Act, 2017;
- ii) Bangladesh Environment Conservation Act, 1995;
- iii) Protection and Conservation of Fish Act, 1950;
- iv) Wildlife (Conservation and Security) Act, 2012
- v) National Biodiversity Strategy and Action Plan of Bangladesh; and
- vi) Bangladesh National Conservation Strategy.

The Bangladesh Biodiversity Act, 2017 provides a clear legal pathway for strengthening conservation of Arial Beel. Under Clauses 28 and 29, the Government may establish biodiversity management groups, societies, and sub-committees to support site-level conservation and coordinated management. In addition, Clause 32 authorizes the Government, in consultation with local communities and relevant institutions, to declare areas of high biological value as Biodiversity Heritage Sites. As Arial Beel currently lacks formal protected status, such designation would create a strong and enforceable legal basis for long-term conservation.

If designation as a Biodiversity Heritage Site is not considered appropriate, Arial Beel may alternatively be declared an Ecologically Critical Area (ECA) under Clause 5 of the Bangladesh Environment Conservation Act, 1995. This Act further empowers the Government to undertake remedial actions for ecosystem damage (Clause 7) and to regulate or prohibit harmful pollutant discharges (Clause 9). Together, these legal provisions offer practical and immediately available instruments for protecting Arial Beel, controlling degradation, and guiding sustainable management through coordinated government action.

8.2.2 Fisheries and Wildlife Protection:

Fish resources are a critical ecological asset and a primary livelihood source for communities surrounding Arial Beel. Protection of fisheries should be strengthened through effective application of the Protection and Conservation of Fish Act, 1950, including regulation of fish extraction and strict prohibition of destructive fishing practices such as gill nets (current jal). Arial Beel also functions as an important habitat for wildlife, particularly migratory birds, and therefore requires protection under the Wildlife (Conservation and Security) Act, 2012. If the wetland is not designated as a Biodiversity Heritage Site or an Ecologically Critical Area (ECA), the Government may declare the core wetland area as a Bird Sanctuary under Clause 13 of the Wildlife Act.

Where sanctuary status is applied, it is essential to safeguard the traditional, occupational, and livelihood rights of local communities, including fishermen and boatmen. In this regard, community-based co-management systems, as provided under Clause 21 of the Wildlife Act, should be adopted to ensure local participation, improve compliance, and reduce conflict. National policy instruments such as the National Biodiversity Strategy and Action Plan and the Bangladesh National Conservation Strategy further support integrated, participatory approaches to biodiversity conservation and sustainable wetland management.

8.2.3 Hydrological Regulation and Flood Risk Management

Protection and restoration of the hydrological functions of Arial Beel are central to its long-term sustainability. Conservation efforts should focus on safeguarding natural water retention areas, preventing further obstruction of canals and floodplains, and restoring connectivity between wetlands and surrounding river systems. Infrastructure development within and

around the wetland must be designed to accommodate natural water flow, using adequately sized culverts, bridges, and drainage structures. Maintaining seasonal flooding patterns where appropriate can reduce downstream flood risk, improve groundwater recharge, and enhance ecosystem productivity. Hydrologically sensitive planning is therefore essential for reducing disaster risk and increasing climate resilience.

8.2.4 Agriculture, Livelihood Security, and Eco-Tourism

Agriculture in and around Arial Beel is closely linked to natural flooding, soil fertility, and water availability. Changes in hydrological regimes have increased dependence on chemical inputs, raised irrigation costs, and reduced predictability of crop production. Management strategies should promote water-sensitive agriculture that allows seasonal flooding while providing controlled drainage to support farming activities. Nature-based solutions such as wetland restoration, vegetated buffer zones, and improved canal management can enhance soil fertility, reduce pollution, and improve agricultural sustainability.

While protection of the core wetland area is essential, it may temporarily restrict access to certain resources for local communities. To address this, environmentally responsible eco-tourism initiatives should be developed in suitable areas of Arial Beel. Activities such as bird watching, seasonal tourism, and nature-based recreation can generate alternative income opportunities for local people by providing services to visitors, while also promoting conservation awareness.

8.2.5 Community Participation and Wetland-Sensitive Urban Planning

Local communities are key stakeholders in the sustainable management of Arial Beel, as their long-standing experience with seasonal flooding, fisheries, agriculture, and wetland resource use provides valuable knowledge for effective management. Institutionalizing community participation in planning, monitoring, and enforcement can improve regulatory compliance, reduce resource-use conflicts, and strengthen local stewardship. Wetland governance frameworks should therefore incorporate community-based co-management mechanisms, formal recognition of traditional resource-use practices, and targeted capacity-building programmes to ensure inclusive and effective conservation outcomes.

Unplanned urban growth and infrastructure development pose significant risks to the ecological and hydrological integrity of Arial Beel. Land-use planning and development control must clearly delineate and protect wetland boundaries, flood retention zones, and hydrological corridors. Development in low-lying and flood-prone areas should be strictly regulated, while green and blue infrastructure solutions should be mainstreamed into urban and peri-urban expansion. Effective wetland-sensitive spatial planning requires strong coordination across administrative jurisdictions and sectoral agencies at the watershed scale.

A key implementation priority is the restoration of natural hydrological connectivity between Arial Beel and surrounding river systems. This should include the systematic identification and

reopening of blocked canals (khals) that function as critical drainage pathways, particularly those connecting the beel with the Padma and Dhaleshwari river systems. Restoring these connections will enhance flood attenuation, improve seasonal water exchange, support fisheries productivity, and reduce prolonged waterlogging in adjacent settlements and agricultural areas.

8.2.6 Institutional Coordination and Financing

Sustainable management of Aerial Beel requires strong institutional coordination and adequate financial resources. Clear roles and responsibilities among government agencies, local authorities, and community organizations are necessary to improve implementation and enforcement. Establishment of a dedicated coordination mechanism or management authority can enhance oversight, monitoring, and inter-agency collaboration.

Long-term financing should be secured through a combination of government budget allocations, environmental funds, payment for ecosystem services, community-based financing, and international development support. Diversified financing mechanisms can ensure continuity of conservation efforts while distributing costs and benefits fairly among stakeholders.

Table-8.1: Short-Term Action Plan

Time Period	Key Actions	Expected Impact	Implementing Ministry / Authority
<p>Short-Term (1–2 Years)</p> <p>Conservation and Awareness</p> <p>Objective: To conserve and restore the ecological integrity and biodiversity of Arial Beel while enhancing awareness and active participation among local communities and stakeholders.</p>	Regulatory & Policy Actions		
	1) Gazette notification declaring Arial Beel as a protected wetland	Legal protection of the beel and prevention of unplanned land conversion	Lead: Ministry of Water Resources Support: Ministry of Environment, Forest and Climate Change; Ministry of Land; Ministry of Law; Department of Bangladesh Haor & Wetlands Development (DBHWD)
	2) Demarcation and physical boundary marking of Arial Beel	Clear identification of wetland extent and reduced land disputes	Lead: Ministry of Land Support: Local Administration (DC/UNO); BWDB; DBHWD
	3) Prevention of illegal encroachment, landfilling, and conversion	Control of wetland loss and hydrological disruption	Lead: Local Administration (DC/UNO) Support: Ministry of Land; MoEFCC; Law-enforcement agencies; DBHWD
	4) Ban on production, sale, and use of harmful fishing nets (e.g., China nets, current nets)	Protection of fish breeding grounds and aquatic biodiversity	Lead: Ministry of Fisheries and Livestock Support: Local Government Institutions; Law-enforcement agencies
	Protect Biodiversity		
	Identification and protection of critical habitats for fish, birds, and wildlife	Reduction in biodiversity degradation; improved ecosystem health	Lead: Ministry of Environment, Forest and Climate Change Support: Department of Fisheries; NGOs; Local Communities

Time Period	Key Actions	Expected Impact	Implementing Ministry / Authority
	Community Engagement		
	Conduct workshops, school programmes, and cultural events on wetland values	Increased public awareness and community stewardship	Lead: Local Administration (DC/UNO) Support: NGOs; Ministry of Environment, Forest and Climate Change; Ministry of Education
	Formation/strengthening of community-based beel management groups	Participatory wetland governance and improved compliance	Lead: Local Administration (DC/UNO Offices) Support: NGOs; Ministry of Fisheries and Livestock
Cross-Cutting (Short-Term)	Hydrological monitoring and immediate flow management support	Improved water circulation and early recovery of fish stocks	Lead: Bangladesh Water Development Board (BWDB) Support: Ministry of Water Resources

Table-8.2: Medium-Term Action Plan

Time Period	Key Actions	Expected Impact	Implementing Ministry / Authority
<p>Medium-Term (3–5 Years): Transition and Restoration</p> <p>Objective: To enable sustainable land use while restoring the ecological and hydrological functions of Arial Beel.</p>	Hydrological & Ecological Restoration		
	1) Restore canals and natural water flow through de-silting of priority canals	Re-establishment of natural drainage and flood retention capacity	Lead: Ministry of Water Resources Support: Bangladesh Water Development Board (BWDB); Local Government Institutions; DBHWD
	2) Canal excavation with clear physical demarcation of canal boundaries	Prevention of canal encroachment; improved water circulation	Lead: Bangladesh Water Development Board (BWDB) Support: Ministry of Land; Local Administration; DBHWD
	3) Plantation of native aquatic and riparian vegetation along canals and beel margins	Enhanced habitat quality and erosion control; improved water quality	Lead: Ministry of Environment, Forest and Climate Change Support: Local Government Institutions; NGOs, Forest Department
	4) Impose and enforce seasonal fishing bans during fish breeding periods	Recovery of fish populations and aquatic biodiversity	Lead: Ministry of Fisheries and Livestock Support: Local Government Institutions; Department of Fisheries; Community Fisheries Groups
	Sustainable Livelihood Diversification		
	1) Promote eco-friendly livelihood options (sustainable aquaculture, floating cultivation, community-based eco-tourism)	Reduced pressure on wetland resources and diversified household income	Lead: Ministry of Fisheries and Livestock Support: Ministry of Tourism (where applicable); NGOs; Local Government Institutions
	2) Promote organic farming and reduction of chemical fertilizer and pesticide use near Arial Beel	Improved soil and water quality and reduced ecological pollution	Lead: Ministry of Agriculture Support: Department of Agricultural Extension (DAE); Local Government Institutions

Time Period	Key Actions	Expected Impact	Implementing Ministry / Authority
	3) Establish fisheries sanctuaries in low-lying areas connected to rivers or canals	Long-term fish stock regeneration and biodiversity protection	Lead: Ministry of Fisheries and Livestock Support: MoEFCC; BWDB; Department of Fisheries
	4) Capacity-building and training for local communities on sustainable aquaculture and handicrafts	Reduced dependence on land conversion and destructive practices	Lead: Ministry of Fisheries and Livestock Support: NGOs; Local Government Institutions; Department of Fisheries
Cross-cutting (Medium-Term)	Institutional coordination and field-level enforcement support	Effective implementation and reduced conflicts	Lead: Local Administration (DC/UNO Offices) Support: All concerned ministries

Table-8.3: Long-Term Action Plan

Time Period	Key Actions	Expected Impact	Implementing Ministry / Authority
<p>Long-Term (6-10+ Years)</p> <p>Integrated and Adaptive Management</p> <p>Objective: To establish a holistic, participatory, and adaptive management framework for Arial Beel that integrates ecological, social, and economic considerations for long-term sustainability.</p>	Adaptive Land Use System		
	1) Prepare and periodically update a comprehensive land-use plan for Arial Beel and its surrounding influence area	Planned and regulated development and protection of wetland functions	Lead: Ministry of Housing & Public Works (MoHPW) Support: Urban Development Directorate (UDD); Local Government Institutions; DBHWD
	2) Integrate wetland-sensitive zoning regulations into statutory local and regional plans	Institutionalization of adaptive land-use policies	Lead: Urban Development Directorate (UDD) Support: MoHPW; Local Administration (DC/UNO Offices)
	3) Establish community-based monitoring systems to detect encroachment and land-use violations	Early detection of illegal activities and improved compliance	Lead: Local Government Institutions Support: Community Groups; NGOs; Local Administration (DC/UNO Offices)
	Ecological Buffer and Green Infrastructure		
	1) Establish and maintain green belts and ecological buffers around Arial Beel	Reduced edge pressure and enhanced ecosystem resilience	Lead: MoEFCC Support: Local Administration (DC/UNO Offices); NGOs
	1) Integrate green and blue infrastructure concepts into surrounding development areas	Improved climate resilience and hydrological balance	Lead: MoEFCC Support: MoHPW; UDD

Time Period	Key Actions	Expected Impact	Implementing Ministry / Authority
	Integrated Wetland Governance		
	1) Establish a multi-stakeholder Aerial Beel Management Board/Committee	Coordinated, transparent, and participatory governance	Lead: ; Ministry of Water Resources Support: MoEFCC; Local Government Institutions; DBHWD
	2) Prepare and implement an integrated wetland management plan aligned with national biodiversity and climate change strategies	Long-term ecological sustainability and climate resilience	Lead: MoEFCC Support: UDD; Ministry of Water Resources; Ministry of Fisheries and Livestock; DoE
	3) Institutionalize periodic monitoring, evaluation, and adaptive revision of management strategies	Continuous learning and adaptive management	All concerned ministries and agencies

8.3 Conclusion

This study provides a comprehensive assessment of the spatial, ecological, hydrological, and socio-economic dynamics of the Arial Beel watershed over the past two decades, using an integrated approach that combines remote sensing and GIS analysis, biodiversity surveys, and socio-economic investigations. The findings confirm that Arial Beel remains one of the most ecologically significant floodplain wetlands in central Bangladesh, playing a vital role in flood regulation, fisheries productivity, agricultural sustainability, biodiversity conservation, and livelihood support for surrounding communities.

Multi-temporal land use and land cover analysis (2005–2025) reveals a clear and persistent transformation of the beel landscape. Wetland and open-water areas have gradually declined, while agricultural land, flooded agricultural land, and built-up areas have expanded. These changes reflect increasing human intervention through land filling, agricultural intensification, settlement expansion, and infrastructure development. Although some land-use changes appear gradual, their cumulative impact has significantly altered hydrological connectivity, reduced natural water retention capacity, and increased vulnerability to waterlogging and flood hazards.

The hydrological assessment highlights that obstruction of canals (khals), disconnection from surrounding river systems, and modification of natural drainage pathways have disrupted seasonal inundation patterns that are essential for sustaining fisheries, soil fertility, and wetland productivity. Loss of connectivity between perennial water bodies (denga), seasonal wetlands, and major rivers such as the Padma and Dhaleshwari has weakened the ecological functioning of the beel and intensified pressure on remaining aquatic habitats.

Biodiversity assessment results indicate that Arial Beel still supports a diverse range of flora and fauna, including indigenous fish species, aquatic vegetation, amphibians, reptiles, and migratory waterbirds. However, habitat fragmentation, shrinking waterbodies, pollution, and overexploitation have contributed to declining species abundance and increased vulnerability of several taxa. The concentration of aquatic life in limited perennial water refuges during the dry season further increases ecological stress and exploitation risk.

Socio-economic analysis demonstrates that local communities remain highly dependent on Arial Beel for fisheries, agriculture, aquatic resource harvesting, and seasonal employment. Despite improvements in electricity access, basic infrastructure and environmental services remain inadequate, with drainage congestion, waste disposal, and declining natural resources directly affecting livelihoods. Reduced fish availability, declining agricultural productivity, and increasing costs of cultivation are already being experienced by wetland-dependent households, indicating growing livelihood vulnerability.

The integrated analysis clearly shows that land-use change, hydrological alteration, biodiversity loss, and livelihood stress are interconnected and mutually reinforcing processes. Continued unplanned development and weak enforcement of existing policies will further

degrade the wetland, increase disaster risk, and undermine long-term socio-economic resilience. At the same time, the study demonstrates that Arial Beel retains strong ecological value, functional potential, and community support, indicating that degradation is still reversible if timely and coordinated interventions are undertaken.

As a whole, this research establishes a robust evidence base for informed decision-making on wetland conservation and management in Arial Beel. Protection of hydrological connectivity, regulation of land use, restoration of degraded habitats, and integration of community-based co-management are essential for sustaining the ecological integrity and livelihood functions of the beel. The findings underscore the urgent need to translate existing legal and policy frameworks into effective on-ground action and to mainstream wetland-sensitive planning within regional development processes. By doing so, Arial Beel can continue to function as a resilient floodplain ecosystem and a critical natural asset for sustainable development and climate resilience in central Bangladesh.

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Appendix I

List of vascular flora recorded in Arial Beel, Munshiganj (based on survey, interviewing, and secondary information). Key for relative abundance: D – Dominant, A – Abundant, F – Frequent, O – Occasional, and R – Rare. Note: *indicates aquatic species.

PTERIDOPHYTES

Sl No	Scientific name	Bengali Name	Habit	Status
	Family: Salviniaceae			
1	<i>Azolla pinnata</i>	Khudipana	Herb*	A
2	<i>Salvinia cucullata</i>	Panidheki	Herb*	O
3	<i>Salvinia natans</i>	Panidheki	Herb*	F
	Family: Pteridaceae			
4	<i>Ceratopteris thalictroides</i>	Pani lettuce	Herb*	O
5	<i>Pteris vittata</i>	Dheki	Herb	O
	Family: Thelypteridaceae			
6	<i>Christella dentata</i>	Binung	Herb	O
	Family: Athyriaceae			
7	<i>Diplazium esculentum</i>	Dheki shak	Herb	O
	Family: Marsileaceae			
8	<i>Marsilea minuta</i>	Susni shak	Herb*	O
9	<i>Marsilea quadrifolia</i>	Susni shak	Herb*	F

DICOTYLEDONS

Sl No	Scientific Name	Bengali Name	Habit	Status
	Family: Acanthaceae			
1	<i>Hemigraphis hirta</i>	Buripan	Herb	O
2	<i>Hygrophila polysperma</i>	Alai kalai	Herb*	O
3	<i>Justicia adhatoda</i>	Basok	Shrub	R
4	<i>Justicia gendarussa</i>	Jagatmadon	Shrub	O
5	<i>Ruellia tuberosa</i>	Potpoti	Herb	O
5	<i>Rungia pectinata</i>	Pindi	Herb	O
	Family: Alismataceae			
7	<i>Sagittaria guayanensis</i>	Kauathukri	Herb*	O
8	<i>Sagittaria sagittifolia</i>	Chotokut	Herb*	O
	Family: Amaranthaceae			
9	<i>Achyranthes aspera</i>	Apang	Herb	O
10	<i>Alternanthera paronychioides</i>	Jhulikatha	Herb	A
11	<i>Alternanthera phyloxoroides</i>	Henchi	Herb*	D
12	<i>Alternanthera sessilis</i>	Malancha	Herb*	D
13	<i>Amaranthus blitum</i>	Goburanotey	Herb	F
14	<i>Amaranthus spinosus</i>	Kantanotey	Herb	F
15	<i>Amaranthus viridis</i>	Notey shak	Herb	F

Sl No	Scientific Name	Bengali Name	Habit	Status
16	<i>Celosia argentea</i>	Morogphul	Herb	O
17	<i>Chenopodium album</i>	Botua shak	Herb	O
	Family: Anacardiaceae			
18	<i>Lannea coromandelica</i>	Jiga	Tree	F
19	<i>Mangifera indica</i>	Aam	Tree	F
	Family: Annonaceae			
20	<i>Annona reticulata</i>	Atta	Tree	R
21	<i>Monoon longifolium</i>	Debdaru	Tree	O
	Family: Apiaceae			
22	<i>Centella asiatica</i>	Thankuni	Herb	D
23	<i>Coriandrum sativum</i>	Dhonia	Herb	O
24	<i>Eryngium foetidum</i>	Bilati dhonia	Herb	O
	Family: Apocynaceae			
25	<i>Alstonia scholaris</i>	Chhatim	Tree	O
26	<i>Ichnocarpus frutescens</i>	Dudhia lota	Climber	F
27	<i>Tabernaemontana divaricate</i>	Tagor	Shrub	O
	Family: Asteraceae			
28	<i>Acmella calva</i>	Nakful	Herb	F
29	<i>Ageratum conyzoides</i>	Fulkuri	Herb	F
30	<i>Blumea lacera</i>	Shialmutra	Herb	F
31	<i>Chromolaena odorta</i>	Assamlota	Herb	O
32	<i>Cyanthillium cinereum</i>	Kukshim	Herb	F
33	<i>Eclipta prostrata</i>	Kalokashi	Herb	A
34	<i>Enhydra fluctuans</i>	Helencha	Herb*	F
35	<i>Grangea maderaspatana</i>	Namuti	Herb	A
36	<i>Mikania micrantha</i>	Tarulota	Climber	D
37	<i>Sphaeranthus indicus</i>	Mundi	Herb	O
38	<i>Sphagneticola trilobata</i>	Lota deiji	Herb	O
39	<i>Synedrella nodiflora</i>	Synedrella	Herb	F
40	<i>Xanthium indicum</i>	Ghagra	Herb	A
	Family: Basellaceae			
41	<i>Basila alba</i>	Puishak	Herb	F
	Family: Bombacaceae			
42	<i>Bombax ceiba</i>	Shimul	Tree	O
	Family: Boraginaceae			
43	<i>Cordia dichotoma</i>	Bohola	Tree	R
44	<i>Heliotropium indicum</i>	Hatishur	Herb	F
	Family: Brassicaceae			
45	<i>Brassica juncea</i>	Shorisha	Herb	O
46	<i>Rorippa indica</i>	Bon shorisa	Herb	F
	Family: Cannabaceae			

Sl No	Scientific Name	Bengali Name	Habit	Status
47	<i>Trema orientale</i>	Jibon	Tree	F
	Family: Capparaceae			
48	<i>Cleome rutidosperma</i>	Nil hurhuri	Herb	O
49	<i>Cleome viscosa</i>	Holud hurhuri	Herb	F
50	<i>Crateva magna</i>	Borun	Tree	F
	Family: Caricaceae			
51	<i>Carica papaya</i>	Pepay	Tree	F
	Ceratophyllaceae			
52	<i>Ceratophyllum demersum</i> L.	Kata jhanji	Herb*	D
	Family: Combretaceae			
53	<i>Terminalia arjuna</i>	Arjun	Tree	R
54	<i>Terminalia catappa</i>	Kathbadam	Tree	R
	Family: Convolvulaceae			
55	<i>Evolvulus nummularius</i>	Khetpapra	Herb	A
56	<i>Ipomea alba</i>	Dhudh kalmi	Climber	R
57	<i>Ipomoea aquatic</i>	Kalmi shak	Herb*	D
58	<i>Ipomoea carnea</i> subsp. <i>fistulosa</i>	Dhol kalmi	Shrub	O
59	<i>Merremia hederacea</i>	Kaladana	Climber	F
60	<i>Operculina turpethum</i>	Dudhkolmi	Climber	F
	Family: Cucurbitaceae			
61	<i>Coccinia grandis</i>	Telakucha	Climber	A
62	<i>Cucumis sativus</i>	Misti kumra	Climber	O
63	<i>Cucurbita maxima</i>	Shosha	Climber	A
64	<i>Lagenaria siceraria</i>	Lau	Climber	F
65	<i>Luffa angustifolia</i>	Jhinga	Climber	O
66	<i>Luffa cylindrica</i>	Dhundal	Climber	F
67	<i>Momordica charantia</i>	Korolla	Climber	A
68	<i>Momordica dioica</i>	Kakrol	Climber	O
	Family: Cuscutaceae			
69	<i>Cuscuta chinensis</i>	Swarnalata	Climber	O
70	<i>Cuscuta reflexa</i>	Aloklata	Climber	F
	Family: Dilleniaceae			
71	<i>Dillenia indica</i>	Chalta	Tree	O
	Family: Dioscoriaceae			
72	<i>Dioscorea alata</i>	Chuprialu	Climber	O
	Family: Ebenaceae			
73	<i>Diospyros malabarica</i>	Deshi gub	Tree	R
	Family: Euphorbiaceae			
74	<i>Acalypha indica</i>	Muktajhuri	Herb	O
75	<i>Chrozophora tinctoria</i>	Khudi okra	Shrub	A
76	<i>Croton bonplandianus</i>	Bonmorich	Herb	F

Sl No	Scientific Name	Bengali Name	Habit	Status
77	<i>Euphorbia hirta</i>	Dudhiya	Herb	F
78	<i>Euphorbia prostrata</i>	Raktokeru	Herb	R
79	<i>Euphorbia thymifolia</i>	Choto dudhia	Herb	D
80	<i>Mallotus philippensis</i>	Pituli	Tree	R
81	<i>Ricinus communis</i>	Bherenda	Shrub	O
82	<i>Trewia polycarpa</i>	Pitali	Tree	A
	Family: Fabaceae			
83	<i>Acacia auriculiformis</i>	Akashmoni	Tree	O
84	<i>Aeschynomene aspera</i>	Shola	Herb	A
85	<i>Albizia niopoides</i>	Raj siris/Chama	Tree	F
86	<i>Albizia procera</i>	Shada/sil koro	Tree	F
87	<i>Cajanus cajan</i>	Arhor	Shrub	O
88	<i>Casia fistulosa</i>	Bandorlathi	Tree	O
89	<i>Clitorea ternatea</i>	Aporajita	Climber	R
90	<i>Crotalaria pallida</i>	Jhonjhoni	Herb	O
91	<i>Dalbergia sissoo</i>	Shisu	Tree	O
92	<i>Erythrina fusca</i>	Polita mandar	Tree	R
93	<i>Grona heterocarpos</i>	Kodalia	Herb	F
94	<i>Grona trifloral</i>	Kulalia	Herb	A
95	<i>Lablab purpureus</i>	Shim	Climber	F
96	<i>Leucaena leucocephala</i>	Ipil-ipil	Tree	F
97	<i>Mimosa pudica</i>	Lajjabati	Herb	F
98	<i>Pithecelobium dulce</i>	Khoibabla	Tree	R
99	<i>Samanea saman</i>	Rain tree	Tree	A
100	<i>Senna occidentalis</i>	Boro kolkashunda	Shrub	O
101	<i>Senna tora</i>	Choto kolkashunda	Herb	F
102	<i>Sesbania bispinosa</i>	Dhochey	Shrub	A
103	<i>Tamarindus indica</i>	Tetul	Tree	O
104	<i>Vigna adenantha</i>	Bon boboti	Climber	O
105	<i>Vigna mungo</i>	Mashkalai	Herb	O
	Family: Flacourtiaceae			
106	<i>Flacourtia indica</i>	Kata boichi	Shrub	R
	Family: Lamiaceae			
107	<i>Clerodendrum indicum</i>	Bamonhati	Shrub	O
108	<i>Clerodendrum infortunatum</i>	Vat	Shrub	F
109	<i>Hyptis capitata</i>	Mastak tokma	Herb	O
110	<i>Hyptis suaveolens</i>	Tokma	Herb	O
111	<i>Leucas lavandulifolia</i>	Shetodron	Herb	F
112	<i>Ocimum sanctum</i>	Tulshi	Herb	R
	Family: Lauraceae			
113	<i>Litsea glutinosa</i>	Pipul tree	Tree	R

Sl No	Scientific Name	Bengali Name	Habit	Status
	Family: Lecythidaceae			
114	<i>Barringtonia acutangula</i>	Hijal	Tree	F
	Family: Lentibulariaceae			
115	<i>Utricularia vulgaris</i>	Patajhajhi	Herb*	F
	Family: Linderniaceae			
116	<i>Lindernia antipoda</i>	Zaighas	Herb	D
117	<i>Lindernia crustacea</i>	Kukshim Thankuni	Herb	F
118	<i>Lindernia procumbens</i>	Bakpuspa	Herb	A
	Family: Lythraceae			
119	<i>Ammannia baccifera</i>	Dadmari	Herb*	O
120	<i>Lagerstroemia indica</i>	Jarul	Tree	O
121	<i>Lawsonia inermis</i>	Mahedi	Shrub	R
122	<i>Rotala indica</i>	Dadmari	Herb	R
	Family: Malvaceae			
123	<i>Abelmoschus esculentus</i>	Dherosh	Herb	A
124	<i>Abutilon indicum</i>	Potari	Shrub	F
125	<i>Ceiba pentandra</i>	Silk cotton	Tree	O
126	<i>Corchorus capsularis</i>	Sada pat	Shrub	A
127	<i>Corchorus olitorius</i>	Mitha pat	Shrub	F
128	<i>Hibiscus rosa-sinensis</i>	Joba	Shrub	O
129	<i>Hibiscus sp. (Malvaviscus)</i>	Jhumko joba	Shrub	O
130	<i>Melochia corchorifolia</i>	Bon pat	Shrub	F
131	<i>Sida acuta</i>	Kureta	Herb	F
132	<i>Sida cordata</i>	Pitberela	Herb	F
133	<i>Sida rhombifolia</i>	Berela	Herb	O
134	<i>Triumfetta rhomboidea</i>	Bon okra	Shrub	O
135	<i>Urena lobata</i>	Ban ghagra	Shrub	F
	Family: Mazaceae			
136	<i>Mazus pumila</i>	Tutra	Herb	A
	Family: Meliaceae			
137	<i>Aphanamixis polystachya</i>	Royna	Tree	R
138	<i>Azadirachta indica</i>	Neem	Tree	O
139	<i>Khaya anthotheca</i>	Lombu	Tree	F
140	<i>Melia azadirachta</i>	Gora neem	Tree	F
141	<i>Swietenia mahagoni</i>	Mehagoni	Tree	F
	Family: Menispermaceae			
142	<i>Cissampelos pareira</i> var. <i>hirsute</i>	Kijri/Batulipati	Climber	A
143	<i>Stephania japonica</i>	Akandi manik	Climber	F
144	<i>Tinospora cordifolia</i>	Guloncha	Climber	O
	Family: Menyanthaceae			
145	<i>Nymphoides indica</i>	Panchuli mala	Herb*	F

Sl No	Scientific Name	Bengali Name	Habit	Status
	Family: Molluginaceae			
146	<i>Glinus oppositifolius</i>	Gima shak	Herb	D
147	<i>Glinus radiatus</i> Rohrb.	Gima shak	Herb	O
148	<i>Mollugo pentaphylla</i>	Julpapra	Herb	F
	Family: Moraceae			
149	<i>Artocarpus heterophyllus</i>	Kathal	Tree	O
150	<i>Artocarpus lacucha</i>	Dewa	Tree	R
151	<i>Ficus benghalensis</i>	Bot	Tree	O
152	<i>Ficus heterophylla</i>	Lota dumur	Herb	A
153	<i>Ficus hispida</i>	Kak dumur	Tree	A
154	<i>Ficus racemosa</i>	Jagdumur	Tree	F
155	<i>Ficus rumphii</i>	Khiri bot	Tree	O
156	<i>Streblus asper</i>	Sheora	Tree	F
	Family: Myrtaceae			
157	<i>Eucalyptus camaldulensis</i>	Eucalyptus	Tree	A
158	<i>Psidium guajava</i>	Payara	Tree	O
159	<i>Syzygium cumini</i>	Jam	Tree	F
	Family: Nymphaeaceae			
160	<i>Nymphaea nauchalli</i>	Nil shapla	Herb*	F
161	<i>Nymphaea pubiscens</i>	Shada shapla	Herb*	F
	Family: Onagraceae			
162	<i>Ludwigia adscendens</i>	Keshordom	Herb*	D
163	<i>Ludwigia hyssopifolia</i>	Panipalong	Herb*	D
164	<i>Ludwigia prostrata</i>	Putidol	Herb	F
	Family: Oxalidaceae			
165	<i>Averrhoa carambola</i>	Kamranga	Tree	R
166	<i>Oxalis corniculata</i>	Amrul	Herb	F
	Family: Passifloraceae			
167	<i>Passiflora foetida</i>	Jhumkolota	Climber	R
	Family: Pedaliaceae			
168	<i>Sesamum indicum</i>	Til	Herb	O
	Family: Phyllanthaceae			
169	<i>Phyllanthus emblica</i>	Amloki	Tree	O
170	<i>Phyllanthus niruri</i>	Bhui amloki	Herb	F
171	<i>Phyllanthus reticulatus</i>	Sitka	Shrub	F
172	<i>Phyllanthus urinaria</i>	Bhui amloki	Herb	O
	Family: Piperaceae			
173	<i>Peperomia pellucida</i>	Luchipatta	Herb	O
	Family: Plantaginaceae			
174	<i>Bacopa monnieri</i>	Brahmi shak	Herb	O
175	<i>Limnophila heterophylla</i>	Patakutra	Herb*	O

Sl No	Scientific Name	Bengali Name	Habit	Status
176	<i>Scoparia dulcis</i>	Misridana	Herb	F
	Family: Polygonaceae			
177	<i>Persicaria glabra</i>	Lal kukri	Herb*	O
178	<i>Persicaria hydropiper</i>	Pani bishkathali	Herb*	D
179	<i>Persicaria lapathifolia</i> var. <i>lanata</i>	Lomosh bishkathali	Herb*	A
180	<i>Persicaria orientalis</i>	Baro panimorich	Herb*	A
181	<i>Polygonum plebeium</i>	Khudi biskathali	Herb	O
182	<i>Rumax dentatus</i>	Bon palong	Herb	F
183	<i>Rumex maritimus</i>	Bon palong	Herb	A
	Family: Portulacaceae			
184	<i>Portulaca oleracea</i>	Boro nunia	Herb	O
	Family: Ranunculaceae			
185	<i>Ranunculus sceleratus</i>	Jhumka phul	Herb*	O
	Family: Rhamnaceae			
186	<i>Ziziphus mauritiana</i>	Boroi	Tree	O
	Family: Rubiaceae			
187	<i>Dentella repens</i> var. <i>serpyllifolia</i>	Bhuiapat	Herb	F
188	<i>Dentella repens</i>	Bhuiapat	Herb	A
189	<i>Hedyotis diffusa</i>	Khetpapra	Herb	F
190	<i>Hedyotis racemosa</i>	Bele dana	Herb	O
191	<i>Neolamarckia cadamba</i>	Kadom	Tree	F
192	<i>Oldenlandia corymbosa</i>	Khetpapra	Herb	A
193	<i>Richardia scabra</i>	Kodalia	Herb	O
194	<i>Spermacoce articularis</i>	Madnabata	Herb	F
	Family: Rutaceae			
195	<i>Aegle marmelos</i>	Bel	Tree	F
196	<i>Citrus aurantiifolia</i>	Lebu	Shrub	O
197	<i>Citrus maxima</i>	Jambura	Tree	O
198	<i>Glycosmis pentaphylla</i>	Motkila	Shrub	O
199	<i>Limonia acidissima</i>	Kodbel	Tree	O
	Family: Sapindaceae			
200	<i>Cardiospermum halicacabum</i>	Lota futki	Climber	D
201	<i>Lepisanthes rubiginosa</i>	Chagol nadi	Tree	R
	Family: Solanaceae			
202	<i>Capsicum frutescens</i>	Morich	Herb	A
203	<i>Cestrum nocturnum</i>	Hasnahena	Shrub	R
204	<i>Datura metel</i>	Dhutra	Shrub	R
205	<i>Nicotiana plumbaginifolia</i>	Bon tamak	Herb	F
206	<i>Physalis minima</i>	Kopalphutki	Herb	F
207	<i>Solanum americanum</i>	Kagmachi	Herb	F
208	<i>Solanum indicum</i>	Titbegun	Shrub	O

Sl No	Scientific Name	Bengali Name	Habit	Status
209	<i>Solanum melongena</i>	Begun	Shrub	A
210	<i>Solanum nigrum</i>	Kagmachi	Herb	A
211	<i>Solanum torvum</i>	Titbegun	Shrub	O
	Family: Urticaceae			
212	<i>Pilea microphylla</i>	Lotamoricha	Herb	F
213	<i>Pouzolzia hirta</i>	Hirazolzi	Herb	F
214	<i>Pouzolzia zeylanica</i>	Kullaruki	Herb	D
	Family: Verbenaceae			
215	<i>Lippia alba</i>	Motmoti	Herb	A
216	<i>Phyla nodiflora</i>	Bhuiokra	Herb	F
	Family: Vitaceae			
217	<i>Cayratia trifolia</i>	Angurlota	Climber	F

MONOCOTYLEDONS

Sl No	Scientific Name	Bengali Name	Habit	Status
	Family: Amaryllidaceae			
1	<i>Crinum asiaticum</i>	Goroshun	Herb	R
	Family: Aponogetonaceae			
2	<i>Aponogeton natans</i>	Ghetu	Herb*	F
	Family: Araceae			
3	<i>Colocasia esculenta</i>	Kochu	Herb	A
4	<i>Lemna minor</i>	Sujipana	Herb*	F
5	<i>Lemna perpusila</i>	Khudipana	Herb*	F
6	<i>Pistia stratiotes</i>	Topapana	Herb*	A
7	<i>Spirodela polyrrhiza</i>	Khudipana	Herb*	F
8	<i>Typhonium flagelliforme</i>	Ghechu	Herb	O
9	<i>Typhonium trilobatum</i>	Getkol	Herb	O
10	<i>Xanthosoma sagittifolium</i>	Dudh kochu	Herb	O
	Family: Arecaceae			
11	<i>Areca catechu</i>	Shupari	Palm	R
12	<i>Borassus flabellifer</i>	Tal	Palm	F
13	<i>Cocos nucifera</i>	Narikel	Palm	O
14	<i>Phoenix sylvestris</i>	Khejur	Palm	R
	Family: Cannaceae			
15	<i>Canna indica</i>	Kolaboti	Herb	R
	Family: Comellinaceae			
16	<i>Commelina benghalensis</i>	Kanshira	Herb	F
17	<i>Commelina difusa</i>	Kanshira	Herb	F
18	<i>Commelina longifolia</i>	Panikanshira	Herb	A
19	<i>Murdannia nudiflora</i>	Kanduli	Herb	O
	Family: Cyperaceae			
20	<i>Cyperus cuspidatus</i>	Mutha ghas	Herb	F
21	<i>Cyperus deformis</i>	Behua	Herb	F
22	<i>Cyperus distans</i>	Pani malanga	Herb*	F
23	<i>Cyperus exaltatus</i>	Boromutha	Herb*	D

Sl No	Scientific Name	Bengali Name	Habit	Status
24	<i>Cyperus iria</i>	Borochecha	Herb	F
25	<i>Cyperus michelianus</i>	Sonali mutha	Herb	A
26	<i>Cyperus mindorensis</i>	Muthaghass	Herb	F
27	<i>Cyperus rotundus</i>	Nagarmutha	Herb	A
28	<i>Fimbristylis dichotoma</i>	Dibivagi ghas	Herb	A
29	<i>Fimbristylis schoenoides</i>	Choto fimbri	Herb	F
30	<i>Kyllinga brevifolia</i>	Shabujnirbisa	Herb	A
31	<i>Kyllinga nemoralis</i>	Sada nirbishi	Herb	F
32	<i>Schoenoplectiella juncooides</i>	Chechra	Herb	O
	Family: Hydrocharitaceae			
33	<i>Hydrilla verticillate</i>	Hydrila	Herb*	D
34	<i>Najas graminea</i>	Desi jhaji	Herb*	A
35	<i>Najas minor</i>	Jal jhaji	Herb*	D
36	<i>Ottelia alismoides</i>	Pani kola	Herb*	F
37	<i>Vallisneria spiralis</i>	Patajhajhi	Herb*	O
	Family: Musaceae			
38	<i>Musa balbisiana</i> Colla	Kola	Herb	F
	Family: Poaceae			
39	<i>Alloteropsis cimicina</i>		Herb	O
40	<i>Arundo donax</i>	Boro nal	Shrub	O
41	<i>Axonopus compressus</i>	Chapraghas	Herb	A
42	<i>Bambusa balcoa</i>	Borak bans	Bamboo	O
43	<i>Bambusa tolda</i>	Mitinga bans	Bamboo	O
44	<i>Brachiaria distachya</i>		Herb	D
45	<i>Chrysopogon aciculatus</i>	Premkanta	Herb	F
46	<i>Chrysopogon zizaniodes</i>	Bennaghas	Herb	F
47	<i>Cynodon dactylon</i>	Durbaghas	Herb	A
48	<i>Cyrtococcum oxyphyllum</i>	Champa ghas	Herb	O
49	<i>Dactyloctenium aegyptium</i>	Kakpaya	Herb	O
50	<i>Digitaria sanguinalis</i>	Anguli ghash	Herb	A
51	<i>Dinebra panicea</i> subsp. <i>panicea</i>	Fulka ghas	Herb	O
52	<i>Echinochloa colona</i>	Shama ghas	Herb*	A
53	<i>Echinochloa crus-gall</i>	Barashama ghas	Herb*	D
54	<i>Echinochloa stagnina</i>	Shamaghas	Herb	F
55	<i>Eleusine indica</i>	Gaocha ghas	Herb	F
56	<i>Eragrostis japonica</i>	Jhiri ghas	Herb	F
57	<i>Hygroryza aristata</i>	Jongli dhan	Herb*	O
58	<i>Imperata cylindrica</i>	Songhas	Herb	O
59	<i>Leersia hexandra</i>	Aralighas	Herb*	F
60	<i>Oplismenus burmannii</i>	Choto Gohur	Herb	O
61	<i>Oplismenus compositus</i>	Boro Gohur	Herb	O
62	<i>Oryza sativa</i>	Dhan	Herb	D
63	<i>Panicum repens</i>	Dhani ghas	Herb	F
64	<i>Paspalidium flavidum</i>	Sona ghas	Herb	O
65	<i>Paspalum conjugatum</i>	Paspalum	Herb	F
66	<i>Paspalum scrobiculatum</i>	Paspalum	Herb*	F
67	<i>Pennisetum polystachion</i>	Faular ghas	Herb	F
68	<i>Phragmites karka</i>	Nol	Herb*	A

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69	<i>Rottboellia cochinchinensis</i>	Chulkani ghas	Herb	D
70	<i>Saccharum spontaneum</i>	Kash	Herb	O
71	<i>Sacciolepis indica</i>	Siltatto ghas	Herb*	O
72	<i>Setaria glauca</i>	Shial leza	Herb	A
73	<i>Sporobolus virginicus</i>	Komorer ghas	Herb	F
74	<i>Urochloa mutica</i>	Para ghas	Herb*	A
	Family: Pontederiaceae			
75	<i>Eichhornia crassipes</i>	Kochuripana	Herb*	D
76	<i>Monochoria hastata</i>	Bara nukha	Herb*	A
	Family: Smilacaceae			
77	<i>Smilax zeylanica</i>	Kumari lota	Climber	R
	Family: Typhaceae			
78	<i>Typha elephantina</i>	Hogla	Herb*	O
	Family: Zingiberaceae			
79	<i>Alpinia nigra</i>	Tara	Herb	R