CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION TO WETLANDS

The Earth is composed of various ecosystems, including both terrestrial and aquatic environments. Every ecosystem possesses diverse physical and functional characteristics that support the existence of a wide range of plant and animal species, as well as provide valuable resources for human beings. Wetlands are the most productive ecosystems among aquatic ecosystems, offering a diverse range of ecological, economic, and social advantages [1][2]. Wetlands are regions that include bodies of water, whether they are man-made or natural, permanent or temporary, and encompass marshes, peatlands, fens, floodplains, and similar habitats. The water in wetlands can be either stagnant or in motion. These areas can contain fresh water, brackish water, or saltwater. They may also include marine water that is no deeper than six meters at low tide. Their vegetation and environment are distinct from those found in other landforms or bodies of water. Topography, geology, climate, water chemistry, soil and sediments, and hydrology are the main drivers of wetlands, which influence the functions and processes that in turn affect the ecosystem services [3]. Different types of wetlands provide different ecosystem services due to the significant variations in these drivers. Wetlands provide several ecosystem functions and services, including support of plants and animals, water purification, processing of carbon and other nutrients, water storage, stabilization of shorelines, and most notably food security and climate change mitigation [4]. The crucial wetland ecosystem services include carbon sequestration and storage, especially in peatlands and marine ecosystems [5]. Additionally, wetlands play a vital role in ensuring the provision of safe and dependable supplies of drinking and irrigation water. They also provide numerous goods and services that contribute to food security. Furthermore, wetlands aid in managing water-related disasters, such as droughts and floods. Costanza et al. (2017) [6] reported that wetlands worldwide contribute 40.6% of the total global ecosystem services. So, it is becoming increasingly important to include these frequently overlooked services in wider land management strategies.

The total estimated wetland area in India is 15981516 ha (2017-2018), which turns out to be 4.86 % of the geographic area [7][8]. Since 1982, India has had 82 wetlands designated as Ramsar sites, and its area is 1332739 ha [9]. Globally, wetlands cover an area of 1.2 billion hectares [10], but they are experiencing a rapid decline. Available data indicates that natural wetlands continue to be depleted at a concerning pace, with a global loss of 35% since 1970. Wetlands are currently the most endangered ecosystem, disappearing at a rate three times faster than forests. The primary cause of this decline is predominantly attributed to land-use change, with agriculture serving as the principal driver for degradation. More than 50% of globally significant wetlands are adversely affected by agricultural activities [5]. Moreover, drainage, pollution, invasive species, unsustainable utilization, disrupted flow patterns, and climate change are affecting the quality of the remaining wetlands and wetland ecosystem services.

1.2 PHYSICOCHEMICAL PROPERTIES OF WATER

Water is a vital resource for life on earth, sustaining ecosystems and human activities. The physicochemical properties of the surface waters are dependent on natural factors as well as human interventions [11]. Local and regional variation in drainage basins, precipitation patterns, runoff volumes, weather conditions, and water levels affects the water quality of the water bodies. Seasonal changes in temperature, precipitation, intensity of sunlight, and biological activities also influence the physicochemical properties of water bodies, shaping their ecological balance. These variations include changes in temperature, pH, dissolved oxygen, conductivity, turbidity, and nutrient concentrations. Increased surface temperature increases the temperatures of water bodies, thereby reducing the dissolved oxygen levels. Thus, it enhanced the microbial activity and metabolic rates of aquatic organisms, leading to potential hypoxic conditions. Conversely, colder water often sees increased oxygen solubility and stratification in water bodies, affecting mixing and nutrient distribution [12]. Seasonal precipitation patterns also affect how pollutants and nutrients enter water bodies. Heavy rainfall can lead to increased runoff, carrying sediments, organic matter, and contaminants, thereby elevating turbidity and altering nutrient concentrations [13]. Conversely, dry seasons may concentrate these substances due to lower dilution rates. In aquatic environments, sediments play a role similar to water in transporting nutrients and pollutants. According to McCready et al. (2006) [14] and Chapman and Chapman (1996) [15], sediments can absorb hydrophobic chemical contaminants that enter water bodies. The contaminants eventually return to the water column.

1.3 IMPORTANCE OF MACROPHYTES

Aquatic macrophytes consist of vascular plants, bryophytes, and macroalgae that thrive in aquatic environments. Aquatic macrophytes refer to macroscopic forms of aquatic vegetation, such as macroalgae, mosses, ferns, and angiosperms that are found in aquatic environments. They have undergone evolutionary changes from various distinct groups and frequently exhibit significant adaptability in their structure and morphology in response to changing environmental conditions[16]. Aquatic plants, also known as macrophytes, are an essential component in freshwater ecosystems. These plants grow in or near bodies of water, either on submerged soil or on soil that is saturated[17]. They can be found in different forms, such as emergent, submerged, floating-leaved, and free-floating. Aquatic macrophytes are a well-established field of study in ecological assessments. Macrophytes have developed adaptive mechanisms that enable them to effectively adapt to different environmental conditions and thrive in a wide range of aquatic habitats, such as freshwater bodies, wetlands, watercourses, seasonally flooded areas, swamps, as well as brackish and marine environments[18][19][12].

Macrophytes play a crucial role in aquatic ecosystems, such as ponds, lakes, streams, and rivers. These ecosystems are vital for the villagers' survival and provide them with necessary resources. They have a crucial function in maintaining the biodiversity of freshwater ecosystems by serving as habitats for other aquatic organisms[20][21][22]. But some macrophytes can be used as food and medicine for humans and livestock, especially for marginalized groups[23]. Wetzel's (2001)[12] research highlights that macrophytes can take in nutrients such as nitrogen and phosphorus, which helps reduce eutrophication and control algal blooms. Therefore, macrophytes can serve as effective indicators of water quality, and their presence can improve it by absorbing an excessive amount of nutrients[24]. The absorption of nutrients is essential for preserving the natural balance of aquatic ecosystems. Aquatic macrophytes have a significant physiological role in regulating water bodies by removing mineral nutrients and heavy metals[25][26]. Additionally, they act as indicators for water quality[27]. Scheffer et al. (1993)[28] showed that macrophytes can help keep sediments in place with their roots, which reduces erosion and keeps the water clear. This stabilization process prevents the disturbance and resuspension of sediment, which can have detrimental effects on the quality of water and the survival of aquatic organisms. Moreover, macrophytes in freshwater have the capacity to alter the flow of water, thereby influencing the hydrology and sediment dynamics that are crucial for freshwater ecosystems[29].

1.4 ROLE OF WETLANDS IN CLIMATE CHANGE

In relation to climate change, wetlands play a significant role in carbon sequestration by converting carbon dioxide into organic matter by plants through photosynthesis and storing and regulating water. Because of their vegetation, deposition of organic matter through rivers, streams, and other inlets, and waterlogged conditions, wetlands are suitable for storing more carbon than other landforms on earth. With only about 4-6% (7 to 9 million km^2) of the earth's land area, wetlands store about one-third of the soil organic carbon pool of the world[30]. About 44.6 million tonnes of carbon are stored in wetlands per year globally, and carbon buried in sediments may be as high as 50 times that of land sinks[31]. Numerous tidal wetlands' capacity to sequester carbon and reduce the flow of methane from tidal sediments has prompted the support of blue carbon projects meant to improve such mechanisms. "Blue Carbon" refers to the carbon sinks in the sea, water, and coast that the representative sediments and flora maintain. As the important carbon sequestration zones of wetlands are being depleted rapidly, there is a release of carbon dioxide, methane, and nitrous oxide, increasing their concentration in the atmosphere, which leads to climate change. Because of their potential to store and emit greenhouse gases, proper conservation and management of wetlands should be featured as a high priority for initiatives to mitigate climate change.

Wetland ecosystems face significant threats resulting from human activities, including climate change, altered watercourses, changes in land use within the surrounding area, pollution, eutrophication (caused by runoff from agricultural, industrial, or urban areas), and the invasion of invasive plant species. Likewise, various threats such as pollution, habitat degradation, invasive species, unsustainable resource exploitation, and climate change endanger the diversity and survival of macrophytes, thus significantly affecting delivery ecological functions in freshwater ecosystems. Hence, it is imperative to enhance our understanding of the ecology and management of macrophytes to address threats to freshwater and protect and restore aquatic habitats[32].

As mentioned above, wetlands are widely recognized as one of the most productive and ecologically important ecosystems on Earth. Analyzing wetland ecosystems, specifically their physicochemical properties, is crucial for the preservation of biodiversity, the enhancement of water quality, the mitigation of climate change, and the improvement of ecosystem services. Researchers have conducted several investigations to examine the structural and functional changes in wetlands in India. Various studies have been conducted on different characteristics and values of wetlands in India (Pant et al., 1985[33]; Pimparkar et al., 2023[34]; Bassi et al., 2014[35]; Bobdey 2014[36]; Chandra et al., 2010[37]; Dar et al., 2021[38]; Siraj et al., 2023[39]; Das and Pandy 1978[40]; Sharma et al. 2010) [41] as well in northeast India (Kangabam et al., 2016[42]; Roy and Majumder 2017[43]; Sharma et al., 2013[44]; Laishram and Dey, 2014[45]; Khwairakpam et al., 2001[46]; Devi, 1998[47]; Singh et al., 2011[48]; Usha et al., 2010)[49]. However, such studies focus on a singular aspect of the physical, chemical, and biological components of the wetlands. However, despite having many reports, there is no extensive and specific ecological study that has documented specific information about the wetlands of northeast India concerning seasonal variation on carbon stock, physico-chemical properties of water, diversity of flora and fauna, and habitat alterations. An integrated study to comprehend the holistic characteristics and dynamics of the wetlands is very limited in northeast India, in Manipur. Therefore, an attempt has been made to study Loktak Lake in Manipur, northeast India, to minimize the existing gaps in knowledge in regard to the structure and functional dynamics of the wetlands. The current study aims to comprehensively investigate the different characteristics of Loktak Lake, including its physicochemical properties of water, carbon stock, diversity of macrophytes, and changes in land use and land cover.

1.5 OBJECTIVES OF THE STUDY

The objectives of the study are as follow:

1. Seasonal changes in physicochemical properties of water of Loktak Lake.
2. Estimation of total carbon stock in sediment of Loktak Lake.
3. Seasonal variation in density and abundance of macrophyte species in Loktak Lake.
4. Decadal changes in the area of Loktak Lake over a time period using satellite imageries.

Studying several characteristics of the wetland of Loktak Lake of Manipur at different temporal and spatial scales is essential to understand how their seasonal changes affect the physical and chemical properties of water, sediments, and the amount of carbon stored in them, as well as how the plant and animal life responds to these alterations. The study's outcome would significantly contribute to formulating the conservation strategies for proper management, policymaking, and wetland sustainability. Moreover, the findings will provide scope to explore the relationships between variables and how they influence each other in maintaining the wetland ecosystem. Thus, this research has the potential to establish the basis for well-informed decision-making and efficient conservation strategies, ensuring the sustainability of these vital ecosystems for future generations.

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