ISSN: 2287-688X

Annals of
Plant Sciences

Volume 14, Issue 09 (2025) pp. 6951-6965

Review Article

Ecological Significance, Emerging Challenges and Conservation Strategies for Samaspur Wetlands in RaeBareli, Uttar Pradesh

Prateek Srivastava, Sabiya Shariq, Medha Gautam, and Prishita Singh

Department of Botany, University of Allahabad, Prayagraj, India, 211002

Abstract

Wetlands are critical ecosystems that provide biodiversity support and essential ecological services such as groundwater recharge, carbon sequestration, and habitat for diverse species. The Samaspur Wetland in Rae Bareli, Uttar Pradesh, designated as a Ramsar Site in 2019, harbors more than 250 species of resident and migratory birds, including globally threatened taxa, along with diverse fish and aquatic vegetation. It also sustains local livelihoods through fishing, agriculture, and eco-tourism. However, the wetland faces severe threats from pollution, overfishing, invasive species, agricultural runoff, grazing, and urban expansion. This review emphasizes Samaspur ecological significance, identifies emerging challenges, and proposes integrated conservation strategies involving ecological monitoring, community participation, and policy enforcement

Keywords: *Wetlands • Carbon sequestration • Ramsar • Eco-tourism • Conservation.*

Introduction

Wetlands are among the most productive ecosystems on Earth, providing a wide range of ecological services vital to human well-being. They play key roles in water purification, flood regulation, carbon sequestration, biodiversity conservation, and livelihood support (Costanza *et al.,* 1997; de Groot *et al.,* 2012). Recognized as integral to the Sustainable Development Goals (SDGs), wetlands contribute to climate regulation, carbon storage, and biological conservation (Moomaw *et al.,* 2018; Zhao *et al.,* 2025). The Ramsar Convention defines wetlands broadly, encompassing both natural and artificial ecosystems such as peatlands, rivers, lakes, aquifers, marshes, mangroves, rice paddies, coral reefs, and coastal lagoons (Aber *et al.,* 2012). Their transitional position between terrestrial and aquatic systems and unique hydrology make them biodiversity hotspots and regulators of ecological balance (Mitsch *et al.,* 1995; Arya *et al.,*2020). Importantly, wetlands absorb large amounts of atmospheric CO_2, thereby mitigating global climate change (Anderson *et al.,* 2016; Villa *et al.,* 2018).

Globally, wetlands occupy about 12.1 million km² but contribute to more than 40% of the total global ecosystem service value (Costanza *et al.,* 2014). Despite this significance, nearly 35% of wetlands have disappeared since 1970 due to anthropogenic activities and natural pressures (Ramsar Convention on Wetlands, 2018; Darrah *et al.,* 2019). In India, wetlands cover around 4.63% of the geographical area but remain under severe threat from agricultural expansion, dam construction, encroachment, pollution, grazing, and unplanned urbanization (Ramachandra *et al.,* 2012; Sharma *et al.,* 2022). Recognizing their vulnerability, India became a signatory to the Ramsar Convention in 1982 and has since designated several ecologically important sites as Ramsar wetlands.

Among these, Samaspur Wetland, located in Rae Bareli district of Uttar Pradesh, holds ecological and conservation value. Covering about 799 hectares, it includes six associated lakes—Mamni, Gorwa-Hasanpur, Nakganj, Rohinia, and Bisaiya Choti—which have been demarcated as a bird sanctuary by the state government under the National Wetland Conservation Programme of the Ministry of Environment and Forests (MoEF). The Gangetic plains, where the wetland lies, are characterized by alluvial soil rich in humus, while the surrounding regions have sandy, saline soils. The wetland is perennial, with water depth ranging between 0.1 and 5 m, and is highly alkaline. Local farmers utilize its waters for irrigation, often resulting in eutrophication from

***Corresponding Author:**
Prateek Srivastava;

DOI: 10.5281/zenodo.17314052.

agricultural runoff. Seasonal extremes in temperature, from 46 °C in summer to 5.5 °C in winter, further shape its ecology (Behera *et al.,* 2012). Figure 1 illustrates the distribution of Ramsar sites at multiple scales. Panel (A) shows Ramsar sites across the world, highlighting their global importance. Panel (B) focuses on India, depicting the 91 designated sites and their geographic spread. Panel (C) presents Ramsar sites within Uttar Pradesh, emphasizing regional wetland conservation. Finally, panel (D) provides a detailed view of Samaspur Wetland, one of the state's key Ramsar sites, showcasing its location and extent. This figure underscores the hierarchical significance of wetlands from global to local levels. (*Wetlands of India portal 2025*)

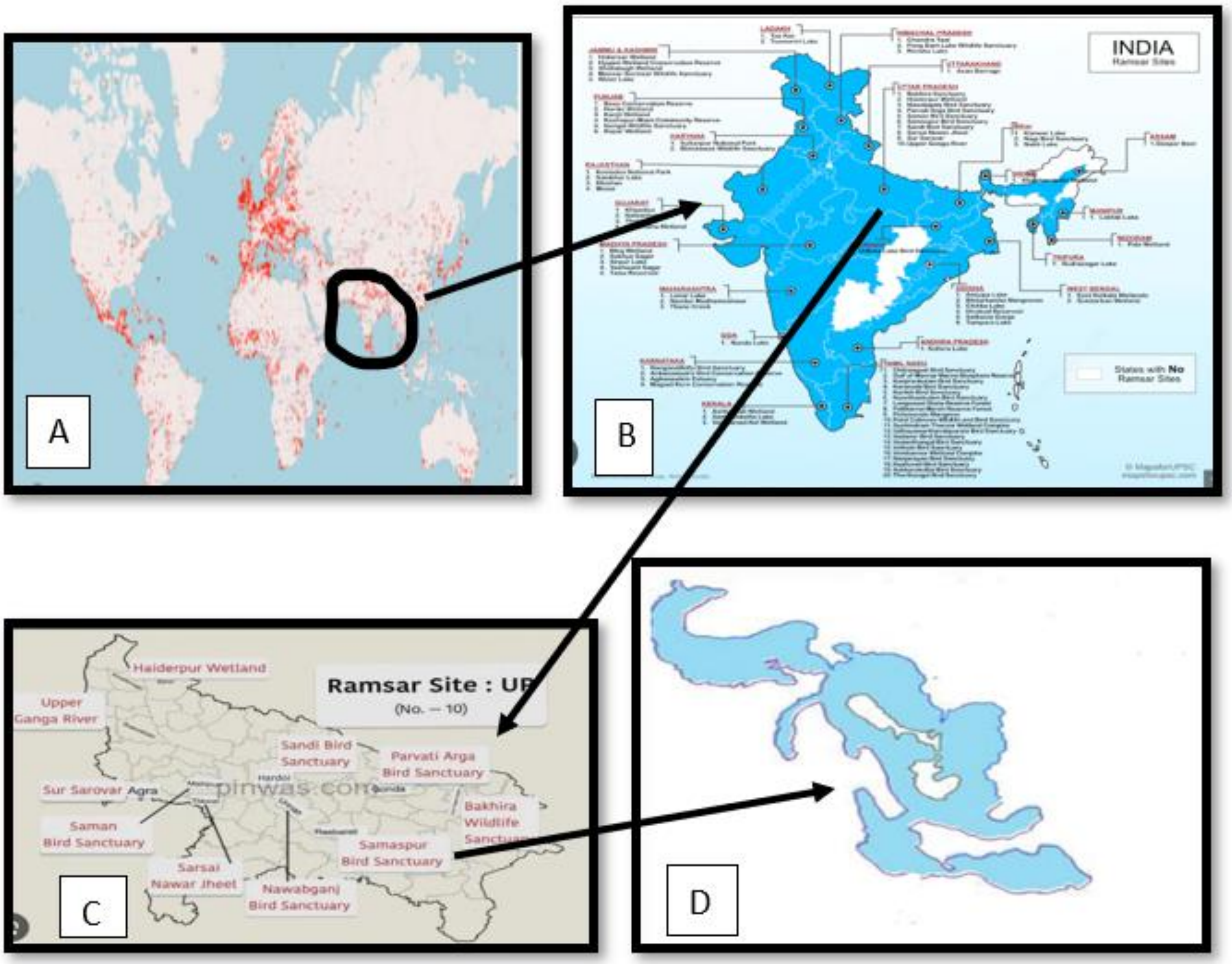

Fig1: RAMSAR SITES:-(A) Ramsar sites: World, (B)Ramsar sites: India, (C) Ramsar sites: Uttar Pradesh and (D) Samaspur wetland (UP)

Samaspur was declared a Ramsar Site in 2019 owing to its rich biodiversity and its role as a critical habitat for more than 250 species of resident and migratory birds, including globally threatened species (Ramshida & Reddy, 2025). It also supports diverse fish populations, aquatic vegetation, and provides livelihood opportunities for nearby communities through fishing, agriculture, and eco-tourism. Fig 2, shows the ecosystem services provided by Samaspur wetland.

However, like many wetlands in India, Samaspur faces multiple threats that undermine its ecological character. Encroachment, agricultural runoff, siltation, overfishing, excessive grazing, and pollution from surrounding villages have significantly altered its natural balance (Jha, 2015). Tourism pressure and climate variability further intensify these problems, leading to habitat degradation and declines in bird populations. Critical concerns such as poaching of birds and submergence of adjacent agricultural land during flooding have also been reported (Korgaonkar & Gokhale, 2007). Moreover, inadequate management interventions and limited local awareness have hindered effective conservation.

Addressing these challenges requires an integrated management approach. Strategies must combine ecological monitoring, habitat restoration, community participation, and strict policy enforcement (Jha, 2015). The Ramsar Strategic Plan (2016–2024) offers a global framework for combating wetland degradation; however, its success at Samaspur depends on site-specific interventions that balance biodiversity conservation with the livelihood needs of local communities (Davidson *et al.,* 2018; Gardner & Davidson, 2011).

This review therefore synthesizes current knowledge on Samaspur Wetland's ecological importance, conservation challenges, and potential strategies. By identifying site-specific pressures, management gaps, and adaptive approaches, it underscores the urgent need for collaborative action to ensure the long-term sustainability of this ecologically and socially significant Ramsar Site.

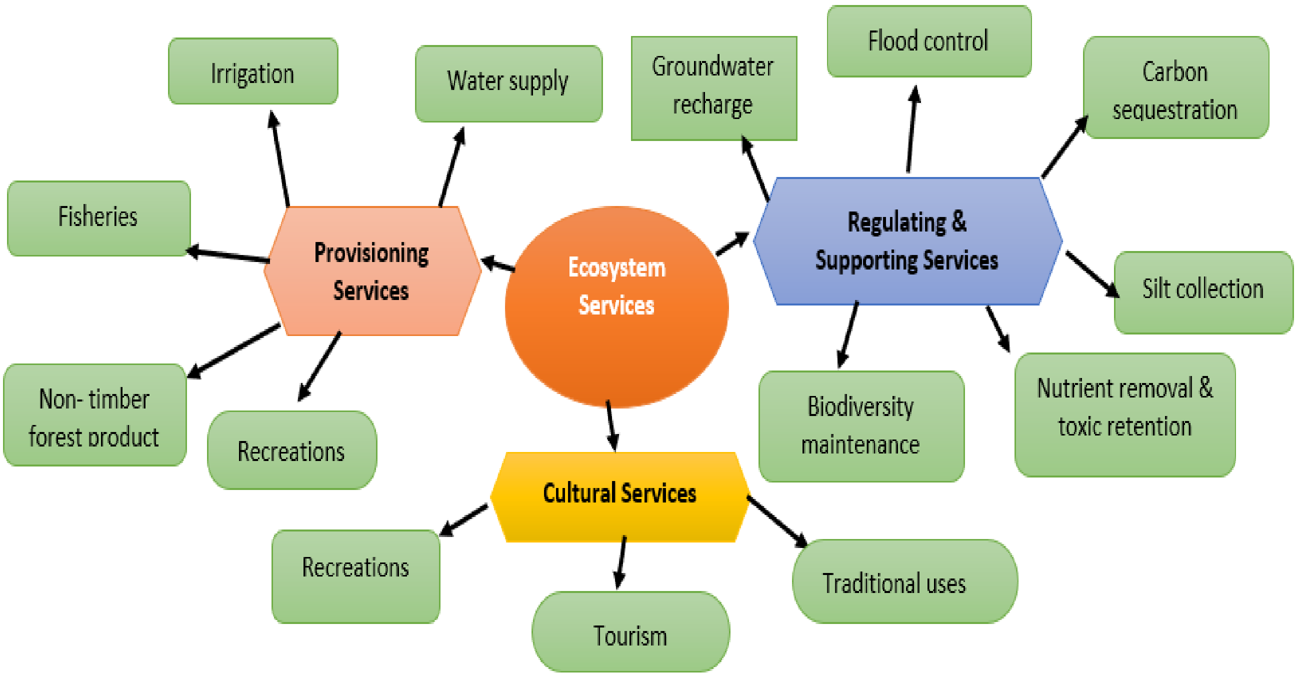

Fig 2: Shows the Ecosystem Services of Wetlands

Ecological Importance of Samaspur Wetland

Samaspur wetland is one of the most productive ecosystems of our environment. They play crucial role maintain of ecological balance and provide many ecological services like flood control, water filtration, carbon sequestration, ground water recharge and serve as biodiversity hotspot (Farheen at el., 2022). It was declared as a Ramsar site because of its significance as the wetland of international importance especially for waterfowl and other aquatic birds. This sanctuary lies between 25° 58' to 26° 01' N (Kumar and Kanaujia., 2015). This sanctuary is one of the largest centers for bird migration, especially during the winter season, stretching from November to March, when about 100,000 migratory birds, including species from Siberia and Tibet, flock into the sanctuary in large numbers, making it a popular destination for bird enthusiasts and tourists (Sahu *et al.,* 2022). As shown in Figure 3, wetlands like Samaspur serve as biodiversity hotspots and play a crucial role in maintaining ecological balance

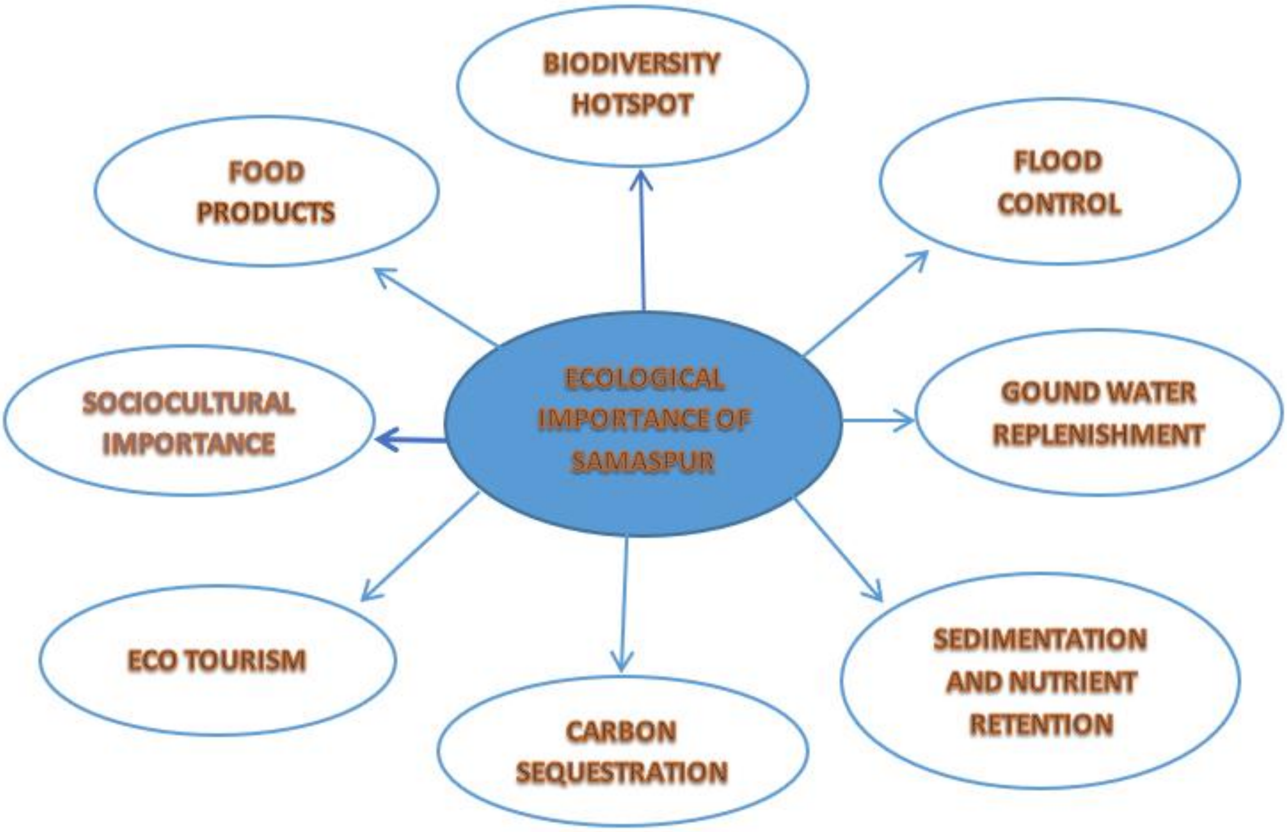

Fig: 3 Show ecological importance of Samaspur wetland

Biodiversity

Samaspur Wetland provides diverse habitats supporting rich flora and fauna, especially migratory birds. It is a biodiversity hotspot, hosting 149 higher plant species, 46 fish species, over 250 resident and migratory bird species, and numerous invertebrates such as molluscs and butterflies, as well as terrestrial and aquatic animals like snakes, turtles, frogs, and mammals including the blue bull (Ramshida & Reddy et al., 2025)

The bird sanctuary includes 78 species from 22 families (Kumar & Kanaujia, 2015). IUCN Red List analysis identifies the Sarus crane as Vulnerable (V), Darter, Painted Stork, Black-necked Stork, Black Ibis, and River Tern as Near Threatened (NT), while White Wagtail and Large Pied Wagtail are Not Assessed (NA), and the remaining species are Least Concern (LC).

Macrophytes play a crucial role in water purification, nutrient cycling, and heavy metal sequestration through phytoextraction, phytotransformation, and rhizofiltration (Singh *et al.,* 2025). Floating vegetation like *Eichhornia crassipes*, *Ipomoea*, and *Typha*, along with grasslands, crops, mixed trees, and *Prosopis juliflora*, enhance biodiversity and ecosystem stability (Lan *et al.,* 2010). Samaspur Lake shows a Simpson diversity of 0.85 and Margalef Diversity Index of 1.09–1.58 (Dubey *et al.,* 2022).

The wetland supports the hydrological cycle and provides ecosystem services including flood control, groundwater recharge, water purification, climate regulation, erosion control, and recreational opportunities, with fish diversity sustaining aquatic food webs, emphasizing its ecological and conservation significance (Millennium Ecosystem Assessment, 2005).

Importance Of Wetland in Flood Control

Heavy or prolonged rainfall reduces water infiltration and increases surface runoff, often leading to flooding, which can harm both the economy and ecological balance (Li & Cai, 2002; Acreman & Holden, 2013). Wetlands play a critical role in mitigating floods by absorbing excess water, lowering surface runoff, and reducing river discharge. Their function is often compared to that of a sponge, as they store water during rainy periods and gradually release it during dry spells (Bucher *et al.,* 1993; Yan *et al.,* 2020).

Conservation of wetlands has been promoted by organizations such as IUCN and Wetlands International as an effective flood-control strategy (Davies & Claridge, 1993). However, studies report varying effects of wetlands on flood regulation. While many demonstrate significant flood reduction, others suggest negligible impact, and some even indicate wetlands may exacerbate flooding under certain conditions (Acreman & Holden, 2013). These discrepancies arise due to differences in wetland types, hydrological characteristics, locations, and management practices. Even similar wetlands can act as sinks or sources of floodwater depending on site-specific features.

Thus, the flood-mitigating capacity of wetlands is context-dependent, emphasizing the need for site-specific conservation and management strategies to optimize their ecological services and maintain hydrological stability.

Role of Wetlands in Groundwater Replenishment

Groundwater replenishment may occur naturally or by anthropogenic activities like the construction of basins or wells. The natural methods include localized or diffuse-type recharges. In diffuse recharging, the water-level rise occurs as a result of precipitation, while in localized recharging, the water-level rise occurs as a result of drainage from surrounding wetlands (Alley, 2009). The changes in land use may increase or decrease the surface runoff from nearby lands to the wetlands which affect the water level and groundwater recharge property of the wetlands (Van der Kamp & Hayashi 1998).

Role of Wetlands in Sediment and Nutrient Retention

Sedimentation in wetlands involves the deposition of particulate matter on the soil surface, which is absorbed by wetland flora. Through decomposition, these nutrients return to the soil, while plant litter supports microbial activity, enhancing nutrient cycling (Johnston, 1991). Wetland soils are highly variable in texture and organic content, and water serves as the main medium for transporting sediments and nutrients into and out of the system. Anthropogenic sources, such as agricultural runoff and household discharges, contribute more sediments and nutrients than groundwater or precipitation (Reed, 1995).

Sedimentation improves water quality by reducing turbidity, retaining phosphorus, and increasing marsh surface elevation through sediment deposition and root growth (Penland & Ramsey, 1990; Cahoon *et al.,* 1999). Wetlands act as storage ecosystems, trapping sediments and nutrients that would otherwise flow downstream. Their retention capacity depends on hydrology, sediment distribution, and nutrient inputs. Receiving materials from surface runoff, groundwater, and atmospheric deposition, wetlands maintain high nutrient retention (Johnston, 1991). Wetland plants absorb nitrogen and phosphorus in various forms for growth and release them back into the water upon decomposition (Silvan *et al.,* 2005), highlighting their essential role in nutrient regulation, water purification, and ecosystem stability.

Role of Wetlands in Water Purification

Wetlands play a vital role in water purification by removing pollutants carried from urban and agricultural areas, including fertilizers, pesticides, oils, soil particles, and road salts. This is achieved through sediment trapping, chemical detoxification, and nutrient removal, which improves water quality (Scholz, 2010). Wetlands can also be utilized for wastewater treatment, providing a sustainable method to recycle water, protect the environment, and safeguard human health (Vymazal, 2014). Artificial wetlands, designed as integrated systems of soil, plants, and microorganisms, can treat wastewater effectively. Their efficiency depends on design, plant and microbial composition, and local climatic conditions (Vacca *et al.,* 2005; Picek *et al.,* 2007). Studies show that wetlands can remove significant amounts of heavy metals—55% Cr, 25–35% Ni, 25–87% Zn, 9% Cu, 33% Cd, and 75% Co—as well as reduce bacterial loads by 1–6 log units (Arroyo *et al.,* 2010; Pedrero *et al.,* 2010; Feigin *et al.,* 2012). Properly maintained artificial wetlands are thus highly effective for secondary and tertiary wastewater treatment and reuse.

Wetland Products

Wetlands provide numerous economically important resources that support the livelihoods of rural communities and offer benefits to people living farther away. They play a crucial role in maintaining biodiversity while supplying a range of goods and ecosystem services (Ramachandra *et al.,* 2011). One of the most fundamental wetland products is freshwater, which feeds wells, dams, and springs, serving household, livestock, and irrigation needs. Tangible benefits include water, food resources, building materials, and handicrafts, while intangible benefits encompass water purification, flood regulation, groundwater maintenance, climate moderation, and storm protection (Karanja *et al.,* 2001; Kakuru *et al.,* 2013). Wetlands also provide habitats for diverse flora and fauna, harbor medicinal plants, and hold aesthetic, cultural, and heritage value. By retaining nutrients and supporting productive ecosystems, wetlands indirectly contribute to food security and agricultural productivity, underscoring their vital socio-economic and ecological significance (Wetlands Management Department, 2009).

Sociocultural Values of Wetlands

Cultural ecosystem services arise from human–nature interactions and are context-specific (Fish *et al.,* 2016; Bryce *et al.,* 2016). Wetlands support human livelihoods through activities such as transportation, fishing, farming, energy production, and water supply, while also providing important intangible benefits. They influence social well-being, help alleviate poverty, and offer opportunities to study ecological processes like nutrient cycling, plant succession, and community interactions (Millennium Ecosystem Assessment, 2005; Verschuuren, 2012). Spiritual and aesthetic values further enhance human connections with nature, as wetlands inspire reverence and cultural identity. These functions underscore wetlands' multifaceted role in sustaining both ecological and sociocultural systems.

Wetlands in Relation to Recreation and Tourism

Environment-based recreation, a growing segment of tourism, is closely linked with wetlands, particularly activities like bird-watching, boating, fishing, and hiking. Wetlands' aesthetic appeal attracts nature enthusiasts, artists, and writers who capture their scenic beauty through various media. A survey of 11 protected areas in India indicated that wetland tourism has grown at an average rate of 15%, with 80% of visitors being domestic, highlighting ecotourism's rising significance (Karanth & Defries, 2011). Enhancing aesthetic and recreational value involves habitat conservation, flora and fauna protection, and landscape management, which collectively boost tourist attraction and support sustainable wetland use (Pueyo-Ros *et al.,* 2016).

Challenges Or Threats for Samaspur Wetland

When wetlands receive the necessary amount of water for a minimal amount of time, the soils, microorganisms, and plant and animal populations are remained intact, ensuring that the functional balance is maintained. Wetland communities have been affected by surface water changes and rising temperatures. Changes in land use must have had a variety of effects on the wetlands' water spread areas and, consequently, the local climate. In addition to causing eutrophication, excessive fertilizer use in agricultural regions around Samaspur wetlands has also made it easier for weed species to proliferate (Bahera at el., 2012). The framework of threats and challenges of wetland is summarized in Figure 4.

Urbanization and land use change

Rapid population growth has placed severe pressure on wetlands and floodplains to meet rising water and food demands. Between 1950–51 and 2008–09, India's cultivated land expanded from 129 to 156 million ha, while non-agricultural land use increased from 9 to 26 million ha, largely at the cost of floodplains, forests, grasslands, and freshwater ecosystems (Indiastat; Zhao *et al.,* 2006). For instance, about 34,000 ha of Kolleru Lake, Andhra Pradesh, have been reclaimed for agriculture (MoEF, n.d.). India has built 276 major and 1,000 medium irrigation projects with a storage capacity of 225 BCM. Though reservoirs supply water, irrigation, and power, unplanned construction, especially in arid regions, causes habitat loss, fragmentation, and reduced environmental flows (Kumar *et al.,* 2008; Zhao *et al.,* 2006). Many river basins in southern and western India now suffer environmental water scarcity (Smakhtin *et al.,* 2004). Poor water management, pollution, and rising demands further threaten these vital ecosystems (Bănăduc *et al.,* 2022).

Fig 4. Shows the threats and challenges for Samaspur wetland

The details of the challenges facing wetlands are provided below:

Agricultural, municipal, and industrial pollution

Due to industrial and municipal wastewater discharges, as well as agricultural runoff of fertilizers and pesticides, the water in the majority of Asian rivers, lakes, streams, and wetlands has been severely degraded, resulting in widespread eutrophication (Liu and Diamond, 2005, Prasad *et al.,* 2002). As a result of intensification of agricultural activities over the past four decades, fertilizer consumption in India has increased from about 2.8 million tonne in 1973–1974 to 28.3 million tonne in 2010–2011 (Data Source: Indiastat). As per estimates, 10–15% of the nutrients added to the soils through fertilizers eventually find their way to the surface water system (Indian Institute of Technology, 2011). High nutrient contents stimulate algal growth, leading to eutrophication of surface water bodies.

Alien species invasion

Invasive alien species (IAS) are considered one of the major threats to native biodiversity (Reddy, 2008). Aquatic weeds are capable of flourishing in continuously wet environments and can withstand waterlogged soils for prolonged periods. The scientific name for water hyacinth is Pontederia crassipes Mart. (Syn. Eichhornia crassipes (Mart.) Solms), belongs to the family Pontederiaceae *(POWO 2025*). 15575036 KEYWORDS Invasion remote sensing wetland change monitoring Samaspur Bird Sanctuary 100 worst IAS due to its ability to grow uncontrollably and cause serious ecological problems (Patel, 2012; Degaga, 2018). The uncontrolled expansion of water hyacinths leads to the formation of dense mats that block sunlight, reduce oxygen levels, disrupt photosynthesis, obstruct water flow, and compete with native species in aquatic habitats. The disrupted water flow affects both the quality and quantity of water, thereby impacting transportation and fishing activities. This reduces the abundance and diversity of the macrophyte community (Mengistu *et al.,* 2017).

Illegal fishing

There is a very good population of fish kinds in the sanctuaries because nearly all of them are carefully protected.The locals are tempted into illegal fishing for their consumption as well as occasional earning. There have also been reports of illegal fishing by residents of the communities that surround Samaspur Sanctuary.Despite constant vigilance by the forest department in Bakhira Sanctuary incidents of illegal fishing are reported and over 6,000 boats operate in this area. The fishing method is traditional and includes capturing fish using pointed sticks (Singh *et al.,* 2011).

Loss of migratory bird population

It was declared as a Ramsar site because of its significance as the wetland of international importance especially for waterfowl and other aquatic birds (Ramshida & Reddy 2025) but as a result, maintaining and managing the sanctuary has grown to be a very challenging task. Approximately one lakh birds flock here annually throughout the winter from places like Siberia. However, over the past eight to ten years, the percentage of visiting birds has dropped to just one-fourth (Korgaonkar & Gokhale., 2007).

Water drainage for irrigation

Due to a lack of food in dried-up wetlands, birds are forced to relocate when water bodies dry up early. This condition arises in Vijay Sagar Sanctuary very frequently because water is drained from the wetland for irrigation of private fields. Surhatal is another sanctuary where drainage of water for irrigation is very common (Islam & Rahmani 2004).

Over Grazing

There are no grazing grounds in the villages surrounding the lakes. So, the cattle in these villages graze in the surrounding area of the sanctuary. Cattle of some villagers also come in the main campus of the sanctuary. Apart from this, the villagers who own lands inside the sanctuary take their cattle to their lands for grazing. Most of the times, such cattle are found grazing in the forestland of the sanctuary. But the forest department does not recognize this as a threat to the sanctuary. Due to limited staff, monitoring such activities also becomes very difficult. Such grazing causes soil erosion in the lands surrounding the lakes, which enhances the siltation of lakes.

Conservation Measures

Ramsar status recognition

Wetlands are among the world's most productive ecosystems, providing essential services such as food, carbon sequestration, flood regulation, groundwater recharge, and habitat for wildlife (Ghermandi *et al.,* 2008; Ballut-Dajud *et al.,* 2022; Yan *et al.,* 2020; Díaz *et al.,* 2012; Kingsford *et al.,* 2016; Lucke *et al.,* 2019). Vegetation in wetlands is utilized for agriculture, construction of mats and houses, as wildlife refuge, and as a food source (Verhoeven *et al.,* 2010; Gray *et al.,* 2013; MOEFCC). Wetlands are areas that are periodically or permanently inundated or saturated with water. The IUCN (1965) defines them as lands with static or flowing water, fresh, brackish, or saline, including marine areas up to six meters deep at low tide. The Ramsar Convention (1971) similarly defines wetlands as natural or artificial areas with water, temporary or permanent. A modified Ramsar/IUCN definition suitable for remote sensing includes all submerged or water-saturated lands, inland or coastal, vegetated or non-vegetated, with a land-water interface (MoSPI, 2023; Mehta *et al.,* 2023).

Ramsar Convention

The Ramsar Convention, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty that provides a framework for the conservation and sustainable use of wetlands through national and international cooperation. It is the only multilateral environmental agreement dedicated specifically to wetlands. The Convention's mission is to promote wise wetland use, designate sites of international importance (Ramsar List), and foster cooperation on transboundary wetlands and shared species (Panini, 1998). India became a party on 1 February 1982 and currently has 91 Ramsar Sites, including freshwater lakes, marshes, mangroves, estuaries, and high-altitude wetlands, ranking third globally (RIS, 2023). The Montreux Record highlights Ramsar sites facing ecological threats due to human activities, prioritizing them for conservation without removing them from the Ramsar List. Two Indian wetlands are currently listed, while Loktak Lake, Keoladeo National Park, and Chilika Lake were removed in 2002 following successful restoration efforts (Mirzajani *et al.,* 2025).

Ministry of Environment and Forests of Indian Government

Each year, around 100,000 migratory birds from Siberia and Tibet visit Samaspur Wetland (Nov–Mar), making it a hub for tourism and birdwatching. Owing to its ecological importance, it was included in India's national wetland protection program (Kumar & Kanaujia, 2015). Wetlands sustain biodiversity, regulate water and climate, buffer disasters, and support livelihoods, yet their degradation threatens both ecology and human survival (Farheen *et al.,* 2022; Kanaujia & Sunita, 2025). Recognized globally under the Ramsar Convention (1971), wetlands function as sponges by storing stormwater, preventing floods, and releasing water in dry periods (Isaac *et al.,* 2025; Johnson *et al.,* 2004). They act as carbon sinks, are climate-sensitive (IPCC, 2001), and support over 40% of global biodiversity, with over 25% of species at risk of extinction (Sahu *et al.,* 2022).

Invasive species removal campaigns

A survey of Samaspur Bird Sanctuary wetlands (Rae Bareli, Uttar Pradesh) recorded 149 higher plant species across 129 genera and 60 families, dominated by Poaceae (28 species). Plants were classified into nine morpho-ecological groups, with planted species (48), dry bank species (46), and hydrophytes (38) contributing most. Alien species accounted for 41.6% of naturally occurring flora, and invasive weeds such as *Eichhornia crassipes*, *Typha angustata*, *Prosopis juliflora*, and *Ipomoea carnea* threaten native diversity and water bodies, underscoring the need for urgent conservation (Kohli *et al.,* 1995; Reddy *et al.,* 2009).

Community awareness & livelihood diversification

Public awareness initiatives are best assessed through biological indicators, behavioral benchmarks, and robust statistical approaches such as BACI or Bayesian analysis to evaluate the campaign. Research should prioritize replicability, long-term consistency, and transparent reporting. Importantly, even unsuccessful campaigns need to be published and critically reviewed to strengthen future designs and reduce bias caused by reporting only positive outcomes (Haley *et al.,* 2023).

Research & monitoring needs

Wetlands are highly productive systems that deliver a wide range of benefits, yet their complexity and dynamic nature make them difficult to monitor remotely. Key challenges include the lack of a distinct land-cover identifier, constantly shifting energy signals, and narrow ecotones that often fall below sensor resolution (Chasmer *et al.,* 2020). To tackle these issues, a special issue on wetland remote sensing addressed three main questions: (1) what new methods and data products are being created for broad-scale, long-term monitoring, (2) which emerging technologies and multisensory strategies can enhance detection accuracy, and (3) How long-term remote monitoring can reveal changes linked to land use, land cover, and climate shifts (Gallant *et al.,* 2015).

Gaps in Current Management

Although Samaspur Bird Sanctuary is recognized as a Ramsar-quality wetland and earlier surveys document rich flora and waterbird assemblages, there are several important knowledge gaps. Specifically,

I. The spatial-temporal dynamics and drivers of invasive macrophytes remain poorly quantified **(**Reddy *et al.,* 2009**).**
II. Continuous water-quality and eutrophication trends are lacking, (Ramsar Information Sheet (RIS) — Site no. 2415, Samaspur Bird Sanctuary (Rae Bareli)
III. Recent standardized multi-taxon biodiversity baselines are absent (Ramshida *et al.,* 2025**).**
IV. The hydrological connectivity and climate-vulnerability of the six lakes have not been modelled (Jha, 2015).
V. There is limited rigorous evaluation of past management interventions and governance out-comes. (Kanaujia *et al.,* 2007).
VI. Wetlands should be maintained, should reduce the rate of pollution, should control the entry of exotic species, and should protect the wetland biodiversity and integrity.

If we conserve in this way, the wetlands will continuously provide the major ecosystem services under the changed climatic conditions also (Kusler 2000). In Samaspur Wetland Bird Sanctuary, out of the total 800 hectares, nearly 370 hectares fall under private and community ownership. This division of land has made the management and conservation of the sanctuary highly challenging, particularly concerning boundary-related issues (Korgaonka *et al.,* 2007). Addressing these gaps will enable evidence-based restoration and sustainable livelihood planning for Samaspur.

Future Recommendations

Conserving and restoring wetlands require integrated ecological, technological, and community-based strategies. Key restoration measures include controlling invasive species, adding uncontaminated sediment layers, seeding and planting native vegetation, maintaining ecological processes, and implementing long-term monitoring of water quality and biodiversity (Ehrenfeld, 2008; Spinelli *et al.,* 2017; Berkowitz *et al.,* 2017; Hoag, 2000; Behera *et al.,* 2012).

Urban expansion and farmland demand have led to wetland loss, groundwater depletion, and soil salinization, converting productive areas into fragile, unproductive landscapes (Madheshiya *et al.,* 2025). Effective conservation must prioritize ecological restoration, efficient water management, and soil treatment to sustain both ecological and socio-economic functions.

Advanced tools such as UAV-based surveys, hyperspectral imaging, and automated real-time monitoring systems with predictive modelling can enhance species mapping, early threat detection, and adaptive management (Ramshida & Reddy, 2025).

Successful conservation also depends on multi-stakeholder collaboration among government agencies, NGOs, and local communities. Cross-sector efforts forestry for Sarus crane monitoring, tourism for minimizing disturbances, agriculture for reducing chemical use, and education for awareness building will strengthen wetland protection. Protecting migratory birds and practicing sustainable management ensures long-term ecological stability and continued socio-economic benefits (Kumar *et al.,* 2015; Zhou *et al.,* 2023).Wetlands directly and indirectly support many of the United Nations Sustainable Development Goals (SDGs) because of their role in biodiversity conservation, water purification, climate regulation, and livelihood support (Kundu, *et al.,*2024).

Conclusion

Samaspur Wetland, a designated Ramsar Site in Uttar Pradesh, exemplifies the ecological, economic, and cultural significance of wetlands. As a highly productive ecosystem, it provides critical services such as water purification, flood regulation, carbon sequestration, groundwater recharge, and habitat for diverse flora and fauna, including over 250 bird species and threatened species like the Sarus crane. Its seasonal influx of nearly 100,000 migratory birds underscores its global ecological importance. The wetland also sustains local communities through fishing, agriculture, and eco-tourism while offering cultural, recreational, and aesthetic value.

Despite its recognition, Samaspur faces multiple threats including land-use changes, agricultural and industrial pollution, eutrophication, invasive species, overfishing, overgrazing, and declining water quality. Weak governance, inadequate community participation, and lack of long-term monitoring exacerbate these challenges, highlighting gaps in current management such as insufficient biodiversity assessments, limited hydrological modelling, and conflicts over land ownership.

Effective conservation requires integrated and participatory strategies, combining ecological restoration, invasive species control, habitat rehabilitation, and advanced monitoring using tools like UAVs and predictive modelling. Strengthening governance, enhancing community engagement, and promoting sustainable livelihood options are essential. Cross-sectoral coordination among forestry, agriculture, tourism, and education sectors, aligned with SDG principles, is crucial for maintaining wetland health. By addressing these challenges, Samaspur Wetland can continue to provide essential ecosystem services, safeguard biodiversity, and support sustainable development for future generations.

References

1. Aber, J. S., Pavri, F., & Aber, S. W. "Wetland Environments: A Global Perspective." *John Wiley & Sons* (2012).
2. Acreman, M., & Holden, J. "How Wetlands Affect Floods." *Wetlands* 33.5 (2013): 773–786.
3. Alley, W. M. "Groundwater Resources: Sustainability, Management, and Restoration." *Groundwater* 47.4 (2009): 479–479.
4. Anderson, F. E., Bergamaschi, B., Sturtevant, C., Knox, S., Hastings, L., Windham-Myers, L., & Fujii, R. "Variation of Energy and Carbon Fluxes from a Restored Temperate Freshwater Wetland and Implications for Carbon Market Verification Protocols." *Journal of Geophysical Research: Biogeosciences* 121.3 (2016): 777–795.

5. Arroyo, P., Ansola, G., & de Luis, E. "Effectiveness of a Full-Scale Constructed Wetland for the Removal of Metals from Domestic Wastewater." *Water, Air, & Soil Pollution* 210.1 (2010): 473–481.
6. Arya, A. K., Joshi, K. K., & Bachheti, A. "A Review on Distribution and Importance of Wetlands in the Perspective of India." *Journal of Applied and Natural Science* 12.4 (2020): 710–720.
7. Ballut-Dajud, G. A., Sandoval Herazo, L. C., Fernández-Lambert, G., Marín-Muñiz, J. L., López Méndez, M. C., & Betanzo-Torres, E. A. "Factors Affecting Wetland Loss: A Review." *Land* 11.3 (2022): 434.
8. Bănăduc, D., Simić, V., Cianfaglione, K., Barinova, S., Afanasyev, S., Öktener, A., & Curtean-Bănăduc, A. "Freshwater as a Sustainable Resource and Generator of Secondary Resources in the 21st Century: Stressors, Threats, Risks, Management and Protection Strategies, and Conservation Approaches." *International Journal of Environmental Research and Public Health* 19.24 (2022): 16570.
9. Behera, M. D., Chitale, V. S., Shaw, A., Roy, P. S., & Murthy, M. S. R. "Wetland Monitoring, Serving as an Index of Land Use Change—A Study in Samaspur Wetlands, Uttar Pradesh, India." *Journal of the Indian Society of Remote Sensing* 40.2 (2012): 287–297.
10. Berkowitz, J. F., VanZomeren, C., & Piercy, C. "Marsh Restoration Using Thin Layer Sediment Addition: Initial Soil Evaluation." *Wetland Science and Practice* 34.1 (2017): 13–17.
11. Bryce, R., Irvine, K. N., Church, A., Fish, R., Ranger, S., & Kenter, J. O. "Subjective Well-Being Indicators for Large-Scale Assessment of Cultural Ecosystem Services." *Ecosystem Services* 21 (2016): 258–269.
12. Bucher, E. H., Bonetto, A., Boyle, T. P., Canevari, P., Castro, G., Huszar, P., & Stone, T. "Hidrovia: An Initial Environmental Examination of the Paraguay-Parana Waterway." (1993).
13. Cahoon, D. R., Day, J. W. Jr., & Reed, D. J. "The Influence of Surface and Shallow Subsurface Soil Processes on Wetland Elevation: A Synthesis." *Current Topics in Wetland Biogeochemistry* 3 (1999): 72–88.
14. Chasmer, L., Mahoney, C., Millard, K., Nelson, K., Peters, D., Merchant, M., & Cobbaert, D. "Remote Sensing of Boreal Wetlands 2: Methods for Evaluating Boreal Wetland Ecosystem State and Drivers of Change." *Remote Sensing* 12.8 (2020): 1321.
15. Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., & Van Den Belt, M. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387.6630 (1997): 253–260.
16. Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., & Turner, R. K. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26 (2014): 152–158.
17. Darrah, S. E., Shennan-Farpón, Y., Loh, J., Davidson, N. C., Finlayson, C. M., Gardner, R. C., & Walpole, M. J. "Improvements to the Wetland Extent Trends (WET) Index as a Tool for Monitoring Natural and Human-Made Wetlands." *Ecological Indicators* 99 (2019): 294–298.
18. Davidson, N. C., & Finlayson, C. M. "Extent, Regional Distribution and Changes in Area of Different Classes of Wetland." *Marine and Freshwater Research* 69.10 (2018): 1525–1533.
19. De Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat, L., & Van Beukering, P. "Global Estimates of the Value of Ecosystems and Their Services in Monetary Units." *Ecosystem Services* 1.1 (2012): 50–61.
20. Degaga, A. H. "Water Hyacinth (Eichhornia crassipes) Biology and Its Impacts on Ecosystem, Biodiversity, Economy and Human Well-Being." *Journal of Life Science and Biomedicine* 8.6 (2018): 94–100.
21. Denny, P. "Biodiversity and Wetlands." *Wetlands Ecology and Management* 3.1 (1994): 55–61.
22. Díaz, F. J., Anthony, T. O., & Dahlgren, R. A. "Agricultural Pollutant Removal by Constructed Wetlands: Implications for Water Management and Design." *Agricultural Water Management* 104 (2012): 171–183.
23. Dubey, D., Kumar, S., & Dutta, V. "Impact of Nutrient Enrichment on Habitat Heterogeneity and Species Richness of Aquatic Macrophytes: Evidence from Freshwater Tropical Lakes of Central Ganga Plain, India." *International Journal of Environmental Science and Technology* 19.6 (2022): 5529–5546.
24. Ehrenfeld, J. G. "Exotic Invasive Species in Urban Wetlands: Environmental Correlates and Implications for Wetland Management." *Journal of Applied Ecology* 45.4 (2008): 1160–1169.
25. Farheen, K. S., Reyes, N. J. D. G., Jeon, M. S., & Kim, L. H. "The Status of Ramsar Wetlands in India: A Review of Ecosystem Benefits, Threats, and Management Strategies." *Journal of Wetlands Research* 24.2 (2022): 123–141.
26. Feigin, A., Ravina, I., & Shalhevet, J. "Irrigation with Treated Sewage Effluent: Management for Environmental Protection." Vol. 17. *Springer Science & Business Media* (2012).
27. Fish, R., Church, A., & Winter, M. "Conceptualising Cultural Ecosystem Services: A Novel Framework for Research and Critical Engagement." *Ecosystem Services* 21 (2016): 208–217.
28. Gallant, A. L. "The Challenges of Remote Monitoring of Wetlands." *Remote Sensing* 7.8 (2015): 10938–10950.

29. Gardner, R. C., & Davidson, N. C. "The Ramsar Convention." In *Wetlands: Integrating Multidisciplinary Concepts.* Dordrecht: Springer Netherlands, 2011. 189–203.
30. Ghermandi, A., Van den Bergh, J. C., Brander, L. M., De Groot, H. L., & Nunes, P. A. "The Economic Value of Wetland Conservation and Creation: A Meta-Analysis." (2008).
31. Gray, M. J., Hagy, H. M., Nyman, J. A., and Stafford, J. D. "Management of wetlands for wildlife." *Wetland Techniques: Volume 3: Applications and Management* (2013): 121–180. Dordrecht: Springer Netherlands.
32. Haley, A. L., Lemieux, T. A., Piczak, M. L., Karau, S., D'Addario, A., Irvine, R. L., and Cooke, S. J. "On the effectiveness of public awareness campaigns for the management of invasive species." *Environmental Conservation* 50.4 (2023): 202–211.
33. Hoag, J. C. "Harvesting, propagating, and planting wetland plants." *USDA, Natural Resources Conservation Service, Plant Materials Center* (2000): 9. Aberdeen, ID.
34. Indiastat. "Source: http://www.indiastat.com/health/.../stats.aspx."
35. Indian Institute of Technology. *Annual Report.* (2011).
36. International Union for the Conservation of Nature and Natural Resources (IUCN). *Proceedings of the IUCN General Assembly.* (1965).
37. Intergovernmental Panel on Climate Change (IPCC). "Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report." *Cambridge University Press* (2001).
38. Isac, G. O., Hamzat, A. B., and Daramola, O. O. "Ecological Importance and Functions of Wetlands." *Wetland Ecosystems: Conservation Strategies, Policy Management and Applications* (2025): 23–42. Cham: Springer Nature Switzerland.
39. Islam, M. Z., and Rahmani, A. R. *Important Bird Areas in India: Priority Sites for Conservation.* Indian Bird Conservation Network: Bombay Natural History Society and BirdLife International (UK), (2004): 1133.
40. Jha, K. K. "Challenges in Sustainable Management of Wetland-Based Sanctuaries of Uttar Pradesh with Reference to Avian Diversity." *UP State Biodiversity Board* (2015): 14–29.
41. Johnson, W. C., Boettcher, S. E., Poiani, K. A., and Guntenspergen, G. "Influence of weather extremes on the water levels of glaciated prairie wetlands." *Wetlands* 24.2 (2004): 385–398.
42. Johnston, C. A. "Sediment and nutrient retention by freshwater wetlands: effects on surface water quality." *Critical Reviews in Environmental Science and Technology* 21(5–6) (1991): 491–565.
43. Kakuru, W., Turyahabwe, N., and Mugisha, J. "Total economic value of wetlands products and services in Uganda." *The Scientific World Journal* 2013.1 (2013): 192656.
44. Kannaojiya, O., and Sunita, K. "Wetlands Types, Function, Distribution, and Restoration: A Short Review." *Wetland Chemistry* (2025): 125–142.
45. Karanja, F., Emerton, L., Mafumbo, J., and Kakuru, W. *Assessment of the Economic Value of Pallisa District Wetlands.* Kampala, Uganda, (2001).
46. Karanth, K. K., and DeFries, R. "Nature-based tourism in Indian protected areas: New challenges for park management." *Conservation Letters* 4.2 (2011): 137–149.
47. Kingsford, R. T., Basset, A., and Jackson, L. "Wetlands: conservation's poor cousins." *Aquatic Conservation: Marine and Freshwater Ecosystems* 26.5 (2016): 892–916.
48. Kohli, D., Pandey, P. S., and Gupta, H. P. "Floristic Composition and Phytosociological Studies of Samaspur Wetland, RaeBareli, U.P." *Geophytology* 24.2 (1995): 159–167.
49. Korgaonkar, C., and Gokhale, Y. *Stakeholder Analysis for Conservation and Management of Samaspur Bird Sanctuary, Uttar Pradesh.* TERI Report, New Delhi, (2007).
50. Kumar, A., and Kanaujia, A. "Waterbird diversity of Samaspur Bird Sanctuary, Rae Bareli District, Uttar Pradesh." *Discovery Nature* 9.23 (2015): 48–57.
51. Kumar, A., and Kanaujia, A. "Wetlands of Lucknow District and their Conservational Requirements." *History* 9.24 (2015): 67–82.
52. Kumar, J. N., Soni, H., Kumar, R. N., and Bhatt, I. "Macrophytes in phytoremediation of heavy metal contaminated water and sediments in Pariyej Community Reserve, Gujarat, India." *Turkish Journal of Fisheries and Aquatic Sciences* 8.2 (2008).
53. Kumar, S., Agarwal, A., Villuri, V. G. K., Pasupuleti, S., Kumar, D., Kaushal, D. R., and Sivakumar, B. "Constructed wetland management in urban catchments for mitigating floods." *Stochastic Environmental Research and Risk Assessment* 35.10 (2021): 2105–2124.

54. Kundu, S., Kundu, B., Rana, N. K., and Mahato, S. "Wetland degradation and its impacts on livelihoods and sustainable development goals: An overview." *Sustainable Production and Consumption* 48 (2024): 419–434.
55. Kusler, J. "Wetland, Climate Change, and Carbon Sequestering." *Association of State Wetland Managers – Protecting the Nation's Wetlands.* US EPA, Region 2 (2000).
56. Lan, Y., Cui, B., Li, X., Han, Z., and Dong, W. "The determinants and control measures of the expansion of aquatic macrophytes in wetlands." *Procedia Environmental Sciences* 2 (2010): 1643–1651.
57. Li, A., and Cai, B. "The title of the paper or book." *Journal/Book Name* Volume(Issue) (2002): pages.
58. *Liu, J., & Diamond, J. (2005). China's environment in a globalizing world. Nature, 435(7046), 1179-1186.*
59. Lucke, T., Walker, C., and Beecham, S. "Experimental designs of field-based constructed floating wetland studies: A review." *Science of the Total Environment* 660 (2019): 199–208.
60. Madheshiya, P., Kumar Gautam, A., Sen Gupta, G., and Tiwari, S. "Zinc amendment as an effective tool in the management of cadmium toxicity: a case study with *Amaranthus cruentus* L." *Journal of Plant Nutrition* 48.3 (2025): 378–396.
61. Mehta, P., Chandravanshi, S., Yadav, S. R., Singh, A., and Jatav, S. K. "Conservation and Management of Ramsar Sites in India: Challenges and Solutions."
62. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being: Synthesis.* Island Press, (2005).
63. Mengistu, B. B., Unbushe, D., and Abebe, E. "Invasion of water hyacinth (*Eichhornia crassipes*) is associated with decline in macrophyte biodiversity in an Ethiopian Rift-Valley Lake—Abaya." *Open Journal of Ecology* 7.13 (2017): 667–681.
64. Ministry of Statistics and Programme Implementation (MoSPI). *Annual Report.* (2023).
65. Mirzajani, A., Bagheri, S., Zahmatkesh, Y., and Ghane, A. "Study of the abundance and biomass of macroinvertebrates in Anzali Wetland and estimation of the potential production of benthophagous fish." *Iranian Scientific Fisheries Journal* 34.3 (2025): 59–73.
66. Mitsch, W. J., Cronk, J. K., Wu, X., Nairn, R. W., and Hey, D. L. "Phosphorus retention in constructed freshwater riparian marshes." *Ecological Applications* 5.3 (1995): 830–845.
67. Moomaw, W. R., Chmura, G. L., Davies, G. T., Finlayson, C. M., Middleton, B. A., Natali, S. M., and Sutton-Grier, A. E. "Wetlands in a changing climate: science, policy and management." *Wetlands* 38.2 (2018): 183–205.
68. Panini, D. "The Ramsar Convention and National Laws and Policies for Wetlands in India." *Case Study prepared for the Technical Consultation on Designing Methodologies to Review Laws and Institutions Relevant to Wetlands,* Gland, Switzerland, (1998): 3–4.
69. Patel, G. "Fish biodiversity in aquatic resources of Raigarh district of Chhattisgarh, India." *M.F.Sc. Thesis (Aquaculture)* (2012): 1–96.
70. Pedrero, F., Kalavrouziotis, I., Alarcón, J. J., Koukoulakis, P., and Asano, T. "Use of treated municipal wastewater in irrigated agriculture—Review of some practices in Spain and Greece." *Agricultural Water Management* 97.9 (2010): 1233–1241.
71. Penland, S., and Ramsey, K. E. "Relative sea-level rise in Louisiana and the Gulf of Mexico: 1908–1988." *Journal of Coastal Research* (1990): 323–342.
72. Picek, T., Čížková, H., and Dušek, J. "Greenhouse gas emissions from a constructed wetland—plants as important sources of carbon." *Ecological Engineering* 31.2 (2007): 98–106.
73. Plants of the World Online. "Facilitated by the Royal Botanic Gardens, Kew." URL: https://powo.science.kew.org/. Retrieved 23 May 2025.
74. Prasad, S. N., Ramachandra, T. V., Ahalya, N., Sengupta, T., Kumar, A., Tiwari, A. K., and Vijayan, L. "Conservation of wetlands of India—a review." *Tropical Ecology* 43.1 (2002): 173–186.
75. Pueyo-Ros, J., Ribas, A., and Fraguell, R. M. "Uses and preferences of visitors to coastal wetlands in tourism destinations (Costa Brava, Spain)." *Wetlands* 38.6 (2018): 1183–1197.
76. Ramachandra, T. V., Aithal, B. H., and Kumar, U. "Conservation of wetlands to mitigate urban floods." *Journal of Resources, Energy and Development* 9.1 (2012): 1–22.
77. Ramachandra, T. V., Alakananda, B., Rani, A., and Khan, M. A. "Ecological and socio-economic assessment of Varthur Wetland, Bengaluru (India)." *Journal of Environmental Science & Engineering* 53.1 (2011): 101–108.
78. Ramsar Information Sheet (RIS). "Site no. 2415: Samaspur Bird Sanctuary (Rae Bareli)." *Official Site Factsheet / RIS.*
79. Sharma, S. "Ramsar Sites in India: Map, State-wise List & Key Facts." (2025).

80. Ramshida, K., and Sudhakar Reddy, C. "Assessing seasonal patterns of water hyacinth (*Pontederia crassipes* Mart.) invasion in Samaspur Bird Sanctuary, a Ramsar site, using Sentinel-2 data." *Journal of Geointerface* 4.1 (2025): 125–134.
81. Reddy, C. S. "Catalogue of invasive alien flora of India." *Life Science Journal* 5.2 (2008): 84–89.
82. Reddy, C. S., Rangaswamy, M., Pattanaik, C., and Jha, C. S. "Invasion of alien species in wetlands of Samaspur Bird Sanctuary, Uttar Pradesh, India." *Asian Journal of Water, Environment and Pollution* (2009).
83. Reed, S. M., and Maidment, D. R. "A GIS procedure for merging NEXRAD precipitation data and digital elevation models to determine rainfall-runoff modeling parameters." (1995).
84. Sahu, A., Sagar, S., and Singh, M. "Wetlands: Kidney of Earth and their conservation with status of wetlands in Uttar Pradesh." *Advances in Fisheries and Aquatic Sciences* 13 (2022).
85. Sarkar, J. "Ramsar Convention and India." *Current Science* 101.10 (2011): 1266–1268.
86. Scholz, M. *Wetland Systems: Storm Water Management Control.* Springer Science & Business Media, (2010).
87. Sharma, L. K., Joshi, B. D., Thakur, M., and Chandra, K. "Status, issues, and challenges of biodiversity: wild animals." *In Biodiversity in India: Status, Issues and Challenges.* Singapore: Springer Nature Singapore (2022): 149–173.
88. Silvan, N., Sallantaus, T., Vasander, H., & Laine, J. "Hydraulic nutrient transport in a restored peatland buffer." (2005).
89. Singh, A. K., & Lakra, W. S. "Risk and benefit assessment of alien fish species of the aquaculture and aquarium trade into India." *Reviews in Aquaculture* 3.1 (2011): 3–18.
90. Singh, P., Sharma, A. K., Khan, A. S., Verma, J., & Srivastava, P. (2025, September). A review of phytoremediation of heavy metals using macrophytes: Mechanisms, efficacy, and future prospects. *International Journal for Research in Applied Science and Engineering Technology (IJRASET), 13*(9), 1544–1570**.** **https://doi.org/10.22214/ijraset.2025.74262**
91. Smakhtin, V., Revenga, C., & Döll, P. "A pilot global assessment of environmental water requirements and scarcity." *Water International* 29.3 (2004): 307–317.
92. Spinelli, R., Magagnotti, N., De Francesco, F., Aminti, G., Stauder, M., & Pari, L. "Biomass recovery from invasive species management in wetlands." *Biomass and Bioenergy* 105 (2017): 259–265.
93. Indiastat. "Health Statistics." Available at: http://www.indiastat.com/health/.../stats.aspx.
94. Vacca, G., Wand, H., Nikolausz, M., Kuschk, P., & Kästner, M. "Effect of plants and filter materials on bacteria removal in pilot-scale constructed wetlands." *Water Research* 39.7 (2005): 1361–1373.
95. Van der Kamp, G., & Hayashi, M. "The groundwater recharge function of small wetlands in the semi-arid northern prairies." *Great Plains Research* (1998): 39–56.
96. Verhoeven, J. T., & Setter, T. L. "Agricultural use of wetlands: Opportunities and limitations." *Annals of Botany* 105.1 (2010): 155–163.
97. Verschuuren, B., Wild, R., McNeely, J., & Oviedo, G. "Introduction: Sacred natural sites—the foundations of conservation." In *Sacred Natural Sites* (pp. 1–13). Routledge, 2012.
98. Villa, C., Miquel, C., Mosses, D., Bernier, M., & Di Stefano, A. L. "The 2016 World Health Organization classification of tumours of the central nervous system." *La Presse Médicale* 47.11–12 (2018): e187–e200.
99. Vymazal, J. "Constructed wetlands for treatment of industrial wastewaters: A review." *Ecological Engineering* 73 (2014): 724–751.
100. *Wetlands of India Portal.* Ministry of Environment, Forest and Climate Change (MoEFCC).
101. World Health Organization. "Diet, nutrition, and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation." *WHO Technical Report Series* 916 (2003).
102. Yan, Z., Li, W., Shen, T., Wang, X., Zhu, M., & Yu, L. "Aquatic microalgal and bacterial communities in a karst wetland watershed." *Journal of Hydrology* 591 (2020): 125573.
103. Zhao, J., Wang, Z., Zhang, Q., Niu, Y., Lu, Z., & Zhao, Z. "A novel feature selection criterion for wetland mapping using GF-3 and Sentinel-2 data." *Ecological Indicators* 171 (2025): 113146.
104. Zhao, S., Da, L., Tang, Z., Fang, H., Song, K., & Fang, J. "Ecological consequences of rapid urban expansion: Shanghai, China." *Frontiers in Ecology and the Environment* 4.7 (2006): 341–346.
105. Zhou, Z., Wang, S., Zhao, M., & Zhi, F. "Research on art design of urban wetland park planning based on the concept of sustainable development." *Ecological Chemistry and Engineering* 30.2 (2023): 175–181.

Source of support: Nil;
Conflict of interest: The authors declare no conflict of interests.

Cite this article as:

Srivastava, P., Shariq, S., Gautam, M. and Singh, P. "Ecological Significance, Emerging Challenges and Conservation Strategies for Samaspur Wetlands in RaeBareli, Uttar Pradesh." *Annals of Plant Sciences.*14.09 (2025): pp. 6951-6965.