AATCC Review

11 October 2024: Received
14 December 2024: Revised
15 January 2025: Accepted
20 January 2025: Available Online

https://aatcc.peerjournals.net/

Review Article Open Access

A Critical review on five major Wetlands of Kashmir: Addressing threats and Restoration Opportunities

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ABSTRACT

The Kashmir Valley is home to a series of wetlands that span over 7,000 hectares. These wetlands are recognized as some of the most biologically diverse ecosystems, providing habitat for a wide variety of plant and animal species. Additionally, wetlands are often referred to as ecotones, highlighting their role as transitional areas between different ecological communities. The Hokersar wetland is the queen of the wetlands of Kashmir valley situated 10 kilometers northwest of Srinagar, was first designated as a conservation reserve under the Jammu and Kashmir Wildlife (Protection) Act, 1978. Anchar is a semiurban, single basin lake. This lake is situated about 14 km from Srinagar city on the northwestern part. Once a 19.4 sq km, pristine water lake, Anchar is now shrunken to just 6.8 sq kms. The Hygam Wetland Conservation Reserve, situated about 40 kilometers from Srinagar, represents the largest remaining reed bed in the Kashmir Valley. This wetland is of considerable ecological and ornithological importance, serving as a critical habitat for numerous bird species and contributing to the region's biodiversity. Shallabugh is a shallow wetland located in Sherpathri area of Ganderbal district at a distance of about 20 km in the northwest of Srinagar city and covers an area of about 17 km^2 . Wular Lake, one of the largest and deepest freshwater lakes in South Asia, is located near Bandipora town in the Bandipora district of Jammu and Kashmir, India. Once covering an extensive area of approximately 20,000 hectares, the lake has significantly reduced in size to around 2,400 hectares. Despite this reduction, Wular Lake remains a popular recreational destination that attracts a large number of tourists each year. The Tulbul Project is a "navigation lock-cum-control structure" at the mouth of Wular Lake. Major threats of these wetlands includes conversion for agriculture and horticulture development, increasing dependence for energy, adoption of erosion intensifying agro- practices in catchments, degradation of high altitude pastures, quarrying etc. Mitigation strategies include an immediate ban on land conversion/construction, effective solid waste management, and effective surveillance by the wildlife protection department, reduction in the use of agrochemicals and community conservation by designating it as a sacred water body based on religious faith can lead to the protection of these water bodies.

Keywords: *Anchar Lake, Conservation, Degradation, Hokersar Wetland, Kashmir, Mittigation measures, Threats, Wular Lake*

1. Introduction

The Union Territory of Jammu and Kashmir has different climatic zones, with Kashmir being temperate, is situated in the lap of Western Himalaya, which is decorated with snow-covered, silver-headed mountains and magical lakes [1,2]. The wetlands of Kashmir Valley cover an area exceeding 7,000 hectares. These wetlands function as highly effective ecological systems, facilitating nutrient cycling, supporting food chains, and maintaining water quality. Characteristically, wetlands are identified by their shallow depths, moist soils, and presence of aquatic vegetation. Their critical ecosystem services encompass water purification, groundwater recharge, and the provision of biodiversity reserves for threatened and endangered species, alongside their role in nutrient cycling [3]. Wetlands are defined as lands transitional between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands provide home for a large diversity of wildlife including birds, mammals, fish, amphibians, insects and plants. Wetlands provide substantial benefits to human communities through the production of renewable resources. Local populations worldwide rely on wetlands for a variety of direct-use resources, including food, fish, and fiber, all of which contribute to human well-being and play an essential role in poverty alleviation. These resources support livelihoods and enhance the quality of life for communities that depend on the ecological wealth wetlands offers.

A wetland is a land area that is saturated with water, either permanently or seasonally, such that it takes the characteristics of a distinct ecosystem.

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DOI: https://doi.org/10.21276/AATCCReview.2025.13.01.01

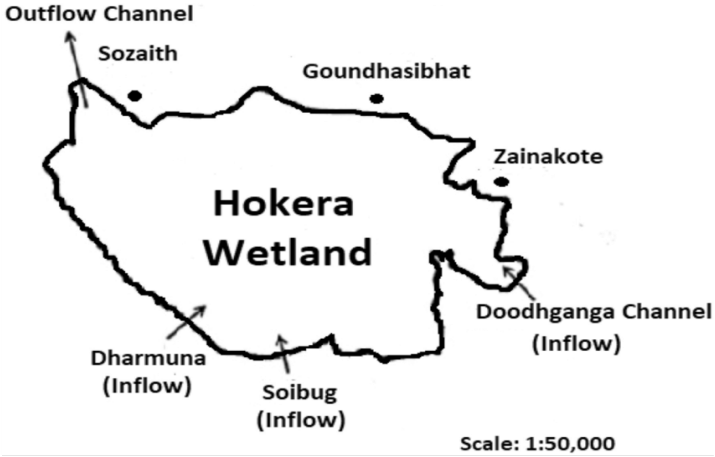
The primary factor that distinguishes wetlands from other land forms or water bodies is their characteristic vegetation of aquatic plants which are adapted to the unique hydric soils. The wetlands play a number of roles in the environment, principally water purification, flood control, carbon sink and shore line stability. These are also considered as the most biologically diverse ecosystems, serving as home for a wide range of plant and animal life. Wetlands have also been described as ecotones, providing a transition between dry land and water bodies. Some of the major wetlands in the world are Pantanal (Brazil, Bolivia and Paraguay), Camargue (France), Wasur National Park (Indonesia) and Kakadu wetlands (Australia). India's wetlands encompass an estimated 58.2 million hectares, with the Kashmir Valley alone hosting a network of wetlands covering over 7,000 hectares [3]. These wetlands are of exceptional importance, serving as vital biodiversity reserves and habitats for waterfowl. Additionally, they hold significant educational and research value, providing rich resources for studies on ecology, conservation, and environmental science. Description of five major wetlands *viz*. Hokersar, Shallabugh, Hygam and Wular lake is as under:

2. HOKESAR WETLAND

Location: - The Hokersar Wetland, located in Zainakote near Srinagar in the Srinagar district of Jammu and Kashmir, India, (Fig. 1) was first designated as a conservation reserve under the Jammu and Kashmir Wildlife (Protection) Act of 1978. Known as the "*Queen of the Wetlands*" in the Kashmir Valley, it is situated approximately 10 kilometers northwest of Srinagar. Currently managed by the Directorate of Wildlife Protection, Hokersar gained international recognition on

Fig. 1: Map of Hokesar Wetland.

November 8, 2005, when it was designated as *Ramsar Site No. 1570*, underscoring its importance as a protected wildlife reserve and a critical ecological habitat as reported by Directorate of Wildlife Protection, Jammu and Kashmir.



2.1 History: The Hokersar Wetland, often referred to as the "Queen of Wetlands," is a prominent ecological site in Kashmir, located approximately 14 kilometers north of Srinagar. Spanning an area of 13.75 square kilometers, which includes both lake and marsh areas, Hokersar has long been recognized for its accessibility from Srinagar. Hokersar has been listed under the National Wetlands Conservation Programme. Hokersar wetland is differentiated into three varied zones, marshy and exposed area extending from North-to-North West, Central deeper area, South Eastern side covering most of the silted area.

The North-Eastern zone comprises of diverse and dense macrophytic set up and maximum numbers of macrophyte species.The central deep area is largely a free expanse of water except at certain places where two predominant species of macrophyes *Trapa natans* and *Phragmites australis* occupy a large area. The marshy zone of the wetland and the open waters provide an efficient habitat to migratory birds [4]. Observations from 1969 to 2008 indicate a reduction in the wetland's spatial extent from 18.75 to 13.00 square kilometers, with these alterations affecting the wetland's ecological functions and impairing its water and sediment quality [5].

The Hokersar Wetland, nourished by two inlet streams—Doodhganga from the east and Sukhnag Nalla from the west [6]—is a protected area under India's National Wetlands Conservation Programme. The wetland is divided into three distinct zones: a marshy and exposed area in the north to northwest, a deeper central zone, and a silted region on the southeastern side. The northeastern zone is characterized by a dense diversity of macrophytes, housing a wide range of macrophyte species. The central deep area is primarily open water, with extensive growths of *Trapa natans* and *Phragmites australis* in certain areas. The wetland's marshy zone and open waters serve as vital habitats for migratory birds, while the southern silted region is used as pastureland for local livestock [3].

The Hokersar Wetland provide habitat for nesting, roosting and feeding ground for large number of birds. But now from so many years it is losing this significant property providing shelter to the bird community. The threatened species in wetlands need special attention as they are more sensitive to disturbance for long- term management and conservation [7]. Study on the macrophyte community in relation to environmental stresses of Hokersar wetland reserves probably is the only long-term study carried out so far [8]. The study indicates a shift in macrophyte community structure of Hokersar wetland as evidenced by the complete disappearance of *Nelumbo nucifera* and near disappearance of *Eurayle ferox* and *Acoru calamus.*

2.2 The major macrophytes that are present in the wetland include: *Butomus umbellatus* Linn. (Flowering rush), *Carex wallichiona* Spreng (Sedge), *Cyperus glomeratus* (Sedge), *Cyperus pumilla* Linn. (Low spikesedge), *Sparganium ramosum* (Bur-Reed), *Phragmites communis* (Common Reed), *Typha latifolia* (Broadleaf cattail), *Nelumbium nucifera* (Indian Lotus), *Trapa natans* L. (Water Chestnut), *Ceratophyllum demersum* (Horn Wort), *Salvinia natans* (Floating Fern), *Azolla pinnata* (Water velvet), *Phragmites australis (Common Reed), Roripa indica* Linn. (Yellow Cress), *Potamogeton crispus* Linn. (Curly Pond Weed), *Potamogeton lucens* Linn. (Shining Pond Weed), *Utricularia aurea* (Golden Bladderwort), *Nymphea alba* Linn. (Water Lily), *Potamogeton natans* Linn. (Floating Pond Weed), *Wollfia polyrhiza* Schield (Duck Weed), *Lemna gibba* L. (Swollen Duck Weed) etc. [9]

Hokersar Wetland has long been a popular hunting ground for ducks and serves as a crucial staging area for migratory shorebirds, geese, cranes, ducks, and other species that breed in the northern latitudes of Siberia and Central Asia. Strategically situated south of the Pamirs and at the western edge of the Himalayan range, the Kashmir Valley lies along the Central Asian Flyway, which is a primary migration route for waterfowl. These birds begin arriving in the valley between September and October and depart by May. In the 2000–2001 period, over 500,000 waterbirds were recorded in the Hokersar Wetland [10].

Among the 45 waterbird species and 66 wetland-associated species documented, seven are globally threatened. The most common waterfowl found in large numbers during the winter include the Northern Pintail, Mallard, Gadwall, Northern Shoveler, *Eurasian Wigeon*, and Common Teal. Other species such as the Eurasian Coot, Red-Crested Pochard, Greylag Goose, Common Pochard, Garganey, and Ruddy Shelduck also inhabit the wetland [11].

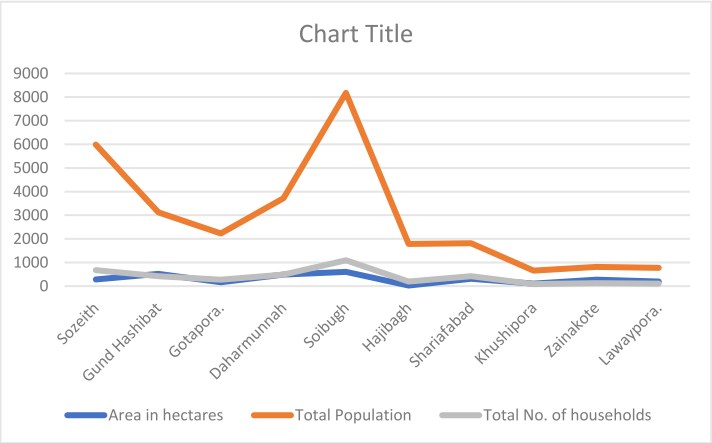


Fig.2: Area, population and name of the villages around Hokhersar Wetland

The marshland provides a variety of ecological and economic services, such as supporting fisheries, providing food products, offering freshwater, purifying water, and contributing to global climate regulation [5]. Furthermore, it plays a vital role in hydrological functions like flood regulation, groundwater recharge, streamflow control [12], and carbon sequestration [5]. Hokersar Wetland is surrounded by ten populous villages, with specific data on their area, population, and number of households [13], provided in Fig. 2.

3. ANCHAR LAKE

Location: Anchar Lake (Fig. 3) is a semi- urban, single-basin lake located between latitudes 34°07′–34°10′ N and longitudes 74°46′–74°48′ E, at an altitude of 1,583 meters above mean sea level. Situated approximately 14 km northwest of Srinagar, the lake originally covered an area of 19.54 km^2 during 1893–1894 [14}, but has since experienced a significant reduction in size, shrinking to 6.5 km^2 by 2012 [15], and currently spans just 4.26 km^2 [16]. The water supply to Anchar Lake is sustained by the Sindh, a tributary of the Jhelum River, and Achan Nallah, along with springs in the surrounding area. The lake's extensive catchment area includes a mix of residential, agricultural, horticultural, and forested land [17]. Over the past few decades, the water quality of the lake has deteriorated significantly, primarily due to anthropogenic activities such as encroachments, sewage, and the dumping of domestic waste, including plastic, polythene, clothes, and hospital effluents [16,18]. The Telbal River, a perennial inflow channel from the north, contributes approximately 80% of the lake's water, while an outflow channel directs the water into a tributary on the southeastern side. The lake has a maximum depth of 16 meters and an average depth of 14 meters. The natural annual water level fluctuation is about 0.7 meters, and the shoreline is bordered on one side by mountain ranges and on the other by urban development. The lake's gross catchment area spans 337.17 km^2 [19].

Anchar Lake is connected to the famous Dal Lake through the Amir Khan Nallah channel, similar to how the Dal Gate connects Dal Lake with Nagin Lake.

During flooding events, excess water from Dal Lake is diverted into Anchar Lake [20]. The Achan dumping site once a wetland was interconnected with Anchar Lake through a web of water bodies. The dumping activity at Achan has badly troubled Anchar Lake as well as other water bodies surrounding the landfill site [21].

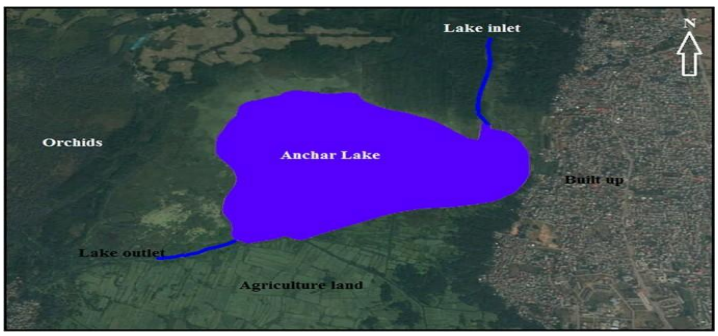


Fig. 3: Map of Anchar Lake

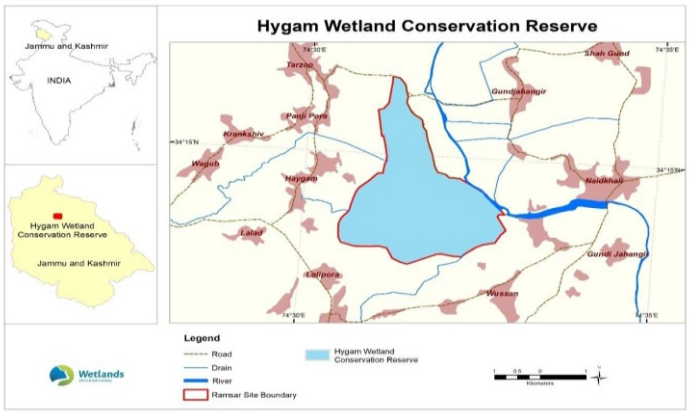
3.1 History: Anchar Lake was once a pristine water body with crystal-clear waters, which were used for drinking and various domestic purposes from ancient times through the British colonial period in India [22]. Historical records indicate that visitors would take boat rides from Dal Lake to Khushal Sar Lake and enjoy leisurely strolls around Anchar Lake. It is also documented that tourists would stay in houseboats, spending nights in the cool summer breeze, marveling at the reflections of the towering mountains such as Mahadev and Fungal Ball [23].

3.2 Present status of Anchar lake: Once a 19.4 sq km, pristine water lake, Anchar is now shrunken to just 6.8 sq kms of filth and garbage [24]. The construction of Sheri-e-Kashmir Institute of Medical Science (SKIMS) in 1977, near the Anchar Lake, proved catastrophic for the lake. Without any proper Sewage treatment Plant (STP), the entire waste generated from the hospital found its way into Anchar. "There has been massive encroachment of lake in last few decades. People first filled it with soil and then constructed houses," [24].

4. HYGAM

Location: The Hygam Wetland (Fig. 4) Conservation Reserve, locally known as *Hygam Rakh*, is the largest remaining reed bed in the Kashmir Valley and holds significant ornithological importance. It is named after the nearby village of the same name [25]. Situated 40 kilometers from Srinagar, in the Baramulla district (34° 15'N, 74° 31'E) of Jammu & Kashmir, the wetland lies on the floodplains of the Jhelum River at an altitude of 1,580 meters above sea level. The area was first designated as a game reserve for duck shooting in 1945. Originally covering a

Fig. 4: A map of Hygam Wetland in Kashmir Valley



approximately 14 km^2, with reed beds spanning 4 km^2 the reserve has since shrunk to 7.25 km^2 [26]. Managed by the Department of Wildlife Protection, Jammu & Kashmir, the wetland is the largest marshland associated with the lower Jhelum hydroelectric project at Gantamullah. It has been classified as wetland types 14, 15, and 19, which include freshwater marshes, swamps, and rice paddies (Scott, 1989). The wetland is a shallow, permanent freshwater lake, with a maximum water depth of 1.25 meters [25].

4.1 History: The Hygam Wetland was originally a vast expanse of open grassland and served as a roosting site for migratory birds from Wular Lake. However, the wetland underwent significant changes when it was acquired by Maharaja Hari Singh. Under his administration, a peripheral bund was constructed around the area, transforming it into a permanent water body [28]. The villages surrounding the wetland were established by the Maharaja, who settled laborers from distant regions for work. These areas were managed by the Twaza Directorate, which was responsible for hosting sporting events for the Maharaja and his distinguished guests. As part of this arrangement, the area was strictly regulated to provide a habitat for both land and water game birds and animals.

Following the partition in 1947, the management of these reserves in the Kashmir region was transferred to the Fisheries Directorate. By 1954, several reserves, including Dachigam, Cheshmashahi, and Rajparian (Daksum), were designated as game sanctuaries in 1951. Subsequently, administrative control shifted between various agencies: first to the Forest Department (1954-1960), then to the Twaza Directorate (1960-1964), and back to the Fisheries Directorate (1972-1977), with certain areas transferred to the Forest Department for future forestry management. In 1978, the administration was transferred once again to the Directorate of Game Preservation under the Forest Department. This department eventually became the independent Department of Wildlife Protection in 1982, overseeing the expansion of protected areas in the region. The number of protected areas increased from 18 to 43, covering both old and newly established areas, significantly expanding the total protected land from 0.20% to 7.5% of the state's total land area, totaling over 15,000 km^2 [25]. Next to Wular Lake, a Ramsar Site, and receiving 90% of its water from surface inlets and precipitation, Hygam Wetland in the Baramulla district serves as an important flood absorption basin, ecological preservation site, ecologic tourism site, and source of income for the neighboring community. With an area of 801.82 hectares, the wetland is shaped like a cone. At 1580 meters above mean sea level, Hygam Wetland is an Important Bird Area that is home to a variety of resident and migratory bird species. However, the wetland has lost a great deal of its qualities due to ongoing siltation and willow plants that have lowered the water levels and depth of the area [28].

The ecological conditions that were once ideal for both migratory and resident bird populations have further deteriorated due to several factors. Both inlet channels have lost their gradient and velocity as a result of heavy silt accumulation. Consequently, these channels now function as deltas, trapping nutrients, pollutants, and sediment before they enter the wetland. Additionally, local villagers often convert the marshy areas and surrounding landmasses into paddy fields, exacerbating the loss of critical habitats. This combination of factors has led to the further degradation of the wetland, reducing its capacity to support both resident and migratory bird populations.

Hygam Wetland falls within the River Jhelum basin and plays a significant role as a flood absorption basin, biodiversity conservation site, eco- tourism site, and livelihood security for the

local communities [29]. The wetland is located adjacent to the Southern tip of Wular Lake which is a Ramsar Site and forms a part of an interconnected ecosystem complex. The wetland is located in the Baramulla district. It lies in the flood basin of the Jhelum River and the Sub-basin of Ningli and Ferozpora Nalah. Of the total water received by the Wetland, 90% is contributed from surface inlets and the remaining 10% through precipitation. The wetland is roughly a cone in outline and spreads over 801.82 ha [30]. The average elevation of the Wetland is 1580m above MSL. It serves as an abode to many residents and migratory bird species. It is also recognized as an Important Bird Area (IBA). Continuous siltation has decreased the depth of the wetland accompanied by a decrease in water levels. The willow plantations at places have also added to the siltation and accumulation of nutrients in the wetland and modified the wetland characteristics. Consequent to the high rate of siltation, Hygam Wetland has lost its wetland characteristics to a large extent and in many places changed its profile into a landmass. This has resulted in further loss of habitat conditions to offer a suitable site for visiting migratory birds and for resident birds as well. Both the inlet channels have lost the gradient and velocity due to heavy silt load and therefore, act as the delta for a l the silt load, pollutants, and nutrients into the wetland. The silted marshes/landmasses in the wetland are often brought under paddy cultivation by the fringe villagers [31].

4.2 Flora diversity: The Rakh is largely covered by a dense growth of reed and other emergent species. Dominant species include *Typha angustata*, *Phragmites communis*, *Phalaris arundinancea*, *Sparganium erectum*, *Scirpus* species, *Carex* species and *Eleocharis* palustris. Open water areas have a floating community of water lilies Nymphaea, Nymphoides and *Trapa natans*, and beds of *Potamogeton crispus* and *Potamogeton nodosus*. Some 183 species of phytoplankton have been recorded, with Chlorophyceae predominating [25].

5. SHALLABUGH

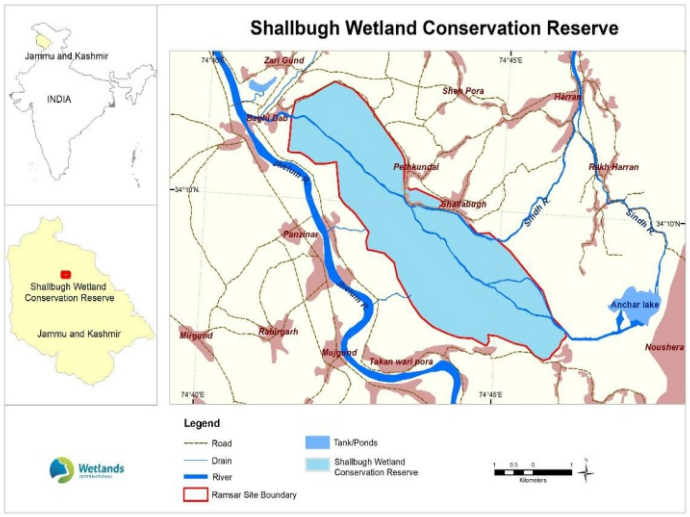
Location: Shallabugh is a shallow wetland (Fig. 5) situated in the Sherpathri area of Ganderbal district, at an altitude of 1,580 meters above sea level (34º10' N Latitude, 74º42' E Longitude). Located approximately 20 km northwest of Srinagar city, the wetland spans about 17 km^2. It receives water from both Anchar Lake and Sindh Nallah. The wetland area extends over 150 hectares and is home to a rich diversity of flora and fauna, attracting tourists throughout the year. The water level in Shallabugh fluctuates depending on the varying amounts of water brought in by Sindh Nallah and Anchar Lake. The wetland supports a wide variety of resident and migratory avifaunal species, as well as macrophytes that hold significant socio-economic value [32].

5.1 History: On October 14, 2022, the Shallabugh Wetland was designated as a Ramsar site in celebration of the 75th year of India's independence, bringing the total number of Ramsar sites in Jammu and Kashmir to five. This wetland is characterized by extensive reed beds and floating aquatic vegetation, providing a crucial habitat for over 21 species of resident and migratory birds.

Many of these bird species are threatened, including the endangered steppe eagle (*Aquila nipalensis*), Pallas's fish-eagle (*Haliaeetus leucoryphus)*, and black-bellied tern (*Sterna acuticauda*), as well as the vulnerable eastern imperial eagle (*Aquila heliaca*), yellow-eyed pigeon (*Columba eversmanni*), and wood snipe (*Gallinago nemoricola*). Several of these species are endemic to the wetland [33].

The wetland provides a variety of ecological services, including supporting fisheries, supplying clean water, regulating flooding, and acting as a carbon sink. However, excessive siltation remains a significant threat to its ecological integrity. In the past, Shallabugh Wetland attracted large

Fig. 5: A map of Shallbugh Wetland Conservation reserve



numbers of migratory birds from distant regions such as Siberia, Central Asia, Northern Europe, Ladakh, and China. However, the number of migratory birds visiting the wetland has drastically declined over the years.

The Hygam Wetland, spanning 7.25 km^2 in Baramulla district, is another prominent wetland in the region. It covers an area of 1,400 hectares, dominated by extensive reed beds, and drains into Wular Lake. Its primary water sources are Nigle Nullah and Babakul. In terms of land use, a study from 1990 to 2018 revealed that the wetland's coverage by macrophyte vegetation decreased by 4.4%, while mixed plantations, built-up areas, and vegetable fields saw significant increases. These changes, largely attributed to siltation, crop cultivation, and construction, highlight the growing pressures on the wetland. Over time, land use and land cover changes, driven by both natural and human activities, have posed severe threats to the wetland's biodiversity and its role as a vital breeding, staging, and wintering ground for waterfowl.

The Shallabugh Wetland is an important ecological and economically significant wetland in Kashmir Valley. Its continued degradation due to land use changes, siltation, and human activities poses a significant threat to the region's biodiversity and the well-being of local communities [32].

6. WULAR LAKE

Wular Lake, (Fif. 6) also known as *Wolar* in Kashmiri, is one of the largest freshwater lakes in South Asia and a vital ecological resource in the Kashmir region. Located near Bandipora town in Bandipora district, Jammu and Kashmir, India, the lake originally covered an area of 20,000 hectares but has since shrunk to around 2,400 hectares.

It is bound by hills to the northeast and northwest, with the Jhelum River draining the lake westward through the Pir Panjal Range into the Indus River.

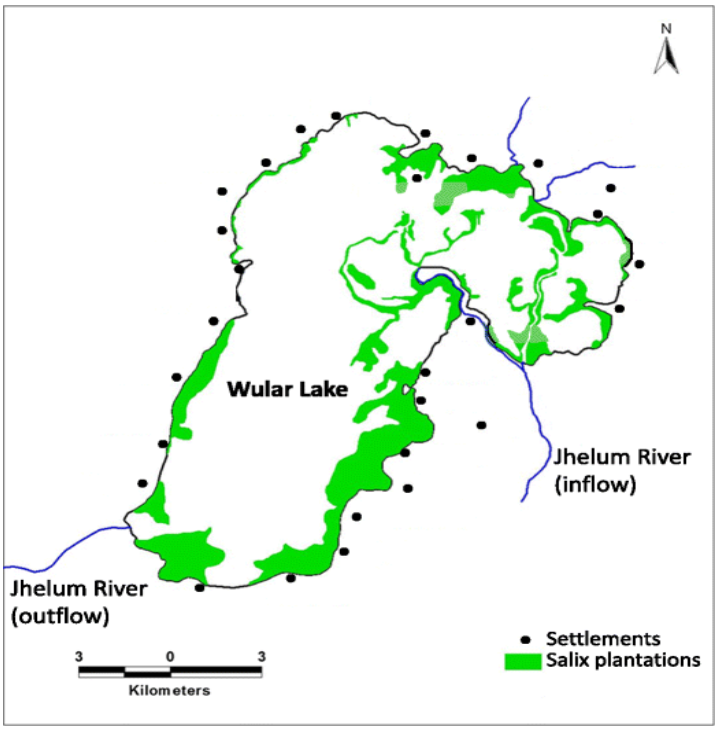


Fig. 6: A map showing Wular Lake

The lake experiences sudden and powerful storms, which are frequent due to the topography of the region. Despite its size reduction, Wular Lake continues to serve as a recreational area, attracting large numbers of tourists. It also provides a livelihood for a significant population living along its fringes, with the surrounding catchment area supporting coniferous forests, alpine pastures, and orchards, which add to the lake's natural beauty and biodiversity.

Wular Lake is fed by the Jhelum River and the Madhumati stream. The lake's size fluctuates seasonally, ranging from 30 to 189 square kilometers, although much of it has been drained due to the construction of willow plantations along the shore in the 1950s. The lake plays a crucial role in water security for the Kashmir valley, regulating floodwaters from glaciers in the surrounding Himalayas. The lake's wetlands are important habitats for migratory waterbirds along the Central Asian Flyway, supporting a wide range of species. Wular Lake is also a major fishery resource in the region, sustaining the livelihoods of local communities living around its shores. Its ecological importance and rich biodiversity make it a critical natural resource for the region's environmental health and economy [34].

6.1 History: In ancient times, Wular Lake was also called *Mahapadmasar*. Nilamata Purana also mentions it as *Mahapadmasaras*. The lake, with its big dimensions and the extent of water, gives rise to high leaping waves in the afternoons, called Ullola in Sanskrit, meaning "stormy leaping, high rising waves". Therefore, it was also being called *Ullola*. It is believed to have gotten corrupted over the centuries to *Wulor* or *Wular* [35].

The origin may also be attributed to a Kashmiri word 'Wul', which means a gap or a fissure, an appellation that must have come also during this period. The word Wul (gap or fissure), is also an indicator of its origin to a fissure or gap created.

The Kashmiri sultan Zain-ul-Abidin is reputed to have ordered the construction of the artificial island of Zaina Lank in the middle of the lake in 1444. According to the traditional beliefs in the vicinity of Wular Lake there once stood a city whose king was Raja Sudrasen. By reason of the enormity of his crimes, the waters of the lake rose and drowned him and his subjects. It was said that during the winter months, at low water the ruins of the submerged idol temple might be seen rising from the lake. Zayn Ul Aabidin constructed a spacious barge which he sank in the lake and upon which he laid a foundation of bricks and stones till it rose high enough to be at level with the water. Upon this he erected a Mosque and other buildings and gave the islet the name of Lanka. The expense of this work was defrayed by the fortunate discovery of two idols of solid gold which had been brought up from the lake by divers [36].

The lake is one of the 75 Indian wetlands designated as a Ramsar site. However it faces environmental threats including the conversion of large parts of the lake's catchment areas into agricultural land, pollution from fertilizers and animal wastes, hunting of waterfowl and migratory birds, and weed infestation in the lake itself [37].

6.2 Recognition: Wular Lake, one of the largest freshwater lakes in South Asia, has been recognized for its significant biological, hydrological, and socio-economic value. In 1986, it was included as a *Wetland of National Importance* under India's *Wetlands Programme* to promote intensive conservation and management. Then, in 1990, it earned international recognition as a *Wetland of International Importance* under the *Ramsar Convention* due to its ecological and environmental importance. However, despite these designations, the lake faces threats, including the alarming issue of garbage dumping, which undermines its health and ecosystem functions [38].

In response to the lake's deteriorating condition, a restoration project has been launched under the *National Lake Conservation Programme*. This project involves the removal of two million trees to restore the lake's natural environment and biodiversity. The Indian Environment Ministry has approved Rs 04 billion for the restoration efforts, which are expected to take 05 to 10 years. The project was initially delayed but was scheduled to start in December 2011. One of the key partners in this initiative is the *South Asian Voluntary Association of Environmentalists* (SAVE), a group committed to the protection of Wular Lake's ecology and its conservation [37].

The restoration of Wular Lake is critical for improving water quality, enhancing biodiversity, and supporting the livelihoods of the communities living along its shores. It is also essential for maintaining the lake's role in regulating floodwaters and providing habitat for migratory waterbirds along the Central Asian Flyway.

6.4 Tourism: Boating, water sports and water skiing have been launched by the Government of India Tourism in collaboration with Kerala Tourism and J&K Tourism. The contract for the operation of the site was awarded in September 2011.

6.5 Biodiversity of the Lake: The Sattar snoetrout (Schizopyge curvifrons), Chirruh
(Schizopyge *esocinus*), *Schizothorax planifrons*, *Schizothorax macropogon, Schizothorax longipinus*, and Chush snowtrout (*Schizopyge niger*) are among the species of snowtrout that have been found in the lake. The Sattar snowtrout (*Schizopyge curvifrons*), Chirruh snowtrout (Sch*izopyge esocinus*), *Schizothorax planifrons*, *Schizothorax macropogon, Schizothorax longipinus*, and Chush snowtrout (*Schizopyge niger*) are among the species of snowtrout that have been found in the lake [39].

Wular Lake plays a crucial role in the livelihoods of thousands of people in the Kashmir Valley. Fish from the lake are a staple part of the diet for many communities living on its shores. Over *eight thousand fishermen* depend on the lake for their livelihoods, primarily catching endemic *Schizothorax* species and non-native *carp*. The fish catch from Wular Lake accounts for about 60 % of the total fish yield in Kashmir.

In addition to fishing, hundreds of local villagers are employed by cooperative societies that trade the fish catch. The lake also supports the collection of other natural resources: plants like *Phragmites* (a type of grass) and *Nymphoides* (a waterlily-like plant) are harvested for animal fodder, providing further economic support to the local population. Thus, Wular Lake is not only a noteworthy ecological strength but also a vital foundation of revenue and capitals for the people who live in and around the region, making its protection even more commanding for both ecological and socio-economic motives.

The lake is home to a diverse range of birds. Black eared kites, Eurasian sparrowhawks, shorttoed eagles, Himalayan golden eagles, Himalayan monal, chukar partridge, koklass pheasants, rock doves, common cuckoos, alpine swifts, Indian rollers, Himalayan woodpeckers, hoopoes, barn swallows, golden orioles, and other terrestrial birds have been spotted near the lake [39].

6.6 The Tulbul Project

The Tulbul Project, also known as the "*navigation lock-cum-control structure",* is located at the mouth of Wular Lake and aims to regulate water flow in the lake for navigation and irrigation purposes. Originally conceived in the early 1980s, it was designed to be 439 feet (134 m) long and 40 feet (12 m) wide, with the capacity to store 300,000 acre-feet (370 million cubic meters) of water. One of the primary goals was to ensure a minimum draught of 4.5 feet (1.4 meters) in the Jhelum River up to Baramulla during the lean winter months, which would support navigation and transport of goods and people. The average annual inflows and outflows from Wular Lake are around 7 billion cubic meters, and the lake plays a crucial role in maintaining water flow and regulating seasonal variations [40].

However, since its conception, the project has been at the center of a dispute between India and Pakistan. Pakistan raised objections to the project in 1987, claiming that it violated the 1960 *Indus Waters Treaty* (IWT). Specifically, Pakistan argued that the planned water storage capacity of more than 10,000 acre-feet violated the treaty's provisions for non-power generation purposes. India, on the other hand, maintains that the project is permissible under the IWT and is necessary for the welfare of Jammu and Kashmir, as well as for ensuring regulated water releases that could benefit Pakistan's irrigation and power sectors [41].

The storage capacity of the lake could potentially be increased to 300,000 acre-feet or more, which would allow for the lake to be used as a reservoir for a run-of-the-river (RoR) hydroelectric plant, with a low head power plant that could generate additional power. This could benefit several hydropower projects downstream, including those at Lower Jhelum, Uri, Kohala, and Azad Pattan (in Pakistan-administered Kashmir). Additionally, this plan could preserve the lake by flushing out sediments, ensuring its long-term ecological health [40].

In addition to supporting hydroelectric projects, the *Kishanganga Hydroelectric Plant* would enhance water inflows into Wular Lake during the lean season, ensuring sufficient water levels for both navigation and power generation. However, the ongoing dispute has prevented the full realization of these benefits, with the project's future still uncertain.

To sustain navigation throughout the year, a minimum depth of water is needed. India contends that the Tulbul Project is permissible per paragraphs 7 (c) and 9 of Annexure E, IWT while Pakistan maintains that the project is a violation of the treaty if the storage is above 10,000 acre-feet (12×106 m3) for non-power generation purposes. India says the suspension of work is harming the interests of people of Jammu and Kashmir and also depriving irrigation and power benefits to the people of Pakistan that may accrue from regulated water releases [41].

The lake storage capacity can be increased per IWT to 300,000 acre feet or more up to 1580 m MSL by considering it as a reservoir for a run of the river (RoR) hydro power plant by envisaging a low head (nearly 8 meters rated head) power plant. The available deepened river bed level at the toe of the dam can be below 1,570 m (5,151 ft) MSL for 4,000 cusecs flow. Simultaneously, the enlarged lake can also meet the downstream navigational requirements fully during the lean flow season. The regulated buffer / surcharge water storage in the Wular lake would substantially enhance the power generation from the downstream Lower Jhelum (105 MW), Uri (720 MW), proposed 1124 MW Kohala (in PaK), proposed 720 MW Azad Pattan (in PaK), 590-MW Mahl hydropower project (in PaK) and proposed 720 MW Karot (in PaK) RoR hydel projects though its own power plant's generation is marginal. Construction of a RoR power plant with sufficient sluice gates would also flush the sediment from the lake area to preserve the lake. The lean season water inflows into the Wular Lake are enhanced from the Kishanganga river by the Kishanganga Hydroelectric Plant after generating electricity [40].

7. MAIN ISSUES / THREATS OF WETLANDS

7.1 Main issues/ threats to Hokersar Wetland include

- → Shrinkage in area due to the human settlements, encroachments and siltation [42].
- → Domestic/sewage pollution,
- → Pollution due to the addition fertilizers,
- → Siltation due to floods,
- → Conversion into agricultural land,
- → Unwanted growth of aquatic weeds etc
- → In addition to various anthropogenic pressures it also contains high inputs of nutrients which affect its health [3].

7.2 Major Threats to Anchar Lake

- → The main reasons for the Lake water quality degradation are anthropogenic activities which includes encroachments, direct sewage disposal etc. [42].
- → The runoff from the surrounding paddy fields including floating gardens and sewage from the surrounding human habitation is also drained into the lake, thereby further enhancing the nutrient levels of the lake [17].
- → The drastic pollution of the lake has now increased the alkalinity of the water and has made navigating through it difficult as it is swamped with wild plants and flowers [17].
- → The upper part of the sediment core revealed intense anthropogenic impact over the lake due to expanding agricultural and land-use activities [43]. (Lone *et al*., 2020).
- → The investigation carried out over a period of time by authors during 2015-2016 indicates that the lake is polluted to a large extent and there is general increase in its nutrient enrichment. The maximum concentration of chloride, Magnesium, Sodium, Potassium, Silicate, Iron, Ortho phosphates and Total phosphorus is recorded at the S.K. Institute of Medical Sciences which reflects the malfunctioning of the treatment plant set up by the hospital authorities and its visible impacts on the hydrochemical features of the lake [44].
- → The oxygen concentration in Anchar Lake has depleted during the last decade. According to Das & Pande (1982) the depletion of oxygen, particularly in the bottom waters, are due to anaerobic bacteria that take over the process of decomposition of biological organic material releasing foul-smelling hydrogen, methane, and ammonia. These gases not only deplete oxygen in water but are toxic, killing most of the plankton, algae, and zooplankton in the lake.
- → Anchar lake water receives a substantial concentration of nutrients (nitrogen, phosphorus and Potassium) due to growing anthropogenic pressure in the form of agricultural, domestic and commercial sources [45].(Showqi *et al*., 2018).
- → Currently the lake is in a dystrophic condition, but rate at the rate nutrients are discharged into the lake could be the potential factor to change the freshwater dynamics of the lake into a eutrophic condition and the water quality in and around the inhabited areas within the lake has deteriorated to a much greater extent [45]. (Showqi *et al.,* 2018).

7.3 Major threats to the Hygam wetland

- → The increasing rate of siltation is a major problem impacting the quality of the wetland, leading to noticeable degradation in recent years. Two primary factors contribute to this issue. First, large-scale deforestation in the surrounding mountains has increased the silt load carried by the water into the wetland. Without the stabilizing effect of trees and vegetation, rainwater and runoff easily erode the soil, leading to higher sedimentation in the wetlands. Second, the increased sediment load in the water contributes to the accumulation of sediment in the wetland, which can reduce water depth, obstruct natural flow patterns, and degrade the habitat for aquatic life, including migratory birds that rely on the wetland ecosystem [46].
- → The second major factor contributing to the wetland's deterioration is the lack of adequate spaces for silt deposition, as most of the valley is used for agricultural purposes. With limited areas for the silt to settle, much of it is carried into the lake, where it accumulates, exacerbating the problem of sedimentation. On one hand nitrogen fertilizer is reported to increase leaf area index, net photosynthetic rate, nitrate reductase activity etc. [47]. But at the same time its excessive use leads to runoff that enters the lake, accelerating the process of eutrophication. This causes nutrient imbalances in the water, promoting excessive algae growth, which further degrades water quality. Other threats to the wetland include encroachment, as more land is converted into rice fields, and heavy grazing, which damages parts of the marshland, further harming the delicate ecosystem.
- → Aijaz Rasool, a wetland technical expert and senior executive member of the Environmental Policy Group (EPG), stated that large-scale illegal encroachments, unchecked pollution, and the lack of responsiveness from authorities to manage

→ human interference have significantly contributed to the deterioration of the wetland. As a result, the wetland has been reduced to little more than a large pond, which has forced migratory birds to seek alternative habitats for their wintering grounds. This loss of habitat is a serious concern for the conservation of these species, as it disrupts their natural migration patterns and breeding cycles [48].
→ The wetland is ill-maintained. Authorities must restore and conserve the wetland for future generations as there is a water siltation of 10 ft which deteriorates its condition," he said, [48].
→ Similarly, Aijaz Ahmed Dar, the Patron of the Central Auqaf Committee in Tarzoo, Sopore, highlighted that several areas of the wetland, including Haritar, Hygam, Lolpora, Gohul, Goshbug, and others, have been encroached upon. He mentioned that over the past several years, numerous structures have been constructed, and hundreds of kanals of land are being illegally used for paddy cultivation by encroachers. This uncontrolled encroachment has further degraded the wetland, contributing to the loss of vital habitats for wildlife and impacting the ecological balance , [48].
→ Dar, who is also a member of EPG said that the authorities earlier had identified the encroached land of at least 2300 Kanals that have not been retrieved yet. In addition to this, approximately 1200 kanals of land have been converted for crop cultivation. Mohammad Shafi Bacha, a retired senior official of the Wildlife department said that he used to count the migratory birds in lakhs in the area. "But we hardly witness any now because the water level capacity of this wetland has been minimized to 1 sq km from 7.2 sq kms due to siltation," he said, [48].
→ "In the year 2000, we had marked the wetland and decided to remove the trees that were planted by the various agencies including social forestry, panchayats and even the wildlife department as well. It has been 20 years since then and nothing has been done till now," Bacha added [48].
→ Similarly, locals too demanded the attention of the authorities to save the wetland from further deterioration.

7.4 Major threats to the Shallabugh wetland

→ The wetland is rapidly losing its charm and urgently needs attention. Due to extensive encroachments and the lack of action from authorities to control human interference, it has deteriorated into a large pond. This degradation has forced migratory birds to seek alternative habitats for their winter stay, significantly impacting the ecological balance of the area.
→ The primary cause behind the decline of the open water area is the continuous inflow of sediments from Sindh Nallah and its tributaries. These water bodies carry a substantial amount of sediment, which is deposited directly into the wetland, thereby reducing its water-holding capacity. This ongoing sedimentation exacerbates the degradation of the wetland's ecosystem [46].
→ Encroachment, unabated pollution and lack of conservation measures had drastically affected the eco-system of the wetland.
→ The major source of nutrients in the Shallabugh wetland are inputs from the feeding channel, mineralization of dead organic matter and the returns from sediments [49].
→ The Shallabugh wetland is undergoing significant bio-ecological changes as a result of persistent anthropogenic activities, including intensive agriculture, pollution, encroachment, and erosion within its catchment and watershed areas. These factors have severely impacted the wetland's ecological integrity. The introduction of heavy silt loads from surrounding agricultural practices has further exacerbated these challenges, leading to alterations in the wetland's hydrology and biodiversity. Studies indicate that the wetland is experiencing shifts in its biotic community structure, particularly with an increase in pollution indicator species, which suggests a transition towards eutrophication. The degradation of water quality and habitat fragmentation due to human encroachment are critical issues that threaten the survival of this vital ecosystem. Urgent management and restoration efforts are necessary to mitigate these impacts and preserve the ecological functions of Shallabugh wetland [49].
→ The water body is facing numerous anthropogenic disturbances that pose significant threats to its survival. These challenges are intensified by the heavy silt load introduced through various feeding channels from the Sindh Nallah. Such perturbations, including agricultural runoff, pollution, and encroachment, have detrimental effects on the water body's ecological balance and overall health. The influx of silt not only alters the physical characteristics of the water but also affects its quality, leading to potential declines in biodiversity and disruptions in aquatic ecosystems. Continuous monitoring and effective management strategies are essential to mitigate these impacts and ensure the sustainability of this vital water resource [50].

7.5 Major threats to the Wular Lake

The Catchments of Wular Lake are highly degraded. Against more than 50% of very dense forests in the 1950s, presently only 30% remain under dense forest cover. Approximately 30% of the catchment area is bare and denuded [51].

The following key factors have been identified based on assessment of land use changes:

I. Conversion for agriculture and horticulture development: The swift population growth has significantly intensified the demand for expanded agricultural and horticultural development, frequently at the cost of forested regions. According to evaluations by the State Department of Environment, forest cover declined by 6.2% between 1950 and 1997, alongside a 13% rise in land allocated for agricultural purposes. This pattern highlights the critical need to strike a balance between agricultural expansion and forest preservation to promote sustainable environmental practices and safeguard biodiversity [52].

II. Increasing dependence for/on energy: The Kashmir Valley demonstrates a significant reliance on forest resources to fulfill its energy requirements [53]. As a result, the forest line has notably retreated along its periphery. For example, in Kuhnis village, situated along the banks of Wular Lake, the forest line has shifted by 0.8 kilometers over the past three decades. Concurrently, women from the nearby Panzgam village have been compelled to walk an additional 02 kilometers to access forest resources. This trend highlights the increasing pressure on local ecosystems due to human activities and the consequent impact on community access to vital natural resources.

III. Adoption of erosion- intensifying agropractices in catchments: Approximately 30% (4,600 hectares) of the dryland agricultural area is severely eroded, primarily due to contour plowing practices [54]. This erosion has resulted in the formation of channels, nullahs, and gullies that contribute a substantial sediment load to Wular Lake. Additionally, the high application of fertilizers in horticultural lands exacerbates nutrient enrichment in water sources that ultimately flow into the lake [55]. The runoff from these agriculturally treated fields carries significant amounts of fertilizers into the lake, leading to severe eutrophication. Furthermore, the use of pesticides and other chemicals on horticultural crops leaches into the lake, further deteriorating its water quality. This combination of factors poses a significant threat to the ecological health of Wular Lake and highlights the urgent need for sustainable agricultural practices and effective management strategies to mitigate these impacts.

IV: Degradation of high altitude pastures: The pastures within the Wular direct catchment are under continuous pressure from nomadic herders, who move large numbers of low-yielding cattle and sheep from one meadow to another in search of grazing land. This overuse of pastureland has resulted in the spread of invasive weeds such as *Euphorbia wallichii*, *Senecio chrysanthemoides*, *Stipa sibirica*, *Sambucus wightiana*, and *Rumex* spp., leading to a decline in both grazing areas and fodder production. As moderately moist environments appear to be more open to invasion than extremely dry or extremely wet ones [56]. Currently, 2,000 hectares of pastureland are classified as severely eroded, 2,500 hectares as moderately eroded, and 4,100 hectares as experiencing slight erosion.

V: Quarrying: Quarrying activities are highly intensive within the direct catchment area, particularly along the Bandipora–Srinagar road in the Sadarkote Sector. A survey has identified 78 stone quarries, with 69 of these concentrated in Sadarkote Bala. These quarries operate year-round, displacing considerable amounts of loose stones, pebbles, and slush, which are subsequently transported into the lake bed during the monsoon season (Brigham, 1903). Additionally, sand and bajri mining operations are conducted intensively within the Madhumati Nallah catchment near Kaloosa. These activities significantly disrupt the natural siltation processes of the catchment area, contributing to ecological degradation and altering sediment dynamics within the lake ecosystem.

VI: Rapid degradation of forests due to over- extraction for fuelwood and over grazing of the pastures leading to soil erosion and consequent sedimentation and loss of water holding capacity of the wetlands [57].

VII: The rapid increase in population encroaching upon wetland area leading to its shrinkage [58].

VIII: Realizing the interconnectivity of the wetland regimes with the river flows, river basin approach needs to be adopted for management planning for Wular Lake [69].

8. Common challenges across Wetlands

I. Policy and Governance Gaps: Absence of integrated wetland management policies tailored to regional needs.

II. Encroachment and Land Use Change: Unchecked conversion of wetland areas into agricultural and urban lands.

III. Pollution: Increasing levels of solid waste, agricultural runoff, and untreated sewage threaten the ecological balance.

IV. Community Engagement: Limited involvement of local communities in conservation efforts, leading to a lack of ownership.

V. Climate Change: Altered precipitation patterns and rising temperatures exacerbate wetland degradation.

V. Monitoring and Research: Insufficient scientific research and weak monitoring mechanisms hinder effective decision-making.

9. Mitigation measures to be taken on priority for restoration of lake/Wetland ecosystem

I. All Lakes, particularly Anchar Lake has reached a critical stage from an ecological point of view therefore urgent steps must be undertaken by the State Govt. of Jammu & Kashmir for its conservation and management before the lake becomes ecologically ill.

II. Immediate demarcation on ground and ban on land conversion/construction, burning of wetland vegetation

III. Increasing forest cover in the direct catchment area, removing excess weeds from the lake on a regular basis, reducing area under degraded pastures and improving the quality of existing pasture lands.

IV. Willow plantations to be removed, accumulated silt dredged and marshes reconnected, and siltation reduced through better land use management.

V. Effective solid waste management. Organic can be converted into using microbial consortium technology [60].

VI. Effective surveillance by Wildlife Protection Department/Protection Force

VII. Wetlands are also considered valuable for their aesthetic appeal and their recreational and educational values, making it imperative that the public participate in wetland management and protection.

VIII. Avoid wetland alteration or degradation during project construction

IX. Reduce the amount of fertilizers, herbicides, and pesticides applied to lawns and gardens near Wetlands.

X. Community conservation by designating Wetlands as sacred water bodies based on religious faith can lead to the protection of wetland/water body.

XI. Qualitative and quantitative understanding of the sediment dynamic processes and their provenances such as natural and anthropogenic sources.

XII. Continuous monitoring of lake health and habitat suitability using various geological and geochemical approaches.

XIII. Adopting approaches to reduce catchment soil erosion, mass wasting and terrestrial organic matter influx into these lakes.

XIV. Local population has to be educated and well trained about the sustainable use of these lakes and consequences of their overuse.

XV. *Restoration or* rehabilitation of a wetland to return it to its historic or natural function. Often, land is reverted to its original wetland state through an alteration in hydrology. The goal is to create a self-regulating system that is integrated into the surrounding landscape. Restoration will lead to increased resilience of the people that live along the lake margins. Millions of people that live downstream in the Kashmir Valley will gain relief from future floods and benefit from enhanced access to water in times of extreme droughts.

XVI. The different departments must regularly conduct anti-plastic drives in and around Wetlands by involving local schools, N, G. O's and other stakeholders in order to keep wetlands plastic free

XVII. Finally, strong and full-fledged capacity-building programmes on sediment and organic matter management involving state ministry, environmentalists, concerned lake and wetland officials, and particularly, the local population are recommended for timely restoration of these freshwater and highly valuable natural ecosystems. If timely robust strategies and action plans are not devised and implemented, there will be gradual extinction of these freshwater bodies as a result of excessive sediment influx, hydrophyte blooms and subsequent eutrophication, and this will affect millions of people who are directly or indirectly dependent on these freshwater ecosystems.

10. Recommendations

I. Integrated Wetland Management: Develop region-specific management plans integrating ecological, social, and economic dimensions.

II. Awareness Campaigns: Educate local communities about the importance of wetlands and sustainable practices.

III. Strengthening Policies: Enforce stricter laws to prevent encroachments and manage pollution sources.

IV. Community-Based Conservation: Promote participatory approaches by involving stakeholders in decision-making and implementation.

V. Climate Resilience: Adopt adaptive measures to address the impacts of climate change, such as restoring catchment areas and ensuring sustainable water use.

11. Conclusion

Spanning an area of more than 7,000 hectares, the wetlands of the Kashmir Valley serve as crucial ecosystems that sustain a wealth of species and act as ecotones between different ecological communities. Urbanization, agricultural growth, erosion-promoting activities, and pollution have all contributed to significant degradation of important wetlands, such as Hokersar, Anchar, Hygam, Shallabugh, and Wular Lake.

As seen by the great biological significance of locations like the Hygam and Shallabugh wetlands, as well as the enormous but dwindling Wular Lake, these wetlands are vital for maintaining flora, wildlife, and migratory bird populations. Effective conservation efforts, such as prohibiting land conversion, controlling solid waste, lowering the use of agrochemicals, and educating local residents about the ecological and cultural significance of wetlands, are crucial to addressing these concerns. It is essential to preserve these wetlands in order to preserve the region's ecological health and biodiversity.

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