

Kallar Kahar Lake and the Salt Range Wetlands Complex: A Review of Avian Diversity, Threats, and Conservation Status in the Central Asian Flyway

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Running Title: Kallar Kahar Lake and the Salt Range Wetlands Complex

Abstract: Wetlands occupy a minor amount of Pakistan's land area but support a disproportionate share of the country's avian life. The Kallar Kahar Lake is a brackish spring-fed lake in the Salt Range of District Chakwal in Punjab. It has a Game Reserve status within the Salt Range Wetlands Complex, but has never been designated as a Ramsar site like the nearby Uchhali Complex. This assessment brings together the published record of the lake's bird richness, taxonomic makeup, migratory status, risks and conservation status, and considers its significance within the Central Asian Flyway, to identify where research is lacking and where management attention is needed. Searches were conducted in Google Scholar, Research Gate, PubMed, Scopus indexed sites, Zoological Society of Pakistan archive and official portals of Ramsar Convention, CMS and IUCN Red List; 23 original sources published from 1991 to 2025 matched the criteria for synthesis. The only comprehensive site-wide survey (Rais et al., 2011) recorded 86 bird species across 16 orders and 36 families, 33.72% of them water birds: 61.62% residents, 25.58% winter visitors, 8.13% summer breeding visitors and 4.65% passage migrants. Black-crowned Night Heron (*Nycticorax nycticorax*) and Little Egret (*Egretta garzetta*) breed in the lake's expanding Phragmites reedbeds. Open water shrank from roughly 220 ha to 133.5 ha between 2003 and 2009, and studies from 2022 to 2025 report substantial microplastic contamination in its water, sediment and fish. No site-wide inventory has appeared since 2011, order- and family-level counts remain untabulated, long-term monitoring is absent, and no site-specific survey confirms whether globally threatened waterfowl still use the lake. The lake is protected under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974, but carries no Ramsar status of its own. Stronger protection, a formal look at Ramsar eligibility, pollution control and standardised monitoring are recommended. Kallar Kahar Lake, however small, plays a vital role in the Salt Range Wetlands Complex and the Central Asian Flyway, and its future depends on research that is up to date.

Key words: Kallar Kahar Lake; avian diversity; Salt Range Wetlands Complex; Central Asian Flyway

INTRODUCTION

Wetlands rank among the most biologically productive ecosystems on Earth, providing breeding, staging and wintering habitat for a large proportion of the world's water bird species (Millennium Ecosystem Assessment, 2005). Pakistan, spanning arid to sub-humid climatic zones along the Indus River system, supports over 7,800,000 ha of inland wetlands and 250,000 ha of coastal mangroves and swamps; of these, 225 sites are recognised as being of national significance and 19 have been designated as Wetlands of International Importance under the Ramsar Convention (Rais et al., 2011).

Among the country's lesser-studied but ecologically important wetlands are the natural lakes of the Salt Range, a semi-arid hill range extending across northern Punjab between the Jhelum and Indus rivers. This range hosts a cluster of brackish to saline lakes -- Kallar Kahar, Khabbeki, Jahlar, Uchhali and Nammal -- collectively referred to as the Salt Range Wetlands Complex (SRWC) (Arshad, 2011). Of these, the Uchhali Complex (Uchhali, Khabbeki and Jahlar lakes) was designated a Ramsar site in March 1996 in recognition of its importance as a wintering ground for globally threatened waterfowl, including the White-headed Duck (*Oxyura leucocephala*) (Ramsar Convention Secretariat, Ramsar Site No. 818). Kallar Kahar Lake, though ecologically and geographically part of the same wetland system, has not itself been designated under the Ramsar Convention; it is instead protected domestically as

a Game Reserve under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974.

Kallar Kahar Lake has attracted scientific attention intermittently since the 1970s, when wintering waterfowl were first systematically counted at Salt Range wetlands, through to the most comprehensive site-wide avifaunal survey to date (Rais et al., 2011), which recorded 86 bird species. Subsequent research has been more narrowly focused, exploring the habitat associations of individual species (Bilal et al., 2013), the breeding ecology of colonial water birds (Rais et al., 2010) and, more recently, emerging pollution concerns such as micro plastic contamination of the lake's water, sediment and fish (Dilshad et al., 2022; Tabinda et al., 2025). Up to the present, no assessment has synthesised this scattered literature to assess the lake's avifaunal importance, its role in regional and international migratory-bird frameworks, and the suitability of its existing conservation status.

The aims of this review are to: (i) synthesise the published record of avian species richness, taxonomic composition and residency status at Kallar Kahar Lake; (ii) evaluate the ecological significance of the lake by comparison with the Central Asian Flyway and the wider Salt Range Wetlands Complex; (iii) critically assess documented and inferred threats to its avifauna; (iv) examine its legal and institutional conservation status, including its relationship to Ramsar and CMS frameworks and to Punjab wildlife legislation; and (v) identify research gaps and priorities to guide future monitoring and management.

Study Area

Kallar Kahar Lake, derived from the local terms "Kallar" meaning salt and "Kahar" signifying valley, is located in the Chakwal District of Punjab Province, roughly 25 km north of Chakwal city, along the periphery of the Pothohar Plateau on the southern border of the Salt Range. The lake is situated at roughly 32°46'30" N, 72°42'24" E, at an elevation of around 554 m above sea level, and is divided by the Lahore-Islamabad (M2) Motorway, which constitutes its eastern perimeter; hills border the lake to the south, while Kallar Kahar town is positioned to the west (Rais et al., 2011).

The lake is mostly nourished by freshwater springs originating at the foot of the adjacent hills, together with seasonal runoff from its watershed; the leaching of salt-laden bedrock makes the water somewhat brackish. Historical documentation reveals a significant decrease in open-water expanse, diminishing from around 220 hectares in 2003 to 133.5 hectares by 2009, a decline ascribed to watershed deterioration, sedimentation, and unregulated water extraction (Rais et al., 2011). Emergent flora, primarily consisting of common reed (*Phragmites australis*) and cattail (*Typha spp.*), has significantly proliferated, especially along the eastern and southeastern peripheries, where it is projected to encompass approximately 42 hectares, or about 31% of the lake's overall expanse (Rais et al., 2011). The eastern coastline is often swampy, featuring shallow waters, a muddy base, and abundant emergent rush vegetation, creating an environment preferred by moorhens, egrets, herons, ducks, and shorebirds.

Kallar Kahar Lake is officially designated as a Game Reserve in accordance with the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act of 1974, and is governed by the Punjab Wildlife & Parks Department. The region accommodates a significant resident populace and serves as a favoured recreational and tourist locale due to its picturesque environment, boating amenities, historical landmarks (such as the Mughal-era Takht-e-Babri), and convenient access from both Lahore and Islamabad via the freeway.

Literature Search Strategy

This evaluation employed a systematic, narrative literature synthesis method suitable for a location with a limited, dispersed primary research foundation. Electronic enquiries were performed utilising Google Scholar, ResearchGate, PubMed, Scopus-indexed journal platforms, the Zoological Society of Pakistan's archive (Pakistan Journal of Zoology), and the official repositories of the Ramsar Convention (Ramsar Sites Information Service), the Convention on Migratory Species (CMS), and the IUCN Red List of Threatened Species. Search terms combined the site name ("Kallar Kahar") with "bird*", "avifauna", "water bird", "wetland", "conservation" and "micro plastic", and were supplemented with broader searches on "Salt Range Wetlands Complex", "Uchhali", "Central Asian Flyway Pakistan" and "Punjab wetland avifauna" to capture comparative and contextual literature.

Records published between 1991 (the earliest widely cited avifaunal reference for the region, Roberts' The Birds of Pakistan) and 2025 were eligible for inclusion. Titles and abstracts were first screened for relevance to avian diversity, habitat, threats or conservation status of Kallar Kahar Lake or directly comparable Punjab wetlands; full texts of potentially relevant records were then examined. Peer-reviewed journal articles were prioritised; technical reports and grey literature (e.g., site management plans, Ramsar Information Sheets, CMS documents) were included only where they originated from recognised institutional sources (WWF-Pakistan, the Ramsar Secretariat, CMS, the Punjab Wildlife & Parks Department) and no peer-reviewed equivalent was available. Only English-language sources were reviewed.

Twenty-three primary sources met these criteria and were retained for detailed synthesis, comprising: (i) five site-specific field studies on the avifauna, habitat associations and breeding ecology of Kallar Kahar Lake (1991-2013); (ii) three recent (2022-2025) studies on water-quality and microplastic contamination at the site; (iii) regional survey literature on the White-headed Duck and other Salt Range waterfowl; (iv) comparative avifaunal studies from other major Punjab wetlands (Chashma Barrage, Taunsa Barrage, Tarbela Dam); and (v) policy and convention documents (the Punjab Wildlife Act 1974 and its amendments, Ramsar Site documentation for the Uchhali Complex, and CMS Central Asian Flyway materials).

One important limitation identified during the search is the sparse and temporally clustered nature of site-specific research: dedicated avifaunal fieldwork at Kallar Kahar Lake is concentrated in two short windows (2008–2013 and 2022–2025), separated by a near-decade gap during which no comprehensive bird survey appears to have been published. This chronological gap and its implications for the credibility of the present species checklist are discussed further in Sections 12 and 13.

Avian Diversity and Species Richness

The only complete inventory of the avifauna of the whole Kallar Kahar Lake site is that of Rais et al. (2011) based on monthly surveys from October 2008 to August 2009. The present study recorded a total of 86 species of birds belonging to 16 orders and 36 families out of which water birds formed 33.72% of the overall species pool. The water-bird component reported 162 ± 17.71 individuals in six species of duck and 440 ± 94.51 individuals in a further 23 species of non-duck water-birds. The most abundant species were the Common Coot (*Fulica atra*) and Northern Shoveller (*Anas clypeata*). Estimated densities were 3.29 birds per hectare for all water birds and 2.56 birds per hectare for ducks.

However, previous, more modest counts suggest a longer history of ornithological interest in the site: 25 water bird species were reported by Ali (2007), and 23 and 30 water-bird species were recorded by Azam et al. (2008, 2009)

During winter waterfowl censuses. These statistics are not directly comparable with the 2011 whole-avifauna inventory because of differences in survey scope and effort, but are broadly consistent with a moderately diversified, but usually species-rich water-bird assemblage compared with larger Punjab wetlands (see Section 6 and Table 3).

No site-wide inventory of species has been published since 2011. Changes to the physical extent of the lake, vegetation structure and pollution status during the intervening period are documented (Sections 8 and 10), and it cannot be assumed that the current species richness and composition of the site reflects the 2011 baseline. An updated, standardised survey is identified, as a priority research need (Section 12).

Representative Species Checklist

Table 1 details species from Kallar Kahar Lake that have been validated as named at the species level in two or more of the analysed references. It is consciously not presented as a thorough checklist: the entire inventory of 86 species documented by Rais et al. (2011) is not reproduced in full detail, as the complete underlying table was inaccessible in the sources reviewed, and reconstructing it without that primary data might result in inaccuracies. Academics seeking the full, itemised checklist of 86 species should immediately examine Table I of Rais et al. (2011), ideally cross-checked with a current taxonomic authority (Section 5).

Taxonomic Composition

Rais et al. (2011) reported 86 species belonging to 16 orders and 36 families indicating taxonomically diverse assemblage characteristic of inland Punjab wetlands which include open water, emergent marsh and adjacent scrub and agricultural habitats. Water birds -- spanning orders such as *Anseriformes* (ducks), *Podicipediformes* (grebes), *Pelecaniformes* (herons, egrets), *Gruiformes* (rails, coots) and *Charadriiformes* (waders) -- accounted for roughly one-third of recorded species, with the remainder comprising raptors, columbids, passerines and other land-bird groups typical of the surrounding cultivated and hill-slope habitats.

Species-level identification in the foundational literature primarily relied on Roberts' *The Birds of Pakistan* (1991, 1992) and Mirza's *A Field Guide to the Birds of Pakistan* (2007), both of which were published prior to numerous taxonomic updates, including generic reassignments and species-level divisions, that have since been integrated into internationally recognised checklists like those of the International Ornithological Committee (IOC) and BirdLife International/Clements. This assessment has maintained the scientific nomenclature as documented in the foundational Kallar Kahar literature to ensure accuracy, yet advises that any forthcoming site inventories should validate the names against the latest IOC World Bird List or a comparable, rigorously updated taxonomic source (Section 13), as order- and family-level tallies from previous surveys may experience minor adjustments in modern taxonomy without any actual alteration in the avian community.

Due to the primary literature providing only cumulative totals at the order and family levels (16 orders, 36 families) instead

of a comprehensive species count per order, this review refrains from presenting a detailed richness table by order; attempting to do so without the original raw dataset could lead to a misrepresentation of the data. Researchers seeking the complete order- and family-level breakdown are referred to Table I of Rais et al. (2011).

Resident and Migratory Birds

Rais et al. (2011) classified the 86-recorded species into four residency categories: residents (61.62%), winter visitors (25.58%), summer breeding visitors (8.13%) and passage migrants (4.65%). This distribution indicates that, while the majority of the avifauna is present year-round, roughly two-fifths of the species pool relies on the lake seasonally, either as a wintering ground for boreal- and Central Asian-breeding waterfowl and waders, as a breeding site for summer visitors, or as a stop-over point for species passing through en route to more distant wintering or breeding grounds.

Among the resident component, the lake supports breeding colonies of at least two colonial waterbirds within its expanding *Phragmites* reedbeds: The Black-crowned Night Heron (*Nycticorax nycticorax*) and the Little Egret (*Egretta garzetta*), with nesting densities estimated at 25 and 13 nests per hectare respectively within the roughly 42 ha of reed cover present on the lake's eastern and western margins (Rais et al., 2011). The seasonal influx of winter visitors and passage migrants situates Kallar Kahar Lake within the broader pattern of trans-continental waterbird movement along the Indus Flyway, a major sub-corridor of the Central Asian Flyway that channels an estimated 700,000 to 1,200,000 birds into Pakistan's wetlands each winter (Rais et al., 2011, citing regional flyway assessments); this flyway context is discussed further in Section 9.

Threatened Species

The Salt Range Wetlands Complex as a whole has long been recognised for its historical importance to the globally Endangered White-headed Duck (*Oxyura leucocephala*) (IUCN Red List category: Endangered; BirdLife International, 2017). Kallar Kahar Lake was among 16 historically important Pakistani sites resurveyed for the species in a targeted national assessment (Ali & Akhter, 2005; Ali et al., 2007); however, these and related surveys found no confirmed evidence of White-headed Duck at Kallar Kahar Lake itself during the survey period, in contrast to the neighbouring, Ramsar-designated Uchhali Complex, where the species continued to be recorded, albeit in sharply reduced numbers compared with historical counts that once exceeded 1,000 individuals in the 1960s (Green & Anstey, 1992; Ali & Akhter, 2005).

The Ramsar Information Sheet for the Uchhali Complex additionally identifies the Ferruginous Duck (*Aythya nyroca*, IUCN Near Threatened) and Greylag Goose (*Anser anser*, IUCN Least Concern but regionally notable in winter aggregations) among the species for which the wider Salt Range wetland system is internationally important. Because Kallar Kahar Lake shares hydrological and ecological continuity with this complex -- and because several species

move opportunistically among the Salt Range lakes in response to water availability -- these regionally significant species are plausible, though not independently confirmed, visitors to Kallar Kahar Lake. This distinction between confirmed on-site records and regionally inferred occurrence is an important caveat for conservation planning and is highlighted as a priority for targeted, site-specific survey work (Sections 12-13)

Habitat Characteristics

Kallar Kahar Lake comprises a mosaic of habitat types within a relatively small overall area (133.5 ha). The central and western portions retain open brackish water, fed by basal springs and used by diving ducks, coots and other pelagic water birds. The eastern and southeastern margins are dominated by dense, expanding stands of *Phragmites australis* and *Typha spp.*, covering an estimated 42 ha (about 31% of total lake area), which provide nesting substrate for colonial herons and egrets and cover for rails and crakes (Rais et al., 2011). The eastern shoreline in particular is shallow, muddy and marshy, attracting moorhens, egrets, herons and shorebirds. Surrounding the lake, rocky hill slopes to the south and scrub vegetation support raptors and dry-country passerines, while agricultural land and the built-up fringe of Kallar Kahar town provide foraging habitat for granivorous and omnivorous land birds.

Ecological Significance

Kallar Kahar Lake's ecological significance operates at three inter-linked scales. At the local scale, it functions as a breeding site for colonial water birds and a year-round refuge for resident species, and as one of relatively few standing water bodies within an otherwise semi-arid landscape, concentrating avian (and other) biodiversity disproportionately to its area. At the landscape scale, it forms one node within the Salt Range Wetlands Complex, a cluster of ecologically linked brackish lakes (Kallar Kahar, Khabbeki, Jahlar, Uchhali, Nammal) that together support wintering and passage waterfowl populations of regional importance, including historically the globally Endangered White-headed Duck (Arshad, 2011; Ramsar Sites Information Service).

At the flyway scale, Kallar Kahar Lake sits within the Indus Flyway corridor of the Central Asian Flyway (CAF), one of the major global water bird migration systems recognised under the Convention on the Conservation of Migratory Species of Wild Animals (CMS). The CAF spans some 30 range states between the Russian Arctic and South Asia and is estimated to support over 180 migratory water bird species (CMS, 2008; WWF, 2024), with the Initiative for the Central Asian Flyway adopted at the 14th Meeting of the Conference of the Parties to CMS (COP14, Samarkand, 2024) seeking to strengthen coordinated, range-wide conservation action. As a wintering and passage site along this flyway, Kallar Kahar Lake contributes -- in aggregate with the other Salt Range lakes and Pakistan's broader network of wetlands -- to the ecological connectivity that

migratory waterbirds depend upon across their annual cycle.

Beyond its avifaunal role, the lake holds secondary ecological and socio-cultural significance: it supports a locally distinct diatom flora (Bacillariophyta) recently documented for the first time at the site, and its scenic and recreational value sustains a substantial local tourism economy, which in turn creates both awareness-raising opportunities and management pressures for the site (Section 10).

Threats to Avifauna

A common set of interacting anthropogenic stresses on the avifauna of Kallar Kahar Lake emerged from the reviewed literature, several of which have escalated since the last extensive bird survey (2011). The most notable of these is the ongoing reduction of the lake's open-water area, which dropped from around 220 ha in 2003 to 133.5 ha in 2009, a decrease of almost 39% over seven years (Rais et al., 2011), adding to a previously observed 30% decrease in lake size between 1990 and 2003. This reduction in open-water habitat is directly detrimental to diving ducks and other pelagic water birds, while benefiting the expansion of *Phragmites* and *Typha* marsh, which is good for breeding herons and egrets, but can cause habitat homogenisation and a reduction in the diversity of microhabitats available to the wider water-bird community if unmanaged (Rais et al., 2011).

Habitat quality is also under pressure from unregulated tourism and recreational boating, encroachment of land around the lake margins, eutrophication and siltation from catchment runoff, and localised mining activity in the surrounding hills (Rais et al. 2011; Bilal et al. 2013). Recently, two independent studies have reported significant micro plastic contamination of the lake. Dilshad et al. (2022) found average micro plastic abundances of 88 ± 14.5 items per liter in surface water and $5,720 \pm 2,580$ items per kilogram in sediment, with fibers and irregular fragments being the most common particles. A subsequent study by Tabinda et al. (2025) provided further evidence of contamination in water, sediment and fish compartments and tested magnetisation and coagulation-flocculation treatments for micro plastic removal. Although no study directly tested micro plastic uptake in birds, the presence of micro plastics throughout the food web (particularly in fish, a prey item for piscivorous water birds) offers a possible but as-yet unquantified avenue of danger to the avifauna of the lake (Section 12).

At the regional (Salt Range) scale, illegal hunting and poaching of waterfowl, including the historically present White-headed Duck, have been repeatedly identified as a persistent threat to the Salt Range wetland bird populations, although they are legally protected under the Punjab Wildlife Act, 1974 (Ali & Akhter, 2005; Chaudhry et al., 1997, as cited in Ali et al., 2007).

Conservation Status and Management

Kallar Kahar Lake is legally protected as a Game Reserve under the Punjab Wildlife (Protection, Preservation,

Conservation and Management) Act, 1974 (Punjab Act II of 1974), which restricts hunting and regulates the possession, transfer and trade of protected animals, trophies and meat within the province. The Act has been amended repeatedly since enactment -- notably in 2007 (expanding protected-species provisions), 2020 (when the Punjab Protected Areas Act transferred sanctuary, national park and game reserve provisions under Sections 16-19 to a dedicated statute), 2023 and 2025 (strengthening enforcement provisions and penalties) -- and is administered by the Punjab Wildlife & Parks Department.

Critically, and in contrast to a widespread public perception reflected in some secondary and tourism-oriented sources, Kallar Kahar Lake itself has not been designated a Wetland of International Importance under the Ramsar Convention. Ramsar status in the Salt Range is held specifically by the neighbouring Uchhali Complex (Uchhali, Khabbeki and Jahlar lakes; Ramsar Site No. 818, designated 22 March 1996), in recognition of its role as a wintering ground for the White-headed Duck and other vulnerable waterfowl (Ramsar Sites Information Service). Kallar Kahar is instead managed under a site-specific management plan prepared as part of WWF-Pakistan's Pakistan Wetlands Programme, explicitly framed as covering "Kallar Kahar Game Reserve, a part of Salt Range Wetlands Complex" (Arshad, 2011). This distinction is important for conservation planning, because international Ramsar designation brings with it reporting obligations and access to international technical and financial support that domestic Game Reserve status does not automatically confer. The absence of international designation at Kallar Kahar is thus both a policy gap and potentially an underused conservation opportunity given the ecological continuity of the lake with the Ramsar-listed complex.

Internationally, Pakistan is a Range State to the Convention on Migratory Species (CMS) and a participant in the Central Asian Flyway framework, including the CAF Action Plan (adopted 2008) and the more recent Initiative for the Central Asian Flyway (adopted at CMS COP14, 2024), both of which provide non-binding but policy-relevant frameworks for range-wide waterbird conservation that are directly applicable to Salt Range sites such as Kallar Kahar Lake.

Comparative Context: Avian Diversity Across Major Punjab Wetlands

To contextualise the avifaunal importance of Kallar Kahar Lake within the wider provincial framework, Table 3 encapsulates analogous published information from other significant wetlands in Punjab. Direct comparisons must be approached with caution due to variations in study duration, taxonomic focus (entire avifauna versus solely waterfowl), and methodology; however, the comparison demonstrates that Kallar Kahar Lake, despite being smaller in size than many of the mentioned barrages and reservoirs, sustains a relatively similar level of species richness.

Research Gaps

This review identifies several substantive gaps in the published knowledge base for Kallar Kahar Lake. First, and

most fundamentally, no comprehensive, site-wide avifaunal inventory has been published since Rais et al. (2011); given documented reductions in lake area, changes in reed cover and newly identified pollution pressures over the past decade, the current species composition and abundance of the site cannot be assumed to match this now fifteen-year-old baseline. Second, publicly available literature reports only aggregate taxonomic totals (orders, families) rather than a fully tabulated, order-by-order species breakdown, limiting the precision with which taxonomic composition can be analysed or compared across sites without access to the original raw datasets. Third, no long-term (multi-year, standardized) population-trend monitoring programme appears to have been established at the site, in contrast to the decadal waterfowl census series available for some other Punjab wetlands (e.g., Chashma Barrage, Taunsa Barrage). Fourth, site-specific, survey-based confirmation of globally threatened species -- particularly the White-headed Duck -- is lacking for the post-2005 period; current evidence for the continued regional presence of such species relies on inference from the broader Salt Range Wetlands Complex rather than direct observation at Kallar Kahar itself.

Fifth, no study has yet examined whether or how the substantial microplastic contamination documented in the lake's water, sediment and fish (Dilshad et al., 2022; Tabinda et al., 2025) translates into measurable exposure or harm in the lake's avifauna, despite the plausibility of such a pathway via piscivorous and benthivorous feeding. Sixth, there is no published assessment of migratory connectivity (e.g., through ringing, colour-marking or satellite/GPS tracking) linking Kallar Kahar's winter-visitor and passage-migrant populations to specific breeding grounds along the Central Asian Flyway. Finally, the socio-economic dimension of the site -- particularly the relationship between tourism intensity, local livelihoods and habitat pressure -- has not been systematically quantified, despite qualitative references to unregulated tourism as a contributing threat.

Synthesis: Knowledge Gaps and Future Research Priorities

Future Research Directions

Addressing the gaps identified above suggests several priority directions for future research and monitoring at Kallar Kahar Lake. A systematic, recurring bird population survey -- preferably consistent with the Asian Waterbird Census framework managed by Wetlands International, facilitating direct comparisons with other wetlands in Pakistan and the region -- would restore an up-to-date benchmark for assessing future changes. All updated inventories must be validated against an active global taxonomic authority (e.g., the IOC World Bird List) to guarantee nomenclatural uniformity with current ornithological publications.

Targeted, multi-season surveys specifically designed to detect or confirm the continued presence (or absence) of the White-headed Duck and other Salt Range wetland specialists at Kallar Kahar Lake itself would resolve the current uncertainty around site-specific occurrence of globally threatened species. Complementary ringing, color-

marking or satellite/GPS-tracking studies of key migratory species would help establish the lake's precise position within Central Asian Flyway migratory networks and identify the breeding and staging sites with which it is functionally connected. Given the documented and substantial microplastic burden in the lake's water, sediment and fish, ecotoxicological research examining microplastic and associated contaminant exposure in resident and migratory birds -- for example through fecal, feather or blood sampling -- is a clear and timely research priority. Long-term, remote-sensing-based monitoring of land-cover and open-water extent (using freely available satellite imagery series such as Landsat or Sentinel-2) would allow habitat change to be tracked systematically and cost-effectively between field surveys.

From a policy-research standpoint, a comprehensive technical evaluation of Kallar Kahar Lake's suitability for Ramsar designation either autonomously or via the expansion of the current Uchhali Complex site boundary would elucidate the necessity and feasibility of enhanced international acknowledgement. Ultimately, systematic socio-ecological investigations assessing tourism carrying capacity, local community perspectives, and reliance on the lake for livelihoods would assist managers in reconciling ongoing recreational activities with habitat conservation, and could be effectively complemented by community-driven citizen-science bird monitoring to maintain data accumulation between formal research assessments.

Conclusion

Kallar Kahar Lake, though modest in size relative to Pakistan's larger wetland systems, occupies a distinctive and ecologically significant position within the Salt Range Wetlands Complex and the wider Central Asian Flyway. The available evidence most substantially the comprehensive 2011 survey recording 86 species across 16 orders -- confirms a taxonomically diverse resident and migratory avifauna, including breeding colonies of Night Heron and Little Egret, and a historical association with globally threatened waterfowl through its connectivity to the Ramsar-listed Uchhali Complex. At the same time, this review has identified a marked contraction in the currency, resolution and continuity of site-specific research, alongside a consistent and, in some respects (microplastic pollution), intensifying set of anthropogenic pressures on the lake's habitat quality.

Securing the lake's continued contribution to avian biodiversity conservation in Pakistan will require three complementary actions: renewed and sustained scientific monitoring to replace the ageing 2011 baseline; a formal reconsideration of the lake's conservation status, including its relationship to Ramsar and CMS frameworks relative to the neighbouring Uchhali Complex; and targeted management responses to documented threats, particularly habitat contraction, reed overgrowth, and water and sediment pollution. Embedding Kallar Kahar Lake more explicitly within regional (Salt Range Wetlands Complex) and international (Central Asian Flyway) conservation planning would help ensure that this lake continues to fulfil

its ecological role for both resident and migratory birds in the decades ahead.

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TABLES AND FIGURES

Table 1: Representative (non-exhaustive) checklist of bird species independently verified at Kallar Kahar Lake.

Order	Family	Species	Common Name	Residency Status
Podicipediformes	Podicipedidae	<i>Tachybaptus ruficollis</i>	Little Grebe	Resident
Anseriformes	Anatidae	<i>Anas clypeata</i>	Northern Shoveler	Winter visitor
Anseriformes	Anatidae	<i>Oxyura leucocephala</i>	White-headed Duck	Historically recorded regionally; status at this site unconfirmed
Gruiformes	Rallidae	<i>Fulica atra</i>	Common Coot	Winter visitor (most abundant water bird)
Pelecaniformes	Ardeidae	<i>Nycticorax nycticorax</i>	Black-crowned Night Heron	Resident breeder
Pelecaniformes	Ardeidae	<i>Egretta garzetta</i>	Little Egret	Resident breeder

Table 2. Globally and regionally threatened waterbirds associated with Kallar Kahar Lake and the Salt Range Wetlands Complex.

Species	IUCN Status	Site-level Evidence	Source
White-headed Duck (<i>Oxyura leucocephala</i>)	Endangered	Historically surveyed at Kallar Kahar; not confirmed on-site in 2003-2005 assessments	BirdLife International (2017); Ali & Akhter (2005); Ali et al. (2007)
Ferruginous Duck (<i>Aythya nyroca</i>)	Near Threatened	Recorded regionally within Salt Range Wetlands Complex; not independently confirmed at Kallar Kahar	Ramsar Sites Information Service, Uchhali Complex RIS
Greylag Goose (<i>Anser anser</i>)	Least Concern (regionally notable winter aggregations)	Recorded regionally within Salt Range Wetlands Complex; not independently confirmed at Kallar Kahar	Ramsar Sites Information Service, Uchhali Complex RIS

Table 3. Comparison of avian diversity between Kallar Kahar Lake and other major Punjab wetlands.

Wetland	Area / Status	Recorded Richness	Primary Source
Kallar Kahar Lake (Chakwal)	133.5 ha; Game Reserve (not Ramsar-listed)	86 species (16 orders, 36 families); whole avifauna	Rais et al. (2011)
Uchhali Complex (Khushab)	1,243 ha; Ramsar Site No. 818 (1996)	Historic wintering site for White-headed Duck, Ferruginous Duck, Greylag Goose, flamingos	Ramsar Sites Information Service
Chashma Barrage (Mianwali)	Wildlife Sanctuary; Ramsar-listed	46 waterfowl species; 533,965 birds counted, 1996-2005	Akbar et al. (2009)
Taunsa Barrage (Muzaffargarh/D.G. Khan)	Wildlife Sanctuary	Avian community diversity indices assessed	Bibi & Ali (2013)
Tarbela Dam (Indus River)	Reservoir	63 waterbird species; 2,990 individuals (Mar 2019-Feb 2020)	Rahman et al. (2021)

Table 4. Principal habitat types at Kallar Kahar Lake and their associated bird guilds.

Habitat Type	Description	Associated Bird Guilds
Open brackish water	Central/western lake basin, spring-fed, moderately saline	Diving ducks, coots, grebes (Anatidae, Rallidae, Podicipedidae)
Phragmites/Typha marsh	~42 ha of emergent reed cover, eastern & western margins	Breeding herons and egrets (Ardeidae), rails, warblers
Shallow muddy shoreline	Eastern margin; shallow water, muddy substrate, marshy	Moorhens, egrets, herons, shorebirds (Charadriidae, Scolopacidae)
Hill slopes & scrub	Rocky slopes flanking the lake to the south	Raptors, dry-country passerines
Agricultural & urban fringe	Cultivated land and Kallar Kahar town margins	Granivorous/omnivorous land birds, columbids

Table 5. Summary of knowledge gaps and corresponding future research priorities for Kallar Kahar Lake.

Knowledge Gap	Future Research Priority
No comprehensive avifaunal survey since 2011	Standardised, repeated census aligned with Asian Waterbird Census protocols
No tabulated order/family-level species breakdown available in the public literature	Re-derivation and publication of a fully itemised, taxonomically current species checklist
No long-term population-trend monitoring	Establishment of an annual/seasonal monitoring program, potentially community-based
No post-2005 site-specific confirmation of White-headed Duck or other globally threatened species	Targeted, multi-season surveys focused on globally and regionally threatened waterfowl
No data on migratory connectivity	Ringling, colour-marking or satellite/GPS tracking of key migratory species
No assessment of micro plastic exposure pathways to birds	Ecotoxicological sampling (feather, blood, faecal) of resident and migratory species
No systematic land-cover change monitoring	Multi-temporal remote-sensing analysis of open-water and marsh extent
Ramsar eligibility not formally assessed	Technical feasibility study for Ramsar designation, independently or as an extension of the Uchhali Complex
Tourism-habitat interaction not quantified	Socio-ecological study of visitor carrying capacity and community livelihood dependence

Synthesis: Threats and Mitigation Measures

Threat	Primary Evidence	Recommended Mitigation
Open-water area contraction (220 ha to 133.5 ha, 2003-2009)	Rais et al. (2011)	Catchment hydrological management; regulation of water abstraction; periodic remote-sensing monitoring of open-water extent
Uncontrolled Phragmites/Typha expansion (~31% of lake area)	Rais et al. (2011)	Managed, rotational reed-cutting and water-level regulation to maintain a habitat mosaic while preserving heronry nesting sites
Land encroachment & urbanisation of lake margins	Rais et al. (2011); Bilal et al. (2013)	Formal boundary demarcation and enforcement under the Punjab Wildlife Act, 1974 and Punjab Protected Areas Act, 2020
Eutrophication & siltation from catchment runoff	Rais et al. (2011)	Riparian buffer establishment; catchment-level agricultural best-practice guidance
Microplastic pollution of water, sediment and fish	Dilshad et al. (2022); Tabinda et al. (2025)	Solid-waste management around the lake and tourist areas; source control; continued trial of treatment technologies (e.g., coagulation-flocculation)
Illegal hunting & poaching (regional Salt Range pressure)	Ali & Akhter (2005); Ali et al. (2007)	Strengthened patrol and enforcement; community-based conservation engagement; public-awareness signage (already present in the area)
Unregulated tourism and recreational use	Rais et al. (2011)	Visitor carrying-capacity assessment and zoning of sensitive breeding/roosting areas
Localised catchment mining	Bilal et al. (2013)	Catchment land-use regulation and environmental-impact oversight

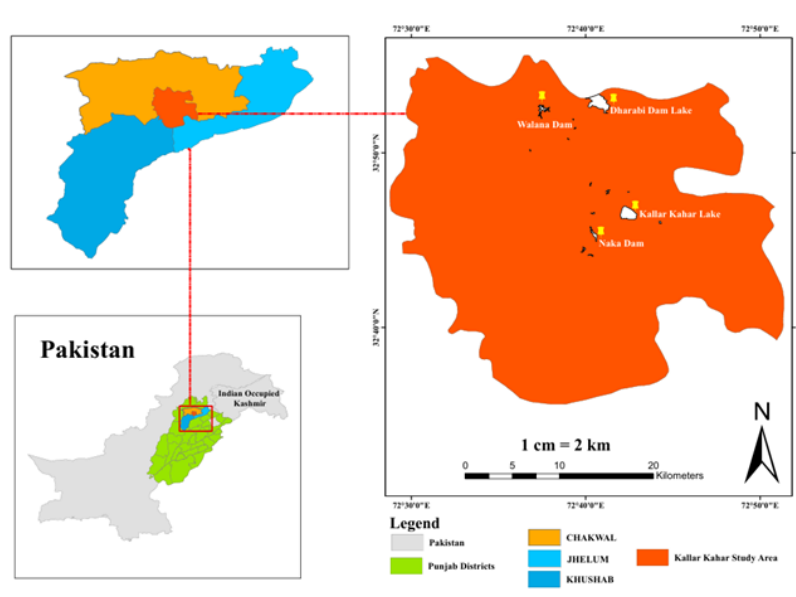


Fig. 1 Location map of Kallar Kahar Lake (placeholder -- see note above).

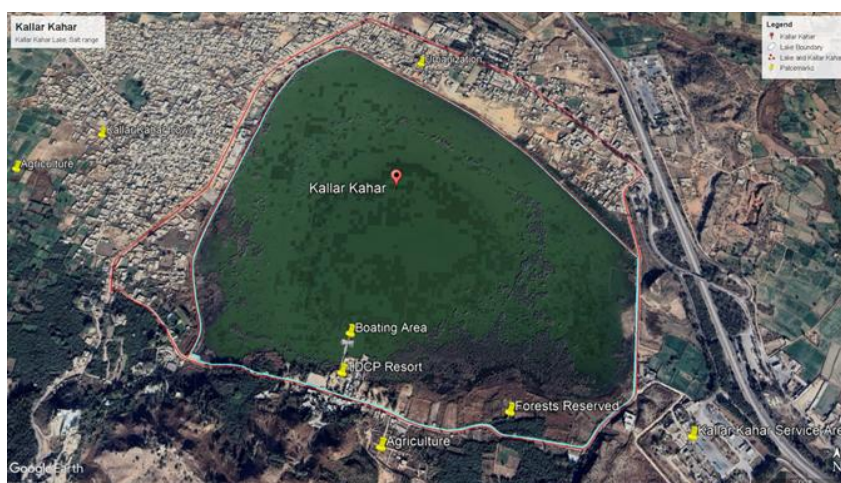


Fig. 2 Satellite image of Kallar Kahar Lake

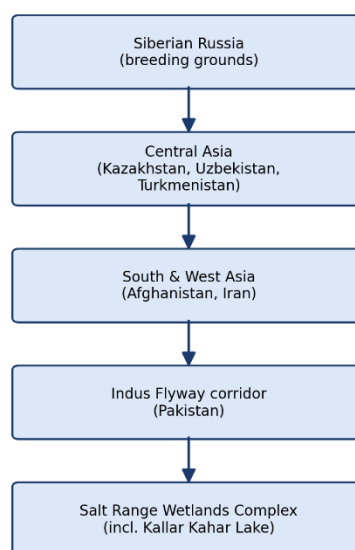


Fig. 3 Generalised schematic of the Central Asian Flyway migration corridor linking northern breeding grounds to Kallar Kahar Lake (based on CMS, 2008).

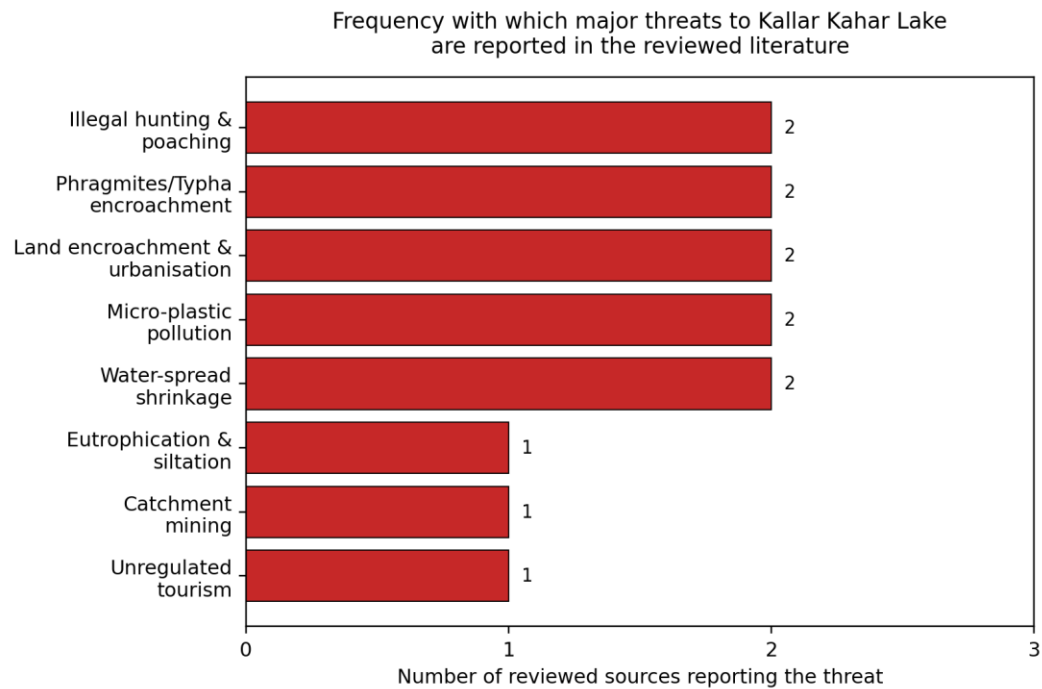
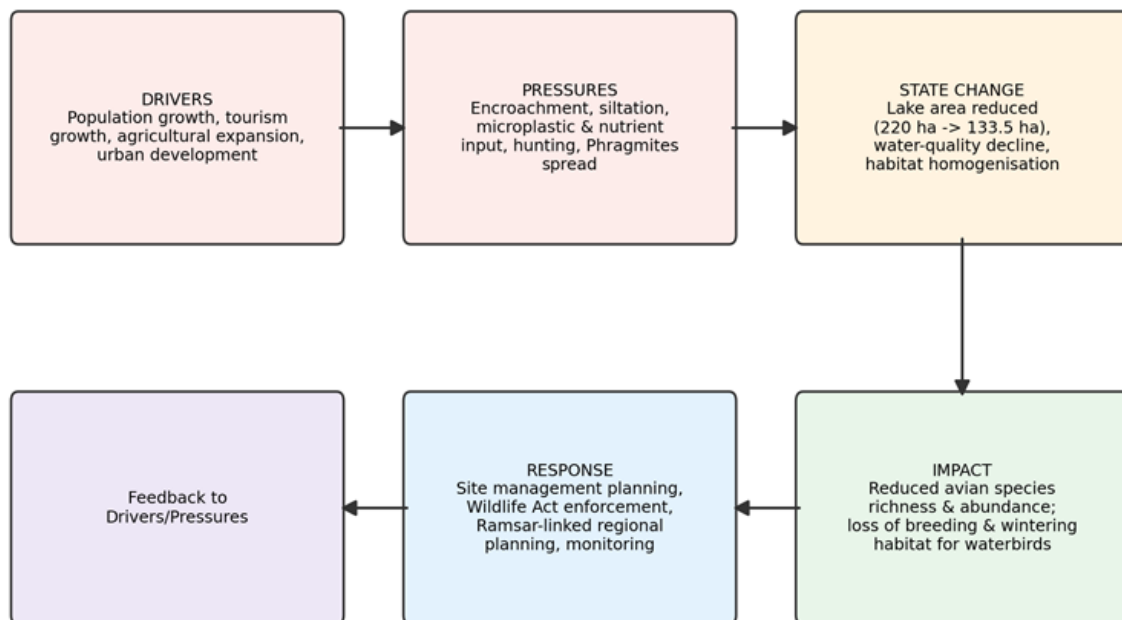


Fig. 4 Frequency with which major threats to Kallar Kahar Lake are reported across the reviewed literature (count of



independent sources reporting each threat category among the studies synthesised in this review
Fig. 5 Conceptual (Drivers-Pressures-State-Impact-Response) framework linking anthropogenic pressures to avian diversity change at Kallar Kahar Lake, synthesised from the reviewed literature.