

Review

Status, Threats, and Conservation of the South Asian River Dolphins (*Platanista*): A Comprehensive Review

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Abstract

The South Asian river dolphins of the genus *Platanista* represent one of the world's most evolutionarily distinct groups of aquatic mammals, consisting of two geographically and genetically isolated species: the Ganges River Dolphin (*Platanista gangetica*), distributed across the Ganges–Brahmaputra–Meghna (GBM) basin of India, Nepal, and Bangladesh, and the Indus River dolphin (*Platanista minor*), confined to the Indus basin of Pakistan and with a small remnant population in the Beas River, India. Both species are listed as Endangered on the IUCN Red List. Once widely distributed throughout South Asia's major river systems, both subspecies have undergone substantial range contraction due to widespread hydrological alteration, habitat fragmentation, bycatch mortality, pollution, vessel disturbance, and climate-driven changes in seasonal flows. The Indus River dolphin, in particular, has experienced an approximately 80% reduction in historical linear range, with the remaining population concentrated in fragmented river sections separated by irrigation barrages. The Ganges River dolphin retains a broader distribution, but its range and abundance have also declined and become increasingly fragmented. This review synthesizes ecological, hydrological, genetic, and conservation literature to compare the status and threats of both species and to identify research and policy priorities. The evidence indicates that long-term conservation requires protection of ecological flows, maintenance of river connectivity, reduction of fisheries-related mortality and pollution, and coordinated basin-scale management that accounts for the socioeconomic realities of riverine communities.

Keywords: South Asian River dolphins; *Platanista*; distribution habitat fragmentation; conservation.

1. Introduction

South Asian River dolphins of the genus *Platanista* occupy a unique evolutionary, ecological, and cultural position within the river systems of the Indian subcontinent [1]. These dolphins once ranged widely across the Ganges–Brahmaputra–Meghna (GBM) and Indus river systems; regarded as the world's most dynamic freshwater landscapes shaped by monsoon floods, glacier water, shifting channels, and extensive floodplains [2, 3]. Historically, both the Ganges River dolphin and the Indus River dolphin distributed long stretches of river, moving seasonally among deep pools, confluences, and floodplain channels in response to fluctuating hydrological conditions [4]. Their ecological adaptations allowed them to thrive in turbid, sediment-rich waters making them apex freshwater



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predators. However, the ecological conditions have profoundly altered the evolution and distribution of these dolphins. Beginning in the nineteenth and accelerating in the twentieth century, the Indus and GBM basins underwent large scale transformation for irrigation, hydropower, flood control, and navigation. These engineering interventions have fragmented rivers into discrete segments, disrupted natural flow regimes, and fundamentally changed sediment transport processes. As a result, both subspecies of *Platanista* now persist only in parts of their former ranges and face ongoing pressures that threaten their long-term viability [5].

Although the Ganges and Indus dolphins share many ecological traits and threats, their conservation concerns are different in many ways. The Indus River dolphin population has declined most dramatically compared to any cetacean, with significant range contraction due to an extensive network of irrigation barrages that block movement along the river [6]. Braulik, Arshad [7] examined the causes of range decline of the Indus River dolphin in a highly fragmented river system and found approximately 80% historical range contraction. Range decline was strongly linked to reduced dry season discharge (30,830 vs 8,022 cusecs) and habitat fragmentation from dams. By contrast, the Ganges River Dolphin persists across a broader geographic area and therefore, faces a more diverse and variable set of pressures, including intense fisheries interactions, high pollution loads, widespread riverbank urbanization, and complex transboundary water governance issues involving India, Nepal, and Bangladesh [1, 2, 8]. Despite this different geographical distribution, both subspecies suffer the profound vulnerability due to hydrological and ecological disruption. The high dependency of these dolphins on continuous river corridors, seasonal flows, and abundant fish communities further puts them at risk. Combined with slow reproductive rates and long lifespans, population recovery for these dolphin species is a slow process.

Available studies across Pakistan, India, Nepal, and Bangladesh highlight that conserving *Platanista* requires an integrated perspective. These dolphins cannot be protected effectively through isolated site-based interventions alone. Therefore, conservation must be linked to basin scale water management, national energy and agricultural policies, fisheries regulation, and climate adaptive planning. This review synthesizes ecological, hydrological, and sociopolitical research to evaluate the status of both species and identify strategies that reflect the shared and distinct challenges faced by dolphins across South Asia.

This review synthesized peer-reviewed articles, books, technical reports, conservation assessments, and country- or basin-specific studies relevant to the taxonomy, distribution, population status, ecology, threats, and conservation of South Asian river dolphins. Literature was identified through searches of the scientific literature and by following references cited in key reviews and conservation assessments. Sources were selected for their relevance to *Platanista*, geographic coverage of the Indus and GBM basins, and availability of information on population status, habitat, threats, or conservation responses. Because population surveys differ in methods, spatial coverage, and survey years, reported abundance estimates were retained as study-specific estimates rather than pooled across countries or years. The review is therefore a narrative synthesis rather than a formal meta-analysis.

2. Phylogenetic relationship of South Asian River dolphins

The genus *Platanista* represents one of the oldest surviving branches of the cetacean evolutionary tree. Genetic, morphological, and behavioral analyses consistently position South Asian River dolphins as exceptionally distinct among extant dolphins, sharing limited affinity with marine odontocetes and showing deeper evolutionary separation from South America's *Inia* and *Pontoporia* than from any living marine dolphin lineage [9] (Fig. 2). This evolutionary distinctiveness is central to their conservation importance, as loss of either subspecies would eliminate millions of years of irreplaceable evolutionary history.

Within *Platanista*, the Indus and Ganges dolphins form two geographically isolated subspecies that diverged long ago under differing hydrological conditions. Extensive genetic analyses indicated strong population structuring between the Indus and GBM basins, with minimal gene flow for thousands of years. The most comprehensive taxonomic review by Braulik et al [10] argues that the two subspecies are sufficiently distinct in morphology, cranial features, body proportions, and genetic markers to justify separate conservation management units. Their long-term geographic separation, resulting from tectonic and hydrological isolation of river basins, has resulted into two lineages adapted to different ecological environments [10, 11]. Morphologically, both subspecies share a common trait adapted to life in turbid freshwater rivers. They possess extremely long, narrow rostra with numerous homodont teeth ideal for grasping small, slippery fish [9]. Their eyes are highly reduced and non-functional for forming detailed images, reflecting reliance on echolocation rather than vision in sediment-loaded waters. Their flexible cervical vertebrae allow tight turning angles within shallow, complex channels [9]. These adaptations underscore a long evolutionary history tied to shallow riverine environments rather than estuaries or marine systems.

Despite these similarities, important morphological differences distinguish the two subspecies. The Indus River dolphin generally exhibits a proportionally smaller body size, slightly reduced rostral length, and cranial characteristics associated with adaptation to the narrower, more regulated flows of the Indus basin (Table 1). In contrast, the Ganges River dolphin exhibits traits linked to historically larger, more braided rivers with high monsoon variability, including greater body size and rostral length (Table 1).

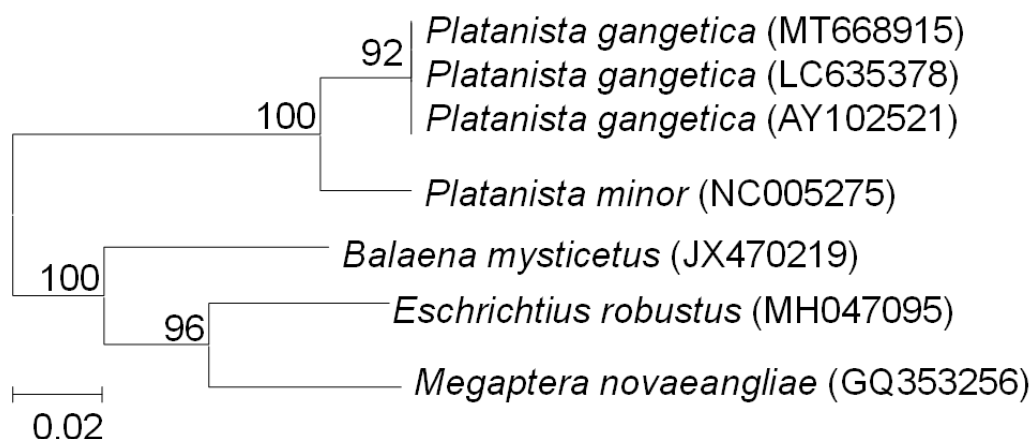


Figure 1: Maximum likelihood tree showing the phylogenetic relationship among the *Platanista* species distributed in south Asian water system using cytb gene. The letters and numbers in the parenthesis refer to the GenBank accession numbers. The tree and sequence data are interpreted in the context of the taxonomic treatment of Braulik et al. [10].

Table 1: Major morphological differences between Indus and Ganges River dolphins (*Platanista* spp.) based on Braulik et al. [7].

Feature	Indus River dolphin (<i>Platanista minor</i>)	Ganges River dolphin (<i>Platanista gangetica</i>)
Skull length	Shorter asymptotic skull lengths compared to Ganges females	Longer asymptotic skull lengths than Indus males
Upper tooth row	An average of 33.2 teeth	An average of 28.4 teeth
Lower tooth row	An average of 32.9 teeth	An average of 29.4 teeth in the lower tooth row
Sexual dimorphism	No evidence of sexual dimorphism	Females are significantly larger than males
Skull morphology	Skulls have a distinct frontal bone shape behind the nasals	Skulls have a different frontal bone configuration

Both subspecies exhibit low genetic diversity, but the Indus River dolphin is particularly constrained. Mitochondrial DNA studies reveal limited haplotype variation across the contemporary Indus population, likely resulting from prolonged fragmentation by barrages and historical bottlenecks [10, 11]. The Ganges subspecies, while also restricted by contemporary barriers, retains somewhat higher diversity across the wider GBM basin. These genetic patterns highlight the urgency of preventing further fragmentation, as loss of connectivity could exacerbate inbreeding and reduce adaptive potential. Understanding this evolutionary and taxonomic context is critical for conservation. Because the two subspecies reflect distinct ecological and genetic histories, conservation planning must be tailored to their specific threats, hydrological contexts, and demographic trajectories. At the same time, recognizing their shared lineage underscores the importance of basin-wide strategies that address the common hydrological pressures threatening river dolphin survival across South Asia.

3. Distribution of *Platanista* in South Asia

Historically, South Asian River dolphins of the genus *Platanista* occupied extensive and largely continuous stretches of the Indus and GBM river systems [2]. Early natural history accounts and twentieth-century survey records describe dolphins occurring far upstream in both basins, including regions that are now completely inaccessible due to dams, barrages, and reduced flows [12, 13]. In the Indus system, dolphins were once reported from the Himalayan foothills downstream to the Indus delta, moving freely along the river in response to seasonal variation in discharge [14, 15]. Similarly, the Ganges River dolphin historically ranged throughout the Ganges mainstem and its major tributaries, as well as across the Brahmaputra and Meghna systems, including rivers in present day Nepal and Bangladesh [1, 8] (Fig. 2).

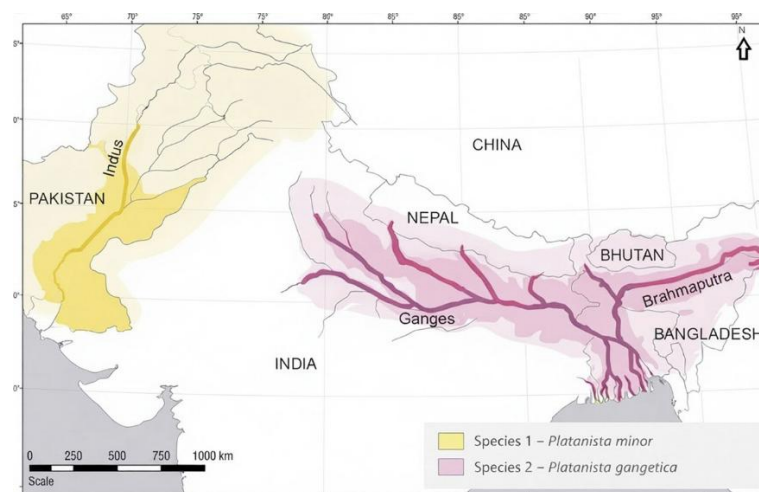


Figure 2: Current distribution of *Platanista* in South Asian river system.

This historical continuity was essential to the ecological functioning of *Platanista*. Seasonal flooding allowed dolphins to access floodplain habitats rich in fish, while dry-season contraction concentrated them in deep pools and confluences that served as refuges [16]. The longitudinal connectivity of river systems enabled dispersal, gene flow, and recolonization of species following local disturbances. These natural dynamics continued for millennia, shaping species divergence in south Asian river system. The disruption of this connectivity marked a defining turning point in the conservation history of South Asian river dolphins [17]. Large-scale river engineering, beginning in the colonial era and accelerating after independence in South Asian states, fragmented river systems into discrete segments. This transformation fundamentally altered dolphin distribution, replacing continuous populations with isolated subpopulations separated by physical barriers and hydrological discontinuities [18].

3.1. Indus River dolphin

The Indus River dolphin (*Platanista minor*) now occupies one of the most restricted ranges of any cetacean species [7]. Contemporary distribution is largely confined to the middle reaches of the Indus River in Pakistan, primarily between major irrigation barrages [14]. The construction of an extensive network of barrages during the twentieth century subdivided the river into multiple isolated fragments, preventing upstream and downstream movement. As a result, dolphins persist in only a subset of these fragments, while they have been extirpated from many others [15].

Population assessments indicate that the majority of the remaining Indus dolphins occur in the river section between the Guddu and Sukkur barrages, with smaller numbers present in adjacent segments [15]. Although recent surveys suggest that some subpopulations may have stabilized or even increased following the cessation of direct hunting, this apparent recovery masks profound vulnerability [19]. The entire population remains dependent on a highly regulated river system, where dry-season flows are controlled primarily by irrigation demand rather than ecological needs [19]. Despite legal protection and targeted conservation efforts in Pakistan, the Indus River Dolphin remains critically dependent on sustained water availability within its fragmented habitat. Any further reduction in dry-season flow or additional infrastructure development poses immediate risks to population viability.

3.2. Ganges River dolphin

The Ganges River Dolphin (*Platanista gangetica*) occupies a broader but increasingly fragmented range across India, Nepal, and Bangladesh. In India, dolphins persist in the mainstem of the Ganges and several major tributaries, including the Ghaghara, Gandak, Kosi, Son, and Chambal rivers [12]. However, even within India, distribution is highly uneven. Some river stretches support relatively

stable populations, while others have experienced severe declines or complete local extirpation. Studies have shown that dolphin encounter rates vary significantly across river segments, with higher densities in less disturbed stretches and very low or absent populations in degraded habitats [4, 15]. For instance, Braulik, Noureen [15] reported strong spatial variation in dolphin abundance across the Ganges–Brahmaputra system, linked to hydrological and anthropogenic factors. Sinha and Kannan [4] documented that certain stretches of the Ganga and its tributaries have lost dolphin populations entirely due to habitat fragmentation and declining water quality.

Nepal represents the upstream limit of the Ganges dolphin's range and currently hosts some of the smallest and most precarious subpopulations [16]. Dolphins in Nepal are restricted to a few river systems, including the Karnali, Narayani, and Sapta Koshi. Surveys conducted over the past two decades consistently report very low numbers, with sightings often limited to single individuals or small groups [18, 20, 21]. Reduced dry-season flows, driven by upstream water extraction and diversion, have dramatically reduced habitat availability [1]. Physical barriers, such as barrages, further restrict movement and concentrate dolphins into small downstream areas [1, 22].

In Bangladesh, Ganges dolphins inhabit a complex deltaic environment shaped by the confluence of the Ganges, Brahmaputra, and Meghna rivers [23, 24]. Dolphins are recorded in several major rivers, including the Jamuna, Meghna, Halda, and Karnaphuli, as well as in heavily modified urban rivers near Dhaka [25, 26]. Although Bangladesh supports multiple subpopulations, these dolphins face intense pressure from pollution, fisheries interactions, and riverbank development [27–29]. The persistence of dolphins in severely degraded rivers highlights both their resilience and the extreme ecological stress under which they survive [30].

Across the GBM basin, population estimates remain uncertain due to methodological challenges and inconsistent monitoring [15, 16]. Nevertheless, available evidence indicates declining trends in many regions, particularly where hydrological alteration and fishing pressure are greatest [4, 27]. Unlike the Indus subspecies, which faces extreme spatial confinement, the Ganges subspecies confronts a broader array of threats distributed unevenly across a vast transboundary basin [24].

4. Ecology of South Asian River dolphins

4.1. Habitat ecology

The habitat ecology of South Asian river dolphins is fundamentally shaped by hydrology [24]. Both subspecies exhibit strong preferences for deep pools, meandering channels, and confluence zones where water depth, flow complexity, and prey availability are highest [31]. These habitats provide critical foraging opportunities and refuge during periods of low discharge [15]. Seasonal variability in flow historically allowed dolphins to move among habitats, exploiting floodplain resources during the monsoon and retreating to deeper river sections during the dry season [16]. Hydrological studies demonstrate that dry-season flow is the most critical determinant of habitat suitability for *Platanista* [12, 32]. Khanal, Suryawanshi [32] reported that irrigation-driven water diversion reduced river depth, forcing dolphins to shift into new habitats with higher fishing pressure. They found that dolphin abundance declined significantly (from 11 to 6 individuals) as low water depth increased exposure to fishing activities and bycatch risk. Aggarwal, Kumar [12] reported that reduced dry season water depth and flow caused by water diversion projects, dredging, and increased vessel traffic significantly disrupts major dolphin habitats through degradation and fragmentation. They also reported that large-scale river modification projects overlap with up to 90% of dolphin populations, posing a severe risk to their long-term survival.

When discharge falls below certain thresholds, deep pools shrink or disappear, forcing dolphins into increasingly confined spaces [18]. This confinement intensifies competition for prey and increases interactions with fishing gear and vessels [4]. In both the Indus and GBM basins, reduced dry-season flows have been directly linked to declines in dolphin occupancy and encounter rates [1, 7, 19, 20]. Channel morphology also plays a crucial role in habitat selection. Dolphins preferentially occupy river

sections with complex cross-sectional profiles, including deep troughs and variable current velocities [33]. Straightened or embanked channels with uniform depth are generally avoided, as they offer limited foraging opportunities and increased risk of stranding [31]. Human activities such as dredging, embankment construction, and sand mining further reducing habitat quality [4].

In the Indus basin, habitat suitability is tightly constrained by irrigation management, which determines the volume and timing of water release [19]. In the Ganges–Brahmaputra–Meghna basin, habitat conditions are influenced by a combination of monsoon variability, upstream water extraction, and downstream sediment dynamics [2, 5]. Despite these differences, both subspecies share a reliance on hydrological regimes that sustain depth, connectivity, and ecological complexity.

4.2. Feeding ecology and movement patterns

South Asian River dolphins are opportunistic predators that feed primarily on freshwater fish, including clupeids, cyprinids, and catfish [2]. Feeding behavior is closely linked to hydrological conditions, with dolphins adjusting foraging strategies in response to seasonal changes in water level and prey distribution [34]. During high-flow periods, dolphins exploit a wider range of habitats, while during the dry season they concentrate in deep pools where fish densities remain relatively high [35]. Historically, both subspecies were capable of extensive longitudinal movement while tracking seasonal changes in habitat availability [21, 30]. However, contemporary movement patterns, however, are severely constrained by barriers such as dams and barrages [7, 12]. Observational studies indicate that dolphins frequently approach these structures but are unable to pass them, resulting in long-term isolation of subpopulations [7, 19]. This restricted movement limits gene flow and reduces the potential for recolonization of suitable habitats following local declines [10].

In the Indus system, movement between river fragments is virtually nonexistent, rendering each subpopulation demographically independent [6, 11]. In the Ganges–Brahmaputra basin, some connectivity remains, particularly in less regulated river sections, but ongoing infrastructure development threatens to further restrict movement [36]. The loss of mobility represents a critical challenge for conservation, as it undermines the species' natural resilience to environmental variability.

5. Anthropogenic threats

5.1. Hydropower development, dams, and river regulation

Among all anthropogenic pressures affecting South Asian river dolphins, hydropower development, irrigation infrastructure, and river regulation constitute the most profound and far-reaching threats across both the Indus and GBM basins [12]. While the exact configuration of barriers and flow alterations differs by country and river system, their collective impact has been the fragmentation of once continuous habitats into isolated segments, the suppression of ecological flows essential to dolphin survival, and the creation of artificial hydrological regimes that deviate sharply from natural conditions [35].

The Indus River dolphin provides one of the most striking examples of ecological fragmentation caused by river regulation. Over the twentieth century, Pakistan constructed one of the world's largest irrigation systems, comprising multiple major barrages that partitioned the Indus River into discrete segments [15]. Each barrage functions as a near absolute barrier to upstream and downstream movement. As a result, the Indus dolphin's historical range, once extending over roughly 3,500 km has been reduced to a series of isolated stretches between barrages [15]. This fragmentation has also coincided with extreme manipulation of water flows. Dry season discharge in many segments is now dictated entirely by irrigation demand, reducing the ecological space available for dolphins and increasing the risk of stranding when flows abruptly drop [37].

In the GBM basin, the hydrological picture is more complex but no less threatening compared to the Indus basin. India, Nepal, and Bangladesh have each developed extensive water-control structures, including dams, barrages, embankments, diversion canals, and flood-management systems [12, 19].

Unlike the Indus River, where the river is regulated primarily for irrigation, the GBM basin is governed by a combination of hydropower development, flood control, and inter-basin transfers [4]. These pressures collectively alter the timing, quantity, and variability of river flows that sustain dolphin habitats [16, 31]. Reduced discharge during the dry season, often associated with upstream storage and diversion, diminishes the depth of critical pools and accelerates siltation [4, 12]. This environment increasingly forces Ganges dolphins into narrow, shallow channels where competition with fishers intensifies and prey availability decreases [31, 32, 34].

Perhaps the most ecologically consequential effect of river regulation is the disruption of natural seasonal rhythms. South Asian River dolphins evolved in systems characterized by strong monsoon-driven flood pulses that expanded habitat availability and stimulated fish recruitment [19]. When dams flatten these seasonal peaks, the ecological conditions necessary for both dolphins and their prey become degraded [5]. Furthermore, altered sediment transport caused by dams and embankments reshapes channel morphology, often resulting in channel narrowing and homogenization [29, 31, 32]. Such changes reduce the hydraulic complexity that dolphins rely on for foraging and refuge. In both basins, river regulation not only removes habitat but transforms the fundamental ecological architecture of the river itself.

5.2. Fisheries

Across the Indus and GBM basins, interactions with fisheries represent one of the most immediate and pervasive threats to river dolphin survival [38]. The majority of documented bycatch events involve monofilament gillnets, which are nearly invisible underwater and present a serious entanglement hazard [31]. Dolphins caught in these nets often drown before they can free themselves [39]. Bycatch mortality is particularly concentrated in the dry season, when low water levels confine dolphins and fishers to the same deep pools [40].

In the Indus basin, bycatch remains a significant, though somewhat less frequently documented, source of mortality compared to the GBM basin. The relative narrowness of many Indus River fragments and the concentration of fishers in accessible areas create conditions in which dolphins are exposed to high levels of risk [6, 19]. The Indus River dolphin population is limited to a few river segments and is the focus of concentrated monitoring programs, mortality events are detected more consistently than in the GBM basin [14]. In the GBM system, bycatch risk is further amplified by high human population densities, widespread fishing pressure, and limited enforcement capacity. In Nepal, where river dolphins occupy extremely small stretches of the Karnali, Sapta Koshi, and Narayani rivers, fishers report frequent accidental entanglement but rarely engage in formal reporting [1, 20]. The overlap between dolphin habitat and fishing zones is especially intense in winter, when fish aggregate in deep pools and dolphins depend on these same refuges for survival [33]. In Bangladesh, bycatch pressures are even more pronounced. Rivers near Dhaka, such as the Buriganga and Turag, support dense fishing communities, and dolphins often become entangled in nets set for small, commercially valuable fish species [41]. Despite legal protections, bycatch mortality remains largely unmonitored and underreported.

The socioeconomic context of fisheries is critical for understanding this threat. Many fishers rely on riverine resources for subsistence or income, and any bycatch mitigation strategy must acknowledge these dependencies [42]. Experimental trials of acoustic deterrent devices have shown promise in reducing dolphin interactions with gillnets, but adoption has been limited by cost, uncertainty regarding long-term effectiveness, and concerns that pingers may affect target fish behavior [43, 44]. Without integrating technical solutions with community engagement and livelihood alternatives, fisheries-related mortality will continue to undermine conservation progress.

5.3. Intentional killing and dolphin oil

Intentional killing of river dolphins persists in some parts of South Asia, particularly in the lower Brahmaputra, Meghna, and Karnaphuli systems, where dolphin oil is still used as bait for catfish and in

local traditional practices [45, 46]. Although dolphin killing is illegal in all range countries, the practice continues due to strong cultural persistence and economic incentives [41, 45]. Fishers sometimes caught dolphins accidentally, but there are also cases of deliberate killing to obtain oil [46]. Kolipakam, Singh [45] reported that dolphin oil continues to be actively used in bait fisheries despite legal restrictions and availability of alternatives. They also highlighted that socioeconomic dependence and perceived effectiveness of dolphin oil over alternatives hinder conservation efforts and enforcement.

5.4. Pollution and habitat degradation

Pollution is a major threat across the range of *Platanista*, affecting both species through reduced water quality, prey depletion, and the introduction of toxic substances [34]. Rapid urbanization and industrial expansion across South Asia have resulted in untreated sewage discharge, heavy metal contamination, chemical effluent release, and agricultural runoff entering major rivers [47]. In Bangladesh and India, urban rivers near cities like Dhaka, Kanpur, and Patna exhibit severe pollution loads that often exceed allowable limits for key water quality parameters [48, 49]. Despite these conditions, dolphins continue to survive in some polluted stretches, indicating remarkable physiological tolerance but also the precarious nature of their persistence [50]. While pollution is less spatially extensive in the Indus Basin, it still remains a concern, particularly downstream of major urban centers and industrial zones [51]. Agricultural runoff loaded with pesticides and fertilizers further degrades water quality and affects fish populations [52]. Habitat degradation is compounded by sand mining, dredging, and riverbank modification, which simplify channel morphology and destroy deep-water refuges essential for dolphin survival [8, 12].

5.5. Vessel traffic, noise disturbance, and collisions

Increasing vessel traffic presents an emerging threat in both the Indus and GBM basins [12, 15]. Since dolphins rely on echolocation to navigate and hunt in turbid waters, noise from motorized boats overlap and interfere with the frequencies used in echolocation clicks and communication signals [53, 54]. In heavily trafficked areas, dolphins experience acoustic masking, which reduces foraging efficiency and increases stress [54]. Dey et al. (2019) [71] examined the effects of vessel noise on Ganges River dolphins and found that increasing boat traffic raised ambient noise levels up to 105.7 dB, especially beyond 5 boats/hour. They also found that noise exposure altered dolphin behaviour due to strongly masked echolocation signals, with acoustic activity increasing up to 3.74 times and communication ranges being reduced to about 0 – 400 m depending on vessel type and frequency. Collisions with fast-moving boats also pose a direct source of injury or death, particularly for calves that surface more frequently and are less adept at avoiding vessels [2].

India's expansion of commercial transport via inland waterways has exacerbated the threat of noise increases and collision risks, where large cargo vessels now operate in some stretches previously dominated by local fishing boats [12]. In Bangladesh, motorized transport in rivers such as the Meghna and Shitalakshya contributes significantly to higher acoustic disturbance [55]. While vessel traffic is less intense in the Indus system in Pakistan, increasing mechanization of fishing and transport boats may elevate risks over time [15].

5.6. Climate change

Climate change intensifies nearly all threats experienced by South Asian River dolphins [56]. Hydrological models for both the Indus and GBM basins showed reduced dry-season flows, altered precipitation patterns, increased glacial melt variability, and introduced more frequent extreme weather events [57]. Reduced flows constrain habitat availability during critical periods, while unseasonal floods can displace dolphins, strand them in unsuitable habitats, or alter fish recruitment cycles [3, 15]. Climate change also interacts with existing anthropogenic pressures in synergistic ways. Reduced base flows amplify the effects of water extraction and dam operation, increasing the frequency and severity

of habitat contraction [12]. Fish populations that dolphins rely upon may shift in distribution or decline due to warming water temperatures and changes in nutrient dynamics [15]. Moreover, climate-induced salinity intrusion in downstream Bangladesh threatens freshwater habitats that historically supported Ganges dolphins [8].

6. Conservation efforts

6.1. Indus River dolphin

Conservation of the Indus River dolphin in Pakistan represents one of the most significant and well-documented freshwater cetacean recovery efforts in the world [15, 19]. Although the species has suffered dramatic fragmentation due to irrigation barrages, the population has shown signs of stabilization and even modest increase in some river reaches, particularly between the Guddu and Sukkur barrages [14]. Pakistan banned deliberate killing of the Indus River Dolphin several decades ago, and enforcement of this prohibition has gradually strengthened [7, 15, 19]. Community outreach programs have played a crucial role in shifting perceptions of dolphins from competitors or nuisances to valued components of the river ecosystem [56]. Rescue programs have also been instrumental in maintaining population numbers. When dolphins become trapped in irrigation canals, rescue teams respond to relocate them back into the main river channel [58]. Such interventions, although reactive, are vital given the number of dolphins that enter canals searching for prey or are inadvertently swept in during periods of high flow [58, 59]. Research and monitoring in Pakistan have improved knowledge of river dolphin population dynamics, distribution, and habitat use, enabling identification of critical habitats and impacts of flow regulation [15]. These efforts have supported better informed conservation and management decisions across key river segments. However, long-term population stability remains dependent on maintaining ecological flows, as increasing water extraction and irrigation pressures threaten the sustainability of recent conservation gains.

Table 2: Population status of river dolphins in south Asian river system

Country	Species	Estimated population	Population trend	River system	Major threats	References
Nepal	Ganges River Dolphin	60–100 individuals	Declining	Karnali, Narayani, Sapta Koshi	Low water flow, dams/barrages, fishing net entanglement, pollution	WWF-Nepal. [22], Shrestha and Ranjan [68], Labh [69]
India	Ganges River Dolphin	3,500–4,000 individuals	Increasing in protected stretches; declining in degraded areas	Ganga, Yamuna, Brahmaputra, Chambal, Ghagra	Pollution, sand mining, dams, vessel traffic, fishing gear	Das, Bhakta [2], Braulik, Kanwar [19]
Pakistan	Indus River Dolphin	80–100 individuals (Indian sub-population)	Stable but critically small	Beas River and Indus river	Water diversion, entanglement, low flow	Braulik, Noureen [15], [70]
Bangladesh	Ganges River Dolphin	1,500–1,800 individuals	Slight decline in major rivers	Padma, Jamuna, Meghna	Pollution, reduced freshwater flow, bycatch, vessel traffic	Aziz, Khan [8], Alam and Sarker [26], Smith, Aminul Haque [30], Braulik, Atkore [70]

6.2. Ganges River dolphin

Conservation strategies for the Ganges River Dolphin across India, Nepal, and Bangladesh have evolved considerably in recent decades [2, 15, 20]. This reflects the growing recognition of ecological and cultural significance of the species, as well as the urgent need to respond to accelerating river degradation. India has implemented the most extensive set of conservation measures, including the designation of protected areas such as the Vikramshila Gangetic Dolphin Sanctuary in Bihar [31, 60]. Although the sanctuary provides an important refuge, its effectiveness is constrained by activities occurring inside and outside its boundaries [26]. Vessel traffic, waterway development, and upstream water abstraction continue to affect habitat quality even within protected reaches [61]. Nevertheless, the sanctuary remains a valuable model for integrating research, community outreach, and legal protection.

The National Dolphin Action Plan of India represents a significant step toward a more coordinated approach to conservation [62]. The plan outlines strategies for habitat conservation, reduction of bycatch, improvement of research capacity, and engagement with local fishing communities. Despite its ambitious goals, implementation remains uneven across states, and enforcement of fisheries regulations continues to lag in many regions.

Initiatives of Nepal towards dolphin conservation emphasize community engagement, awareness-building, and targeted monitoring [20]. Efforts have focused on working closely with riparian communities to reduce accidental killing and improve reporting of dolphin sightings [20]. However, conservation efforts are fundamentally constrained by hydrological factors originating outside its borders [22]. Reduction of dry season flow is the most significant threat to dolphins due to upstream diversions for irrigation, therefore proper water management should be incorporated for flow regulations.

Bangladesh faces a distinct conservation landscape shaped by dense human populations, heavy pollution, and complex deltaic hydrology [16, 40]. National action plans and recently established conservation units aim to identify priority habitats and address the most pressing threats, namely bycatch and intentional killing [27]. Despite progress in some regions, widespread pollution and the persistence of dolphin oil use remain significant challenges [16]. Efforts to reduce intentional killing must account for both the cultural history and economic value associated with dolphin oil, requiring livelihood-based interventions that reduce dependence on destructive practices.

Across the GBM basin, successful conservation depends on addressing the diverse threats faced by dolphins in different ecological and political contexts. While India must confront large-scale infrastructure development and waterway expansion, Nepal must secure ecological flows, and Bangladesh must improve pollution control and fisheries management [15, 26, 32, 61]. Despite these differences, the shared opportunity lies in basin-wide coordination that integrates hydrology, development, and biodiversity conservation.

7. Policy gaps

Governance challenges remain at the center of South Asian River dolphin conservation. All four range countries have enacted legal protections prohibiting the killing of river dolphins, and each has established specific national strategies or protected areas [15, 26, 32, 61]. However, the implementation of these policies is frequently limited by overlapping institutional mandates, inconsistent enforcement, and competing developmental priorities that overshadow ecological considerations. Transboundary governance represents the most critical gap. The Indus River Dolphin is restricted primarily to Pakistan today, but its survival remains contingent on water allocation decisions involving upstream regions and irrigation policies that reflect national agricultural priorities [6, 63]. The dependence of Ganges River dolphin on the hydrology of the GBM basin makes it particularly vulnerable to inter-country water management decisions. River flows in Nepal and Bangladesh are highly influenced by infrastructure and water use in India, yet ecological flow needs are rarely central in transboundary agreements [4, 33, 39]. Effective governance also requires

improved coordination among national agencies responsible for wildlife, fisheries, water resources, transport, and energy. Fragmented management often results in policies that work at cross-purposes. For example, a river section may be designated as a dolphin conservation area, while simultaneously being developed for commercial navigation or hydropower generation. Such contradictions undermine conservation and fuel conflict among stakeholders [64].

8. Community based conservation and the human dimension

Conservation of South Asian River dolphins cannot succeed without addressing the human dimension. Millions of people depend on the Indus and GBM rivers for fishing, transportation, domestic water use, and agriculture [14]. As a result, conservation strategies that rely solely on enforcement without community engagement are unlikely to succeed [65]. Across Pakistan, India, Nepal, and Bangladesh, studies consistently emphasize that fishers possess detailed ecological knowledge of riverine environments and dolphin behavior [8, 15, 20, 31]. Communities can become invaluable allies in conservation monitoring if engaged respectfully and meaningfully, such as for the reporting of entanglement events and participating in rescue operations [15, 57]. However, community participation is highly influenced by socioeconomic factors. In regions where poverty is widespread and alternative livelihoods are limited, fishers may perceive dolphins as competitors and engage in illegal practices, such as dolphin oil extraction [16, 45]. These realities underscore the importance of conservation approaches that link ecological goals with improvements in human and societal well-being. Programs that provide fishers with training, alternative sources of income, or access to sustainable fishing techniques have shown promise in reducing illegal activities [27, 66]. Campaigns focused on education and awareness are insufficient without corresponding tangible socioeconomic benefits. Community-based conservation is most effective when it creates shared stewardship rather than adversarial enforcement [67]. Long-term success depends on aligning incentives so that riverine communities see value in protecting dolphins and river ecosystems more broadly. This alignment is particularly critical in Bangladesh and Nepal, where economic dependency on river resources is high and regulatory capacity is limited [8, 20].

9. Knowledge gaps and future research priorities

Despite decades of research, substantial gaps remain in our understanding of South Asian River dolphins. Reliable, standardized population estimates are needed across both basins, particularly in regions where access is difficult and populations are extremely small [15, 20]. Genetic studies must be expanded to further clarify the degree of isolation among subpopulations, especially in the Indus basin where fragmentation is extreme [7, 10]. Research linking hydrological change to dolphin behavior, survival, and reproduction remains limited, even though river regulation is the primary driver of habitat alteration [16].

Future research must adopt integrated, interdisciplinary approaches. Understanding dolphin ecology requires not only biological data but also hydrological models, sediment transport analysis, and detailed assessments of fisheries interactions. Most importantly, there is a need for research on the socioeconomic and cultural dimensions of riparian communities, including community perceptions, livelihood dependencies, and institutional barriers to effective conservation. Priority questions include standardized abundance estimation and demographic monitoring; genetic and genomic assessment of fragmented populations; quantification of ecological-flow requirements; evaluation of fisheries and bycatch mitigation; and assessment of pollutant exposure and cumulative effects. For policymakers and government agencies, priorities include maintaining ecologically relevant dry-season flows, protecting connectivity between occupied river sections, reducing destructive fishing practices and pollution, incorporating dolphin habitat into infrastructure and navigation planning, and strengthening coordination across basin and national boundaries.

10. Conclusion

South Asian River dolphins (*Platanista* spp.) are endangered freshwater cetaceans endemic to the Indus and GBM river systems. Although they are evolutionarily unique and play an important ecological and cultural role, they face a wide range of threats across their range. Their population have been declining due to the combination of factors such as river regulation, habitat fragmentation, pollution, fishing pressure, boat traffic, and climate change. Because of these human-induced factors, their population has been fragmented into many subpopulations and isolated groups living in degraded habitats. Conservation efforts are thus crucial to sustaining river dolphin populations in South Asia. While initiatives in India, Nepal, and Bangladesh focus on the creation of conservation areas, increased public awareness, and efforts to include dolphin protection in broader river management plans, a more comprehensive approach is necessary to yield and sustain concrete outcomes. There are rare cases that have proven how synergistic conservation efforts can stabilize and even increase river dolphin populations. This is observed in Pakistan, where employed efforts include a combination of strong legal protection, active community involvement, rescue programs, and consistent monitoring. However, the long-term survival of *Platanista* will ultimately depend on addressing the structural drivers of river degradation. Conservation actions must be linked to basin-wide governance reforms that prioritize ecological flows, regulate destructive fishing practices, mitigate pollution, and ensure that infrastructure development does not irreversibly damage remaining habitats. As climate change intensifies, these efforts must become more urgent, adaptive, and collaborative. South Asian River dolphins are a significant indicator of river health. Conserving these dolphins enhances the ecological integrity of the Indus and GBM systems, while also supporting the ecosystems and communities that rely on these rivers for their livelihoods.

Author Contribution

Conceptualization (EQ and JK), **Data curation** (EQ and JK), **Formal analysis** (JRK), **Software** (JRK), **Supervision** (JRK), **Validation** (JRK), **Visualization** (JRK), **Writing – original draft** (EQ), **Writing – review & editing** (JRK).

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