



Chapter

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Avian diversity at Beas River conservation reserve under urbanization and intensive agriculture in Punjab, India

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Abstract

Punjab is an agrarian state nurtured by the river Beas and Satluj with a maximum gross cropped area of 98.5% in India. River Beas had been designated as “Conservation Reserve” in 2017 and “Ramsar site” in 2019. Agriculture affects 87% of the globally threatened bird species. Birds are the most noticeable and specialized species in the river habitats; hence the abundance and distribution of birds are often readily interpreted in the context of river health and vice versa. The chapter has been designed to understand the impact of agriculture, urbanization, tree diversity and wetlands along the river on avian diversity based on literature available for the state of Punjab. The chapter aims to generate sustainable management strategies for the conservation of avian diversity at Beas river conservation reserve without hampering the development of the region. The present work reveals that agriculture intensification and urbanization are major concern for avian diversity conservation as both these factors negatively impacts the habitat specialist bird species and favors generalist and insectivore species. The study concludes that significant number of species recorded have specific niche area requirements that are completed by the river’s sub-habitats including feeding, foraging, roosting and nesting therefore the whole area needs protection as a single unit.

Keywords

Agriculture, Beas, Birds, Conservation reserve, Punjab, Urbanization

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Introduction

India is a large country blessed with 47 large rivers and hundreds of small tributaries. Indian Rivers consist of Himalayan and peninsular river systems. Himalayan rivers of the country constitute three major river systems i.e., Ganga, Brahmaputra, and Indus. River Beas is an important tributary of Indus River system (Srivastava, 2007) originating in the Shiwalik hill ranges of Himachal Pradesh and feeding a large area of Punjab for its irrigation needs (Moza and Mishra, 2007). Punjab is a small state with a 1.53% area having maximum agricultural intensification with the production of 17 % of wheat, 11 % of rice, and 6 % of cotton in the country (Kaur *et al.*, 2018; Gulati and Juneja, 2021). Particularly, Punjab is fed by two major rivers i.e., Beas and Satluj (Grover *et al.*, 2017). The irrigation in the state is done majorly by canal systems derived from these rivers. The underground water is another source of irrigation in the state which has decreased drastically due to unsustainable agricultural practices, and has created a cascading effect on the demand for water from canals and rivers (Srivastava *et al.*, 2015; Kumar *et al.*, 2018). Urbanization and the rapid growth of agriculture during the last few decades have adversely impacted the environment, water quality, and quantity of the flow of rivers (Sharma *et al.*, 2017; Pannu, 2018; Rafie and Kumar, 2020). The gross cropped area (GCA) of the state has reached 98.5% (Gulati *et al.*, 2021), and there is little scope for the extension of more agricultural area in the state. The quantum of sullage, sewage and agricultural runoff has significantly increased and ran into natural drains, eventually reaching the riverine system of river Beas (Anonymous, 2019).

All these conditions created an inevitable pressure on the natural resources including, rivers and wetlands in the state. The state has only 6.12% of the total area under forest and tree cover accounting for 3,084 sq. km of the state's geographical area. Out of this, only 1181 sq. km area is under reserved and protected categorization. Several studies are available for the avian diversity of Punjab in different habitats, including agriculture (Kler and Kumar, 2015; Kaur *et al.*, 2016; Kaur and Kler, 2018; Sethi and Kumar, 2018; Sidhu and Kler, 2018; Kaur and Kler, 2019; Dutta and Dhillon, 2020; Sidhu and Kler, 2021) urban (Kler and Kumar, 2015; Kaur *et al.*, 2016; Kaur and Kumar, 2018; Kler *et al.*, 2018), natural resources, village pond and wetlands (Brraich *et al.*, 2003; Ladhar, 2002; Kler, 2009; Kaur and Kler, 2018; Kler *et al.*, 2018; Khalid, 2019; Singh *et al.*, 2020; Sidhu *et al.*, 2021).

The River Beas provides key habitats for more than 500 bird species and act as a host for summer and winter migratory water birds. The river supports many species of freshwater turtles such as Indian flapshell turtle, Indian softshell turtle, Narrow-headed softshell turtle, Crowned river turtle, Spotted pond turtle, and Brown roofed turtle. Harike and Beas conservation reserve together support more than 90 fish species (RIS, 2020). River Beas was declared a conservation reserve in 2017 under section 36A of the Wildlife Protection Act 1972 by the state government of Punjab (Anonymous, 2019) and designated as the Ramsar site in 2019 (RIS, 2020). The Government of Punjab has made an action plan for conserving the river under the Directorate of Environment and Climate Change, Department of Science, Technology, and Environment (Anonymous, 2019). The action plan emphasizes regulating and cleaning the effluents into the river. River ecosystems are impacted by various stressors that precede a loss of sensitive species and an overall reduction in diversity; therefore, a successful management plan should

include the ecological restoration of the habitat. An extensive evaluation of published studies in Punjab and areas near the river Beas were evaluated to generate the habitat management guidelines. Natural conservation of a river is considered much effective if the conservation management efforts are made focusing Hydrology, Biology, Water Quality, and the Morphology of the river (Addy *et al.*, 2016). Birds respond very quickly to any alteration in their habitat at any scale. They are also sensitive to disturbances due to human activities as they exhibit specific habitat preferences (Ortega-Álvarez and MacGregor-Fors, 2009). Although a large amount to work is available on avian diversity in different habitats of the state, no conclusive work is available for the faunal diversity of River Beas. The present work has been produced to understand the effect of agriculture and urbanization on ecology of avian diversity in the stretch in Punjab to provide recommendations for the conservation of faunal diversity along the river Beas.

History of River Beas

River Beas is an ancient river with descriptions in Vedas. Vipasa of Mahabharata (Pandey, 2009), Hyphasis of Alexander (Crindle, 1992) were the most commonly known names of this river in ancient India. The river was named Vipasa in Rig-veda, which means unfettered. The river was later named as 'Vipasa' in Sanskrit texts (Griffith, 1971). It is believed that the River Beas has been named eponym for rishi Vyasa (author of Indian Epic Mahabharata) (Pandey, 2009). River Beas has been named differently in different periods of time. The other names that were commonly used were Arjikiya (Dey, 1899), Arjikuja (Frowde, 1908), Darya-e-Siyah (Yadgaar, 1985), Beas (Al-Balazari, 1986), Biah (Babur, 1987), Dand Nurni (Fazal, 1988), Ab-i-Siyah (Sirhindi, 1990), Bipasa, Hurhari, Darya-e-Sultan Pur (Ahmad, 1990), Machala (Baqi, 1990) and Darya-e-Gobindwal (Jahangir, 1995). The present name 'Beas' was seen in the imperial gazetteer of India in 1908, describing the tributaries at that time. The chief tributaries are Chakki and Bein. The Chakki collects the drainage of the Chamba hills and joins the Beas near Mirthal, while The Bein formally called Black (Siydh) Bein rises in the Siwaliks, and joins the Beas to miles above its junction with the Sutlej (Forwde, 1908).

The river flowed in its natural phase for millions of years. In the early nineteenth century, plans were initiated to control the flow of this river for irrigation and hydroelectric power generation purposes. Two major dams were built on the river named Pong and Pandoh Dam. The former was completed in 1974 and later in 1977 (Moza and Mishra, 2007). Additionally, the river has rich biodiversity with two main Ramsar sites, i.e., Pong Dam reservoir and Harike wetland. Pong Dam reservoir, also known as Ranjit Sagar Reservoir situated behind the Pong Dam, was constructed in 1975. The reservoir was designated as 'Wetlands of international importance' under the Ramsar Convention in 2002 for its rich diversity. Further, it acts as a temporary shelter for winter migratory birds (Malik and Rai, 2019). The river merges with Satluj at Harike, where another wetland is formed named Harike wetland. This wetland was designated as Ramsar wetland designated in the year 1990 (Mabwoga and Thukral, 2014).

Course of the River

The river originates in Shiwalik hills in the state of Himachal Pradesh and merges with the river Satluj in plains of Punjab state near Harike. River Beas is 460 km long and originates from two primary sources, Beas Rishi on the right of Rohtang Pass at an elevation of 4350 m and Beas Kund at an elevation of 4060 m on the South having a cavern within North-Western Himalaya. Both the streams merge at village Palchan near Manali to give the first appearance of river Beas. The approximate length of the river is 256 km in Himachal Pradesh (HP) and 214 km in Punjab. The total catchment area of the river is 38030 km², where 12130 km² is spread within Himachal Pradesh and 25900 km² Punjab (Moza and Mishra, 2007; Kamboj *et al.*, 2021).

Headwaters of the river are steep and, leading 120 km stretch of river with an average fall of 1 in 40. It decreases downstream to 1 in 500 in Beas Valley. The main tributaries of Beas are Parbati, Spin, Malana Nala in the east and Solang, Manalsu, Sujion, Phoal, Sarvati in the west. The river joins Tirthan, Hansa, Bakhli, Jiuni, Suketi, Panddi, Son and Bather from Northside near district Mandi of Himachal Pradesh. Further the river flows toward district Kangra, fed by Banganga, Binwa, Chakki, Dehr, Gej, Neugal from North, and Kunah, Khairan, Maseh, Man from South. The eastern and northern tributaries of Beas are snowfed, making it a perennial river by drainage from southern slopes of Dhauladhar Mountains. The southern tributaries show fluctuation in the flow because of seasonal rains. The flow of water is maximum during monsoon and minimum in winter. In the last decades, the water quantity has been decreased (Moza and Mishra, 2007). The first major anthropogenic manipulation on the course of river is made at village Pandoh in Mandi, where an earth cum rockfill dam with 74.37m height named "Pandoh reservoir" has been constructed (Kumar *et al.*, 2007). The reservoir provides 1.58 million cusecs of water, and simultaneously, 4716 cumecs of water are diverted to river Sutlej through the Beas-Sutlej Link canal. The water is diverted via 12.38 km long, 8.15 m. wide tunnel and 11.8 km long lined canal. Another major earth cum rock fill reservoir and dam has been constructed near village Pong in Kangra district to form Pong reservoir, also known as Ranjit Sagar Reservoir. The water spread area is 6000- 24000 ha. The water in the reservoir is utilized for multipurpose activity, mainly irrigation and power generation (Moza and Mishra, 2007).

The river enters the plains of Punjab after leaving Pong dam via Barrage at Talwara (Distt. Hoshiarpur); a large chunk of water is diverted at barrage for irrigation through Shah Nehar Canal. The canal grabs 4170-8611 cusecs of water depending upon the season results in a wide variation in water released in the river ranging from 4.53-68840 cusecs. The river took a loop-like course and traversing through foothills of the Himachal-Nurpur area and gains some water from the Ravi-Beas Link canal made originating from Modhoptar and Chakki near Mirthal. In the way, another tributary named Sarri joins at village Vhed Pattan. The river regains its resources fully through re-induction of Shah Nehar canal near village Terrikein (Distt. Hoshiarpur); thereafter river flows unrestricted in the plains of Punjab, running through district Amritsar, Kapurthala and Ferozpur for approximately 100 km towards Hari-Ke-Pattan (Harike). The river collects some more water in between from Chakwal Nalla at village Chakwal (Distt. Hoshiarpur) and Kali Bein near its culmination point at Harike (Moza and Mishra,

2007). The river has higher forest cover before it enters Punjab, and after that, the forest cover decreases at a faster rate. The width of riparian zone decreases, and area get dominated by agriculture. The change in habitat along the river led to variation in the river's diversity (Anonymous, 2019; Brar *et al.*, 2020).

Water quality of Beas River

During 2014-15 water quality analysis along with heavy metal contamination was done for river Beas at Beas Kund, Kullu, and Pong dam in Himachal Pradesh, where the maximum parameters were found in the acceptable limits during monsoon, winter, and summer seasons; however, Cd and Pb were found to be higher than acceptable limit of WHO (2011) and BIS (2012). In Punjab, agricultural lands usually receive contaminants from different sources characterized by harmful contaminants and constant bio-accumulation. River Beas has shown contamination by metals in the sediments in recent times. Kumar *et al.* (2018) recorded significantly high pollution levels during pre-monsoon and post-monsoon season with an ecological risk factor of 23.8%, due to heavy metals present in the river. Water quality is a big concern for humankind (Brack *et al.*, 2017), and water resources are being contaminated by various anthropogenic activities (Alam *et al.*, 2009; 2010).

Anthropogenic activities such as agriculture, mining, and industries, produce a large quantity of heavy metals. These heavy metals are released into the aquatic environment, leading to heavy metal contamination causing the negative impact on biogeochemical cycles (Liu *et al.*, 2003; Chabukdhara and Nema, 2012). The assembly of these sediments also causes biomagnification via the food chain (Uluturhan and Kucuksezgin, 2007; Yi *et al.*, 2011). Increasing population and intense agricultural practices in Punjab put severe pressure on the natural resources. The whole stretch of the river has been designated as a conservation reserve in 2017. Restrictions were imposed as per Wildlife (Protection) Act, 1972 along the whole stretch (Bisht, 1999).

Lower valleys with agricultural land are prone to contamination from various sources. River Beas is no such exception when it enters the plains of Punjab. Recent studies have observed 28.5% metals contamination during the pre-monsoon season, and 42.8% of metals showed moderate to high pollution during post-monsoon and winter. Overall, the ecological risk factors (ERF) resulted in 23.8% metals in the river, posing moderate to high ecological risk (Kumar *et al.*, 2020; Kamboj *et al.*, 2021). The population of Punjab has increased drastically in the last few decades and is expected to increase exponentially (PSOP, 2011).

The population of major cities around river Beas is also increasing which would negatively impact the biodiversity around the river. Exponential agricultural growth and urban development result in elevated levels of changes in land use, which cause degradation of natural habitats (Foley *et al.*, 2005; Hanski, 2005). River ecosystems are fragile and support rich biodiversity. The present water quality status of river Beas is a matter of concern and needs more substantial efforts.

Effect of urbanization on avian diversity along the river

Urbanization negatively affects natural habitats, woodlands, and riparian areas of streams (Keten *et al.*, 2020). Saklani *et al.* (2018) have reported that avian diversity decreases as we go close to the areas having dense population. The nearest available study along river Beas in urban landscape has shown only 17 residential bird species in urban landscape in Kapurthala (Begowal) region (Kler *et al.*, 2015). A total of 63 species of migratory species have also been recorded in urban landscape in Punjab region (Kler and Kumar, 2015). Workers have observed that generalist species were more favored in the urban landscape, with two commensal bird species, i.e., Blue Rock Pigeon and House Crow as the most abundant species in the region of Punjab due to easy food availability (Kler *et al.*, 2015). Urbanization along the river may favor the generalist and commensal species in the region. Major cities are usually grown around the rivers due to easy accessibility of river serveries such as drinking water, food, and transport (Groffman *et al.*, 2003). Siddiqui *et al.* (2019) have reported that the urban sites are dominated by omnivore species, whereas insectivorous species dominate semi-natural, semirural, and rural natural areas. An increase in non-native bird species due to anthropogenic effects (Marzluff, 2001) is also a stumbling block that may alter the already stressed avian diversity of the region.

Electromagnetic Radiations (EMR) are an integral part of Human settlements in the present time. EMR poses significant health hazards to birds and humans. Sparrows, pigeons, parrots, and swans are some of the birds highly affected by these radiations (Surendran *et al.*, 2020). Maximum EMR (Electromagnetic radiations) are generated from mobile towers. Various studies has been conducted in India to check the impact of mobile towers on avian diversity (Durgam *et al.*, 2017; Kler *et al.*, 2018; Kumar and Singh, 2018; Siddiqui *et al.*, 2019; Surendran *et al.*, 2020). Most of these studies have shown a negative or neutral relation of avian diversity in proximity of mobile towers. Radio frequency waves hurt the regular navigational capacities of birds (Surendran *et al.*, 2020). Low avian abundance and breeding success near mobile towers and high voltage power transmission towers have been observed in Punjab might be due to the clandestine effect of electromagnetic radiations along with the other unforeseen factors (Kler *et al.*, 2018). However, uncertainty exists in possible biological effects arise from electromagnetic field exposure on birds (Bhattacharya and Roy, 2013). River Beas harbors a rich avian diversity; it also hosts a large number of migratory birds at Harike wetland. Communication towers may negatively impact the richness and abundance of the species, which needs to be addressed in conservation plans.

River resources are being polluted by industrial and domestic pollutants, where exploitation of ecosystem services in river catchments areas is a well-known phenomenon under downstream effects (Maltby and Ormerod, 2011). However, river Beas also faces similar problems at a lower scale (Kamboj *et al.*, 2021). Among all riverine organisms, birds are most noticeable, with specialized traits to exploit the habitat conditions provided by rivers (Buckton and Ormerod, 2002); hence the effects of environmental changes on the abundance and distribution of river birds are often readily interpreted (Ormerod *et al.*, 2000) in context of river health. Conservation of Avian diversity could help to conserve the overall river biodiversity (Vaughan *et al.*, 2007). Exotic tree and shrub species in urban habitat

affects the natural flora and fauna (Acar *et al.*, 2007). Due to lower nest predation and higher food availability, native bird species prefer urban areas dominated by native rather than exotic vegetation (Donnelly and Marzluff, 2004; White *et al.*, 2005). The urban population is growing continuously and affecting biodiversity within urban environments (Seto *et al.*, 2013). Habitat loss, fragmentation, altered species interactions, biotic homogenization, extinction of native species, and proliferation of alien species are the major impacts of urbanization on biodiversity (Grimm *et al.*, 2008; Goddard *et al.*, 2010; Keten *et al.*, 2020). Avian diversity is often taken as biological indicators for the impacts of urbanization on ecosystems because they are easy to observe, identify, ecology is well known, and respond quickly to changes in habitat structure (Vandewalle *et al.*, 2010; Fontana *et al.*, 2011; Wenny *et al.*, 2011). Rivers and wetlands are vital for urban ecological infrastructure. However, rivers are heavily degraded and altered along with urban cities. This phenomenon is known as urban stream syndrome. This syndrome includes alteration in chemical, physical and biological elements of the river by urban development, pollution, disturbance, and catchment inurement (Paul and Meyer, 2001; Walsh *et al.*, 2005). Rivers flowing near urban landscape usually experience altered vegetation structure, loss of riparian forest, and reduced diversity (Urban *et al.*, 2006). The area along urban streams is usually considered as natural ecosystems having the potential of a local hotspot. However the potential of urban streams and rivers to act as refuges for urban biodiversity has not been explored widely. Some work has been done to understand the avian diversity along urban streams (Dallimer *et al.*, 2012; Suri *et al.*, 2017), yet the explanation for the impact of the riparian zone of rivers on the functional configuration of urban bird communities is unknown. Although Punjab has made a roadmap for cleaning the river water (Anonymous, 2019) and protecting the river from 'urban stream syndrome,' the plan has no provision for the conservation of natural habitat to create a healthy ecosystem for avian diversity along the river Beas.

Effect of agriculture on avian diversity of river system

There are various threats to bird diversity, but agriculture alone affects 87% of the globally threatened bird species (Bli, 2008). Punjab is a small state with 1.5% area of the total area of India. Still, it alone contributed 1/3rd and 1/4th of central pool wheat and rice, respectively, as per the economic survey of 2019-20. For this purpose, the state relies on intensive agricultural practices. Prevailing condition are creating encroachment pressure on already stressed and small extents of natural habitats available in the state (Singh *et al.*, 2020). A significant course of the river Beas flows through an intensive agricultural region of Punjab. After the adoption of new agriculture technology, including hybrid seeds, chemical fertilizer, and new agriculture practices from the mid-1960s, Punjab has made wonderful progress in the field of agriculture (Sidhu, 2005). In 1974, 73 percent area of Punjab was under agriculture, reaching 95 percent in 1983-85 (Jodhka, 2006). Furthermore, rice production had increased from 920,000 tons in 1970-71 to 13,382,000 tons in 2017-18. The intensification of agriculture has increased water scarcity and pressure on land-use changes in the state (Rafie and Kumar, 2020; Gulati *et al.*, 2021). Although agricultural intensification has positive impacts, the natural habitats for

specialist bird species have decreased in the region.

The state has used its natural resources at a much higher intensity after the green revolution and tilted towards a monoculture system of wheat-paddy (Grover *et al.*, 2017; Gulati *et al.*, 2021). A total of 189 species have been observed in the villages and agricultural landscape of Punjab, including 111 residents, 47 resident migrants, and 30 migrants with one species in the vagrant category. The diversity includes one endangered, one vulnerable, and eight near threatened species (Kler and Kumar, 2015). A total of 12 carnivorous bird species have been observed in agricultural and mixed fruit orchard of Punjab (Kaur and Kler, 2019). A mixed fruit tree orchard seems to encourage avian abundance than the mono fruit crops orchard. Tree diversity supports more avian richness and is paramount for avian conservation in the agricultural landscape of Punjab (Sidhu and Kler, 2017). Avian composition and their foraging ecology can be utilized for pest management strategies by identifying the insectivorous species for biological control in agricultural fields (Kler and Parshad, 2012). Habitat preference for some species is directly proportional to feeding, roosting, and nesting material in the area (Sohi *et al.*, 2017).

Floodplains of a river are one of the most fragile ecosystems and have attracted humans since the dawn of civilizations. The natural land cover of these floodplains has always got the impact of anthropogenic activities. Flood plains of river Beas have also witnessed such changes. Agriculture and human settlements along the river have recorded a sharp increase in the last few decades. GCA of Punjab state is 98.5% (Gulati *et al.*, 2021) which infers that the river Beas has agricultural lands on both sides of the river throughout its length in Punjab. The data of land use and land cover shows that anthropogenic pressure is overtaking the natural processes along the river Beas. The ratio of area under land use and land cover was 86:14 in 1989, which infers that the anthropogenic activities had already overtaken the natural ecosystems in the floodplain of Punjab. The ratio further deteriorated during the next decades to 89:11 and 93:07 for the years 2000 and 2015, respectively (Brar *et al.*, 2020). Agricultural intensification is considered as one of the leading causes for widespread farmland biodiversity loss (Stoate *et al.*, 2001; Tilman *et al.*, 2001; Green *et al.*, 2005), including reductions in the abundance and richness of many plants and invertebrate taxa (Sotherton and Self, 2000; Preston *et al.*, 2002; Piha *et al.*, 2007) and the declines of farmland bird populations (Chamberlain *et al.*, 2000; Donald *et al.*, 2001; Murphy, 2003; Newton, 2004).

The intensification of agriculture in Punjab has pushed the boundaries of the rivers in the state and has narrowed the riparian zone between the river and agricultural areas (Brar *et al.*, 2020). The information of bird communities around crop fields and urban settlements is not entirely understood, as there is a contradiction between the results of various studies. For example, it was observed that crop fields do not show complex and diverse bird communities when compared to cattle grazing lands, this was suggested by Morris (2000), whereas MacGregor-Fors and Schondube (2011) shows that the pattern of bird communities may vary with remaining vegetation and the locality of grazing lands in the nearby landscape. At the same time, it was observed that urbanization might not consistently harm birds compared to the agricultural landscape (Bellocq *et al.*, 2008), as some agricultural practices may be more harmful to bird communities than the impact of urban development (Faggi *et al.*, 2008). Agricultural land use and landscape structure are the principal components of determining bird assemblage;

however, it is not equally accurate for overall avian density, richness, diversity, or biomass. Although the state has rich avian diversity, many bird species are still habitat specialists and are not found in the agricultural landscape. Therefore, the minimum natural areas available in-state are required to be protected. Agricultural grasslands strongly and positively determined the bird assemblage (Piha *et al.*, 2007). Studies have shown that greater avian diversity is observed in the forest than in the paddy field. The number of bird species declines if forested areas are converted to agricultural landscapes (Waltert *et al.*, 2004; Azman *et al.*, 2011). The commercial plantation system is also booming in Punjab to break the regular wheat-paddy cycle of the agroecosystem (Chauhan *et al.*, 2012). Some lands are also getting converted into commercial plantations in Punjab; however, conversion of forest to commercial plantations also led to a decline in bird richness and an increase in the relative abundance of wide-ranging, adaptable species (Aratrakorn *et al.*, 2006). Fewer species can be observed in paddy fields because these habitats are structurally simpler and offer fewer feeding niches (Fujioka and Yoshida, 2001). Relatively generalist bird species are common in commercial plantations as they have higher adaptability to unfavorable environmental conditions. Commercial plantations are generally categorized as an unfavorable environment owing to the frequent disturbance caused by humans and the low availability of food sources (Aratrakorn *et al.*, 2006). Foraging guilds often respond to environmental conditions differently (Balestrieri *et al.*, 2015). A decline in the avian population of long-distance migrant species of insectivore birds has been demonstrated by Vickery *et al.* (2014) and Gregory *et al.* (2007) in commercial plantation zones. Avian foraging guilds are more closely associated with plant diversity for insectivores (Sullivan *et al.*, 2007) and frugivores bird species richness (Kissling *et al.*, 2007). Fewer bird species have been observed in commercial plantations compared with the secondary forest and agricultural fields, especially paddy fields (Azman *et al.*, 2011). Farming and paddy seasons are essential aspects of the abundance and distribution of birds in the area (Kelly *et al.*, 2008; Ibáñez *et al.*, 2010; Wood *et al.*, 2010). Studies have suggested that paddy fields are suitable for water birds and land birds as a place to forage, breed, and shelter (Zou *et al.*, 2006; Razafimanjato *et al.*, 2007; Takahashi and Ohkawara, 2007; King *et al.*, 2010; Wood *et al.*, 2010). Flood plains of Punjab along river Beas have also witnessed the anthropogenic intervention in the landscapes of the river led to depleted natural ecosystems and land use patterns. Intensive agriculture and urbanization along the river have recorded a sharp increase in the last few decades. The impact of agriculture intensification along the rivers on avian diversity has not been studied, and literature review has shown that agricultural intensification may negatively impact the habitat specialist bird species in the state. On the other hand, generalist and insectivore species seem to increase in the regions along the river in the agricultural landscape; however, deeper studies would be required to understand the variation in species diversity in regions near rivers.

Effect of trees on avian diversity

It is a well-known fact that the natural habitat harbours healthy avian diversity. However, in the states like Punjab, it is not possible to have large forest ranges. Therefore, one of the best ways to deal with

the problem is tree plantation. Suitable habitats can be provided to the threatened (Delarze and Ciardo, 2002) and common species by increasing the size of plantation in the region (Godreau, 1998; Britt *et al.*, 2007); however, some adverse effects are associated with the type of plantation (Castano *et al.*, 2019).

Under the various negative implications of intensive agriculture, the state has started diverting towards tree plantation and agroforestry models. Poplar (*Populus deltoides*), Eucalyptus (*Eucalyptus tereticornis*), Dek (*Melia composita* and *M. azedarach*), Leucaena (*Leucaena leucocephala*), Kadam (*Anthocephalus cadamba*), and Teak (*Tectona grandis*) are grown on a commercial scale in Punjab (Chauhan, 2005). Poplar is a non-native tree species adopted at a large scale by the farmers of North India, especially Punjab, for monoculture or agroforestry (Chauhan *et al.*, 2009; Rizvi *et al.* 2020). Although non-native tree and grass species have not been associated with increased predation risk for nesting birds, they impose a threat to diversity conservation. Land-cover of poplar plantation was 4% in 2012 of the global forest and is continuously increasing (Pawson *et al.*, 2013). Adjoining natural habitats along poplar plantations have several effects, including a decrease in bird species richness in the nearby agricultural lands and riparian forests; therefore, the practice should be avoided in areas of high conservation value (Godreau *et al.*, 1999; Archaux and Martin, 2009). The second commercially grown tree species in Punjab is Eucalyptus, which harbor lesser avian diversity (Barlow *et al.*, 2007; Proena *et al.*, 2010; Calvino-Cancela, 2013; Kaur and Kumar, 2020) as compared to the native plantation. A total of 23 species has been recorded in non-native trees in Punjab. Birds are exclusively sensitive and have very close association with trees. Vegetation cover and foliage height influence avian abundance and diversity. Non-native invasive species block the growth of native flora and ultimately result in the decline of nesting sites for birds (Kaur and Kumar, 2019). Avoiding the removal of undergrowth and low branches of trees can create better foraging and nesting niches for birds (Archaux and Martin, 2009).

Banks of the river are generally covered with grass and native tree species. As River Beas has been declared as a conservation reserve, the riparian area of the river can be used to enhance the avian diversity of the region. Native vegetation along with grasslands can provide suitable habitats for native grassland breeding birds (Kennedy *et al.*, 2009), whereas forest specialist species are strongly related to landscape characteristics. Secondary forests are essential for conservation efforts; however under the agricultural pressure closed-canopy plantation may present a viable compromise (Carrara *et al.*, 2015). Indigenous trees like Neem (*Azadirachta indica*), Banyan (*Ficus benghalensis*), Jamun (*Syzygium cumini*), Mulberry (*Morus alba*), Pipal (*Ficus religiosa*), and Sheesham (*Dalbergia sissoo*) harbor a significant avian diversity in Punjab (Kaur and Kumar, 2018) hence can be planted in the riparian zone of the river. At the same time, large monocultures of exotic non-native trees with short rotation times can have negative implications whereas, mixed plantations of native trees can provide similar avian diversity as to native forests of the area (Castano *et al.*, 2019); hence, the practice of mixed plantation should be promoted in the adjoining agroforestry areas along the river.

Avian diversity at small ponds and wetlands of state

In Punjab, some documentation has been done on water-dependent birds by various authors (Kler and

Kumar, 2015; Soni *et al.*, 2017; Kaur *et al.*, 2018; Soni *et al.*, 2019; Sidhu *et al.*, 2021). The state has many small and large wetlands where Keshopur-Miani Jheel, Chhawarian Bhangar Chhamb, Jastarwal Jheel, Mand Bharthala, and Dholbaha Reservoir are designated as wetlands of state significance. In contrast, Harike, Kanjli, and Ropar wetlands have been designated as wetlands of national importance (Ladhar, 2002). However, there is a lack of information about detailed information and trends of avian diversity along the river Beas. The majority of the work has been done on various aspects of Harike wetland in Punjab (Chopra *et al.*, 2001; Jain *et al.*, 2008; Sarkar and Jain, 2008; Kaur *et al.*, 2014; Br्राich and Jangu, 2016; Singh *et al.*, 2020). Various studies have shown a decline in the water quantity of rivers, leading to degradation of the habitat and increased anthropogenic activities in the area, including agriculture (Jain *et al.*, 2008; Malik and Rai, 2019; Singh *et al.*, 2020).

Conservation of biodiversity is essential for the stability of ecosystems. Anthropogenic activities constitute a significant threat to biodiversity these days. It has been observed that with the growing human population, biodiversity is decreasing at a faster rate (Bilgrami, 1995; Cincotta *et al.*, 2000; Kremen and Merenlender, 2018). Avian populations play a central role in ecosystem services and ecosystem functioning and provide economic benefits like seed dispersal and pollination. They also play a role in the restoration of distressed ecosystems (Sekercioglu *et al.*, 2004). The avian diversity along the rivers is generally got impacted by agricultural intensification and urbanization. Flood plains of river Beas are fertile and best suitable for agriculture that makes the river habitat prone to habitat degradation.

Land use and land cover changes are responsible for the loss of ecosystem services of wetlands worldwide. Anthropogenic activities have severely affected the habitat of the Pong dam wetland posing risks of habitat degradation destruction. In the last decade, the barren area has decreased to half while the agricultural area has increased by 159%. Rapid conversion of scrubland land for agriculture purposes has created severe pressure in wetland existence. Under the various anthropogenic and natural pressures, the survival age of the wetland has been estimated to be about 100 years (Malik and Rai, 2019). The case of Harike wetland on river Beas is almost the same. All these conditions can severely change the avian composition of the region, and many essential bird species could get swept out of the region.

The bird species richness is significantly associated with the percent cover of native habitat; however, fragmentation tolerant bird species remains consistent in the region. Riparian banks of rivers exhibit both high avian species richness and abundance. They may act as migration dispersal corridors on a regional scale (Bolger *et al.*, 2001) which might get negatively affected by dams and other flood control measures leading to alter the natural river flow system. Artificial structures like dams regulate the flow of the river and can impact the abundance and richness of birds via changes in habitat parameters, which provided food and shelter to birds near dam areas (Wu *et al.*, 2017). Studies have suggested that reservoirs play a vital role as staging and wintering areas for migratory birds, especially waterfowls (Wang *et al.*, 2013; Ali *et al.*, 2011); however, the extent of the repercussions of dam operations is still not known. Most of the studies are done for studying the avian diversity, richness, and abundance of reservoirs made for the rivers. However, the effect on downstream river flow and its effect on avian

diversity still needs to be understood. The formation of ponds along rivers is a natural phenomenon. These ponds can be seasonal and sometimes perennial fed by river water (Williams and Fryirs, 2020; Ren *et al.*, 2018). Ponds play a significant role in maintaining rich avian diversity by unique habitat and ecosystem services (Smith *et al.*, 2002; Cereghino *et al.*, 2014; Sidhu *et al.*, 2021). Ponds act as a tiny but complete habitat for various plants, insects, amphibians, fish, reptiles, birds, and mammals (Froneman *et al.*, 2001; Fairchild *et al.*, 2005; Sidhu *et al.*, 2021), where birds play major tertiary roles in the ecological pyramid (Lu *et al.*, 2007; Ma *et al.*, 2010). Various studies in Punjab on ponds have shown significant avian species richness with water-dependent and terrestrial birds (Kaur *et al.*, 2018; Kaur and Kler, 2018; Sidhu *et al.*, 2021). The village ponds of Punjab are typically recognized by the presence of agricultural fields, weeds, heaps of cattle dung on the side of the pond, which acts as an abundant source of food supply for highly diverse waders and mud probing bird species. At the same time presence of greater tree diversity and wild vegetation near ponds supports more bird species richness (Mahesh *et al.*, 2018; Mishra *et al.*, 2019; Soni *et al.*, 2019; Sidhu *et al.*, 2021), where rich floral diversity plays a significant role in maintaining migratory and wintering waterbirds (MacroMendez *et al.*, 2015; Mahesh *et al.*, 2018).

Most of the wetlands in the state are lost due to a decrease in the water available in wetlands, including Bhupinder Sagar, Chhangali Chhamb, and Rahon de Chhamb. Reduced water flow, siltation, and encroachment are significant reasons for the degradation and loss of the biological diversity of the wetlands (Ladhar, 2002). Harike wetland that harbors the maximum avian abundance and richness faces the same challenge, and the landscape of the wetland is changing (Singh *et al.*, 2020). Ponds and wetlands along the rivers can play a vital role in the conservation of avian diversity. Therefore these areas should also be taken into consideration for conservation reserves. Plantation of native weeds, shrubs, and trees can help in increasing the avian diversity of ponds and wetlands.

Importance of riparian zone of river system

The adjoining area of the river bank and flood plains is typically known as riparian zone of the river. This corridor supports aquatic life and riparian wildlife in a number of ways (Collins *et al.*, 2010). In a typical system, riparian zones are generally known as Ecotones between terrestrial and aquatic habitats of a river (Sabo *et al.*, 2005). Terrestrial and freshwater habitats are linked via riparian zones through physical and energy fluxes (Burdon and Harding, 2008; Johnson and Hering, 2009). These habitats are sensitive to land-use changes due to the high edge-to-area ratio (Martin *et al.*, 2006). Anthropogenic activities continuously create a threat to riparian habitats by casing pollution and progressive encroachment of catchment areas along rivers for human use (Allan, 2004). Birds get ample food from emerging insects and various other sources provided by the river and its riparian area (Nakano and Murakami, 2001; Baxter *et al.*, 2005). Various processes directly influence birds in riparian areas; therefore, they are considered valuable indicators of the river ecosystem. Bird surveys are generally more cost-effective than classical biological indicators (Mattsson and Cooper, 2006; Vaughan *et al.*, 2007). Francl and Schnell (2002) have observed that birds are more responsive to human disturbances

than mammals, fish, and macrobenthos in riparian habitats. Bird species that occupy high trophic levels appeared negatively affected. Their abundance and distribution of avian species at higher trophic levels are negatively affected by urbanization and agricultural development (O'Connor *et al.*, 2000; Bryce *et al.*, 2002; Lussier *et al.*, 2006; Mattsson and Cooper, 2006).

Riparian zones along the irrigation canals have been studied in Punjab along the Sidhawan canal. A significant avian diversity with 37.25% of the bird species falling under scarce to the rare category was observed in the zone (Kler, 2009). The riparian zone of the river Beas is much broader and less disturbed than the canal. Therefore, there is a high probability of finding rich avian diversity. Rivers provide complex habitats with distinct resources allowing several species to coexist. The obligate riverine birds are diverse in the world with high topographic variation (Buckton and Ormerod, 2002; Buckton and Ormerod, 2008). River birds potentially suitable indicators of river quality as they get affected at multiple scales by both aquatic and terrestrial changes along the rivers (Larsen *et al.*, 2010). Global environmental changes have affected the Himalayan river systems, including glacial retreat, urban encroachment, modification of catchments, and riparian zones (Manel *et al.*, 2000). The ecological outcomes of these modifications, including the impact on avian diversity along the rivers, are poorly understood. Several anthropogenic degradation activities have made the river less habitable for avian communities, including agricultural intensification, disturbed hydrology, invasive plants, degraded habitat, alterations of channels, reduced biodiversity; and dams (Sinha *et al.*, 2019). Almost all parameters can be seen along the river Beas. Generally, avian abundance is higher on riversides (Mason *et al.*, 2006; O'Neal Campbell, 2008). Avian abundances along the rivers are positively correlated with vegetation and stream size (Ivicheva *et al.*, 2019). Both water birds and terrestrial birds benefit from riparian nutritional pathways along the rivers (Jackson *et al.*, 2020). Therefore, habitat monitoring along rivers is crucial for the conservation of avian abundance and diversity.

The riparian area provides a complex and diverse terrestrial habitat with unique vegetation compared to adjoining areas. Therefore, these areas generally have distinct avian composition and richness. Various studies have been done to understand the impact of local habitat structures in riparian zones on species diversity (Martin *et al.*, 2006; Palmer and Bennett, 2006; Palmer *et al.*, 2008; Pennington *et al.*, 2008; Berges *et al.*, 2010; Bennett *et al.*, 2014; Gomez *et al.*, 2016; Liang *et al.*, 2018). Studies have shown that avian richness is positively related to the width of riparian habitats in where trees usually play an important role (Shirley and Smith, 2005; Hillman *et al.*, 2016; Nimmo *et al.*, 2016). Complex landscapes in riparian strips attract a higher number of bird species (Woinarski *et al.*, 2000; Bennett *et al.*, 2014; Berduc *et al.*, 2015; Terraube *et al.*, 2016), while livestock grazing in the region can negatively impact bird species richness (Jansen and Robertson, 2001; Martin and Possingham, 2005; Nelson *et al.*, 2011). The other decisive factor affecting species richness in riparian zones includes climate factors, such as precipitation and temperature (Li *et al.*, 2013). Riparian landscapes are beneficial to biodiversity and ecosystem functions in tropical areas (Luke *et al.*, 2019). The tree diversity along riversides is generally rich with a higher number of old trees. Trees are a vital element of nature and play an essential role in maintaining the balance of nature. They have a long life span and die slowly with time. During their life span, they support many organisms to co-exist and assist in completing the life process. The trees

may be alive or dead, but they are defined as habitat trees if they act as a habitat for some or other species. These trees provide ecological niches (microhabitats) such as cavities, large dead branches, epiphytes, sap runs, bark pockets, cracks, or trunk rot. These habitat trees have different names based on their characteristics, i.e., ancient or monumental trees have remarkable age or size, whereas cavity trees host cavity-nesting species such as woodpeckers. Habitat trees primarily host avian biodiversity and harbor many endangered species of birds. Around 10-25 % of bird species are benefited from deadwood and habitat trees. Many threatened organisms in the forest ecosystems depend upon these habitat trees. The role of old trees has caught the attention of humans as they play an important role in managing the habitat of a forest. They also have consequently acquired a symbolic role in the life of humans, either directly or indirectly (Butler *et al.*, 2013). Every taxon has its role, and single biota reflects its importance. Birds have been generally regarded as a critical factor in monitoring the biodiversity of an area. Birds are unlikely to be an indicator taxon for other biotas. They can be used to monitor greater or less effort than other biotic components (Mac Nally *et al.*, 2004). Birds also help monitor climate changes, habitat fragmentation, with a mounting focus on habitat quality (Major *et al.*, 2001).

The diversity and abundance of birds are strongly linked with tree diameter, height, bark thickness, dried wood canopy, and tree age. Old trees provide cracks, wide cavities, fruits, loose bark, and other microhabitats that attract birds for feeding, foraging, roosting, and nesting. Thus, old trees provide dwelling grounds for bird diversity. Habitat trees are known for their role in forest biodiversity and the ecological services provided by them. As a result, foresters consider them optimistically. These trees offer habitat for various species, and when they fall, they become a source of woody debris and finally, through decay, contribute to maintaining ecosystem functions via nutrient cycling (Larrieu and Cabanettes, 2012).

During the last few decades, the number of habitat trees has increased in some parts of developed countries. However, the conservation of older, dead, and dried trees is part of government policies applicable to the government-owned forest in India, not favoring the conservation of these trees. The future of habitat trees on private lands in urban areas and villages will influence the conservation policies. So, conservation policies will be needed to protect these habitat trees. The old trees act as a substrate for a significant part of forest biodiversity, so particular attention should be given to old trees. On realizing the importance of old trees, several countries have promoted their preservation and are being inventoried. Therefore, coordinated measures should be taken to protect habitat trees and their microhabitats, and it should be of prime concern in the present day scenario (Saresh *et al.*, 2018).

River buffer strips provide a wide range of ecosystem services, including enhancing the aesthetic value, protecting biodiversity, mitigating pollution, and provide freshwater systems. The multifunctional nature of river systems makes it difficult to develop management prescriptions, results in complex plans with a review of parameters like conflicts, interactions, and synergies between the services offered (Cole *et al.*, 2020). Such a diverse ecosystem provides a range of habitats for different species and leads to higher species richness in the area. Avian diversity also gets influenced, and habitat

heterogeneity provides higher avian abundances and diversity in such areas (Lorenzón *et al.*, 2016). The presence of non-native plants species may alter riparian community's structure by competing with native species and hindering the restoration of degraded areas (Brooks *et al.*, 2004). Punjab is not an exception. Many invasive species have entered into Punjab via anthropogenic activities (Dhami, 2018). The interacting hydrological and ecological processes of functional riparian support biodiversity and provide critical ecosystem services, including flood, water, and quality habitat (Cole *et al.*, 2020). The habitat structure of river Beas has got deformed up to some extent, and the hydrology of the river has been changed for irrigation and electricity production (Moza and Mishra, 2007). The water quality index of River Beas has also decreased towards Harike (Kumar *et al.*, 2017). River Beas was declared a conservation reserve in 2017 under section 36A of the Wildlife Protection Act 1972 and designated as a Ramsar site in 2019 (Anonymous, 2019; RIS, 2020). A wide range of efforts is required to understand, monitor, and restore the habitats along the river. The nesting of birds in the riparian zone of the river is an essential part of sustaining the avian diversity in the area. Restoration of hydrologic function unrelated to riparian deciduous vegetation for nesting and foraging can improve habitat quality for birds (Campos *et al.*, 2020). Therefore the present study has been done to monitor and collect the crucial information required for the development of conservation strategies for the newly built conservation reserve.

Conclusion and recommendations

Effective natural conservation of a river should focus on management efforts emphasize hydrology, biology, water quality, and morphology of the river (Addy *et al.*, 2016). In the case of the river Beas Conservation Reserve, it should be taken into consideration that the river flows through a state practicing intensive agriculture. The floodplain, and more specifically the riparian zone of the river, is the last shelter for the wildlife diversity, specifically to the habitat specialist bird species in the state. Along with this, Beas Conservation Reserve connects the two wetlands of international importance (Harike and Pong) harboring rich avian diversity and hosts thousands of migratory birds every year. It acts as a corridor for the faunal diversity to move between the two, especially avian and fish species. There is a need for a more scientific approach to conserving the overall habitat of the river. On the basis of the above study, the following management strategies are recommended:

- Agricultural land use and landscape structure near the floodplain zone of the river is principal component for overall avian density, richness, and diversity. The state has rich avian diversity with a significant number of habitat specialist species that are not found in an agricultural landscape. The minimum natural areas like riparian zones of the river and small seasonal and perennial ponds in flood plains of the river should be protected.
- Agriculture intensification along the rivers negatively impacts the habitat specialist bird species; however, it seems to favor generalist and insectivore species. Paddy fields may increase the diversity in the region, whereas crops like maize should be avoided near the river zone as it may

attract more generalist species that may damage the crop and create competition for the species living in the riparian zone. However, more deep studies would be required to understand the variation in species diversity and its impact on agriculture near rivers.

- Native trees like Neem (*Azadirachta indica*), Banyan (*Ficus benghalensis*), Jamun (*Syzygium cumini*), Mulberry (*Morus alba*), Pipal (*Ficus religiosa*), and Sheesham (*Dalbergia sissoo*) harbor a rich avian diversity in Punjab; hence these species should be promoted for plantation in the riparian zone of the river.
- Generally, the banks of the river are covered with native grasses and native tree species. Native vegetation, including trees and grasses, provides suitable habitat for native breeding birds. Therefore plantation of native grass species during plantation drives should be taken into consideration along the bank of the river.
- The most prevalent tree species in agroforestry of Punjab are Poplar (*Populus deltoides*), Eucalyptus (*Eucalyptus tereticornis*), Dek (*Melia composita* and *M. azedarach*), Leucaena (*Leucaena leucocephala*), Kadam (*Anthocephalus cadamba*), and Teak (*Tectona grandis*). Poplar has been adopted at large scale by farmers for agroforestry, but the poplar plantation near riparian zones should be avoided as it negatively affects the avian diversity of the region. Agro-forestry using Dek, Leucaena, Kadam, and Teak should be more favorable for conservation and increase the avian diversity along the river in agricultural fields.
- Large-scale monocultures of exotic non-native trees with a short rotation period can have negative implications, whereas mixed plantations of native trees, including orchards, should be promoted in the regions adjoining agroforestry areas along the river.
- Urbanization along the rivers is inevitable, which comes with the problem of industrial pollutants, sewage waste, and EMR in the form of mobile towers. The government is already working on industrial pollutants and sewage waste; however, there are no guidelines for mobile towers in the region. Studies in the region have shown low avian abundance and breeding success near mobile towers and high voltage power transmission towers. It will be appropriate to avoid the installation of mobile towers near the conservation reserve.
- Sensitization of the local people living along the river is important at the first step. This will help deal with the first problem of encroachment of the land, which is the last host for specialist species.
- The region between Talwara barrage and Mirthal has rich faunal and floral diversity; however, there is a scarcity of water between these courses of the river. Without sufficient water supply, it will be difficult to keep the river's habitat healthy and functional; therefore, there is a need to increase the amount of water released into the river.
- The river merges with Satluj at Harike, forming a large wetland known as Harike wetland. This region of the river has one of the richest avian diversity in north India. Land-use changes and decreases in water levels are responsible for the loss of ecosystem services of wetlands around the world. Harike is a wetland of international importance; however, land-use changes have been

reported in recent times in the wetland area. It may alter the avian diversity of the wetland, so it needs to be addressed as early as possible.

- Generally, avian abundance is higher on rivers sides and is positively correlated with vegetation and stream size. Both water birds and terrestrial birds get benefited from riparian nutritional pathways along the rivers. Around 10-25 % of bird species are benefited from deadwood and habitat trees. The natural habitat of the riparian zone of the river consists of native trees of all age groups, shrubs, and grasses. Older trees, alive or dead, need to be protected in the riparian zone as they ecological niches (microhabitats) in the form of cavities, epiphytes, sap runs, bark pockets, cracks, trunk rot, etc. for a number of avian species.
- The presence of non-native and invasive plants species may alter species community structure by competing with native species and hindering the restoration of degraded areas. Many invasive species have entered into Punjab via anthropogenic activities, including agriculture. Constant monitoring is required to protect the region for maintaining a healthy ecosystem along the river.

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