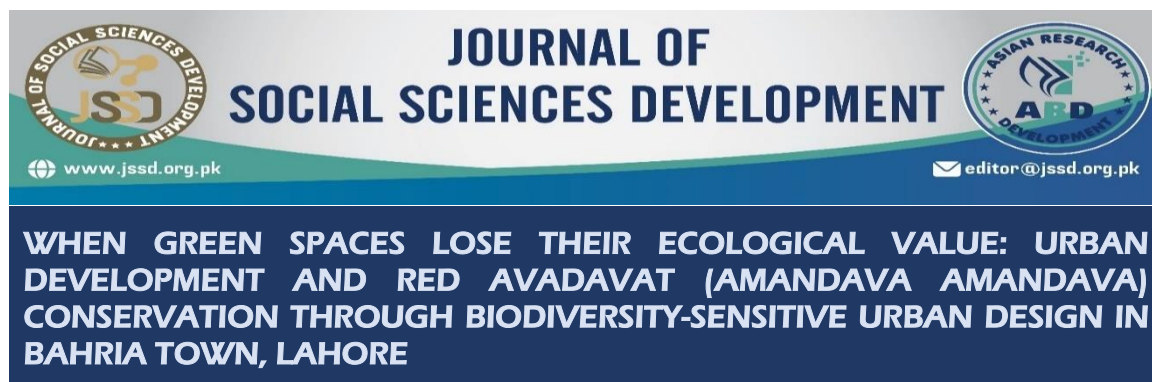




Shanze Gul Arshad¹, Jungiaan Dashti², Shifa Rasul³ & Muhammad Fawad Aziz⁴

¹MS Scholar, School of Architecture, Design & Urbanism, Federal Chartered Degree Awarding Institute for Art and Culture, Raiwind Road, Lahore, Pakistan. Email: shanze.arshad@gmail.com

²CEO / Vice Chairman, Evac Architects and consultant / QCCI. Email: Jungiaanb00@gmail.com

³Associate Architect, Organisation - BHSP Architects, Faisalabad. Email: shifarasulsr@gmail.com

⁴Architect, Maestro Architects, Pvt Ltd. Email: fawad.aziz@hotmail.com

KEYWORDS	ABSTRACT
Avian biodiversity, Urbanisation, Habitat loss, Biodiversity-sensitive urban design, Red Avadavat, Green infrastructure, Bahria Town Lahore.	The transformation of Lahore's green landscapes into built environments is increasingly associated with biodiversity loss, particularly among avian species. As urban development expands, buildings, reflective surfaces, and impervious structures replace ecologically valuable landscapes, reducing habitat availability for birds and other wildlife. This pattern is evident in Bahria Town Lahore, where the conversion of ecologically diverse landscapes, including farmlands, wetlands, and native vegetation, into built environments dominated by ornamental landscaping and hard surfaces raises concerns about habitat degradation and fragmentation. This study examines the relationship between construction-driven green space loss, the expansion of impervious surfaces, vegetation loss, and the fragmentation of green infrastructure, focusing on their implications for avian biodiversity and local climatic conditions in Bahria Town Lahore. It adopts a qualitative, comparative, and analytical methodology informed by the framework of Biodiversity-Sensitive Urban Design (BSUD) to explore how urban development patterns influence ecological connectivity and habitat suitability. Particular attention is given to the Red Avadavat (Amandava amandava), a bird associated with grasslands, dense grassy vegetation, and suitable shrub habitats. Its habitat requirements provide a basis for evaluating species-responsive urban planning and the ecological limitations of predominantly ornamental landscaping. The study emphasises that urban development and ecological conservation need not be competing objectives. Integrating biodiversity-oriented green infrastructure, native vegetation, habitat corridors, green roofs, and green walls into urban planning can help reconcile urban growth with biodiversity conservation. Ultimately, the research advocates a shift from predominantly ornamental landscaping towards ecologically informed urban development in Bahria Town Lahore, where green spaces are valued not only for their aesthetic and recreational benefits but also for sustaining wildlife, enhancing ecological connectivity, and supporting a climate-responsive urban environment.
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Corresponding Author	Shanze Gul Arshad
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Introduction

The ecological systems are crucial for environmental stability, biodiversity conservation and human well-being. They play a key role in maintaining climate, purifying the air, ensuring soil fertility and nutrient cycling, etc. (IPCC, 2022). But the rapid urbanisation, large-scale construction, and unsustainable land-use practices are also affecting the ecological relationships, leading to habitat fragmentation, biodiversity loss, and environmental degradation (Xu et al., 2018; Danmallam et al., 2024). Therefore, the inclusion of ecological aspects in the urban planning and architecture is of crucial importance for sustainable cities (McCloy et al., 2024). Birds play a role in the maintenance of ecological balance by dispersing seeds, pollinating plants, controlling insects, and maintaining food-webs (Mariyappan et al., 2023; Whelan et al., 2015). They are also used as bioindicators, as their abundance and distribution can be used to assess the quality of the habitat and environmental conditions (Arya et al., 2024; Xu et al., 2018). Avian biodiversity is therefore crucial to the health of a thriving and sustainable urban environment. Native vegetation loss, expansion of impervious surfaces and fragmentation of green space are all threats to birds from urban development, with a reduction in food, shelter, nesting sites, and habitat connectivity (Peng et al., 2024; Xu et al., 2018; Sultana et al., 2021). While parks and ornamental gardens can enhance the visual appeal of cities, their ecological function relies on diversity, complexity, and connectivity of their vegetation (Thompson et al., 2022; Peng et al., 2024). So, the mere presence of green does not guarantee appropriate wildlife habitat.

The issues are especially pertinent to Lahore where urbanization has altered the natural environment. The diversity of birds has been studied across different levels of urban congestion, and the local bird community and passerine diversity (Joshua & Ali, 2011; Fazal et al., 2014; Khan et al., 2015). At the University of the Punjab, the relationships between land-use gradients and the structure of the bird community have also been studied (Khan et al., 2024). The development of open spaces, agricultural lands, wetlands and native vegetation in Bahria Town Lahore is a concern due to loss of habitat and ecological connectivity. This difference between ornamental landscaping and ecologically beneficial green infrastructure is therefore very important. Less diverse, less connected habitats may offer less resources to wildlife than simplified planting schemes and isolated green patches (Thompson et al., 2022; Peng et al., 2024). Loss of grasslands, wetlands and native vegetation can have a special impact on birds with specific habitat requirements (Xu et al., 2018; Wenzel et al., 2023). In addition, the large amount of construction and impervious surfaces can exacerbate urban heat island effects and changes in urban microclimates (IPCC, 2022). Evaluation of urban green spaces should, therefore, be based on their ecological functions as well as their aesthetic value.

The Red Avadavat (*Amandava amandava*) can be used as a case study to explore these issues from a species-specific point of view. It is a small passerine bird that is linked to grassland and thickets of vegetation, so appropriate grassland, shrub cover and habitat continuity are important factors to consider in landscape planning. Loss and fragmentation of habitat can be a potential threat to the resources required by species with these needs (Khan et al., 2015; Xu et al., 2018). Therefore Red

Avadavat is used as a focal species to assess the suitability of habitat in Bahria Town Lahore. But, to determine whether a population is declining locally, one must make species-specific observations or have reliable ecological records. This research is aligned to the United Nations Sustainable Development Goals (SDGs) 11, 15 and 13, which are sustainable cities, terrestrial ecosystems and climate action, respectively (United Nations General Assembly, 2015). SDG 11, specifically SDG 11.7, highlights the importance of accessible and inclusive green public spaces, and Indicator 11.7.1 focuses on the percentage of urban built-up area covered by public open space (UN-Habitat, 2023). This indicator is not directly related to biodiversity but it does give a policy context to consider urban green space planning and access.

SDG 15 is about conserving and restoring terrestrial ecosystems. The targets 15.1 and 15.5 are related to ecosystem conservation, habitat degradation and biodiversity loss, while Indicator 15.5.1 monitors the trend in the extinction risk of species' using the Red List Index (United Nations General Assembly, 2015; International Union for Conservation of Nature [IUCN], 2012; United Nations Statistics Division, 2023). This study is not able to make a definitive contribution to the global assessment of progress towards the biodiversity indicators, but can offer a local perspective on habitat suitability and conservation planning. SDG 13 also emphasizes the links between protecting the environment and building climate resilience. The vegetation characteristics and conditions can influence the urban vegetation's ability to provide shade, evapotranspiration, temperature regulation and stormwater regulation (IPCC, 2022). Thus, the study of construction-induced loss of green space in conjunction with habitat fragmentation can provide information for more climate responsive urban planning.

To address these challenges, this study takes a Biodiversity-Sensitive Urban Design (BSUD) approach which incorporates ecological needs into urban planning, design and management (Kirk et al., 2021). Past studies have identified the opportunities for BSUD to include biodiversity in the built environment (Kirk et al., 2021; Garrard, 2015; Kirk et al., 2019). Strategies that are relevant include the conservation of native vegetation, grassland and shrub habitat restoration, creating connected green corridors and enhancing vegetation complexity. If planned to fulfill ecological needs, green roofs and walls can also create additional habitats (Partridge & Clark, 2018; Chiquet et al., 2013). There should be a focus on appropriate grassy vegetation and linked habitat patches, not only on ornamental landscaping, for the Red Avadavat. Finally, the implications of loss of green space due to construction activities on birds' biodiversity and the application of BSUD in Bahria Town Lahore is discussed. It does not see the conservation of ecological functions and urban development as mutually exclusive goals, but as goals that can be met in an urban plan. The research is designed to guide the architectural and landscape planning in Pakistan with a focus on green spaces as functional urban ecosystems and not just aesthetically pleasing.

Literature Review

Birds are key players in the ecosystem in several ways, including seed dispersal, pollination, pest control, nutrient cycling and waste removal. These contributions help to support agricultural

productivity, vegetation regeneration and ecological balance (Whelan et al., 2015). For instance, bulbuls and jays are responsible for seed dispersal, sunbirds and hummingbirds are responsible for pollination (Arya et al., 2024). Scavenging birds also help to eliminate animal waste and carcasses, which can pose a health risk to humans (Mariyappan et al., 2023). In addition to these roles, birds are important indicators of environmental health as they are sensitive to habitat quality and ecological conditions, and their diversity and abundance vary with them. Avian diversity is at risk from urbanisation and land-use change, which is leading to the loss of natural vegetation and habitat fragmentation. The study conducted in Lahore revealed that there was a significant difference in the diversity of birds in urban areas, with the Shalimar Town having only two to three bird species while the Nishtar Town had 43 species. The results indicate that the variation in urban conditions and in vegetation cover could affect the local diversity of birds (Joshua & Ali, 2011). Likewise, the composition of the bird community in Lahore has been influenced by the changes in land use and the growing urbanisation, as generalist and scavenger species are more common in highly urbanized areas (Khan et al., 2024). The results show the need to preserve ecologically functional green spaces in the rapidly growing urban areas.

The quality of the habitat is especially of interest because not all green spaces benefit the environment in the same way. Desirable plantings and infrastructure development and use can decrease food availability, nesting sites and cover for native birds. Studies on the avifauna of Lahore have raised the alarm on the issue of urban habitat changes and its impact on the diversity of birds (Fazal et al., 2014). Likewise, Lahore Canal, which is more developed and urbanised, was compared to the comparatively less developed BRB Canal and was found that greater the infrastructure development, pollution and human intervention in the canal, less was the avian diversity, which is important to maintain indigenous vegetation in the canal (Khan et al., 2015). This is a sign that the ecological contribution of urban vegetation should be taken into account in its assessment rather than its aesthetics. These are especially important for the Red Avadavat (*Amandava amandava*) locally called Lali, which is linked to grassy habitat, and dense vegetation. Grasslands, wetlands, shrublands and natural areas, which are important habitat features, may be lost, which decreases habitat suitability for birds that rely on these habitats for particular habitat structures. Studies on urban expansion and habitat fragmentation have revealed that the destruction of natural habitats is correlated with a decrease in bird diversity, disturbance of breeding habitats and changes in species composition (Xu et al., 2018). Similarly, a reduction in farmland and grassland birds can also have a negative effect on ecosystem services such as pest control and ecological regulation (Wenzel et al., 2023). A geospatial analysis of the urban growth in Lahore has also revealed that the city is losing its ecologically productive land and is becoming less resilient in terms of ecological impacts and urban heat stress (Adnan et al., 2026). But, the local population level of Red Avadavats needs to be observed or reliable ecological records be made for the extent of any local decline.

Bahria Town Lahore is an important context to explore the correlation between planned urban development and avian habitat suitability. Landscapes that are predominantly paved, built, and have a limited diversity of ornamental plantings may provide less habitat resources than those with a variety of vegetation and linked green spaces. The aesthetic and infrastructure aspects of urban development can therefore reduce the potential for native birds to feed, nest and move between habitats if not taken into account. The inclusion of biodiversity sensitive planning within the urban fabric is therefore significant to balance development and ecological conservation (Sultana et al., 2021). Architectural design can play a role in this integration through the use of features in buildings and landscape that are friendly to birds. Bird-friendly building design may involve minimizing reflective glass problems, creating appropriate nesting sites, and incorporating vegetated building surfaces (Klem Jr., 2013). In urban densification, green walls offer the possibility of adding layers of vegetation and offer potential shelter, feeding, resting and nesting opportunities, which increases their ecological value over bare building facades (Chiquet et al., 2013). Likewise, green roofs can offer additional habitats and ecological stepping stones in the broken urban landscape. The design of vegetated roofs that provide appropriate vegetation, food sources, and habitat complexity have been shown to support bird abundance and species richness (Partridge & Clark, 2018). These systems can also benefit urban biodiversity conservation by the inclusion of native plants and ecologically suitable vegetation.

The literature as a whole, in general, supports the connection between urbanization, habitat alteration, and alteration of avian diversity. The ecological effectiveness of the urban green space is not only related to its presence, but also to the composition of the vegetation, the structural diversity and connectivity. This is particularly applicable to Bahria Town Lahore as the interaction between ornamental landscaping, green loss due to construction activity and habitat suitability needs to be explored. Based on this, the current research uses Biodiversity-Sensitive Urban Design (BSUD) as a guideline to explore the role of native vegetation, connected green infrastructure, green roofs, green walls and species-sensitive landscape planning in enhancing avian biodiversity, specifically the Red Avadavat.

Methodology

The study design is qualitative and analytical, using literature approach, to analyze the relationship between the transformation of land use due to construction activities, changes in vegetation structure, and urban biodiversity, specifically the habitat needs of the Red Avadavat (*Amandava amandava*) which is locally known as Lali. The transformation of landscape can be explored in the context of suitability of habitat for this species at Bahria Town Lahore. Study brings together existing research, urban ecological literature, relevant reports and planning documents. It does not include primary bird surveys, direct habitat measurements and interviews, and therefore its conclusions draw on existing evidence and its implications for changes in local bird populations in Bahria Town Lahore are not measured. The following five themes were identified and used to

select secondary sources: (1) urban growth and land-cover change in Lahore; (2) vegetation removal, habitat fragmentation and avian community responses; (3) habitat requirements of the Red Avadavat; (4) the ecological functions and limitations of urban green infrastructure; and (5) Biodiversity-Sensitive Urban Design (BSUD) and its application to urban planning. Studies that were relevant to Lahore and Pakistan and were peer-reviewed were given priority. Other cities' research was also taken into consideration to find out the ecological mechanisms and design principles rather than as a direct example of Bahria Town Lahore. The trends of decreasing bird diversity with urbanisation were not seen as a decline, but rather as evidence of other ecological trends. The Red Avadavat was studied in the context of its known habitat preferences, including grassy habitat, shrub cover and appropriate wetland habitat.

For the purpose of comparison, the study also compares the Fishermans Bend Urban Renewal Project in Melbourne, Australia with Bahria Town Lahore, Pakistan. Fishermans Bend is not a direct ecological case but is used as a planning precedent for the incorporation of BSUD principles into urban development. Both sites are located in very different geographic and climatic areas and have very different socio-economic contexts; however, both offer contexts for examining the impacts of large scale urban development on landscapes, and the ways in which biodiversity can be considered in planning and design. The comparison is therefore based on pertinent planning approaches and possible ecological consequences, not on the assumption that the sites have the same environmental conditions or consequences. The study compares Bahria Town Lahore with Fishermans Bend, and then provides some ideas for planning principles and design strategies that could be used to mitigate the loss of green space and the potential impacts on avian biodiversity caused by construction. The comparison serves as a starting point for thinking about the integration of native vegetation, connectivity of habitat, and green infrastructure for biodiversity in urban development. The Red Avadavat is used as a focus species for assessing habitat requirements and for species responsive landscape planning. But, any statement about decrease in local population in Bahria Town Lahore must be supported by ecological evidence from the site. Therefore, the study does not make a blanket statement of an unproven decrease in the local population of the species, but rather explores possible habitat pressures and conservation opportunities.

Results and Discussion

Construction and Green Loss and Avian Habitat Suitability

Literature-based analysis shows that land transformation, loss of vegetation and habitat fragmentation are key potential pressures to urban avian biodiversity associated with construction. Studies reviewed are linked to urbanisation and human landscape modification, and both are related to declines in bird diversity and shifts in community composition (Danmallam et al., 2024; Xu et al., 2018). Changes are especially important for species that require specific vegetation structure and habitat conditions. Local evidence from Lahore will help to understand these relationships. Joshua and Ali (2011) reported variations in bird diversity in various urban zones of Lahore and Khan et al. (2015) compared the differences in avian diversity between the more

urbanised Lahore Canal and the BRB Canal, which is less urbanised. Khan et al. (2024) also found that there is a relationship between land-use gradients and bird community structure. These studies suggest that urban development and habitat conditions should be taken into consideration when evaluating the diversity of avifauna in Lahore. The transformation of open spaces, agricultural land, grassy areas, and other naturally vegetated areas into buildings, roads, and paved surfaces, and ornamental landscapes, in Bahria Town Lahore, is a cause for concern in terms of availability and continuity of appropriate bird habitats. This study does not involve field survey or direct land-cover measurements, however, so the magnitude of the loss of green space and its particular impact on local bird populations cannot be determined. The results therefore highlight the potential ecological pressures, and do not measure the actual biodiversity loss in Bahria Town.

Ornamental landscaping vs. ecologically functional Green Infrastructure.

The second discovery relates to the difference between the visual presence of the greenery and its ecological function. The literature reviewed shows that not only the quantity of green space, but also the vegetation composition, structural complexity, habitat maturity and connectivity, are important factors affecting bird diversity (Peng et al., 2024; McCloy et al., 2024; Thompson et al., 2022). Landscapes featuring simplified plant community dominated by well managed lawns, scattered ornamental plants, or non-native species may offer less habitat value to certain bird species than those with more diverse native plant species, shrubs, grasses, and habitat connectivity. Peng et al. (2024) point out that specialist species are sensitive to urbanisation and vegetation characteristics, and Thompson et al. (2022) note that habitat complexity is crucial to bird richness. The results indicate that landscape areas in Bahria Town Lahore cannot be considered as a substitute of natural habitats automatically. Their ecological value is related to the provision of suitable feeding resources, nesting opportunities, shelter and links with other green spaces. Therefore, ecological functionality should be considered as a main concern in urban landscape planning, in addition to aesthetic and recreational concerns.

Table 1. Summary of Literature-Based Findings on Urbanisation and Avian Biodiversity

Theme	Key findings from the literature	Implications for Bahria Town Lahore	Supporting studies
Urbanisation and bird diversity	Urban development and land-use changes are associated with changes in bird diversity and community composition.	Assess whether construction patterns and habitat conditions affect local bird habitat suitability.	Joshua and Ali (2011); Khan et al. (2024); Danmallam et al. (2024)
Habitat fragmentation	Loss and fragmentation of natural habitats can reduce feeding, nesting, and movement opportunities.	Retain existing vegetation and improve connectivity between green spaces.	Xu et al. (2018); Sultana et al. (2021)

Vegetation composition	Native vegetation and Move beyond ornamental habitat complexity influence landscaping towards the ecological value of urban diverse, ecologically green spaces. functional planting.	Thompson et al. (2022); Peng et al. (2024)
Species-specific habitat requirements	Birds with specialised habitat requirements may be and suitable shrub cover more vulnerable to when evaluating habitat urbanisation than generalist suitability for the Red species. Avadavat.	Xu et al. (2018); Peng et al. (2024)
Urban climate	Vegetation loss and impervious surfaces can contribute to local heat accumulation and changes in environmental conditions. Retain vegetation and integrate climate-responsive green infrastructure.	IPCC (2022); Adnan et al. (2026)
Green roofs and walls	Vegetated building systems can provide supplementary walls as complementary habitat opportunities when elements of biodiversity appropriately designed. sensitive planning.	Partridge & Clark, (2018); Chiquet et al. (2013)

Source: Synthesised from the literature reviewed in this study. The implications for Bahria Town Lahore are analytical interpretations, not independently measured site outcomes.

Implications for the Red Avadavat (*Amandava amandava*)

The Red Avadavat, or Lali, is a focal species for thinking about the possible impacts of landscape change. This association with grassy habitats and dense vegetation indicates the need to ensure appropriate grassland, low growing vegetation and shrub cover in urban areas. Loss or degradation of these habitats could make them less suitable for birds that have similar habitat needs. The study of urbanisation and habitat fragmentation has shown that habitat and land use changes can affect the composition of bird communities, and certain species can be more sensitive to these changes than others (Xu et al., 2018; Peng et al., 2024). In the same way, Wenzel et al. (2023) address the ecological effects of farmland and grassland birds' declines, such as the loss of ecosystem services. Applied to Bahria Town Lahore, this evidence indicates that the presence of diverse vegetation structure may be reduced by the presence of extensive paved surfaces and simplified ornamental landscaping, which may lead to potential habitat constraints for the Red Avadavat. However, there is no evidence to confirm that its population has decreased in the area. Systematic surveys of birds, habitat assessment, and reliable historical or comparative ecological records would be needed to confirm such a decline. The main implication of this is that the species' habitat needs should be taken into account when planning landscapes before more habitat is altered. A species responsive approach may be useful in identifying opportunities to retain or restore appropriate vegetation and ecological continuity in the built environment.

Fishermans Bend as a Biodiversity-Sensitive Planning Precedent

The Fishermans Bend Urban Renewal Project in Melbourne, Australia, is presented as a case study to demonstrate how biodiversity can be integrated into larger scale urban planning. The Biodiversity-Sensitive Urban Design (BSUD) framework is a more holistic approach than one that considers built form and visual amenity and includes habitat requirements in planning and design decisions. Lambe (2019) outlines the implementation of BSUD at Fishermans Bend, such as a target-species approach, habitat connectivity, vegetation management and the incorporation of biodiversity into parks and streetscapes. Selected native species were taken into account in the planning framework and the influence of green spaces, understory vegetation, linear parks and other green elements on the habitat connectivity were examined. This case is not directly ecological but its planning principles are relevant to the planning of Bahria Town Lahore. The climate, geography, ecological conditions and development context vary between the sites. As such, the results of Fishermans Bend should not be extrapolated to Lahore. However, the comparison shows that this approach can be useful in integrating biodiversity targets into development planning at an early stage. This can be done by the identification of locally relevant bird species, assessment of their habitat needs, maintaining existing vegetation wherever possible and creating connected green spaces within residential and commercial development for Bahria Town Lahore. The case is thus a planning precedent for the application of ecological issues for urban design decisions.

Table 2. Comparative Analysis of Bahria Town Lahore and Fishermans Bend

Comparative dimension	Bahria Town Lahore	Fishermans Melbourne	Bend, urban former	Relevance to this study
Development context	Planned residential and commercial development.	Large-scale renewal of industrial land.		Both provide contexts for examining biodiversity considerations in urban development.
Ecological concern	Potential loss and fragmentation of vegetated habitats due to construction and landscaping.	Integration of biodiversity objectives into urban renewal planning.		Highlights the importance of considering ecological functions alongside development.
Planning approach	BSUD provides a framework for potential improvements; its local implementation requires assessment.	Biodiversity-sensitive planning incorporates target species and habitat requirements (Lambe, 2019).		Demonstrates how ecological objectives can inform urban design.

Habitat connectivity	Connectivity between existing green spaces requires site-specific assessment.	Green corridors, linear parks, understory vegetation, and other green elements are infrastructure in Lahore. considered in planning.
Species-oriented design	The Red Avadavat is a focal species for examining habitat suitability.	Target-species planning considered selected native species, including the brolga and spotted pardalote (Lambe, 2019). Supports identifying locally relevant species and translating their needs into design measures.
Transferability	Strategies must reflect Lahore's ecological, climatic, and development conditions.	Provides a planning precedent rather than a directly comparable ecological outcome. Adapt principles locally rather than assuming identical results.

Source: Comparative synthesis based on the study's reviewed literature and Fishermans Bend case material.

Potential Contributions of Green Roofs and Green Walls

The literature reviewed shows that green roofs and green walls can be used as additional elements of urban green infrastructure. Green roofs can offer vegetation, food, shelter and even nesting opportunities, and green walls can add complexity to vegetated areas and introduce extra habitat features in highly developed areas (Partridge & Clark, 2018; Chiquet et al., 2013). The design of buildings can also be made to be bird friendly by using techniques to minimize reflective-glass hazards as well as creating appropriate nesting opportunities to ensure that birds are not excluded from the building, and that bird considerations are part of the building design process (Klem Jr., 2013). These methods are especially applicable when traditional development reduces the amount of understory plants. In Bahria Town Lahore, the implementation of green roofs and walls could be a complementary measure to ground level habitat restoration, by adding green elements and enhancing the green cover in the built environment. Their effectiveness would be determined, however, by design, plant selection, maintenance, location and ecological needs of target species. They should not be considered as full replacements for existing grasslands, wetlands or other natural habitats. The Red Avadavat should be focused on appropriate ground-level grassy plants and low growing plants. Green roofs and walls could be part of a wider biodiversity approach, but the appropriateness of the species for this would be determined rather than assumed.

Table 3. Potential BSUD Strategies for Bahria Town Lahore

Identified concern	Proposed strategy	Expected contribution	ecological	Consideration for implementation
Loss of grassy habitats	Retain and restore suitable grassland and low-growing vegetation.	Potentially improves habitat suitability for grassland-associated birds.		Confirm local species presence and habitat requirements.
Fragmented green spaces	Develop connected green corridors and vegetated links.	May improve movement between habitat patches.		Map existing green spaces and barriers.
Simplified ornamental landscaping	Introduce locally appropriate native plants and structurally diverse vegetation.	May increase food, shelter, and nesting resources.		Select plants according to local ecological conditions.
Limited vegetation on buildings	Integrate green roofs and walls where feasible.	Provides supplementary vegetation and potential habitat.		Assess plant suitability, maintenance, and connectivity.
Building-related bird hazards	Incorporate bird-friendly glazing and building design.	Can help reduce collision risks.		Apply appropriate architectural standards.
Insufficient ecological evidence	Conduct bird surveys and habitat mapping.	Establishes a baseline for monitoring biodiversity.		Use repeated observations and suitable survey methods.

Source: Author's recommendations informed by BSUD principles, Lambe (2019), Klem Jr. (2013), Partridge & Clark (2018), and Chiquet et al. (2013).

Implications for Urban Climate and Ecological Resilience

Land alteration due to construction activities has implications other than habitat availability. Vegetated land is being replaced by impervious surfaces, which can increase local heat, and change the urban environment (IPCC, 2022; Adnan et al., 2026). But, with proper planning, vegetation can offer shade, evapotranspiration, and stormwater management (as well as other benefits) depending on the local landscape and conditions. Ecological resilience and the composition of urban green spaces are highlighted by McCloy et al. (2024) and relationships between urbanisation and taxonomic and functional dimensions of bird communities by Danmallam et al. (2024). These studies together offer a foundation for the joint consideration of

biodiversity and climate responsiveness as urban-planning issues. Vegetation retention, enhancing green space connectivity and incorporating ecologically appropriate planting in Bahria Town Lahore could help to foster a more environmentally responsive urban landscape. The present study does not, however, measure the local temperature difference, loss of vegetation, or changes in ecological resilience. These results should therefore be considered as implications based on the broader literature, not as measured results for the study area.

Table 4. Evidence, Limitations, and Research Needs

Research issue	What the reviewed evidence supports	What remains unverified in Bahria Town Lahore	Recommended step	next
Avian diversity	Urbanisation is associated with changes in bird diversity and community composition.	The magnitude and direction of local changes in species richness.	Conduct systematic bird surveys.	
Green-space loss	Urban expansion can replace vegetated land with built surfaces.	The actual extent and rate of vegetation loss within the study area.	Compare historical and current imagery.	satellite
Red Avadavat habitat	The species' habitat associations make vegetation structure relevant to habitat assessment.	Its current local abundance, population trend, and breeding activity.	Conduct species-specific surveys and habitat assessments.	
Habitat connectivity	Connected green infrastructure is a relevant BSUD planning principle.	The current connectivity and effectiveness of green spaces on the site.	Map habitat patches and barriers.	
Green roofs and walls	These systems can provide supplementary habitat under suitable conditions.	Their effectiveness for local bird species and the Red Avadavat specifically.	Evaluate installations and monitor outcomes.	pilot and ecological

Source: Author's synthesis of the reviewed literature and the limitations of the present study.

From the literature review and comparative analysis, four interlinked issues emerged which are relevant to the development of Bahria Town Lahore that takes into consideration biodiversity. Urban expansion and the loss of natural vegetation for development can decrease the availability and continuity of habitat. Secondly, ecological value of the green space is not just about green cover, but also about the diversity of vegetation and structural diversity and connectivity. Thirdly, species-specific habitat requirements are demonstrated by the Red Avadavat, which indicates the importance of planning urban landscapes with species-specific requirements in mind. Lastly, the Fishermans Bend case shows how BSUD can be used to plan for the integration of target-species requirements, vegetation management and connected green infrastructure into urban

development (Lambe, 2019). The results indicate the need to move from a mostly decorative landscaping to a more ecological and functional approach to urban development. They do not however, define the extent of habitat loss or the reduction of Red Avadavat population in Bahria Town Lahore. These potential effects must be confirmed through site-specific ecological surveys and land-cover assessments and need to be assessed to determine the effectiveness of proposed interventions.

Conclusion and Recommendations

Conclusion

The present study highlighted the potential implications of the transformation of green space during the construction process on the avian biodiversity of the city of Bahria Town Lahore with a special focus on the Red Avadavat (*Amandava amandava*) and the use of Biodiversity-Sensitive Urban Design. Bird diversity and habitat suitability could be influenced by urbanisation, vegetation removal, habitat fragmentation and vegetation structure changes (Xu et al., 2018; Danmallam et al., 2024; Peng et al., 2024). The analysis points to a significant difference between ornamental greenery and ecological functional green infrastructure. The potential for landscaping to enhance the visual quality of residential environments can also lead to an increase in biodiversity, provided that suitable vegetation, food resources, shelter, and habitat linkages are available (McCloy et al., 2024; Thompson et al., 2022). These factors highlight the need to consider grassy habitat, low-growing vegetation and habitat connectivity in urban landscape planning for the Red Avadavat. The Fishermans Bend case provides an example of how BSUD principles can be applied to urban renewal to include biodiversity in planning for target species, vegetation management and connected green spaces (Lambe, 2019). While the planning context is different from Bahria Town Lahore, the approach here provides useful principles to follow to adapt urban development to local ecological needs. The study concludes that biodiversity conservation should be considered as a part of urban planning and not as an afterthought. Existing natural habitats and enhancing native vegetation, creating connected green infrastructure and introducing biodiversity-sensitive building and landscape design can serve as foundation for more ecologically responsive development. However, habitat loss and impacts on Red Avadavat in Bahria Town Lahore are yet to be confirmed based on a site-specific investigation. The study does not seek to quantify a local population loss, but rather offers a literature-based base to inform future ecological assessment and planning for biodiversity.

Recommendations

Incorporate BSUD in Urban Planning: Urban planners and developers in Bahria Town Lahore should ensure that the principles of Biodiversity-Sensitive Urban Design are included in future development applications, master planning and landscape design. Residential, commercial, recreational and infrastructural needs must be taken into account when considering the need for biodiversity. **Retain and Restore Ecologically Valuable Vegetation:** Grasslands, native vegetation,

shrub habitats, and wetland associated vegetation should be evaluated prior to construction or landscaping changes. The retention of ecologically valuable habitats should be given priority where these still exist. Restoration should involve locally appropriate plants and take account of the habitat needs of native wildlife. Create Connected Green Infrastructure: Green spaces should be designed as a network of spaces, not ornamental patches. Ecological continuity and movement opportunities for birds could be enhanced through the use of vegetated corridors, linear parks and appropriate understory plants. The location and design should be based on local habitat evaluations and surrounding built environment. Use Species-Responsive Landscape Design: The Red Avadavat should be used as a focal species for habitat suitability research, but not for the presumption of a local population decline. When considering landscape strategies, appropriate grassy vegetation, dense low growing plants and other appropriate habitat features should be evaluated. Conservation interventions should be selected and sited based on ecological evidence specific to the site.

Consider the use of Green Roofs and Green Walls Where Appropriate: Green Roofs and Green Walls should be used as an additional component of biodiversity sensitive development. They should be designed to include appropriate vegetation, habitat diversity, maintenance and connection with ground level green spaces. Such interventions should be in addition to, not in lieu of, retaining and restoring natural habitats. Encourage Bird-Friendly Building Design: When designing buildings, architects and developers should take into account the potential for bird friendly building measures such as reducing reflective glass hazards and implementing appropriate vegetated building measures, if possible (Klem Jr., 2013). These measures should be part of the landscape planning process, and should consider both building-related risks and habitat availability. Future research should involve systematic bird surveys conducted across representative locations in Bahria Town Lahore accompanied by habitat assessments and, if possible, historical records, to conduct Site-Specific Ecological Surveys. Seasonal observations could be repeated to help determine species presence, relative abundance and habitat use. This evidence is required to establish if the Red Avadavat occurs, to find out what pressures may be affecting them, and to monitor local population changes over time.

Historical and current satellite imagery should be used for geospatial analysis to determine the changes in vegetation, impervious surfaces and green space connectivity. A relationship between construction patterns and avian habitat suitability could be better evaluated by integrating land-cover mapping with observations in the field. Institute Long-Term Monitoring and Maintenance: A long-term monitoring plan should be considered to evaluate vegetation condition and habitat connectivity and bird diversity in the landscape, by developers, landscape managers and environmental stakeholders. Vegetation complexity and ecological value should be maintained, not just for visual uniformity during maintenance. Implement International Planning Practices in a Local Way: The Fishermans Bend case should not be replicated, but rather inform the development of locally appropriate BSUD strategies. All interventions must be assessed in the context of Lahore's climate, vegetation, target species, maintenance needs and development context. The

implementation of pilot projects and ecological monitoring could help to identify the most effective and feasible strategies in Bahria Town Lahore.

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