City Lights, Dimming Diversity: A Statistical Analysis of Urbanization's Impact on Biodiversity in Bangladesh

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**Abstract.** Bangladesh has been rapidly urbanizing in recent years, which is causing concerns about its impact on local wildlife. As cities grow, natural habitats are shrinking, leading to fewer species and damaged ecosystems. This study aims to understand how urban growth affects biodiversity in Bangladesh. The goal is to see how much urbanization harms wildlife and what factors are driving these changes. This study uses secondary data to study the relationship between urbanization and biodiversity. Statistical methods like correlation and regression analysis are used to find patterns between urban growth and changes in wildlife. The data helps identify key factors that affect biodiversity as urbanization expands. The findings imply that urbanization significantly affects biodiversity, offering important implications for both environmental and urban policy frameworks. This study helps to highlight the serious effects of urbanization on wildlife in Bangladesh. It offers useful insights for policymakers to create plans that can balance city growth with the protection of nature. This study stresses the need for sustainable urban planning to protect biodiversity and maintain healthy ecosystems in the country.

# Introduction

Bangladesh has experienced rapid urbanization in the last couple of decades, leading to significant environmental change. The urban population increases steadily through rural-urban migration, economic development, and industrialization. However, this urban expansion occurs at the cost of natural habitats in the area, causing fragmentation of habitats, loss of biodiversity, and degradation of the ecosystem. Urbanization transforms landscapes by replacing forests, wetlands, and agricultural lands with infrastructure such as roads, buildings, and industrial sites. This changes the landscape and transforms wetlands, forests, and agricultural lands into buildings, roads, and industrial sites. These negative transformations have less biodiversity support at macro-level food and shelter resource availability for wildlife. A study by Rahman and Szabó (2021) found that Dhaka had lost 56% of its green areas between 1989 and 2020, while the percentage of healthy vegetation had fallen from 17% to merely 2% over this timespan [1]. Moreover, urbanization increases pollution, which exerts adverse impacts on biodiversity. Industrial emissions, construction activities, and waste accumulation lead to air, water, and soil pollution that degrade the habitats even further. According to the IUCN Red List Assessment 2015, 390 out of 1619 species in Bangladesh (25%) are threatened, mainly due to habitat destruction, hunting and human-wildlife conflict [2]. While urbanization is an unavoidable process in any growth of a nation, sustainable planning and conservation of such areas can help mitigate the negative impacts on biodiversity. This study will investigate the impact of urbanization in Bangladesh on local wildlife through a statistic exploration of the correlation between urban expansion and biodiversity loss. This study will provide a basis for guiding policymakers, urban planners, and environmentalists can consider their plan towards a strategy for sustainable urban growth.

This study examines the effects that urban growth in Bangladesh caused to forest regions and agricultural territories between 2000 and 2019 while assessing environmental sustainability outcomes. The research explores both habitat safety of various species among urbanizing areas and the effects of habitat loss on biodiversity. The study aims to identify which biodiversity variables demonstrate ecological changes and to determine how urbanization affects wildlife species populations. The study evaluates how new road construction and urban immigration influence wildlife through analysis of habitat splitting and restricted animal movement effects. The research investigates green spaces in major Bangladeshi cities by exploring their effects on biodiversity preservation and urban sustainability.

# Literature review

Several studies have investigated the impact of urbanization on biodiversity in Bangladesh, providing valuable insights into the challenges and opportunities in urban settings.

By applying geospatial techniques, it is found that urban green spaces of the Dhaka South City Corporation over a period of thirty years (1991 to 2021) [3]. This study revealed 36.5% decline in the vegetation cover of the area, with green area coverage decreasing from 46% in 1991 to just 9.5% by the end of the study in 2021. One survey was conducted for butterflies in urban parks of Dhaka from the years 2018 to 2020, where 137 species were identified [4]. This study comprises around 45% of the entire diversity of butterflies in Bangladesh. The authors mentioned that species richness had a rapid decline as the study progressed and found nationally threatened. The influences behind avian diversity patterns in Dhaka were assessed and land cover related to social factors was highlighted as significant in the formation of the bird populations. There were negative correlations of abundance with poverty, which points towards the effects of socioeconomic factors on urban patterns of biodiversity [5]. One study found land-use changes around Dhaka and Gazipur districts spreading over the last three decades (1990-2020) and their impact on ecosystem service values. The study revealed that a high degree of land fragmentation was due to urban sprawl, which looked down on ecosystem services [6]. Although another study displayed the tree diversity of the Ramna area of Dhaka while identifying threats like construction activities and exotic species. Native species were advocated in the study for promoting urban biodiversity [7]. The population growth of Aedes aegypti mosquitoes in Dhaka found that urban areas had faster larval development than suburban or rural sites. Evidence shows that the combination of impervious surfaces and habitat heterogeneity influences bird richness patterns in urban areas of South Asia, inferring that cities with varied habitats can sustain higher avian diversity amidst urban pressure [8]. Another study analyzed the dynamics of land use and land cover across four cities: Mumbai, Colombo, Karachi, and Dhaka. Urbanization trends mapped through Sentinel-2 data showed a sharp diminution of green spaces and further decline in the ecosystem service value [9]. Another prior study investigated urbanization and biodiversity in Bhubaneswar, India, and pinpointed significant habitat fragmentation and loss of biodiversity hotspots due to rapid urban expansion [10]. An extensive study of urban wildlife in Dhaka documented an impressive 209 species from various areas. The study indicates the importance of urban habitats for wildlife and the need for conservation intervention in the urban context [11]. Another study of urbanization in Concepcion, Chile, where rapid urban growth influences habitat fragmentation and introduces non-native species, resulting in increased homogenization of biodiversity [12].

These studies indicate the significance of the effects urbanization has had on the biodiversity and ecosystem services of Bangladesh. The reduction of green spaces to a significant degree and habitat loss, therefore, merit integrated urban planning and conservation strategies as an immediate priority. Finally, sustainable land use policies and protection of urban green spaces are needed to minimize biodiversity loss while maintaining ecological balance in fast urbanizing areas.

# methodology

To do this study, the data were gathered from the Bangladesh Bureau of Statistics (BBS), the World Bank, the Bangladesh Environmental Lawyers Association (BELA), and the International Union for Conservation of Nature (IUCN) [2], [13], [14], [15], [16].

Bangladesh’s biodiversity patterns were evaluated through a quantitative analysis of species populations, land resource allocation, and conservation practices. The study collected data on species diversity, habitat loss, ecological changes, human activities, and environmental policy initiatives. These datasets facilitated the exploration of multiple interrelated factors, allowing the projection of expected biodiversity trends in Bangladesh.

This study used correlation coefficients (refer to Equation (1)) to evaluate the relationship magnitude and pattern between habitat loss, together with urban expansion and biodiversity reduction, to understand population changes in species [17].

(1)

A regression analysis (refer to Equation (2)) functions as a trusted statistical procedure for discovering variable relationships and making outcome predictions, along with identifying how different elements affect the response metric. The study used regression analysis to measure the effects that urbanization has on biodiversity. A linear regression model analyzed the link between species counts as the outcome variable and measures of urban expansion throughout the study. The main research goal focused on determining coefficients that minimized error squares for producing the most suitable data prediction model. The variable-based projection system enables precise prediction along with complete insight into biodiversity decrease caused by urban development for developing effective conservation and sustainable urban development strategies [17]. Mathematically:

(2)

In this study, there are various drawbacks explained which involve both outdated data gathering and incomplete analysis of distinct animal behavior under urban distress circumstances. The research fails to provide adequate quality analysis of green spaces or investigate the effect of urban-to-non-urban transition zones making essential updates necessary for effective biodiversity loss prevention strategies.

Although limited by certain factors the research adds relevant knowledge about biodiversity patterns in Bangladesh. The study presents valuable recommendations to protect biodiversity which aims to boost conservation efforts during the era of urbanization and environmental transformation.

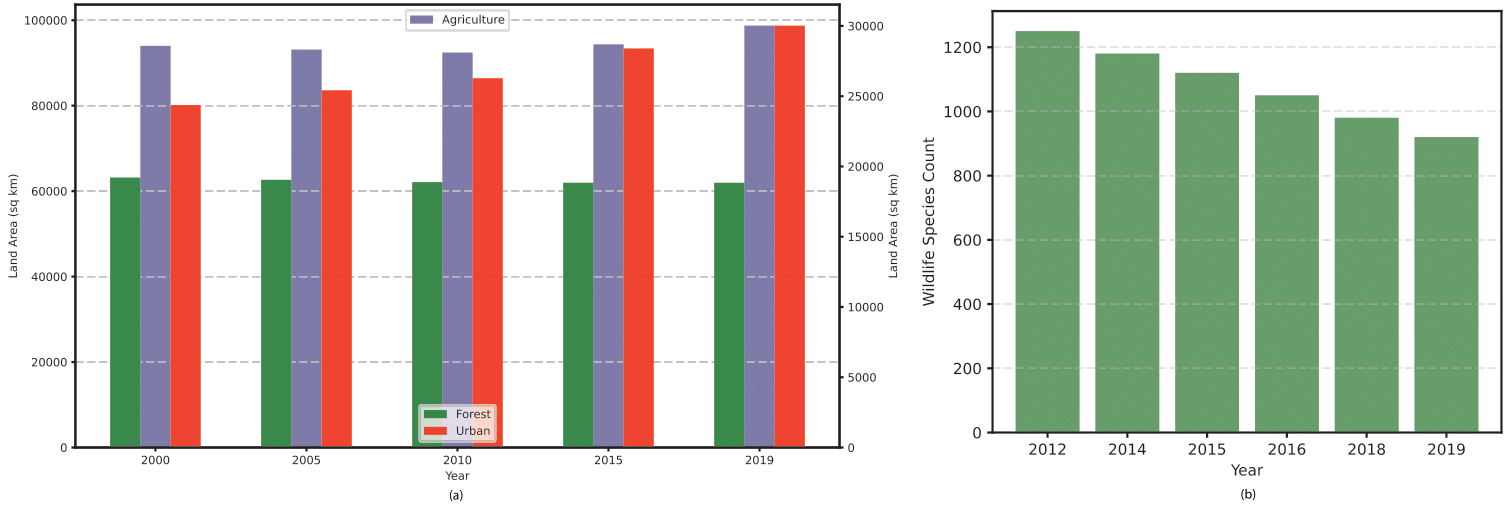
# results

Table 1 shows the dramatic increase in urban dwellers who coincided with the reduction of green areas throughout twenty years. Between 2000 and 2020 the population in cities expanded from 35.7 million to 60.4 million which represents about a 69% growth. The reduction of green space accelerated at a fast pace because urbanization drove green spaces to decline by 15% between 2000 and 2020. Nature's loss reveals numerous negative impacts on biodiversity since habitat destruction causes animals to relocate while eliminating various species and disturbing the natural environment.

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| **TABLE 1.** Urban expansion and green space reduction in Bangladesh [16] | | |
| **Year** | **Urban Population (Million)** | **Green Space Reduction (%)** |
| 2000 | 35.7 | 10 |
| 2010 | 45.3 | 15 |
| 2020 | 60.4 | 25 |

Figure 1(a) shows that from 2000 to 2019 how urban expansion in Bangladesh grew significantly by eating into natural areas and rural land bases. Urban territory registered substantial enlargement from its 2000 measurement of 24,367 sq. km to reach 30,016 sq. km in 2019. A decrease occurred in forest area coverage from 19,203 sq. km in 2000 to 18,834 sq. km in 2019 which demonstrates deforestation.

The changes in land use have resulted in the decreasing numbers of wildlife species which Figure 1(b) illustrates. The recorded wildlife species numbers demonstrate a consistent falling trend between 2012 and 2019 which reduced from 1,250 to 920. Evidence shows habitat destruction together with urbanization and agricultural expansion as possible factors that led to biodiversity reduction.

**FIGURE 1.** (a) Changes in land use over time in Bangladesh (b) wildlife species count over time

The assessment of various species groups presented within Table 2 exhibits conservation status information for urbanizing environments. The assessment system puts species into specific risk categories starting from Critically Endangered to Endangered and moving through Vulnerable before achieving Least Concern status due to habitat destruction and pollution along with human disturbances. Freshwater fishes alongside reptiles demonstrate substantial negative impact by urbanization because their populations face 6% endangered and 15% vulnerable status while reptiles have 4% endangered and 12% vulnerable. Both mammals together with birds demonstrate notable statistics in the endangered and vulnerable categories because urban development is destroying their natural habitats.

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| **TABLE 2.** Biodiversity loss in urbanized areas [2] | | | | | |
| **Species Group** | **Total Assessed** | **Critically Endangered (%)** | **Endangered (%)** | **Vulnerable (%)** | **Least Concern (%)** |
| Mammals | 138 | 1 | 5 | 10 | 84 |
| Birds | 566 | 0.6 | 3 | 8 | 88.4 |
| Reptiles | 167 | 1 | 4 | 12 | 83 |
| Amphibians | 49 | 0 | 2 | 5 | 93 |
| Freshwater Fishes | 253 | 0.56 | 6 | 15 | 78.44 |
| Butterflies | 305 | 0.32 | 1 | 3 | 95.68 |
| Crustaceans | 141 | 0 | 0.5 | 2 | 97.5 |

Butterflies together with crustaceans exhibit high levels of species being Least Concern indicating either strong survivability or insufficient assessment activities.

The data in Table 3 highlights wildlife casualties from road development on various highways in Bangladesh between 2018 and 2021. The Dhaka-Demra Highway reported the highest number of reported roadkill casualties in 2018 as 120 animals of different species lost their lives. The Chittagong-Cox's Bazar transportation route resulted in 95 casualties during 2019 which affected 35 mammals and 45 birds together with 15 reptiles. Road accidents along the Rajshahi-Pabna Road resulted in eighty cases that killed twenty-five mammals and thirty-five birds while taking twenty reptiles. The total roadkill cases on Sylhet-Shariganj Road reached 110 in 2021 resulting in the deaths of 30 mammals together with 40 birds and 40 reptiles. The increasing menace to wildlife from urbanization and roads calls for immediate deployment of wildlife corridors and safe crossings as protection measures for biodiversity conservation.

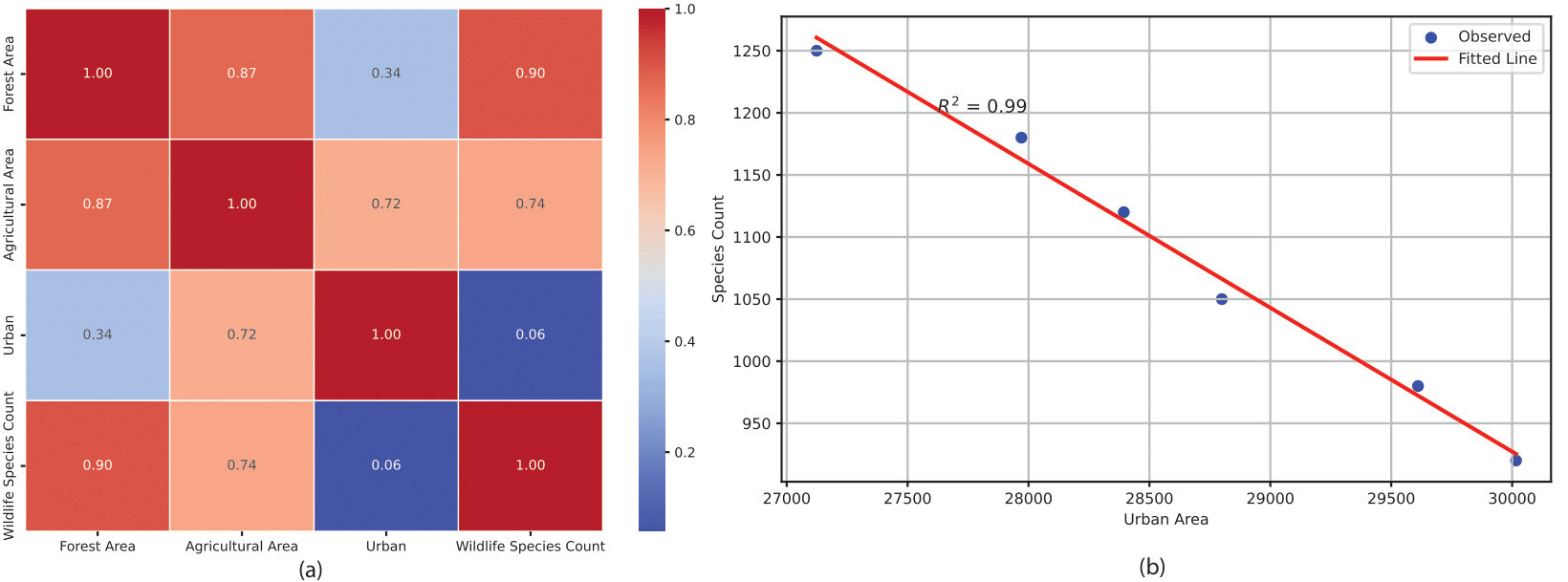
Table 4 showcases data regarding five Bangladeshi cities' green spaces' areas and percentages of total city space they occupy. Dhaka functions as the capital city with its 22.5 sq km green space representation reaching 4.80% of the total city area footprint. In the second position stands Chattogram with its 15.3 sq km of green areas that amount to 5.60% of the municipal territory. The city of Khulna holds 9.8 square kilometers of green area that accounts for 6.20% of its total space whereas Rajshahi dedicates 7.50% of its urban space through 12.1 square kilometers of green area. Sylhet holds the leading position in green space footprint with 8.10% of its territory spread over 14.6 sq km.

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| **TABLE 3.** Wildlife roadkill incidents due to urban expansion [14] | | | | | |
| **Location** | **Year** | **Total Roadkill Incidents** | **Mammals Affected** | **Birds Affected** | **Reptiles Affected** |
| Dhaka-Demra Highway | 2018 | 120 | 40 | 50 | 30 |
| Chittagong-Cox’s Bazar | 2019 | 95 | 35 | 45 | 15 |
| Rajshahi-Pabna Road | 2020 | 80 | 25 | 35 | 20 |
| Sylhet-Shariganj Road | 2021 | 110 | 30 | 40 | 40 |

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| **TABLE 4.** Availability of urban green spaces in major cities of Bangladesh (2019) [13] | | |
| **City** | **Green Space Area (sq km)** | **% of Total City Area** |
| Dhaka | 22.5 | 4.80% |
| Chattogram | 15.3 | 5.60% |
| Khulna | 9.8 | 6.20% |
| Rajshahi | 12.1 | 7.50% |
| Sylhet | 14.6 | 8.10% |

Figure 2(a) illustrates the relationship between Forest Area and Agricultural Area and Urban Area and Wildlife Species Count through the correlation heatmap. The data shows that an increase in forest territory leads to growth in species diversity as well as increased agricultural areas (0.90 and 0.87 correlations respectively). The relationship between Urban Area and Wildlife Species Count is quite insignificant based on the weak correlation value of 0.06 suggesting that urban expansion does not effectively promote biodiversity. This heatmap highlights how land use types correlate with biodiversity levels, emphasizing the importance of forest preservation for maintaining species richness.

Figure 2(b) demonstrates an opposite trend relationship between species count and expanding urban areas, which shows the negative consequence urbanization has on biodiversity. The rising urban zone leads to a drastic decrease in species number, thus indicating substantial biodiversity reduction due to growing cities. The observations align precisely with the regression model predictions; moreover, the $R^2$ value reaches 0.99, which signifies that 99% of species count variation relies on urban area variations. The relationship between urban growth and biodiversity decline is strongly confirmed by this measurement of correlation. Sustainability in urban planning and protection of natural habitats with remaining species becomes increasingly vital because of growing urbanization pressure.



**FIGURE 2.** (a) Correlation analysis (b) regression analysis: urban area vs species count

Biodiversity has changed because of urbanization during the period from 2000 to 2020 as green spaces gradually decreased while habitats diminished greatly. The 69% growth of urban areas resulted in a 15% reduction of green spaces which in turn caused habitat destruction as well as fragmentation and species extinction. The colossal amount of timber removal for agricultural purposes along with urban building projects disrupts ecosystems thereby creating deteriorations such as air pollution and heat wave effects. The conservation listing of species demonstrates the dire effects of these impacts because numbers of species become endangered or vulnerable. Analysis shows a weak connection between urban development and diversity levels because urbanization has negative effects on biological diversity. The preservation of forests together with sustainable land practices must be maintained to stop biodiversity decline because of fast urban development.

Several important recommendations need implementation in order to protect and support biodiversity preservation. The first mandate requires policy measures to stop deforestation and rebuild former forest areas with restored habitats. Creating wildlife corridors along with safe passageways remains crucial to lowering human-wildlife clashes and enabling species migration. The growth of urban biodiversity requires improved quantities of green spaces and higher quality urban vegetation in urban planning initiatives. Assessment improvements combined with continuous monitoring of various species groups should lead to better vulnerability identification that will make appropriate conservation strategies possible. To lessen biodiversity loss sustainable agricultural practices, need promotion since this help decrease habitat destruction and minimize pesticide use alongside chemical pollution. Several management tools synchronize to protect both ecosystems and build biodiversity resistance against quick development.

# CONCLUSION

The study establishes urbanization as one major driver of biodiversity loss in Bangladesh where urban expansion has clearly been associated with habitat destruction. Habitat destruction is further compounded as wildlife is threatened with death and injury from increasing pollution, increasing habitat fragmentation, and, ultimately, the destruction of forests, wetlands, and agricultural land into urban infrastructure. Through statistical analysis, the study identified major causes of biodiversity loss, including road construction, urban migration, and the reduction of green spaces. These not only restrict the movement of species but impair ecological balance and reduce ecosystem resilience. Declining vegetation cover and rising species threatened provide clear justification for enforcing sustainable urban planning solutions. Policy measures should provide for conservation and restoration of any green areas, ecological corridors, and sustainable land use practices. The present research will help urban planners, environmentalists, and policymakers to explore a development trajectory appropriate for establishing a balance between urban growth and environmental sustainability.

This study has various limitations even though it carries useful data but neglects the secondary impacts of urbanization and lacks sufficient data on wildlife mortality statistics. The research does not evaluate green space quality while maintaining limited coverage of non-urban zones. The future research demands species vulnerability evaluations to be redone while developing different biodiversity metrics beyond species numbers with better roadkill collection practices and evaluations of green space quality and biodiversity shifts throughout rural and peri-urban areas.

# References

1. N. Nawar, R. Sorker, F.J. Chowdhury, and Md. Mostafizur Rahman, “Present status and historical changes of urban green space in Dhaka city, Bangladesh: A remote sensing driven approach,” Environmental Challenges **6**, 100425 (2022).
2. M.A.R. Khan, and M.S.M. Chowdhury, *Red List of Bangladesh* (IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, 2015).
3. M.S. Misty, M.A.-A. Hoque, and S.A. Mukul, “Assessment of Urban Green Space Dynamics in Dhaka South City Corporation of Bangladesh Using Geospatial Techniques,” Land **13**(9), 1426 (2024).
4. S. Chowdhury, S.A. Shahriar, M. Böhm, A. Jain, U. Aich, M.P. Zalucki, T. Hesselberg, F. Morelli, Y. Benedetti, A.S. Persson, D.K. Roy, S. Rahman, S. Ahmed, and R.A. Fuller, “Urban green spaces in Dhaka, Bangladesh, harbour nearly half the country’s butterfly diversity,” Journal of Urban Ecology **7**(1), juab008 (2021).
5. M. Sultana, I. Storch, M.N. Naser, and M. Uddin, “Land cover and socioeconomic factors explain avian diversity in a tropical megacity,” E&S **27**(1), art19 (2022).
6. R. Sorker, M.W. Khan, A. Kabir, and N. Nawar, “Variations in ecosystem service value in response to land use changes in Dhaka and Gazipur Districts of Bangladesh,” Environ Syst Res **12**(1), 32 (2023).
7. M.A. Shila, A. Shomrat, and M.Z. Uddin, “Assessent of tree diversity in the vegetation of ramna areas of dhaka city for better management,” Bangladesh J. Bot. **53**(3), 605–617 (2024).
8. A. Sultana, A. Islam, A. Hosna, A. Tahsin, and A. Islam, “The impact of Urbanization on the Proliferation of Aedes Aegypti (Diptera: Culicidae) Mosquito Population in Dhaka Mega City, Bangladesh,” Bangladesh J. Zool. **52**(2), 201–215 (2024).
9. M. Ranagalage, T. Morimoto, M. Simwanda, and Y. Murayama, “Spatial Analysis of Urbanization Patterns in Four Rapidly Growing South Asian Cities Using Sentinel-2 Data,” Remote Sensing **13**(8), 1531 (2021).
10. P. Behera, J. Rout, and D.J. Mohanty, “Impact of Urbanization on Biodiversity Hotspot: A Case of Bhubaneswar City,” JoRSG **15**(3), 20–28 (2024).
11. M. Firoj Jaman, A. Razzaque Sarker, M. Alam, M. Rahman, F. Rabbe, A.S. Rana, A.R. Shome, and S. Hossain, “Species diversity, distribution and habitat utilization of urban wildlife in a megacity of Bangladesh,” Biodiversity Journal **12**(3), 635–653 (2021).
12. A. Pauchard, M. Aguayo, E. Peña, and R. Urrutia, “Multiple effects of urbanization on the biodiversity of developing countries: The case of a fast-growing metropolitan area (Concepción, Chile),” Biological Conservation **127**(3), 272–281 (2006).
13. B.B. of S. (BBS), *Agriculture Census 2019: Structure of Agricultural Holdings and Livestock & Fisheries, National Series* (Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People’s Republic of Bangladesh, Dhaka, 2022).
14. B.E.L.A. (BELA), *Annual Report* (Bangladesh Environmental Lawyers Association, Dhaka, Bangladesh, n.d.).
15. W. Bank, *Bangladesh Development Update Vol 1* (The World Bank, 2024).
16. B.B. of S. (BBS), *Statistical Yearbook Bangladesh 2023*, 43rd ed. (Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People’s Republic of Bangladesh, Dhaka, Bangladesh, 2024).
17. S. Puri, Md.M. Ahmmed, V. Choudhary, K.M.T. Kabir, E. Haque, and Mst.N. Noor, “A statistical odyssey: Mapping the current and future terrain of wind energy in Bangladesh,” (Jaipur, India, 2025), p. 030005.