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Chapter

Role of Biodiversity - Opportunities, Threats, and Strategic Interventions for a Resilient Indian City

Souporni Paul, Suchandra Bardhan
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Abstract

Cities are at the core of current environmental problems due to their ever-increasing demand for land surfaces and their impact on natural resources. Urban expansion compromises the functioning capacity of the ecosystems and creates complex effects on local and regional biodiversity. As cities grow, vital habitats are altered, destroyed, or fragmented into patches not big enough to support complex ecological communities, which is presently the most prominent factor contributing to the current global extinction and one of the pressing environmental issues. Hence, biodiversity conservation is integral to sustainable development and a significant concern of this millennium. Accurate assessment of urban biodiversity and implementation of strategies to arrest its loss at the local level is one of the most discussed topics in contemporary environmental research and international policies. The present study attempts to understand and analyse the urban biodiversity of Kolkata - a high-density megacity in eastern India with multiple environmental issues. It addresses the global agenda of biodiversity loss through a detailed assessment of the biodiversity status in the Indian city of Kolkata, followed by formulating relevant biodiversity strategies.

Keywords: biodiversity, landscape ecology, urban resilience, city biodiversity index, urban biodiversity strategies, habitat restoration, biodiversity conservation

1. Introduction

We live in the Urban Age and the Anthropocene [1]. Since the mid-twentieth century, rising population and extensive urbanisation have surpassed the earth's carrying capacity beyond its ability to recover [2]. These anthropogenic impacts contribute to two significant global implications: climate change and loss of biodiversity.

Biodiversity is the "variety of life" on earth [3] and is crucial to the survival of humanity. Article 2 of the Convention on Biological Diversity (CBD) refers to biodiversity as the "variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems". A robust biological diversity is nature's resilience and adaptability to unprecedented

natural calamities [4]. A large adaptive capacity and adaptive management of natural areas and native species are essential conditions for a climate-proof ecosystem. In sustainability and climate change research, much attention is being given to issues like air pollution, greenhouse gas emissions, fossil fuels, etc. However, urban biodiversity and cities' preparedness for climate change have not been explored. Especially in India, one of the world's most biodiverse countries, maintaining a stable ecosystem and rich biodiversity in cities is an essential and fundamental aspect of urban development.

The Convention on Biological Diversity (CBD), for the first time, recognised the importance of biodiversity for the well-being, resilience, and sustenance of human civilisation at the United Nations Conference on Environment and Development, UNCED (also known as "Rio Earth Summit"), held at Rio de Janeiro in June 1992 [5]. Accurate assessment of urban biodiversity and implementation of biodiversity plans to arrest its loss at the local level is one of the most discussed topics in contemporary environmental research and international policies. Despite the immense significance and contributions of biodiversity towards community resilience and human health, wealth, and sustenance, its global loss is considered one of the significant environmental challenges of this century [6]. Urbanisation, accompanied by changes in land-use patterns, habitat fragmentation, degradation of terrestrial and aquatic ecosystems, urban heat island effect, and air pollution, is a significant driver of both climate change and biodiversity loss (ibid). Therefore, there is an urgent need to draw our focus on protecting our biodiversity for a sustainable urban environment and resilient community structure. Biodiversity conservation is an integral component of the Sustainable Development Goals 2030 in many ways, as it provides the foundation for a "sustainable" and "resilient" society. At present, climate resilience efforts involve social, economic, technological, and political strategies at every scale of society. From local community action to global treaties, addressing climate resilience is becoming a priority, but the outcomes are still debatable.

With 2% of the world's surface area, India is home to 7–8% of verified species, four out of 34 global biodiversity hotspots across 10 different bio-zones, and several largest and fastest-growing cities [7]. Considering the magnitude of India's multiple crises, foremost being its population, inequality, illiteracy, lack of healthcare and sanitation, and pollution, climate change and biodiversity issues remain ignored. With limited awareness and support, it becomes an enormous challenge for city administrators to address climate change concerns or manage urban biodiversity and natural resources.

The current research has been taken up for the Indian city of Kolkata (formerly Calcutta). Located on the eastern bank of River Bhagirathi-Hooghly in the lower Gangetic delta, Kolkata is India's third-largest city and the capital of West Bengal. Once bestowed with rich biological diversity and efficient ecological systems within the city, it is considered an 'environmentally subsidised' city [8]. The natural features have not only articulated its urban growth but also influenced its infrastructure, sustenance, and liveability by offering essential ecosystem services, preserving natural habitat, and fulfilling the recreational need of its residents [9]. Currently, with a population density of around 24,252/Sq. Km., it experiences ever-increasing pressure on its urban biodiversity and natural resources due to its growing footprint and continuous infrastructural augmentation to meet the apparent developmental needs [10, 11]. It suffers from urban environmental challenges of deforestation, pollution, land-use changes, biodiversity loss, and over-exploitation of natural systems resulting in deterioration (**Figure 1**).
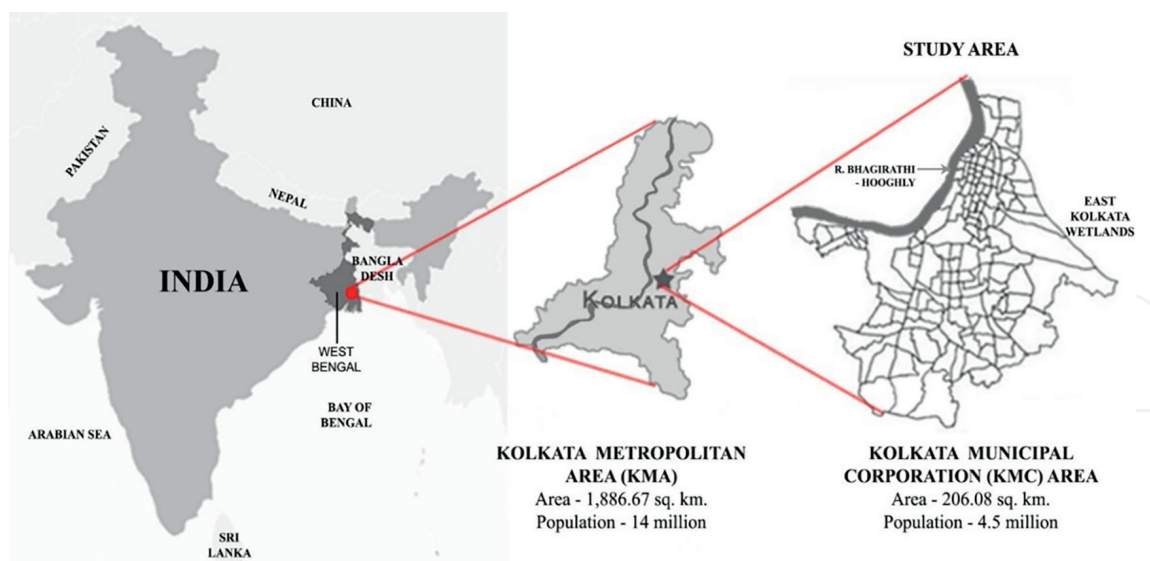
Figure 1.
Location and profile of Kolkata city.

2. Background and research proposal

Kolkata is one of the eight megacities most vulnerable to disaster-related mortality, in line with the recent United Nations (UN) report on climate change. According to the UN Intergovernmental Panel on Climate Change (IPCC) report, it is also one of the 20 largest coastal cities with potentially the highest flood losses by 2050, owing to the additional risk of subsidence due to sea-level rise and flooding. Cyclones in India are most frequent in the state of West Bengal in districts adjoining Kolkata, as per a recent report prepared by the Indian Meteorological Department (IMD). A UN report said that Kolkata had already lost a substantial portion of its green cover due to Cyclone Amphan, which struck India's east coast in May 2020. According to the IPCC report, the city is also highly vulnerable to extreme heat waves. Future assumptions about climate change impact by JICA include a rise in temperature by 1.20 to 1.80°C, an increase in precipitation by about 16%, and a sea level rise of 0.27 m by 2050. Thus, multiple reports underline the city's vulnerability to multiple climatic risks. At the same time, there is a lack of resilience in combating those risks. Kolkata demonstrates limited resilience plans to address the effects of climate change, such as the provision of shelters for the informal settlements and urban poor. Past studies conclude that the drainage and sewage network is inefficient enough to prevent the annual waterlogging the city faces annually in events of high rainfall or high tide of the river Bhagirathi-Hooghly [12–14]. Hence, urban infrastructure systems need to be designed for greater resource efficiency and disaster resilience by integrating biodiversity and other natural assets for improved liveability and sustainability.

Detailed studies show that Kolkata is steadily declining in terms of its urban biodiversity and open spaces. Studies of urban growth by [10] and Paul and Bardhan [13, 14] display the severe loss of valuable natural areas over the past decades. Rapid encroachment of vacant lands and water bodies in the eastern periphery drastically influenced land use and resource management. In 2015, collaborative research stated that the open areas in the city dropped from 25% of the total area in 1990 to a meagre 10% by 2015, while residential and commercial land covered 79% of the

total area [15]. Paul and Bardhan [13, 14] showed that presently the urban-blue-and-green-spaces (UBGS) of Kolkata occupy only 11.51% of the total land area with an individual share of UBGS is 5.08 sq. m/person (**Figure 2**), which is far below the minimum requirement set by national and global standards. Kolkata faces an acute shortage and unequal distribution of UBGS concerning social and environmental injustice and is critically insufficient to support urban biodiversity. Ironically, the prominent Master Plans of the city refer to climate change mitigation and adaptation but have not mentioned the word "biodiversity" to date.

The biodiversity of Kolkata has been accounted for sporadically. Historical accounts by A.P. Benthall provide a detailed account of as many as 276 species of trees found till 1944, including 61 endemic, 69 naturalised, 41 truly indigenous, 20 natives to other parts of India, and six introduced species. After Benthall, many naturalists and professional scientists have also recorded butterflies, fishes, herpetofauna, birds and small mammals available in the city. The most recent accounts by [16] and Ghosh [17] reveal that at least 21 per cent of the species have disappeared from the cityscape within 64 years, of which 12 were indigenous. Ghosh [17] reported about 84 species of butterflies and at least 70–75 bird species available throughout the year in and around Kolkata. However, their numbers are decreasing due to a decrease in greenery and wetlands, a decrease in trees appropriate for nesting, accumulation of garbage, growth of high-rise buildings, increased paved areas and vehicular traffic causing noise and air pollution. The People's Biodiversity Register (PBR) is the most comprehensive accounting of biodiversity, released in 2012 and 2022. The PBR 2012
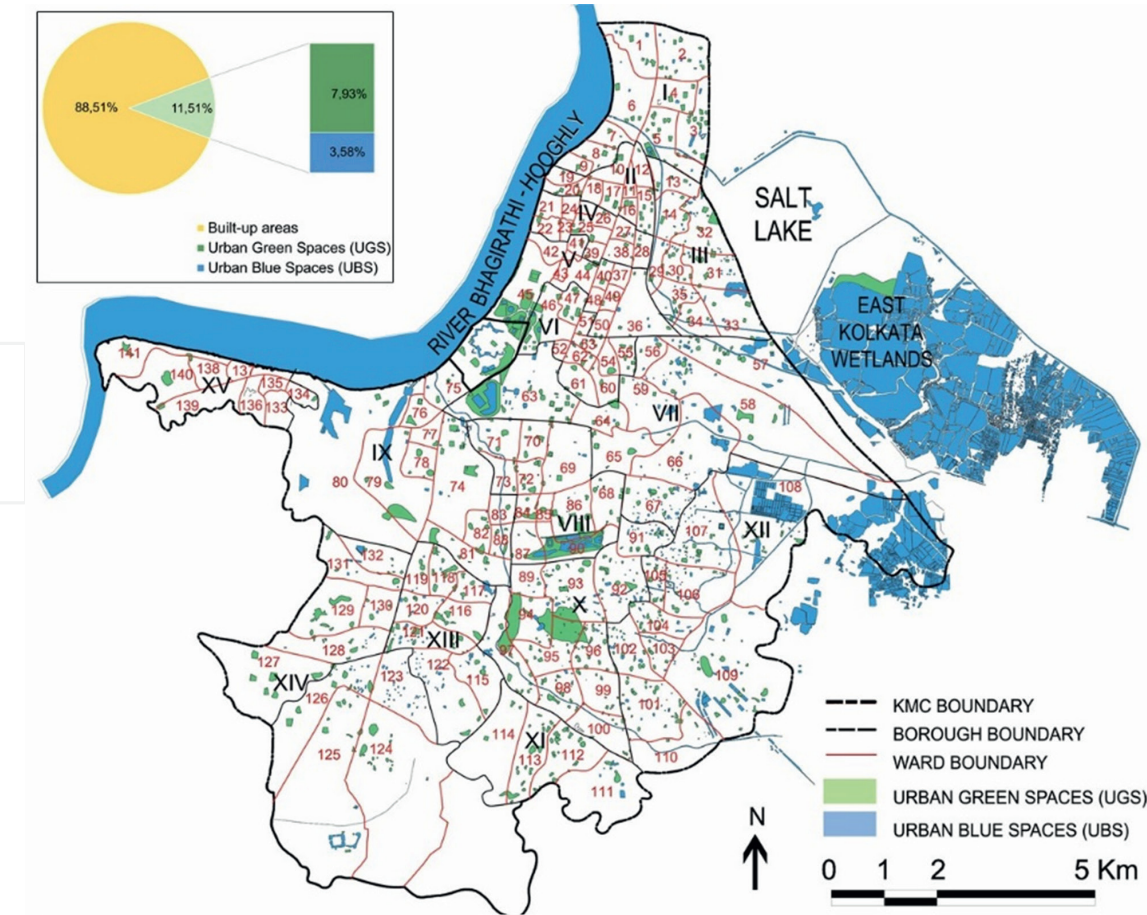

Figure 2.
Comprehensive map of Kolkata showing the distribution of UBGS on 2020 [13, 14].

recorded 676 plants, 30 mammals, 40 reptiles, 12 amphibia, and 34 fish species. The latest PBR released in May 2022 has documented 138 species of trees, 26 types of Chinese vegetables, 33 species of medicinal plants and about 100 other plant species and around 290 animal species, including about 70 species of butterflies, 47 varieties of fish, 84 varieties of birds and 22 varieties of mammals.

Recent application of the City Biodiversity Index (CBI) by Paul and Bardhan [18, 19] gives an overview of the present status of biodiversity in Kolkata, including their governance and management. The assessments show that the valuable urban-blue-and-green-spaces (UBGS) are continually decreasing, affecting the overall environmental conditions and, eventually, the city's native biodiversity. Similarly, there is good institutional capacity but a significant lack of coordination, broad-level policy planning, adequate budget and research. The studies revealed the root causes, underlying causes, and immediate causes leading to biodiversity loss in the city. They helped thoroughly understand the status, trends, and threats to biodiversity. With an increasing population, extending city limits, and decreasing natural resources, Kolkata needs a comprehensive conservation and management policy for its urban biodiversity for community resilience against climate change impacts.

3. Results for biodiversity conservation and community resilience for climate change preparedness

Urbanisation is a significant global driver of land-use conversion and deforestation, leading to biodiversity loss. Thus, cities can remain healthy by integrating biodiversity augmentation measures in city planning and management policies. The article focuses on community resilience as the ability to address climate-related hazards and their impacts with the help of robust biodiversity and efficient ecological systems within the city. It aims to mainstream biodiversity into the local policies with species management, large-scale preservation of the city's natural areas, institutional capacity, and active participation by the community. Conservation strategies are rooted protection, preservation, and enrichment of a city's native species and natural resources, while management strategies focus on governance, mandates, awareness, and community participation (**Figure 3**).

Aligned with the Sustainable Development Goals 2030, the framework consists of the following:

- Short-term resiliency planning encourages awareness about species and their habitats, awareness of the ecosystem benefits and establishes a connection with nature

- Long-term resiliency planning focuses on the ability to adapt and thrive despite changing climate, environmental, social, and economic conditions with biodiversity planning and management

The context is challenging since Kolkata is a divergent urban area with multiple complex ecological systems and an extensive network of people, infrastructures, and services that are strongly interconnected. The complexity is enhanced due to the diversity of stakeholders and areas involved in the administration and planning processes (**Table 1**).

Figure 3.
Conceptual framework of the research (Source: Authors).

Urban biodiversity results from the city's inherent natural landscape and artificially designed infrastructure of parks and waterways. Kolkata's blue infrastructure in the form of rivers, canals, and wetlands offers multiple ecosystem services, including flood regulation and stormwater management. A reliable drainage system is the city's lifeline catered by the canal network. The emergence of sewage-fed fisheries and peri-urban agriculture of East Kolkata Wetlands (EKW) is also nature's gift and a source of livelihood for thousands. It is possible to revive the age-old tradition of water transport as a cheap, eco-friendly, and convenient conveyance mode by linking them to the major arterial roads to develop a multi-modal transport exchange. These longitudinal water bodies can provide an excellent opportunity to create a continuous

Issues identified from literature and analysis	Pre-requisites	Long-term goals	Short-term strategies
Species diversity			
Lack of systematic data on existing species, habitats, and ecosystem services	Systematic collection, classification, management, monitoring, and review of data regularly	Make local area programs for biodiversity conservation through open space planning and management, awareness of invasive species, habitat fragmentation and loss, indirect pressures on biodiversity and how they disrupt ecological processes	Conduct a city-wide biodiversity survey Rare and endangered species Endemic species Non-existent (wiped-out) or locally extinct species. Protect and manage existing native and vulnerable species

Issues identified from literature and analysis	Pre-requisites	Long-term goals	Short-term strategies
		Make concerted efforts to protect existing native species, vulnerable species, habitats and ecosystems and to re-establish species which once existed	Encourage appropriate development that mimics pre-urbanisation ecology and biodiversity to reducing the impact on native species
Natural areas (Urban-blue-and-green-spaces)			
Lack of conservation strategies for urban biodiversity and habitats	Formulation of strategies and systematic conservation of the existing natural areas	Restore the degraded habitats and improve the quality of existing habitats	Preserve, create, and maintain optimal green spaces in each neighbourhood for proportionate distribution
Lack of natural areas and poor ecosystem services	Qualitative and quantitative upgradation of natural habitats	Prepare and implement biodiversity management plans, outlining the approach to biodiversity conservation and habitat management work in large areas of nature reserves like wetlands, urban parks, sanctuaries, national lakes, riverfront, and canal banks	Prepare holistic strategies to revive, restore and reinstate the degraded natural streams and wetlands to maximise the socio-cultural, economic, and ecological benefits they offer
Lack of connectivity between the existing natural habitats	Establishment of connectivity between valuable natural habitats	Increase ecological connectivity through biodiversity corridors within and beyond the core city to protect regionally significant natural areas.	Identify the existing and potential ecological cores and connecting corridors through a city-wide review of existing and proposed natural or landscaped (anthropogenic) Urban-Blue-and-Green-Spaces (UBGS).
Institutional capacity			
Lack of coordination between the governmental and non-governmental bodies involved in biodiversity and environmental management.	Interdepartmental collaboration for a holistic approach towards biodiversity	Take a holistic and multi-sectoral approach that will directly or indirectly contribute towards the enhancement of biodiversity and ecosystem services	Utilise, protect, and upgrade local biodiversity and ecosystem services without compromising their value to people and the environment
Lack of sufficient budget for biodiversity management	Ensure a minimum proportion of funds allocated towards biodiversity and environmental management	Recognise biodiversity and healthy ecosystems as an aspect of good economic development	Improvement in the existing policy and legislation, collaboration between the relevant stakeholders
		Mainstream the national level targets and strategies into local (city-level) biodiversity plan	Develop and implement a city-level biodiversity strategy and actions plans with possibilities of periodic upgradations

Issues identified from literature and analysis	Pre-requisites	Long-term goals	Short-term strategies
Public participation			
Lack of knowledge, awareness, and participation among the citizens	Awareness, public participation and social inclusion for all ages and sections of the society	Reinforce human connections with natural areas	Promote regular direct contact with nature through a variety of open spaces (such as allotments, private gardens or incidental green areas, school grounds, environmental education centres and city farms, urban parks, and informal wildlife areas).
		Increase public participation and community engagement to encourage positive actions that support environmental conservation.	Maximise the health benefits of green spaces
		Engage and optimise local knowledge, networks, and resources, and improve local capacities.	Schools should arrange visits to local parks, urban parks, and other natural areas more frequently
		Increase public understanding and awareness of biodiversity and ecological processes to improve social resilience, health, and well-being	Appointment of knowledgeable people to create awareness and motivate students towards nature and biodiversity

Table 1.
Biodiversity conservation and community resilience for climate change preparedness for the city of Kolkata.

network of greenery within the city with their dynamic, complex landscape and rich aqua-terrestrial interface.

4. Conclusions

Urban biodiversity is an integral component of urban ecology and a significant parameter of sustainable development. Biodiversity is a basis for establishing a resilient ecosystem, and diverse ecosystems provide essential ecological services for humans, such as food, timber, pollination, and climate mitigation. Loss of urban biodiversity is one of the most pressing concerns, a widely discussed topic in environmental research and international policies. Cities need to understand that addressing biodiversity loss and climate change helps to achieve climate, ecological, and social resilience. Conserving urban biodiversity and restoring and connecting natural areas are essential for the community's well-being. Appropriate regulations and policies can significantly reduce biodiversity loss through land-use policies while providing physical and mental health benefits for city dwellers. Restricting construction on the precious East Kolkata Wetlands (EKW) can maintain natural ecosystems, conserve

biodiversity, and prevent natural risks. The EKW is a natural protection against floods and other natural calamities. Contributions from the national government, international organisations, the private sector, residents, and academicians are required to address biodiversity conservation adequately.

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References

[1] Crutzen P. Geology of mankind. Nature. 2002;**415**:23. DOI: 10.1038/415023a

[2] Mahbub P, Goonetilleke A, Ayoko G, Egodawatta P, Yigitcanlar T. Analysis of build-up of heavy metals and volatile organics on urban roads in Gold Coast, Australia. Water Science & Technology. 2011;**63**(9):2077-2089

[3] SCBD. Cities and biodiversity outlook - Action and policy, secretariat of the convention on biological diversity, Montréal. 2012. Available from: http://www.cbd.int/en/subnational/partners-and-initiatives/cbo/cbo-action-andpolicy-executive-summary/cbd-cbo1-book-f-web-rev2

[4] Seddon N, Chausson A, Berry P, Girardin CAJ, Smith A, Turner B. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions Royal Society B. 2020;**375**:20190120. DOI: 10.1098/rstb.2019.0120

[5] UNCED. United Nations Conference on Environment and Development. 1992. Available from: http://www.un.org/geninfo/bp/enviro.html. [Accessed: 14 September 2017]

[6] UNEP. 21 Issues for the 21st Century: Result of the UNEP Foresight Process on Emerging Environmental Issues. Nairobi, Kenya: United Nations Environment Programme; 2012. pp. 16-18

[7] CBD: India - Main Details, n.d. Convention of Biological Diversity. Available from: https://www.cbd.int/countries/profile/?country=in. [Accessed: 09 December 2017]

[8] Ghosh AK. Ecology and Environment of Calcutta. Government of West Bengal: Calcutta's Urban Future; 1991

[9] Mukherjee J, Chakraborty G. Commons vs Commodity: Urban Environmentalisms and the Transforming Tale of the East Kolkata Wetlands. Urbanities. 2016;**6**(2):78-88

[10] Mukherjee S, Bebermeier W, Schütt., B. An overview of the impacts of land use land cover changes (1980-2014) on urban water security of Kolkata. Land. 2018;**7**(3):1-25. DOI: 10.3390/land7030091

[11] Ramachandra TV, Aithal BH, Sowmyashree MV. Urban structure in Kolkata: metrics and modelling through geo-informatics. Società Italiana di Fotogrammetria e Topografia (SIFET). 2014;**6**:229-244. DOI: 10.1007/s12518-014-0135-y

[12] Mukherjee J. Sustainable flows between Kolkata and its peri-urban interface: challenges and opportunities. In: Allen A, Lampis A, Swilling M, editors. Untamed Urbanisms. New York: Routledge; 2015. DOI: 10.4324/9781315746692

[13] Paul S, Bardhan S. Framework for quantitative assessment of urban-blue-and-green-spaces in a high-density megacity. International Review for Spatial Planning and Sustainable Development. 2022a;**10**(3):208-301. DOI: 10.14246/irspsd.10.3_280

[14] Paul S, Bardhan S. Landscapes to eco-scapes: Prescriptive transitions for urban waterways for a sustainable megacity. Urban Water Journal. 2022b. DOI: 10.1080/1573062X.2022.2086883

[15] Staff Reporter. Study bares loss of open space in city. The Telegraph. 17 February 2017. 2017. Available from: https://www.telegraphindia.com/states/west-bengal/study-bares-loss-of-open-space-in-city/cid/1397757, [Accessed 19 November 2019]

[16] Ghosh AK, Samling CL, Ghosh S, Chatterjee NN. Changes in tree species diversity in Kolkata: 1946-2010. Indian Journal of Landscape Systems and Ecological Studies. 2013;**36**(2):1-21

[17] Ghosh S. Urban Biodiversity of Calcutta: Flowering Plants, Butterflies, Birds and Mammals. Kolkata: Zoological Survey of India; 2010

[18] Paul S, Bardhan S. Biodiversity accounting of cities: A case study of Kolkata, India. WIT Transactions on Ecology and the Environment. 2017;**226**:815-826. DOI: 10.2495/SDP170711 Available from: https://www.witpress.com/elibrary/wit-transactions-on-ecology-and-the-environment/226/36344

[19] Paul S, Bardhan S. Reinstating nature in a city with the help of biodiversity indicators: A framework for a resilient Kolkata. Urban India. 2018;**38**(2):115-135 Available from: https://www.niua.org/urban-india/urban-india-2018-jul-dec