Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Urban green space research in Bangladesh: Knowledge gaps and opportunities for advancing nature-based solutions

Ronju Ahammad

ronju.ahammad@cdu.edu.au

Charles Darwin University https://orcid.org/0000-0001-7978-0721

Maruf Rahman Maxim

Charles Darwin University

Arif M. Faisal

Independent Consultant

Panna Husnain

Charles Darwin University

Kerstin Zander

Charles Darwin University https://orcid.org/0000-0002-2237-1801

Research Article

Keywords: Green and blue spaces, Health, Social-ecological, Urbanisation, Urban policy

Posted Date: October 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-5755475/v2

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: The authors declare no competing interests.

Urban green space research in Bangladesh: Knowledge gaps and opportunities for advancing nature-based solutions

Ronju Ahammad[1], Maruf Rahman Maxim[1], Arif M. Faisal[2], Panna Husnain[1], Kerstin Zander[1]

[1]Charles Darwin University, NT 0810, Australia
[2]Faculty of Arts and Society, Charles Darwin University, NT 0909, Australia
[3]Independent Consultant, Bangladesh

ABSTRACT

Rapid urbanisation results in profound changes in green spaces. In countries experiencing rapid urbanisation, maintaining green spaces can support nature-based solutions (NbS). However, in many low- and middle-income countries, our understanding of urban green space trends and the associated social-ecological challenges is limited. To address this knowledge gap and to allow us to advance NbS in Bangladesh, we systematically reviewed the literature to determine the relevant trends and changes in urban green spaces, the underlying drivers of these and the social-ecological impacts. We found that, first, there has been a steady decline in green spaces across major cities in Bangladesh, driven by increased population growth, economic activities and infrastructure development in urbanised areas. Second, the decline in green spaces has exacerbated heat island effects and reduced marginalised urban communities' access to heat relief. Third, in terms of solutions, beyond rooftop gardening or other urban agriculture practices, green space protection, restoration and enhancement measures remain more hypothetical than practical. Overall, we found a lack of understanding of the most pressing climate change processes and their spatial and temporal implications, and of the role urban policy and targeted measures should be playing in reversing the loss of green space in order to secure broad social and ecological benefits. To guide future research on and practice in improving green spaces and advancing NbS, we identified five key priorities relevant to Bangladesh and other low-income countries: 1) urban planning and regulation; 2) policy and incentivising support for greening; 3) cross-sectoral coordination; 4) inclusive and equitable green space for diverse groups; and 5) science-based decision-making.

KEYWORDS: Green and blue spaces, Health, Social-ecological, Urbanisation, Urban policy

Accepted

1. INTRODUCTION

By 2050, nearly 6.47 billion people (~66.7% of the estimated ~9.7 billion global population) will reside in urban areas (United Nations [UN] 2023), with these areas already having accumulated 80% of global gross domestic production (Acuto et al. 2018; Khatri et al. 2022). As such, urbanisation has shown a potential for underpinning socioeconomic well-being, advancing most of the 2030 Sustainable Development Goals (SDGs) and the specific targets under SDG 11 (Chen et al. 2022). Sustainable Development Goal 11 pertains to the development of inclusive, safe, resilient and sustainable cities, requiring the development of affordable housing, infrastructure and services to meet the demands of the burgeoning population and also a transformation in the way urban spaces are built and managed (UN 2023). To achieve this target, urbanisation needs to ensure equitable access to healthcare, education and employment while also preserving critical green (i.e. vegetated) and blue (i.e. water bodies) spaces that can withstand changing climatic and environmental risks (Lee et al. 2015). This is particularly important because urbanised areas are increasingly experiencing waterlogging or flooding, heat waves and water stress, which affect the infrastructure, economy and public health.

Urbanisation in low- and middle-income countries has led to the exploitation of natural resources (mainly green and blue spaces), air and water pollution, increased energy consumption and, consequently, enhanced climate change vulnerability (Ahammad 2011; Fraser et al. 2020; Arku and Marais 2021; Derdouri et al. 2025). The World Bank Group (2020) has posited that, by 2030, the expansion of urban areas into previously undeveloped land will outpace population growth by 50%, driven by an increasing demand for infrastructure, such as housing and transportation. This expansion could result in the loss of 1.8–2.4% of global cropland and biodiversity by 2030, with two-thirds of the loss occurring in Asia and Africa (Bren d'Amour et al. 2017). The rapid, and often unplanned, physical expansion of urbanised areas has significantly contributed to the degradation of natural ecosystems, which has led to demands for the urgent restoration of natural habitats in urban areas to promote an equitable coexistence between humans and nature (UN Environment Programme [UNEP] 2023). The rapid pace of ecosystem degradation—mainly the loss of green and blue spaces, biodiversity decline and pollution—requires that urban planners make integrating nature into urban infrastructure and policy measures an urgent priority (Kabisch et al. 2022; Mansur et al. 2022).

Green spaces are broadly understood as being any vegetated areas found in the urban environment and include parks, forests, open spaces, lawns, residential gardens and street trees (Rall et al. 2015). Urban green spaces are increasingly being considered to be critical components of nature-based solutions (NbS) (Kabisch and Haase 2013; Lindley et al. 2018). Green (i.e. green space or vegetated areas) and blue (i.e. water bodies) infrastructure represent more cost-effective NbS than traditional grey infrastructure (i.e. pipes, roads and canals) in terms of improving social-ecological resilience in urban areas (Lafortezza et al. 2018; Zhou et al. 2024). By integrating and interconnecting green and blue spaces, NbS strategies could support natural flood protection, carbon sequestration and temperature regulation, among other challenges in urban contexts (Dorst et al. 2019; UNEP 2021). This kind of integration can ensure a number of co-benefits, including public health and economic well-being through greening activities (Hunter et al. 2023). When managed effectively, urban green spaces can underpin NbS. However, there is a knowledge gap concerning the relationship between green spaces and urbanisation processes in developing countries.

Accepted

Achieving the full potential of green spaces to augment NbS benefits requires transforming urban governance, adopting a systems approach, integrating natural ecosystems into urban planning and mobilising investment (Kabisch et al. 2016). Kabisch et al. (2022) suggested five interlinked principles to follow through the planning, design and implementation phases to specifically underpin urban NbS: (i) systemic understanding—using a system-level approach to understand socioecological–technological interactions to ensure the protection and maintenance of green spaces during infrastructure development at different scales; (ii) benefiting people and biodiversity—enhancing urban biodiversity for the balanced delivery of multiple benefits for humans and non-humans; (iii) inclusive solutions—involving diverse actors through the design, planning and implementation phases of ensuring green spaces that can provide long-term benefits and ensure equity; (iv) context consideration—incorporating site-specific natural and cultural contexts and traditional, local and scientific knowledge; and (v) communication and learning—fostering mutual learning from the successful application of greening strategies for sustainability transitions in cities. These integrated principles can inform urban NbS discourse in general and, in particular, transcend green space governance gaps to ensure effectiveness, equitability and alignment with sustainable development.

While research on urban green spaces and their social-ecological outcomes in high-income countries has increased over the last few years (Giannico et al. 2021), little to no research has been performed on lower-income countries (Abass et al. 2019; Cinderby et al. 2021). Meanwhile, recent studies on NbS in urban contexts have advanced our understanding of European cities through multi-case studies, generating integrated information for urban policy, planning and governance (Frantzeskaki 2019; Frantzeskaki et al. 2020; Xie and Bulkeley 2020). By contrast, such information is largely lacking for cities in low- and middle-income countries that are at the frontier of rapidly changing urban landscapes. To support the implementation of urban NbS in these countries, it is essential to obtain knowledge concerning the quality and quantity of their green spaces, their accessibility and patterns of use, in order to maximise the benefits, including those related to human health and well-being (Geary et al. 2021; McPhearson et al. 2025).

Accepted

Bangladesh is one of the most rapidly urbanising countries in the world, with an urban population of 71.56 million (i.e. 41% of its total population as of 2024) (World Bank 2024). This urbanised population has grown steadily, doubling between 1990 (19.81% of the total population) and 2024 (to 41%). The cities of Dhaka and Chattogram also host large urban populations, at 21 and 11 million, respectively (the national urban population being ~52 million as of 2022) (UN 2018; Bangladesh Bureau of Statistics 2022). Urban areas are the economic hubs of the country, contributing to over half of its gross domestic product—more than double that of the traditional agricultural sector. Over the years, urbanisation has led to more and more people moving to the cities, which has necessitated the expansion of built-up areas, leading to land-use changes and declines in natural resources. Between 1991 and 2019, the country's largest megacity, Dhaka, expanded from its original core area of 116 to 234 km^2 with built-up outskirts (Roy et al. 2021). This physical expansion has been primarily driven by industrialisation, the increasing demand for housing, higher living costs in the city centre and weak regulatory control. Unregulated development, including expanding industries, formal and informal housing and settlements, and infrastructure to accommodate the growing population, has come at the expense of green and blue spaces (Siddique and Uddin 2022).

Urban expansion has increasingly affected the green and blue spaces in Bangladesh (Shahid et al. 2016; Hasan et al. 2022). However, there is limited information on the extent and

configuration of these changes—specifically, the processes driving the change and their impacts on the environment, economy and public health—in the cities undergoing urbanisation (currently comprising 12 city corporations and hundreds of municipalities) (Figure 1). A more granular understanding of the contexts, drivers, impacts and practices around green (and blue) spaces will provide information that can be applied to their protection and restoration and help to identify potential ways to realise urban NbS. Urban green spaces can underpin NbS by improving environmental quality, contribute to global climate change mitigation by decreasing greenhouse gas emissions, and reduce the vulnerability of growing urban populations to climate change impacts in Bangladesh and in similar low- and middle-income country contexts.

In this context, we aimed to determine the current status of changes in green spaces in Bangladesh, and the drivers and impacts associated with those changes, and to identify the conditions necessary for realising urban NbS. We had three objectives: 1) determine the trends, drivers and impacts of green space changes from the literature; 2) understand where the knowledge gaps were; and 3) identify specific features that promoted green-space-based NbS in an urban context. The policy recommendations arrived at from this study are among the first of their kind, our findings on Bangladesh potentially being applicable to similar urbanised contexts in low- and middle-income countries where NbS remain largely unrecognised.

Accepted

2. METHODOLOGY

Employing a systematic literature review approach, we initially searched Web of Science (WoS) and Scopus databases using the terms “urban green space” AND “Bangladesh”. This search resulted 49 papers from WoS and 66 papers from Scopus. After removing 35 duplicates and articles not covering Bangladesh, we obtained 70 unique papers. To cover the topic comprehensively, we conducted a second search using the terms “urban green space” AND “nature-based solution” AND “Bangladesh”, which returned an additional 8 papers, but they overlap with the unique list.

The screening process involved reviewing the titles and abstracts of the 70 papers. Of those, we selected 30 articles for further analysis which focused on urban green spaces more substantively, including drivers of green space change, impacts, and comparisons across major cities in Bangladesh (Figure 1; Abdullah et al. 2022, Kafy et al. 2021, Islam et al. 2023, Chowdhury et al.2022, Chowdhury et al.2021, Ahmed et al. 2023, Rahman and Zhang 2018, Miah et al.2022, Sultana et al. 2024, Hasan et al.2022, Leya et al. 2022, Anjum et al.2024, Parvin et al. 2022, Syed and Haider 2023, Sultana et al. 2022a, Byomkesh et al. 2012, Rahman and Hasan 2024, Sultana and Selim 2021, Rahman et al.2020, Siddique and Uddin 2022, Birtchnell et al. 2019, Sultana et al. 2022, Shammi et al. 2023, Dewan et al. 2021, Ahmed et al. 2019, Begum et al. 2021, Labib et al. 2020, Nawar et al. 2022, Rahman and Shorkar 2021, Hassan and Nazem 2016) (Details in Supplementary Material).

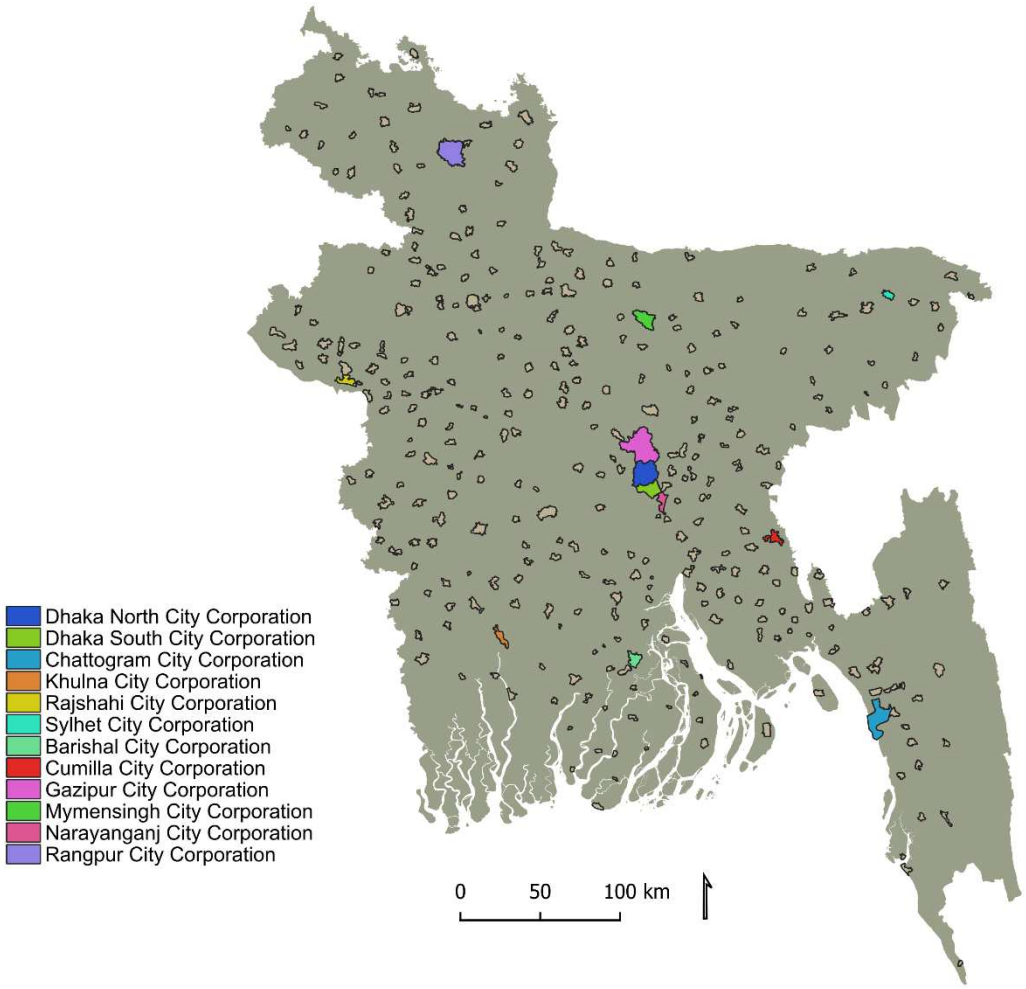


Figure 1: Spatial distribution of urbanised areas, i.e., city corporations (indicated in the legends) and municipalities/towns in Bangladesh.

The literature review provided information on the types of green spaces, patterns of green space changes, drivers contributing to green space loss, and social-ecological impacts. Our review also considered the recommendations for improving green space mentioned in the studies, particularly enhancing NbS. Given the scarcity of papers on urban NbS in Bangladesh, we identified green space practices from both local and global perspectives to provide specific recommendations in advancing NbS. The selected literature was analysed using NVivo, a qualitative data analysis software. Our preliminary analysis shows that half of the reviewed papers (14 papers) focused on green space, with the majority addressing green space changes (11 papers), the use (2) and cultural ecosystem services (e.g. recreational, aesthetics, sense of place etc.) (2) [Figure 2(a)]. Regarding study coverage, 17 papers focused on green space in Dhaka megacity and only other cities were Chattogram, Khulna, Rajshahi, Barisal, Sylhet, and Mymensingh, among others (Figure 1, Figure 2 [b]).

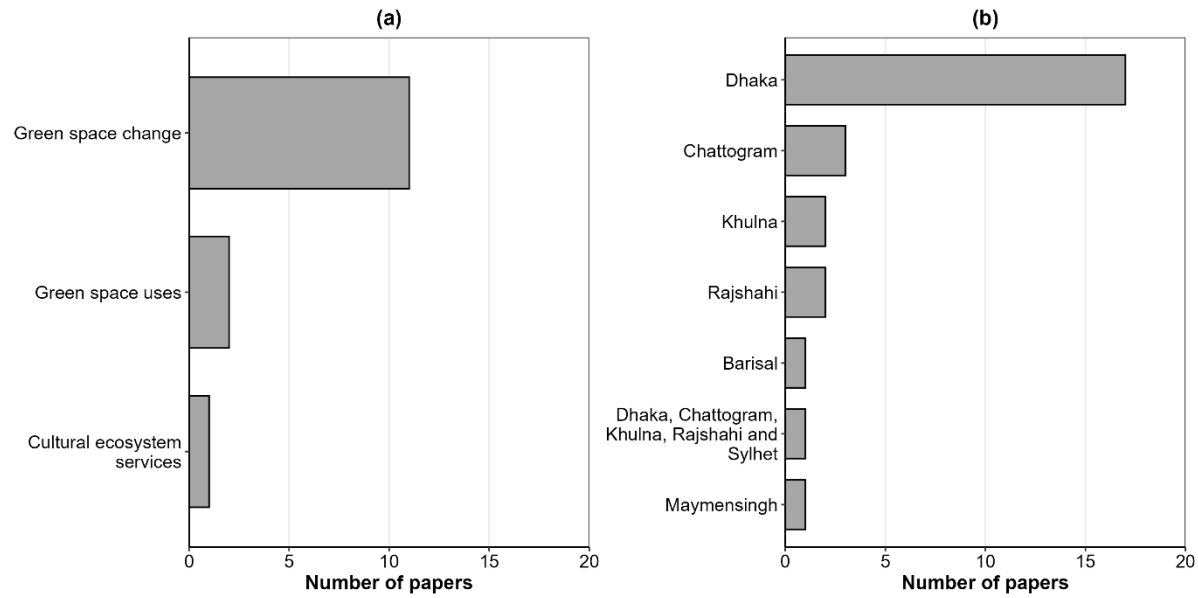


Figure 2: Number of reviewed papers focused on green space (a) and different cities (b) in Bangladesh.

Accepted

3. RESULTS

3.1. Findings of urban green space change and underlying drivers in Bangladesh

Figure 3 shows an increase in built-up areas, accompanied by decreases in natural vegetated areas, agricultural lands and water bodies in urbanised areas of Bangladesh. Across all these cities, land use changes were primarily from green spaces to bare land and agricultural areas, whereas the transformation into built-up land was most pronounced in Dhaka (Abdullah et al. 2022). We found a declining trend of green spaces, mainly vegetation land cover, compared to an expansion of built-up areas in four selected cities (Dhaka, Chattogram, Khulna and Sylhet) that the literature review provided the consistent information to draw the comparison. Between 1990 and 2022, vegetation cover in Dhaka North City Corporation decreased by up to 66%, while urban areas expanded by as much as 95% (Shammi et al. 2023). Only 16.17% of the Dhaka North City Corporation's total area is covered with vegetation, although the required green space should be 15-30% of land cover (UN-Habitat 2018). During the same period, it is estimated that the annual growth of built-up areas in Chattogram city reached 18% (Hassan and Nazem 2016). This expansion has degraded vegetated areas, agricultural lands, and wetlands, with 56% of the city's land cover undergoing significant change. In Khulna, built-up areas increased by 27% between 2000 and 2020, primarily replacing vegetation, agricultural land, and water bodies. During this period, vegetation cover decreased by 18.31%, agricultural land by 7.55%, and water bodies by 0.16% (Haque et al. 2022).

Population growth, economic activities, and urban expansion have been the primary drivers of changes in both the extent and quality of green spaces (attractive features, e.g. tree canopy, facilities, safety, accessibility) in the urbanised areas of Bangladesh (Roy et al. 2016) (Figure 4). Only three studies mentioned that the growing demand for housing and infrastructure has placed immense pressure on land resources, leading to the conversion of open and green

spaces into built-up areas to accommodate the rising population (Figure 3-4) (Byomkesh et al. 2012, Abdullah et al. 2022, Shammi et al. 2023). Economic activities, primarily textile industries and informal activities (i.e. self-employment, business, not registered formally) pulled rural-urban migration as well as recent increased service sectors resulted the demand for housing. By and large, housing and industrial development constitute a major contributor to the loss of green space, as the expansion of industrial zones (e.g. steel mills, cement industry plant, export processing) encroaches upon extensive areas of land previously designated for green or agricultural purposes, diminishing the natural vegetation cover (Hassan and Nazem 2016). Additionally, road construction, transport network, residential complexes and commercial buildings, and other infrastructure projects often accelerates the conversion of green spaces. In specific case (e.g. Chattogram city), urban growth has placed the vegetated hillsides and other natural ecosystems around the city under severe pressure, leading to the loss of greenery and biodiversity and an increased risk of landslides (Hassan and Nazem 2016).

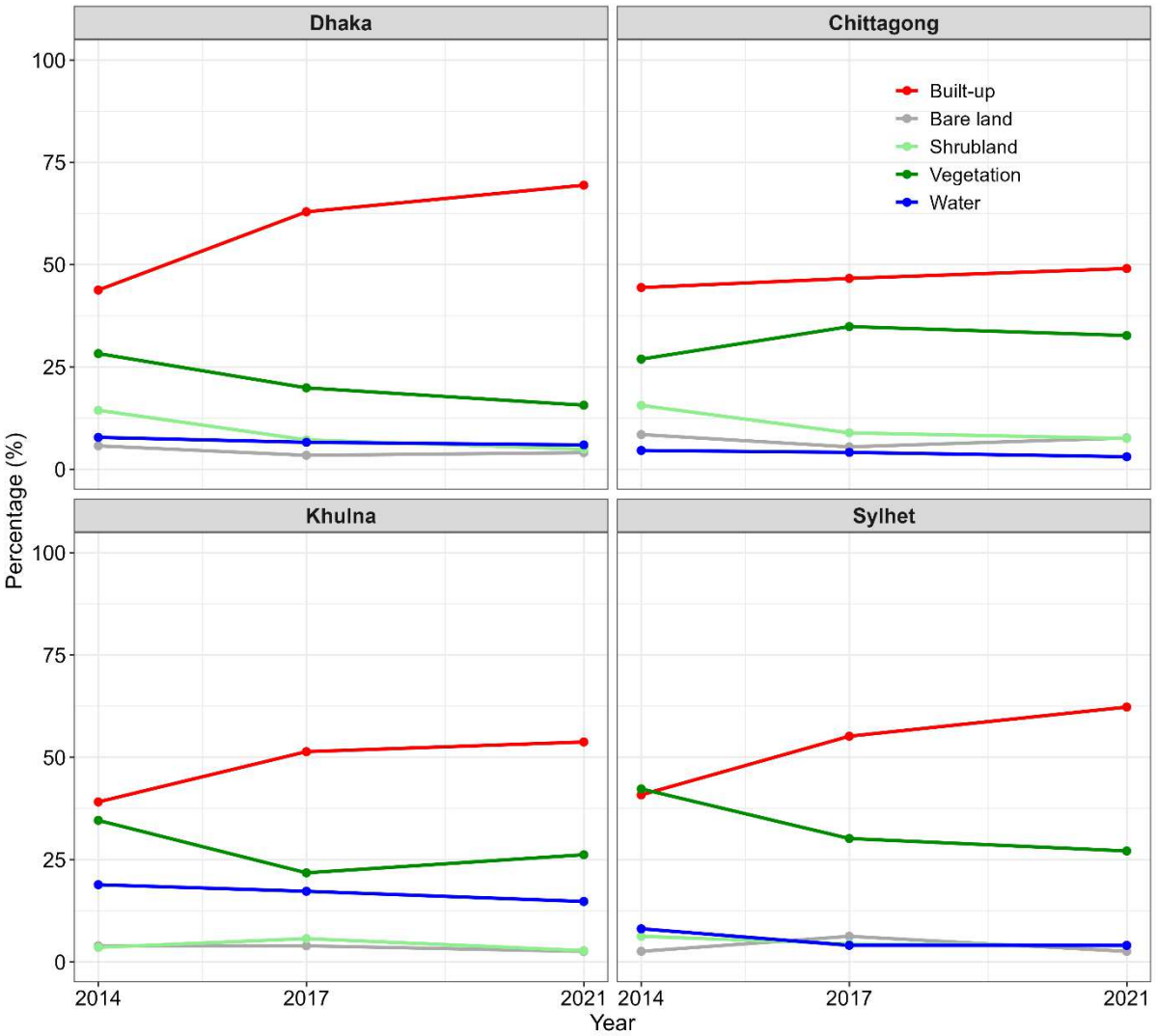


Figure 3: Pattern of green space/vegetation areas of urban land cover change in selected cities of Bangladesh.

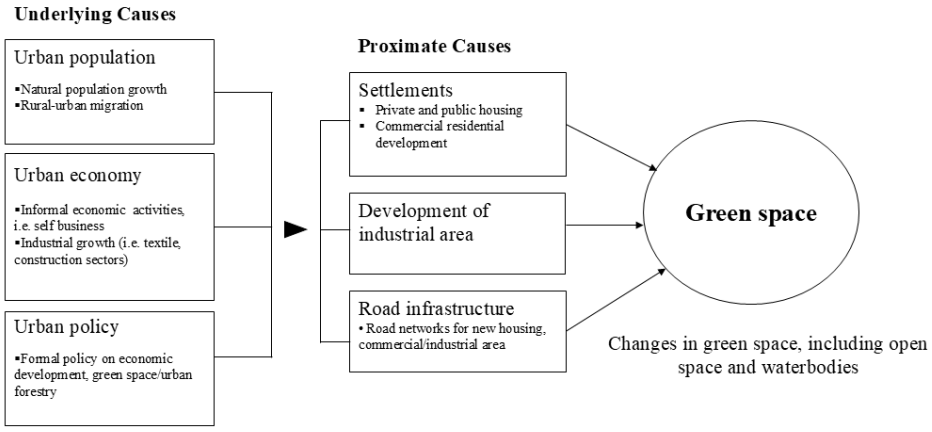


Figure 4: Process of urbanisation (underlying and proximate causes) affecting green space in Bangladesh.

Accepted

3.2. Finding on impacts of urban green space changes

The loss of green spaces and vegetation cover, and the increase in built-up areas, led to higher Land Surface Temperature (LST) and surface urban heat island intensity (SUHII) across cities (Kafy et al. 2021, Hasan et al. 2022, Leya et al. 2022). Studies have noted increased LST in Dhaka, Chattogram, Khulna, and Mymensingh cities in the past 30 years (Dewan et al. 2021, Kafy et al. 2021, Hasan et al. 2022, Leya et al. 2022). Across city comparisons of SUHII, Dhaka experienced the most significant increase in inter-annual daytime surface urban heat island intensity rising by 0.98°C, while Chattogram saw the highest increase in nighttime SUHII at 0.52°C between 2000 and 2019. Studies showed average surface temperature (LST) increase by 2°C in Chattogram and Khulna cities for the time period of 1990-2020 and 2014-2019 respectively (Abdullah et al. 2022, Leya et al. 2022) consistent with the decline of green space (Figure 3). For instance, the study showed Khulna city's average LST 24°C in 2014 (21-31°C) which rose to 26°C in 2019 (24-33°C) (Leya et al. 2022).

Among the reported cities, an increased LST or SUHII have been associated with the urban land cover changes from green space to built-up and bare lands. Studies revealed that rising surface temperatures are associated with increased built-up and bare land areas, compared with lower or unchanged temperatures in areas adjacent to green spaces such as botanical gardens, open spaces, parks, and lakes (Dewan et al. 2021, Abdullah et al. 2022). The green space regulates surface temperature as its decline shows an upper trend in LST in cities (e.g., Dhaka, Chattogram, Sylhet (variation of night at Khulna) (Dewan et al. 2021). While urbanisation and green space change affects the LST has been reported across the cities, Dhaka and Chattogram experience more substantial heat island effects, which surpass those of other cities (Dewan et al. 2021). Larger cities experience more severe SUHI effects due to extensive impervious surfaces and high population density, smaller or greener cities retain

greater resilience—though this advantage diminishes without careful land-use planning and increased built-up areas at the expense of green spaces (Rahman et al. 2022). Smaller cities like Mymensingh, Rajshahi and Sylhet show less pronounced heat island effects, but there is a positive trend in heat island (Dewan et al. 2021, Hasan et al. 2022). The authors specifically reported a high heat island effect in small, urbanised districts like Maymensingh or Barisal. This is partly due to urbanisation process, and spatial heterogeneity of growing cities in terms of size of built-up areas, contiguity of green space and population density, and governance. Another study by Leya et al. (2022) noted that urban expansion and the degradation of green cover have compounded the increase in temperature in the coastal city of Khulna, which is already exposed to hazards such as flooding and heat stress.

Further information evolved from two studies on the loss of ecosystem services value and biodiversity due to declining green space (Chowdhury et al. 2021, Sultana and Selim 2021, Abdullah et al. 2022). A loss of green space resulted in significant loss of ecosystem services value in all these four cities with Dhaka being the largest decline (US$244 - $90.22 million), Chattogram (US$455.78 million - $296.9 million), Khulna (US$103.33 million - $84.44 million) and Sylhet (US$44.94 million - $18.3 million) during 1991-2021 (Abdullah et al. 2022). This declining pattern of ecosystem services poses challenges for ensuring a healthy and ecologically balanced urban environment for large populations.

In fact, with the declining availability (quantity) and accessibility to green space in Bangladesh, Dhaka's green space per capita is critically low, with just 8.5% of tree-covered land compared to the recommended 20% (UN-Habitat 2018). Urban green space constraints and its impacts are most evident in newly developed, substandard areas (e.g. informal settlements/slums) with poorly enforced housing regulations across cities of Dhaka, Chattogram, Khulna (Dewan et al. 2021). In particular, green spaces such as open spaces and wetlands are poorly managed or inadequately protected in and around the urban slums of Dhaka city, leading to public health concerns (Sultana et al. 2022b). Informal settlers are exposed to significant health risks due to limited access to open spaces, safe drinking water, and proper sanitation facilities (Birtchnell et al. 2019). The direct impact of green spaces on physical and mental health and well-being is evident among those affected by non-communicable diseases and poor health conditions, who are most likely to visit parks in Dhaka city (Labib et al. 2020). Another study mentioned the indirect impacts of green space, i.e. the psycho-social benefits for the elderly people who considered the social acknowledgement through infrastructural facilities and safety measures and age-friendly parks contributes to their self-esteem (Rahman and Shorkar 2021). Overall, lower-income residents and marginalised communities represent the disadvantageous and socially vulnerable groups who do not have access to green open space and, therefore, miss out on associated well-being benefits.

Accepted

3.3. Findings of existing practices of green space management

In response to the decline in green space and its effects, specific solutions such as rooftop gardening/agriculture and balancing green infrastructure networks with urban planning have been proposed in some studies (Begum et al. 2021, Anjum et al. 2024). Studies have recommended investing in rooftop agriculture practices can provide environmental, economic, and social benefits by reducing temperatures, saving energy, and producing fresh food (Begum et al. 2021, Sultana et al. 2024). For instance, a rooftop vegetation (mainly farming vegetables, e.g. tomato, brinjal, spinach, bottle gourd) on 216 square meters can

reduce temperature by 1.2% to 5.5% compared to bare roofs, a decrease in cooling demand from 3.62% to 23.73%, leading to energy savings of 5.87% to 55.63% (Begum et al. 2021). This strategy can advance the implementation of NbS through reducing temperature, energy savings, return on investment through increased fresh food production and reduce carbon dioxide concentrations (e.g. lower rise of CO2 concentration (1 to 10 ppm) with proximity to vegetation on roofs) (Anjum et al. 2024). Over two-thirds of rooftops in Dhaka city are suitable for urban agriculture (Sultana et al. 2024).

Focusing on informal settlements with limited open green space, one study has examined how slum dwellers' skills and practice-based greening can improve their lives and green their immediate surroundings, particularly in Dhaka city (Birtchnell et al. 2019). Although similar examples are not identified in our current review, however the study considers the participation of low-income residents and the integration of their skills into green planning as crucial for establishing context-specific forms of urban greening practices. Low-income residents' competence in planting and gardening within limited space, and in conserving soil moisture using available materials like shredded leaves and straw mixed with soil to prepare mulch, as an example, demonstrates their potential role in decision-making for green planning around them. Meaningful engagement, recognition, and support, along with materials from urban government and non-governmental institutions, can scale up the practice-based greening and broaden its scope in growing cities.

Another study by Rahman et al. (2020) found that vertical development can alleviate space constraints and reduce pressure on natural ecosystems from building density and infrastructure. Vertical growth has a weaker effect or no association with land surface temperature, whereas low-height, high-density building areas contribute to higher LST in Dhaka city. The authors particularly recommend vertical development, the further protection of green spaces within core cities, and the redevelopment/adjustment of land to conserve natural features can enhance microclimatic benefits in combating urban heat island effects.

Accepted

4. DISCUSSION

4.1. Urban green space research and practice in Bangladesh

Although research on urban green spaces in Bangladesh has increased over the last decade, it has largely focused on megacities, reinforcing that there is a knowledge gap pertaining to low- and middle-income countries (Rigolon et al. 2018). We identified a trend of declining green spaces resulting from the physical expansion of urbanisation (e.g. Kafey et al. 2021; Hasan et al. 2022). Only a few studies have pointed to urban sprawl, zoning decisions and infrastructure development disproportionately diminishing green spaces around the outskirts of cities and low-income neighbourhoods (Byomkesh et al. 2012; Abdullah et al. 2022). Although some studies mentioned the general driver of urbanisation—the physical expansion—affecting green spaces in megacities (Hassan and Nazem 2016; Shammi et al. 2023), this offers only a broad, generalised understanding, with limited information on the demographic, economic, environmental or climate-change-related drivers affecting green spaces and other natural resources across cities of different sizes.

Green space management and practices have received momentum within a limited number of studies focusing on urban heat islands in Bangladesh, a pattern also reflected in low- and middle-income countries more broadly, where the role of green space-based solutions remains understudied (Kotharkar et al. 2018, Huang et al. 2019). Specific studies emphasised the importance of green spaces, including specific strategies such as green rooftops to mitigate the urban heat island effect (e.g. Begum et al. 2021). Vertical greening and rooftop gardening systems on high-rise buildings have been found to mitigate urban heat island effects effectively, enhance air quality, and increase biodiversity, all while avoiding competition for land in the example of Singapore (Tan et al. 2013, Wong et al. 2021) and Hong Kong (Morakinyo et al. 2019). Research and practices of managing urban green spaces (parks, roadside greenery, lawns) for ecological functions, biodiversity has predominately in largely developed countries, e.g. Europe (Chollet et al. 2018, Fischer et al. 2020) in contrast to limited evidence of knowledge-based practices in Bangladesh. Research on low- and middle-income countries is slowly increasing, advancing understanding and exploring strategies for green infrastructures that integrate NbS to improve urban resilience against climate change aggravated risks, including increased and more frequent heat stress and flooding (Hobbie et al. 2020). However, there are no apparent examples of such strategies being implemented in urbanised areas of Bangladesh or in low- and middle-income countries.

4.2. Knowledge gaps in urban green space research and practices to achieve NbS

Accepted

Our study identified key gaps that can inform future research and practices in Bangladesh and countries with similar contexts. For instance, the existing studies barely focus on spatial and temporal expansion patterns in peri-urban and small urban centres and how drivers and pressures evolve within and across cities in Bangladesh. Although the process of urbanisation may differ across cities and beyond (i.e. megacities to medium-, small-cities), the pattern of population growth and land use impacts have not yet been explored (Nassary et al. 2022). Urbanisation in megacities, for example, has led to high population densities and high ratios of land consumption to population growth (Marshall 2007). Newly urbanised areas of small cities, including peri-urban and rural areas, are increasingly becoming vulnerable to climate change-induced risks like flooding, cyclones, and storm surges (Roy et al. 2021). While climate change risks drive increased migration to both mega- and small cities, their implications for green space within Bangladesh and low-income countries remain largely unexplored. Without more fine-scale, place-specific research on green space trends, the challenges posed by increased migration mean that existing knowledge barely informs policies and measures to account for these risks and pressures.

While some studies have shown a positive relationship between the development of green spaces and heat relief and good air quality (Kabisch et al. 2015, Wu et al. 2021), there is no such evidence from the mega-cities in Bangladesh. The preservation of green and blue spaces can mitigate urban heat islands and reduce the intensity of flooding (Gunawardena et al. 2017, Wu et al. 2021), which has yet to be present in the research to inform policy and strategic planning in Bangladesh and other growing cities of low- and middle-income countries. Current research does not explicitly assess how to effectively integrate greenery into broader city planning, policies, and strategies. Interdisciplinary studies remain sparse in these countries, although they are considered crucial for strengthening evidence-based measures for the protection, restoration, and conservation of urban green spaces in low- and middle-income countries (Toor et al. 2024). In this context, there is a critical knowledge gap in integrating knowledge from scientists, policymakers, businesses, practitioners and urban

communities to effective planning and measures for urban green space. This overlooked science-policy gap in decision-making processes impedes the adoption of a science-based approach to biodiversity conservation and broader natural resource management in urbanised areas of Bangladesh.

Improving access of marginalised and low-income groups to urban green spaces has been identified as crucial for addressing health inequalities in particular research from developed countries, e.g. United States (Wolch et al. 2014, Hsu et al. 2021) and China (de Macedo et al. 2021). The existing literature in Bangladesh does not explore the green space planning process to understand how it ensures benefits without increasing social disparity and health inequalities. Without an equitable green space arrangement in urban planning, future greening efforts remain business-as-usual which results in "green gentrification", by only raising property values and further displacement of low-income residents (Anguelovski et al. 2022). At present, it remains unclear how urban planners and policymakers in Bangladesh address the availability, accessibility and equitable benefit of green space both in the short- and long-term (Byomkesh et al. 2012, Leya et al. 2022). Indeed, the spatial disparity of green space among residents in low- and middle-income countries is double that of high-income countries, highlighting the need for further urban research on this issue (Rigolon et al. 2018; Chen et al. 2022).

4.3. Critical features of green space research and practices for advancing NbS

Accepted

Some features emerged as critical for future consideration to support greening strategies for achieving NbS. These related to urban planning and regulation as a way of protecting and supporting greening, policy and incentivising support for greening measures, cross-sectoral coordination, inclusive and equitable green spaces, and science-based decision-making (Figure 5). These holistic features are briefly outlined below.

4.3.1. Urban planning and regulation for green space

Urban planning is critical for providing strategic directions for infrastructure development while integrating and maintaining green spaces, including parks and forests. One significant drawback in urban planning in Bangladesh and other countries with similar contexts is that it does not keep pace with the physical expansion, where allocating land for sustainable use, apart from productivity, has to be assessed and accompanied by regulation (Koroso and Zevenbergen 2024). Indeed, in Bangladesh, most urban fringe areas and clusters lack any mandate to regulate development and protect green spaces (Roy et al. 2021). Those regulations that do exist are often outdated and inadequate for the needs of physical planning, infrastructure and informal practices (i.e. housing). In addition, partisan political and economic power shapes the regulatory enforcement. In response, there is a need for the practical applications of existing zoning regulations, building codes and land-use management strategies to be assessed in order to prevent unplanned urbanisation, the conversion of green spaces into alternative land uses, and construction in ecologically sensitive areas, all while promoting environmentally sustainable building practices. The evaluation of existing city master plans and detailed area plans would be the first step towards identifying the measures needed to enhance greening measures alongside the physical development processes. The role of urban planners in the early physical development process should be to ensure that green spaces are protected. Urban development authorities in each city corporation and at each local level (i.e. municipalities) should

implement zoning systems that consider the environmental risks of any physical development, and should impose stricter restrictions, with different social-ecological considerations, on the loss of green or open spaces, wetlands and rivers.

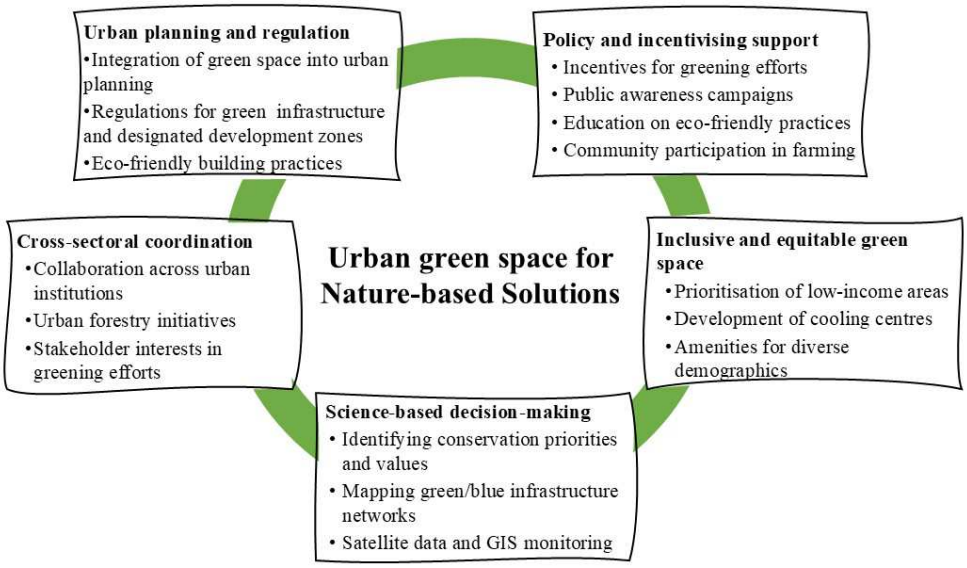


Figure 5: Critical features of green space management for advancing urban NbS.

Accepted

4.3.2. Urban policy and incentivising support for greening measures

The Bangladesh government has not yet produced any urban policy directed at cities other than mentioning the importance of urbanisation in its periodical (five-year) plan. In response, an explicit urban policy to set greening goals at the national level and for different cities, specifying the roles of the various institutions and stakeholders associated with the management and broader urban planning process, is an urgent necessity. With the changes in green space roles and trends happening so rapidly, triggered by development and diverse interests, there are immense challenges to be considered in the formulation of necessary new policies and strategies, in terms of integration and coordination in developing countries, including Bangladesh (Derkzen et al. 2017). One of the key policy measures would be supporting the stewardship activities of the landowners and individuals engaged in protecting, restoring and managing the different types of green space. For instance, to encourage urban greening, such as rooftop agriculture, government policies could provide incentives through tax reductions, subsidies for maintaining green infrastructure, and support for local urban farmers, with the primary aim of making the practice of greening more accessible to city dwellers (Liberalesso et al. 2024). Business owners could apply for tax reductions, invest in new tree-planting with native species, maintain street trees and channel financial support towards greening practices in informal settlements. With the right set of policies, the restoration of underutilised lands through the reintroduction of native plants and the creation of green corridors could be done in park-poor neighbourhoods. In doing this, any of these greening efforts would have social (shade, reducing urban heat, lowering energy consumption for cooling, jobs and aesthetic quality) and ecological (enhanced biodiversity and ecosystem services) outcomes (Richards and Thompson 2019).

4.3.3. Cross-sectoral coordination

Cross-sectoral coordination through collaboration within the various departments involved in urban planning (e.g. housing, road and infrastructure, greening and health) could enhance the effectiveness of NbS by leveraging the multiple benefits of green space management. However, the initial step would be to facilitate the goals shared between various sectors concerning urban NbS and the outcomes of greening strategies in order to break down the 'siloed' positions of the institutions and enhance their acceptance (Naumann et al. 2023). For Bangladesh, collaborative green space management requires identifying synergies between the sectoral programmes of the city corporations, the city development authorities, the Department of Environment and the Bangladesh Forest Department, all these agencies having some strategic goals to manage and improve green spaces, including parks, recreational areas and urban forests. The entry point of collaboration would be between the forest departments and local/urban governments to implement the National Forestry Policy 2025 in Bangladesh, which mentioned urban forestry and tree cover outside traditional forested areas (Government of Bangladesh 2025). This collaborative approach would broadly encourage the promotion of urban forestry in city corporations and municipalities, providing technical assistance and support for greening measures that specifically consider the requirements of urban ecosystems and the need for resilience to climate change. Future urban forestry programs could also involve women, youths, schools and non-governmental organisations in actively contributing to protecting urban green spaces and enhancing tree-growing efforts.

Accepted

4.3.4. Inclusive and equitable green space for diverse social groups

Equitable forms of urban green space would be those that included accessibility for diverse social groups and low-income neighbourhoods in terms of their health and adaptation to heat island conditions. Almost half of Bangladesh's urban people live in informal settlements across different cities, and they are already being exposed to the severity of the heat island effect, landslides and waterlogging (UN-Habitat 2013). Notably, green space locations, their quantity, quality, type and composition, and their governance would be required to be assessed around those neighbourhoods and rapidly growing heterogenous urban and peri-urban settings to enhancing their cooling effects and the people's psychological well-being (Chawla et al. 2025). In practical terms, to distribute the function of NbS equitably, the greening initiative would need to differ from the traditional focus on wealthy areas to meet the place-specific demands for mitigating the heat island effects in local communities, and for youths and diverse sociocultural and economic groups. Although green space equity as a research topic and policy agenda is relatively underrepresented in Bangladesh and other developing countries (Rigolon et al. 2024), future participatory processes should include diverse citizens in the co-designing, co-implementation, evaluation and co-translation of greening initiatives. Considering the diverse needs of different demographic groups would help create equal opportunity and accessible green areas, ultimately contributing to NbS.

4.3.5. Science-based approaches to decision-making

Although the utility of urban science is only slowly becoming understood in Bangladesh, the science-based information it can provide is required to inform the public about the value of green spaces, policy-making and increased public–private investment in NbS. The immediate need is to further map and analyse the spatial structures of different cities in order to identify

potential areas for green and blue space networks in addition to those that already exist, especially in areas with varying urban densities. Mainstreaming biodiversity in urban green space management would benefit from a spatial understanding of the green networks and the conservation of green corridors to promote habitat connectivity and protect vulnerable species. In this regard, remote sensing and geographic information system technologies would be very useful for tracking vegetation changes, monitoring land surface temperatures and providing information for policy decisions concerning measures for protecting green spaces and any other interconnected ecosystems, including wetlands (Giezen et al. 2018).

5. CONCLUSIONS

By analysing the state-of-the art in urban green space research, this study synthesises current knowledge on urban green space change and practices and discuss the potential for NbS. We identified a significant decline in green space driven by population growth, built infrastructure, and weak financial and regulatory frameworks, common across many low- and middle-income countries. Our review contributes to understanding the critical social-ecological impacts of green space changes, such as urban heat island effects, and highlights the importance of equitable access and protection of green spaces. Nevertheless, evidence of greening initiatives, including green roofs and urban agriculture, remains limited, and little is known about how these practices can be integrated into urban planning and policy to create inclusive green spaces (Sultana et al. 2024). Further studies on urban green space management in low- and middle-income countries can fill these knowledge gaps, leverage best practices, and strengthen urban planning and policy to realise future NbS.

Accepted

The main challenges of green space change in low- and middle-income countries remain associated with the increasing urban sprawl and ecological degradation driven by weak and narrow development policy and research support to urban planning and investments in green space and their services (Cilliers et al. 2018). Our study has implications for reintegrating green space knowledge and management in the rapidly developing and extremely climate vulnerable urbanised parts of the low- and middle- income countries. In light of the urban NbS, we proposed five interconnected strategic features, which require transdisciplinary research to ensure their effective implementation within urban planning, policy frameworks, and inclusive governance structures, ultimately supporting the realisation of urban NbS:

1) urban planning and regulatory enforcement for integrating green space early in the development process with urbanisation;
2) incentivising support to private landowners to introduce and maintain greening practices;
3) inclusion of marginalised communities in community based governance that ensures equitable and accessible green space;
4) cross-sectoral coordination between public and private sectors involved with urban development, green and blue space management for implementing short-term and long-term greening measures; and
5) science-based decision-making to support the robust strategies for the green space within the established and future urbanised areas, greening networks along with other inter-connected ecosystems, including blue space, that can incorporate biodiversity values.

REFERENCES

Abass, K., Appiah, D. O. & Afriyie, K. 2019. Does green space matter? Public knowledge and attitude towards urban greenery in Ghana. *Urban Forestry & Urban Greening,* 46.

Abdullah, S., Adnan, M. S. G., Barua, D., Murshed, M. M., Kabir, Z., Chowdhury, M. B. H., Hassan, Q. K. & Dewan, A. 2022. Urban green and blue space changes: A spatiotemporal evaluation of impacts on ecosystem service value in Bangladesh. *Ecological Informatics,* 70**,** 101730.

Acuto, M., Parnell, S. & Seto, K. C. 2018. Building a global urban science. Nature Sustainability*,* 1**,** 2-4.

Ahammad, R. 2011. Constraints of pro-poor climate change adaptation in Chittagong city. *Environment and urbanization,* 23**,** 503-515.

Ahmed, N., Lee, J., Liu, D., Kan, Z. & Wang, J. 2023. Identifying urban green space deserts by considering different walking distance thresholds for healthy and socially equitable city planning in the Global South. *Urban Forestry & Urban Greening,* 89**,** 128123.

Ahmed, S., Meenar, M. & Alam, A. 2019. Designing a Blue-Green Infrastructure (BGI) network: Toward water-sensitive urban growth planning in Dhaka, Bangladesh. *Land,* 8**,** 138.

Anguelovski, I., Connolly, J. J., Cole, H., Garcia-Lamarca, M., Triguero-Mas, M., Baró, F., Martin, N., Conesa, D., Shokry, G. & del Pulgar, C. P. 2022. Green gentrification in European and North American cities. *Nature communications,* 13**,** 3816.

Anjum, B., Sultana, R. & Saddaf, N. 2024. The effectiveness of nature-based solutions to address climate change in Dhaka, Bangladesh. *Social Sciences & Humanities Open,* 10**,** 100985.

Arku, G. & Marais, L. 2021. Global south urbanisms and urban sustainability—challenges and the way forward. Frontiers Media SA.

Bangladesh Bureau of Statistics. 2022. Preliminary Report on Population and Housing Census 2022. http://nsds.bbs.gov.bd/storage/files/1/Publications/BBS_Preliminary_Census_2022.pdf

Begum, M. S., Bala, S. K., Islam, A. S. & Roy, D. 2021. Environmental and social dynamics of urban rooftop agriculture (URTA) and their impacts on microclimate change. *Sustainability,* 13**,** 9053.

Birtchnell, T., Gill, N. & Sultana, R. 2019. Sleeper cells for urban green infrastructure: Harnessing latent competence in greening Dhaka's slums. *Urban Forestry & Urban Greening,* 40**,** 93-104.

Bren D'amour, C., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K.-H., Haberl, H., Creutzig, F. & Seto, K. C. 2017. Future urban land expansion and implications for global croplands. *Proceedings of the National Academy of Sciences,* 114**,** 8939-8944.

Byomkesh, T., Nakagoshi, N. & Dewan, A. M. 2012. Urbanization and green space dynamics in Greater Dhaka, Bangladesh. *Landscape and Ecological Engineering,* 8**,** 45-58.

Cilliers, S.S., Breed, C.A., Cilliers, E.J. & Lategan, L.G., 2021. Urban ecological planning and design in the Global South. In Urban ecology in the Global South (pp. 365-401). Cham: Springer International Publishing.

Chawla, S., Morrison, T. H., & Cumming, G. S., 2025. How spatial feedbacks between institutional and ecological patterns drive landscape dynamics in peri-urban commons. Ecology and Society, 30(4).

Chen, M., Chen, L., Cheng, J. & Yu, J. 2022. Identifying interlinkages between urbanization and Sustainable Development Goals. *Geography and Sustainability,* 3**,** 339-346.

Accepted

Chen, B., Wu, S., Song, Y., Webster, C., Xu, B. & Gong, P., 2022. Contrasting inequality in human exposure to greenspace between cities of Global North and Global South. Nature Communications, 13(1), p.4636.

Chollet, S., Brabant, C., Tessier, S. and Jung, V., 2018. From urban lawns to urban meadows: Reduction of mowing frequency increases plant taxonomic, functional and phylogenetic diversity. *Landscape and Urban Planning*, 180, pp.121-124.

Chowdhury, A. I., Uddin, M. J., Baul, T. K., Akhter, J., Nandi, R., Karmakar, S. & Nath, T. K. 2022. Quantifying the potential contribution of urban trees to particulate matters removal: A study in Chattogram city, Bangladesh. *Journal of Cleaner Production,* 380**,** 135015.

Chowdhury, S., Shahriar, S. A., Böhm, M., Jain, A., Aich, U., Zalucki, M. P., Hesselberg, T., Morelli, F., Benedetti, Y. & Persson, A. S. 2021. Urban green spaces in Dhaka, Bangladesh, harbour nearly half the country's butterfly diversity. *Journal of Urban Ecology,* 7**,** juab008.

Cinderby, S., Archer, D., Mehta, V. K., Neale, C., Opiyo, R., Pateman, R. M., Muhoza, C., Adelina, C. & Tukhanen, H. 2021. Assessing Inequalities in Wellbeing at a Neighbourhood Scale in Low-Middle-Income-Country Secondary Cities and Their Implications for Long-Term Livability. *Front Sociol,* 6**,** 729453.

Derdouri, A., Murayama, Y., Morimoto, T., Wang, R. and Aghasi, N.H.M., 2025. Urban green space in transition: A cross-continental perspective from eight Global North and South cities. *Landscape and Urban Planning*, 253, p.105220.

de Macedo, L. S. V., Picavet, M. E. B., de Oliveira, J. A. P. & Shih, W.-Y. 2021. Urban green and blue infrastructure: A critical analysis of research on developing countries. *Journal of Cleaner Production,* 313**,** 127898.

Derkzen, M. L., van Teeffelen, A. J., Nagendra, H. & Verburg, P. H. 2017. Shifting roles of urban green space in the context of urban development and global change. *Current Opinion in Environmental Sustainability,* 29**,** 32-39.

Dewan, A., Kiselev, G., Botje, D., Mahmud, G. I., Bhuian, M. H. & Hassan, Q. K. 2021. Surface urban heat island intensity in five major cities of Bangladesh: Patterns, drivers and trends. *Sustainable Cities and Society,* 71**,** 102926.

Dorst, H., van der Jagt, A., Raven, R. & Runhaar, H. 2019. Urban greening through nature-based solutions–Key characteristics of an emerging concept. *Sustainable Cities and Society,* 49**,** 101620.

Fischer, L.K., Neuenkamp, L., Lampinen, J., Tuomi, M., Alday, J.G., Bucharova, A., Cancellieri, L., Casado-Arzuaga, I., Čeplová, N., Cerveró, L. and Deák, B., 2020. Public attitudes toward biodiversity-friendly greenspace management in Europe. *Conservation Letters*, 13(4), p.e12718.

Frantzeskaki, N. 2019. Seven lessons for planning nature-based solutions in cities. *Environmental science & policy,* 93**,** 101-111.

Frantzeskaki, N., Vandergert, P., Connop, S., Schipper, K., Zwierzchowska, I., Collier, M. & Lodder, M. 2020. Examining the policy needs for implementing nature-based solutions in cities: Findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland). *Land Use Policy,* 96**,** 104688.

Fraser, A., Anjum, G., Bukachi, V., Eltinay, N. & Kraudie, A. 2020. Urbanisation and climate security: towards integrated approaches for cities. UK: Planetary Security Initiative Policy Brief, Clingendael Institute.

Geary, R. S., Wheeler, B., Lovell, R., Jepson, R., Hunter, R. & Rodgers, S. 2021. A call to action: Improving urban green spaces to reduce health inequalities exacerbated by COVID-19. *Preventive medicine,* 145**,** 106425.

Accepted

Giannico, V., Spano, G., Elia, M., d'este, M., Sanesi, G. & Lafortezza, R. 2021. Green spaces, quality of life, and citizen perception in European cities. *Environmental research,* 196**,** 110922.

Giezen, M., Balikci, S. and Arundel, R., 2018. Using remote sensing to analyse net land-use change from conflicting sustainability policies: the case of Amsterdam. ISPRS *International Journal of Geo-Information*, 7(9), p.381.

Government of Bangladesh 2025. National Forestry Policy, 2025. Bangladesh Forest Department. https://objectstorage.ap-dcc-gazipur-1.oraclecloud15.com/n/axvjbnqprylg/b/V2Ministry/o/office-bforest/2024/12/fc9fe5b2a7a14d3fb5129caecb0e44e2.pdf

Gunawardena, K.R., Wells, M.J. and Kershaw, T., 2017. Utilising green and bluespace to mitigate urban heat island intensity. *Science of the total environment*, *584*, pp.1040-1055.

Haque, M. N., Rahman, S., Saroar, M., Morshed, S. R. & Fattah, M. A. 2022. A geospatial approach for environmental risk susceptibility mapping of Khulna city in Bangladesh. *Physics and Chemistry of the Earth, Parts A/B/C,* 126**,** 103139.

Hasan, M., Hassan, L., AL, M. A., Abualreesh, M. H., Idris, M. H. & Kamal, A. H. M. 2022. Urban green space mediates spatiotemporal variation in land surface temperature: a case study of an urbanized city, Bangladesh. *Environmental Science and Pollution Research,* 29**,** 36376-36391.

Hassan, M.M. and Nazem, M.N.I., 2016. Examination of land use/land cover changes, urban growth dynamics, and environmental sustainability in Chittagong city, Bangladesh. *Environment, development and sustainability*, *18*(3), pp.697-716.

Hobbie, S. E., & Grimm, N. B. 2020. Nature-based approaches to managing climate change impacts in cities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 375(1794).

Hsu, A., Sheriff, G., Chakraborty, T. and Manya, D., 2021. Disproportionate exposure to urban heat island intensity across major US cities. *Nature communications*, *12*(1), p.2721.

Huang, K., Li, X., Liu, X. and Seto, K.C., 2019. Projecting global urban land expansion and heat island intensification through 2050. *Environmental Research Letters*, *14*(11), p.114037.

Hunter, R.F., Nieuwenhuijsen, M., Fabian, C., Murphy, N., O'Hara, K., Rappe, E., Sallis, J.F., Lambert, E.V., Duenas, O.L.S., Sugiyama, T. and Kahlmeier, S., 2023. Advancing urban green and blue space contributions to public health. *The lancet public health*, *8*(9), pp.e735-e742.

Islam, M., Sarker, D., Hasan, J. & Momtaz, Z. 2023. Public perceptions on urban open space and city livability in Barishal, Bangladesh. *Geology, Ecology, and Landscapes***,** 1-10.

Kabisch, N., Frantzeskaki, N. & Hansen, R. 2022. Principles for urban nature-based solutions. *Ambio,* 51**,** 1388-1401.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H. & Stadler, J. 2016. Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and society,* 21.

Kabisch, N. & Haase, D. 2013. Green spaces of European cities revisited for 1990–2006. *Landscape and urban planning,* 110**,** 113-122.

Kabisch, N., Qureshi, S. & Haase, D. 2015. Human–environment interactions in urban green spaces—A systematic review of contemporary issues and prospects for future research. *Environmental Impact assessment review,* 50**,** 25-34.

Accepted

Kafy, A.-A., AL Rakib, A., Akter, K. S., Rahaman, Z. A., Mallik, S., Nasher, N. R., Hossain, M. I. & Ali, M. Y. 2021. Monitoring the effects of vegetation cover losses on land surface temperature dynamics using geospatial approach in Rajshahi City, Bangladesh. *Environmental Challenges,* 4**,** 100187.

Khatri, A., Bustamante, D., Ruta, M., Garcia-Reyes, C., Thompson, F., Kohli, S., Pantelidou, H., Free, M., Magnani, G. & Schemel, S. 2022. BiodiverCities by 2030: Transforming Cities' Relationship with Nature. World Economic Forum. https://www3.weforum.org/docs/WEF_BiodiverCities_by_2030_2022.pdf

Koroso, N. H. & Zevenbergen, J. A. 2024. Urban land management under rapid urbanization: Exploring the link between urban land policies and urban land use efficiency in Ethiopia. *Cities,* 153**,** 105269.

Kotharkar, R., Ramesh, A. & BAGADE, A. 2018. Urban heat island studies in South Asia: A critical review. *Urban climate,* 24**,** 1011-1026.

Labib, S., Shuvo, F. K., Hem Browning, M. & Rigolon, A. 2020. Noncommunicable diseases, park prescriptions, and urban green space use patterns in a global south context: the case of Dhaka, Bangladesh. *International Journal of Environmental Research and Public Health,* 17**,** 3900.

Lafortezza, R., Chen, J., van den Bosch, C. K. & Randrup, T. B. 2018. Nature-based solutions for resilient landscapes and cities. *Environmental research,* 165**,** 431-441.

Lee, A. C. K., Jordan, H. C. & Horsley, J. 2015. Value of urban green spaces in promoting healthy living and wellbeing: prospects for planning. *Risk management and healthcare policy***,** 131-137.

Leya, R. S., Jodder, P. K., Rahaman, K. R., Chowdhury, M. A., Parida, D. & Islam, M. S. 2022. Spatial variations of urban heat island development in Khulna City, Bangladesh: implications for urban planning and development. *Earth Systems and Environment,* 6**,** 865-884.

Liberalesso, T., Silva, C.M. and Cruz, C.O., 2024. Combined strategies for green roof incentive policies in Lisbon: Evaluating the potentiality of concession grants and identifying priority intervention areas. Urban Forestry & Urban Greening, 99, p.128451.

Lindley, S., Pauleit, S., Yeshitela, K., Cilliers, S. & Shackleton, C. 2018. Rethinking urban green infrastructure and ecosystem services from the perspective of sub-Saharan African cities. *Landscape and Urban Planning,* 180**,** 328-338.

Mansur, A. V., Mcdonald, R. I., Güneralp, B., Kim, H., de Oliveira, J. A. P., Callaghan, C. T., Hamel, P., Kuiper, J. J., Wolff, M. & Liebelt, V. 2022. Nature futures for the urban century: Integrating multiple values into urban management. *Environmental Science & Policy,* 131**,** 46-56.

Marshall, J.D., 2007. Urban land area and population growth: A new scaling relationship for metropolitan expansion. *Urban Studies*, 44(10), pp.1889-1904.

McPhearson, T., Frantzeskaki, N., Ossola, A., Diep, L., Anderson, P.M., Blatch, T., Collier, M.J., Cook, E.M., Culwick Fatti, C., Grabowski, Z.J. and Grimm, N.B., 2025. Global synthesis and regional insights for mainstreaming urban nature-based solutions. *Proceedings of the National Academy of Sciences*, *122*(29), p.e2315910121.

Miah, M. D., Hasnat, G. T., Nath, B., Saeem, M. G. U. & Rahman, M. M. 2022. Spatial and temporal changes in the urban green spaces and land surface temperature in the Chittagong city corporation of Bangladesh between 2000 and 2020. *Forestist*.

Morakinyo, T.E., Lai, A., Lau, K.K.L. and NG, E., 2019. Thermal benefits of vertical greening in a high-density city: Case study of Hong Kong. *Urban Forestry & Urban Greening*, 37, pp.42-55.

Accepted

Nassary, E. K., Msomba, B. H., Masele, W. E., Ndaki, P. M. & Kahangwa, C. A. 2022. Exploring urban green packages as part of Nature-based Solutions for climate change adaptation measures in rapidly growing cities of the Global South. *Journal of Environmental Management,* 310**,** 114786.

Naumann, S., Cuevas, N. B., Davies, C., Bradley, S., Mahmoud, I. H. & Arlati, A. 2023. Harnessing the power of collaboration for nature-based solutions: New ideas and insights for local decision-makers. *Harnessing the power of collaboration for nature-based solutions.* European Commission.

Nawar, N., Sorker, R., Chowdhury, F. J. & Rahman, M. M. 2022. Present status and historical changes of urban green space in Dhaka city, Bangladesh: A remote sensing driven approach. *Environmental Challenges,* 6**,** 100425.

Parvin, G.A., Esraz-ul-Zannat, M., Ahsan, R., Islam, I. 2022. Disaster Risks and Resilience of Urban Bangladesh: Role of Blue-Green Infrastructure. In: Dhyani, S., Basu, M., Santhanam, H., Dasgupta, R. (eds) Blue-Green Infrastructure Across Asian Countries. Springer, Singapore. https://doi.org/10.1007/978-981-16-7128-9_19

Rahman, K. A. & Shorkar, M. A. N. 2021. Analyzing association between public green space and self-esteem linked to social acceptance for elderly population in Dhaka. *SAGE Open,* 11**,** 21582440211054473.

Rahman, K. A. & Zhang, D. 2018. Analyzing the level of accessibility of public urban green spaces to different socially vulnerable groups of people. *Sustainability,* 10**,** 3917.

Rahman, M. M., Avtar, R., Yunus, A. P., Dou, J., Misra, P., Takeuchi, W., Sahu, N., Kumar, P., Johnson, B. A. & Dasgupta, R. 2020. Monitoring effect of spatial growth on land surface temperature in Dhaka. *Remote Sensing,* 12**,** 1191.

Rahman, M. M. & Hasan, J. 2024. Evaluating the Impact of Green Spaces on Urban Heat Reduction in Rajshahi, Bangladesh Using the InVEST Model. *Land,* 13**,** 1284.

Rahman, M.N., Rony, M.R.H., Jannat, F.A., Chandra Pal, S., Islam, M.S., Alam, E. and Islam, A.R.M.T., 2022. Impact of urbanization on urban heat island intensity in major districts of Bangladesh using remote sensing and geo-spatial tools. *Climate*, 10(3).

Rall, L., Niemela, J., Pauleit, S., Pintar, M., Lafortezza, R., Santos, A. and Železnikar, Š. 2015. A typology of urban green spaces, eco-system services provisioning services and demands. Report D3, 1.

Richards, D. R. & Thompson, B. S. 2019. Urban ecosystems: A new frontier for payments for ecosystem services. *People and Nature,* 1**,** 249-261.

Rigolon, A., Browning, M. H., Lee, K. & Shin, S. 2018. Access to urban green space in cities of the Global South: A systematic literature review. *Urban Science,* 2**,** 67.

Rigolon, A., Owusu, R. O., Becerra, M., Cheng, Y. D., Christensen, J., Connolly, J. J., Corbin, C., Douglas, J. A., Fernandez, M. & Jennings, V. 2024. Advancing green space equity via policy change: A scoping review and research agenda. *Environmental Science & Policy,* 157**,** 103765.

Roy, S., Dutta, S. and Hoque, M.M., 2016. Urban forestry and urban greening for sustainable urban development-A case of Dhaka north city corporation area (Zone-1). Journal of the Bangladesh Agricultural University, 14(2), pp.167-176.

Roy, S., Sowgat, T., Islam, S.T. & Anjum, N., 2021. Sustainability challenges for sprawling Dhaka. Environment and Urbanization Asia, 12(1_suppl), pp.S59-S84.

Shahid, S., Wang, X.-J., Harun, S. B., Shamsudin, S. B., Ismail, T. & Minhans, A. 2016. Climate variability and changes in the major cities of Bangladesh: observations, possible impacts and adaptation. *Regional Environmental Change,* 16**,** 459-471.

Shammi, M., Reza, F., Sarker, A. C. & Sakib, A. A. 2023. Prospects and challenges of achieving sustainable urban green-spaces: A case study of urban greening in Dhaka

Accepted

North City Corporation (DNCC), Bangladesh. *PLOS Sustainability and Transformation,* 2**,** e0000061.
Siddique, S. & Uddin, M. M. 2022. Green space dynamics in response to rapid urbanization: Patterns, transformations and topographic influence in Chattogram city, Bangladesh. *Land Use Policy,* 114**,** 105974.
Sultana, N., Sharifi, A., Haque, M. N. & Aghaloo, K. 2024. Urban greening in Dhaka: Assessing rooftop agriculture suitability using GIS and MCDM techniques. *Journal of Environmental Management,* 368**,** 122146.
Sultana, R., Birtchnell, T. & Gill, N. 2022b. Grassroots innovation for urban greening within a governance vacuum by Slum Dwellers in Dhaka. *Sustainability,* 14**,** 11631.
Sultana, R. & Selim, S. A. 2021. Residents' perceptions of the role and management of green spaces to provide cultural ecosystem services in Dhaka, Bangladesh. *Ecology & Society,* 26.
Sultana, R., Selim, S. A. & Alam, M. S. 2022a. Diverse perceptions of supply and demand of cultural ecosystem services offered by urban green spaces in Dhaka, Bangladesh. *Journal of Urban Ecology,* 8**,** juac003.
Syed, M. H. & Haider, M. A. 2023. Green Infrastructure Development for a Sustainable Urban Environment in Chittagong city, Bangladesh. *Journal of Architectural/Planning Research and Studies (JARS),* 20**,** 1-24.
Tan, P. Y., Wang, J. & Sia, A. 2013. Perspectives on five decades of the urban greening of Singapore. *Cities,* 32**,** 24-32.
Tasnim, S., Mahbub, F., Biswas, G. & Haque, D. M. E. 2022. Spatial indices and SDG indicator-based urban environmental change detection of the major cities in Bangladesh. *Journal of Urban Management,* 11**,** 519-529.
Toor, G., Tater, N.G. and Chandra, T., 2024. Exploring recent trends in integrating urban planning and ecology. Environment, Development and Sustainability, 26(8), 19093-19111.
UN 2023. What is Goal 11- Sustainable Cities? https://www.un.org/sustainabledevelopment/wp-content/uploads/2023/09/Goal-11_Fast-Facts.pdf
UNEP 2021. Smart, Sustainable and Resilient cities: the Power of Nature-based Solutions. *UNEP: Nairobi, Kenya***,** 1-32.
UN-Habitat. 2013. State of the world's cities 2012/2013: Prosperity of cities. Routledge. https://unhabitat.org/sites/default/files/download-manager-files/State%20of%20the%20World%20Cities%2020122013.pdf
UN-Habitat. 2018. Developing Public Space and Land Values in Cities and Neighbourhoods. https://unhabitat.org/sites/default/files/download-manager-files/Discussion%20Paper%20-%20Developing%20Public%20Space%20and%20Land%20Values%20in%20Cities%20and%20Neighbourhoods.pdf
UN 2018. The World's Cities in 2018. United Nations Department of Economic and Social Affairs. https://doi.org/10.18356/c93f4dc6-en
UNEP 2023. State of Finance in Nature in Cities: Time to Assess. Paris, United Nations. https://wedocs.unep.org/rest/api/core/bitstreams/428ddf87-b07f-49f9-b757-474b31989023/content
Wolch, J.R., Byrne, J. & Newell, J.P., 2014. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and urban planning*, 125, pp.234-244.

Accepted

Wong, N. H., Tan, C. L., Kolokotsa, D. D. & Takebayashi, H. 2021. Greenery as a mitigation and adaptation strategy to urban heat. *Nature Reviews Earth & Environment,* 2**,** 166-181.

World Bank Group 2020. Demographic Trends and Urbanization. Washington, DC. https://documents1.worldbank.org/curated/en/260581617988607640/pdf/Demographic-Trends-and-Urbanization.pdf

World Bank Group 2024. Urban population – Bangladesh. https://data.worldbank.org/indicator/SP.URB.TOTL?end=2024&locations=BD&start=1990&view=chart

Wu, C., Li, J., Wang, C., Song, C., Haase, D., Breuste, J. & Finka, M. 2021. Estimating the cooling effect of pocket green space in high density urban areas in Shanghai, China. *Frontiers in Environmental Science,* 9**,** 657969.

Xie, L. & Bulkeley, H. 2020. Nature-based solutions for urban biodiversity governance. *Environmental Science & Policy,* 110**,** 77-87.

Zhou, K., Kong, F., Yin, H., Destouni, G., Meadows, M. E., Andersson, E., Chen, L., Chen, B., Li, Z. & Su, J. 2024. Urban flood risk management needs nature-based solutions: a coupled social-ecological system perspective. *npj Urban Sustainability,* 4**,** 25.

Accepted

Supplementary material: Literature review information about urban green space change, underlying drivers, social-ecological impacts and solutions/recommendations in Bangladesh.

Source	Green space	Drivers	Impacts	Solutions	Studied cities	Temporal coverage
Abdullah et al. (2022)	Declining green space	Population growth Urban sprawl Development of dense road networks	Loss of monetary value of ecosystem services		Dhaka, Chattogram, Khulna, Rajshahi and Sylhet	1991-2021
Kafy et al. (2021)	Declining/reduction in green cover		Increase in land surface temperature	Natural resource management	Rajshahi	1990-2020
Islam et al. (2023)			Lower quality of life		Barisal	2022
Chowdhury et al. (2021)			Decline of butterfly population	Green space management	Dhaka	2014-2016
Ahmed et al. (2023), Rahman and Zhang (2018)			Access to green space (socially vulnerable groups' demand for and access to urban green spaces)	Sustainable city development must focus on balancing the pressures of high population density with equitable access to urban green spaces.	Dhaka	2011, 2018
Miah et al. (2022)	Increasing green space		Increase in land surface temperature	Healthy, eco-friendly city planning	Chattogram	2000-2020
Sultana et al. (2024), Begum et al. (2021)				Rooftop agriculture suitability	Dhaka	2023-2024, 2018-2019
Hasan et al. (2022)	Declining green space and increase of built up		Increase in land surface temperature		Mymensingh	1988-2016
Leya et al. (2022)	Declining green space and increase of built up		Increased in land surface temperature		Khulna	2020
Anjum et al. (2024)				Rooftop agriculture and balcony gardens were considered the most helpful and feasible NbS approaches	Dhaka	2023
Parvin et al. (2022)	Declining green space			Balanced incorporation of blue-green infrastructure in urban planning	Khulna	2006-2016
Hasan and Haider (2023)	Declining green cover			Greenbelt and green wedges	Chattogram	1989-2011
Sultana et al. (2022a)	Satisfaction with green spaces (use and value)		Dissatisfaction with the quantity of green space		Dhaka	2018-2019
Sultana et al. (2022b)				Inclusive green space management	Dhaka	2016-2018
Byomkesh et al. (2012)	Declining green space	Population growth by rural-urban migration	Landscape fragmentation	Strategic green space planning	Dhaka	1975-2005
Rahman and Hasan (2024)				Role of green spaces in reducing urban heat, with every unit increase in Heat Mitigation Index leading to a 2.80°C decrease in air temperature, emphasizing the need to integrate green infrastructure into urban planning	Rajshahi	2023
Nawar et al. (2022)	Declining green space			Role in improving air quality, mitigating urban heat islands, and providing essential ecosystem services. To combat these challenges, experts emphasise the importance of creating more green spaces and adopting sustainable urban planning strategies	Dhaka	1989-2020
Labib et al. (2020)	Green space use intensity was more closely tied to personal attachment to the space, poor health (i.e., noncommunicable diseases), and the influence of health care professional's perceptions				Dhaka	2017
Ahmed et al. (2019)				Blue-Green Infrastructure network as a solution, integrating natural (blue and green) and man-made (grey) elements to form a multifunctional urban system	Dhaka	2016-2035
Rahman and Shorkar (2021)			Importance of urban green spaces in enhancing the mental and social health of the elderly population in a densely populated and rapidly urbanizing city	Inclusive, accessible, and socially supportive elderly-friendly green spaces	Dhaka	Not mentioned
Sultana and Selim (2021)	Cultural Ecosystem Services (CES) provided by urban green spaces			Rooftop gardens and green parks are considered the most valuable for delivering CES	Dhaka	2018-2019

Accepted

Source	Green space	Drivers	Impacts	Solutions	Studied cities	Temporal coverage
Rahman et al. (2020)				Vertical development is better than horizontal development for providing enough open spaces, green spaces, and preserving natural features, this study provides city planners with a better understating of sustainable urban planning and can promote the formulation of action plans for appropriate urban development policies	Dhaka	2013-2014
Siddique and Uddin (2022)	Declining green space and increase of built up		Built-up areas increased along all topographic gradients, increasing the risk of land degradation	Sustainable land management	Chattogram	1990-2020
Birtchnell et al. (2019)				Latent competence of slum dwellers in urban green infrastructure	Dhaka	2016-2018
Chowdhury et al. (2022)			Tree contribution to air particulate matter deposition on leaves		Chattogram	2020-2021
Shammi et al. (2023)	Declining green space	Institutional inefficiencies, lack of coordination, and weak governance			Dhaka	1992-2022
Dewan et al. (2021)				Continuous monitoring of urban heat islands impacts, develop data-driven policies and adaptation strategies	Dhaka	2000-2019
Hassan and Nazem (2016)	Encroachment and degradation of vegetated hills	Expansion of built-up areas and human activities			Chattogram	1977-2013

Accepted