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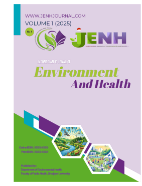

Research Paper

The Role of Green Open Space in Mitigating Climate Change Impacts in Developing Countries: A Narrative Review

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Abstract

Climate change, triggered by human activities such as fossil fuel combustion and deforestation, has become a global health emergency. Although the benefits of Green Open Space (GOS) are recognized, a comprehensive review summarizing its mitigation role across various developing countries remains limited. This study aims to synthesize the role of GOS in climate change mitigation strategies in developing countries. This study employed a narrative review method, conducting an independent literature search in April to June 2025 across three scientific databases: ScienceDirect, PubMed, and Google Scholar. Eleven scientific articles from countries including India, Ethiopia, Brazil, Sri Lanka, Indonesia, and Ghana were selected and analyzed. The findings consistently demonstrate that GOS plays a crucial role in climate mitigation, primarily by acting as a CO_2 absorber, reducing the effects of global warming, mitigating flood risks, and enhancing environmental quality. This study concludes that GOS is a vital nature-based solution for building climate resilience in developing countries. The primary implication is the need for collaboration among academics, policymakers, and the community to formulate data-driven strategies for the optimal development and utilization of GOS.

Keywords

climate change, developing countries, green open space, mitigation, nature-based solutions

1. INTRODUCTION

Climate change has now become a global health emergency, triggered by various human activities such as the burning of fossil fuels for energy and transportation and illegal deforestation, which eliminates the crucial function of forests as carbon dioxide absorbers (Nunes, 2023). The impacts of climate change are predicted to cause approximately 250,000 additional deaths per year between 2030 and 2050, with these deaths expected to result from factors like increased extreme temperatures or excessive heat stress (World Health Organization, 2023). In urban areas, the effects of climate change tend to worsen due to rapid population growth and the rate of urbanization (Li et al., 2022). Fast-paced urbanization drives an increase in energy consumption, particularly for transportation, industry, and household needs (Vo et al., 2024). This rise in energy consumption directly contributes to higher air pollution emissions, especially carbon dioxide (CO_2) gas. CO_2 is one of the primary greenhouse gases that plays a significant role in accelerating the rate of climate change, including in Indonesia. Under these conditions, the role of Green Open Space (GOS) becomes critically important as a nature-based solution to counteract the negative impacts of climate change (Batasuma et al., 2025).

Green Open Space (GOS) is defined as an area or corridor within an urban region dominated by vegetation, not covered by permanent buildings, and possessing various important functions, including ecological, social, aesthetic, and economic roles (Wakhidah et al., 2024). GOS plays a vital part in lowering atmospheric carbon dioxide (CO_2) levels, mitigating the urban heat island effect, reducing flood risk, and decreasing air pollution levels (Ferrini et al., 2020). The presence of GOS is an essential component in the effort to improve the overall quality of the urban environment. Several studies have specifically examined the role of GOS in mitigating the impacts of climate change. For example, research has demonstrated a significant mitigation role by showing GOS can reduce CO_2, heat effects, and air pollution, thereby enhancing environmental quality (Kabir et al., 2023). Furthermore, its importance in lowering urban air pollution levels, a key contributor to the acceleration of global climate change, has also been emphasized (Ofremu et al., 2024).

Based on the various causative factors of climate change previously described, this review becomes crucial to ascertain the extent of the role of Green Open Space (GOS) in climate change mitigation in developing countries. Although there is substantial evidence demonstrating the benefits of GOS, a comprehensive review that summarizes its mitigation role is still limited. This study presents a unique contribution compared to previous works, which have generally focused on only a single country.

Therefore, the objective of this study is to provide a comprehensive overview of the contribution of GOS as a strategy for mitigating the impacts of climate change in developing countries. Furthermore, this review also discusses the various responses undertaken by these nations to address and reduce the climate change impacts they face.

2. METHOD

2.1 Study Design

This study was conducted as a narrative review. This design was chosen for its flexibility in synthesizing findings from various study types (e.g., observational, qualitative, and case studies), which is ideal for exploring a broad and complex topic such as the role of Green Open Space (GOS) in climate change mitigation. The approach allows for a thematic and reflective analysis of the existing literature, considering diverse geographical and policy contexts.

2.2 Search Strategy and Information Sources

A systematic literature search was conducted in April to June 2025 across three major scientific databases: ScienceDirect, PubMed, and Google Scholar. To ensure a comprehensive search, keywords were combined using Boolean operators. The search strings included variations of terms such as: ("Green Open Space" OR "Urban Green Infrastructure") AND ("Climate Change Mitigation") AND ("Developing Countries"). The search was limited to publications from the last decade.

2.3 Eligibility Criteria and Study Selection

Studies were selected based on a predefined set of inclusion and exclusion criteria to ensure relevance and quality. Inclusion Criteria: • The study was an original research article. • The publication date was between January 2015 and April 2025. • The study specifically discussed the role of GOS in mitigating climate change impacts. • The study was conducted in a country classified as a low-income, lower-middle-income, or upper-middle-income economy by the World Bank (World Bank, 2025). • The article was published in a peer-reviewed international journal. Exclusion Criteria: • The article was a systematic review, meta-analysis, commentary, or editorial. • The study was not available in full-text format. • The study was not published in English.

2.4 Data Selection and Synthesis

The study selection process followed a structured screening procedure, as illustrated in the flowchart in Figure 1. The initial database search yielded 300 articles. After removing 50 duplicates, a total of 250 articles were screened based on their titles and abstracts. This initial screening, conducted independently by two authors to minimize bias, resulted in the exclusion of 220 articles that were clearly not relevant to the research topic. The full texts of the remaining 30 articles were then thoroughly assessed for eligibility against the inclusion criteria. Following this detailed review, 19 full-text articles were excluded for reasons such as having an inappropriate study design or not focusing specifically on climate change mitigation. Ultimately, a final selection of 11 articles that met all criteria was included in this narrative review. A thematic synthesis was then conducted to analyze the findings.

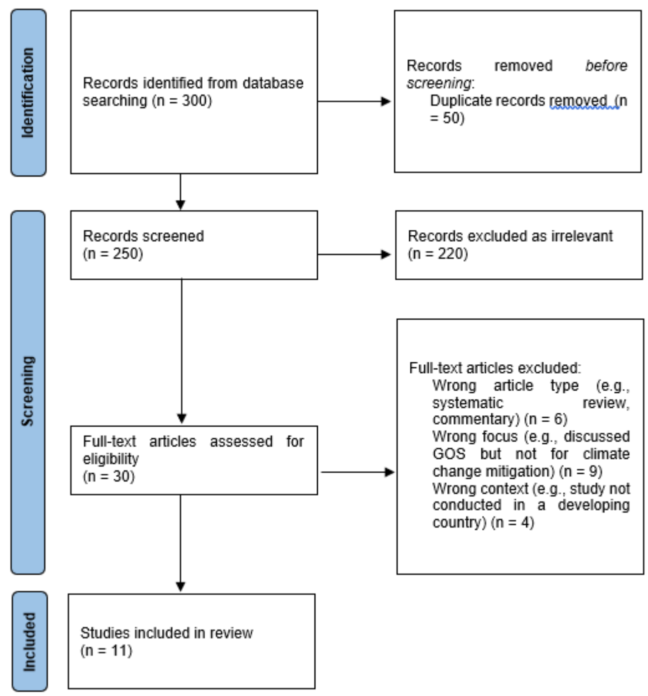

Figure 1. Study Selection Flowchart

2.5 Ethical Considerations

Ethical approval was not required for this study, as it was based exclusively on the analysis of previously published and publicly available literature, with no involvement of human or animal subjects.

3. RESULTS

A total of 11 studies that met the inclusion criteria were included in this narrative review. The included studies utilized a range of original research designs, including observational methods, in-depth analyses, field studies, and qualitative case studies. The studies originated from a diverse range of developing countries, including Argentina, Bangladesh, Brazil, Ethiopia, Ghana, India, Indonesia, Kenya, Sri Lanka, and Thailand. The thematic synthesis of the selected articles revealed four primary themes concerning the role of Green Open Space (GOS) in climate change mitigation: (1) CO_2 absorption and air pollutant removal, (2) urban heat reduction, (3) flood risk mitigation, and (4) enhancement of environmental quality and biodiversity. A comprehensive summary of the key findings from each included study, categorized by these themes, is presented in Table 1.

In general, the reviewed studies consistently underscore the effectiveness of GOS as a multi-functional strategy to mitigate the impacts of climate change, including the absorption of carbon dioxide (CO_2), the reduction of air temperatures, the mitigation of flood risks and the improvement of environmental quality. The role of GOS as a carbon sink is critical at a continental scale, where deforestation across Africa was found to have a strong negative correlation (-0.99) with CO_2 emissions, resulting in 15.73 Pg C of emissions from forest loss over two decades (Nzabarinda et al., 2025). At the city level, the direct impact on air quality is quantifiable; for instance, Green Infrastructure in Hawassa, Ethiopia, removes 274.2 tons of pollutants annually, providing an economic value of $1.79 million (Gebreyesus et al., 2024). In combating the urban heat island effect, GOS demonstrates significant potential. In Jakarta, Indonesia, a 5.1% loss in tree cover was directly linked to a 2-3°C rise in air temperature (Ramdhoni et al., 2016). Conversely, proactive GOS implementation shows powerful cooling effects; a study in Thailand found that extensive green roofs can lower surface temperatures by up to 12°C and reduce heat transfer by 84% (Kachenchart and Panprayun, 2024). This cooling function is a key reason for proposing GOS strategies in other climate-vulnerable urban areas, such as the coastal districts of Brazil (Rodrigues et al., 2023). For hydro-meteorological hazards, GOS serves as a vital natural defense. In Sri Lanka, modeling showed that riparian forest restoration could reduce downstream flood inundation by 7% (Jayapadma et al., 2024). This aligns with traditional ecological knowledge from Bangladesh, where mangrove forests and triple-tier planting systems provide effective protection against cyclones and tidal surges (Rahman and Rahman, 2015). The primary challenge, as highlighted in a study from Ghana, lies in effectively integrating these nature-based solutions into urban spatial planning and policy (Asare et al., 2023). Finally, GOS significantly enhances overall environmental quality and community well-being, particularly in vulnerable contexts. In the informal urban settlements of Kenya and Argentina, Nature-Based Solutions were shown to improve biodiversity and resident wellbeing (Kibii et al., 2025). Similarly, in Dhaka, Bangladesh, residents perceive small-scale GOS like rooftop and balcony gardens as highly effective for providing cooling and improving their immediate environment (Anjum et al., 2024).

4. DISCUSSION

This narrative review synthesizes evidence from 11 studies across Africa, Asia, and South America, collectively affirming that Green Open Space (GOS) is a crucial multifunctional instrument for climate change mitigation in developing countries. These findings interpret the role of GOS beyond its aesthetic value, demonstrating its capacity to provide measurable ecosystem services. However, this analysis also uncovers a paradox: although the potential of GOS is scientifically proven, its on-the-ground implementation is often fragmented and fails to be integrated into urban planning frameworks, leaving its multifunctional capacity underutilized.

4.1 The Role of GOS in CO_2 Absorption and Air Pollutant Removal

The role of GOS as an air quality regulator manifests at various scales. At the macro scale, a very strong negative correlation (-0.99) between the loss of forest cover and an increase in CO_2 emissions, with deforestation being responsible for 15.73 Pg C of CO_2 emissions (Nzabarinda et al., 2025). This finding supports data from other study, which consistently identifies deforestation in tropical countries as a primary driver of greenhouse gas emissions (Pearson et al., 2017). Descending to the urban micro-scale, the city's green infrastructure is capable of removing 274.2 tons of air pollutants (primarily SO_2) annually, an ecosystem service with an economic value of up to $1.79 million (Gebreyesus et al., 2024). The biological mechanism underlying this finding is the absorption of gaseous pollutants through leaf stomata and the deposition of particulate matter (PM) on vegetation surfaces (Ha et al., 2021). This finding is consistent with other research, which also used the i-Tree model in Chinese cities and found similar effectiveness (Zhao et al., 2023). However, they also highlighted that GOS effectiveness can be drastically reduced in areas with very high PM concentrations, as it can clog leaf stomata. An important complexity revealed is the emission of Biogenic Volatile Organic Compounds (BVOCs) by some tree species like Eucalyptus, which can potentially form secondary pollutants such as ozone amidst high temperatures and NOx pollution (Gebreyesus et al., 2024). This underscores that GOS planning is not just about quantity, but also about the proper selection of species.

4.2 The Role of GOS in Mitigating the Urban Heat Island Effect

In mitigating the urban heat island effect, the reviewed studies provide strong evidence of a cause-and-effect relationship between the loss of GOS and rising temperatures. A study clearly illustrate this problem in Jakarta, where a 5.1% loss of tree cover directly correlated with a 2–3°C increase in air temperature (Ramdhoni et al., 2016). Conversely, proactive GOS interventions, even at the building scale, show remarkable results. An experimental study in

Table 1. Summary of included studies and key findings

Author(s) and Year	Country/Region	Key Findings
Theme 1: CO Absorption and Air		
Turaga et al. (2019)	India	Urban Green Spaces (UGS) in India's urban planning are primarily seen for recreation, often overlooking their multifunctional role in mitigating climate impacts like reducing pollution and the urban heat island effect.
Gebreyesus et al. (2024)	Hawassa, Ethiopia	Green Infrastructure (GI) removes 274.2 tons of pollutants (primarily SO_2) annually, valued at $1.79 million. However, improper species selection (e.g., *Eucalyptus*) can lead to high emissions of Biogenic Volatile Organic Compounds (BVOCs).
Nzabarinda et al. (2025)	Africa	Significant deforestation across Africa directly correlates with carbon emissions (-0.99 correlation). A net loss of 32,000 kha (32 million ha) of forest over two decades resulted in 15.73 Pg C of CO_2 emissions.
Theme 2: Urban Heat Reduction		
Ramdhoni et al. (2016)	Jakarta, Indonesia	In Jakarta, the loss of 5.1% of tree cover (2001–2014) was directly linked to a 2–3°C increase in air temperature. Developing urban forests is a key strategy to mitigate the urban heat island effect.
Rodrigues et al. (2023)	Fortaleza, Brazil	Proposes specific Green Infrastructure (GI) solutions, such as multiple-use roads and rain gardens, to mitigate climate change effects like high temperatures and extreme rainfall in a socially vulnerable coastal district.
Kachenchart and Panprayun (2024)	Thailand	Extensive green roofs in a tropical climate can lower surface temperatures by up to 12°C, reduce heat transfer by 84%, and mitigate up to 28.46 $kgCO_2$ eq/m^2/year, showing high potential for energy conservation.
Theme 3: Flood Risk Mitigation		
Rahman and Rahman (2015)	Bangladesh	Traditional, nature-based defense mechanisms, such as mangrove forests and a triple-tier planting system, are effective in reducing climate-related risks like cyclones and tidal surges by breaking wind speed and preventing erosion.
Asare et al. (2023)	Accra, Ghana	Identifies key strategies and barriers for integrating Nature-Based Solutions (NBS) into urban spatial planning and flood management policies, based on the perspectives of flood management experts.
Jayapadma et al. (2024)	Sri Lanka	Riparian forest restoration, a form of GOS, is a quantifiable flood mitigation strategy that can reduce downstream flood inundation areas by up to 7%.
Theme 4: Enhancement of Environmental Quality and Biodiversity		
Anjum et al. (2024)	Bangladesh	Urban residents perceive Nature-Based Solutions (NBS) like rooftop agriculture and balcony gardens as effective for providing cooling effects and improving air quality, highlighting the role of small-scale GOS in enhancing urban resilience.
Kibii et al. (2025)	Kibera, Kenya and Villa 20, Argentina	In urban informal settlements, Nature-Based Solutions (NBS) improve air quality, reduce surface runoff and heat, and enhance biodiversity, thereby increasing community well-being and resilience to climate impacts.

Thailand found that green roofs can lower surface temperatures by up to 12°C and reduce heat transfer into buildings by 84% (Kachenchart and Panprayun, 2024). The primary mechanisms behind this phenomenon are the shading effect and cooling through evapotranspiration (Zhang and Brookhouse).

Globally, a meta-analysis found that urban parks can, on average, cool their surrounding areas by about 1°C (Bowler et al., 2010), which positions the findings regarding green roofs (12°C) as a very intensive and effective microclimatic intervention (Kachenchart and Panprayun, 2024). The effectiveness of GOS as a cooling agent is widely recognized, prompting proposals for its application in vulnerable areas in Brazil (Rodrigues et al., 2023), and its acknowledgment as a primary mitigation strategy for cities in China (Yu and Piao, 2025).

4.3 The Role of GOS in Reducing Flood Risk

For hydrometeorological risks, this review highlights how modern science can validate traditional ecological wisdom. A study in Sri Lanka, using advanced hydrological modeling, provides quantitative evidence that riparian forest restoration can reduce downstream flood inundation by up to 7% (Jayapadma et al., 2024). This figure offers scientific justification for traditional practices in Bangladesh (Rahman and Rahman, 2015), where mangrove forests and a "triple-tier" planting system have long served as natural defense barriers against storms and tidal surges. The mechanisms at play are that GOS slows down surface runoff, increases water infiltration into the soil, and acts as a physical barrier (Liu and Zhang, 2025). However, this technical and traditional potential is often hampered by implementation challenges. As revealed by a study in Ghana (Asare et al., 2023), the main obstacle is integrating these nature-based solutions into existing urban spatial policies. This governance issue is a recurring theme in development literature. Previous research highlight that the implementation gap in cities of the Global South is not due to a lack of technical solutions, but rather to institutional fragmentation and a lack of political will (Kuller et al., 2022).

4.4 The Role of GOS in Enhancing Environmental Quality and Well-being

The benefits of GOS extend beyond physical mitigation to include the enhancement of environmental quality and social well-being, especially in the most vulnerable contexts. Research in the informal settlements of Kenya and Argentina shows that Nature-Based Solutions (NBS) not only reduce surface runoff and heat effects but also increase biodiversity and resident well-being (Kibii et al., 2025). This indicates that the benefits of GOS are inclusive. This perspective is supported by findings in Dhaka (Anjum et al., 2024), where city dwellers perceive small-scale GOS like rooftop and balcony gardens as highly effective for providing cooling and comfort. Nevertheless, it is important to consider the social implications of greening projects. A growing body of external literature on green gentrification shows that improving environmental amenities through GOS can unintentionally raise property values. For example, in South Jakarta, Indonesia, documented how a linear park project also led to the displacement of low-income residents (Ramadhan and Saputra, 2025). This serves as a caution that GOS projects must be planned with a social justice lens.

4.5 Interpretation of Key Findings

This review establishes Green Open Space (GOS) as a demonstrable and effective instrument for addressing the urgent impacts of climate change in the urban centers of developing nations. The findings confirm that the efficacy of GOS is evident across a spectrum of scales, from the continental to the local city environment. At the macro level, for instance, a research established a quantitative link between forest loss in Africa and a subsequent rise in CO_2 emissions (Nzabarinda et al., 2025). Meanwhile, at the micro-scale, GOS provides a direct means of intervention against environmental degradation. For example, in Ethiopia quantified the annual removal of hundreds of tons of air pollutants by GOS (Gebreyesus et al., 2024), while in Thailand experimentally verified that specific technologies like green roofs can substantially decrease surface temperatures (Kachenchart and Panprayun, 2024). Consequently, these findings carry substantial weight for the fields of urban planning and public health. They indicate that GOS should be considered a foundational investment in urban resilience rather than a mere environmental amenity. This perspective is reinforced by observed trends, such as the correlation quantified between diminished tree cover and the intensified urban heat island effect in Jakarta, which illustrates how unregulated urban growth amplifies climate vulnerabilities (Ramdhoni et al., 2016).

4.6 Comparison with Previous Studies

The quantitative results on air pollutant removal in Hawassa (274.2 tons/year) (Gebreyesus et al., 2024) and the cooling effect of green roofs in Thailand (up to 12°C reduction) (Kachenchart and Panprayun, 2024) align with numerous studies globally that document these benefits. Research in Tabriz, Iran (Parsa et al., 2019), estimated that urban green spaces remove 238 tons of pollutants annually, while in Barcelona, Spain (Anguelovski et al., 2018), the figure reached over 300 tons per year. These studies confirm that the capacity of GOS to act as a natural air filter is a consistent and significant ecosystem service across diverse urban settings.

Similarly, the cooling effect of the green roof in Thailand reinforces a large body of global evidence. A comprehensive meta-analysis, which reviewed numerous studies, found that urban parks on average cool their surroundings by approximately 1°C compared to non-green areas (Bowler et al., 2010). This places the specific finding on green roofs (up to 12°C reduction) at the higher end of effectiveness, highlighting how targeted GOS technologies can provide intensive microclimate regulation. However, this review provides crucial context for developing countries, where rapid urbanization and resource constraints pose unique challenges.

A key contribution is the juxtaposition of modern scientific validation with traditional ecological knowledge. For instance, the hydrological modeling in Sri Lanka (Jayapadma et al., 2024), which quantified that riparian forest restoration can reduce flood inundation by 7% , scientifically validates the principles behind traditional defense mechanisms in Bangladesh (Rahman and Rahman, 2015), where mangrove forests have protected coastal areas for centuries. This alignment suggests that effective, nature-based solutions are often rooted in long-standing local practices that are now being proven by modern science (Cohen-Shacham et al., 2019).

Furthermore, this review highlights a critical discrepancy often seen in developing countries: the gap between policy and practice. While the benefits of GOS are well-documented, studies from Ghana and India (Asare et al., 2023) (Turaga et al., 2020) reveal that the primary obstacles are often related to governance, lack of policy integration, and a failure to conceptualize GOS as multi-functional infrastructure rather than just recreational space. This contrasts with some developed country contexts where Green Infrastructure is more formally integrated into statutory spatial planning (Mell and Clement, 2020). This cooling function is recognized as a primary mitigation strategy in major Asian developing countries like China and India, as well as in proposals for climate-vulnerable urban areas like the coastal districts of Brazil.

4.7 Limitations and Cautions

It is important to acknowledge several limitations inherent in this study's design. First, the methodology employed is a narrative review, which, unlike a systematic review, does not follow a strictly replicable protocol for literature selection. Consequently, the collection of articles may not be fully comprehensive and could be influenced by a degree of author subjectivity. Second, the generalizability of the findings is constrained. Although the review encompasses a wide geographical scope, the specific results from a single urban area, such as the heat island effect in Jakarta, cannot be universally applied to all cities in the developing world due to the vast differences in local climatic, social, and political conditions. Finally, the review is based exclusively on published literature, which introduces the risk of publication bias. This phenomenon occurs because studies with statistically significant or positive findings are often more likely to be published than those reporting null or negative outcomes, potentially skewing the overall body of available evidence.

4.8 Recommendations for Future Research

Further studies could conduct quantitative measurements to assess the direct respiratory health impacts of GOS. For instance, research could explore the relationship between the quality and quantity of GOS in a region and a corresponding decrease in the incidence of air pollution-related illnesses, such as Acute Respiratory Infections (ARI). This type of research would provide direct evidence of the respiratory health benefits of GOS for urban residents. Additionally, research from an environmental health perspective is needed to investigate the design of GOS for disease vector control. While GOS is proven to reduce flood risk, studies should focus on ensuring that designs like rain gardens or retention ponds do not inadvertently create stagnant water that becomes a breeding ground for the Aedes aegypti mosquito, which is critical for preventing vector-borne diseases like Dengue Fever. Finally, subsequent research could focus on the optimal selection of local plant species for air quality. Referencing the finding that some plants can emit compounds that may form secondary pollutants, studies could identify local flora with the highest pollutant absorption capacity (such as for PM_{2*5} and SO_2) but with low emissions of Biogenic Volatile Organic Compounds (BVOCs). The results would provide a practical guide for municipal governments.

5. CONCLUSION

This narrative review was conducted to synthesize evidence from 11 studies across Africa, Asia, and South America on the role of Green Open Space (GOS) in mitigating climate change impacts in developing countries. The findings confirm that GOS serves four primary and quantifiable functions: (1) carbon sequestration and air pollutant removal, thereby improving air quality; (2) significant reduction of the urban heat island effect through cooling and shading; (3) mitigation of hydrometeorological risks such as flooding and storm surges; and (4) enhancement of environmental quality, biodiversity, and community well-being. The evidence, drawn from diverse methodologies including quantitative modeling, experimental studies, and policy analysis, is unequivocal: GOS is a critical, multi-functional instrument for building climate resilience.

The central conclusion of this review, however, is the significant disconnect between the proven potential of GOS and its current implementation in the urban planning frameworks of many developing nations. The studies reveal that GOS is often treated as a passive, aesthetic amenity rather than as a core component of critical urban infrastructure. This perspective leads to fragmented planning and a failure to leverage the full, synergistic benefits that a well-integrated GOS network can provide.

Therefore, a paradigm shift is required. Policymakers and urban planners must move towards a holistic view that integrates GOS into all facets of urban development.

While this review is limited by its narrative approach and the heterogeneity of its sources, its primary contribution is the comprehensive case it builds for this shift. Ultimately, maximizing the climate mitigation potential of GOS in the developing world will depend on collaborative efforts between researchers, governments, and communities to create data-driven, context-specific, and socially equitable greening strategies that are fundamental to sustainable urban futures.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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