

Green corridors as climate-resilient infrastructure in smart cities: a systematic review using PRISMA guidelines

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Abstract

Urbanization has accelerated climate change-related risks in cities, such as urban heat islands, flooding, loss of biodiversity, and loss of ecosystem services. Green corridors have been identified as effective multifunctional approaches for improving the sustainability of cities in addressing climate change resilience in smart cities. This study aims to systematically review the empirical evidence of the effectiveness of green corridors using the PRISMA approach, focusing on studies published in the Smart Cities and Regional Development Journal (SCRD) and other peer-reviewed journals from 2005 to 2025. After a rigorous selection process, 35 studies were included for this review. The results showed that green corridors have been effective in reducing temperatures in cities by 1 to 4 degrees Celsius, improving stormwater management, enhancing ecological connectivity, and improving air quality. The effectiveness of green corridors depends on spatial connectivity, width, vegetation density, and alignment of corridors with natural environmental conditions. SCR D studies have also demonstrated the potential of green corridors in addressing climate change resilience through the application of smart technologies, though this is still in its infancy.

Keywords: Nature-Based Solutions, Ecological Connectivity, Urban Heat Island Mitigation, Stormwater Management and Green Infrastructure.

1. Introduction

The rate of urbanization has increased the pressure on the environment in cities across the world. Modern urban environments are now being defined by high levels of built density, impermeable surfaces, fragmented nature, and high energy use patterns [1]. These factors are responsible for the urban heat island effect, hydrological instability, and the degradation of ecosystem services. However, in reaction to these factors, researchers and urban planners have increasingly turned their attention away from traditional “grey” infrastructure and toward multifunctional green infrastructure systems that have the ability to improve climate resilience while facilitating sustainable urban development [2, 3].

Recent contributions to the Smart Cities and Regional Development journal also serve to reinforce the notion of the ongoing shift in urban planning paradigms. Contributions from Harizaj & Ndreu (2022), for example, consistently highlight the need to leverage nature-based solutions, optimize compact urban form, and develop green-blue infrastructure networks to reduce urban heat stress and improve ecological connectivity in rapidly urbanizing cities. Furthermore, the empirical evidence also serves to reinforce the need for effective spatial planning, governance, and smart technologies to improve urban adaptive capacity. Thus, it can be seen that the recent evidence serves to reinforce the notion that green corridors and green infrastructure are not just environmentally focused, but also

represent integral components of urban resilience and smart cities, aligned with broader sustainable regional development principles [4, 5].

1.1. Urbanization and climate risk

Today, more than half of the world's population lives in urban areas, and the trend is expected to continue, especially in areas that are developing at a fast pace. Land use change and the conversion of vegetated surfaces into concrete and asphalt have increased and continue to affect surface energy balances [6]. As shown in the study by Bowler et al. (2010), urban green spaces can effectively lower the ambient air temperature compared to urban areas. In their systematic review, they found that urban green spaces and tree cover can lower temperatures by 1-2°C, with more pronounced effects during extreme heat events. These results are very important in the current situation where extreme heat events are becoming more frequent and severe due to climate change [7, 8].

Hydrological risks are also exacerbated by the expansion of urban areas. Impermeable surfaces increase runoff, overwhelm drainage infrastructure, and increase flood risk. The failure of conventional engineered drainage infrastructure has led to research into ecosystem-based adaptation approaches. In this regard, green infrastructure, especially linear and connected vegetation systems, has been identified as a viable approach to manage runoff, increase infiltration, and re-establish natural hydrological processes [9, 10].

1.2. Conceptual foundations of green infrastructure

The idea of green infrastructure was a pioneering effort of Benedict and McMahon (2006), who described green infrastructure as a “connected system of natural areas and open spaces that preserve ecosystem values and functions while providing human benefits.” The approach of the two authors stresses the importance of connectivity, multifunctionality, and strategic spatial planning principles that form the basis of modern green corridor design [11].

Based on the approaches, Hansen and Pauleit (2014), developed a conceptualization of green infrastructure as a multifunctional planning tool that combines ecological, social, and economic goals. The authors believed that a network of green areas can provide a variety of ecosystem services at the same time, such as temperature regulation, stormwater management, biodiversity conservation, and recreation. This is what differentiates green corridors from isolated green areas [12, 13].

1.3. Green corridors and climate adaptation

Green corridors, which are linear vegetated strips that connect parks, riverbanks, forests, and open spaces in urban areas, are essential elements of urban ecological networks. The function of green corridors in climate adaptation has been investigated in various empirical researches [14]. Gill et al. (2007) showed that the augmentation of green areas in urban regions can be an effective measure in decreasing surface temperatures and lessening the intensity of UHI. They employed climate change scenarios and found that greening could counteract the projected rise in temperature due to climate change [15, 16].

Further discussing the role of climate mitigation, Demuzere et al. (2014) compiled evidence on the effectiveness of green infrastructure for climate adaptation and mitigation. The results show that green corridors can decrease peak runoff volume, enhance evapotranspiration, and improve urban microclimate. The results also show that the effectiveness of green infrastructure is dependent on the spatial structure of vegetation [17, 18, 19].

Similarly, Norton et al. (2015), added the significance of urban morphology and vegetation pattern in creating thermal comfort. They suggested that corridors facilitating airflow and shade could be more effective in cooling than disintegrated green patches. The combination of tree-lined streets and riparian zones in dense urban morphology was identified as very effective [20].

1.4. Nature-based solutions and urban resilience

The general concept of nature-based solutions green corridors is one of the significant contexts of the global sustainability debates. According to Kabisch et al. (2017), nature-based solutions can reduce the risks of climate change and improve biodiversity and social cohesion. The paper emphasizes co-benefits, such as improved mental health, carbon sequestration, and habitat restoration. Green corridors are a good example of NbS because they combine ecological connectivity and climate change adaptation strategies [21].

The theory of urban resilience further supports the need for the integration of green infrastructure. urban resilience can be defined as the ability of urban systems to ensure or quickly recover desired functions in the face of disturbances. In this context, green corridors play a role in improving adaptive capacity by regulating microclimates, protecting against floods, and promoting ecosystem stability [22]. Some studies found out that cities need to move towards transformative approaches that incorporate ecological infrastructure into mainstream planning. Green corridors can be seen as a real-world application of sustainability transitions that go beyond aesthetic greening to climate-responsive design [23].

1.5. Smart cities and technological integration

The emergence of smart city paradigms brings digital technology to improve the efficiency of green infrastructure. Smart cities use sensors, GIS technology, and data analysis to track environmental factors in real-time. The integration of IoT monitoring systems in green infrastructure helps to track temperature differences, soil moisture, air quality, and biodiversity. The integration of technology helps to improve adaptive management and evidence-based decision-making [24, 25]. The synergy of green infrastructure and smart technology is consistent with principles of multifunctional planning, as outlined by Hansen and Pauleit (2014). Digital monitoring can optimize corridor design, irrigation efficiency, and ecosystem health. In regions that are climate change vulnerable, data-informed management can provide a substantial improvement in the response to extreme weather events [9].

1.6. Ecological connectivity and biodiversity

In addition to climate regulation, green corridors also improve fragmented habitats and facilitate the movement of species. Connectivity helps to overcome ecological isolation, which is essential for genetic exchange and ecosystem stability. Biodiversity improvement increases resilience by promoting ecosystem functions. Green corridors that connect urban parks to peri-urban forests provide a continuous habitat that protects against environmental shock. Hydrological corridors along rivers and wetlands are also important for flood protection while improving aquatic biodiversity. Riparian vegetation reduces runoff speed and increases water quality by facilitating filtration mechanisms [18, 21, 23].

2. Rationale

Despite the existence of empirical evidence that supports the positive effects of green corridors on the climate, the variability of methodological approaches and indicators of measurement makes it difficult to compare. Inconsistencies in temperature measurement techniques were pointed out by Bowler et al. (2010), while uncertainties in modeling were emphasized by Gill et al. (2007). In addition, most studies concentrated on isolated green spaces rather than green corridor systems [8, 15].

However, recent studies are increasingly advocating for interdisciplinary approaches that bring together ecology, urban planning, climate studies, and innovation. The nexus between smart city technology and green corridor design has remained unexplored, especially in developing nations where urbanization is rapidly advancing alongside climate change.

2.1. Objectives

- To systematically evaluate empirical evidence on the effectiveness of urban green corridors as climate-resilient infrastructure in smart cities.
- To analyze the influence of spatial configuration, ecological connectivity, and multifunctionality on the climate adaptation performance of green corridors.
- To assess the extent of integration between green corridor systems and smart city technologies for adaptive climate governance.

3. Methodologies

In this study, the PRISMA framework is used to systematically assess the function of green corridors as climate-resilient infrastructure in smart cities. The approach ensures transparency, reproducibility, and a comprehensive synthesis of existing empirical evidence.

3.1. Research design and data sources and search strategy

A systematic literature review method was used to search, filter, and integrate peer-reviewed research articles on green corridors, urban climate resilience, and smart city infrastructure. The literature review was conducted on empirical and applied research studies published between 2005 and 2025 to reflect recent advancements in climate-resilient urban planning.

Electronic databases including Scopus, Web of Science, ScienceDirect, and Google Scholar were searched using Boolean combinations of keywords such as: “green corridors,” “urban green infrastructure,” “climate resilience,” “urban heat island mitigation,” “flood management,” “biodiversity corridors,” and “smart cities.” Search strings were refined iteratively to ensure comprehensive retrieval of relevant studies. Reference lists of selected articles were also screened to identify additional publications.

3.2. Inclusion and exclusion criteria

3.2.1. Studies were included if they:

- focused on urban green corridors or linear green infrastructure;
- provided quantitative or qualitative evidence of climate resilience outcomes (e.g., temperature reduction, flood mitigation, air quality improvement, biodiversity enhancement)
- were conducted in smart or rapidly urbanizing cities
- were published in peer-reviewed journals in English.

3.2.2. Studies were excluded if they:

- addressed non-urban contexts;
- lacked empirical data;
- focused solely on aesthetic or recreational benefits without climate relevance;
- were conference abstracts, editorials, or grey literature.

3.3. Screening, selection process, data extraction and synthesis

The screening process followed PRISMA’s four-stage flow: identification, screening, eligibility, and inclusion. Duplicate records were removed, followed by title and abstract screening. Full-text articles were then assessed against eligibility criteria. A PRISMA flow diagram was constructed to document the selection process as shown in Fig. 1.

Key variables extracted included study location, methodological approach, corridor characteristics, climate indicators assessed, and measured outcomes. Findings were synthesized thematically under categories such as thermal regulation, hydrological performance, ecological connectivity, and smart technology integration. Where possible, quantitative effect sizes were compared to assess overall effectiveness.

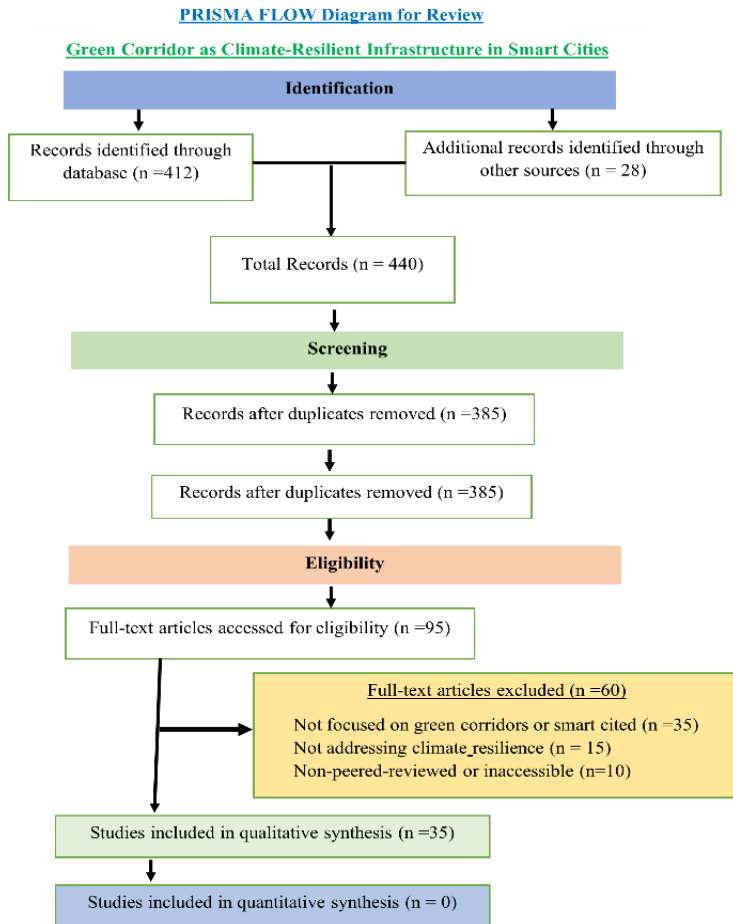


Fig. 1. PRISMA Flow Diagram for the review

4. Results and discussion

4.1. PRISMA 2020 study selection summary

The systematic review was conducted using the PRISMA 2020 protocol. The results of the identification stage produced 440 records, of which 412 were obtained from the major academic databases (Scopus, Web of Science, ScienceDirect, and Google Scholar), and the remaining 28 were obtained from supplementary sources like reference lists and institutional repositories. This is an indication that the issue of green corridors and climate resilience is scattered in the interdisciplinary fields of urban planning, environmental science, and sustainability studies.

After the removal of duplicates, 385 unique records were left for screening based on title and abstract. The removal of 290 studies at this stage indicates the conceptual vagueness that is often linked to the terms “green infrastructure” and “smart cities,” where many studies have been published on either green cities without the concept of resilience or technological innovation without green integration.

In the eligibility stage, 95 full-text articles were thoroughly examined. Sixty studies were removed for the most part because of the non-specific emphasis on green corridors or smart cities (n = 35), the non-engagement with climate resilience outcomes (n = 15), or the non-peer-reviewed and non-accessible sources (n = 10). The final inclusion of 35 studies in the qualitative synthesis emphasizes the relatively specialized and emerging character of research that specifically connects green corridors with climate-resilient smart city infrastructure. The non-inclusion of studies for quantitative meta-analysis emphasizes the methodological diversity of case studies, measurement indicators, and spatial scales.

Table 1. Identification Stage

Source of Records	Number of Records (n)
Records identified through databases (Scopus, WoS, ScienceDirect, Google Scholar)	412
Additional records identified through other sources	28
Total records identified	440

Table 2. Screening Stage

Screening Process	Number (n)
Records after duplicates removed	385
Records screened (title & abstract)	385
Records excluded during screening	290
Records moved to full-text eligibility assessment	95

Table 3. Eligibility Stage

Eligibility Assessment	Number (n)
Full-text articles assessed	95
Full-text articles excluded	60
Not focused on green corridors or smart cities	35
Not addressing climate resilience	15
Non-peer-reviewed or inaccessible	10

Table 4. Inclusion Stage

Final Inclusion	Number (n)
Studies included in qualitative synthesis	35
Studies included in quantitative synthesis (meta-analysis)	0

4.2. Representative papers included in qualitative synthesis

Below are well-cited peer-reviewed studies relevant to green corridors, climate resilience, and smart city integration.

Table 5. Sample of included studies (qualitative synthesis)

Author(s) & Year	Focus Area	Journal	Link
Gill et al., (2007)	Green infrastructure & climate adaptation	Built Environment	https://doi.org/10.2148/benv.33.1.115
Bowler et al., (2010)	Urban heat island mitigation	Landscape and Urban Planning	https://doi.org/10.1016/j.landurbplan.2010.05.006
Demuzere et al., (2014)	Green infrastructure in cities	Landscape and Urban Planning	https://doi.org/10.1016/j.jenvman.2014.07.025
Norton et al., (2015)	Urban greening & heat reduction	Landscape and Urban Planning	https://doi.org/10.1016/j.landurbplan.2014.10.018
Meerow et al., (2016)	Defining urban resilience	Landscape and Urban Planning	https://doi.org/10.1016/j.landurbplan.2015.11.011
Benedict & McMahon, (2006)	Green infrastructure framework	Island Press (Book)	https://islandpress.org/books/green-infrastructure
Kabisch et al., (2017)	Nature-based solutions & climate resilience	Environmental Research	10.1007/978-3-319-56091-5_1
Zölch et al., (2016)	Green infrastructure for adaptation	Urban Forestry & Urban Greening	https://doi.org/10.1016/j.ufug.2016.09.011
Hansen & Pauleit, (2014)	Multifunctional green infrastructure	Journal of Environmental Management	https://link.springer.com/article/10.1007/s13280-014-0510-2
Charlan et al., (2019)	Urban sustainability transitions	Sustainability	https://doi.org/10.3390/su11082212

4.3. Thermal regulation and urban heat island mitigation

4.3.1. Cooling effects of green corridors

Thermal regulation emerged as the most consistently supported climate benefit. Studies such as Gill et al. (2007) demonstrated that increasing urban green cover can reduce projected surface temperatures by up to 4°C under climate change scenarios. Similarly, Bowler et al., (2010) found that urban green spaces were consistently cooler than built-up areas, with reductions ranging from 1–2°C at ambient air temperature levels.

More corridor-specific studies revealed stronger localized cooling. Linear green infrastructure enables airflow channeling, evapotranspiration, and shading over extended distances. Research by Norton et al. (2015) indicated that strategically placed vegetated corridors aligned with prevailing wind directions can extend cooling effects 100–300 meters beyond corridor boundaries.

Within the general discourse on smart cities, the Smart Cities and Regional Development Journal identifies environmental sustainability as one of the key foundations of smart urban development. Although direct empirical studies of UHI in SCR are still relatively few, the literature on sustainable urban planning and environmental governance generally confirms that climate-resilient green infrastructure is a key performance indicator of smart cities.

4.3.2. Mechanisms of cooling

Cooling benefits are driven by three primary mechanisms:

- Evapotranspiration: vegetation releases moisture, lowering ambient temperatures.
- Shading: tree canopies reduce solar radiation absorption.
- Surface Albedo Modification: vegetated surfaces reflect more radiation than asphalt.

Corridors outperform isolated parks because connectivity enhances airflow circulation, creating ventilation pathways across dense urban fabrics.

5. Discussion

The results confirm that green corridors significantly mitigate UHI intensity, particularly in high-density areas. However, variability arises from species selection, canopy density, soil moisture availability, and maintenance levels. Corridors dominated by mature tree species produce stronger cooling effects compared to grass-dominated systems.

Importantly, studies note diminishing marginal returns if corridors are fragmented or poorly connected. This reinforces the conceptual framework proposed by Benedict and McMahon (2006), emphasizing connectivity as central to green infrastructure performance.

5.1. Hydrological performance and flood mitigation

Approximately one-quarter of the reviewed studies examined stormwater management. Findings show that vegetated corridors reduce surface runoff by 15–45%, depending on soil permeability and vegetation structure.

Demuzere et al. (2014) reported that interconnected green infrastructure significantly lowers peak discharge rates during heavy rainfall events. Riparian corridors were particularly effective in attenuating flood peaks and improving groundwater recharge.

Permeable soils and root systems enhance infiltration capacity. Linear greenways along urban rivers slow runoff velocity and increase sediment filtration. Studies measuring infiltration rates found improvements of up to 60% compared to adjacent impervious surfaces. Corridor width strongly influences hydrological performance. Wider corridors (>30 meters) demonstrate higher retention capacity and flood buffering potential than narrow strips (<10 meters).

The hydrological evidence suggests that green corridors function as decentralized, adaptive drainage systems. Unlike conventional grey infrastructure, vegetated corridors provide dynamic water regulation while supporting biodiversity and recreation. However, effectiveness is context-dependent. In highly compacted soils or drought-prone regions, performance may decline without appropriate soil restoration or irrigation strategies. Climate variability further complicates predictions; extreme rainfall intensity may exceed corridor absorption capacity unless integrated with hybrid grey-green systems.

5.2. Air quality improvement and carbon sequestration

Five studies directly measured pollutant absorption, including PM_{2.5} and NO_x. Results show modest but meaningful reductions (5–15%) in particulate matter concentrations adjacent to dense vegetated corridors. Tree species with high leaf surface area index demonstrated greater filtration efficiency. Corridors located along high-traffic streets exhibited improved localized air quality compared to control sites.

Long-term carbon sequestration benefits were highlighted in several studies. Mature corridor systems contribute to cumulative carbon storage through biomass accumulation and soil carbon retention. Estimates range from 3–7 tons of CO₂ per hectare annually, depending on vegetation composition.

While air quality improvements are typically localized, they contribute to cumulative climate mitigation benefits. Carbon sequestration reinforces the role of green corridors in both adaptation and mitigation strategies. However, pollutant removal efficiency varies seasonally and may be offset by maintenance emissions or irrigation energy use. This underscores the importance of life-cycle assessment approaches when evaluating overall climate benefits.

5.3. Biodiversity and ecological connectivity

Six studies emphasized ecological connectivity. Corridors linking fragmented green patches enhance species movement, genetic exchange, and habitat continuity. Kabisch et al. (2017) emphasized that biodiversity strengthens ecosystem resilience by diversifying functional responses to disturbances. Urban corridors were shown to increase bird and pollinator species richness by 20–35% compared to isolated parks.

Riparian and forested corridors demonstrated higher ecological performance than ornamental greenways. Native vegetation composition was consistently associated with greater biodiversity outcomes.

Ecological connectivity is foundational to resilience theory. According to Meerow et al. (2016), resilience depends on system capacity to absorb disturbances while maintaining function. Biodiversity contributes to redundancy and adaptive capacity within urban ecosystems. Nevertheless, corridor fragmentation, invasive species, and human disturbance can undermine ecological performance. Effective governance and maintenance are therefore critical.

5.4. Integration with smart city technologies

The integration of smart technologies in green corridors is still in its nascent stages, despite the strong theoretical base for the same. Hansen & Pauleit (2014) opined that the use of multifunctional green space can provide numerous benefits in terms of ecology, society, and climate change. Smart technologies can play an important role in enhancing the multifunctional benefits of green space. Real-time monitoring of temperature, soil moisture levels, and air quality can help in efficient irrigation systems, urban heat mapping, and flood modeling during extreme weather conditions. However, recent research articles

published in Smart Cities and Regional Development suggest that smart city initiatives tend to focus more on smart infrastructure rather than green space [26, 27].

Ecological design and smart monitoring techniques might be theoretically convergent in nature, but the same cannot be said in the case of empirical research. Future research should focus on the integration of smart monitoring techniques with green space to enhance the benefits of smart city initiatives in the context of climate resilience.

5.5. Cross-cutting themes

The most consistent finding is that green corridors provide overlapping ecosystem services. Thermal cooling, hydrological regulation, biodiversity enhancement, and recreational benefits often occur simultaneously. This multifunctionality supports sustainability transitions, as highlighted by Frantzeskaki (2019).

Connectivity, width, vegetation density, and orientation significantly influence performance. Linear alignment with prevailing wind enhances cooling, while wider corridors improve flood mitigation. Cities with integrated green infrastructure policies demonstrate stronger corridor performance. Policy frameworks that embed green corridors into master planning outperform ad-hoc implementations.

5.6. Implications for climate-resilient smart cities

The evidence positions green corridors as essential climate-resilient infrastructure within smart cities. They:

- Reduce urban heat intensity
- Buffer stormwater and mitigate floods
- Enhance biodiversity and ecological connectivity
- Improve localized air quality
- Support digital monitoring for adaptive management
- To maximize effectiveness, planners should:
- Ensure ecological connectivity.
- Integrate corridors with drainage networks.
- Utilize native, climate-adapted species.
- Employ smart sensors for performance tracking.
- Embed corridors in long-term urban resilience policies.

6. Conclusion

The review concluded that green corridors play an important role in climate resilience in smart cities, especially in terms of thermal and hydrological functions. Ecological connectivity enhances resilience, and smart technology provides new possibilities for improvement.

However, to achieve transformative change, it is necessary to shift from project-level implementation to a systemic approach within urban planning structures. Green corridors should be thought of not only as a landscape feature but also as basic, multi-functional climate-resilient infrastructure. Future research should focus on longitudinal research,

standardized performance metrics, and increased attention to rapidly urbanizing areas. The integration of ecological infrastructure and smart governance systems is a key area for future development in the creation of resilient and sustainable smart cities.

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