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PREPLANNED CITY: BGI IN SONGDO

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ABSTRACT

Over the past few decades, Blue-green infrastructure (BGI) has emerged as one of the cornerstones of sustainable urban development, balancing ecological restoration, climate resilience, and human well-being. Cities across the globe have different policy frameworks, design priorities, and governance structures that shape the implementation of BGI systems. In South Korea, in particular, Songdo's design highlights how a top-down, master-planned eco-city integrates BGI with smart city technologies and climate adaptation measures. In New York City, decentralized implementation and public–private partnerships have been vital to scaling up BGI. In Singapore, the nation-state illustrates a nationally coordinated approach, positioning BGI as both ecological infrastructure and a critical climate adaptation strategy. Vienna offers a contrasting European model, where BGI is closely related to long-term planning traditions. Together, these diverse governance models highlight how BGI can be tailored to local environmental, social, and political contexts while contributing to global climate resilience and human enjoyment.

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1. Introduction

Green Infrastructure (GI) is an urban planning approach that integrates natural ecosystems with built environments to enhance sustainability and resilience. Initially introduced as an alternative to traditional grey infrastructure, GI emphasizes the use of green spaces and vegetation strategies to address urban challenges. Over time, the concept has expanded into Blue-Green Infrastructure (BGI), incorporating green elements like parks and forests, and water management systems such as rivers, wetlands, and stormwater solutions. BGI aims to restore ecological balance, mitigate climate change impacts, and improve urban livability by managing water resources efficiently and fostering biodiversity. Songdo, a smart city in South Korea, was designed as a global business hub. Unlike conventional cities that evolve gradually, Songdo was constructed on reclaimed land, allowing for a premeditated integration of BGI principles. The city employs advanced technologies to optimize energy efficiency while prioritizing environmental sustainability. Key features such as Central Park and a network of seawater canals exemplify Songdo's effort to incorporate nature-based solutions into urban planning. However, despite its progressive design, Songdo faces challenges in fully realizing the potential of BGI, including limited biodiversity, over-reliance on technological solutions rather than ecological processes, and questions about long-term environmental and social sustainability.

2. Methodology

To examine the current state and future direction of BGI in Songdo, this study draws comparative insights from three global case studies: New York City, Singapore, and Vienna. These cities were not selected merely for their international recognition in implementing BGI, but because they share structural, procedural, or experimental similarities with Songdo that make them relevant for comparison. New York provides a meaningful reference point in terms of urban morphology—a dense, mixed-use coastal city facing similar challenges related to flooding and heat islands. Projects such as Central Park, the High Line, and citywide stormwater management initiatives that integrate ecological and social functions demonstrate these values. Singapore offers insight from a state-led, centrally planned development model, mirroring Songdo's own government-driven origins. Singapore further exemplifies the advancement of BGI through its nationwide ABC Waters Program and landmark projects like Bishan–Ang Mo Kio Park, strengthening green and blue infrastructure for biodiversity and climate resilience. Finally, Vienna, particularly through its Aspern Seestadt district, illustrates how a city can designate a strategic experimental zone to pilot integrated BGI strategies—paralleling Songdo's role as a testbed for innovative environmental infrastructure within the broader Incheon metropolitan context. Vienna as a city has published environmental visions and policies that emphasize the integration of green belts and ecological corridors.

Although Songdo is well known as a master-planned and smart city, there are relatively fewer studies focusing on its BGI strategies compared to other global cases. Considering that Songdo was designed with integrated water management systems and ecological green spaces from its inception, researching and analyzing its BGI framework would provide valuable insights for understanding the role of planned cities in advancing sustainable urban development.

This study examines Songdo's current BGI strategies, identifying both successes and shortcomings in fostering long-term sustainability, ecological resilience, and social inclusivity. Specifically, the study evaluates Songdo's development through three key dimensions:

- Factual Analysis: An objective review of Songdo's existing BGI implementation, assessing its strengths and weaknesses.
- Value-Based Considerations: Examination of broader environmental, social, and economic implications of BGI in Songdo.

– Policy-Oriented Perspectives: Strategies for future improvements, governance, and long-term sustainability planning.

Through this structured analysis, the research contributes to the ongoing discourse on sustainable urban planning, offering insights into how Songdo can enhance its urban resilience and ecological sustainability by learning from global best practices.

3. Results

3.1. New York Case Study

As the largest city in the United States and arguably the most important port in North America, New York City is an American counterpart for a case study of Songdo's blue-green infrastructure planning. Developed as a smart city with ocean proximity, the two cities face many of the same issues, including high water table, limited space, and a large population. This similarity is confirmed by a history of Korean design influenced by New York City, with the opening of the Seoul Sky Garden eight years after the completion of the first section of the Highline. For these reasons, it appears elements of New York's design were considered when planning the new development of Songdo.

Awarded by competition to Frederick Olmsted, the design of Central Park has influenced a large portion of American park design. The English garden design style allowed Olmstead to create a seamless connection with nature, hiding roads and paths behind water features, rolling hills, and wooded areas. A style later replicated in the design for Prospect Park, and green spaces across the US, posing a conversation around the evolving role of parks and the needs of a population when considering the more recent urban parks like the Highline. The New York Highline represents one future of parks, nestled into unused urban space, snaking between buildings, and stretching several blocks. This new style injects outdated infrastructure with social benefits, providing gathering spaces, and creating safe pedestrian paths removed from the constant flow of traffic. Why are mature cities moving away from the Central Park model and opting for the highline instead? What does it tell us about the desires of the population when parks shift from fields of grass to pylons of steel and ivy or is it just another axis to escape the velocity of the street, or something else entirely?

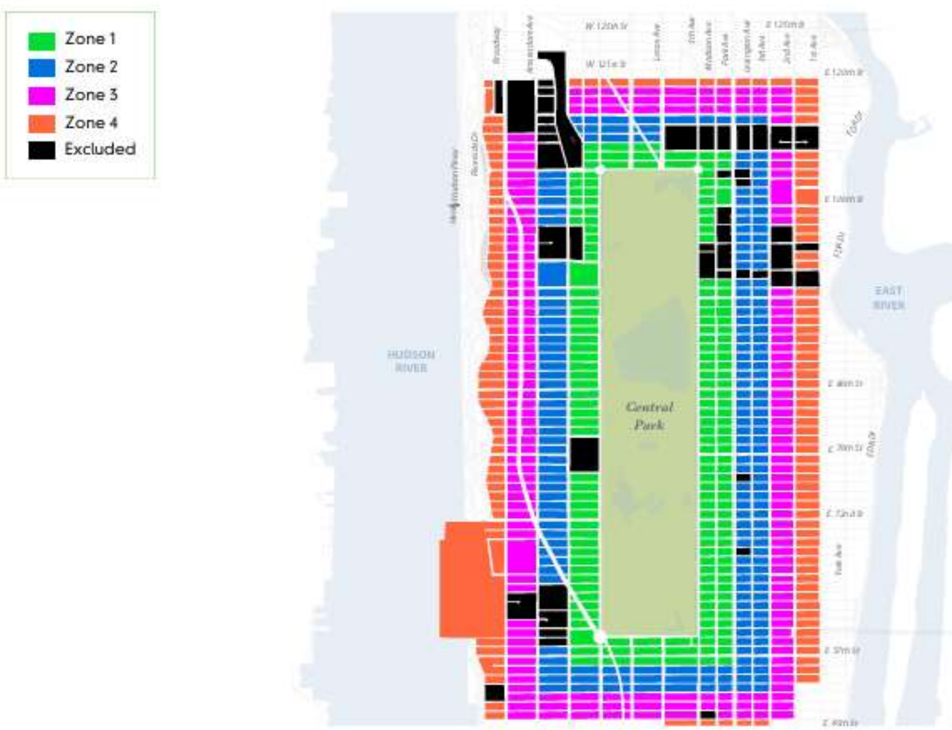
In 2020, the American Planning Association (APA) awarded the NYC parks system the National Planning Excellence Award for Advancing Diversity and Social Change in honor of Paul Davidoff (APA, 2023). Started in 2014, this award celebrates equity planning and social improvements in areas of historic underinvestment, including the development of new green spaces to ensure environmental justice. When awarded, 99% New Yorkers currently live within a 10-minute (half-mile) walk of a park, according to GIS maps from the Trust for Public Land. Since winning this award, 70 new parks have been proposed, creating 100% equitable access. In a 2015 study conducted by the Trust for Public Land, New York residents reported visiting New York Parks 527 million times per year; Central Park alone boasts more than 41 million yearly visits, equating to approximately 115,000 people per day. Connecting with nature on a walk, run, or bike ride, the study by the Trust for Public Land estimates savings of $54 million in gym membership fees and $1.1 billion in healthcare costs each year.

Managing pollutants is an important part of maintaining physical health. The New York Department of Environmental Protection (NYC DEP) fulfills this role by managing approximately 75 urban blue belts to preserve natural drainage corridors. Using green stormwater treatment, a series of sewer systems, rain gardens, green roofs, infiltration basins, green streets, permeable pavement, streams, ponds, and wetlands, minimizes treatment facility intervention. Taking advantage of the natural treatment, slowing of stormwater runoff to reduce peak flows, and scrubbing of many of the harmful pollutants, New York saves an estimated $2.5 billion each year (Clinton et al., 2022).

Using the average density across the five boroughs (29,302 people/sq. mile), 40,000 people could live, work, and recreate in Central Park's 1.3 sq. miles. Aside from helping alleviate the urban heat island and functioning as a carbon sink for a city with the third largest carbon footprint in the world (Moran et al., 2018), Central Park adds an almost incalculable value to the health and identity of New York. A 2017 study performed by the New York Botanical Garden found 438 species of flora within the 843 acres. In a 2014 study out of the University of Colorado, Ramirez et al. found 160,000 types of microbes within the soil, "the majority of which were unknown to Science." As well as more than 250 types of vertebrates and more than 100 invertebrate species, all with specific niches to maintain healthy ecosystems (Ramierz et al., 2014). Central Park acts as a secret habitat and conservation space for hundreds of species critical to a healthy ecosystem.

There are benefits to maintaining Central Park for Manhattan's financially minded, as Central Park has an enormous impact on real estate values. In 1873, the first year since the park's completion, properties along the perimeter saw a real estate value increase of 15%. A much larger increase than their neighbors further from the park, so much so that now the Central Park Area accounts for 18% of real estate value across all boroughs (Clinton et al., 2022). The same study from the Trust for Public Land continues, estimating that property values within 500 ft of park proximity have increased by more than $30 billion, totalling real estate valued at more than $303 billion (Clinton et al., 2022),

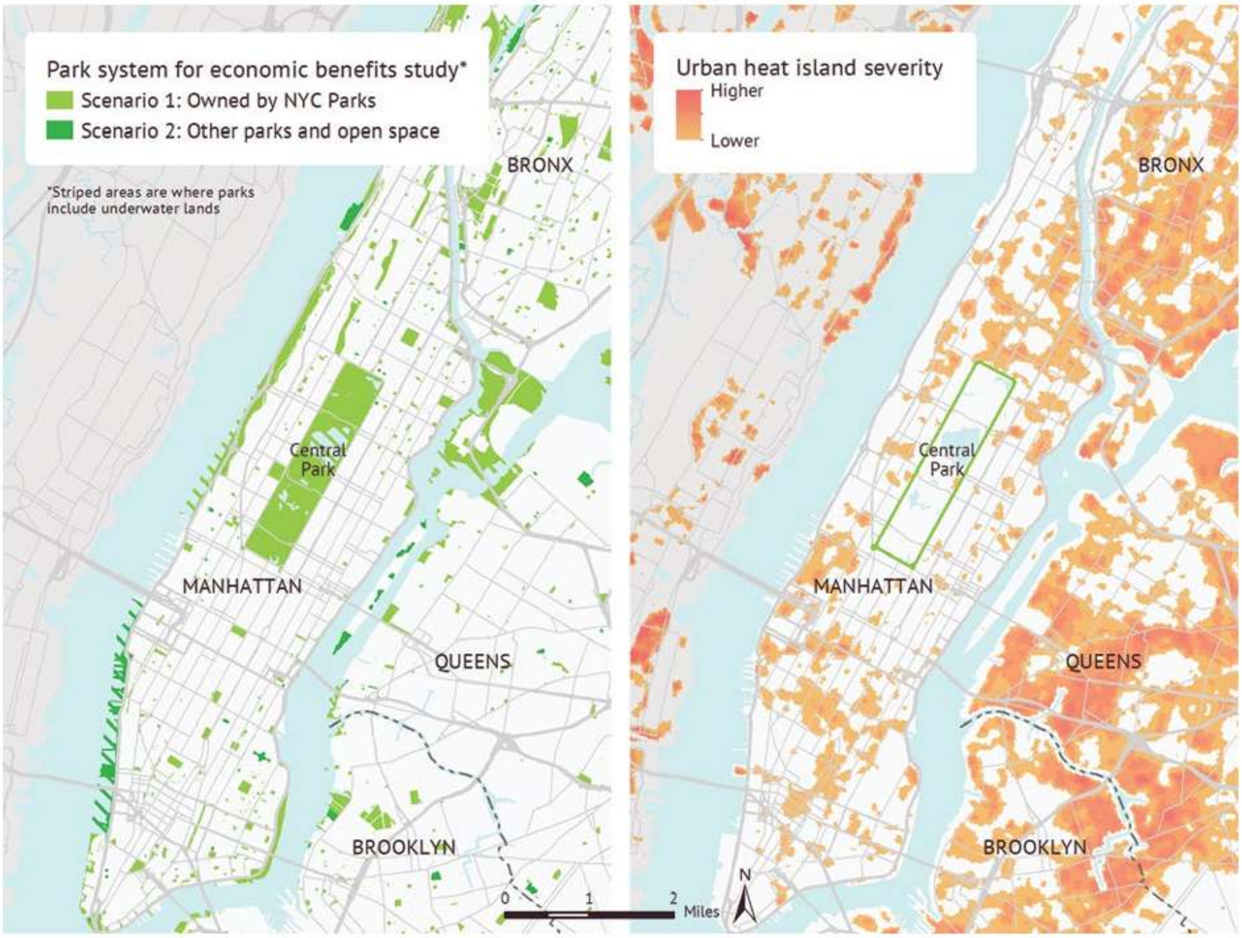
Figure 1 and 2. Tax lot groups and the average value per lot square foot, by distance from Central Park, 2014



Source(s): Central Park Conservancy, 2015, pg 36-37.

Along with being the largest city in the US, New York City is also the most densely populated. While this kind of density is exactly what Jane Jacobs was advocating for in her book *The Economy of Cities* (Jacobs, 1969), the daily realities of accommodating this population are not without challenges, and New York's solutions give us insight to possible solutions. According to the New York Department of Environmental Protection, the city receives one billion gallons of potable water from upstate reservoirs each day, and produces an estimated carbon footprint of 223 million tons each year (Moran et al., 2018). A 2023 study from Columbia University has found that urban greenery uptakes 40-85% of daily carbon emissions, season dependent. (Krajick, 2023) This is due in part to the large urban canopy coverage of 22%, which came from the successes of environmental protection laws passed by the city and state Senates. In the state legislature, *Chapter 43-B* (New York Senate, 2025) covers environmental protections within New York and outlines restrictions and methods for improving ecological health. *Chapter 43-B* includes more than 70 articles for improving blue-green infrastructure within the city, and thus, the quality of life. Each one represents a special consideration and populous goal, using specific callouts in environmental policy. Articles such as *Article 3: Tree Conservation and Urban Forestry*, *Article 16: Flood Control*, *Article 21: Pollution Control*, *Article 49: Protection of Natural and Manmade Beauty*, and a variety of environmental quality bond acts in 1972, 1986, 1996, and 2023. Many of these policies have been long-standing and time-tested, continuously working to improve environmental conditions. Robust and specific environmental policy is critical to urban health, and New York serves as a high-quality framework to build upon for developing new urban policy conditions.

Figure 3A and 3B. Central Park and its surroundings (left), and Urban Heat Island Map provided by the Trust for Public Land (right)



Source(s). Clinton et al., 2022, p. 23.

3.2. Singapore Case Study

Figure 4. The Green Blue Plan Arising From The 1991 Concept Plan

Source(s): Rowe & Hee, 2019, p. 116.

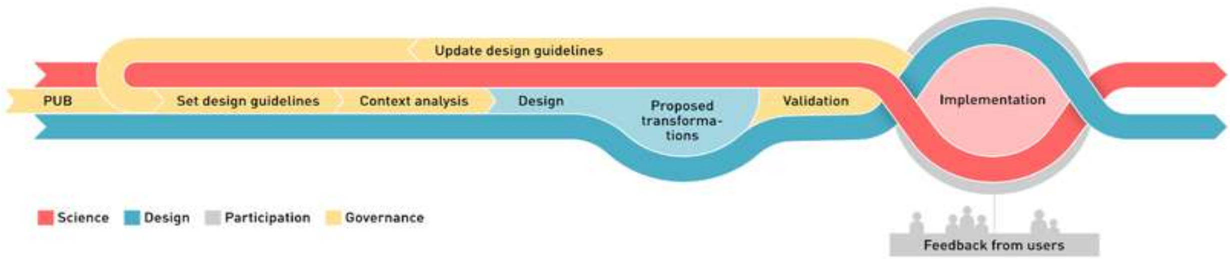
Figure 5A and 5B. From A "Garden City" To A "City In Nature"

Source(s): Rowe & Hee, 2019, p. 117.

Over the past few decades, Singapore has significantly advanced its urban infrastructure, positioning itself as a global leader in sustainable urban development. A central component of this progress is the city-state's implementation of blue-green infrastructure, which integrates natural water systems and vegetated landscapes into the urban fabric. This systematic approach addresses pressing environmental and climate-related challenges while simultaneously enhancing urban livability and resilience (Lim & Xenarios, 2021).

The cornerstone of Singapore's BGI strategy is the *Active, Beautiful, Clean Waters* (ABC Waters) Programme, launched in 2006 by PUB, the national water agency. This initiative embodies a paradigm shift in stormwater management from conventional, hard-engineered solutions like concrete canals to nature-based solutions that embrace a low-impact development (LID) ethos (PUB, 2020). By 2030, over 100 sites across Singapore are expected to incorporate ABC Waters features, such as bioswales, rain gardens, vegetated rooftops, and retention ponds, all designed to slow runoff, filter pollutants, and increase biodiversity (URA & NParks, 2021). Singapore's BGI also encompasses a vast network of 8,000 kilometers of waterways, 32 rivers, and 17 reservoirs, which serve both ecological and infrastructural functions.

Figure 6. Summary of the design process in the ABC Waters program in Singapore. (PUB is Singapore's National Water Agency.)



Source(s): Salliou et al., 2023.

Figure 7. Singapore's Blue Map "With over 8,000 km of waterways and 17 reservoirs, Singapore has much potential to integrate blue spaces with urban development." Diagram Courtesy of PUB, Singapore's National Water Agency.

Source(s): The Active, Beautiful, Clean Waters Programme: Water as an Environmental Asset, n.d., p. 2.

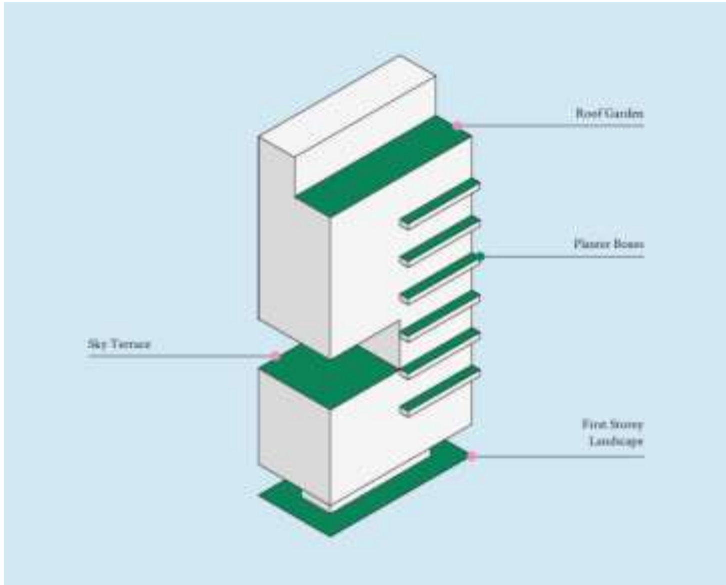
Figure 8. The ABC Waters Concept. "The ABC Waters Programme aims to integrate the Environment, Waterbodies, and the Community seamlessly to create new community spaces around existing waterbodies." Diagram Courtesy of PUB, Singapore's National Water Agency.

Source(s): The Active, Beautiful, Clean Waters Programme: Water as an Environmental Asset, n.d., p. 44.

The transformation of the Bishan-Ang Mo Kio Park serves as a flagship example: a previously concrete canal was redesigned into a naturalized, meandering river, offering both flood mitigation and recreational opportunities (Tan & Jim, 2018).

This exemplifies the evolution of Singapore's relationship with water—from a utilitarian model that distanced people from waterways to an integrated design philosophy that reconnects urban communities with blue spaces. Singapore's green landscapes fall broadly into two categories: (1) natural ecosystems, such as native forests and water catchments, and (2) constructed landscapes, including urban parks, rooftop gardens, green streetscapes, and canal-side terraces (NParks, 2019).

Figure 9. Biophilic Design of Integrating Natural Elements



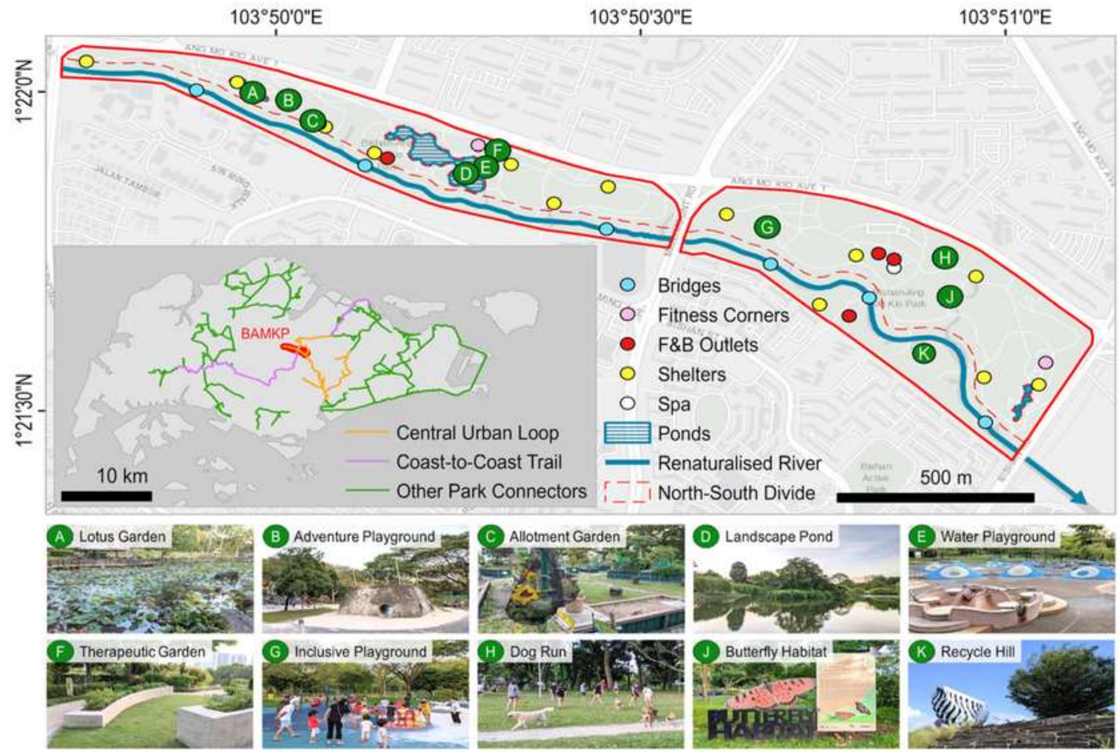
Source(s): Rowe & Hee, 2019, p. 111.

The integration of these elements into city planning, enabled by coordinated efforts between the Urban Redevelopment Authority (URA) and the National Parks Board (NParks), has yielded measurable benefits: reduced urban flooding, improved water quality, enhanced thermal comfort, and enriched biodiversity (Chong et al., 2021). Despite constraints posed by dense urbanization and a changing climate, Singapore continues to adapt and innovate within its BGI framework, demonstrating how holistic, multi-agency collaboration and long-term planning can yield resilient and ecologically integrated cities.

Singapore's approach to BGI embodies a forward-thinking, ethical paradigm of urban development, one that prioritizes environmental stewardship, human well-being, and intergenerational equity. By rejecting the conventional dichotomy between nature and the built environment, Singapore has demonstrated that ecological systems can be harmoniously woven into even the most densely developed urban landscapes (Tan et al., 2020). This integrative ethos reinforces a powerful value claim: sustainable growth and urban prosperity are not mutually exclusive, but mutually reinforcing.

BGI in Singapore serves as more than just a technical solution; it is a moral and civic commitment. Initiatives like the *Active, Beautiful, Clean Waters* (ABC Waters) Programme underscore a belief in cities as inclusive, multifunctional spaces that serve both ecological and social needs (PUB, 2020).

Figure 10. Bishan-Ang Mo Kio Park's Key Features

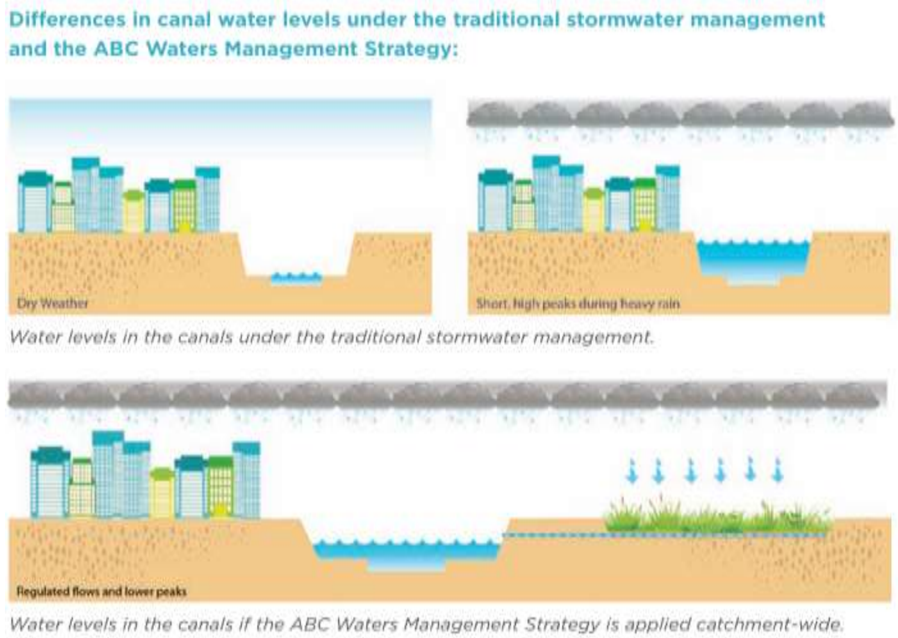


Source(s): Koh et al., 2022, p. 3.

These interventions support a holistic vision of urban life, where beauty, functionality, and sustainability coalesce. Importantly, the societal benefits of BGI extend into the economic and cultural domains. Estimates suggest that Singapore's blue-green spaces generate between S$100 million and S$220 million annually through recreational, socio-cultural, and tourism-related services (Tan & Jim, 2019). These figures not only validate the financial rationale behind nature-based solutions, but also affirm their value in fostering civic pride, mental health, and social cohesion—intangibles essential to a high quality of urban life. At its core, Singapore's investment in BGI reflects a deeply rooted ethic of care—both for the environment and for future generations. In prioritizing long-term climate resilience over short-term convenience, Singapore sets a compelling example for rapidly urbanizing nations navigating similar environmental pressures. The BGI strategy upholds fundamental values such as collective well-being, public responsibility, and innovation in the face of global climate uncertainty (URA & NParks, 2021). Singapore's model reveals a profound lesson: ecological responsibility does not impede modern life, but instead bolsters national identity, community dignity, and hope for a more sustainable urban future. In this light, Singapore's urban strategy is not only effective, it is exemplary. It presents a vision of city-making grounded not just in efficiency, but in ethical foresight and collective purpose.

Singapore's BGI stands as a globally significant policy model, showcasing how comprehensive, enforceable, and multi-sectoral planning can embed sustainability into the very foundation of urban development. At the core of this strategy is the *Active, Beautiful, Clean Waters* (ABC Waters) Programme. This initiative is not merely aspirational but legislatively mandated through instruments such as the *Drainage Act* and the *Building Control Act,* passed in 2014, which require new developments to incorporate bioretention swales, cleansing biotopes, and rain gardens into their site designs (PUB, 2020). These regulations ensure that new building approvals are contingent on water-sensitive urban design.

Figure 11. Diagram Courtesy of PUB, Singapore's National Water Agency



Source(s): The Active, Beautiful, Clean Waters Programme: Water as an Environmental Asset, n.d., p. 92.

The policy impact of the ABC Waters Programme is evident in successful projects such as Bishan–Ang Mo Kio Park and the naturalization of the Kallang River, both of which are outcomes of state-driven mandates rather than private greening initiatives. Such interventions exemplify how legal and infrastructural coordination can transform utilitarian assets into multifunctional public goods (Tan et al., 2021). Beyond PUB, cross-agency alignment is also evident in the *Singapore Green Plan 2030*, particularly in its "City in Nature" pillar. This national agenda includes quantifiable targets such as planting one million trees, increasing parkland by 50%, and ensuring that every household is within a 10-minute walk to a green space by 2030 (Ministry of Sustainability and the Environment, 2021). These goals are built into spatial planning and enforced by the Urban Redevelopment Authority (URA) through the 2019 Master Plan. The 2019 Master Plan mandates BGI integration into township-level zoning, requiring new districts like Tengah and Punggol Digital District to incorporate eco-sensitive design and blue-green networks into precinct layouts (URA, 2019). This is complemented by the Building and Construction Authority's (BCA) *Green Building Masterplan 2030*, which targets to achieve Green Mark Certification for 80% of Buildings in Singapore. The Green Mark criteria include stormwater treatment infrastructure, vegetated roofs, and passive cooling features, all of which are directly tied to BGI policy outcomes (BCA, 2020).

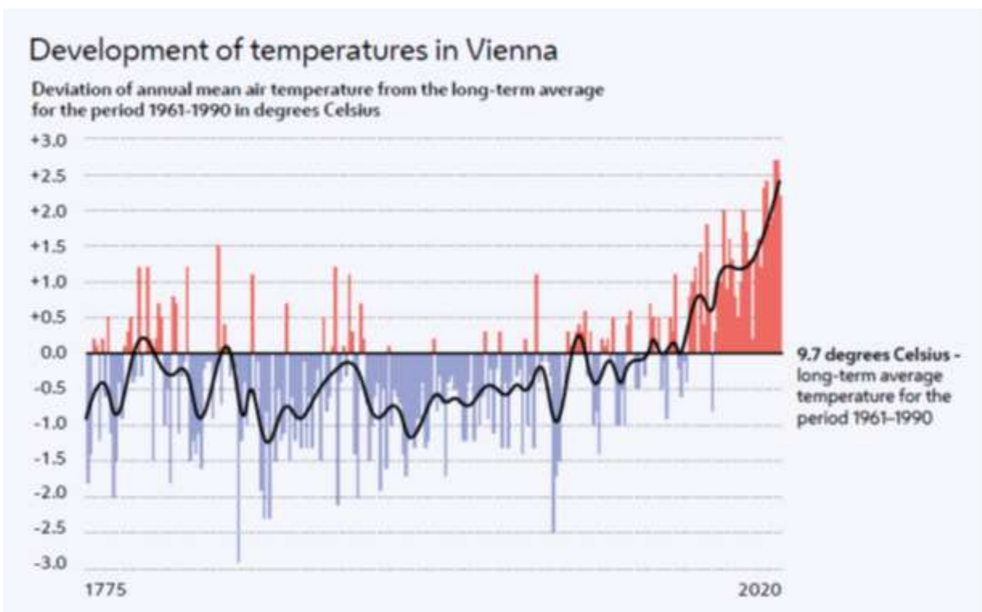
Furthermore, Singapore's commitment to BGI extends into climate resilience policy through PUB's *Coastal Protection and Flood Resilience Plan*. This includes the Long Island Project, which merges coastal defense with ecological urban design, signaling a shift from reactive infrastructure to anticipatory planning that blends land reclamation with nature-based solutions (PUB, 2023). This level of integration affirms that BGI in Singapore is not a series of disconnected environmental projects, but a coordinated, long-range national development priority embedded in law, governance, and urban systems. In sum, Singapore's BGI strategy is a powerful policy case study in urban governance. It illustrates how a city-state can institutionalize sustainability through a combination of legal mandates, cross-agency coordination, spatial planning integration, and climate resilience strategies. The policy coherence, scalability, and enforceability of Singapore's approach provide a replicable model for other urban governments seeking to embed blue-green infrastructure within their legislative and planning frameworks.

3.3 Vienna

Vienna is considered one of the leading cities in advancing BGI. The city has made efforts to mitigate the urban heat island effect through mandatory policies on green areas. Beyond the expansion of green spaces, Vienna has implemented integrated blue infrastructure; systems designed to absorb, retain, filter, and recharge rainwater (Reinwald et al, 2021). This "sponge city" approach enables the city to manage stormwater sustainably, linking green and blue infrastructure. As a result, Vienna is recognized as a pioneer not only in ecological conservation but also in water-sensitive urban design.

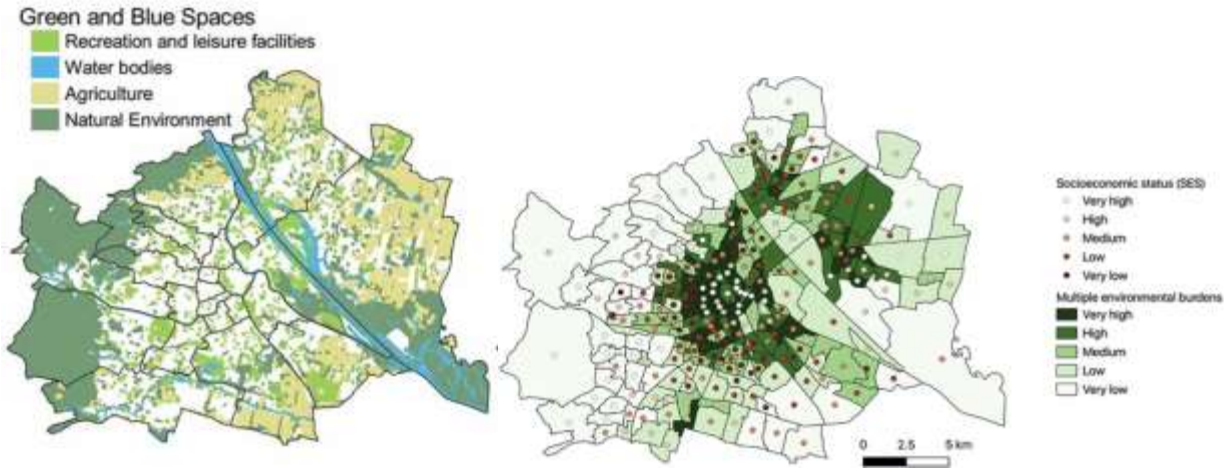
Urban Heat Island (UHI) refers to the temperature difference between cities and their surrounding rural areas. In Vienna, this difference can reach up to 12°C due to impermeable surfaces, urban density, and a lack of green space. Vulnerable populations, such as the elderly, are particularly at risk (Reinwald et al, 2021). As cities grow and become denser, green and open spaces are being lost, further exacerbating the UHI effect.

Figure 12. Development of temperatures in Vienna



Source(s): Towards a Climate-Friendly City Vienna Climate Guide, 2022, p.15.

Figure 13A & 13B.



Source(s): (left) Friesenecker et al., 2023, p.10 (right) Khomenko et al., 2020, p.8.

Vienna has developed a city-wide strategy to deal with urban heat. *The Urban Heat Islands Strategy Plan* (developed 2011–2014) combines green infrastructure to reduce temperatures and improve resilience (Gantner et al, n.d.). It includes more parks, street trees, green roofs, and green façades. Larger parks (particularly over 40 hectares) have a noticeable cooling effect on their surroundings (Žuvela et al, 2016).

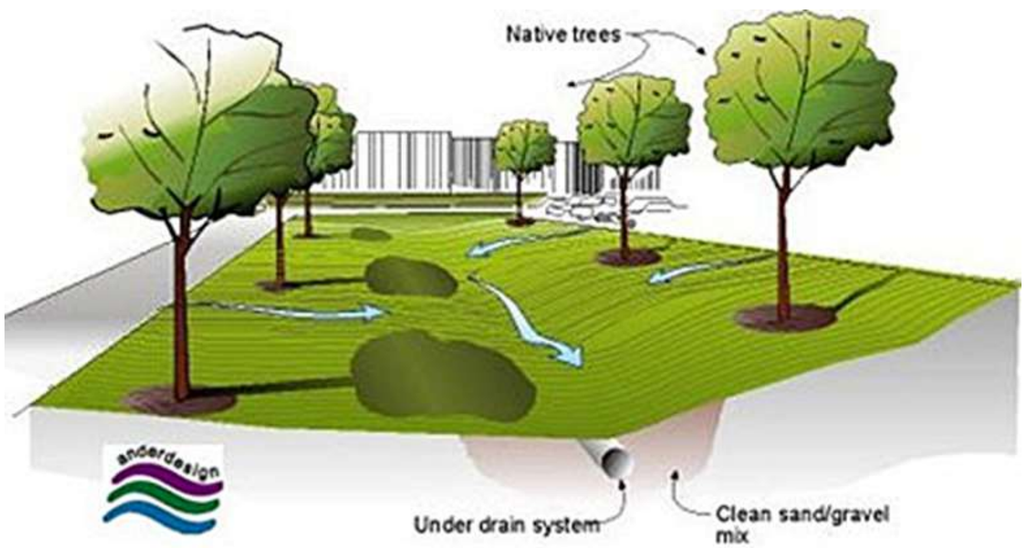
Low Impact Development(LID) Rainwater System is used for blue infrastructure for sponge cities. Aspern Seestadt, an area located in eastern Vienna, tested a dual infiltration model that allows clean stormwater to percolate and recharge groundwater, while polluted runoff is treated separately, restoring water health and reducing the UHI. Under streets, porous gravel-soil layers and bioswales capture and store stormwater, which can be released for manageable treatment or gradually infiltrates the ground, consumed by vegetation (Reinwald et al., 2021). Polluted water from de-icing salts is diverted into separate sewers. This LID concept balances street safety in winter with ecological goals. The system reduces stormwater peak flows, supports plant health during dry periods, enhances urban cooling, and contributes to groundwater recharge. It has shown operational stability without road subsidence.

Beyond water management, BGI has also proven especially effective at mitigating heat stress by introducing vegetation and water into the cityscape. The greatest cooling benefits occur in densely built areas, but importantly, the study showed that city-wide temperature reductions require extensive implementation of BGI. Simulation results by Žuvela-Aloise el al. (2016) suggested that only broad, combined measures – for example, reducing building density by 10%, decreasing paved surfaces by 20%, and increasing green or water areas by 20% – yield substantial cooling at the city scale. In practice, this means isolated green interventions are not enough; a network of parks, street trees, green roofs, and water bodies must be woven throughout the urban environment to noticeably counteract heat. Indeed, Vienna's urban planners have adopted this insight: a recent project developed a multi-level toolset combining climate simulation models with green infrastructure planning to determine how much greening is needed at various scales of the city to achieve specific cooling targets (Reinwald et al., 2021). These case studies in Vienna underscore that BGI is a cornerstone of climate resilience, helping the city adapt to more frequent heatwaves by naturally cooling neighborhoods and reducing heat stress on residents.

At the same time, many BGI measures contribute to climate mitigation by supporting carbon sequestration. Planting street trees, for instance, not only provides shade but also absorbs carbon dioxide. As an example, the design of Vienna's new Aspern "sponge city" includes 330 newly planted trees that will sequester carbon and cast broad shadows as they mature (TIME, 2022). These trees, along with other greenery, are expected to make the area significantly cooler and more comfortable during hot summers, demonstrating how natural cooling can be achieved alongside other climate benefits.

Vienna's Aspern "sponge city" development incorporates water-sensitive design – as seen in this canal and adjacent green space – to absorb stormwater and mitigate flooding. Blue–green infrastructure like wetlands, retention basins, and permeable landscapes, helps replicate the natural water cycle in urban neighborhoods (Reinwald et al., 2021). Vienna has placed a strong emphasis on using BGI for stormwater management and flood resilience. This approach is sometimes described as creating a "sponge city," where the urban landscape is designed to soak up heavy rainfall instead of simply piping it away. The goal is to reduce runoff, prevent sewer overflow, and buffer the city against flooding during extreme weather events. In conventional cities, expanses of asphalt and concrete repel water, causing precipitation to accumulate and overwhelm drains. By contrast, Vienna's blue–green infrastructure uses natural processes – soil, vegetation, and open water – to retain and slowly release rainwater.

Figure 14. Sponge city

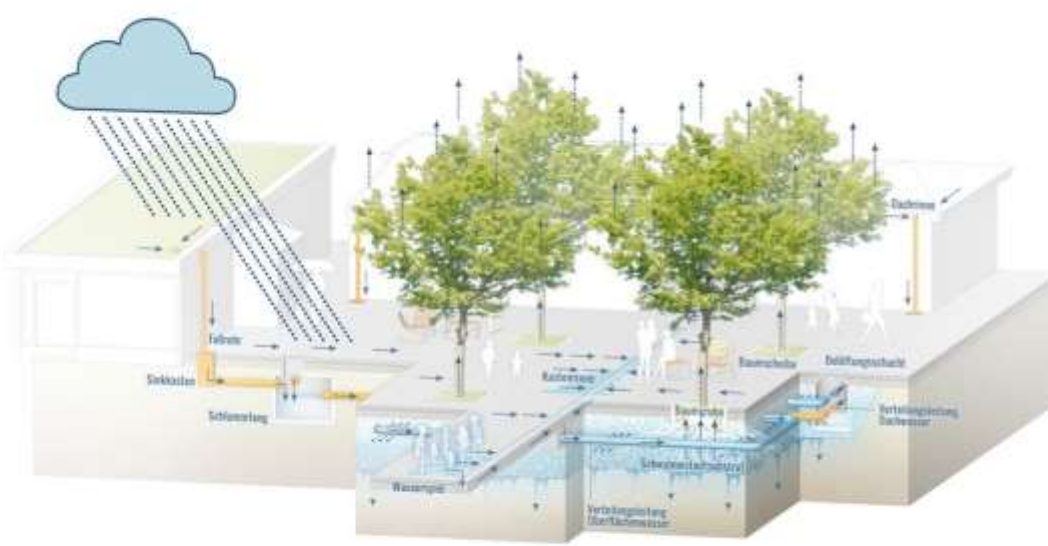


Source(s): Swales-diagram, n.d.

Figure 15. Sponge-City (Schwammstadt) Strategies in Quartier “Am Seebogen”, Vienna

Source(s): Schwammstadt, n.d.

Figure 16. Sponge City principle for trees



Source(s): Isopp, 2022.

As early as 1905, the city introduced the *Forest and Meadow Belt Protection Act* (*Schutzgesetz Wald- und Wiesengürtel*) to preserve green spaces surrounding the urban area. After the devastation of World War II, Vienna enacted the *Vienna Nature Conservation Act* to prevent uncontrolled urban sprawl and to systematically manage and expand its green belt system (Terada et al., 2008).

In 1999, the City of Vienna created an ambitious and committed environmental program with its Climate Protection Program (KLiP I). It aimed to avoid 2.6 million tons of carbon dioxide (CO_2), which proved to be a success in 2006 (City of Vienna, n.d.).

There were 36 KLiP programs and 241 individual measures in the areas of district heating and electricity generation, housing, businesses, city administration, and mobility. Aimed at reducing greenhouse gas emissions and improving Vienna's quality of life (City of Vienna, n.d.).

On December 18th, 2009, the city council of Vienna updated the Climate Protection Program (KLiP II), valid until the end of 2021. It included individual measures in 5 fields of action:

- Energy supply
- Use of energy
- Mobility and town-structure
- Procurement, waste management, agriculture and forestry, nature conservation
- Public relations

Vienna's climate protection measures were effective. Per capita greenhouse gas emissions were 39% lower in 2019 than in 1990, far exceeding the KLIP's target for 2020 (21% reduction in per capita values of 1990) (City of Vienna, n.d.).

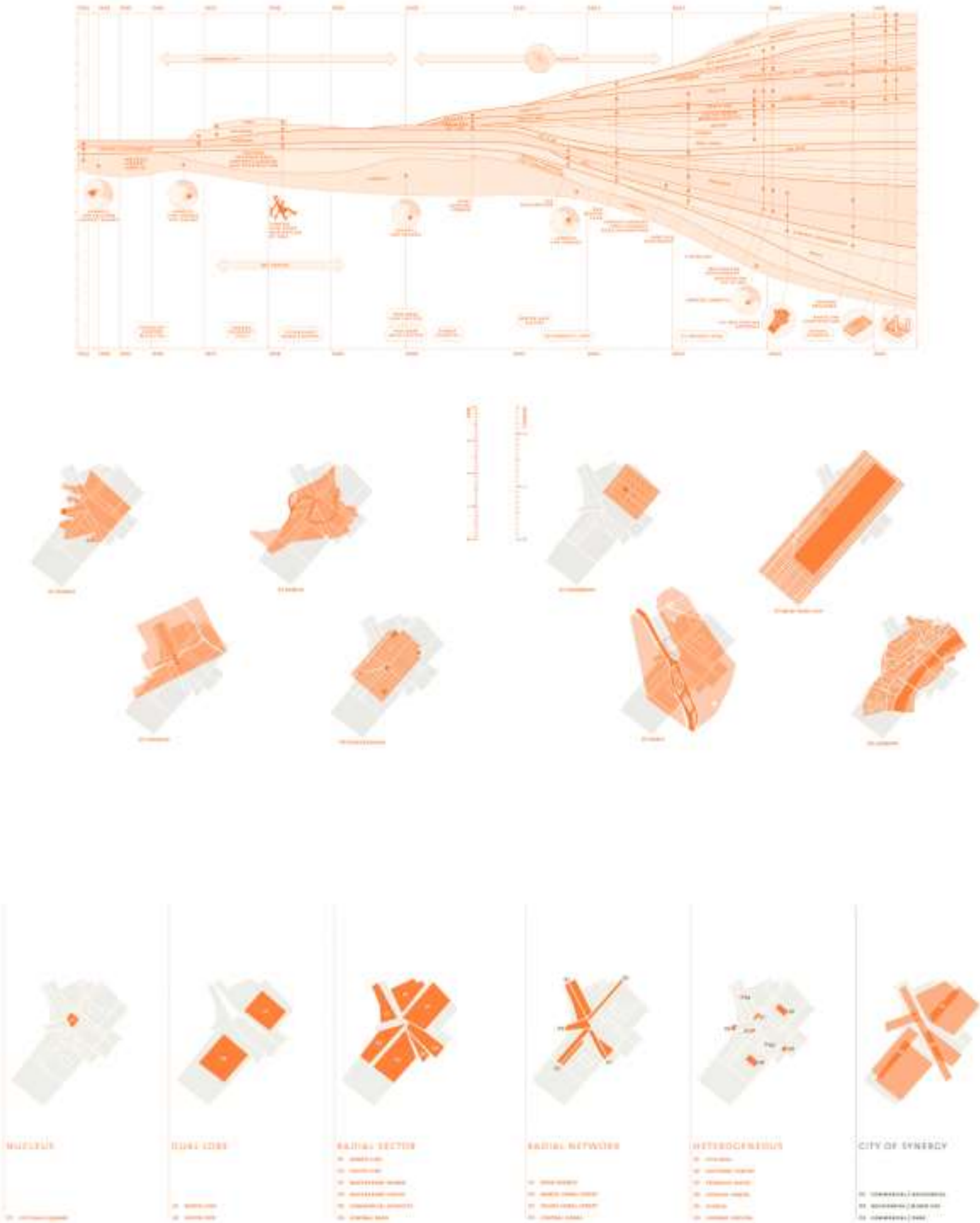
4. Discussion

4.1.1. Songdo

The development pattern of Songdo suggests a certain zeitgeist for urban planning and can serve as a comparative analysis of urban planning ideals found in textbooks and planning in practice. A type of Corbusier’s radiant city, Songdo balances the weight of urban density with contemporary research on ecosystem services and benefits, expertly weaving these green and blue spaces between the steel and concrete supporting urban life.

Among the global leaders experimenting with large-scale BGI implementation is Songdo International Business District (IBD) in South Korea. Designed as a purpose-built smart city on reclaimed land, Songdo has gained international attention for integrating environmental technologies, green spaces, and smart urban systems into a single, master-planned development. This section critically examines Songdo's BGI framework, evaluating its design, water reuse, emissions performance, and planning logic. It then compares Songdo’s model with other global benchmarks- Singapore, New York City, and Vienna - to highlight both the innovations and challenges embedded in technocratic, centrally planned BGI systems.

Figure 17. Virtual Presentation of Songdo's Master Plan



Source(s): KPF Songdo City - TM/R Design, 2023.

4.1.2 Songdo's Blue-Green Infrastructure Model

Songdo's BGI vision is rooted in its identity as a high-tech eco-city. Approximately 40% of its land area is dedicated to green space, an impressive figure for a new urban development (KPF, 2021). At its core is Central Park, a 101-acre urban oasis that incorporates a wind-powered seawater canal, refreshed every 24 hours. This system aids in passive cooling, supports biodiversity, and offers recreational amenities for residents - demonstrating the potential for ecological functions to coexist with urban amenities (Tomorrow Water, 2022). In addition to surface-level greenery, all residential parking is located underground, allowing for uninterrupted pedestrian pathways and park-like landscapes. The city's layout promotes 15-minute walkability, with tree-lined streets, green rooftops, and cycling infrastructure enhancing its ecological and social fabric. The city also employs a pneumatic waste collection system and smart energy grids, monitored through an Integrated Operations Center, aligning its green infrastructure with its broader smart city aspirations.

Figure 18. Songdo Wastewater Reuse Plant

Facility Detail

Capacity: 5.28 MGD

Area: 1,571 ㎡

Treatment Process:
Chemical coagulation/flocculation + Bio-filtration + Ozone Oxidation + Disinfection

Water Quality Summary:

	BOD	SS	T-N	T-P
Influent (mg/L)	10.0	10.0	20.0	2.0
Effluent (mg/L)	3.0	5.0	10.0	0.5

Source(s): Park, 2019.

One of Songdo's most notable BGI contributions is its advanced wastewater reuse system. The Songdo Wastewater Reuse Plant, with a capacity of 5.28 million gallons per day, treats water for non-potable uses such as toilet flushing, irrigation, and park maintenance. This system reduces dependence on potable water and significantly cuts greenhouse gas emissions, contributing to an estimated 70% reduction in emissions compared to similar-scale developments (Shin & Park, 2020).

Figure 19. Key feature of Songdo's urbanism is its emphasis on pedestrian-friendly environments and mixed-use neighborhoods

Source(s): KPF, n.d.

4.2 Comparative Insights Factual Analysis:

4.2.1 Songdo vs New York City

New York's BGI model differs significantly from Songdo's top-down framework. Over the last two decades, New York has pursued decentralized, community-driven green infrastructure, with over 5,000 installations including bioswales, green roofs, and rain gardens (NYC DEP, 2023). Programs like *Cool Neighborhoods NYC* actively target vulnerable neighborhoods with urban heat mitigation projects. While Songdo excels in infrastructure performance, New York leads in equity-oriented innovation. New York's programs of heat vulnerability mitigation and community engagement programs contrast with Songdo's technocratic and developer-driven approach. However, New York's efforts are often hampered by bureaucratic fragmentation and limited cohesion across agencies, where Songdo benefits from a unified development vision.

4.2.2 Songdo vs Singapore

Singapore shares Songdo's emphasis on centrally coordinated, infrastructure-led BGI. Through initiatives like the *Active, Beautiful, Clean Waters* (ABC Waters) Programme and the Green Plan 2030, Singapore mandates the use of bioswales, cleansing biotopes, and stormwater management features in new developments (PUB, 2022). Like Songdo, Singapore's BGI is highly engineered, with green spaces designed to maximize function, aesthetics, and resilience. However, Singapore's approach is more mature in its ecological authenticity and legal integration. The city-state's *Drainage Act*, *Building Control Act*, and Urban Redevelopment Authority Master Plan embed BGI requirements into law, ensuring long-term compliance and adaptation. Where Songdo offers rapid, one-time implementation, Singapore demonstrates the value of iterative, legally entrenched planning and a broader cultural alignment with ecological goals.

4.2.3 Songdo vs Vienna

Vienna presents a slower but more ecologically embedded approach. The city maintains over 50% green space, including the Danube floodplains and protected forests that function as both ecological corridors and climate buffers (UN-Habitat, 2021). Green infrastructure in Vienna is not imposed on the landscape but emerges through participatory planning, often tied to social housing developments and neighborhood needs. Unlike Songdo's engineered and performance-driven BGI, Vienna's model emphasizes long-term ecological continuity and social cohesion. It relies less on technological solutions and more on natural processes, such as river floodplains for water management and passive cooling. Yet, this model may be less replicable in rapidly urbanizing regions, where greenfield developments like Songdo can deploy large-scale infrastructure from the outset.

4.3 Songdo Value Claim

Limited by land area, South Korea has been experimenting with innovative urban systems, such as Oceanix Busan, the floating city, and Songdo, the smart city. Reclaimed from the ocean floor, the 53.4 square kilometers includes 100 million square feet of planned development, including 10 million square feet in the planned Central Park and other integrated green spaces. "Developers promoted a vision of walkable, dense, and mixed-use neighborhoods with all amenities…" (Jung, 2024). This vision was a success, with Songdo being the first LEED-certified city. Public green space makes up 32.4% of the 40% land allocated for public parks, about twice as much land percentage allocation as New York City (Ayral & Cha, 2024). Aligned with the definition of the Smart City, an extensive sensor network collects data on all aspects of urban life and packages that data for the convenience of the population. Pneumatic tube systems and plenty of public waste disposal receptacles have almost eliminated litter and the need for trash collection, automatically sorting urban waste to be sent to the correct processing facility. The pneumatic tube infrastructure is unfeasible to retrofit, making implementation in older cities unlikely. New York would receive the most value from this kind of trash system, the Sanitation Foundation, the official nonprofit partner of the New York Department of Sanitation, found in a 2025 study that 80% of New Yorkers felt litter was a major problem in their community. (Dreyfus Advisors, 2025) Integration of hydrological and urban forest conditions provides many of the necessary ecosystem benefits, such as temperature and humidity control, along with urban heat, and softening the visual rigidity that can appear in rectilinear constructions. The inclusion of a central park further breaks this urban rectilinearity, creating a respite within the grid of city streets. Containing 24 kilometers of urban bike trail and a heavy rail line, (Garfield, 2017) Songdo is improving alternative transportation, reaching for the standards set by the other case study cities. Despite this goal of walkability, Songdo's population remains heavily reliant on personal cars commuting to Seoul for the workday. The future of Songdo transportation policy should focus on reducing commutes to Seoul, and helping residents work within the community they live in.

4.4 Songdo Policy Claim

A state-sponsored development, Songdo has carefully considered the national priority of BGI since the beginning. In this study, policies related to BGI are divided into two categories: those applied during the city planning process and those used for the city's operation. The former focuses on green areas such as Central Park in Songdo, while the latter concerns the city's BGI-related operational systems.

4.4.1 Start of Blue-Green Infrastructure in Songdo

At the outset of the project, it was necessary to establish new guidelines for eco-infrastructure. Although South Korea began addressing issues in haphazard development after the 1990s, there were still not enough policies in place to build an eco-friendly city that meets global standards. Therefore, through various frameworks, the city tried to make green infrastructure planning the cornerstone of every new project. Through policies, mandating green spaces and supporting water by discouraging the use of impermeable paving materials.

The manual for environmentally-friendly urban development provides guidelines on the placement of green spaces to promote eco-conscious city construction. Emphasizing not only improving accessibility to green areas but also highlighting the importance of establishing a green network. The green network refers to a system designed to prevent the fragmentation of wildlife habitats and to promote ecosystem conservation and biodiversity. It is established by systematically connecting key areas such as major mountains and hills with surrounding farmlands, rivers, and wetlands. This network is structured to connect green areas and biological resources along urban axes such as rivers and roads. By attracting wildlife into urban areas through green corridors, it also offers city residents—who may have limited access to nature—opportunities to experience and interact with the natural environment.

Urban green networks are based on the concept of coexistence between humans and nature. Forests and nearby mountainous areas serve as biodiversity reservoirs or genetic resource hubs (core areas), while small mountains, parks, rural farms, and wetlands act as nodes of the green system. Elements such as urban greenbelts and streams serve as ecological corridors. Gardens, rooftop gardens, street trees, and even potted plants are connected through these pathways, forming a cohesive ecological network throughout the city (Ministry of Construction and Transportation & Korea Land Corporation, 2000).

Figure 20. A key feature of Songdo's urbanism is its emphasis on green networking

Source(s): KPF (https://www.kpf.com/project/new-songdo-city)

Figure 21. (left) parks in Songdo (right) green spaces in Songdo

Source(s): Data from Public Data Portal

4.4.2 Green Infrastructure through Landscape Design Guidelines.

As part of Songdo's urban planning strategy, the Incheon Free Economic Zone (IFEZ) provides directional guidance for buildings within Songdo through its Landscape Design Guidelines. While these guidelines primarily focus on the aesthetic aspects of the urban environment, certain elements are closely related to Songdo's Blue-Green Infrastructure model. In particular, the promotion of green roofs and the creation of landscaped areas around buildings contribute to increasing the overall quantity of green space, enhancing public accessibility to greenery, and facilitating more efficient stormwater drainage within the city (Incheon Free Economic Zone Authority, 2020).

5. Conclusion

In comparative terms, Songdo's BGI strategy exemplifies the potential of a clean-slate approach — one that integrates smart technologies, emissions reductions, and high-quality public green spaces from the outset. The city achieves measurable gains in climate resilience, energy efficiency, and water reuse, and offers a compelling testbed for integrated smart-green systems. However, the lack of community involvement, low organic growth, and overemphasis on aesthetics over ecology raise critical concerns. Songdo's BGI, while technically impressive, can feel detached from local cultural and social needs. Without strong place-making, public participation, or ecological spontaneity, Songdo risks becoming a symbol of greenwashing rather than ecological transformation.

Songdo's blue-green infrastructure framework sets an important precedent in demonstrating how advanced technology and centralized planning can yield substantial environmental performance in newly built urban environments. However, comparisons with Singapore, New York, and Vienna suggest that infrastructure alone is insufficient. The long-term success of BGI depends on its ability to combine technological innovation with legal robustness, community participation, and ecological depth. Songdo's lessons are thus both inspiring and cautionary, highlighting the promise of design-led sustainability and the pitfalls of overlooking the environmental and human dimensions of truly resilient urban futures

A master-planned city built entirely on reclaimed land, Songdo incorporated environmental infrastructure into its initial design phase. This positions Songdo as a forward-looking example of how future cities might embed BGI directly into their spatial and technological foundation. This approach becomes more significant when compared with other globally recognized cities for BGI innovation. Cities such as New York, Singapore, and Vienna have all adopted BGI strategies only after their urban forms had already been established. In contrast, Songdo embedded BGI from the outset, allowing for seamless integration between ecological systems and urban infrastructure. This "planning-first" strategy offers a rare model for how environmental functions can be structurally aligned with the overall logic of city-building.

However, in practice, BGI in Songdo remains a component of a broader smart city initiative, rather than a central guiding vision. The city's environmental infrastructure often functions as a supporting element—focused on aesthetics and performance—rather than as a socially embedded or legally institutionalized system. Without stronger regulatory frameworks or civic engagement mechanisms, Songdo's BGI risks being underutilized or disconnected from everyday urban life.

Nonetheless, Songdo's case provides valuable insight into the future of planned urban BGI. Its large-scale, infrastructure-led approach demonstrates how climate adaptation can be addressed from the ground up. To fully realize this potential, Songdo must move beyond a purely technological approach and develop a BGI system that is shaped and sustained by local residents and communities.

6. Conflict of Interest

The authors declare no conflict of interest.

7. Acknowledgements

To the best of the authors' knowledge, this paper is an independent student-led research containing no material which has been accepted for any publication, previously published, or written by another person, except where references are made in the text and where the authors submitted the paper. Every reasonable attempt has been made to identify owners of copyright. Errors or omissions will be corrected in subsequent additions.

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8. Abbreviations List

Abbreviation	**Definition**
(ABC) Waters Programme	Active, Beautiful, Clean
APA	American Planning Association
BCA	Building and Construction Authority
BGI	Blue-Green Infrastructure
GI	Green Infrastructure
LEED-ND	Leadership in Energy and Environmental Design for Neighborhood Development
LID	Low-Impact Development
NParks	National Parks Board
NYC DEP	New York Department of Environmental Protection
URA	Urban Redevelopment Authority
UHI	Urban Heat Island
IBD	International Business District

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