

Comparative Analysis of Sustainable Strategies in Tivoli Greencity, The Garigate Park, Sege Park, and Madrid Nuevo Norte Using Sustainable Rating Tools

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ABSTRACT

This research paper evaluates the role of sustainable rating tools in urban development through a comparative analysis of four (4) certified sustainable projects: Tivoli GreenCity in Belgium, Garigate Park in Bulgaria, Sege Park in Sweden, and Madrid Nuevo Norte in Spain. Certified under frameworks such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Methodology (BREEAM), and Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL), these projects demonstrate different approaches to sustainability in urban planning and implementation. As cities face increasing challenges related to climate change and resource management, sustainable rating tools have become important mechanisms for guiding environmentally responsible urban growth. Data were collected from official planning documents, sustainability reports, and secondary sources, and analysed using qualitative content analysis supported by a comparative matrix framework. The assessment focused on key sustainability dimensions, including energy performance, material use, water management, green infrastructure, and community-oriented planning. The findings indicate that Garigate Park shows strong performance in material sustainability and health-focused design, Tivoli GreenCity emphasises energy efficiency, while Sege Park and Madrid Nuevo Norte demonstrate strengths in community engagement and land-use integration. The study highlights how contextual, regulatory, and planning factors influence sustainability priorities, offering insights for future sustainable urban development.

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INTRODUCTION

Strategic improvements to enhance the built environment are crucial in reducing the emission of greenhouse gases and mitigating the negative impact of climate change (Sekban & Düzgüneş, 2021). A drastic approach through the cooperation of the community and government may provide a resilient environment for all sectors (Labaran et al., 2022). Rapid development in the urban area leads to deleterious impacts to our nature, especially on the heat island, global warming, and carbon emission (Huang et al., 2024). Additionally, according to International Energy Agency (2023), the transportation and buildings sector was identified as among the main contributors to the final energy consumption. An effective approach to the development of building design within the urban area requires consideration based on sustainable guidelines. The implementation of active and passive design strategies can enhance the built environment condition (Ibrahim & Sajjadian, 2024) through a systematic sustainable regulation system. Sustainable rating tools were recognised as the vital instruments to assess both buildings and urban development (Wen et al., 2020). Sustainable rating tools such as Building Research Establishment Environmental Assessment Methodology (BREEAM) and Leadership in Energy and Environmental Design (LEED) have become pivotal to shape the modern urban development practices. These tools serve as comprehensive frameworks that evaluate the construction's impact to the nature and design decisions. Most of the rating tools consider various aspects, such as water conservation, waste management, energy efficiency and societal contributions that inspired professional people in the construction industry to develop more eco-conscious, resilient communities and built environment.

LEED places strong emphasis on measurable outcomes and impacts such as mitigation of carbon dioxide (CO₂) emissions, energy savings, enhancement of indoor environmental quality, water efficiency, and responsible use of natural resources throughout a building's life cycle (Romano et al., 2023). Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) and BREEAM share similar environmental objectives but extend their scope to include broader dimensions such as social responsibility, stakeholder engagement, and resilience planning to adapt to climate change impacts (Sangiao & Hermida, 2023). By embedding these assessment systems into the urban planning and policy-making process, city planners, architects, and developers gain access to quantifiable benchmarks and best practices that guide decision-making. This integration ensures that urban spaces are purposely developed to mitigate the negative impacts to the natural environment, accessibility, improving community health and well-being of city dwellers. In term of rapid urbanisation and mounting climate pressures, the adoption of these frameworks becomes essential, as they support the creation of resilient, low-carbon cities helping to mitigate environmental harm and elevate the community life quality, making urban areas more liveable, inclusive, and sustain to the challenges ahead (Sala Benites et al., 2022).

Sustainable rating systems like LEED, BREEAM, and CEEQUAL have become important frameworks for guiding environmentally friendly urban and infrastructure development. Over the past decade, these tools have been adapted to different regional contexts. They now support emerging sustainability policies such as the European Union Level(s) framework (Sánchez Cordero et al., 2020) and address various performance priorities in different countries (Piętocha, 2024). Comparative studies show that while these systems successfully promote environmental performance and resource efficiency, differences in scoring criteria, social engagement, and economic assessment still exist (Silva & Ramirez, 2021). Recent developments, including the integration of CEEQUAL into BREEAM Infrastructure, highlight a broader focus on civil engineering and public projects. This shift reflects the increasing demand for comprehensive sustainability in large-scale developments (Mehraban et al., 2025).

LITERATURE REVIEW

Introduction To the Selected Sustainable Urban Development

Tivoli Greencity, Belgium (Recognised by BREEAM)

Tivoli Greencity, Belgium, has been recognised by Building Research Establishment Environmental Assessment Methodology (BREEAM) with 95% Outstanding in the version of BREEAM Communities 2012. Tivoli Greencity embraced a visionary sustainable approach, aiming to transform a neglected urban area at the junction of Laeken's dense housing district and the Brussels Port industrial zone. This initiative intends to integrate mixed-use development, harmonising housing with economic activities seamlessly. Its flagship, the Greenbizz pole, launched in 2016, serves as an innovation hub, fostering sustainable entrepreneurship with facilities like a small and medium-sized enterprises park, fab lab, and innovation hub under one (1) roof (Bilande et al., 2016). The district comprises around 400 sustainable residences, promoting energy efficiency and eco-friendly living (Ecobuild Brussels, 2025).

Emphasising community, Tivoli GreenCity offers shops, daycare centres, and communal spaces, fostering social interaction. It sets a high standard in sustainable living by focusing on resource management and incorporating eco-friendly infrastructure such as passive building techniques, cogeneration systems, photovoltaic panels, greywater treatment, and an urban heating network. This development, crafted through a collaborative approach involving renowned architectural firms and engineering expertise, showcases innovative design features like the Greenbizz construction, a remarkable architectural standout in the landscape (Ecobuild Brussels, 2025).



Fig. 1. Aerial View of Tivoli Greencity, Belgium

Source: CERAU (2024)

Tivoli Greencity in Belgium (Figure 1) exemplifies a multifaceted approach to sustainability across various elements of urban development. Energy efficiency takes centre stage with a district heating system and rooftop photovoltaic panels, ensuring a collective energy supply and reduced consumption costs.

Innovation shines through in the green roofing design, fostering biodiversity support and featuring vegetable gardens atop buildings. Land use planning prioritises biodiversity, seamlessly integrating diverse biotopes into both public and private spaces. Waste management initiatives encourage responsible sorting and composting, minimising environmental impact. Transport strategies prioritise sustainability, with a focus on reducing traffic and promoting cycling routes and footpaths adorned with green spaces. Efficient water management strategies, including rainwater utilisation and permeable materials, not only reduce city water usage but also enhance water retention. Moreover, Tivoli Greencity's commitment to sustainable materials and waste reduction underscores its dedication to environmentally conscious architecture, setting a commendable example for sustainable urban development worldwide.

Requiring BREEAM certification for Tivoli Green City in Belgium serves several important functions. Initially, it ensures that the project conforms to stringent environmental sustainability standards, demonstrating a firm commitment to eco-friendly practices. Through thorough evaluation and verification procedures, BREEAM certification guarantees the quality and adherence to optimal approaches in design and construction, thereby assuring the community regarding the project's credibility. Furthermore, by achieving sustainability goals and embracing environmentally conscious design principles, BREEAM-certified buildings within Tivoli Green City become more attractive to potential buyers and tenants seeking environmentally responsible living spaces. Additionally, adhering to BREEAM standards can simplify the regulatory approval process, thereby facilitating the project's advancement. Moreover, the enduring benefits of BREEAM certification, including energy efficiency improvements and enhanced indoor air and comfort quality, promote significantly to the resilience and life quality, fostering a resilient and environmentally conscious community in Belgium. The recognition of Tivoli Green City as the first neighbourhood in the Benelux region to attain BREEAM Communities certification with one of the highest scores globally, at 95.0%, underscores its leadership in sustainable urban development and establishes a model for forthcoming projects in the area.

The Garigate Park, Bulgaria (Recognised by BREEAM)



Fig. 2. Aerial View of The Garigate Park, Bulgaria

Source: Ivanova and Popova (2017)

Building Research Establishment Environmental Assessment Methodology (BREEAM) has recognised the Garigate Park with 71% Excellent in the version of BREEAM Communities 2012. Garigate Park in Bulgaria stands as a comprehensive development, prioritising not just the immediate needs of residents and businesses but also sustainability and community connectivity. Encompassing a vast expanse of 165,000 square metres, it combines residential, commercial, educational, and recreational elements. A significant portion of the project, a 90,000 square metre park with a lake, footpaths, and playgrounds, emphasises natural communal spaces. Its residential segment includes 48 row houses and 14 apartment blocks designed for comfort and scenic views, complemented by nearby amenities such as retail units, a sports centre, restaurants, and a supermarket (SGI Architects & Masterplanners, 2017).

The project's core theme centres on fostering a thriving community, ensuring a balanced environment for living, working, studying, and leisure. Furthermore, Garigate Park's commitment to infrastructure enhancement involves plans for bicycle and pedestrian paths, promoting connectivity, and easy access to multiple transportation modes for efficient commuting (SGI Architects & Masterplanners, 2017).

Garitage Park in Bulgaria stands as a reflection to a steadfast commitment to a more resilience development across multiple facets of its design and operation. Energy efficiency is paramount, with sophisticated recuperating and heat recovery systems efficiently harnessing waste heat energy and optimising energy use within buildings. Transportation infrastructure is also a priority, integrating eco-friendly modes like bicycle lanes and shared options to alleviate congestion and foster sustainable commuting. Moreover, the park prioritises user comfort and wellbeing, improving air quality and implementing a "green ring" design to mitigate noise and dust pollution, creating a serene environment. Biodiversity preservation is central to its land use strategy, connecting wildlife habitats within the park and adjacent protected areas to promote ecological balance. Water management is meticulously addressed, with significant areas allocated for rainwater harvesting and measures in place to prevent water pollution. Furthermore, the park upholds stringent environmental standards in its material selection for public spaces, ensuring sustainability throughout. Lastly, active management of construction waste underscores its commitment to responsible waste management, exemplifying Garitage Park's dedication to environmental responsibility and effective on the sustainable programme.

Integrating BREEAM requirements into the Garigate Park project in Bulgaria serves as a pivotal step towards ensuring its sustainability and resilience, aligning with the BREEAM Community 2012 standard. By committing to achieving 71% compliance with BREEAM Community 2012 criteria, the project not only prioritises minimising its environmental impact but also emphasises social responsibility and economic viability. Through comprehensive assessments covering ecological preservation, water management, energy efficiency and waste handling, Garigate Park potentially reduce the carbon emission and operational costs over time. Moreover, BREEAM's emphasis on factors like health, wellbeing, accessibility, and community engagement fosters a vibrant and inclusive environment within the project, enhancing its social value and marketability. Embracing BREEAM certification not only demonstrates Gate Park's commitment to environmental stewardship but also positions it as a beacon of sustainable development, setting a precedent for future projects in Bulgaria and beyond.

Sege Park, Sweden (Recognised by CEEQUAL)

Sege Park has been recognised by Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) with 76.9% Excellent. Sege Park, situated in Malmö's eastern region, represents a sustained effort over nearly a decade to transform an erstwhile hospital area into a sustainable residential district. Its primary goal is to introduce new apartments, amenities, and expansive public spaces, including a revamped park, to set a benchmark for sustainability and climate resilience in Malmö. A notable emphasis

lies in the project's dedication to preserving Sege Park's cultural, historical, and ecological heritage, ensuring its lasting significance for future generations (Bregroup, 2023).

The project meticulously considered the existing trees, protecting them during construction to maintain biodiversity, fostering community participation by offering vegetable patches to residents. Additionally, Sege Park's focus on retaining most of the 1930s buildings preserves the area's cultural heritage while enhancing the urban layout through the creation of a central alley linking green spaces within and outside the district. This strategic approach places paramount importance on conserving biodiversity and preserving Sege Park's unique architectural identity (Bregroup, 2023).



Fig. 3. Aerial view of Sege Park, Sweden

Source: Malmö stad. (2016)

Sege Park in Sweden embodies effective strategy in term of sustainable programme across multiple facets via its design and operation. Its energy strategy integrates innovative grid systems, renewable sources, and energy-saving technologies to prioritise eco-consciousness and resource efficiency. At the same time, sustainable transportation solutions, including cycling lanes and improved public transit, aim to reduce private vehicle reliance and promote an eco-friendlier commuting environment. Community-oriented sustainability initiatives intertwine with landscape design, integrating community gardens for urban agriculture and rainwater harvesting strategies to foster efficient water usage. Educational workshops and events raise awareness, fostering an eco-conscious culture among residents. Furthermore, the park's landscape design incorporates flood-resistant and stormwater management systems, preserving aesthetics while managing stormwater runoff. Emphasising biodiversity through wildlife corridors and green spaces, Sege Park nurtures diverse ecosystems with native plant species and innovative installations like green roofs and vertical gardens. Moreover, the park focuses on comprehensive waste management, promoting recycling, composting, and reduced usage of non-recyclable materials, fostering an environmentally responsible community committed to sustainable living practices.

Sege Park, located in Malmö's eastern region, has garnered acclaim with a remarkable 76.9% Excellent rating from CEEQUAL, underscoring its steadfast commitment to sustainable development. This recognition reflects Sege Park's holistic approach to sustainability, evident in its energy-efficient building

design, innovative water management systems, responsible materials sourcing, and active community engagement initiatives. By exceeding industry standards and fostering partnerships with local stakeholders, Sege Park successfully minimises the negative impact to the environment, creates economic and social benefits, including job opportunities and community cohesion. As a pioneering example of sustainable urban development, Sege Park sets a new benchmark for responsible growth, inspiring similar initiatives globally while enhancing the well-being and resilience of its residents and surrounding communities.

Madrid Nuevo Norte (Recognised by BREEAM & CEEQUAL)

Building Research Establishment Environmental Assessment Methodology (BREEAM) has recognised Madrid Nuevo Norte with a pass and Leadership in Energy and Environmental Design (LEED) with a gold rating in the version of BREEAM Communities. Madrid Nuevo Norte stands as Europe's most significant ongoing urban revitalisation endeavour, approved by the Governing Council of the Community of Madrid. This monumental initiative aims to position the region, particularly the capital, as a model for 21st-century urban planning, focusing on cutting-edge trends in mobility, energy efficiency, and environmental sustainability. With plans to generate 250,000 jobs, significantly impacting economic growth, the project aims to become a nucleus for innovation, drawing global companies and investments. Housing development, accounting for 10,500 new homes, allocates 20% for public use while prioritising sustainable transportation, linking public spaces to eco-friendly travel alternatives like walking or cycling (ARUP, 2023).

Its focus on public transport enhancement, including new Metro and Cercanías stations, marks a shift towards sustainable mobility, complemented by plans for extensive green spaces, such as a Central Park atop the Chamartín railway. Additionally, Madrid Nuevo Norte integrates cultural heritage into its green corridors, fostering community interaction while emphasising over 13 kilometres of new bike lanes to connect neighbourhoods and promote environmentally friendly commuting (ARUP, 2023).



Fig. 4. Aerial view of Madrid Nuevo Norte, Spain

Source: Fernández (2023)

Madrid Nuevo Norte showcases an unwavering commitment to Sustainable Development Goals (SDGs) through innovative strategies for efficient energy production, conservation, and management (Melcón et al., 2024). The project focuses on establishing low-carbon energy systems, integrating smart grids, and promoting electric transport (Metaxas et al., 2021). The aim is to reduce CO₂ emissions, emphasising sustainable energy consumption, mitigating the usage of fossil fuels and significantly increasing solar energy production across buildings and public spaces (CREA, 2020). Additionally,

prioritising health and wellbeing, Madrid Nuevo Norte designs interconnected green spaces, including walking paths, cycling lanes, and parks, fostering physical activity, relaxation, and community engagement. This commitment to sustainability influences every design choice, with parklands, playgrounds, and green spaces spanning approximately 450,000 square metres, aimed at restoring natural hydrologic processes for better stormwater management and biodiversity promotion. Moreover, the project emphasises sustainable transport solutions, upgrading railway and road infrastructure to reduce car usage, establishing a transport-centred city model, and fostering economic growth while prioritising sustainability. Water conservation and intelligent management are also integral, with innovative measures like rainwater collection and porous pavements ensuring wise water usage, replenishing aquifers, and promoting a sustainable water cycle within the community. Madrid Nuevo Norte's holistic approach showcases its dedication to sustainable practices across energy, health, land use, transportation, and water management, aiming to create a model urban environment prioritising sustainability and community wellbeing.

In the ambitious Madrid Nuevo Norte urban development, sustainability is paramount. To achieve this goal, incorporating assessment methods like BREEAM and CEEQUAL is crucial. BREEAM's comprehensive criteria cover various aspects of building sustainability, from energy efficiency to waste management, ensuring that the development aligns with environmentally friendly practices. Likewise, CEEQUAL's focus on civil engineering and infrastructure projects ensures that critical components such as transportation systems and public spaces are designed and constructed sustainably. By embracing these frameworks, Madrid Nuevo Norte not only minimises its environmental footprint but also enhances its marketability and appeal to stakeholders who prioritise sustainability. This holistic approach to sustainability provides various benefits especially on the positive contribution for the community and environment it serves.

Sustainable Rating Tools

BREEAM Assessment

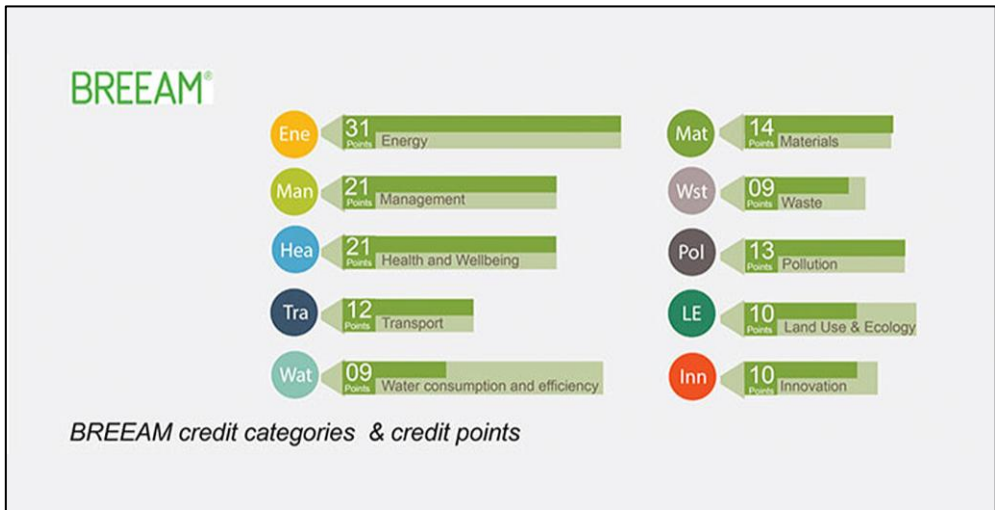


Fig. 5. BREEAM Credit Categories & Credit Points

Source: On greening (2018)

The Building Research Establishment Environmental Assessment Methodology (BREEAM) evaluation process is a comprehensive assessment that evaluates in various categories, including water, energy, waste and materials (Feijão et al., 2024). It considers the operation, building's design and construction to determine its sustainability against specific criteria and benchmarks. The assessment methodology is detailed, with over 400 pages of guidelines covering a wide range of assessment issues. These categories include management, land use, energy, health, water, pollution, materials and waste. Every category has specific criteria that the building must meet to earn points (On greening, 2018).

The BREEAM assessment examines a building's specifications, construction, design and operation through recognised measures of performance. These measures are compared against benchmark criteria in nine (9) categories, including energy (covering both facility operational consumption and embodied CO₂ emissions), management (evaluating policies, commissioning, site management, and procurement practices), health and wellbeing (considering indoor and external factors affecting health), materials (assessing environmental impacts of building materials), transport (evaluating transport-related CO₂ emissions and accessibility), water (assessing consumption and efficiency), waste (evaluating waste management), pollution (assessing measures to reduce pollution), and land use & ecology (considering site and building footprint, ecological value, and conservation efforts).

Table 1. BREEAM Credit Categories and Credit Points

Credit Categories	Good	Very Good	Excellent	Outstanding
Credit Points	> 45% score	> 55% score	> 70% score	> 85% score

Source: On greening (2018)

As shown in Table 1, BREEAM evaluates the building based on its performance in each category and assigns points accordingly. These points are then multiplied by an environmental weighting factor to calculate an overall score. The final score determines the BREEAM rating, which ranges from Acceptable to Pass, Good, Very Good, Excellent, and Outstanding. Each rating corresponds to a different level of sustainability performance. (Kaur & Garg, 2019).

Tivoli GreenCity in Laeken, Belgium, is an exemplary sustainable neighbourhood that won several awards, including the BREEAM Award for the best BREEAM project in Western Europe in 2021. The project's sustainable elements, such as passive buildings, green energy production, water management, and biodiversity, have been recognised by the BREEAM Awards, with an excellence rating in sustainable construction. The project's BREEAM certification, with 95.0% - Outstanding, is the highest score ever achieved worldwide. The project outlines a clear road-map for safeguarding our environment, committing to tangible targets in energy saving, biodiversity support, renewable energy output, water stewardship, awareness-building, and grassroots engagement. Every building meets the stringent demands of the 'passive PEB 2015' standard, while 35% of dwellings are engineered for a 'zero energy' distinction. The project also includes the renovation of the Belgacom building, which will serve as a cornerstone for the new district in the old one, preserving architectural heritage and reducing waste.

LEED Assessment

Leadership in Energy and Environmental Design (LEED) assessment requires projects to meet specific prerequisites and earn points through credits across various categories. Every project must first satisfy mandatory prerequisites in areas such as indoor environmental quality, sustainable sites, energy use and water efficiency. Following this, projects earn points by fulfilling credit criteria in several key areas, including location and transportation, integrative process, sustainable sites, water efficiency, materials and

resources, energy and atmosphere, design innovations and indoor environmental quality, as shown in Figure 6.

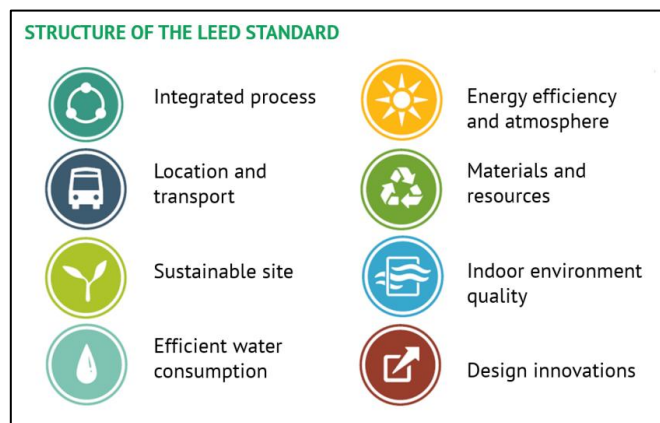


Fig. 6. Structure of the LEED Standard

Source: Sustainable Planning Associates (2015)

For instance, credits can be earned by implementing a variety of strategies designed to improve the building's environmental performance. One such strategy is rainwater management, which involves the capture and reuse of rainwater for non-potable uses such as irrigation, thereby reducing the demand on municipal water supplies and mitigating stormwater runoff. Another strategy is the installation of alternative-fuel stations, which support the use of electric or hybrid vehicles by providing convenient charging infrastructure, thereby promoting sustainable transportation and reducing greenhouse gas emissions.

Additionally, using renewable materials in construction, such as bamboo flooring, recycled steel, or low-emission adhesives and paints, contributes to the conservation of natural resources and the reduction of toxic emissions. Each of these strategies aligns with specific LEED credit criteria, which are designed to address various environmental and health impacts associated with building projects. The total number of points a project accumulates from these credits determines its certification level within the LEED rating system. Projects must earn between 40 and 49 points to achieve the Certified level, which indicates that the building meets basic standards of sustainability. A Silver certification, requiring 50-59 points, signifies a higher level of commitment to sustainable practices. Gold certification, achieved with 60-79 points, represents a significant advancement in sustainability and efficiency measures. The highest level, Platinum, requires 80 or more points and denotes exceptional environmental performance and leadership in sustainable building practices.



Fig. 7. LEED Rating System

Source: Fiveable Content Team (2025)

Madrid Nuevo Norte, a large-scale urban redevelopment project in Madrid, Spain, serves as a prime example of a project aiming to achieve LEED certification. This ambitious initiative, one of the most significant urban regeneration projects in Europe, seeks to transform a substantial area of northern Madrid into a sustainable, modern, and vibrant urban environment.

CEEQUAL Assessment

Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) is an internationally recognised framework designed to assess, improve, and celebrate the sustainability and environmental performance of civil engineering, infrastructure, landscaping, and public realm projects (BRE, 2018). Administered by the Building Research Establishment (BRE), CEEQUAL covers a broad spectrum of categories, including project management, land use and landscape, ecology and biodiversity, water environment, energy and carbon, material use, waste management, transport, and social and economic aspects. The assessment process involves a self-assessment by the project team, followed by independent verification by an accredited CEEQUAL Assessor. Projects are scored based on their performance, earning ratings that range from Pass to Outstanding. CEEQUAL encourages the integration of sustainable practices, enhances reputations, engages stakeholders, and identifies cost-saving opportunities through efficient resource use. For example, a new railway line project undergoing CEEQUAL assessment would ensure minimal environmental impact, sustainable material use, and effective community engagement. Ultimately, CEEQUAL drives sustainable practices in civil engineering and infrastructure projects, contributing to environmental, social, and economic benefits.

Table 2. CEEQUAL Rating System

Grade	Pass	Good	Very Good	Excellent
Score	> 25%	> 40%	> 60%	> 75%

Source: Rageh et al. (2023)

CEEQUAL assessments provide a structured evaluation of civil engineering and infrastructure projects, resulting in certifications that range from Pass to Outstanding, reflecting the project's sustainability performance. The rating levels are determined by the percentage of total possible points a project earns. A Pass rating is awarded to projects that achieve 25-39% of the total points, indicating basic compliance with CEEQUAL's sustainability criteria. A Good rating, given to projects earning 40-59%, signifies a more substantial implementation of sustainable practices. Projects that achieve 60-74% receive a Very Good rating, demonstrating significant achievements in areas such as energy efficiency and water management. An Excellent rating is awarded to projects scoring 75-89%, showcasing exceptional performance across all sustainability categories. The highest level, Outstanding, is reserved for projects that earn 90% or more of the total points, reflecting extraordinary achievements and innovation in sustainability.

Sege Park, an urban development project in Malmö, Sweden, serves as an exemplary case of a project aiming for CEEQUAL certification. This innovative initiative focuses on transforming a former hospital area into a sustainable and vibrant residential neighbourhood, demonstrating the principles of sustainable urban planning and development. Sege Park aims to achieve a high CEEQUAL rating, with the potential to achieve Very Good or Excellent status. The project's comprehensive sustainability strategies and holistic approach to urban development are designed to meet the rigorous standards set by CEEQUAL. By scoring

well in various categories, Sege Park demonstrates a strong commitment to environmental stewardship, social responsibility, and economic sustainability.

METHODOLOGY

This study adopts a qualitative comparative research design encompassing the data collection, case studies, and analysis of sustainable strategies according to the respective sustainable tools to evaluate how different sustainable rating tools influence sustainability priorities in certified urban development projects. Rather than assessing numerical certification scores, the research focuses on identifying patterns of emphasis and omission across sustainability dimensions embedded within LEED, BREEAM, and CEEQUAL-certified projects.

Data Sources Collection

Data were collected exclusively from secondary but authoritative sources, including:

- (i) Official LEED, BREEAM, and CEEQUAL certification and assessment reports.
- (ii) Approved urban master plans and project documentation released by developers and municipal authorities.
- (iii) Peer-reviewed academic publications addressing sustainable urban development and rating tools.

These sources were triangulated to enhance analytical reliability and minimise interpretive bias.

Case Study Selection Criteria

The selection of urban development's adheres to established criteria recognised by renowned sustainable rating tools like LEED, BREEAM, and CEEQUAL. Four (4) European urban developments were selected based on the following criteria:

- (i) Formal certification under internationally recognised sustainability rating tools (LEED, BREEAM, and/or CEEQUAL);
- (ii) Representation of different geographical, regulatory, and climatic contexts within Europe;
- (iii) Comparable urban scale and mixed-use development typology;
- (iv) Availability of publicly accessible certification and planning data.

Each development holds distinct ratings showcasing its commitment to sustainability. Tivoli Greencity secured an outstanding rating within the BREEAM framework, Garigate Park achieved an excellent BREEAM rating, and Sege Park obtained an excellent rating from CEEQUAL. At the same time, Madrid Nuevo Norte showcased its commitment by securing both a BREEAM pass rating and a prestigious LEED Gold certification.

Final Selection and Analysis

A comparative content analysis was conducted using a sustainability checklist derived from common categories across the three (3) rating tools. These categories include energy consumption, innovation, land use, waste, transport, water, health and wellbeing, people and communities, ecology and biodiversity, materials, and physical resource use.

Each case study was examined to identify the explicit presence and strategic emphasis of these categories within certified outcomes and planning narratives. A comparative matrix was then constructed to enable cross-case analysis, highlighting convergences, divergences, and contextual drivers. This approach strengthens methodological rigour by moving beyond description toward structured comparison.

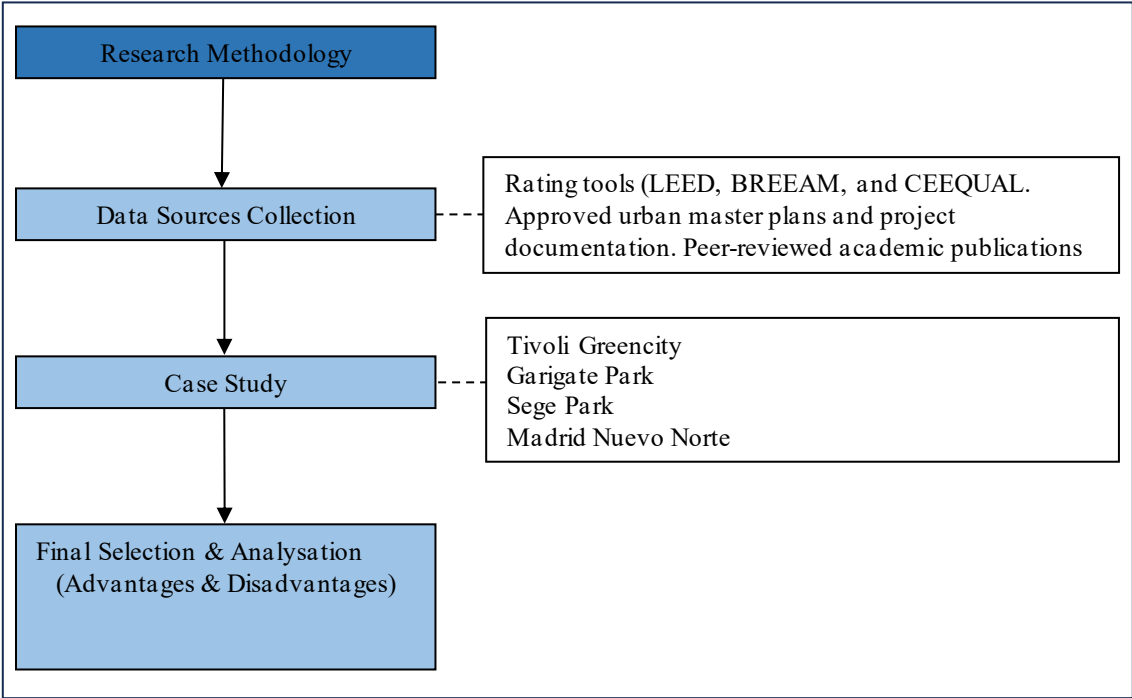


Fig. 8. Flow Chart for Research Methodology
Source: Authors (2024)

RESULTS AND DISCUSSION

Table 3. Sustainable Elements in Four (4) Cities Between Tivoli Greencity (Belgium), The Garigate Park (Bulgaria), Sege Park (Sweden), And Madrid Nuevo Norte (Spain).

Cities/ Sustainable Elements	Energy Consumption	Innovation	Land Use	Waste	Transport	Water	Health & Well-being	People & Communities	Ecology & Biodiversity	Material	Physical Resources Use	Total
Tivoli Greencity, Belgium	/	/	/	/	/	/						6
The Garigate Park, Bulgaria	/		/	/	/	/	/			/		7
Sege Park, Sweden	/		/					/	/		/	5
Madrid Nuevo Norte, Spain	/		/		/	/	/					5
Total	4	1	4	2	3	3	2	1	1	1	1	

Source: Authors (2024)

Analysis of Sustainable Elements in Four Cities

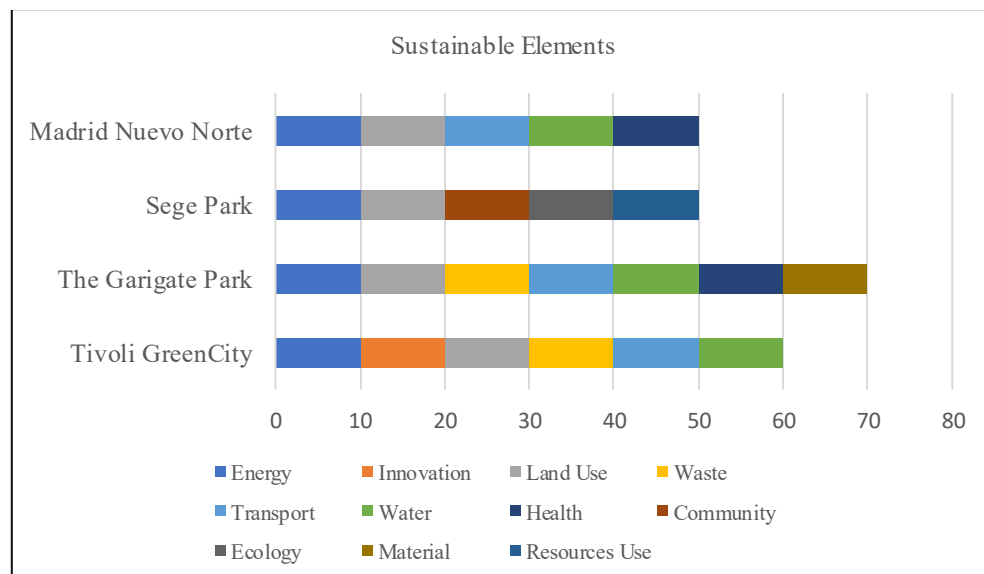


Fig. 9. The Graph Analysis of Sustainable Elements In four (4) Cities Between Tivoli Greencity (Belgium), The Garigate Park (Bulgaria), Sege Park (Sweden), And Madrid Nuevo Norte (Spain).

Source: Authors (2024)

The comparison of sustainable elements across Tivoli Greencity, The Garigate Park, Sege Park, and Madrid Nuevo Norte offers a detailed overview of urban sustainability strategies, each tailored to meet

distinct goals shaped by regional priorities, environmental concerns, and social needs. Each of these urban developments, located in different parts of Europe, employs unique approaches to achieving sustainability, ranging from firm commitments to energy efficiency and infrastructure development to the integration of health, community wellbeing, and biodiversity conservation.

Tivoli Greencity: A Comprehensive Focus on Resource Efficiency

Tivoli Greencity adopts a sustainability model with a total focus of 60%. Its key priorities are Energy Consumption, Innovation, Land Use, Waste, Transport, and Water Management. The significant focus on energy efficiency reflects Tivoli Greencity's commitment to minimising carbon emissions and lowering the overall energy footprint of the development. Energy-efficient systems, such as passive building standards, renewable energy sources, and green energy production, are likely employed throughout the project, contributing to its well-rounded approach to resource conservation. In addition to its energy focus, Innovation stands as another significant pillar of Tivoli Greencity's strategy. The emphasis on innovation could translate to the use of cutting-edge building technologies, innovative infrastructure, and integrated energy and transport systems that enhance both sustainability and convenience for its residents. The integration of Transport systems within the development likely addresses urban mobility, mitigating usage on fossil-fuel-powered transportation modes, and encouraging the use of electric vehicles (EVs), public transport, cycling, and walking.

Land Use and Waste Management are also strong areas in Tivoli Greencity's sustainability agenda. By optimising land use, the development likely balances urban density with green spaces, contributing to both environmental sustainability and quality of life. Effective Waste Management practices, such as recycling programmes, waste reduction initiatives, and circular economy principles, further contribute to its sustainable framework (BSI, 2014). However, Tivoli Greencity's relatively lower focus on Material and Ecology presents an area for potential improvement. While the development excels in energy and resource efficiency, the limited attention to sustainable materials suggests an opportunity to incorporate more eco-friendly, recycled, or renewable materials into its buildings. Furthermore, the reduced emphasis on Ecology indicates a gap in integrating biodiversity-friendly solutions, such as urban green spaces, wildlife corridors, and conservation of flora and fauna, which are critical to enhance the engagement through urban and built environment.

The Garigate Park: Prioritising Material Sustainability and Wellbeing

The Garigate Park, in Bulgaria, stands out with a higher total sustainability focus of 70%, reflecting its broader range of priorities, including Energy Consumption, Land Use, Waste, Transport, Water, Health & Wellbeing, and Material. This development highlights the importance of sustainable material use, with Material being its highest focus. By prioritising sustainable building materials, the development aims to reduce embodied carbon—an often-overlooked contributor to a building's carbon footprint—and promote circular economy principles. The implementation of local recycle material resources is likely encouraged, thus reducing the unnecessary impacts of the construction activities to the built environment.

Health & Wellbeing receives significant attention, indicating that the Garigate Park prioritises on the environmental sustainability and the community health. The strategy focuses in design elements such as recreational areas, green spaces, pedestrian-friendly pathways, and indoor air quality improvements. Buildings and public spaces designed to enhance natural light, reduce noise pollution, and promote physical activity are also likely features, contributing to overall well-being.

While the Garigate Park adopts a balanced approach across several sustainability elements, its lower emphasis on Ecology and Community suggests a more infrastructure-centred development. While the focus on Energy Consumption, Land Use, and Transport aligns with traditional urban sustainability goals, the relative neglect of biodiversity and community engagement might limit its potential for fostering inclusive and ecologically vibrant urban spaces. By incorporating more biodiversity conservation efforts and encouraging community participation in sustainability initiatives, the Garigate Park could further enhance its environmental and social impact.

Sege Park: Emphasising Community and Ecological Sustainability

Sege Park follows a different sustainability strategy, with a total focus of 50%, primarily emphasising Energy Consumption, Land Use, People and Communities, Ecology and Biodiversity, and Physical Resources Use. This development demonstrates a more socially inclusive and environmentally conscious approach to sustainability. The strong emphasis on People and Communities suggests that Sege Park prioritises social cohesion, community engagement, and participatory planning. Such a focus might be reflected in the creation of shared spaces, community gardens, or initiatives that encourage residents to participate in local sustainability efforts.

The attention to Ecology and Biodiversity also highlights Sege Park's commitment to preserving natural ecosystems and promoting biodiversity within urban environments. By incorporating green spaces, urban forests, or wildlife-friendly habitats, the development seeks to maintain an ecological balance, providing residents with opportunities to reconnect with nature while promoting environmental health. This focus on biodiversity also supports climate resilience, as green spaces serve to reduce the carbon emission to the environment and decrease the climate change effect.

Physical Resources Use especially on the efficient water usage, energy consumption and materials, reflects Sege Park's dedication to minimising resource consumption and promoting environmental sustainability. The reduced emphasis on Innovation and Health suggests that while the development effectively manages resources and fosters community wellbeing, it may follow more conventional approaches to urban sustainability rather than pursuing cutting-edge solutions.

Madrid Nuevo Norte: Balancing Energy, Transport, and Health

Madrid Nuevo Norte, also focuses on sustainability with a total score of 50%. Its sustainability strategy revolves around Energy Consumption, Land Use, Transport, Water, and Health & Wellbeing, indicating a strong contribution for both social and environmental sectors. The inclusion of Health & Wellbeing in its strategy demonstrates Madrid Nuevo Norte's dedication to enhance on the community lifestyle. Through the creation of pedestrian-friendly spaces, green areas, and recreational facilities, the development likely aims to enhance the mental health and physical among the community.

Energy Consumption and Transport remain key priorities, reflecting the development's commitment to efficient urban mobility and reducing its carbon footprint. By integrating sustainable transport systems, such as electric vehicles, public transportation, and cycling paths, Madrid Nuevo Norte seeks to reduce emissions and promote cleaner forms of mobility. Its focus on Land Use and Water management indicates that the development strives to balance urban density with green spaces, while also ensuring efficient water use, possibly through rainwater harvesting systems and water recycling initiatives.

However, the lower focus on Waste and Ecology suggests room for improvement in these areas. While Madrid Nuevo Norte excels in energy efficiency and transport planning, it may benefit from integrating

more waste reduction strategies, such as recycling programmes or circular economy initiatives, to reduce its environmental impact further. Additionally, enhancing Ecology and biodiversity conservation efforts could help create a more resilient and vibrant urban ecosystem, contributing to both environmental and social sustainability.

In conclusion, the comparison of Tivoli Greencity, The Garigate Park, Sege Park, and Madrid Nuevo Norte reveals diverse approaches to sustainable urban development, each shaped by regional contexts, environmental priorities, and social objectives. While all four (4) developments place a high priority on Energy Consumption and Land Use, their strategies diverge in other areas. Tivoli Greencity and Madrid Nuevo Norte focus on energy, transport, and infrastructure efficiency, while The Garigate Park expands its approach to include Health & Wellbeing and sustainable materials. Sege Park stands out for its emphasis on People and Communities and Ecology, demonstrating a more community-centred and ecologically conscious approach. Each development's unique emphasis reflects the adaptability of sustainable urban development practices to address specific challenges and opportunities. By learning from these varied approaches, future urban planners and developers can design more resilient, inclusive, and environmentally sustainable cities that cater to both global sustainability goals and local needs.

Advantages and Disadvantages of Each Sustainable Element

The four (4) urban developments: Tivoli Greencity, The Garigate Park, Sege Park, and Madrid Nuevo Norte, each incorporate a variety of sustainable elements that reflect their specific priorities. These elements, such as energy consumption, land use, waste management, transport, water conservation, health and wellbeing, material use, community engagement, ecology, and biodiversity, are crucial for creating sustainable urban environments. However, each sustainable element presents its own set of advantages and disadvantages, based on how they are implemented and integrated within the urban landscape.

Tivoli Greencity, Belgium

Advantages: Tivoli Greencity's strong focus on energy consumption is a significant advantage, as energy efficiency is a critical factor in reducing the overall carbon footprint of urban areas. The integration of renewable energy sources and advanced technologies ensures that the development can significantly reduce greenhouse gas emissions. Moreover, Tivoli's commitment to waste management is another strength. By implementing efficient waste separation and recycling programmes, the development reduces the volume of waste sent to landfills, contributing to a circular economy. Transport infrastructure is another strong point in Tivoli Greencity. The emphasis on sustainable transport modes such as public transport, cycling paths, and pedestrian-friendly areas not only reduces air pollution but also enhances the quality of life by encouraging a more active lifestyle. Additionally, the inclusion of water management systems that optimise water usage and reduce wastage helps conserve this vital resource in the face of increasing urban water demands.

Disadvantages: Despite its strengths, Tivoli Greencity shows a relatively lower focus on the use of sustainable building materials and ecological conservation, which presents potential drawbacks. Without a strong emphasis on material sustainability, the development may rely on conventional construction methods that contribute to environmental degradation through high embodied energy and resource extraction. The limited focus on ecology and biodiversity conservation could also lead to missed opportunities for enhancing urban green spaces and integrating natural ecosystems into the built environment, which are crucial for promoting resilience against climate change.

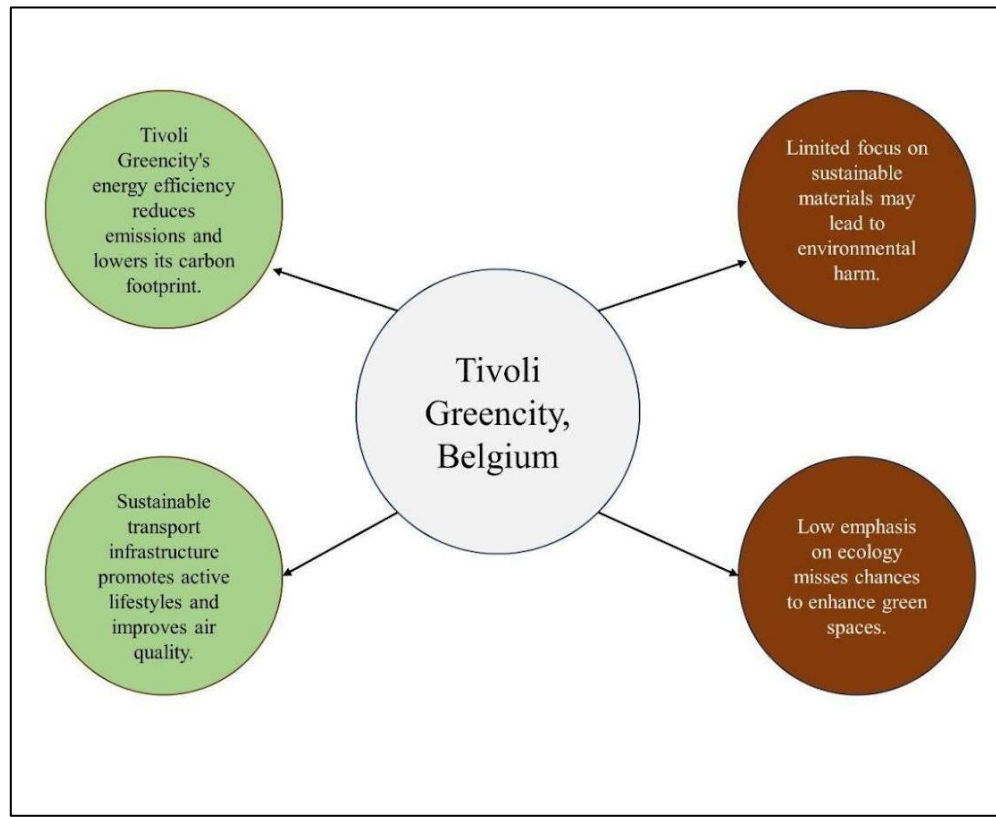


Fig. 10. Advantages and Disadvantages of Tivoli, Greencity, Belgium.

Source: Authors (2024)

The Garigate Park, Bulgaria

Advantages: The Garigate Park distinguishes itself with a well-rounded approach, particularly in its use of sustainable materials. The emphasis on materials that are low in embodied carbon, recyclable, or derived from renewable sources reflects a commitment to lowering the ecological footprint of construction. This strategy aligns with the theory of a circular economy and reduces the long-term carbon footprint of the development. Additionally, the development's attention to health and well-being ensures that buildings are designed with human comfort in mind, incorporating elements like natural lighting, good air quality, and thermal comfort. This focus on occupant wellbeing can lead to higher productivity, improved mental health, and a stronger sense of community. Furthermore, the Garigate Park's focus on waste management and water conservation is commendable. By optimising waste reduction strategies, the development contributes to a more sustainable urban lifestyle. Water conservation measures, such as rainwater harvesting and greywater recycling, also help mitigate the increasing pressure on freshwater resources.

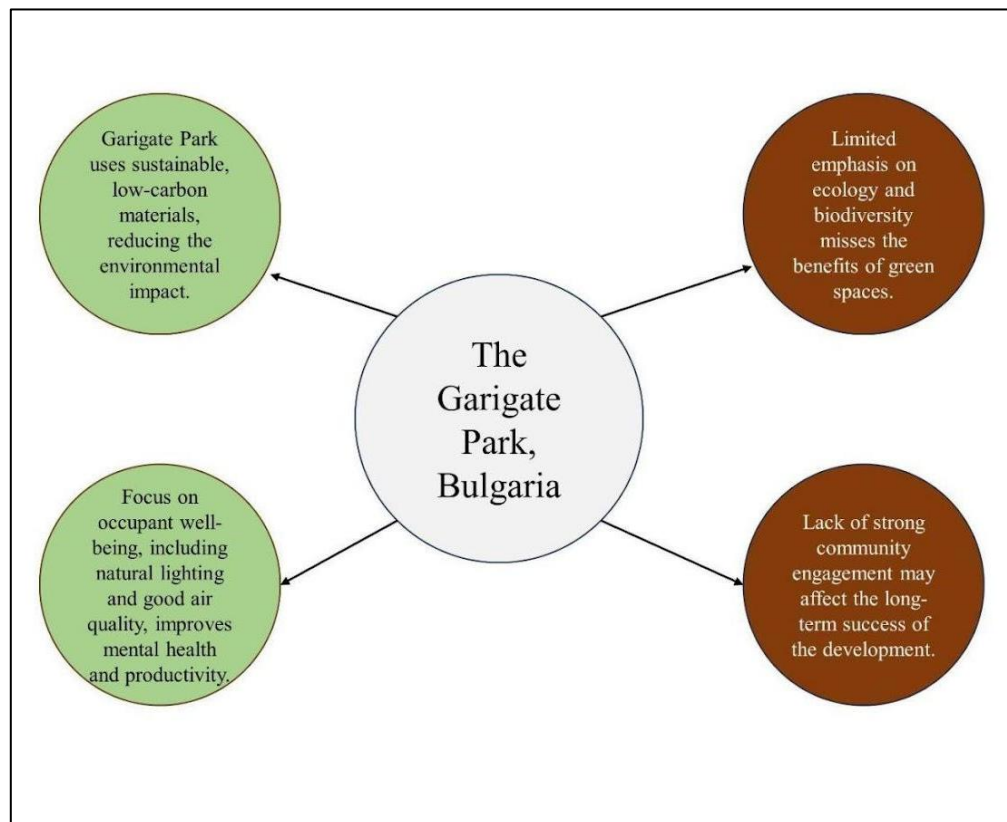


Fig. 11. Advantages And Disadvantages of the Garigate Park, Bulgaria.

Source: Authors (2024)

Disadvantages: One of the potential weaknesses in The Garigate Park's sustainability strategy is its limited emphasis on ecology and biodiversity. While the development focuses heavily on material use and infrastructure, it may overlook the benefits of integrating green spaces and promoting biodiversity. Ecological elements play a crucial role in mitigating urban heat islands, supporting local wildlife, and enhancing the aesthetic and recreational value of the urban environment. Similarly, the development's relatively lower focus on community engagement could be a disadvantage. While health and well-being are prioritised, sustainable urban development thrive when communities are actively engaged in the planning and management of their spaces. A lack of strong community engagement may lead to developments that do not fully address the social needs of residents, potentially impacting long-term sustainability.

Sege Park, Sweden

Advantages: Sege Park takes a strong approach to ecological and community sustainability. The development's focus on ecology and biodiversity conservation ensures that natural elements are integrated into the urban landscape, supporting wildlife habitats and enhancing the quality of life for users. This approach also helps mitigate environmental risks such as flooding and air pollution, while promoting climate resilience. Additionally, Sege Park's attention to people and communities is another significant strength. By creating spaces that encourage social interaction and community engagement, the development fosters a sense of belonging and improves social cohesion. This can lead to a more inclusive and resilient

urban environment, where residents actively participate in the management and stewardship of their community spaces. The development's focus on physical resource use is also advantageous. By optimising the use of energy and water, Sege Park contributes to a reduction in the environmental impact of urban living, ensuring that residents can enjoy high-quality urban services without placing undue strain on natural resources.

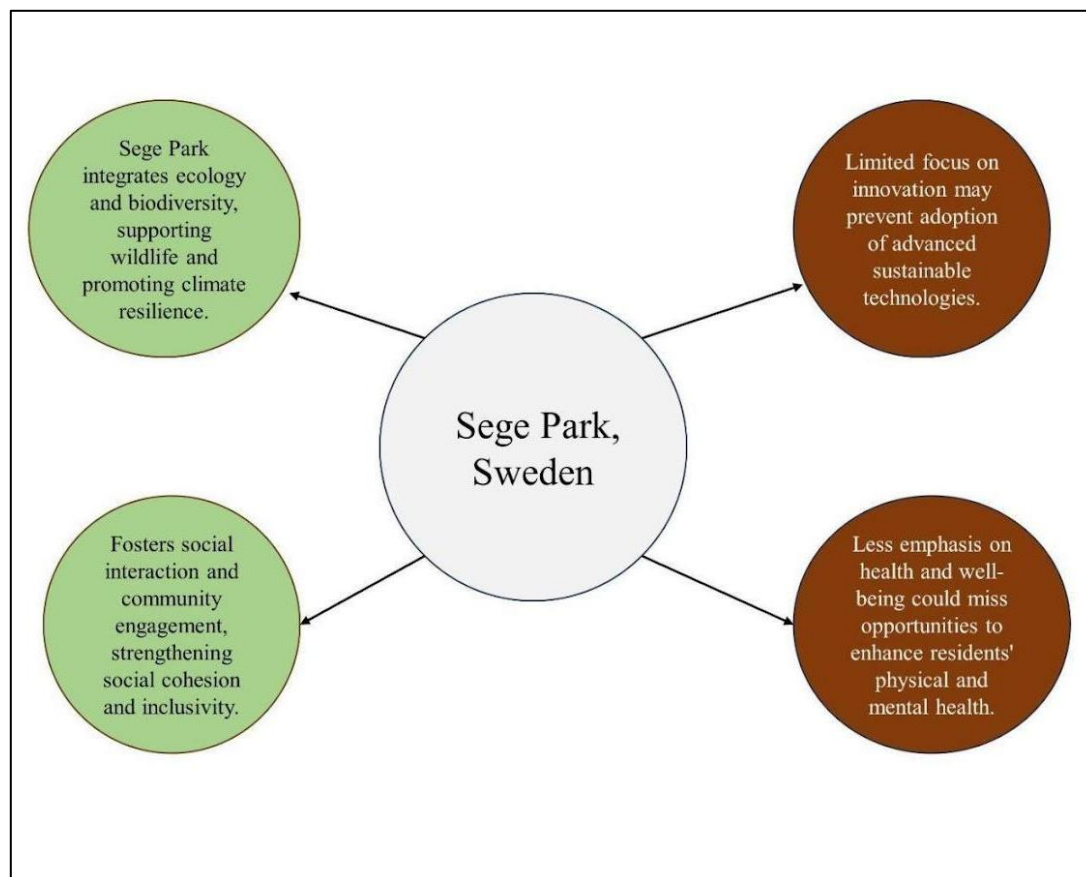


Fig. 12. Advantages and Disadvantages of Sege Park, Sweden.

Source: Authors (2024)

Disadvantages: Despite its strong focus on community and ecology, Sege Park places relatively less emphasis on innovation and health. The limited focus on innovation could hinder the development's ability to adopt cutting-edge sustainable technologies that could enhance energy efficiency, waste management, and water conservation. Without significant investment in innovation, Sege Park risks falling behind in terms of technological advancements that could further improve sustainability outcomes. Moreover, the development's lower focus on health and well-being could be a drawback. While the community-oriented approach is beneficial, attention to building design elements that enhance indoor environmental quality, such as air quality, lighting, and thermal comfort, is also crucial for promoting the health of residents. Without these considerations, Sege Park may miss opportunities to enhance the physical and mental well-being of its residents.

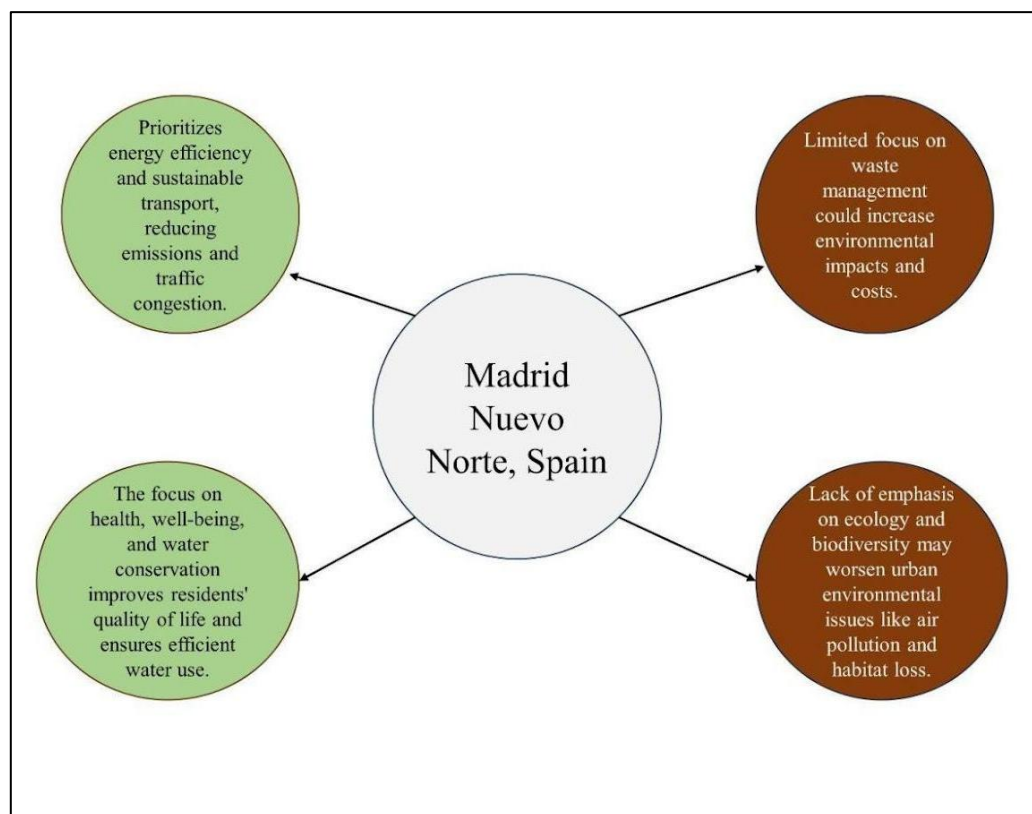
Madrid Nuevo Norte, Spain

Fig. 13. Advantages and Disadvantages of Madrid Nuevo Norte, Spain.

Source: Authors (2024)

Advantages: Madrid Nuevo Norte emphasises energy consumption, transport, water, land use, and health and wellbeing, reflecting a comprehensive approach to urban sustainability. The focus on energy efficiency and sustainable transport is particularly beneficial in a large urban area like Madrid, where reducing greenhouse gas emissions and improving air quality are critical challenges. By investing in sustainable transport infrastructure, the development helps reduce traffic congestion and promote more sustainable mobility patterns.

The inclusion of health and well-being as a key sustainability element ensures that buildings and public spaces are designed with human comfort in mind. This could lead to improved quality of life for residents, making Madrid Nuevo Norte an attractive and liveable urban environment. Water conservation is another strength, as the development seeks to manage water resources efficiently through measures such as rainwater harvesting and wastewater recycling. This is particularly important in regions prone to water scarcity, ensuring that the development can meet the needs of residents without overexploiting local water resources.

Disadvantages: While Madrid Nuevo Norte excels in energy, transport, and water management, its lower focus on waste management and ecology could be seen as a limitation. Without a strong emphasis

on waste management, the development may struggle to minimise the amount of waste generated by its residents, leading to increased environmental impacts and higher waste disposal costs. Waste management is a crucial element of sustainable urban living and overlooking it could hinder the development's long-term sustainability.

Additionally, the limited attention to ecological conservation and biodiversity presents another drawback. Urban developments that fail to integrate natural ecosystems into their design risk exacerbating environmental problems such as air pollution, heat islands, and habitat loss. By not prioritising ecology, Madrid Nuevo Norte may miss opportunities to enhance the resilience and environmental quality of its urban spaces.

Cross-Case Comparative Insights

The comparative analysis reveals that while all four (4) developments prioritise energy efficiency and land use optimisation, their broader sustainability strategies diverge significantly due to contextual, regulatory, and rating-system-specific influences.

Tivoli Greencity demonstrates a strong emphasis on energy efficiency and innovation, reflecting Belgium's stringent energy performance regulations and BREEAM's weighting of operational energy outcomes. However, comparatively less emphasis is placed on ecological integration and material circularity, indicating a technologically driven rather than ecosystem-driven sustainability model.

The Garigate Park performs more strongly in material sustainability and health and wellbeing. This outcome can be attributed to BREEAM Communities' explicit criteria on embodied carbon, indoor environmental quality, and user comfort, as well as Bulgaria's emerging policy focus on sustainable construction practices. The prioritisation of materials reflects a growing recognition of life-cycle impacts beyond operational energy.

Sege Park adopts a community-centred and ecological sustainability approach. Its stronger performance in people-and-community criteria and biodiversity reflects Scandinavian planning traditions that prioritise participatory design, social cohesion, and landscape-led urbanism. While innovation scores are comparatively moderate, the project demonstrates robustness in long-term social and ecological resilience.

Madrid Nuevo Norte, as a mega-scale regeneration project, foregrounds transport integration, energy systems, and land-use restructuring. Its sustainability strategy aligns closely with SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). Nevertheless, the comparatively lower emphasis on waste management and urban ecology highlights the challenges of embedding fine-grain environmental strategies within large infrastructural developments.

Alignment with Sustainable City Frameworks

Across all cases, sustainability priorities align with multiple United Nation (UN) SDGs, particularly SDGs 7, 11, and 13. However, uneven attention to SDGs related to biodiversity (SDG 15) and responsible consumption (SDG 12) suggests that certification-led urban sustainability remains selectively implemented rather than holistically integrated.

CONCLUSION

This study demonstrates that sustainable rating tools significantly influence how sustainability is interpreted and operationalised in large-scale urban developments. While LEED, BREEAM, and CEEQUAL provide robust assessment structures, their differing emphases shape divergent sustainability outcomes across projects. The comparative findings highlight that no single rating tool comprehensively addresses all dimensions of sustainable urbanism. Energy and transport performance are consistently prioritised, whereas ecology, material circularity, and community co-production remain unevenly addressed. For policymakers and practitioners, this underscores the importance of selective and contextual integration of rating tools, rather than their uncritical adoption.

The developments of Tivoli GreenCity, Garigate Park, Sege Park, and Madrid Nuevo Norte exemplify exceptional strides in sustainable urban planning. They underscore a commitment to eco-friendly practices, energy efficiency, waste management, biodiversity conservation, and community wellbeing. These ventures represent significant strides toward sustainable urban development. To ensure their continued success, ongoing innovation and adaptability are imperative. Collaboration with local communities, businesses, and governing bodies is key for these initiatives to flourish.

Recommendations for these projects include sustained investment in renewable energy, advanced waste management strategies, eco-friendly transportation solutions, and comprehensive water management systems. Sustainability oriented lifestyle among community could be enhanced via the effective education system and community engagement. Continuous research and integration of emerging technologies will further fortify their sustainability objectives.

The study contributes a transferable comparative framework that can support future evaluations of certified urban developments. Future research should integrate mixed-method approaches, including post-occupancy evaluation and stakeholder perspectives, to assess whether certified sustainability outcomes translate into long-term environmental and social benefits. Looking forward, the hope is for these urban developments to become global benchmarks for sustainable living, inspiring future city planners and developers worldwide. They can serve as catalysts for prioritising environmental consciousness, creating cities that coexist harmoniously with nature, and prioritising the well-being of their inhabitants. Ultimately, these projects aspire to become living models, motivating other urban planners and communities worldwide to embrace sustainable practices. By evolving, adapting, and learning from these endeavours, cities can aspire to create harmonious, eco-conscious spaces that prioritise both people's and the planet's wellbeing.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts, and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

In preparing this manuscript, Muhammad Haziq Yahya served as the primary author and conducted the research underpinning this study from conceptualising the research idea, designing the methodology, conducting the investigation, collecting and analysing the data, and drafting the manuscript. Mohd Hafiz Mohammad Zin contributed his expertise in organising, validation of the research findings and structuring the evaluation tools utilised in this study. Azlan Ariff Ali Ariff provided critical validation of the research findings, ensuring the accuracy and reliability of the facts presented. Muhamad Syariz Niza Salehuddin contributed his expertise from the perspective of an industrial practitioner with an architectural background, especially in design and construction. The combined efforts have resulted in a thorough and robust examination of the subject matter, contributing valuable insights to green and sustainable architecture.

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