Evaluation of neighbourhood sustainability assessment tools for practicing on an existing neighbourhood in Great Paris

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Abstract
This article presents a comprehensive analysis of five tools used to assess urban sustainability both internationally and nationally, with a focus on the French case study of Meudon la Forêt. The tools evaluated include HQE Development, BREEAM Co., SPToolPT-UP, LEED-ND, and DGNB District. A review of the state-of-the-art literature was conducted, and a classification of the indicators in the tools was made to identify the most and least stressed topics. Based on a comparative analysis of the tools, HQE Development was selected as the most suitable tool for the evaluation of the case study due to its compatibility with the geographical context, applicability and feasibility, rating method, and lack of hierarchy for evaluation. Thirteen indicators were identified to meet the sustainability performance of the neighborhood, with the results indicating strong performance in social and environmental aspects but requiring improvement in the economic aspect. A new matrix of urban sustainability indicators is proposed, consisting of twelve major categories to achieve urban sustainability for the evaluation of existing neighborhoods. HQE Development was identified as the most suitable tool for the evaluation of Meudon la Forêt. The article provides a useful tool for the evaluation of existing neighborhoods and emphasizes the importance of context-specific indicators for assessing urban sustainability.

Highlights
- Provides a comprehensive analysis of five NSA tools for evaluating urban sustainability internationally and nationally.
- Proposes a new matrix of urban sustainability indicators that covers 12 major categories for evaluating existing neighborhoods.
- Demonstrates the suitability of HQE Development, BREEAM Co., and SPToolPT-UP for evaluating the Meudon la Forêt case study.
- Emphasizes the importance of considering context-specific indicators and evaluating social, economic, and environmental aspects.
- Suggests that this assessment could be a tool for stakeholders to monitor and invest towards sustainability in existing neighborhoods.

Introduction
The assessment of sustainability in building projects and neighborhoods is of utmost importance in the pursuit of a more environmentally conscious and socially responsible built environment. Various evaluation tools have been developed to measure the sustainability performance of these projects, providing valuable insights into their environmental, economic, and social impacts. However, the effectiveness and applicability of these tools require continuous examination and critical evaluation.

In this paper, we present a comprehensive analysis of five sustainability rating tools, namely HQE Development, BREEAM Co., SPToolPT-UP, LEED-ND, and DGNB District. Our study focuses on evaluating their suitability and relevance in the context of a French case study in Meudon la Forêt. By scrutinizing the strengths and limitations of these tools, we aim to shed light on their practicality and potential for supporting sustainable neighborhood development.

It is essential to note that sustainability rating tools often have country-specific variations to accommodate regional adaptability. For instance, certain criteria or parameters, such as bike racks, might differ between BREEAM UK and BREEAM International. Moreover, some tools, like LEED, emphasize the inclusion of detailed simulations as an integral part of the assessment process. These nuances must be considered when evaluating the tools’ effectiveness and aligning them with specific project requirements.

However, existing research and literature have pointed out several shortcomings and assumptions inherent in these sustainability rating tools. The omission of critical analysis in previous studies is a notable gap that we aim to address in our research. By critically examining these tools, we intend to provide a more comprehensive understanding of their limitations and potential biases.

In the context of this paper, it is crucial to establish a clear and transparent evaluation methodology to ensure the reliability and reproducibility of our findings. The evaluation process will consider various factors, including environmental performance, energy efficiency, social impact, and economic viability. By adopting a rigorous and transparent approach, we aim to provide a robust foundation for our evaluation and subsequent recommendations.

To address the aforementioned gaps and provide a more comprehensive analysis, we propose a comparative study that encompasses both quantitative and qualitative
assessments. This approach allows us to capture the nuances and complexities associated with evaluating sustainability performance accurately.

By undertaking this research, we aspire to contribute to the field of sustainable neighborhood development by providing valuable insights into the strengths and weaknesses of commonly used sustainability rating tools. Our findings will assist decision-makers, architects, urban planners, and stakeholders in making informed choices that align with sustainable development goals.

In the subsequent sections of this paper, we will delve into the details of the evaluation methodology, present the case study of Meudon la Forêt, analyze the results, and provide recommendations for future improvements. Through this rigorous evaluation process, we aim to enhance the understanding and application of sustainability rating tools in the context of sustainable neighborhood development.

Overall, this paper endeavors to bridge the gap between theoretical concepts and practical implementation by critically assessing sustainability rating tools and providing recommendations for their effective application.

Method
To achieve a comprehensive evaluation of the sustainability rating tools, we have designed a systematic methodology that combines quantitative and qualitative analyses. This approach enables us to assess the suitability, relevance, novelty, and technical merit of the tools while considering their application in the context of sustainable neighborhood development.

- Selection of Sustainability Rating Tools:
  We carefully identified five widely recognized sustainability rating tools for our analysis: HQE Development, BREEAM Co., SPToolPTUP, LEED-ND, and DGNB District. These tools represent a diverse range of approaches and have been extensively used in assessing the sustainability performance of neighborhoods in Europe.

- Data Collection:
  The data collection process involved gathering relevant information from various sources. We extensively reviewed the official documentation, guidelines, and technical manuals of each sustainability rating tool to understand their evaluation criteria, metrics, and assessment procedures.

- Evaluation Criteria:
  Based on our evaluation framework and extensive literature review, we identified specific evaluation criteria to assess the performance of the sustainability rating tools.

- Comparative Analysis:
  We conducted a comparative analysis of the selected sustainability rating tools, considering their alignment with the evaluation criteria. The analysis involved assessing the tools' ability to address key sustainability challenges, their level of detail and specificity, the inclusion of simulation or building performance analysis, and their compatibility with regional or country-specific requirements.

- Case Study Application:
  To provide practical insights, we applied the evaluated sustainability rating tools to a specific case study: Meudon la Forêt, a sustainable neighborhood project in France. The case study allowed us to assess the tools' effectiveness in the context of a real-world scenario, considering the project's unique characteristics, local regulations, and community needs.

- Evaluation Process:
  The evaluation process involved a thorough review of the assessment criteria and metrics used by each sustainability rating tool. We critically analyzed the strengths and weaknesses of the tools, considering their suitability, relevance, novelty, and technical merit based on the case study.

- Data Analysis:
  The collected data and evaluation results were analyzed using a combination of quantitative and qualitative methods. Quantitative analysis involved comparing numerical scores and performance indicators, while qualitative analysis focused on identifying patterns, strengths, and limitations of the sustainability rating tools. This analysis enabled us to draw meaningful conclusions and recommendations based on the findings.

- Recommendations:
  Based on our comprehensive evaluation and analysis, we provide recommendations develop a matrix that analyzes the evaluation results of Meudon la Forêt based on the HQE Development tool in conjunction with four other assessment tools. These recommendations aim to address the identified limitations and enhance the tools' ability to support sustainable neighborhood development in French context.

By adopting this systematic and rigorous methodology, we strive to ensure the objectivity, reliability, and reproducibility of our evaluation process. The combination of quantitative and qualitative analyses, coupled with the application of the evaluation framework to an existing case study, allows us to provide valuable insights into the strengths, weaknesses, and potential improvements of the selected sustainability rating tools.

Case Study: The Parc Residence in Meudon-la-Forêt
The Parc Residence, located in Meudon-la-Forêt, a neighborhood in the southwest of the Greater Paris region, serves as a suitable case study for the research on the evaluation of neighborhood sustainability assessment tools.

Meudon-la-Forêt is located in the inner district in the South-West of Paris, between the Seine to the North and the Yvelines to the South. It covers an area of 993 hectares, with 40% of the land covered by the national forest. The district is part of the Greater Paris Seine Ouest urban community (GPSO), which includes eight municipalities and has a population of over 320,000 inhabitants (Insee, 2022)

This neighborhood stands out for its implementation of sustainable construction practices, particularly the use of natural stone as the primary construction material. The choice of natural stone contributes to the longevity and
reusability of the buildings while promoting energy-efficient policies and ensuring a secure supply with a low carbon footprint.

![Figure 1 Aerial view of the Parc residence in the 1960s/1970s](Municipal Archives, IFi 530)

The Parc Residence serves as a significant example of sustainable solutions aimed at reducing CO2 consumption and sets a model for future projects. With its emphasis on sustainable construction practices and energy efficiency, the neighborhood showcases the successful implementation of sustainable principles in urban development.

Meudon-la-Forêt, where the Parc Residence is located, has distinct architectural characteristics compared to the neighboring district of Meudon-ville. Meudon-ville features a traditional fabric of old suburban towns with a mix of pavilions and small collectives. On the other hand, Meudon-la-Forêt represents a suburban fabric of the 1960s and 70s, characterized by block buildings and towers. The district was constructed during the 1960s as part of the ZUP procedure (Zone Urbaine Prioritaire), which saw the implementation of modern designs, including those by Le Corbusier, on a large scale (Colchen, 2011). This period witnessed a significant increase in housing construction, particularly social housing, leading to the development of large housing estates.

Meudon was chosen as an ideal location to address the pressing housing demand in the Paris Region at that time (Briand et al., 2007).

The town's proximity to the capital and the availability of vast agricultural land south of the Meudon forest made it a suitable site for accommodating the growing population. The Meudon-la-Forêt site itself had no established urban context nearby, except for a small district of social housing built earlier. To meet the demand efficiently, a rationalized production method was adopted, including the use of concrete posts, limited window models, and pre-cut stones, facilitating the construction process.

Despite the challenges faced during its construction, the Parc Residence in Meudon-la-Forêt became one of the most significant operations in addressing the housing shortages in the Paris Region after World War II. Spanning an area of over sixteen hectares, the project consists of 69 buildings and 2,635 accommodation houses, along with fifty shops. Notably, the cost of housing per square meter in the Parc Residence is lower compared to other large complexes that underwent extensive rehabilitation during the same period.

The unique characteristics and sustainable construction practices of the Parc Residence make it a suitable case study for evaluating neighborhood sustainability assessment tools. Its historical significance, architectural quality, and successful implementation of sustainable solutions provide valuable insights into the applicability and effectiveness of sustainability assessment tools in the context of existing neighborhoods in Greater Paris.

### Evaluation the Neighbourhood Sustainability Assessment Tools

The evaluation of neighborhood sustainability assessment tools (NSA) for assessing existing neighborhoods has been a crucial research topic in recent years. This literature review examines relevant studies that have contributed to our understanding of sustainability assessment tools and their applications in neighborhood evaluation. Several studies have been reviewed to gain insights into the effectiveness and limitations of these tools:

Slootweg, Vanclay, and van Schooten (2001) proposed a framework for integrating social and environmental impact assessment, which evaluates the positive and negative impacts of a project on various aspects such as the economy, environment, and social and cultural aspects of a neighborhood.

Ameen, Mourshed, and Li (2015) conducted a critical review of environmental assessment tools for sustainable urban design, identifying gaps in existing tools and proposing a new framework that focuses on measuring the performance of urban designs in different stages of the design process.

Sharifi (2013) explored various neighborhood sustainability assessment tools and highlighted the importance of integrating social, environmental, and economic factors in assessments, emphasizing their role in guiding decision-making and promoting sustainable development practices.

Pedro et al. (2019) conducted a systematic review of international assessment systems for urban sustainability, emphasizing the strengths and weaknesses of existing sustainability assessment tools and the need for further research on measuring the social, environmental, and economic impacts of urban development.

Braulio-Gonzalo (2016) proposed sustainability indicators for the Spanish context to evaluate the sustainability of urban development projects, focusing on factors such as energy efficiency, green spaces, and public transport accessibility.

The studies reviewed in this literature review underscore the importance of integrating social, environmental, and economic factors in neighborhood sustainability assessments. While existing tools have made significant contributions to sustainability assessments, there are still
limitations, particularly in measuring the social and economic impacts of urban development. Further research is needed to address these limitations and promote sustainable development practices in neighborhoods.

Table 1 General Characteristics of NSA Tools

<table>
<thead>
<tr>
<th>Criteria</th>
<th>HQE Development</th>
<th>BREEAM Com.</th>
<th>LEED-ND</th>
<th>SToolPT-UP</th>
<th>DGNB District</th>
</tr>
</thead>
<tbody>
<tr>
<td>National scope</td>
<td>France</td>
<td>UK</td>
<td>USA</td>
<td>Portugal</td>
<td>Germany</td>
</tr>
<tr>
<td>Themes</td>
<td>Quality of life, Respect the environment, Economic performance</td>
<td>Governance, social, and economic well-being, Resources, and energy, Land use, and ecology, Transport, and mobility, Innovation</td>
<td>Smart location, and linkage Neighbourhood pattern, and design Green infrastructure, and buildings And two additional: Innovation, Regional priority</td>
<td>Urban form, Land use, and infrastructure, Eco-design, and biodiversity, Energy, Water Material, and wastes Comfort of outdoor area, Mobility, Local, and culture, Identity, Employment, promotion, and investment</td>
<td>Environmental quality, Economic quality, Sociocultural, and functional quality, Technical quality, Process quality</td>
</tr>
<tr>
<td>Number of indicators and criteria</td>
<td>19 indicators, 33 management criteria</td>
<td>43 criteria</td>
<td>56 criteria</td>
<td>41 criteria</td>
<td>23 indicators, 31 criteria</td>
</tr>
<tr>
<td>Number of points</td>
<td>Not issued</td>
<td>119 points</td>
<td>110 points</td>
<td>Not issued</td>
<td>66 points</td>
</tr>
<tr>
<td>Approval modality</td>
<td>Documentary verifications</td>
<td>Indicator calculations</td>
<td>Indicator calculations</td>
<td>Documentary verifications</td>
<td>Indicator calculations</td>
</tr>
<tr>
<td>Contribution to the 3 dimensions of sustainable development</td>
<td>Environment Social Economic</td>
<td>Environment Social Economic</td>
<td>Environment Economic</td>
<td>Environment Social</td>
<td>Environment Social Economic</td>
</tr>
</tbody>
</table>

For this study, five specific tools were selected for evaluation: HQE Development, BREEAM Com., LEED-ND, STool PT-UP, and DGNB District. These tools were chosen primarily because of their recognition and adoption in Europe, their evolution from assessing individual buildings to neighborhood and urban developments, and their availability of technical documents and guidance. Additionally, these tools have been widely adopted in various jurisdictions and contexts, providing a wealth of knowledge on their usability, applicability, and flexibility. While all these tools share common goals, each one focuses on specific aspects based on the local context. Table 1 presents an overview of the general characteristics of these urban sustainability assessment tools, highlighting their organizational structures.

When evaluating the Meudon-la-Forêt case study, it is important to consider the national scope, thematic approach, applicability, evaluation method, and sustainability dimensions of the NSA tools. LEED-ND has been widely used outside the United States, while BREEAM Communities can be adapted to the global context by adjusting project characteristics to local conditions. However, these tools are typically applied based on their local standards when used in other countries. The HQE Development tool, being rooted in French public policies and adaptable to the local context, is the most suitable NSA tool for evaluating the Meudon-la-Forêt case study.

The sustainability assessment tools vary in the number of themes they cover. While HQE Development focuses on the three main dimensions of sustainability, BREEAM Com. and LEED-ND emphasize innovation and smartness in projects. STool PT-UP and DGNB District focus on process quality during the construction phase. Given that Meudon-la-Forêt was built in 1963, there is limited information available on the construction process, waste management, and local integration. Therefore, HQE Development is more suitable for evaluating the case study due to its focus on the three main sustainability dimensions and its fewer number of indicators.

The applicability of sustainability assessment tools depends on the specific project or context being evaluated. Some tools are more suitable for assessing new construction projects, while others are better suited for evaluating existing buildings or neighborhoods. In the case of Meudon-la-Forêt, HQE Development is more appropriate due to its focus on the three main dimensions of sustainability and its fewer number of indicators. This
simplifies the evaluation process and accommodates the challenges of accessing comprehensive data for existing neighborhoods. Understanding the differences in sustainability dimensions and their indicators among

In the case of Meudon-la-Forêt, the planners made efforts to address all three dimensions of sustainability. They provided housing for a modest population without social housing and promoted social mix by offering a range of accommodations. Additionally, the project was built using natural stone, which has numerous environmental advantages. The HQE Development assessment tool supports all aspects of the project.

**Evaluation of Residence du Parc based on HQE Development**

The sustainability assessment of Résidence du Parc involved the analysis of various project information using the sustainability indicators provided by the HQE Development tool. The tool encompasses 19 indicators categorized into Quality of Life, Respect for the Environment, and Economic Performance. These indicators were carefully selected based on their relevance, applicability, and ability to address the multifaceted challenges of sustainable development, including climate change, resource scarcity, biodiversity loss, health and well-being, social cohesion, and economic considerations.

To gather the necessary data for the assessment, information was sourced from diverse entities such as the municipality, the Meudon Local Urban Plan (PLU), Engie company, INSEE, CARTELIE, Noise Exposure Plan (PEB), Geoportal, and the Rhinoceros program. In addition to utilizing available data sources, custom codes were developed using Grasshopper, a graphical algorithm editor, to aid in the physical calculations required for the assessment.

By employing these indicators and integrating data from various sources, a comprehensive evaluation of the sustainability performance of Résidence du Parc was conducted. The assessment examined key aspects of the development, including public transportation accessibility, active transportation infrastructure, accessibility of nature spaces, energy consumption for heating, water consumption, waste management, indoor air quality, thermal comfort, sustainable construction materials, biodiversity preservation, urban heat island effect, and economic performance as shown in the table 2.

![Figure 2 Disparities in the affective dimension of urban sustainability according to indicators analysis](image)

The evaluation methods used by NSA tools involve assessing a neighborhood’s performance against a set of criteria and themes. NSA tools employ different evaluation criteria, which can be classified into scoring evaluation based on point calculation and documentary verification. LEED-ND uses a simple scoring model, while BREEAM Com. and DGNB employ weighted criteria, making the approach more complex. HQE Development and SPTool PT-UP require compliance with management requirements and do not provide an aggregate index of sustainability. For the Meudon-la-Forêt case study, HQE Development is selected as it simplifies the evaluation process and provides a comprehensive assessment of the neighborhood’s sustainability across the three dimensions.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Index of Indicator</th>
<th>Indicator</th>
<th>Calculation Parameters</th>
<th>Data</th>
<th>Result of Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of life</td>
<td>1</td>
<td>Nuisance-free housing and workspaces</td>
<td>Surfaces of quiet areas in m²</td>
<td>938,276.5</td>
<td>96%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Functional diversity</td>
<td>Number of dwellings and offices within 500 m</td>
<td>500</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Accessibility of public transport</td>
<td>Number of accommodation and activities within 500 m</td>
<td>500</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Accessibility of nature spaces</td>
<td>Number of dwellings and premises within 500 m</td>
<td>2,635</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Practicability of active modes</td>
<td>Length of cycle paths, sidewalks, and roads limited to 30 km/h</td>
<td>61,650</td>
<td>96.5%</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Housing orientation and activities</td>
<td>Building orientations</td>
<td>ON and E5</td>
<td>100%</td>
</tr>
<tr>
<td>Respect the environment</td>
<td>7</td>
<td>Energy performance of buildings and street lighting</td>
<td>Energy consumption of light points in kWh/EF/m²/year</td>
<td>62</td>
<td>129 kWh/m².year building×br×And 64 kWh/m</td>
</tr>
</tbody>
</table>
Results

The implementation of the HQE Development tool in an existing neighborhood presents promising opportunities for enhancing its sustainability. The case study of Residence du Parc in Meudon la Forêt exemplifies the positive outcomes that can be achieved by utilizing sustainability indicators to address social, environmental, and economic aspects. Out of the 19 indicators proposed by HQE Development, 13 were applicable to the project, enabling a comprehensive evaluation of its sustainability performance.

The Residence du Parc neighborhood demonstrated impressive results in the Quality-of-Life theme, indicating the initial focus on social issues during the project's development. With a result exceeding 96% in all six indicators, the neighborhood showcases the positive governance and decision-making processes that prioritized the well-being of residents. This outcome underscores the importance of incorporating social dimensions into sustainability strategies for existing neighborhoods.

While the environmental performance of Residence du Parc was generally satisfactory, there were areas that could be improved. For example, the Coefficient of Biotopes per Surface (CBS) indicator could have yielded higher values if the project had considered the preservation and enhancement of its forested areas. Additionally, the lack of available data for waste management indicators posed a challenge in assessing the neighborhood's waste reduction and recycling practices. These findings emphasize the importance of implementing robust data collection and monitoring systems to effectively evaluate and improve environmental sustainability in existing neighborhoods.

When evaluating economic performance, careful consideration is required when applying the HQE Development tool to existing neighborhoods. The tool primarily focuses on urban construction and regeneration projects, which may not accurately reflect the economic viability of neighborhoods like Residence du Parc, located in rural areas without pre-existing local integration. Therefore, using the tool's criteria to assess economic performance in such contexts may yield misleading results.

The case study of Residence du Parc highlights the potential of the HQE Development tool in enhancing the sustainability of existing neighborhoods. By employing a comprehensive set of indicators, the tool enables a holistic assessment of social, environmental, and economic aspects. The positive outcomes observed in the Quality-of-Life theme underscore the importance of prioritizing social dimensions in sustainability strategies for existing neighborhoods.

To further improve environmental sustainability, it is crucial to consider the specific characteristics and potential of the neighborhood. Addressing indicators such as the Coefficient of Biotopes per Surface and waste management can contribute to enhancing the ecological performance of the neighborhood. Additionally, enhancing data collection and monitoring systems will facilitate better evaluation and management of environmental aspects.

When applying the HQE Development tool to assess economic performance, it is important to acknowledge its limitations and adapt the criteria to suit the specific context of an existing neighborhood. Taking into account the unique economic circumstances and considering alternative indicators that align with the neighborhood's characteristics will provide a more accurate representation of economic viability.

Overall, the successful application of the HQE Development tool to the Residence du Parc case study highlights the potential of incorporating sustainability indicators in evaluating and improving existing neighborhoods. By addressing social, environmental, and economic aspects, neighborhoods can strive towards greater sustainability and contribute to the well-being of their residents and the broader community.

Proposal of a new matrix indicators for NSA tools

Urban indicators and sub-indicators are essential variables that contribute to evaluating the sustainability elements of urban development and design performance (Shen et al., 2011). These indicators include factors such as walking distance between common spaces, reduction of noise impact, and proximity between home and workplace. They address specific issues and challenges of urban development within different regions, such as co2 emissions from transportation, natural ventilation, and the use of local materials. To enable comparison between assessment tools, various scope indicators have been considered to facilitate the evaluation process. However, adopting a single global assessment tool as a universal solution applicable in all contexts is not feasible. Nonetheless, we can explore the similarities among NSA tools and derive corresponding outcomes. In this study, our objective is to develop a matrix that analyzes the evaluation results of Meudon la Forêt based on the HQE
Development tool in conjunction with four other assessment tools.

Considering the three fundamental dimensions of sustainability (economic, environmental, and societal) and a thorough examination of all criteria, the main indicators and sub-indicators from the five assessment methods were categorized into 36 main categories and 187 subcategories. Ameen et al. (2015) proposed a comprehensive list of common indicators that encompassed LEED-ND, BREEAM Co., and SPTool UP indicators. The selection of these indicators prioritized clarity, pluralism, inclusiveness, and the reduction of redundancy across sustainability dimensions. This list, combined with the HQE Development and DGNB indicators, formed the selected indicators for evaluating the sustainability of urban design.

To facilitate the analysis, a matrix was created to assess the availability of indicators across the chosen sustainability assessment tools. After completing the matrix, it was decided to consolidate similar criteria together. Table 3 presents the themes addressed by the five tools and the percentage of criteria falling under each theme. These percentages represent the total number of indicators, irrespective of the points assigned to each.

Table 3 demonstrates that each tool emphasizes different aspects. All the tools prioritize criteria related to resources, environment, and pattern design. HQE Development, being a specialized tool, places more focus on social and well-being issues. The environmental dimension shows a strong contribution from all four assessments, particularly in terms of energy-related criteria, strategy, and energy efficiency. This underscores the importance of reducing CO2 emissions, primary energy production, and addressing issues such as pollution, noise, flood avoidance, pollution prevention, transport assessment, walkable streets, ecosystems, agricultural and natural systems, and strategy.

In the social category, BREEM Co. values design process, land use, consultation, smart location, integrated strategy, and natural design, while LEED-ND places emphasis on community indicators, demographic needs, ecological and connected communities, urban systems, and amenity provision.

Based on the evaluation results of the Residence du Parc in Meudon la Forêt using the HQE Development method, the project excels in the social sustainability theme. However, BREEM Co. and SPToolPT-UP exhibit a better ability to address social sustainability concerns, with nearly 50% and over 40% of their indicators, respectively, dedicated to this dimension compared to less than 20% for HQE Development.

Regarding environmental sustainability, the results confirm the careful consideration given to energy strategies, CO2 reduction, and environmental impact in the decision-making and planning processes. BREEM Co. has the highest frequency of environmental sustainability indicators, followed by the other tools, except for DGNB District, which has fewer indicators.

The economic performance results are less conclusive than the other two dimensions due to insufficient information, and thus cannot be directly compared with other tools. However, considering that all NSA tools, except for HQE Development, allocate less than 10% of their indicators to economic sustainability, it can be assumed that this dimension would not significantly influence the overall evaluation.

In summary, considering the limitations of territorial aspects in the NSA tools, BREEM Co. and SPToolPT-UP appear to be more suitable for evaluating the Meudon la Forêt case study. However, it is important to note that this conclusion is specific to the given parameters and does not account for factors such as scoring complexity, rating methods, and overall capability.

### Table 3 Frequency of distribution of each indicator, relevant to three sustainability dimensions

<table>
<thead>
<tr>
<th>Theme</th>
<th>Criteria</th>
<th>Scope of indicators</th>
<th>HQE Development</th>
<th>BREEAM Co.</th>
<th>LEED-ND</th>
<th>SPTool PT-UP</th>
<th>DGNB District</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Environment</td>
<td>Energy</td>
<td>Strategy, and energy efficiency</td>
<td>2</td>
<td>10,4</td>
<td>3</td>
<td>6,98</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>Strategy, and water efficiency</td>
<td>2</td>
<td>10,5</td>
<td>3</td>
<td>6,98</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>Walkable streets, and transport assessment</td>
<td>1</td>
<td>5,2</td>
<td>8</td>
<td>18,60</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Ecosystem</td>
<td>Agricultural, and natural system, and strategy</td>
<td>1</td>
<td>5,2</td>
<td>3</td>
<td>6,98</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Waste</td>
<td>Construction, and operational waste management, recycle management</td>
<td>2</td>
<td>5,2</td>
<td>3</td>
<td>6,98</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pollution, and hazard</td>
<td>Noise, flood avoidance, and pollution prevention</td>
<td>1</td>
<td>5,2</td>
<td>4</td>
<td>9,30</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>9</td>
<td>41,7</td>
<td>24</td>
<td>55,81</td>
<td>26</td>
</tr>
<tr>
<td>Social</td>
<td>Design process, and land use</td>
<td>Consultation, smart location, integrated strategy &amp; natural design</td>
<td>0</td>
<td>3</td>
<td>6,98</td>
<td>7</td>
<td>12,50</td>
</tr>
<tr>
<td></td>
<td>Community Culture</td>
<td>Demographic needs, ecological &amp; connected community, urban system,</td>
<td>1</td>
<td>5,2</td>
<td>1</td>
<td>2,33</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Culture</td>
<td>Compact development</td>
<td>1</td>
<td>5,2</td>
<td>7</td>
<td>16,28</td>
<td>4</td>
</tr>
</tbody>
</table>
Conclusions

This research analysed the five NSA tools, their focus areas, and their differences in approaches for assessing urban sustainability. The proposed matrix of urban sustainability indicators, consisting of twelve categories, was used to evaluate the Meudon la Forêt case study. The results revealed that the HQE Development tool is the most suitable for the evaluation of the case study due to its compatibility to the geographical context, applicability, feasibility, and rating method. However, BREEAM Co. and SPToolPT-UP were found to be more suitable based on their strong focus on social and environmental aspects. The proposed matrix of urban sustainability indicators is not exhaustive and may require additional indicators specific to the characteristics of the geographical area being evaluated. Moreover, the differences in approaches and focus areas of the NSA tools show that their suitability for a specific case study depends on various factors, such as complexity of scoring, capability, and rating methods.

The analysis and proposed matrix of urban sustainability indicators provide a useful tool for policymakers and stakeholders to evaluate existing neighbourhoods and invest in sustainability. It is crucial for authorities to consider the specific requirements of each region to ensure that the appropriate indicators are used to evaluate urban sustainability.

In conclusion, this research contributes to the existing knowledge of urban sustainability assessment by analysing five NSA tools and proposing a matrix of urban sustainability indicators. This tool can be used to evaluate existing neighbourhoods in the Great Paris region and may be adapted for other regions. It is important for policymakers and stakeholders to carefully consider the specific requirements of each region to ensure that the appropriate indicators are used to evaluate urban sustainability.

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