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A REVIEW OF FRAMEWORKS FOR ASSESSING SUSTAINABILITY IN REAL ESTATE PRICING AND PERFORMANCE

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Abstract

The real estate sector plays a significant role in sustainable development due to its substantial environmental, social, and economic impacts, particularly in resource utilization, energy consumption, and carbon emissions. Consequently, there has been an increasing need for comprehensive sustainability assessment frameworks to evaluate and improve the sustainability performance of real estate assets. This paper provides a comprehensive review of existing frameworks for evaluating sustainability in real estate performance, examining their approaches, assessment criteria, strengths, limitations, and relevance to contemporary sustainability challenges. The review considers prominent frameworks, including Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), and Global Real Estate Sustainability Benchmark (GRESB), alongside other frameworks addressing [redacted] sustainable housing, property valuation, environmental management, structural performance, and life-cycle assessment. The reviewed frameworks demonstrate the importance of integrating environmental, social, economic, and governance considerations into real estate sustainability assessment. Key indicators include energy and resource efficiency,

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affordability, social equity, environmental impact, economic feasibility, residents' satisfaction, institutional performance, and life-cycle costs. The review highlights the importance of adopting systematic and integrated assessment approaches to support informed decision-making among investors, developers, property managers, and policymakers. It concludes that robust sustainability assessment frameworks are essential for improving building efficiency, strengthening resilience, promoting sustainable housing delivery, and creating sustainable communities. Future research should focus on integrating existing assessment frameworks and addressing their limitations to improve sustainability evaluation in the real estate sector.

Introduction

The necessity for sustainable development has progressively infiltrated various sectors, highlighting real estate as a crucial focal point due to its significant environmental, social, and economic repercussions. The real estate sector holds substantial influence over resource utilization, energy consumption, and carbon discharges, thereby presenting challenges and opportunities in the realm of sustainability (Hettiarachchi & Gunawardhana, 2022). Acknowledging the fundamental role of the constructed environment in promoting sustainable communities, there has been an increasing focus on establishing comprehensive frameworks for evaluating sustainability in real estate performance (Ibiyemi et al., 2015).

Frameworks for sustainability assessment play a vital role in gauging and enhancing the sustainability performance of real estate assets. These frameworks furnish standardized methodologies for assessing different aspects of sustainability, covering environmental, social, and governance (ESG) criteria (Martins et al., 2021). Through providing extensive metrics and standards, these frameworks empower stakeholders—including investors, developers, property managers, and policymakers—to make well-informed decisions that are in line with sustainable development objectives (Sala et al., 2015).

Tupenaite et al (2018) asserts that numerous sustainability assessment frameworks have emerged in the past twenty years to evaluate sustainability in real estate, each with unique approaches and criteria. Notable examples comprise the Leadership in Energy and Environmental Design (LEED) certification, the Building Research Establishment Environmental Assessment Method (BREEAM), and the Global Real Estate Sustainability Benchmark (GRESB). These frameworks vary in scope, methodology, and geographical relevance, reflecting the diverse priorities and regulatory environments in which they function (Adamec et al., 2021).

This paper aims to provide a comprehensive review of existing frameworks for evaluating sustainability in real estate performance. By scrutinizing the strengths and weaknesses of different frameworks, this analysis aims to clarify the evolving landscape of sustainability assessment in real estate and emphasize best practices. Additionally, the article investigates the crucial sustainability indicators utilized in these frameworks and their pertinence to contemporary challenges in real estate.

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Comprehending the effectiveness and suitability of various sustainability assessment frameworks is crucial for promoting sustainable practices in real estate. As the sector grapples with the challenges of climate change, dwindling resources, and urban development, robust assessment instruments can steer significant enhancements in building efficiency and resilience. This analysis contributes to the dialogue on sustainable real estate by providing insights into the current status of sustainability assessment and pinpointing areas for future growth and creativity.

Framework for integrating sustainability issues into valuation of non-market industrial real Estates

The conceptual specification for a system dynamics model for sustainability in real estate valuation for non-market industrial properties figure 12 contributes to the understanding of sustainability in real estate valuation by providing a framework for integrating sustainability considerations into the valuation process. This model helps to identify the key components and relationships between sustainability metrics and property value.

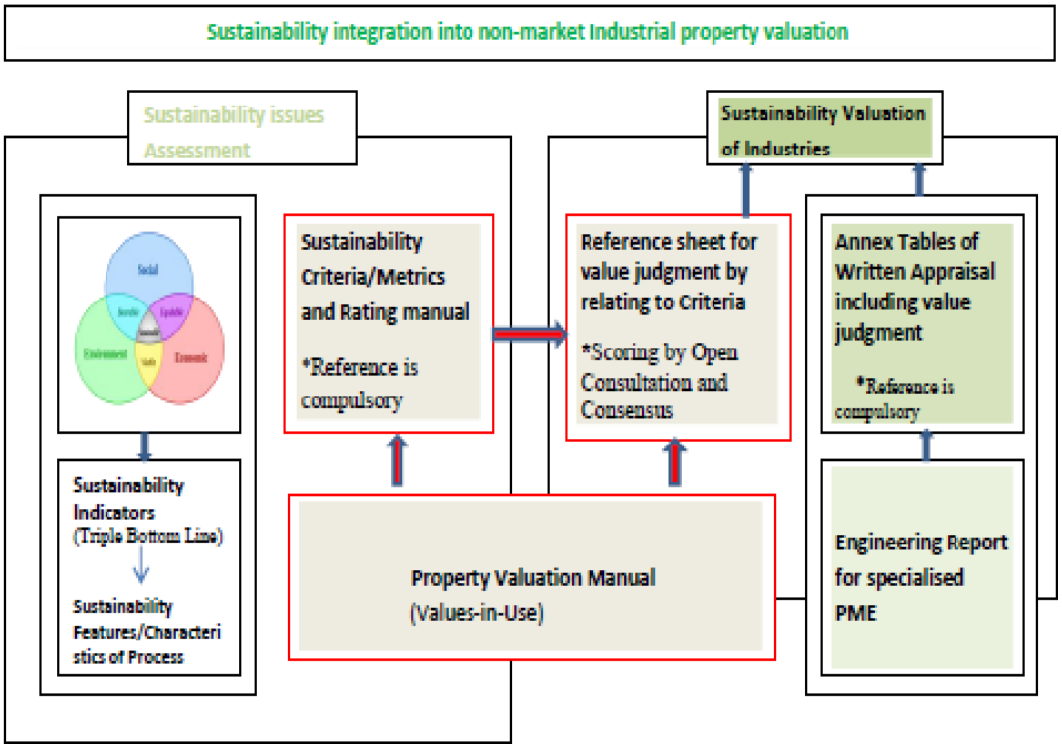

Figure 1: Framework for Integrating Sustainability into Valuation
Source: Ibiyemi, Adnan, and Daud (2015)

The framework outlined in the document for incorporating sustainability aspects into the assessment of non-market industrial real estate is grounded in a system dynamics methodology. It offers a theoretical outline for a system dynamics model concerning sustainability in real estate appraisal for non-market industrial assets, with the objective of capturing the dynamic

relationships between sustainability elements and property valuation. Furthermore, the framework encapsulates essential valuation methods that have been devised to include sustainability considerations in real estate assessment. These methods offer a methodical approach to incorporating sustainability elements in the valuation procedure. It also stresses the necessity of a non-market internalization foundation to include sustainability in the assessment of industrial real estate. This strategy surpasses conventional market-oriented valuation techniques to encompass the non-market value of sustainability. It suggests employing a sustainability obsolescence factor to evaluate industrial activities in relation to sustainability standards established by eco-friendly rating organizations or environmental regulators. This factor assists assessors in gauging the influence of sustainability on the value of industrial properties.

The framework scrutinizes the significance of sustainability from a compliance-impact standpoint, concentrating on how industrial activities conform to specified sustainability criteria. This method seeks to discourage further CO_2 emissions and externalities, advancing sustainable behaviors. Through attributing a scarcity value to environmental absorption potential and prompting companies to invest in sustainability, the framework strives to motivate industrial enterprises to embrace sustainable behaviors and contribute to environmental preservation. Summarily, the framework furnishes a methodical strategy for appraisers to include sustainability aspects in the valuation of non-market industrial real estate, underscoring the significance of contemplating sustainability elements in property assessment processes.

A systemic framework for sustainability assessment

The framework establishes a methodological strategy for Sustainability Assessment (SA) that merges various analytical methods, models, and indicators to facilitate decision-making and policy formation in sustainability scenarios. The framework further deals with fundamental distinctions at Ontological, Methodological, and Epistemological Levels, underscoring the significance of values, boundaries, sustainability frameworks, scenario design, analytical models, and measurable indicators during the assessment process as indicated in figure 13.

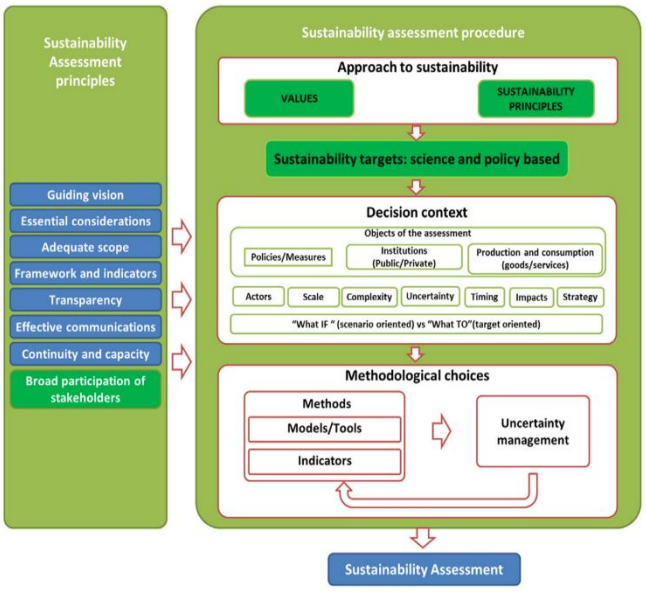

Figure 2: Schematic representation of the conceptual framework for sustainability assessment Source: Sala, Ciuffo, and Nijkamp (2015)

The framework establishes a methodological strategy for Sustainability Assessment (SA) that merges various analytical methods, models, and indicators to facilitate decision-making and policy formation in sustainability scenarios. It further deals with fundamental distinctions at Ontological, Methodological, and

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

Epistemological Levels, underscoring the significance of values, boundaries, sustainability frameworks, scenario design, analytical models, and measurable indicators during the assessment process.

The methodology strives to guarantee the thoroughness and strength of the evaluation process, concentrating on technical and scientific sustainability assessment while recognizing the intricacy of decision-making procedures. The framework is designed to lead researchers and professionals through coherent and systematic procedural stages in executing sustainability assessments. It comprises two primary sections: SA principles and SA procedure.

Along with sustainability principles, the framework takes into account principles like those delineated by Bellagio STAMP, which stress guiding vision, stakeholder engagement, transparency, and adaptability in sustainability evaluations. It further requires the identification of appropriate assessment methodologies, the performance of sensitivity and uncertainty analyses, and the definition of monitoring approaches to monitor advancement towards sustainability objectives. It makes a distinction between the functions of framework, methodology, method, model, tool, and indicator in the assessment process.

On the whole, the framework furnishes a methodical strategy for executing sustainability assessments, fusing varied analytical methods and models while considering values, uncertainties, and stakeholder participation to back informed decision-making in practical settings.

Sustainable Housing Delivery Assessment

The assessment framework for sustainable housing delivery discussed in the study considers a range of dimensions to gauge the efficacy of housing policies and programs within the context of Nigeria. Sustainable housing, beyond its environmental aspects, encompasses social, cultural, and economic dimensions which are imperative for sustainable development within the housing sector. In line with the multiple dimensions of sustainability, identified parameters for assessing the sustainability of housing policies and programs are shown in figure 14.

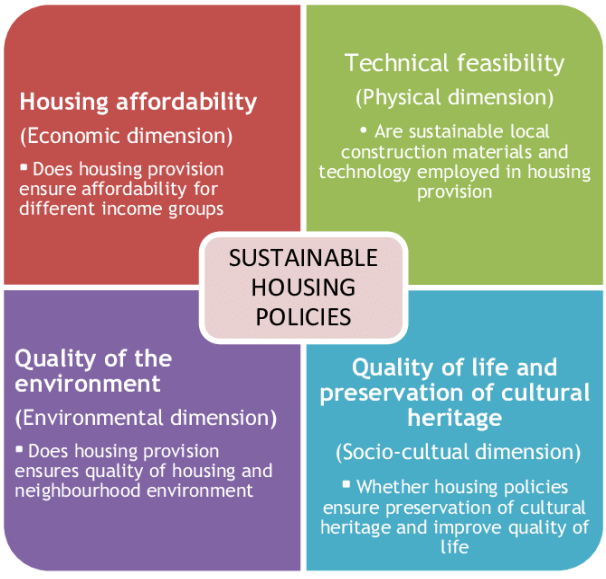

Figure 3: A framework for assessing sustainable housing delivery
Source: Muhammad et al. (2015)

Within the framework, there is a stress on the significance of criteria used to evaluate the sustainability of housing policies and programs. These criteria cover environmental concerns such as resource and energy efficiency, social equity, affordability, economic implications, and the capacity to ensure security for all members of society. The framework underlines the necessity for housing policies to encompass not only environmental factors but also social

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

integration, affordability, and economic consequences to promote sustainable housing delivery in Nigeria.

HEALTH, WELL-BEING AND SUSTAINABLE HOUSING

The framework in figure 15 aims to guide the literature on sustainable housing's impact on residents' health and well-being by focusing on three components: housing, environmental sustainability, and health. The purpose of which to inform the central theme where all three components overlap.



Figure 4: Guiding framework for review of health and sustainable housing
Source: Prochorskaite and Maliene (2013)

An historical connection between health and housing is brought to light in the paper, tracing back to the 19th century, a period when substandard housing conditions were associated with elevated disease prevalence, consequently leading to advancements in public health. The framework delineates three principal themes: "Housing and health," "Sustainable housing," and "Health and sustainable development," with a primary focus on the health repercussions of housing. Acknowledgment is given to the difficulties in quantifying social and economic factors in contrast to environmental aspects within sustainable housing, underscoring the significance of harmonizing these components for the efficacious implementation of policies.

The primary objective of the framework is to investigate the priorities of stakeholders concerning the socio-economic and environmental facets of sustainable housing, particularly emphasizing residents' inclination towards health and well-being attributes as opposed to environmental characteristics.

Integrating environmental, economic and social aspects in Sustainability Assessment

The proposed framework for integrating sustainability assessment of energy systems is outlined in Figure 16. The specification of energy technologies to be evaluated, the definition of scenarios, and the time horizon for the assessment, as well as the conduct of environmental, economic, and social assessments on a life cycle basis. The integration of sustainability indicators via multi-criteria decision analysis for ascertaining the most sustainable options for the future. The framework endeavors to present a methodical approach for evaluating the sustainability of energy systems by concurrently considering environmental, economic, and social facets.

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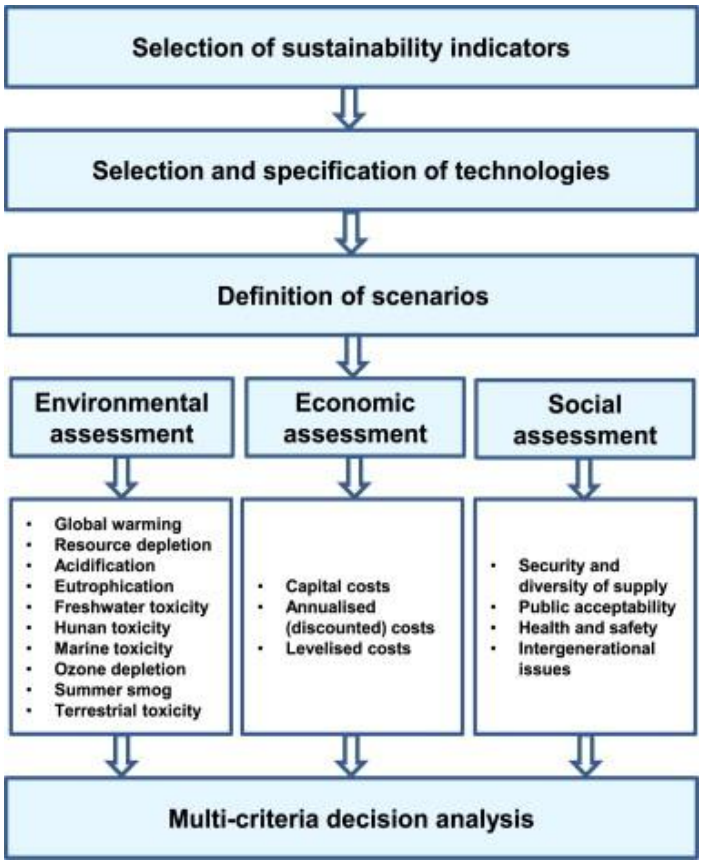

Figure 5: Decision-support framework for integrated sustainability assessment of energy systems
Source: Santoyo-Castelazo and Azapagic (2014)

Through the integration of diverse sustainability dimensions and the utilization of a life cycle approach, the framework facilitates assessments at both technological and systems levels. It underscores the significance of incorporating multiple criteria and preferences to pinpoint the most sustainable energy options for decision-making and policy formulation. The methodology expounded in the manuscript is crafted to be not only relevant to the electricity system in Mexico but also to other energy systems and regions. The framework evaluates sustainability by utilizing life cycle assessment for evaluating environmental sustainability. Employing life cycle costing for assessing economic sustainability. Considering various social indicators grouped into security of supply, public acceptability, health and safety, and intergenerational issues for evaluating social sustainability. Utilizing a total of 17 sustainability indicators to evaluate each scenario across environmental, economic, and social dimensions. Feeding the assessment results into multi-criteria decision analysis to scrutinize outcomes and pinpoint sustainable options.

By integrating these evaluation methods and indicators, the framework delivers a thorough evaluation of sustainability encompassing environmental, economic, and social dimensions. This comprehensive approach allows for the identification of the most sustainable energy options predicated on a meticulous analysis of varied criteria and stakeholder preferences.

Sustainability Assessment of New Residential Projects

The framework in figure 17 assesses sustainability of new residential projects in the Baltic States. The first step analyzes the residential market, identifies trends and new development, while the second step develops a system of sustainability indicators for assessing projects. Third and fourth steps involve weighting indicators with input from experts and using a multiple-criteria method to assess sustainability of selected projects respectively.

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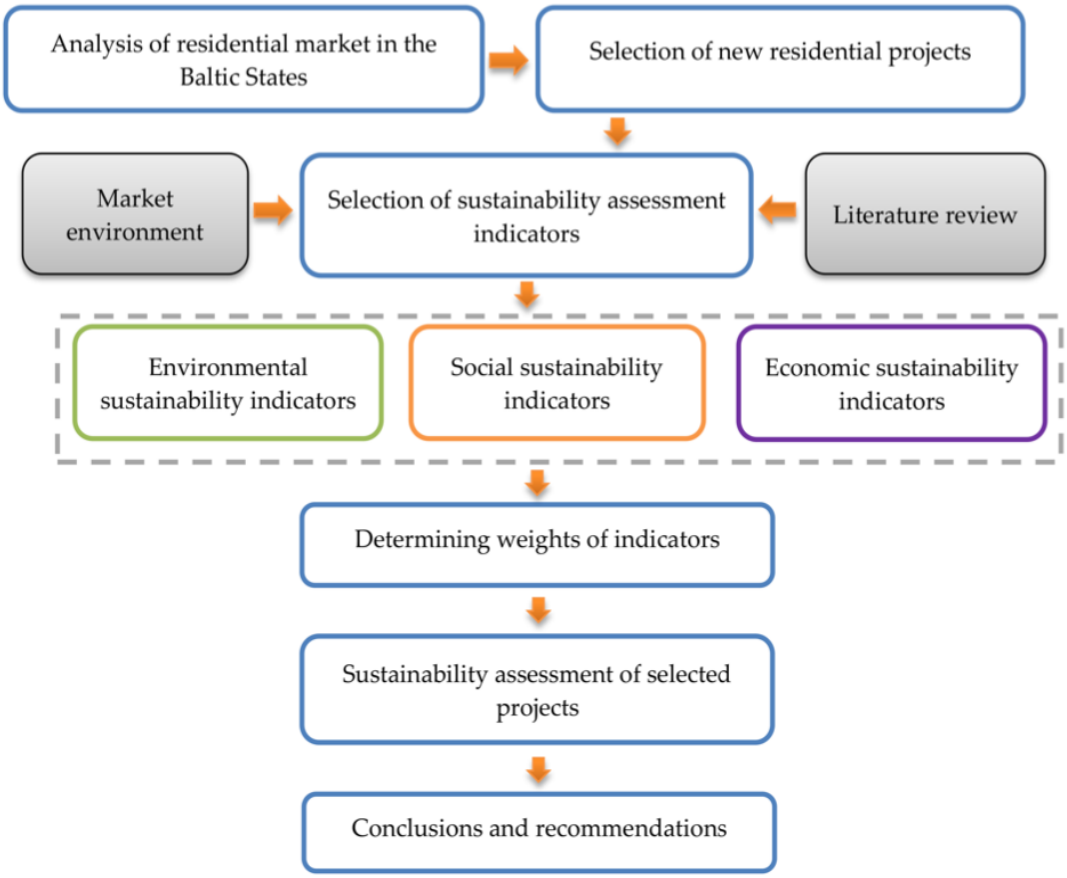

Figure 6: The sustainability-assessment framework for new residential projects Source: Tupenaite et al. (2018)

The methodology combines risk analysis with Life-Cycle Cost Analysis (LCCA) to assess building project sustainability. It applies risk analysis and LCCA to predict future building project costs. Previous studies emphasize economic evaluation techniques in the construction industry. Sensitivity analysis and risk management aid decision-making during the building's life cycle. Identifies cost drivers as stochastic variables with varying uncertainty. Uses Probability Distribution Functions (PDFs) for each stochastic input. Different lifespans scenarios introduce uncertainty in component duration. Monte Carlo Method (MCM) with Latin Hypercube Sampling (LHS) resolves iteration and sampling. Simulation and regression analysis quantify input variables' impact on Global Cost. Applied to a case study selecting technological components for a building glass facade. Evaluates
sustainability using a synthetic "economic-environmental indicator". Uncertainty in discount rates, environmental variables, and component lifespans influences output. Spider graphs show the impact of Embodied Energy (EE) and Environmental Cost (EC). Emphasizes residual value and uncertainty's effect on component lifespans. Considers time as a stochastic variable in future analyses for accurate economic modeling. Structured approach to assess economic and environmental implications of building projects. Enhances decision-making processes in

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

sustainable building design. phases are used to understand the localities past, present situation of site and surrounding areas.

Regeneration Guidelines for Sustainable Housing

The framework in Figure 18 focuses on four phases of analysis: economic sustainability, social sustainability, institutional sustainability, and environmental sustainability. These phases are used to understand the localities past, present situation of site and surrounding areas.

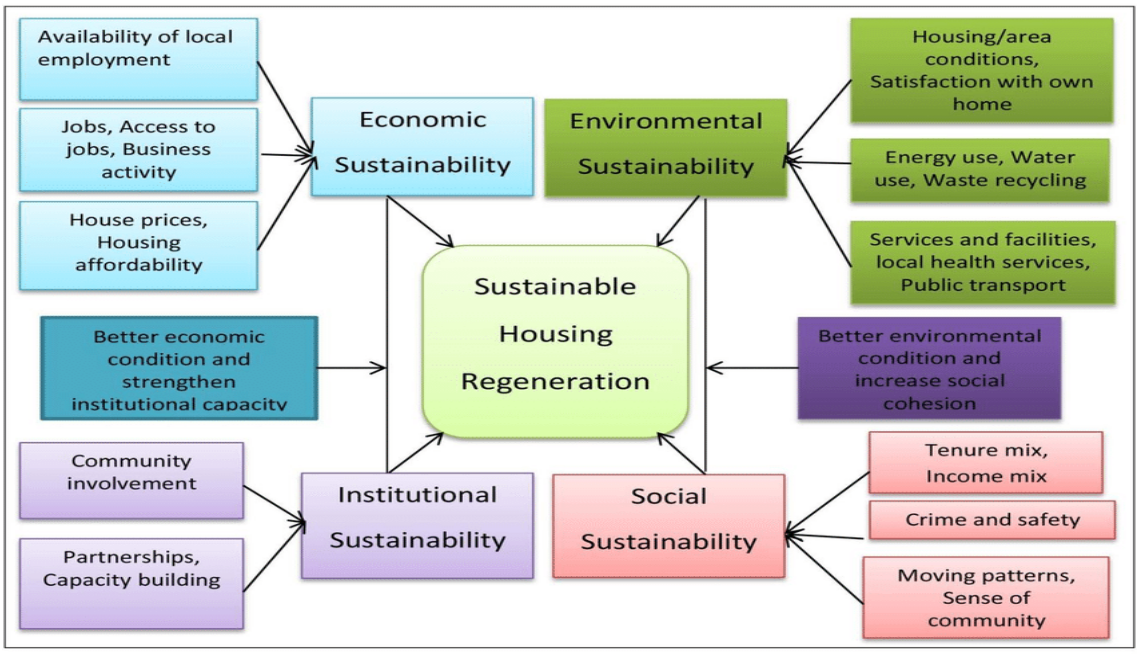

Figure 7: Analytical Framework for sustainable Housing Regeneration
Source: Raju and Roy (2016)

The framework outlined in the study emphasizes four primary stages of examination: economic sustainability, social sustainability, institutional sustainability, and environmental sustainability. These stages play a vital role in comprehending the holistic sustainability of housing revitalization initiatives in urban settings such as Khulna City, Bangladesh. The initial stage evaluates the economic feasibility of housing rejuvenation projects, entailing the scrutiny of factors like affordability, employment prospects, and the economic ramifications of the revitalization on the local populace. Subsequently, the phase of Social sustainability delves into the societal facets of housing rejuvenation, encompassing community engagement, unity, and the cultivation of a sense of community among inhabitants. Furthermore, it addresses matters concerning social fairness and inclusiveness. The subsequent stage centers on the institutional structure that underpins housing revitalization projects, examining the functions and obligations of various stakeholders, including governmental bodies, developers, and community groups, in ensuring the enduring prosperity of the revitalization endeavors. Lastly, the Environmental sustainability phase evaluates the ecological impact of housing regeneration, encompassing initiatives to enhance energy efficiency, waste disposal, and the general environmental integrity of the revitalized localities.

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

By contemplating these four dimensions of sustainability, the framework offers a comprehensive methodology for appraising and directing housing regeneration projects in urban areas. It aids in guaranteeing that revitalization initiatives not only cater to immediate housing requirements but also contribute to the overall welfare and sustainability of the concerned communities.

Sustainable Housing Satisfaction

Diagrammatic depiction of the theoretical framework utilized to evaluate the degree of contentment among inhabitants, comprising four distinct influential factors and variables is illustrated in figure 19. Regarding the structural and architectural aspects of the residence, as indicated by Ogu (2002), it pertains to the contentment, the effectiveness of the residence, the degree of convenience, and the geographical placement and community environment. These variables encompass anticipations, socio-economic trends, and demographic information.



Figure 8: Schematic representation of the residency satisfaction measurement model Source: Ibrahim (2020)

The model presents an extensive framework for sustainable housing development, underscoring the importance of the satisfaction element within this context. The framework is composed of three primary elements: environmental sustainability, social sustainability, and economic sustainability, all of which are interconnected and essential for attaining overall sustainability in housing development.

Environmental sustainability concentrates on diminishing the environmental impact of housing initiatives by focusing on energy efficiency, waste management, and the utilization of sustainable materials. Social sustainability entails establishing inclusive and thriving communities, fostering social unity, and guaranteeing the welfare of inhabitants through access to facilities and services. Economic sustainability deals with the affordability of housing, efficiency in construction costs, and the long-term financial feasibility of housing projects. The satisfaction element is emphasized as a

crucial aspect within this framework, underscoring that meeting the needs and preferences of residents is vital for the prosperity and sustainability of housing projects. By merging these elements and accentuating satisfaction, the framework strives to lead stakeholders in the housing industry towards more sustainable approaches that take into account environmental, social, and economic factors while giving priority to resident satisfaction.

Practical tool to assess sustainability

The framework proposed by Rosen et al. (2015) is comprised of four primary stages as shown in figure 20, each playing a crucial role in the assessment of wastewater treatment systems (WWTS). The extent of the EVAS tool is indicated by the dashed red line.

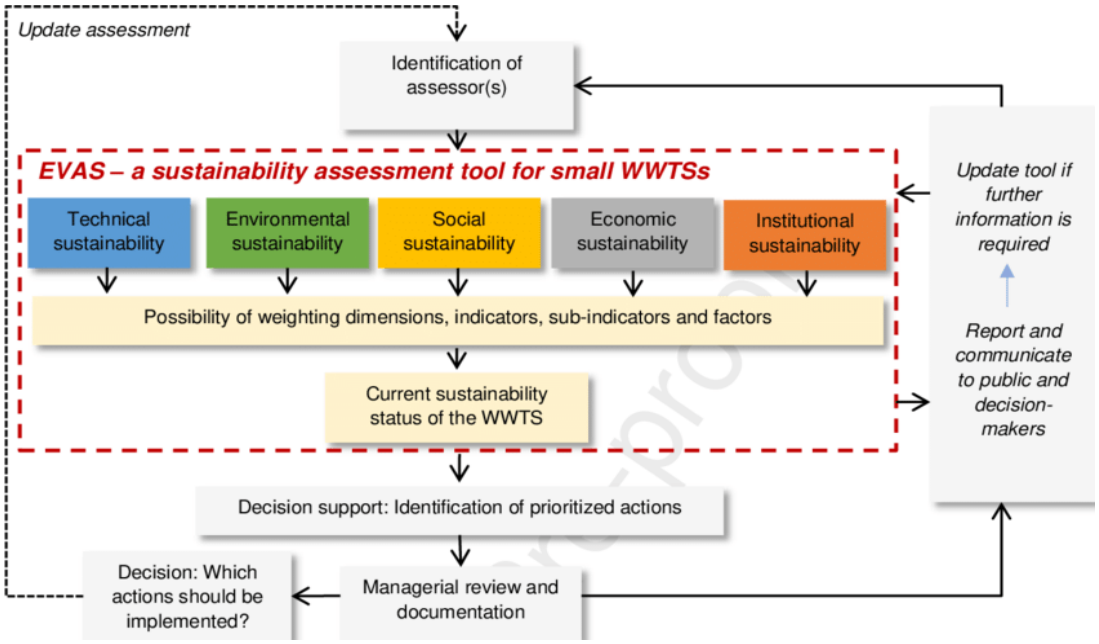

Figure 9: Sustainability Assessment Framework Adapted from Rosén et al. (2015)
Source: Cossio et al (2020)

In the initial stage, the focus lies on the meticulous selection of assessors or a panel of assessors, with a strong recommendation for the inclusion of both the manager and staff members responsible for overseeing WWTS activities. Moving on to the second stage, the framework directs attention towards the evaluation of the current sustainability status of the WWTS through the utilization of the EVAS tool. This stage also allows for the potential adjustment of weights, if deemed necessary, with a preference for involving stakeholders in the decision-making process. The third stage accentuates the significance of effectively communicating the assessment results to the general public and key decision-makers. This step is essential for garnering support and fostering initiatives aimed at bolstering the sustainability of the system. Moreover, the framework underscores the importance of maintaining an iterative working process, which enables continuous updates and adaptations based on the availability of new data. This iterative approach

ensures that the assessment remains dynamic and responsive to evolving circumstances within the WWTS domain.

Sustainability Management Framework

The frameworks for sustainability management encompass a variety of components, such as organizational structure, delineation of roles and responsibilities, strategic planning processes, and day-to-day operational procedures. These elements collectively form the foundation upon which sustainable practices within an organization are built and sustained over time. In order to align with these frameworks, numerous ISO standards have been tailored to address the specific needs of sustainability management as indicated in figure 21. These standards serve as a universal language, offering common concepts and precise definitions that facilitate the implementation and evaluation of sustainable practices across different industries and sectors.

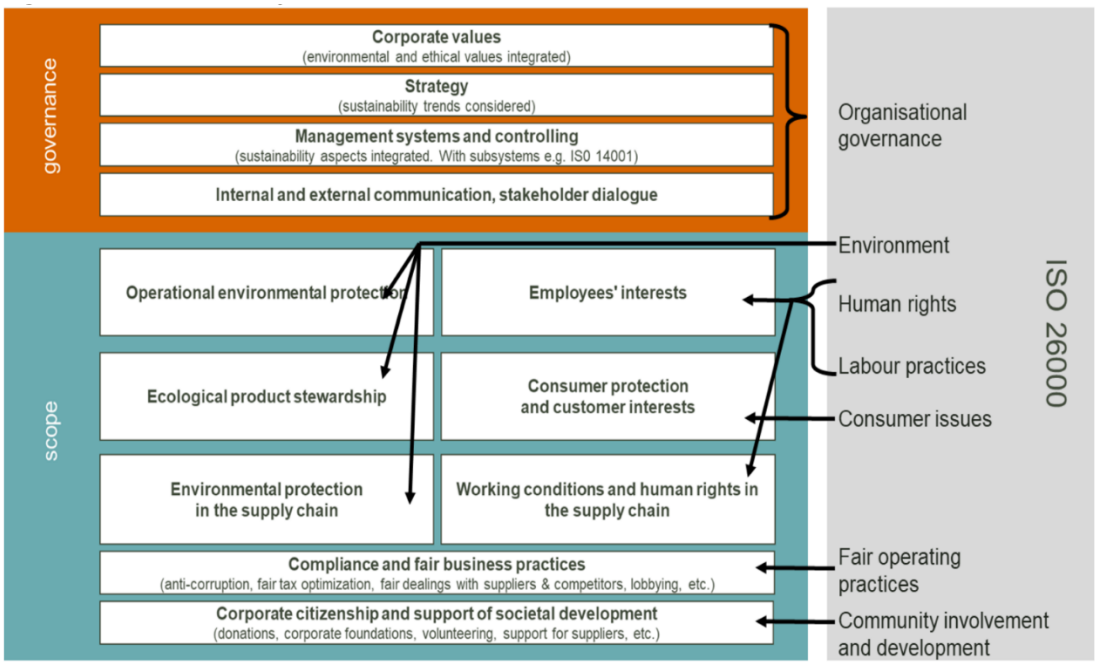

Figure 10: ISO Frameworks for Sustainability Management
Source: Al-Jebouri et al. (2017)

The detailed guidelines outlined in ISO standards play a pivotal role in enhancing the efficiency and efficacy of sustainability management strategies. By providing a comprehensive framework for establishing, maintaining, and improving management systems, these standards contribute to the overall success and impact of sustainability initiatives within organizations. In-depth examinations of pertinent frameworks such as ISO 26000, SA 8000, and Equator Principles have been undertaken to gain insights into the fundamental components of sustainability management. Through these analyses, essential elements crucial for promoting sustainable practices and responsible business conduct have been identified and are integral to the long-term success of sustainability efforts.

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

STRUCTURAL PERFORMANCE ASSESSMENT IN SEISMIC SUSTAINABILITY

The framework in figure 22 presents an innovative Sustainability Assessment that aims to comprehensively evaluate the seismic sustainability of various structures. It considers different life-cycle stages and components, such as the overall cost implications, environmental considerations, and social impacts associated with the structures under evaluation.

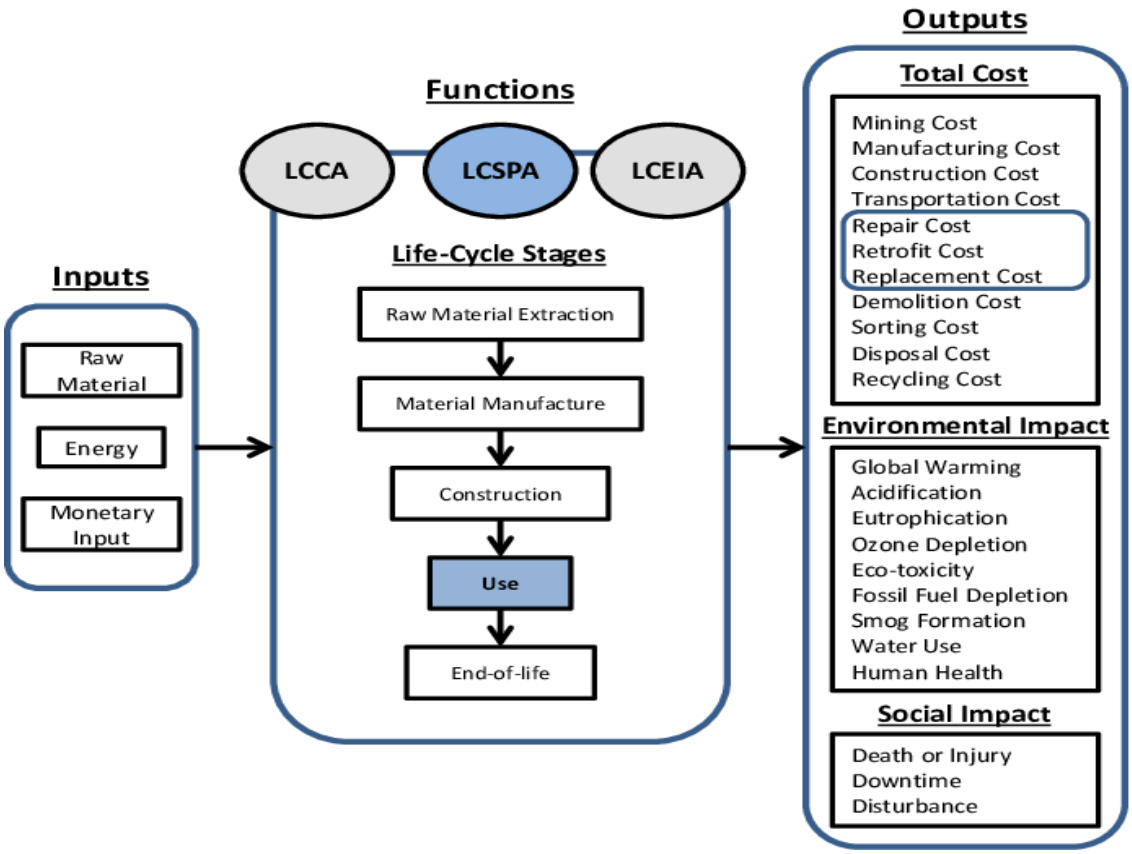

Figure 11: Sustainability Assessment Framework
Source: Gencturk and Hossain (2013)

The approach integrates three key functions to facilitate a thorough analysis: Life-Cycle Cost Assessment (LCCA), which delves into the financial aspects of a structure's life-cycle; Life-Cycle Structural Performance Assessment (LCSPA), which focuses on assessing the structural integrity and performance over time; and Life-Cycle Environmental Impact Assessment (LCEIA), which specifically examines the environmental implications of a structure throughout its life-cycle. These functions are instrumental in analyzing the inputs of raw materials, financial resources, and energy consumption in relation to the overarching concept of sustainability. Moreover, the framework is designed to encompass all stages of a structure's life-cycle, starting from the extraction of raw materials, through the manufacturing process, construction phase, utilization stage, and finally culminating in the end-of-life considerations. Through this comprehensive evaluation process, the sustainability of structures can be assessed from multiple perspectives, including economic,

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

environmental, and societal dimensions, thereby providing a holistic understanding of their overall impact and sustainability performance.

Measuring Sustainability in Housing Through Indicator-Based Assessment Tool

The Housing Sustainability Assessment Tool (HSAT) encompasses a wide array of sustainability dimensions, which include but are not limited to economic, environmental, institutional, and social aspects. Within this tool, one can find a diverse range of assessment methods that have been strategically integrated to provide a comprehensive evaluation of sustainability. These methods encompass individual indicators, such as the calculation of annual water consumption per person, as well as more complex indices like the weighted urban proliferation index, and intuitive dashboards designed to facilitate the understanding of intricate concepts such as green spaces as shown in figure 23.

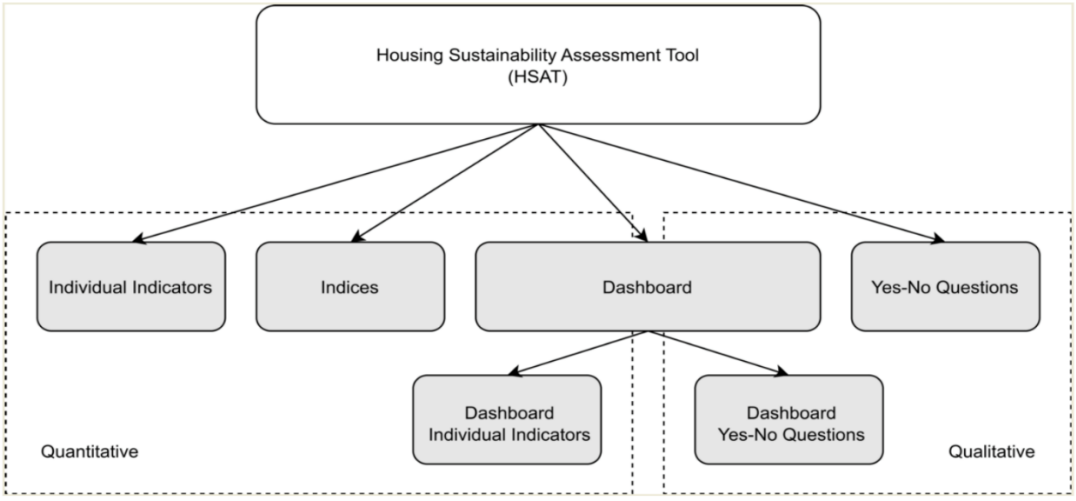

Figure 12: The housing sustainability assessment tool (HSAT) structure
Source: Adamec, Janoušková, and Hák (2021)

When delving deeper into the composition of the HSAT, it becomes apparent that social indicators take precedence with a significant representation of 19 indicators. Following closely behind are environmental dimensions with 17 indicators, institutional aspects with 15 indicators, and economic considerations with 4 indicators. It is important to note that there may be a degree of overlap among these dimensions, where certain indicators can be interpreted from multiple perspectives. For instance, an indicator like "the percentage of the cost of locally sourced materials from all materials used for construction" not only pertains to economic considerations but can also be viewed through the lens of sustainability from an environmental standpoint.

Assessing Risk and Uncertainty in Sustainable Building Projects

The framework for defining the model input entails a series of crucial steps, as delineated within the scheme. Figure 24 shows the initial step involves the identification of pertinent cost drivers in the form of stochastic variables. Subsequently, a Probability Distribution Function (PDF) is

EDITOR-IN-CHIEF
Prof. W. F. HILL [MALAWI]

allocated to each of these stochastic input variables. Furthermore, the process includes the delineation of various alternative scenarios, each with distinct lifespans, in order to introduce a level of uncertainty into the model.

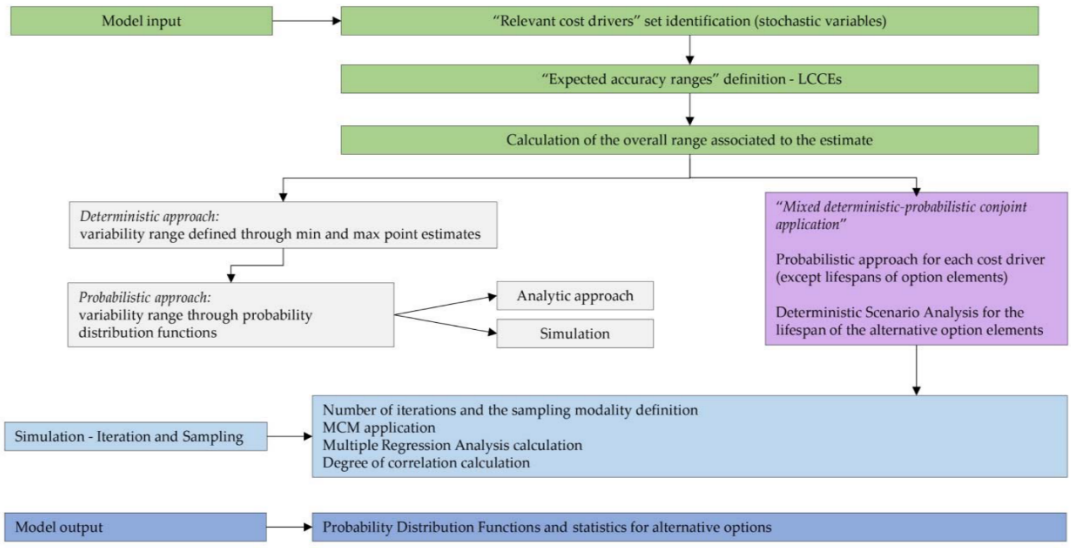

Figure 13: Model Input Definition Framework
Source: Fregonara, Ferrando, and Pattono (2018)

The subsequent stage entails iteration and sampling, utilizing methodologies such as Latin Hypercube Sampling (LHS). Following this, simulations are executed and regression analysis is performed to accurately quantify the impact of the input variables on the resulting output value. Finally, graphical representations like tornado graphs and spider graphs are generated to visually depict the outcomes of the analysis.

Sustainability Assessment Tools for Real Estate Sector - An Applicative Primer

Sustainability is now a priority for policymakers at all levels in the real estate sector, with various stakeholders considering it crucial. The framework in figure 25 stresses the rising importance of sustainability in real estate and the necessity for effective assessment tools. International agreements and directives like the Kyoto Protocol and city-level regulations promote sustainability in real estate.

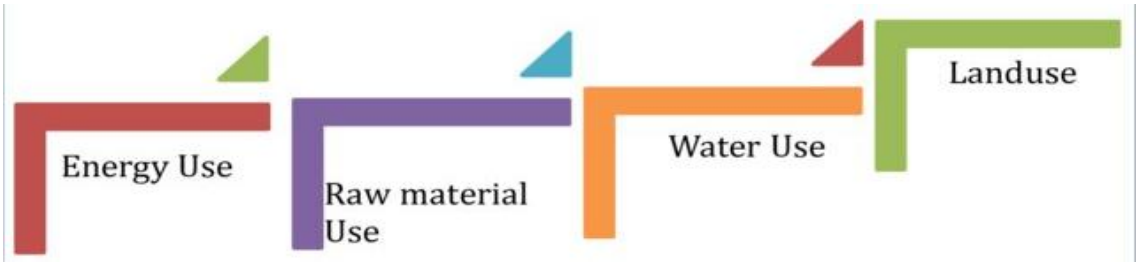

Figure 14: Basis for integrating sustainability in real estate property valuation and rating assessment
Source: Pimpalkhute (2019)

Acknowledging risks like uncertainties in policies and environmental challenges, the framework emphasizes the need for integrating sustainability in real estate valuation. People's attitudes towards sustainable design can impact real estate market decisions. A variety of rating tools track sustainable design and development, tailored to specific locales instead of a universal approach. It depicts a scenario narrative involving residents, constructors, developers, and investors on sustainable design. It discusses issues like the availability of sustainable buildings and market demand for such projects. Overall, it highlights the importance of sustainability in real estate, the associated challenges and risks, the role of policies, and the diversity of available rating tools.

Conclusion

The review emphasizes the importance of robust methods in sustainability assessment in real estate. Different frameworks like LEED, BREEAM, and GRESB aim at improving ESG outcomes. Strengths and limitations of these frameworks are discussed, along with key sustainability indicators. Sustainability frameworks are crucial as the real estate sector faces global challenges like climate change. They help in making informed decisions for creating sustainable communities. Future research should focus on integrating frameworks and addressing limitations to lead towards a sustainable future in real estate.

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