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Editorial

Latest Research on the Theme of "Sustainability, Challenges, and Opportunities to Optimize Building Performance"

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1. Introduction

In the face of escalating climate change, rapid urbanization, and dwindling natural resources, the imperative for sustainable practices within the construction and architectural sectors has never been more critical. Buildings are not only fundamental to human habitation and economic activity but also significant contributors to global energy consumption and carbon emissions. "Sustainability: Challenges and Opportunities to Optimize Building Performance" offers a comprehensive exploration of the multifaceted strategies and innovations essential for enhancing building performance while minimizing environmental impact. This collection of 21 meticulously curated articles delves into the various dimensions of sustainable building design, construction, and operation, presenting both the theoretical frameworks and practical applications that address contemporary challenges and pave the way for a resilient, efficient, and sustainable built environment.

The book is organized into five sub-themes, each addressing a core aspect of sustainability in building performance. This structured approach facilitates logical and scientific progression, enabling readers to grasp the foundational concepts before delving into advanced applications and specialized topics. Each article within these sections contributes uniquely to the overarching theme, creating a cohesive narrative that underscores the interconnectedness of sustainable practices in the construction industry.

The following editorial sequence facilitates the reader's understanding of sustainability in the built environment, from overarching theoretical concepts to practical application.

1. Foundational Concepts in Sustainable Building Design;
2. Advanced Applications and Modular Design Solutions;
3. Structural Innovations and Energy Efficiency;
4. Energy Optimization in Extreme Climates;
5. Retrofit Strategies and Energy Efficiency in Urban Housing.

2. Thematic Content

This collection showcases 21 studies and is structured to provide logical and scientific progression, beginning with fundamental research on energy optimization in building design and advancing towards more specific, innovative solutions that address the myriad challenges of sustainable construction. Each article contributes to a holistic understanding of sustainable building performance, highlighting the current research, innovative methodologies, and practical applications that push the boundaries of conventional design practices.

It should be noted that the researchers contributing to this collection are drawn from every continent, truly representing the concerns and priorities of those around the world working at making our built environment truly sustainable. Represented here are the

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cutting-edge work of experts from the USA and Brazil in the Americas; the UK, Portugal, Spain, Italy, and France in Europe; Egypt, Saudi Arabia, and Turkey in the Middle East; South Africa, Namibia, and Zambia in Africa; China, Hong Kong, South Korea, Japan, and Thailand in Asia; and researchers from Australia.

2.1. Foundational Concepts in Sustainable Building Design

This initial section establishes the essential principles and methodologies that underpin sustainable building performance. It lays the groundwork for understanding how strategic design and early-stage planning can significantly influence a building's energy efficiency and environmental footprint.

Thus, in this section, the bigger picture is presented. Simulations have long been understood as potential aids in the optimization of building design, and, in particular, with regard to energy use. Yet to date, the standardization of simulation models has remained elusive. Our first study offers a solution by way of a framework. Similarly, we would expect the efficiencies inherent in modular construction to leverage the affordability of housing. Yet, modular construction continues to suffer from a lack of traction. If this is to be addressed, a clearer understanding of the impediments must be had, and this insight is offered in our second paper. The decision-making process, so necessary to be attuned with sustainable design principles, also remains underexplored. Thus, offered in this collection is a comparison of the current systems which wrestle with the competing criteria of economic, social, and environmental considerations, with a validated multi-criteria model proposed. Finally, this section also examines BIM. Much has been said on the topic and in regard to the potential of BIM to lift construction productivity. However, here we present a paper that reveals BIM's capacity to integrate the digital technologies on which leverage of productivity is predicated.

A precis of the four papers comprising this first section is presented as follows:

The first paper "The Use of Energy Simulations in Residential Design: A Systematic Literature Review" underscores the importance of energy efficiency, examining how early-stage simulations can help optimize residential building design. By identifying critical design parameters and proposing a standardized nine-step framework, it aligns residential energy optimization with the United Nations' Sustainable Development Goal 11 for sustainable cities. The paper emphasizes how energy simulations can optimize designs early on, reducing energy consumption and enhancing environmental performance. The systematic review identifies gaps in standardized approaches, establishing a nine-step framework for integrating energy simulations into early design phases. These simulations are critical for sustainable urban densification, where efficient energy use can mitigate the environmental impact of growing cities.

The second paper "Overcoming Deterrents to Modular Construction in Affordable Housing: A Systematic Review" explores the deterrents to adopting modular construction in affordable housing, identifying key barriers, and proposing strategies for overcoming them. Modular construction holds great potential to reduce material waste, minimize environmental impact, and streamline construction processes, but as this study reveals, significant economic, regulatory, and technical barriers prevent widespread adoption. By highlighting the interconnections among various challenges, this study provides a strategic blueprint for promoting sustainable and cost-effective housing solutions.

Ma and Siddhpura [1] introduces a decision-making framework that evaluates structural systems based on economic, social, and environmental criteria using the Fuzzy Analytic Hierarchy Process (FAHP). The comparison of the innovative and traditional structural systems offers a guideline for selecting sustainable designs that balance multiple sustainability dimensions.

Finally, the fourth paper "Building Information Modeling Technology Capabilities: Operationalizing the Multidimensional Construct" of this section focuses on the digital transformation of the construction industry; this study operationalizes Building Information Modeling (BIM) capabilities as a multidimensional construct. It provides a robust frame-

work for measuring and enhancing BIM's role in integrating sustainability across a building's lifecycle, facilitating informed decision making and efficient project management.

2.2. Advanced Applications and Modular Design Solutions

Building upon the foundational concepts, this section explores the advanced applications of sustainable practices with a particular emphasis on modular design and disaster resilience. It showcases innovative solutions that integrate sustainability with practicality and resilience.

Moving from the necessary theoretical abstractions to application is the focus of this second group of research. The theme of modular design is revisited, but this time in regard to the manufacture of inflatable cabins to be used in flood scenarios. The first paper in this section explores the added layer of 'green' considerations in the design of such life-saving innovations. Similarly, while Japanese construction expertise is widely recognized with respect to earthquake resilience, soil subsidence, and wind resistance, such as in typhoons, transferring such expertise to less capable nations represents a significant step in globalizing sustainability capacity. The second paper explores the transference of Japanese technologies to needy communities in impoverished Northern Vietnam. The third paper explores a more controversial problem; the suppression of vernacular construction practices at the behest of far-off governments, whose policies seek to homogenize national values. Here, the interests of minority voices are championed in alignment with the UN's Sustainable Development Goals that seek for 'inclusion.' The final paper in this section is a somewhat personal case study of single-house construction, which may easily be extrapolated to indicate the fundamental problem underlying building construction everywhere. That problem is the pervasive limited knowledge building designers, tradesmen, and regulators have that are ultimately essential to the success of the sustainable built environment mission.

A summary of the four papers comprising this second section is provided in the following:

Wang, Pan, and Liu [2] present a green, inflatable cabin for flood prevention utilizing a combined Analytic Hierarchy Process (AHP) and Geographic Information Systems (GIS) analysis. By prioritizing design elements and developing spatial strategies, it offers a scalable solution for enhancing disaster resilience in urban environments prone to natural disasters.

Zhang, Li, and Komai [3] integrate Japanese construction techniques with the local conditions in Northern Vietnam. This empirical study enhances structural safety and disaster resistance. It demonstrates how tailored design approaches can optimize building performance in challenging geographical and climatic contexts, promoting sustainable and resilient construction practices.

The paper "Sustainable Construction through the Lens of Neoliberal Governance: The Case of Vernacular Building Systems in Catalonia, Spain" examines the impact of neoliberal governance on vernacular construction methods in Catalonia. It highlights the tension between expert-driven systems and traditional sustainable practices, emphasizing the need to preserve diverse building techniques that contribute to sustainable construction.

Finally, Wehbi and Messadi [4] delve into the pre-construction challenges and modular sustainable design solutions of a multi-generational Passive House. The paper provides insights into the gaps and barriers encountered, aligning with the advanced and innovative applications of the sustainable design principles explored in this section.

2.3. Structural Innovations and Energy Efficiency

Focusing on structural advancements and energy-efficient technologies, this section delves into the innovations that enhance the sustainability and performance of buildings. It explores how cutting-edge materials and structural designs can reduce environmental impacts and improve energy efficiency.

Improving the sustainable usage of concrete, which is both ubiquitous and at the same time environmentally costly, is a worthy research pursuit. Two papers in this section

cover this theme. In the first study, the authors investigated a substitute for the declining availability of fly ash, which is used in processes such as cement manufacture. Here, the emphasis is on finding materials that might be recycled, one of which is waste clay brick powder. Though it is still environmentally impactful, if it is used in the right proportions, efficient results are obtained. The second study also investigates concrete optimization. Again, concrete and its negative impact on the environment is tackled. This time, the study reveals how concrete volumes in foundation members may be reduced with the use of suggested optimal retrofit detailing.

An overview of the two papers that comprise this third section is given as follows:

Sharmin, Biswas, and Sarker [5] explore the use of waste clay brick powder in geopolymer binders. This study assesses the economic and environmental benefits of recycling construction materials. The lifecycle analysis highlights the potential of waste clay brick powder (WCBP) to reduce environmental impact while maintaining mechanical strength, advocating for sustainable material reuse.

Finally, the paper "Investigation of Load-Bearing Capacity for Reinforced Concrete Foundation Retrofitted Using Steel Strut–Tie Retrofit System" presents an optimized steel strut–tie retrofit system for reinforced concrete foundations, significantly reducing foundation thickness and material usage. Through finite element simulations, it demonstrates how structural innovations can enhance load-bearing capacity while minimizing environmental and economic costs.

2.4. Energy Optimization in Extreme Climates

Addressing the unique challenges of energy optimization in extreme climatic conditions, this section presents solutions that balance thermal comfort, energy efficiency, and aesthetic considerations. It emphasizes the importance of adaptive strategies in regions with harsh weather patterns.

Often understood as the most pressing aspect of sustainable construction, energy usage remains a key research concern, and with that, heating and cooling. In this section, we present studies that address how energy use in buildings may be mitigated. The first study looks at redressing the poor thermal performance of office buildings in the remote city of Turpan, China. The researchers demonstrate that the three measures of energy consumption, carbon emissions, and lifecycle costs can all be reduced with the judicious use of intelligent systems. Similarly, in the second study, the author shows that the optimal use of adjustable blinds in the hot environment in Saudi allows architects to continue to favor glazed facades for aesthetic purposes while reducing ingress heat flow from 7.1 W/m^2K to as little as 4.2 W/m^2K. Overheating also proves to be a problem in the UK, especially in post-2012 terraces and flats. Reducing window area along with triple glazing reduces solar gains by 85%. The final contribution to this section explores the superior predictive quality in regard to the energy consumption of the author's predictive multi-head transformer model.

A synopsis of the four papers comprising this fourth section is offered as follows:

The first paper of this section "Prediction and Optimization Analysis of the Performance of an Office Building in an Extremely Hot and Cold Region" utilizes a Convolutional Neural Network (CNN) model to optimize energy use and reduce carbon emissions in an office building located in Turpan, China. Through multi-objective optimization and decision analysis, it provides a framework for enhancing building performance in regions with extreme seasonal temperatures.

The paper "Aesthetic and Thermal Suitability of Highly Glazed Spaces with Interior Roller Blinds in Najran University Buildings, Saudi Arabia" evaluates the thermal performance of highly glazed spaces equipped with dark-tinted double low-E glass and interior roller blinds in hot arid climates. It balances aesthetic appeal with thermal efficiency, offering insights into how architectural elements can mitigate heat gain while maintaining visual attractiveness.

Jariwala and Taki [6] address the rising risks of overheating in UK housing stock by employing Dynamic Thermal Simulations (DTS) to evaluate passive cooling mitigation strategies in modern flats. The findings highlight effective design modifications that significantly reduce solar gains and energy consumption, guiding policymakers to develop resilient housing strategies.

Zhao and Zhang [7] explores energy efficiency in photovoltaic-integrated buildings. Utilizing a hybrid optimization approach combining Particle Swarm Optimization (PSO), Support Vector Machine (SVM), and Non-dominated Sorting Genetic Algorithm II (NSGA-II), the author aims to reduce energy consumption, carbon emissions, and operating costs by optimizing building envelope and photovoltaic components. The results demonstrate a 41% reduction in energy consumption, 34% in carbon emissions, and 20% in retrofit costs over 25 years. Sensitivity analysis highlights the significant roles of window–wall ratios and photovoltaic elements in maximizing building efficiency, suggesting a sustainable model for energy optimization in building retrofits.

Finally, Oliveira and Oliveira [8] introduce a modified multi-head transformer model; this study enhances energy consumption forecasting accuracy, enabling more effective energy optimization in building operations. By outperforming traditional neural network models, it underscores the potential of advanced machine learning techniques in promoting sustainable and energy-efficient building practices.

2.5. Retrofit Strategies and Energy Efficiency in Urban Housing

The final section focuses on retrofitting the existing structures to improve energy efficiency and sustainability. It explores innovative tools and methodologies that facilitate the transition from traditional to sustainable building practices in urban settings.

This portion of the collection is the largest, with seven submissions. The first paper looks at retrofitting from a health perspective. While the economic benefits and energy consumption reduction benefits are well known, here the health benefits of retrofitting are examined. Second, in the section is a study on how the shadows cast by buildings impact the environment. However, computing the geometry of shadow movements to be cast by a proposed building has remained difficult to predict. Here, an adaptation of BIM is presented which can accomplish this. A third aspect of human comfort is that of indoor environmental quality as experienced in mass transit. The study presented here looks at aspects of the thermal, acoustic, and visual environment offered by Nigerian train cabins. The results, while revealing the sub-optimal quality of the tested trains, offer a framework for assessing similar environments in an effort to responsibly inform retrofits. The retrofitting of domestic houses is also examined, this time with the homeowners' limited budgets for doing so in mind. The authors explore a simulation tool that advises users of the cost–benefits and payback periods for any retrofitting option that may be considered. The fifth study also attempts to make complex applications available to novice users. This time, BIM modeling and simulation data are shown to be accessible to non-digital experts charged with improving the performance of the existing building stock.

A feature of a sustainable built environment that should not be neglected is its economic contribution, noting of course that this should not be achieved at the expense of the environment. The pursuit of economic development and environmental preservation often appears contradictory. Finding the optimal balance of one against the other is the subject of the sixth study presented in this section, where the commercial attractiveness of a three-star hotel was measured against the personal preferences of consumers. Finally, we have the most eclectic paper of the mix. Our final contribution examines food security, and specifically the fisheries of the Kavango-Zambezi, Africa. As might be expected, the findings reveal government policy, regulations, and enforcement to be far from adequate. However, again, the revelations of this one case hold lessons that may be extracted more broadly. Indeed, the take-away from each paper presented in this mix can be extrapolated far and wide to good effect; and this is their ultimate value.

An outline of the seven papers comprising this final section is provided as follows:

Benites-Aguilar and Marmolejo-Duarte [9] examine how residents' perceptions of health benefits influence their willingness to undertake energy retrofits. The findings reveal a low awareness of health co-benefits among less educated households, highlighting the need for policy interventions that promote both energy efficiency and public health.

Voivret, Bigot, and Rivière [10] introduce a novel solid clipping method by automating shadow geometry computations in BIM tools, facilitating the verification of solar protection measures. This innovation streamlines the integration of thermal regulations into the design process, enhancing energy conservation efforts in hot climates.

The third paper "Indoor Environmental Quality Assessment of Train Cabins and Passenger Waiting Areas: A Case Study of Nigeria" of this section focuses on indoor environmental quality (IEQ) in mass transit environments; this study assesses the air quality, thermal comfort, noise levels, and lighting in Nigerian train cabins. The results highlight significant IEQ deficiencies, emphasizing the need for sustainable design interventions in public transportation to ensure commuter well-being.

Algohary, Mahmoud, and Yehya [11] present a decision-making tool designed to help homeowners select optimal energy retrofit measures for gated communities. By prioritizing budgets, payback periods, and energy savings, the tool promotes informed and strategic retrofitting decisions that enhance energy efficiency and sustainability in urban housing.

The fifth paper "Building Information Modeling and Building Performance Simulation-Based Decision Support Systems for Improved Built Heritage Operation" of this section explores the integration of BIM and performance simulation technologies into decision support systems (DSSs). This study enhances the management and operation of built heritage. Making building data accessible to non-experts supports sustainable preservation efforts and informed decision making for energy performance improvements.

Sirirat and Thampanichwat [12] analyzes how architectural design and service factors influence consumer choices in the hospitality sector. By aligning aesthetic and comfort elements with sustainable design principles, it demonstrates how hotels can enhance customer satisfaction while promoting sustainability.

Finally, the last paper "Transboundary Fisheries Management in Kavango–Zambezi Transfrontier Conservation Area (KAZA-TFCA): Prospects and Dilemmas" underscores the broader implications of sustainable resource management on community well-being and environmental conservation. It connects to the book's overarching theme by highlighting the interdependence of sustainable practices across different sectors, including those beyond the built environment.

3. Conclusions

"Sustainability: Challenges and Opportunities to Optimize Building Performance" is a timely and essential resource for professionals, researchers, and policymakers in the fields of architecture, engineering, urban planning, and environmental management. As the world strives to meet ambitious sustainability targets, the insights and methodologies presented in this book offer valuable guidance for optimizing building performance across diverse contexts and challenges.

The relevance of this compilation lies in its comprehensive coverage of both foundational concepts and cutting-edge innovations in sustainable building practices. By addressing a wide array of topics—from energy simulations and modular construction to advanced forecasting models and retrofit strategies—the book provides a holistic perspective on the multifaceted nature of sustainability in the built environment. Moreover, the inclusion of case studies from different geographical regions emphasizes the global applicability of the research, fostering a cross-cultural understanding of sustainable practices.

In the current context, where sustainable architecture and building optimization are pivotal in mitigating climate change and enhancing urban livability, this book stands out as a critical tool for fostering informed decision making and promoting innovative solutions. It not only highlights the existing challenges but also illuminates pathways for overcoming

them, empowering stakeholders to contribute to a more sustainable and resilient future for our built environment.

By weaving together theoretical insights, empirical research, and practical applications, "Sustainability: Challenges and Opportunities to Optimize Building Performance" serves as a cornerstone for advancing sustainable construction and architectural practices, ultimately contributing to the creation of healthier, more efficient, and environmentally responsible buildings worldwide.

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