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SUSTAINABLE ENVIRONMENTAL DESIGN STRATEGY AND ITS IMPACT ON SUSTAINABLE BUILDINGS

Salah Mahdi Saleh Al-Adilee
Institute of Najaf Technical, Al-Furat Al-Awsat Technical University, Al-Najaf 31001, Iraq

Abstract
Sustainable environmental design solutions are crucial to reducing negative environmental impacts and maximizing the comfort of building inhabitants. This article emphasizes how these practices and ideas affect building performance and delves into the essentials of sustainable environmental design. Energy efficiency, water conservation, sustainable material use, and renewable energy source integration are some of the measures examined in the project, which aim to lessen environmental consequences and promote sustainability.
This study aims to illuminate effective, sustainable design solutions by analyzing current case studies and sustainable building certifications like LEED and BREEAM. Modern ventilation systems, green roofs, and passive solar architecture are just a few examples of the creative ideas shown in these case studies that help make buildings more sustainable. Considerations of economics, regulatory frameworks, and technical developments are among the opportunities and threats that the article lists as consequences of embracing sustainable design approaches.
The findings show that sustainable environmental design offers many economic and social benefits, including reduced operational costs, enhanced indoor air quality, and increased occupant happiness. The paper concludes with suggestions for how sustainable design concepts might be more widely used in architectural practices and policy frameworks to create truly sustainable built environments. It argues for a comprehensive strategy that combines economic, social, and environmental objectives.

Keywords Economics, regulatory frameworks, sustainable environmental design.

INTRODUCTION

Sustainable building practices incorporate environmental knowledge and function into the design and construction process to ensure that the construction and operation of buildings do not negatively impact natural environment processes, air quality, climate change, water management, or aquatic health (Beermann & Chen Austin, 2021). While the environmental impact of building construction and operations is considered, green design is often regarded as sustainable. Planners and developers work hand in hand with stringent policy goals regarding limiting and lowering environmental burden, which assumes resource productivity. According to Peng et al. (2023), there are three primary approaches to minimizing the negative impact of buildings on the environment. These include adhering to green ratings, setting sustainability priorities or standards, and optimizing for multiple factors.

Importance of Sustainable Environmental Design Strategy

Sustainable architecture and design have become more critical in this age of increasing energy costs and demands as people become more conscious of the importance of environmental issues. A sustainable design that lessens pollution, ecological stress, and environmental strain has emerged as a challenge in modern times, even though buildings are primary, constant, and susceptible consumers of natural resources. In recent years, one of the most lofty objectives has been identifying and collecting sustainable techniques in diverse human and environmental settings. Because of the substantial environmental impact, designing communities, buildings, and sustainable spaces is crucial to preserving sustainable development. These designs are examined and assessed with a focus on the economic and social aspects, the health of the environment, and its natural components. These plans lay the groundwork for sustainable development's environmental initiatives and movements (Venugopalan & Aydt, 2023).

Sustainable environmental design strategies are seen as crucial in managing almost all constructed forms towards sustainability. A thorough examination of the social, ethical, cultural, and physical landscapes and their interplay is required to design environmentally friendly buildings and spaces. To provide an ecological approach and system for making appropriate surroundings for sustainable buildings, sustainable environmental design strategies often respond to ecologically focused criteria. On top of that, it primarily addresses the following points: Efforts to ensure water sustainability, rely on passive systems and natural resources, choose environmentally friendly plant species, conduct biophysical planning, regulate energy consumption, implement policies for material and plant ecology, and clean dirty air by natural means. According to Taraka Naga Veerendra et al. (2022), these measures have increased the space's environmental quality while leading to sustainable management of natural resources and the environment.

The need for energy has increased, along with pollution and its adverse environmental effects. The societal consequences of lousy design far outweigh the financial and environmental costs. The fact is that some of the most apparent ecological issues we face today result from bad design, which, in turn, has many unintended consequences. The elements that are working against solutions are, thus, the most essential parts of these difficulties. Here, the modern era's driving force emphasizes eco-friendly, sustainable building design. According to Andrikopoulos et al. (2022), a combination of a robust market system, affordable public services, practical technology application, efficiency rule guidance, and strong regulations can create a more robust and more human-friendly economy, which in turn can have a positive impact on any adverse environmental problems.

Key Principles of Sustainable Environmental Design Strategy

By distributing risk over numerous potential options and drastically reducing the possibility of catastrophic, large-scale failures, various techniques are frequently highly successful at increasing urban resilience. Various environmental strategies require different amounts of time, and short-termism can impede adaptation (T. Lesko et al., 2011). An essential consideration in developing a growth-optimal strategy for sustainable cities is the clear benefit of early investment in development and planning for the future. Most modern cities have probably been slowed down from attaining their ideal configurations by legislation due to the conservative nature of many urban indices. This shows how transformational tactics are painful and warns against combinatorial explorations of

optimal configurations for city resource efficiency.

Promoting preservation, development, and conservation to replenish rather than deplete natural resources is the goal of a sustainable environmental strategy. Integrated analysis and a solution framework are essential tenets of sustainable environmental design (Mauree et al., 2019). The world we inhabit is intricately woven with unintended effects. According to T. Ferguson et al. (2016), designers should always consider all relevant facts while acknowledging that uncertainty is inevitable. Designing for resilience is the third premise. At the community, habitat, and city levels, resilient strategies aim to build resilient urban settings capable of returning from the destruction wreaked by natural catastrophes.

Integration of Sustainable Environmental Design Strategy in Building Design

It is possible to assess the urban material inventory and its life-cycle-related elements for every infrastructure system, material, or building. The evaluation of infrastructure's service life commonly includes evaluating the implications of demolitions, removals, and decommissions and considering lifecycle operations, maintenance, upgrades, and substituted materials. Urban laws, rules, and ordinances significantly coordinate and govern cities, particularly regarding environmental sustainability. Some of these can encompass a broad spectrum of architects who employ planning and design tactics based on laws, such as zoning restrictions, building codes, development regulations, and health and sanitation codes. Furthermore, further restrictions mandate specific types of buildings to adhere to eco-friendly construction requirements, such as the use of resilient materials, water conservation systems, and thermal building coatings. One such strategy could involve enhancing the ability and expertise of local governments through targeted initiatives, educational endeavors, or training opportunities.

Incorporating environmentally sustainable strategies in the urban setting is crucial. Still, it is essential that these strategies are integrated and put into action within the first stages of urban conceptualization and planning and that the corresponding policies are effectively executed. Scientific study indicates that incorporating environmentally sustainable solutions will facilitate the development of an environment, landscapes, and structures that utilize renewable energy and resources, restore natural systems, and safeguard ecosystems from deterioration. A well-designed layout, convenient public transport connections, and the promotion of biking and walking in metropolitan areas contribute to a welcoming environment. To mitigate air pollutants, noise, and heat, it is recommended to substantially incorporate trees, low-maintenance plants, lawns, and roof gardens in buildings and public areas. Wind speed and temperatures also decrease when trees, hanging green, climbers, green screens, and gardens cover buildings and public spaces.

Using passive design strategies and high-performance building enclosures holds the most significant promise for minimizing energy consumption and ensuring optimal indoor comfort. Passive building design's potential advantages manifest in designs that offer optimal lighting, thermal, and acoustic performance. Integration of design, solar techniques, and mechanical systems is necessary for achieving this goal. Nevertheless, the credibility and acceptance of the passive design principles will be enhanced by implementing enabling frameworks and raising knowledge of their potential benefits. Implementing passive solar design solutions in buildings can mitigate the significant increase in energy consumption of new structures in developing countries. This discussion will focus on

the influence of design on the efficient use of space and the level of comfort experienced. By implementing effective climate-responsive solutions, it is expected that future designs in the DRC will experience a reduction. As a result, the optimal indoor comfort conditions in the designated areas will be effectively regulated, leading to enhanced building efficiency and economic benefits. The successful cooperation of climate experts, architects, engineers, and developers with building occupants is a crucial factor in determining the sustainability of a construction project. Future building designs with advanced environmental strategies will feature qualities such as using non-toxic and sustainable materials, spaces with excellent indoor air quality, access to outdoor surroundings, and the ability to achieve high-performance interiors in net zero buildings. Integrating sustainable environmental design strategies into building design is crucial to adopting an ecologically and environmentally focused practical approach. Ensuring the well-being of users and integrating the environment into the architectural framework is essential for promoting social connections, involving the community directly, establishing educational and organizational strategies, and implementing these strategies through contemporary architecture. Further research is required to assess the potential effects of ecologically sustainable techniques on the urban-built environment in urban settings. Architectural designers can utilize the data to create a site-design application that lowers the temperature in Adelaide, thus enhancing the urban climate and limiting the effects of urban warming.

There has been a lot of focus on building energy efficiency in the last several years. According to Anand et al. (2023), implementing passive design methods and ensuring good performance in building enclosures can be a practical and economical way to decrease energy use. Incorporating sustainable environmental design principles into building plans aims to place and direct structures in a way that minimizes their adverse effects on the environment. This includes site planning, water and energy conservation, renewable power, low-impact development, material optimization, climate responsiveness, and certification (Mauree et al., 2019). A realistic method for built-in environmental performances, especially for green building features targeted at structures, can be achieved by incorporating sustainable environmental design strategies into building design, namely through passive design and suitable placement.

Energy Efficiency in Sustainable Buildings

The primary focus in the period of global warming is on energy efficiency and sustainability. Attaining sustainable development and reducing energy demand pose significant global challenges. The prompt rise in temperatures and heat waves are having a progressively notable impact, particularly in recent years. By 2030, the proportion of the global population residing in urban regions will be projected to range from 60 percent to 70 percent. To mitigate the ongoing increase in energy consumption and the subsequent development of heat island conditions in urban areas, it is imperative to implement measures to create Environmentally-conscious Urban Areas (EAUs). Literature highlights the significant energy inefficiency inherent in metropolitan contexts, which burdens the population. More precisely, globally, over 47% of the total annual energy consumption, roughly 3.2 Petajoule (PJ) or 891 Gigawatt-hours (GWh), is identified as wasted energy every year. Moreover, the yearly expenditure must amount to a minimum of 25 billion US dollars in squandered energy inside a metropolitan region. An efficient and practical approach is to reduce the amount of wastewater produced in coastal areas of contemporary life.

The study provides valuable insights into urban

sustainability by examining many crucial aspects of implementing Sustainable Energy Development Strategies (SEDS) in the context of transforming High-rise Buildings (HBs) into Net Zero-Energy and Carbon-Neutral Buildings (NZECBs) (Anand et al., 2023). The primary aim of this study is to enhance the EDS (Environmental Data System) and mitigate the Urban Heat Island (UHI) phenomenon. This paper makes two distinct contributions. The study begins by thoroughly analyzing outdoor pedestrian comfort fixtures that need to be addressed or considered in the study area. It then develops a set of indices for outdoor pedestrian comfort (PC) and new intensities for Urban Heat Island (UHI) by utilizing significant albedo enhancement indexes (AEIs). This aims to incorporate these findings into Environmental Design Strategies (EDS). Secondly, it encourages vigorous pedestrian movement and walking in hot outdoor climatic situations. This paper also examines enhancements in monitoring urban outdoor comfort and albedo in warm regions during operational hours and their influence on building energy efficiency by utilizing previously measured AEIs. This article provides a comprehensive analysis of the relationship between outdoor pedestrian comfort (PC) and building energy performance fittings to inform policy-makers and urban building designers.

Water Conservation in Sustainable Buildings

Stormwater quality is a central concern regarding sustainable housing at the local level (Saheb & Dehghani, 2021). Stormwater degradation occurs due to surface contaminants and the entrance of industrial wastes and car-washing products into the stormwater network during periods of heavy rainfall. Implementing wetland systems at a neighborhood level can effectively decrease the accumulation of salt and litter in urban water networks. An essential intervention in a water-sensitive neighborhood-scale strategy is incorporating emergency flood management into the housing's open space. This can involve the implementation of low-footprint detention basins, as well as the creation of open spaces and parks. These emergency water resources serve as detention basins in large neighborhood networks, providing storage capacity during periods of severe rainfall. They discharge water absorbed by the rooftops and surfaces of roadways and buildings during the runoff of the permeable terrain after intense rainfall. Simultaneously, flooding can potentially deteriorate the construction and foundation of adjacent houses.

To promote water conservation, the first step is effectively managing leaks and runoff within the building. Additionally, flood prevention and sewage discharge are integrated at the neighborhood level (Dühr et al., 2023). By implementing a neighborhood-scale approach to water infrastructures, it is possible to enhance the integration of green spaces, water features, and urban furniture in housing areas and their surrounding landscapes. At the local level, parks, squares, and plazas have the potential to be more responsive to water management. This can involve implementing planned watering, allowing unrestricted water usage, and utilizing temporary water storage. The reference is from Williams and Dair's work published in 2007. The collaboration among various operators in the suburb can enhance the local capacity to retain rainwater and regulate temperatures in green spaces across the city. This can be achieved by implementing water-sensitive building and precinct designs and strategically planning and locating open-space corridors to mitigate the urban heat island effect (Sugiarto et al., 2022).

Materials and Resources in Sustainable Buildings

An essential aspect of sustainable development is the focus on the environmental results attained by

the project. The United Nations Environment Programme categorizes resource depletion into five input categories: land and soil, water, fossil fuel, metal ores, and non-metallic minerals (Nosratabadi et al., 2019). The three "E Perils" collectively suggest that the current trajectory of building and infrastructure projects is not sustainable due to their adverse environmental effects, which are projected to increase. Every plan and program utilizes procedures that involve materials and resources. A rational cycle incorporates sustainability to minimize resource impacts, reduce waste and emissions, enhance social and economic performance, and clarify decision-making. The primary objective is to reduce or avoid the excessive utilization of natural resources and the inadequate supply of environmental services.

The topic of sustainability is widely discussed in several areas of developed nations. The significance of sustainability lies in the potential of sustainable buildings to promote energy efficiency through various components such as lighting, automation, and air conditioning (Tang et al., 2022). The expansion of human civilization, specifically through the development of construction projects such as office buildings, residential areas, highways, bridges, tunnels, airports, trains, dams, ports, industrial facilities, and agricultural infrastructure, as well as the process of urbanization, has placed a more significant burden on natural resources. There exist three overarching approaches to handling overutilization of material resources effectively. The three main strategies for sustainable resource management are (1) minimizing consumption, (2) reusing products, and (3) recycling products. Diverse programs and firsthand experiences can mold individual and societal conduct, as well as the distribution of human and physical resources, to achieve sustainable development. Furthermore, they can impact a country's capacity to achieve these objectives.

Indoor Environmental Quality in Sustainable Buildings

As part of our daily indoor activities, we contribute to indoor air pollution by using inappropriate insulation, avoiding ventilation, misusing household chemicals, and burning things improperly. This leads to respiratory diseases, allergic reactions, headaches, and heart diseases. The standards were set by ASHRAE, even though indoor air quality dramatically affects human health and productivity. There was a correlation between worse indoor environmental conditions, financial losses, and health problems. A household's exposure to unhealthy air levels can range from 0.1% to 0.35 percent over a year, with a global average of roughly 0.4% for homes; this causes an economic loss of $6 billion without even accounting for the costs to people's health. It would be pretty challenging to evaluate various viewpoints for many characteristics. Thus, much human interaction has gone into understanding which facilities are valuable for indoor environmental protection. The building structure has been given particular attention.

The highly sought-after indoor environmental quality can only be achieved with environmentally conscious designs and a performance-oriented architecture. To meet these expectations, prominent professional organizations like WELL, LEED, and BREEAM have developed standards for controlling and improving buildings' indoor environmental quality. As a result of these groups' work, policymakers can better address air, light, water, and thermal quality issues by tailoring control tactics to local conditions and cultural norms. The experts in this field believe that buildings should be seen as places where people can find a variety of environmental supports that are beneficial to their health (Kohl et al., 2024).

Hello there! According to Maureen et al. (2019),

the quality of the built environment inside different spaces determines the occupants' health and happiness. Nearly 90% of people's waking hours in industrialized countries are spent inside. Keeping tenants in a state of high happiness and good health is, thus, crucial. Conditions, air quality, ventilation, facilities, designs, furnishings, and decisions made during interior design and management are only a few of the many factors that affect the environmental quality of a space. The occupants are satisfied when the components above are in their optimal condition.

Sustainable Site Planning and Land Use

Living systems are present on sites. They might include native flora and fauna that human activity has affected or preserved. They can also provide various ecological services that humans rely on to enjoy various activities. There is some evidence that heavily populated areas reduce biodiversity, limit ecosystems, and alter the movement of water and soil. There are health-related concerns, and they can change people's walkability. The optimal density for development up to 24,000 people/hectare has been determined by calculating the energy consumption of similar places with varied land use primary. Such places should have well-utilized lawns and spaces to support various uses and maintenance, particularly for public transportation, biking, and walking (Tang et al., 2022).

Program and building design comes after sustainable land use and site planning. No matter the size of the structure, it significantly affects its social, environmental, and economic performance (Loftness et al., 2007). Since site analysis affects the sustainable implications of design and building performance, it has been the center of attention for most green rating systems. Before any infrastructure is installed, the site must be selected. Then, the building must be designed and placed on the site. Land usage must be regulated with consideration for energy and water consumption, ecology, human health, and other factors. The architect must know the site's local climate, vegetation, Humidity Zone, and wind, rain, and sun exposure. Alterations to the site's location and layout can improve communities through increased walking and cycling, reduced climate change impacts, more connectivity to green spaces, and more efficient use of natural resources.

Sustainable Transportation Strategies for Buildings

Touati and Jost (2012) note that sustainable transportation methods include reducing fuel usage by utilizing gasoline cars, which can be challenging without multi-story park and journey services. If vehicle waiting is a significant enough concern to warrant decision-making, improved vaccine scheduling may also influence the current modeling guidelines' recommendations for waiting space links, which should reduce the number of trips released each year. Furthermore, cutting-edge transportation methods facilitate the living section's observation of vacation routes and the operation of trucks to generate surface parking product charts and motorcycle and vehicle wait lists. Before this year, emergency transportation system commands had aimed to reduce service prices so that attendees could, among other things, find free parking and other amenities that did not cost anything. When gained influentially, availability and Deternestes instruction employed corresponding services to be separated. You can pay a parking garage for its door drive as an additional norm.

Reliable services, processing runs, and software promoting mobility options might further reduce car utilization, which would minimize traffic during shuttle periods. According to Yusoff et al. (2021), an information application is necessary for routing resources like shared workspaces, park patrons, bicycles, and more. Organizations and

their employees can offer alternate mobility technology choices throughout the business. However, with an I.T. system, the algorithms above can compete with one another and other digital software and tools to identify a hole, promote sites to increase resource compliance, and ultimately win. Drainage systems, new power and hydrant systems, medium ways for cars, vehicle cataracts, and new streets and street development that prioritizes safety for pedestrians by reducing the length of staff roads and intersections while simultaneously meeting security standards and cooling down vehicles rapidly are all possible components of such roadways.

In a problematic public transportation situation, the main feature of sustainable building transportation plans is the provision of accessible programs to avoid wasteful travel and transportation activities (Dabiri & Heaslip, 2018). For example, high-capacity transportation systems should be developed and made available to significantly lessen the environmental damage that extensive and urban transportation causes daily. This would reduce the need for things like pavement mass, HVAC, security, and public facilities that provide meals, among other things. In addition, instead of pushing, this mode of transportation will encourage people to spend time with friends and family, meditate, cook, relax, etc. In addition to motorization, central city infrastructure development will reduce automobile dependence and provide room for newly created needs like trains, paddleboards, and carpools. Additionally, there needs to be a rationale for utilizing public transportation to evade the worsening of suburban traffic caused by vehicles with enhanced capabilities in these places or for utilizing environmentally friendly and high-quality route materials.

Waste Management in Sustainable Buildings

Slope stabilization, ground improvement, sub-base, fill 649 material, and crushed demolition debris can be utilized as road/pavement material, according to the in situ investigation article "Application of Demolition Waste for New Construction Works" (Teo et al. 648). According to the laboratory data, soil stabilization with 63.29% CBR was not achieved using the soil mixture of demolition debris and 6% cement. Because additional researchers should examine the study's weaknesses, future research should carefully examine the disparities in regulations, building practices, economic circumstances, and climatic settings between nations to provide a worldwide perspective for developing strategies to handle demolition debris at the regional level.

For complete recycling, the following materials are considered: concrete, bricks, fly ash, foundry sand, broken glass, and rubber. This research is on reusing and recycling solid waste from steel plants.91, According to Rodrigues da Silva et al. (2021), the recycled aggregates had a TIO value of 90% demolition waste aggregate and 10% red asphalt. However, there was only a tiny amount of demolition waste aggregate in the recycled material. Reusing aggregates allows railway ballast reconstruction (68, 14). Compared to virgin aggregate, which absorbs only 1-2% water, demolition waste aggregate absorbs 2-5% water. In the instance of virgin aggregate, water absorption is slightly higher but still within the acceptable range of no more than 2% by the weight of the material. Test results on the slag production site's aggregate crushing and impact values were within the norm, lending credence to the research goal. A total of 23 and 10.5% were found. For non-loaded constructions such as low-strength embankments and trench backfills, slag aggregate is a good choice due to its lightweight. The reason is that steel slag's strength is ten times less than that of natural aggregate.

Life Cycle Assessment in Sustainable Building

Design

A vital component of the sustainable built environment's value-chain system is life-cycle assessment (LCA), which compares the environmental impacts of different options, such as conventional and traditional materials, and determines the environmental performance of the finished building and its long-life assets. Environmental impact assessment (LCA) is a delicate part of the research and evidence-based sustainable building process regarding green building innovations and ideas. With the help of over fifty prominent experts and practitioners from various technical backgrounds, a preliminary study on the ideal sustainability level of building and infrastructure layouts was published in 1978 (Walk et al., 2023). A federal agency in the US that deals with environmental protection and solid waste management.

The introduction of sustainable building systems and sustainable design practice, management capital, and investments are two fundamental aspects of the built environment's sustainable development that have emerged in response to the increased global awareness of environmental and climate-related challenges (Carrobé et al., 2024). Environmental impacts of the built environment have been the primary focus of the design and construction industries and the academic and professional bodies concerned with sustainable building design and innovation. Many life cycle assessment (LCA) studies of buildings and building products have shown that sustainable building principles can be environmentally friendly and climate efficient (Khanam et al., 2021). It is worth noting that there is a growing body of research that shows sustainable buildings have unique advantages. These include but are not limited to, increased productivity, better health, and more social equality.

Case Studies of Successful Sustainable Building Designs

The hot, dry, and wet environment with rain at Bambey University, Senegal, is enjoyed all year round, with little difference in temperature or precipitation. Bioclimatic design incorporates natural light and ventilation strategies to make buildings more lively. Because of the high expense of HVAC systems, none have been installed, so no fresh air has been absorbed, and no carbon emissions have been produced (Chen et al., 2024).

Revit Architecture software conducts A life cycle evaluation for a nearby suburban building. The goal of construction life cycle evaluation is to examine and convert sustainable construction practices into the ongoing economic processes of a built environment. This article uses the Regenerates plugin in Revit software to assess the environmental impacts and costs of selected building materials across their whole life cycle. Improved economic performance, cost savings, and lower energy consumption are key reasons to incorporate green buildings into constructed environments as a substitute for standard building approaches (Taraka et al., 2022).

A sports facility in Hamburg, Germany, designed by Johann "Voy" KEREN, is a model of sustainable architecture. Its energy-efficient performance is achieved using natural resources, environmentally friendly materials, and optimal landscaping. The dragon boat competitions take place in this strange-looking sports hall, which is hidden from view from the canal and surrounding areas. The venue can hold many spectators and offers a raised viewing platform thanks to its two-story design, automated curtains, and modern aluminum composite cladding made of white and metallic blades (Peng et al., 2023).

Economic Benefits of Sustainable Buildings

On top of all these benefits, green buildings are more valuable in the market than conventional

ones, according to Bhangale et al. (Venugopalan & Aydt, 2023), who also addressed this issue. Numerous studies have shown that, in comparison to non-certified buildings, green buildings provide 4–15 percent additional value. Compared to more conventional structures, it increases the property's resale value and enables the owner to charge a greater rental rate. There are perks to occupational health that come along with green construction practices. Reduced absenteeism and increased productivity are two outcomes of green building practices that aim to promote building inhabitants' physical and emotional well-being. It is becoming increasingly practical and viable to construct commercial premises, both new and old, based on the economic benefits they provide.

Similarly, Lamb et al. (Mauree et al., 2019) noted that sustainable buildings can increase profits through efficient building operations, add value to real estate, and contribute to cost savings over the building's life cycle. Green buildings are expected to use 20 to 30 percent less water and power than conventional ones. The life-cycle savings of a building are more than its initial or nominal construction cost, which is a significant selling point for developers and investors. Whether it is a public or private sector firm, doing good deeds as a citizen and accomplishing CSR goals improves public perception.

There is a pressing need to enhance the environmental performance of buildings while simultaneously promoting the health and well-being of renters, according to Li et al. (Beermann & Chen Austin, 2021), who have identified this as one of the economic benefits of sustainable buildings. The United Nations Environmental Programme reports that the Sustainable Development Goals will be achieved by 2030 due to new approaches, improved materials, and technological capabilities. More efficient use of existing resources and a general reduction in resource intensity across all industries can make this a reality. In addition to being a significant source of waste and pollution, the construction and operation of structures use many resources that can be harnessed. Although more costly than conventional building methods, sustainable buildings that reduce environmental impact offer a potential answer to this issue.

Social Benefits of Sustainable Buildings

Researchers generally agree that sustainable building types outperform traditional ones in terms of human health and welfare. For example, according to Hu et al. (2021), occupants' health, comfort, and well-being can significantly improve when green building design is coupled with a well-operated ventilation system. This is because, among other benefits, it will lead to better ventilation, lower carbon dioxide levels, better temperature controls, fewer outdoor contaminants, and better ventilation overall. Lighting, air quality, and temperature regulation are three areas where additional research has shown green architecture to affect human health positively. Consider a study that compared data from digital building simulations of twenty green office buildings with twenty conventional ones. The researchers hypothesized that, due to a statistically significant reduction in average sleep disturbances and self-reports of the occupant's likelihood of being alert and refreshed sleep, the occupants of the green buildings would sleep better and be more alert. According to new research, green buildings can improve indoor air quality and mental health more than conventional ones.

One theory is that these structures can improve people's health and happiness by creating a more conducive atmosphere. Sustainable construction practices can create an atmosphere that promotes individual well-being and comfort (Marsh et al., 2016). In most cases, sustainable building materials significantly improve people's health

and comfort by eliminating or significantly reducing the negative impacts of conventional construction materials, such as increased noise, decreased thermal comfort, and poor indoor air quality. Pursuing human regeneration in sustainable construction has been prevalent for several decades. The UN Development and Sustainable Development Goals (SDGs) include human well-being as a vital component. Increased awareness of environmental issues, better health and wellness for individuals, higher quality of life, more robust social connections, and psychological resilience are some of the potential social benefits of sustainable construction, according to scholars (Tang et al., 2022)

Environmental Benefits of Sustainable Buildings

In order to reduce adverse effects on the environment and maximize positive ones, sustainable design adheres to a life cycle methodology that begins with the conception of the idea and ends with demolition or disintegration. Compared to current methods, the effects of material disposal on growth, agriculture, energy consumption, emissions (both air and water), land consumption, product use, and the end-of-life construction cycle are likely to be substantial. The green building's construction uses goods that persist and require less care, which helps to reduce the amount of trash generated by the building's use and upkeep over time. Intentionally planning and designing a building to be flexible may provide the user with a wide choice of facilities. One of the most significant contributions to societal environmental and economic performance is a building with a lengthy service duration. There is an opportunity to conserve water while constructing and operating a single building that contributes to preserving freshwater resources. Onsite systems for collecting and reusing grey water and rainwater are a feature of sustainable buildings. Recycling grey water has met the demands of the toilet and the unclean water from washing machines. Sewer systems, or even smaller neighborhood water systems, will decrease in the event of surface water releases and flooding hazards.

The built environment and the construction industry are two examples of the many human- and industry-driven activities typically associated with urban settings. Construction is one of the most significant industries that negatively affects the environment (Nosratabadi et al., 2019). More than three-quarters of all greenhouse gas emissions, a quarter of all landfills, and seventy percent of all electricity consumption comes from structures, according to US Environmental Protection Agency research. To illustrate, a sustainable building seeks to reduce its adverse effects on the environment through careful planning and construction. Sustainability in building design, construction, and operation has significant positive effects on society, the economy, and the environment, as Yudelson pointed out (Loftness et al., 2007). Sustainable buildings produce far less carbon dioxide than conventional structures due to their low energy use. First, efforts to save energy help lower levels of greenhouse gasses. Heating, ventilation, and air conditioning (HVAC) systems account for over 57% of total energy use and contribute significantly to atmospheric carbon dioxide levels (primarily from the combustion of fossil fuels). This is the standard practice in the construction industry, focusing on using high-quality materials and finishes. The environmental benefit of letting in natural light through buildings is ignored (Taraka et al., 2022).

Challenges and Barriers in Implementing Sustainable Environmental Design Strategy

There are further significant obstacles, such as the need for more data regarding alternative materials and components that are easier on the

environment. It is still challenging to locate construction firms and consultants in some areas with proven competence in energy-efficient design, and there needs to be more availability of specialized skills among builders/construction workers and sustainable building designers. Financial institutions and real estate investors are highly risk-averse. Short planning periods result in deploying universally applicable building solutions compatible with all climate zones. Inexperienced designers and, even more importantly, investors are less likely to reuse development-related documents that outline and support the building's strategy for environmental performance (Easthope et al., 2023). Several studies have shown that to complete a sustainable project, the project manager typically follows a conventional procedure that is both sequential and linear, with "one-off" decisions influenced by factors such as budget, rules, and the interests of different stakeholders.

According to Maqbool and Echezona Amaechi (2022), five main elements should be considered while developing strategies for environmentally friendly design: restrictions, barriers, and methods to overcome these limitations. In order to limit environmental design, the interview inputs are classified into parameters and graded according to their severity. In order to uncover ways to overcome the identified barriers, investigations are conducted after classifying them into subcategories and assigning them to their corresponding vital themes. Parameter constraints significantly impact sustainable design decisions and, by extension, the direction of the design process toward improved environmental performance (Dühr et al., 2023).

Policy and Regulatory Framework for Sustainable Buildings

Policy administration is a crucial instrument in influencing design and promoting sustainable construction. In most cases, the distinctiveness of adequate legislation and commandeering needs to be improved. Administrative competence and supportive legislative frameworks are necessary for their successful implementation. An equivalent amount of weight is given to substantial engagement with socioeconomic grassroots and other plan components (Huang et al., 2021). In order to implement changes, the policy climate needs to be based on economic realities so that rules and regulations are helpful. Other possible administrators include international accords, accreditation, tax and subsidy systems, environmental commerce and money, real estate development, available funding sources, and organizational efficiency.

The shift from traditional production design to a more sustainable one can only be achieved by making sustainable construction theory more widely known (Taraka et al. et al., 2022). The gap between theoretical sociology and practical practice and policymaking can only be filled with a solid administrative and legitimate framework and strengthened policies. Rules are predictable and tailored to each country's unique circumstances and requirements. To ensure that design and construction are sustainable, the importance of administration in allocating funds for R&D, disseminating information and empowering exercises, putting regulations and laws in place to represent the actual cost of construction, and privatizing the use of shared or environmental expanse infrastructures are universal policy suggestions within the construction industry (Jin et al., 2021).

Role of Architects and Designers in Sustainable Building Design

Everyone working on the project, regardless of their field, should respect and honor the team leader's vision and approach. With greater authority comes the ability for architects and

designers to personalize their file management software to showcase these projects. Motivating team members to think outside the box is possible when the leader maintains strict control over assignments while allowing for extensive study and concept tape periods. Many organizations must form a partnership before utilizing architectural and market instruments to boost leadership. Now that everyone on the team knows what to expect, performance will be consistent and quick. To guarantee that program and demand dependencies are met, market management continues scrutinizing approaches to improve based on Innovative Design's architectural and technical methods (Maqbool & Echezona Amaechi, 2022). Additional controls for the B.I.S. implementation project were developed from the structure of the S.I. program. Significant advancement at the trim company waste management hierarchy level and efficient networking to report on architectural project leadership frameworks are required.

According to Beermann and Chen Austin (2021), architects and designers play a significant role in creating environmentally friendly building designs. How much say they have in the final product is based on where they fall in the architectural pecking order. It is common for architects and designers to report to the team leader, who is responsible for guiding the design process. Developing or reusing floor surfaces, designing and shaping, establishing mechanical systems and architectural features, and anticipating energy use are all part of the basic design (T. Ferguson et al., 2016). The project manager's signature should appear on all blueprints, measurements, and details to show how seriously the project takes renewable energy and environmentally friendly design. Architectural drawings and more complex designs integrate fundamental design components or processes when work is documented. Project leaders are responsible for ensuring the documents are customized to reflect the desired effect if the direction does not do so.

Role of Engineers in Implementing Sustainable Environmental Design Strategy

Recently, there has been a significant focus on the worldwide environmental emergency and, as a result, the imperative for sustainability by governmental environmental departments, environmental agencies, and research institutions (Lin et al., 2023). As a result of human civilization and the industrial revolution, the Earth's environmental health is currently in a precarious state. The Earth's natural resources are being heavily exploited, leading to a significant increase in the concentration of CO2 from the recommended level of 350 ppm to a concerning level of 400 ppm. This increase is causing global warming and depletion of the ozone layer. In order to address the diverse environmental challenges, it is imperative to intervene in all sectors of life, including engineering (David et al., 2023). Sustainable environmental design is a crucial approach to address environmental issues effectively. It involves considering the design and functioning of buildings and the built environment and the effects on ecosystems, natural resources, water, and human health and well-being. The built environment is already responsible for 29% of global pollution in the form of direct CO2 emissions. This 29% is attributable to direct emissions, waste generated at construction sites, and indirect emissions from shipping or manufacturing processes. In order to reduce this quantity, we require the combined knowledge and expertise of every sector of the environment, focusing on renewable energy, trash reduction, and future recycling. The involvement of engineers and architects is crucial in developing sustainable buildings (Zhang et al., 2021). They must comprehend the significance of environmental

preservation, sustainability, and green technologies. They carry out several responsibilities and ensure that the design is sustainable, cost-effective, reliable, and performs well. Engineers, such as Structural Engineers, Civil Engineers, and Sanitary Engineers, can make numerous design alterations to accommodate environmental considerations. They possess the requisite academic qualifications, professional experience, and knowledge of economics and the environment to engage in sustainable design. The role involves designing in a manner that is both cost-effective and sustainable, so combining financial considerations with a focus on long-term viability. Construction Engineers play a vital role in ensuring the sustainability of construction processes. They achieve this by implementing methods such as recycling building materials, employing sustainable project management approaches, and minimizing the environmental consequences of construction sites during construction and operation. Environmental impact assessments should be conducted for each project to develop a strategy for constructing sustainable buildings. Environmental engineers are essential in countries that require financial assistance, as they consistently require comprehensive environmental impact evaluations to be submitted for aid requests and urban transformation projects.

Role of Building Owners and Developers in Sustainable Building Design

These companies facilitate organizational change. Corporation personnel must undergo authentication and be rewarded for job design in a respectable position. The firm must provide incentives such as corporate sports programs and flexible schedules to accommodate employees who balance work and home responsibilities, including childcare and parenting. Assuming that less than 10% of business owners with a maximum of 5 years of experience, JK "Kvarner gradnja" is an example of such a business owners. The objective is to attain the GBC Gold Certificate. In order to accomplish this, their architectural team employed the principles outlined in Building Construction Methodologies, which aim to reduce carbon emissions. The design of the building was intentionally oriented towards maximizing the use of natural light. Essential construction tools such as windward-start curb and delightful sadness were utilized. The current clientele has shown a favorable response towards the efficiency, quality of products, and architectural functionality.

All these analyses must be conducted using an efficient and exact procedure regulated and managed in compliance with the first two standards. Regrettably, these works are intricate and cannot be resolved using precise techniques. Therefore, employing and creating appropriate hanger restrictions that meet the customer's and environmental preferences is advisable, ultimately manifesting their impact in sustainable urban planning (Peng et al., 2023). When constructing structures, it is crucial to have a strong collaboration between owners and developers, as Tang et al. (2022) emphasized. The objectives of building developers have shifted towards constructing more sustainable and environmentally friendly buildings. While sustainable buildings require financial investment and time and entail more significant risk, they also enhance brand and economic value in the social sphere. Therefore, developers must adapt and educate to promote sustainable structures construction.

The involvement of building developers and owners in sustainable design is essential for achieving sustainable development in contemporary construction projects. Previous research has overlooked this subject because it needs to adequately consider the significant

influence of entrepreneurs, planners, and engineers on the architectural design and construction methods of construction systems. The success of a building is not solely determined by its architectural design and structural and electrical standards. It is also influenced by factors such as urban planning, sustainability, and the implementation of green building strategies (Awada et al., 2021).

Role of Government in Promoting Sustainable Building Practices

ASBEC states that governments can effectively intervene by implementing well-coordinated energy-efficiency policies. Successfully adopting energy-efficient technologies requires policies addressing the hurdles posed by costs. Governments should actively encourage and adopt innovative practices in sustainable building to enhance development and simultaneously achieve emissions reductions. Allocating funding and implementing legislation will improve the current condition of repairs and demolitions, making them significantly more sustainable. The UN Sustainable Buildings and Construction Program emphasized the need for rules to facilitate a fair and efficient transition through a comprehensive "whole of government" approach. These policies would involve the implementation of incentives and educational measures to ensure the transition towards a future with zero and positive carbon emissions. The role of governments will inevitably differ significantly based on the political, social, and economic distinctions among nations. The structure of countries' governments will determine the allocation and composition of responsibilities, which their economies and political cultures will influence.

The growing global awareness of the significant environmental impact of buildings has resulted in a need to implement sustainable building techniques to promote the sustainable development of society (Easthope et al., 2023). Governments are crucial in supporting sustainable building practices in the construction sector. They are responsible for creating regulations that support sustainability in construction and the long-term operation of structures (Jin et al., 2021). This is remarkably accurate, given the exorbitant expense associated with sustainability. Builders and entrepreneurs would persist in conventional, unsustainable, and wasteful practices without governmental involvement. With enough regulation for sustainability, it is common for builders and enterprises to voluntarily adopt sustainable practices (Yang et al., 2022).

Certification and Rating Systems for Sustainable Buildings

Many building assessment systems are available globally that promote environmentally friendly buildings and spaces (Dühr et al., 2023). These systems certify and evaluate the site and categorize the developed facilities into various categories. There is a deficiency in such a national or regional rating system specifically designed for small-scale residential and commercial building projects. The GRIHA rating system was created and adopted by the Indian Green Building Council in 2009, specifically for residential and small-sized commercial buildings. The Green Rating for Integrated Habitat Assessment (GRIHA) was mandated in response to the specific climatic and environmental circumstances of the Indian subcontinent. This rating tool is specifically developed to be highly adaptable to the diverse climatic, geological, and cultural characteristics found in various regions of the Indian subcontinent. Its purpose is to create a universally applicable rating system that may also be adopted in the state of J&K. GRIHA now categorizes projects based on their built-up area into six levels of GRIHA rating. It also has distinct certification categories for existing buildings and completed

buildings, taking into account site work and the absence of new construction. Build Green is a rating tool that prioritizes energy efficiency, environmental considerations, and water conservation.

The fields of engineering and architecture have begun integrating the idea of sustainability into their practices. This involves ensuring that sustainable development aligns with different countries' existing systems and technical advancements (Castanheira & Bragança, 2014). Sustainable development is a viable approach to reducing the earth's ability to fulfill the needs and demands of present and future generations (Chapman & Chapman, 2011). Multiple global grading and certification systems revolve around sustainable development, including LEED, BREEAM, Green Star, Green Globes, and Estidama. These solutions aim to mitigate environmental degradation in several areas by encouraging sustainable construction projects.

CONCLUSION

Sustainable environmental design methods encompass the needs and goals of designers, investors, the natural environment, the future of urban development and its social aspects, and economic policy objectives in the short and long term. Additionally, they play a role in optimizing the value contributed by developing and improving sustainable structures' competitiveness in the real estate market. Regular updates, including the latest knowledge, standards, legislation, and technology, must be crucial in sustainable environmental design plans. Lastly, the crucial aspects are the transparency and visibility of the achieved performances and their correlation with the primary design objective, as evaluated by various certification processes.

In addition, the building's lighting and thermal comfort, views, psychological well-being, natural daylighting, potential energy savings, and structural building materials are considered. The building rating system includes factors such as an inside green environment, a green-protected natural heat sink, and the proximity and accessibility of adjacent stores, schools, and public transportation amenities.

Typically, in most sustainable building rating systems worldwide, the sole criterion for rating is a strategic approach to sustainable environmental design that addresses both environmental and social sustainability objectives (Peng et al., 2023). The building rating considers the contributions of the architect, engineer, and builder in incorporating energy-efficient devices, renewable energy sources, natural and operable ventilation systems, green energy water supply and disposal systems, and innovative technologies to enhance energy efficiency and minimize the environmental impact of the architecture.

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