A Methodology for Evaluating Sustainable Building Technology to Raise the Efficiency of Urban Clusters: Analytical Study

Mai Niazy Moustafa Ahmed[1], Prof. Abdullah Badawy Mohammed Goda [2], Prof. Sherif Mohamed Sabry Elattar[3]

[1] *Department of Architecture, Faculty of Engineering– Fayoum University*

[2] *Associate Professor of Architecture, Faculty of Engineering – Fayoum University*

[3] *Professor of Architecture, Dean of Faculty of Engineering Fayoum University*

Abstracts: Sustainability evaluation methodologies are distinguished from other evaluation tools, such as the LEED system and the BREEAM system, in that they include a new local evaluation methodology. The life cycle of a building is divided into distinct phases, including production of materials and components, construction and implementation, use/operation, maintenance, demolition, and disposal. Understanding the classification of assessment tools based on the building to be assessed, tool users, and building life cycle stages will inform selection of appropriate assessment tools and development of a comprehensive methodology. The study aimed to extract and evaluate opinions and perspectives from users, stakeholders, and researchers about the current status of sustainable technology in urban communities and to analyze the basic factors and indicators that contributed to the efficiency of urban communities and their relationship to sustainable technology. An inductive and analytical research was conducted using a questionnaire form on a sample of 100 participants to collect the opinions of users, relevant authorities, and researchers in the field. The questionnaire was designed to collect opinions and perspectives from different groups, including residents, local authorities (such as provincial officials, engineering administration, etc.), and experts in the field of sustainable technology. It covered a range of topics related to sustainable technology, including perceptions of current sustainability practices, barriers to implementation, potential areas for improvement, and proposals to enhance the efficiency of urban clusters. The research provided a comprehensive understanding of views on sustainable technology and help identify key areas for evaluation and improvement.

Keywords: Sustainable Technology, Urban Clusters, Efficiency, Sustainability Assessment Criteria.

1. INTRODUCTION

The construction industry is a significant contributor to the acceleration of climate change and the depletion of natural resources. Every iteration of this process - construction, utilization, and ultimately demolition and disposal - imposes a substantial ecological load, which greatly fluctuates based on the kind and whereabouts of each structure [1]. The rapid growth of construction in urban areas has a significant and wide-ranging impact on the environment, economy, public health, and overall well-being in cities [2]. It is responsible for 40%–50% of all energy consumption [3]. This increased energy consumption contributes to higher levels of anthropogenic greenhouse gas emissions. With an alarming 37% of worldwide emissions, the building and construction sector is by far the largest emitter of greenhouse gases. Materials like cement, steel, and aluminum have a large carbon footprint during manufacturing and use [4]. Construction also consumes 30% of raw materials and 25% of global water resources, including 17% of the world's freshwater [5].

The problem has prompted authorities, organizations, professionals, and citizens to advocate for a sustainable construction industry. This industry should be able to tackle the environmental and health issues associated with buildings, minimize the industry's impact on the environment and people, and reduce the environmental footprint of the built environment [6]. The sustainable development framework is based on three dimensions: environmental, social, and economic [7]. The aim of this research is to provide valuable insights into the utilization of passive design principles, in conjunction with other sustainable technologies, to develop urban communities that prioritize energy efficiency, indoor comfort, climate resilience, and community health, thereby promoting sustainability and resilience. This study aims to offer helpful assistance to policymakers, urban planners, and designers by efficiently implementing sustainable technology in urban environments. By bridging the gap between theory and practice, it seeks to produce healthier, more livable, and environmentally friendly urban communities.

2. LITERATURE REVIEW

2.1. HISTORICAL EVOLUTION OF URBAN SUSTAINABILITY

Sustainability in architecture refers to the compatibility of design with nature [10]. Design must follow environmental methods to benefit from its natural resources and employ them scientifically to meet the needs of the individual. It is worth noting the importance of employing the components of the natural environment and relying on them as basic elements in interior and exterior planning and design, as the role of architecture is represented by the systems necessary for life on the surface of the Earth in order to produce sustainable and environmentally friendly urban complexes. It is possible to consider architecture as one of the ways and methods that help protect living organisms from weather and climate changes. Therefore, it can be said that relying on construction technology and following modern technical methods in the building's structure, shape and finish is the basis for producing unconventional urban complexes that are compatible with nature and save environmental resources [11]. The origins of urban sustainability may be traced back to the early 20^{th} century, when pioneers such as Ebenezer Howard and his Garden City movement laid the groundwork as in Figure 1. Howard's concept prioritized the incorporation of natural spaces, communal housing, and effective transit networks in order to establish self-sufficient urban ecosystems. This signaled the initiation of a transition towards comprehensive approaches to urban planning that took into account social, economic, and environmental factors [12].

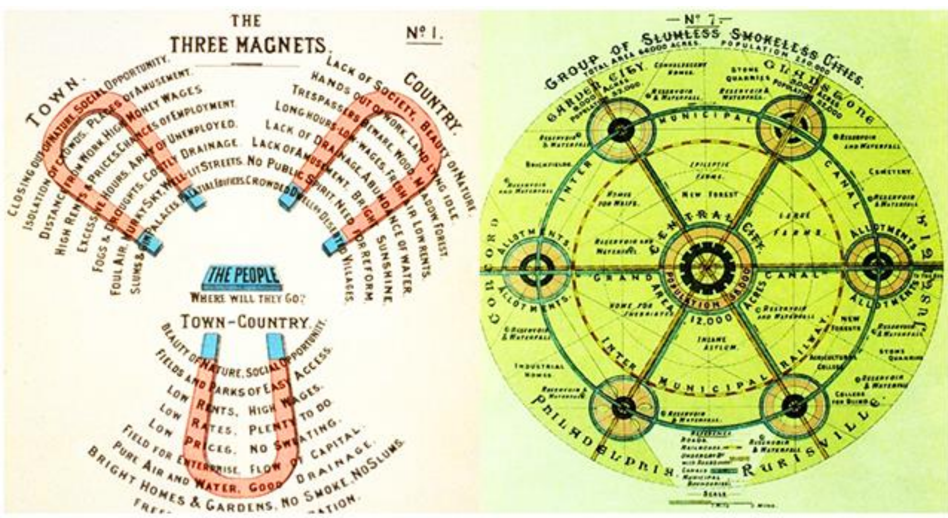

Figure 1. The principle of the Garden City of Ebenezer Howard (Adapted from ref. [12]).

During the 1960s and 1970s, the environmental movement emphasized the need of sustainability in urban planning and architecture. The rise of worries regarding pollution, resource depletion, and urban sprawl led to the increasing popularity of concepts such as sustainable development and ecological design. During this period, concepts such as green building practices, energy efficiency, and waste reduction were essential elements of sustainable urban development [12]. In the 1990s, the Brundtland Report was published, which introduced the idea of sustainable development as "development that satisfies the current requirements without jeopardizing the capacity of future generations to fulfill their own requirements." This research reinforced the importance of sustainability in urban planning and policy-making, highlighting the interdependence of social, economic, and environmental factors.

Urban sustainability has become increasingly crucial in the 21st century due to the pressing need to tackle climate change and accommodate growing metropolitan populations. Urban centers worldwide are encountering difficulties stemming from increasing population, limited resources, and environmental deterioration. As a result, there is a renewed emphasis on creating sustainable urban designs, implementing green infrastructure, and adopting resilient planning practices.

2.2. Relationship Between Urban Communities and Sustainability

The relationship between urban communities and sustainability has attracted increasing attention on the international political and economic agenda over the past few decades. However, the role of cities in global economic development as well as social and environmental conditions has gained more attention recently [13]. Sustainable technology refers to processes of structural transformation – radical and multidimensional change – that can effectively guide urban communities towards ambitious sustainability goals. This indicates the importance of making contributions to enhancing knowledge and understanding of sustainable urban agglomeration across a range of areas, including governance and planning, innovation and competitiveness, lifestyle and consumption, resource management, climate change mitigation and adaptation, transport and accessibility, buildings and infrastructure, environment, spatial and public space [14]. Several studies addressed these topics in addition to issues beyond them in transformative change towards urban sustainability [15].

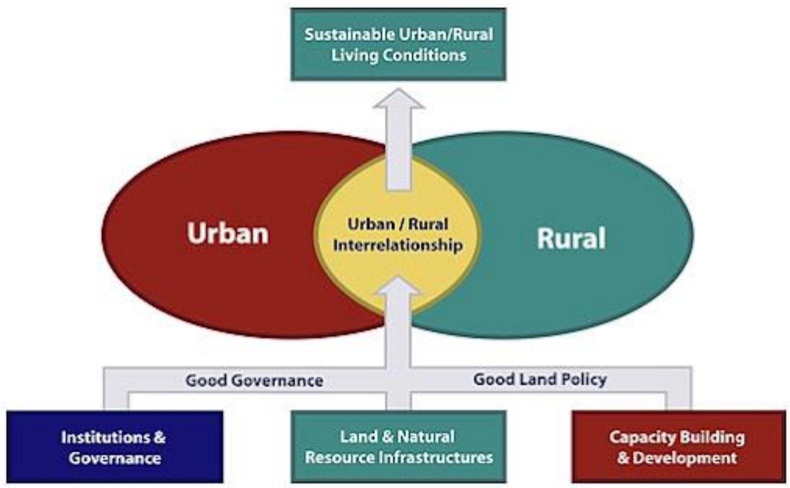

Figure 2. The relationship between urban communities and sustainability [15]

Current building certifications offer the most generally recognized method for linking sustainability to greenhouse gas emissions from a life cycle assessment standpoint. Some examples of these methods include BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design), SBTool (Sustainable Building tool) [16], Green Star, and CASBEE (Comprehensive Assessment System for Built Environment Efficiency) [17]. These certificates greatly enhance our understanding of the environmental impacts of buildings by analyzing life cycle assessment approaches. They have the potential to influence consumers' purchasing decisions about building stock and serve as valuable sources of information for decision-makers in both developed and developing nations.

Urban communities are highly valued for their role in driving innovation, social experimentation, and economic growth. However, they are inherently complex systems that possess the capacity to adapt to both external and internal factors. This adaptability allows them to function as dynamic entities, constantly changing and evolving in response to major social and environmental challenges caused by uncontrolled urbanization [18]. The capacity of urban communities to autonomously coordinate themselves amidst ongoing transformation can be elucidated by an evaluation of the "discriminatory and dispersed movement of substance, energy, and information among its constituent elements". The ongoing self-organization of all components of urban communities (such as energy generation and distribution systems, transportation, food consumption, waste management, water supply, and other ecosystem services) can be considered a complex system for evaluating sustainability [19].

2.3. Biophilic Design and Sustainable Urbanism

Biophilic design prioritizes the relationship between humans and nature in constructed spaces, with the goal of enhancing health, well-being, and sustainability. Biophilic design aims to improve the occupants' quality of life and minimize the environmental effect of buildings by integrating natural elements such as plants, natural light, and water features into urban spaces. Sustainable urbanism involves a variety of philosophies and practices that strive to create cities that are ecologically sustainable, socially fair, and economically viable. This strategy prioritizes the integration of diverse land uses, the creation of dense and efficient urban growth, the establishment of effective transportation networks, and the implementation of environmentally-friendly infrastructure to encourage sustainable lifestyles and minimize carbon emissions.

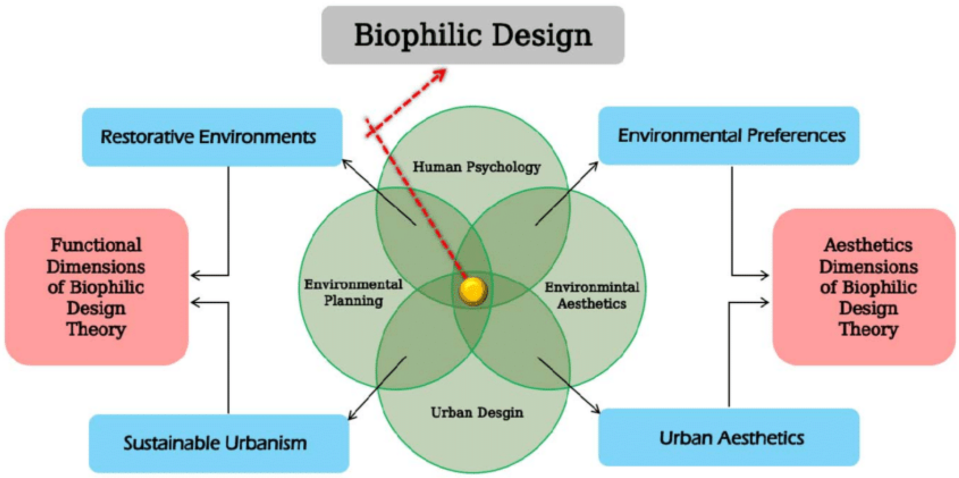

Figure 3. The features of Biophilic Design.

Kellert and Gregory [20] emphasized the significance of biophilic design in improving human health and well-being by integrating natural components into built environments. They highlighted both the psychological and physical advantages of being exposed to nature in urban settings. Beatley [21] examined the impact of biophilic urbanism on the development of cities that prioritize environment and biodiversity. This approach results in enhanced air quality, decreased stress levels, and heightened community involvement. The study highlighted the necessity of incorporating biophilic design principles into urban planning and development.

Steemers and Giddings [22] examined the fundamental tenets of sustainable urbanism and their influence on the development of ecologically conscious and socially integrated cities. The significance of including a variety of land uses, designing for pedestrian accessibility, and implementing green infrastructure to encourage sustainable living and mitigate carbon emissions was emphasized. In his study, Beatley [23] analyzed case studies of sustainable urbanism efforts in different cities throughout the world and identified essential techniques for attaining sustainable urban development. The study highlighted the significance of community engagement, smart urban development concepts, and innovative solutions for transportation in constructing sustainable urban settings.

Biophilic design and sustainable urbanism are closely linked concepts that aim to create healthier, more resilient, and ecologically friendly building environments [24]. The connection between biophilic design and sustainable urbanism is defined by their mutual emphasis on enhancing human well-being, environmental sustainability, resilience, and community involvement in the planning and construction of urban spaces. By incorporating biophilic design principles into sustainable urbanism plans, communities may establish healthier, more habitable, and sustainable environments for both present and future generations [25].

Biophilic design and sustainable urbanism stress the welfare of inhabitants and communities. Biophilic design aims to integrate natural aspects into constructed spaces in order to increase mental and physical well-being, alleviate stress, and improve overall quality of life. Sustainable urbanism seeks to establish cities that foster human health and well-being through the promotion of walkability, availability of green spaces, and active transportation alternatives [26]. Biophilic design and sustainable urbanism both prioritize environmental sustainability. Biophilic design aims to mitigate the ecological footprint of buildings through the utilization of organic materials, optimizing energy efficiency, and minimizing resource usage. Sustainable urbanism promotes the implementation of dense, diverse projects that combine different types of land use, as well as the establishment of effective transportation networks and environmentally friendly infrastructure. The goal is to decrease carbon emissions, protect natural habitats, and encourage the adoption of sustainable lifestyles [27].

Both biophilic design and sustainable urbanism enhance the ability of urban areas to withstand and adapt to climate change and other obstacles. Biophilic design enhances the resilience of buildings and urban areas to cope with fluctuating environmental circumstances, such as intense heat or flooding, by integrating natural features that offer cooling, shading, and water control. Sustainable urbanism advocates for the use of robust urban planning and design solutions that improve cities' capacity to endure and bounce back from environmental shocks and stressors [28]. Biophilic design and sustainable urbanism promote community involvement and active participation in the planning and design of urban areas. Biophilic design integrates natural components and green areas into the built environment, providing occupants with opportunity to connect with nature, socialize, and interact with their surroundings. Sustainable urbanism prioritizes the significance of inclusive and participatory planning processes that engage communities in decision-making and foster social cohesion and community well-being [25].

2.4. Passive Design Strategies and Sustainable Urbanism

Passive strategies for design prioritize the optimization of natural resources such as sunlight, ventilation, and thermal mass in order to minimize the energy usage of buildings. Orientation, shade, insulation, and natural ventilation techniques are utilized to establish suitable indoor conditions, minimizing dependence on mechanical systems. In a thorough investigation, Omrany and Marsono [29] examined passive design principles in buildings and their effects on energy efficiency and indoor comfort. The study emphasized the significance of orientation, shading devices, and natural ventilation in diminishing the dependence on mechanical systems and decreasing energy usage. Peshwaz [30] investigated the utilization of passive design principles in urban planning and architecture to establish sustainable built environments. The study highlighted the incorporation of passive solar architecture, thermal mass, and natural light to improve the performance of buildings and ensure the comfort of occupants.

Passive design strategies and sustainable urbanism are interrelated concepts that collaborate to establish ecologically conscious, energy-efficient, and habitable urban settings. The relationship between passive design principles and sustainable urbanism is defined by their mutual objectives of enhancing energy efficiency, indoor comfort, climatic resilience, and community health in urban settings. By integrating passive design principles into sustainable urban planning and design, cities can develop urban areas that are more sustainable, resilient, and livable, thereby benefiting both the environment and the well-being of citizens [31]. Passive design strategies prioritize the optimization of a building's design and orientation to maximize natural heating, cooling, and lighting. This approach aims to minimize reliance on mechanical systems and decrease energy usage. Sustainable urbanism prioritizes the reduction of energy use in urban areas by focusing on efficient land use planning, transportation networks, and building design. Sustainable urbanism can meet energy efficiency goals and contribute to overall sustainability by integrating passive design methods into urban planning and architecture [29].

Passive design strategies are essential for improving indoor comfort and building performance. They make use of natural components like sunshine, ventilation, and thermal mass to produce a healthy and comfortable indoor environment. Sustainable urbanism seeks to establish urban environments that prioritize the well-being and quality of life of individuals, encompassing the provision of optimal comfort for residents through well-designed buildings. By incorporating passive design principles into sustainable urban planning, communities may develop buildings and neighborhoods that are both energy-efficient and provide a comfortable and healthy living environment for residents [32].

Passive design strategies and sustainable urbanism both play a role in constructing urban landscapes that are robust to climate change. Passive design solutions enable buildings to adjust to varying climatic conditions by incorporating natural heating and cooling mechanisms, hence reducing the need for energy-intensive HVAC systems. Sustainable urbanism advocates for urban planning and design methods that prioritize resilience, taking into account the effects of climate change and implementing strategies to reduce risks and improve adaptability. Cities can enhance the resilience of their structures and neighborhoods by integrating passive design ideas with sustainable urbanism concepts, enabling them to better withstand climate-related difficulties [33]. Passive design strategies and sustainable urbanization exert a beneficial influence on community health and well-being. Passive design solutions aim to create indoor environments that encourage occupant health and comfort. Sustainable urbanism, on the other hand, promotes areas that are walkable, provide access to green spaces, and offer active transportation options to support physical and mental well-being. Through the incorporation of passive design principles into sustainable urban planning, cities have the ability to establish environments that foster healthy lifestyles, encourage social engagement, and enhance the general well-being of their residents [34].

The study aims to fill the knowledge gap regarding the effective integration of passive design strategies and sustainable technologies into urban environments. It analyzes the factors and indicators that contribute to the efficiency of urban communities and their relationship to sustainable technology. The study seeks to promote energy efficiency, resilience, and community well-being in urban settings.

3. MATERIEL AND METHODS

3.1. Research Design

The research was based on the inductive and analytical method. This approach involved identifying the basic factors and indicators of sustainability in urban communities, exploring obstacles to implementing sustainability, and analyzing the strengths and weaknesses of sustainable technology. The approach also included measuring the potential and obstacles of implementing sustainable technology in urban communities.

3.2. Study Population and Sample

The research included selecting a representative sample of 100 participants from urban communities for the study. The study population consisted of users, local authorities (e.g. provincial officials, engineering administration, etc.) and experts/researchers in the field of sustainable technology. The sampling process aimed to ensure diversity and representation from different urban communities to gain a comprehensive understanding of sustainable technology implementation and efficiency across different community settings; ensuring that a wide range of viewpoints were captured. The sample also ensured the selection of individuals or communities based on their accessibility and willingness to participate.

3.2.1. Inclusion and Exclusion Criteria

Inclusion Criteria:

- Participants who are accessible and willing to participate in the study, either through in-person interviews, surveys, focus groups, or other data collection methods.
- Individuals or communities who demonstrate a genuine interest in contributing to the research and sharing their insights on sustainable technology in urban clusters.
- Individuals residing in urban communities who have direct experience with sustainable building technology or are interested in the topic.
- Users who are willing to share their perspectives, experiences, and opinions on the efficiency of urban clusters in relation to sustainable technology.
- Provincial officials, engineering administration personnel, or other stakeholders involved in decision-making processes related to urban development and sustainability.
- Authorities who have knowledge or experience in implementing sustainable technology in urban settings and can provide insights from a governance and policy perspective.
- Professionals with expertise in sustainable technology, urban planning, architecture, or related fields.
- Researchers who have conducted studies or projects focusing on sustainable building technology and its impact on urban communities.

Exclusion Criteria:

- Individuals who do not have direct experience or knowledge related to sustainable building technology or urban sustainability.
- Participants who do not have a stake or interest in the efficiency of urban clusters and the role of sustainable technology in enhancing urban living.
- Participants who have a conflict of interest that may bias their opinions or perspectives on sustainable technology in urban communities.
- Individuals who have a vested interest in promoting a specific technology or agenda that may influence their responses and undermine the objectivity of the study.
- Individuals or communities who are unwilling to engage in the research process or share their viewpoints on sustainable technology and urban efficiency.

3.3. Data Collection Tools

The study relied on the primary data collection tool, which was a designed questionnaire. The questionnaire was organized to collect opinions and ideas from the various groups mentioned above. The questionnaire included a range of topics related to sustainable technology, including current sustainability practices, barriers to implementation, potential areas for improvement, and proposals to enhance the efficiency of urban communities. The questionnaire was designed to obtain qualitative and quantitative data, allowing for a comprehensive analysis of the views and ideas collected from various stakeholders. Responses to the statements were graded using a five-point Likert grading scale as follows: (Strongly agree - Agree - Neutral - Disagree - Disagree) takes the scores (5-4-3-2-1) respectively.

3.4. Data Analysis Tools

Data collected from the questionnaire and any other sources were analyzed using qualitative and quantitative methods. This allowed for a deeper understanding of perspectives and experiences related to sustainable technology in urban communities. The quantitative analysis involved statistical techniques to identify trends, patterns and interrelationships within the numerical data obtained from the questionnaire. The analysis helped provide a comprehensive understanding of the challenges and opportunities for sustainable technology implementation and efficiency in urban agglomerations.

4. FINDINGS OF DATA ANALYSIS

4.1. First: Demographic Data

The distribution of the study sample according to age showed that the highest percentage was among 31-40 years old, which was 40%, followed by 21-30 years old, 32%, then 41-50 years old, 15%. The lowest percentage was for those over 50 years old, at 13%. Regarding gender, the percentage of males was 52%, and females were 48%. Regarding the distribution of the study sample according to years of experience, the highest percentage was from 4-10 years, which was 42%, followed by the percentage of 1-3 years, which was 34%, and at the last level, the percentage of more than 10 years, which was 24%.

4.2. Second: Questionnaire Topics

First Topic: Current Sustainability Practices from the Users' Point of View

It is clear from the following table that statement No. 2 came in the first level with a mean of 1.70 and a standard deviation of 0.927, and the direction of the sample members' answers to this statement was strongly agree, while statement No. 6 came in the second level with a mean of 1.68 and a standard deviation of 0.649, and the direction of the sample members' answers to this statement was agree. While statement No. 7 came at the third level with a mean of 1.65 and a standard deviation of 0.592, and the trend of the sample members' answers to this statement was agree, and statement No. 5 came at the fourth level with a mean of 1.65 and a standard deviation of 0.592, and the direction of the sample members' answers to this statement was agree.

Table 1. Current Sustainability Practices from the Users' Point of View

S.	Current sustainability practices from the users' perspective	Mean	Std. deviation	Direction	Rank
1.	I am satisfied with the current sustainability practices and initiatives in my urban community	1.61	0.634	Strongly Agree	6
2.	I believe that sustainable technology practices are effectively integrated into everyday life in my urban community	1.70	0.927	Strongly Agree	1
3.	It is important for urban communities to prioritize sustainable technology practices to preserve the environment	1.59	0.605	Strongly Agree	7
4.	I feel that the urban community is actively promoting and supporting sustainable technology practices	1.63	0.597	Agree	5
5.	I believe that current sustainability practices in my urban community address environmental challenges	1.65	0.592	Agree	4
6.	I have knowledge of sustainable technology practices and their impact on urban sustainability	1.68	0.649	Agree	2
7.	There is a possibility that I will be actively involved in or support sustainable technology initiatives within my community	1.65	0.592	Agree	3
Current sustainability practices from the users' perspective		1.6443	0.35663	Agree	

Second Topic: Obstacles to Implementation

It is clear from the following table that statement No. 7 came at the first level with a mean of 2.11 and a standard deviation of 1.034, and the direction of the sample members' answers to this statement was agree. While statement No. 4 came in the second level with a mean of 2.03 and a standard deviation of 0.989, and the direction of the sample members' answers to this statement was agree. Statement No. 2 came at the third level with a mean of 1.72 and a standard deviation of 0.780, the direction of the sample members' answers to this statement was agree. Statement No. 5 came in the fourth level with a mean of 1.71 and a standard deviation of 0.671, and the direction of the sample members' answers to this statement was agree. Statement No. 6 came in the fifth level with a mean of 1.67 and a standard deviation of 0.817, and the direction of the sample members' answers to this statement was strongly agree. Statement No. 1 also came in the sixth level with a mean of 1.60 and a standard deviation of 0.636, and the direction of the individuals' answers to this statement was agree. As for statement No. 3, it came in the seventh and final level with a mean of 1.52 and a standard deviation of 0.577. The direction of the sample members' answers to this statement was strongly agree.

Table 2. Obstacles to Implementation

S	Obstacles to Implementation	Mean	Std. deviation	Direction	Rank
1	I believe that the lack of awareness and education about sustainable technology is an obstacle to its implementation in urban communities	1.60	0.636	Agree	6
2	I believe that financial constraints hinder the widespread adoption of sustainable technology practices in urban areas	1.72	0.780	Agree	3
3	I believe that there are effective government policies and regulations to support the implementation of sustainable technology in urban communities	1.52	0.577	Strongly Agree	7
4	I believe that social and cultural attitudes pose barriers to the adoption of sustainable technology in urban areas	2.03	0.989	Agree	2
5	I believe that stakeholder resistance hinders the implementation of sustainable technology in urban communities	1.71	0.671	Agree	4
6	I believe that bureaucratic obstacles hinder the implementation of sustainable technology practices in urban areas	0.67	0.817	Strongly Agree	5
7	I believe that the lack of technological infrastructure is an obstacle to implementing sustainable technology in urban communities	2.11	1.034	Agree	1
Obstacles to Implementation		1.7657	0.42472	Agree	

Third Topic: Potential Areas for Improvement

It is clear from the following table that statement No. 2 came at the first level with a mean of 2.00 and a standard deviation of 0.953, and the direction of the sample members' answers to this statement was "agree". While statement No. 1 came in the second level with a mean of 1.70 and a standard deviation of 0.718, the direction of the sample members' answers to this statement was "strongly agree". Statement No. 6 came at the third level with a mean of 1.68 and a standard deviation of 0.649, and the direction of the sample members' answers to this statement was "agree", and statement No. 7 came at the fourth level with a mean of 1.65 and a standard deviation of 0.592, and the trend of the sample members' answers to this statement was "agree". Statement No. 5 came in the fifth level with a mean of 1.65 and a standard deviation of 0.592, and the direction of the sample members' answers to this statement was "agree." Statement No. 6 came in the sixth level with a mean of 1.63 and a standard deviation of 0.597, and the direction of the sample members' answers to this statement was "agree." As for statement No. 3, it came at the seventh and final level with a mean of 1.49 and a standard deviation of 0.577, and the direction of the sample members' answers to this statement was "agree".

Table 3. Potential Areas for Improvement

S.	Potential Areas for Improvement	Mean	Std. deviation	Direction	Rank
1.	There is importance of integrating sustainable technology into public transportation and mobility systems in urban communities	1.70	0.718	Strongly Agree	2
2.	I believe that sustainable technology can contribute to improving the quality and availability of green spaces and natural environments in urban communities	2.00	0.953	Agree	1
3.	There is importance of integrating sustainable technology into construction and infrastructure development to enhance sustainability in urban communities	1.49	0.577	Agree	7
4.	I believe that sustainable technology can contribute to addressing the challenges of waste management and recycling in urban communities	1.63	0.597	Agree	6
5.	I believe that sustainable technology can be leveraged to enhance energy efficiency and conservation efforts in urban communities	1.65	0.592	Agree	5
6.	It is important to make sustainable technology accessible and affordable to residents of urban communities	1.68	0.649	Agree	3
7.	I believe that sustainable technology can contribute to improving public health and well-being in urban communities	1.65	0.592	Agree	4
Potential Areas for Improvement		1.6857	0.32361	Agree	

Fourth Topic: Proposals to Enhance the Efficiency of Urban Communities

It is clear from the following table that statement No. 7 came at the first level with a mean of 1.73 and a standard deviation of 0.664, and the direction of the sample members' answers to this statement was agree. While statement No. 2 came in the second level with a mean of 1.68 and a standard deviation of 0.649, and the direction of the sample members' answers to this statement was agree. While statement No. 1 came at the third level with an arithmetic mean of 1.68 and a standard deviation of 0.649, and the direction of the sample members' answers to this statement was agree. Statement No. 2 came at the fourth level with a mean of 1.65 and a standard deviation of 0.592, and the direction of the sample members' answers to this statement was agree. Statement No. 4 came in the fifth level with a mean of 1.65 and a standard deviation of 0.592, and the direction of the sample members' answers to this statement was "agree." Statement No. 6 came in the sixth level with a mean of 1.63 and a standard deviation of 0.597, and the direction of the individuals' answers to this statement was "agree." As for statement No. 7, it came in the seventh and final level with a mean of 1.60 and a standard deviation of 0.569, and the direction of the sample members' answers to this statement was "agree".

Table 4. Proposals to Enhance the Efficiency of Urban Communities

S.	Proposals to Enhance the Efficiency of Urban Communities	Mean	Std. deviation	Direction	Rank
1.	There is an importance of motivating companies and industries to adopt sustainable technology practices in urban communities	1.68	0.649	Agree	3
2.	I believe that sustainable technology can contribute to the development of smart and sustainable urban infrastructure	1.65	0.592	Agree	4
3.	In your opinion, there is importance in enhancing community participation and participation in sustainable technology projects in urban communities	1.68	0.649	Agree	2
4.	I believe that sustainable technology can contribute to addressing issues of environmental justice and equality in urban communities	1.65	0.592	Agree	5
5.	I believe that sustainable technology can improve energy consumption and reduce environmental impact in urban communities	1.60	0.569	Agree	7
6.	It is important to consider policies and incentives to encourage the adoption of sustainable technology in urban communities	1.63	0.597	Agree	6
7.	I believe that collaborative efforts and partnerships can enhance the integration of sustainable technology into urban planning and development	1.73	0.664	Agree	1
Proposals to Enhance the Efficiency of Urban Communities		1.6600	0.35390	Agree	

5. DISCUSSION OF MAIN FINDINGS

This study aimed to extract and evaluate opinions and perspectives from users, stakeholders, and researchers about the current status of sustainable technology in urban communities and to analyze the basic factors and indicators that contributed to the efficiency of urban communities and their relationship to sustainable technology. The establishment of urban communities and the advancement of buildings are inherently interconnected [35,36]. Green buildings serve as a method for achieving urban environment objectives [37]. In order to foster the ecological advancement of urban areas, it is imperative to alter the management approach to architectural development. Urban ecological building is the fundamental task of conserving the environment and efficiently utilizing resources. As the primary body responsible for energy consumption, we must prioritize urban construction and transform the existing urban development model. This entails establishing a green building management system that emphasizes ecological and environmental protection, thereby enhancing the urban development paradigm. This phenomenon is an unavoidable trajectory in the progression of human existence, and it is implausible to contravene the inherent principles governing the evolution of phenomena [38].

Currently, conventional urban development method is unsuitable for global implementation. Hence, constructing environmentally sustainable urban communities is a beneficial approach to address the critical situation of major cities. The study's findings highlight the diverse viewpoints and perceptions surrounding sustainable technology in communities. The diverse perspectives on present sustainability practices across various groups, such as users, stakeholders, and researchers, emphasize the intricate nature of the matter. While many participants reported satisfaction with current sustainable technology projects, others identified areas for enhancement, highlighting the necessity for a nuanced and focused strategy to tackle urban communities' varied demands and concerns. Discovering barriers to the adoption of sustainable technologies is a vital finding. Prominent obstacles that have arisen include financial constraints, inadequate comprehension or education regarding sustainable methods, and regulatory challenges. These findings emphasize the significance of tackling systemic obstacles that impede the use of sustainable technology, such as the requirement for financial incentives or assistance, educational initiatives to enhance awareness, and legislative reforms to allow the incorporation of sustainable solutions.

Multiple studies have identified financial constraints as a substantial obstacle to the extensive adoption of sustainable technologies in urban settings. This obstacle involves multiple facets, such as the exorbitant upfront expenses of sustainable infrastructure, restricted availability of funding for sustainable initiatives, and the perceived economic uncertainties linked to the adoption of novel technologies. To overcome financial limitations, it is necessary to create financial incentives, subsidies, or new financing methods that can make sustainable technology more easily attainable and cost-efficient for urban stakeholders [39-42]. Upon comparing the study's findings with those of previous research, it becomes apparent that the obstacles to the adoption of sustainable technology in urban communities are well documented and widely acknowledged. The significance of tackling these obstacles through focused interventions and structural modifications is shown by this consistency. Furthermore, it emphasizes the necessity of cooperative endeavors between policymakers, urban planners, industry players, and community members to surmount these obstacles and establish a conducive atmosphere for the adoption of sustainable technology. The combined findings from multiple studies offer a thorough comprehension of the obstacles and emphasize the need to promptly tackle these problems in order to promote sustainable urban growth. Moreover, multiple studies have consistently highlighted the need to increase awareness and deliver education regarding sustainable practices among urban residents, businesses, and policymakers. The limited knowledge and understanding of the advantages and possibilities of sustainable technology can impede its acceptance and implementation. Proposals have been made to use educational programs, public outreach efforts, and knowledge-sharing initiatives as crucial measures to overcome this obstacle and foster a more profound comprehension of sustainable solutions among urban residents [23, 43,44].

Obstacles related to regulations, such as obsolete policies, complicated permitting procedures, and contradictory rules, have constantly been recognized as hindrances to incorporating sustainable technology in urban settings. This was in accordance with the findings of [45]. To tackle regulatory difficulties, it is necessary to advocate for policy reforms, simplify approval processes, and provide regulatory frameworks that encourage and promote the implementation of sustainable solutions. The identification of prospective areas for improvement in sustainable technology, encompassing the integration of renewable energy, management of waste, and sustainable transportation, aligns with conclusions drawn from prior research in the realm of sustainable urban development. Research from multiple sources has repeatedly identified these specific areas of focus and emphasized their importance in promoting sustainable practices within urban communities. Multiple studies have emphasized the significance of incorporating renewable energy sources, such as solar, wind, and geothermal power, into urban infrastructure to decrease dependence on fossil fuels and alleviate environmental impacts. The incorporation of renewable energy into buildings, public transportation systems, and community-wide energy grids has been a consistent focus in sustainable urban development studies. This highlights the need of directing investments and policy assistance towards renewable energy projects [46,47].

Sustainable waste management strategies, such as recycling, composting, and waste-to-energy technologies, are constantly recognized as important areas of concentration for urban sustainability. Research has emphasized the possibility of enhancing waste management infrastructure, decreasing dependence on landfills, and advocating for circular economy concepts to minimize waste and resource usage in urban settings [48,49]. The advancement of sustainable transport modes, such as public transit, cycling infrastructure, and electric automobiles, has been a significant topic of emphasis in research on sustainable urban development. Research has highlighted the importance of giving priority to investments in sustainable transport systems, decreasing dependence on private vehicles, and improving access to low-carbon mobility options. These measures aim to tackle urban congestion and air pollution, while also encouraging fair access to transport services [50].

The study emphasizes the alignment between the proposals to improve the efficiency of urban clusters using sustainable technology and prior research that underscores the significance of rewarding sustainable practices, increasing public awareness, and promoting collaboration. These suggestions align with conclusions drawn from other research, suggesting a widespread agreement on the necessity of synchronized endeavors and diverse approaches to promote favorable advancements in urban sustainability. Multiple studies have consistently emphasized the significance of providing incentives for sustainable activities, including the implementation of energy-efficient building design, acceptance of renewable energy, and promotion of sustainable modes of transportation. Research has highlighted the necessity of implementing financial incentives, regulatory measures, and supportive policies to promote the adoption of sustainable technology and practices by individuals, enterprises, and local governments [51-53].

Increasing public awareness has consistently been a prominent topic in research on sustainable urban development. Research has emphasized the importance of educational campaigns, community outreach programs, and public engagement activities in educating and empowering individuals about sustainable living, resource preservation, and the advantages of environmentally friendly technologies [54-57]. Moreover, the promotion of cooperation among stakeholders with an interest or involvement in a particular issue has been seen as a critical element in promoting the progress of urban sustainability. Studies have emphasized the importance of collaborations across government agencies, private sector entities, academic institutions, and community organizations to create and execute sustainable technology solutions, urban planning plans, and policy frameworks [58,59].

By utilizing these consistent findings from other studies, it becomes clear that the ideas in the study are in line with wider patterns observed in research on sustainable urban development. The focus on promoting sustainable practices, increasing public awareness, and encouraging collaboration demonstrates a widespread agreement on the necessity of coordinated endeavors and diverse techniques to facilitate beneficial advancements in urban sustainability. The significance of tackling these focal points via integrated methods that include multiple stakeholders and utilize a range of tools to advance sustainable urban development is emphasized by this collective understanding.

CONCLUSIONS

The study effectively obtained and assessed viewpoints and insights from users, stakeholders, and researchers regarding the present state of sustainable technology in urban settings. The study employed an inductive and analytical research methodology, utilizing a questionnaire form to gather the perspectives of 100 participants. These participants consisted of residents, local authorities, and professionals specializing in sustainable technology. The questionnaire encompassed a range of subjects on sustainable technology, such as individuals' perceptions on existing sustainability measures, obstacles to their implementation, potential areas for improvement, and suggestions for increasing the effectiveness of urban communities. The research findings yielded a thorough comprehension of perspectives on sustainable technology, emphasizing the varied viewpoints of distinct stakeholder groups. The study identified crucial aspects and indicators that contribute to the effectiveness of urban communities and their correlation with sustainable technology. Furthermore, it illuminated the current obstacles to the deployment of sustainable technology and unveiled future avenues for enhancement. In summary, the research highlights the significance of taking into account many perspectives when assessing sustainable construction technologies in urban communities. The knowledge acquired from users, stakeholders, and researchers might be a helpful basis for future endeavors targeted at improving urban sustainability. The findings of the study can be used to develop specific strategies to overcome the obstacles that have been identified, take advantage of possibilities for improvement, and encourage the use of sustainable technology to increase the efficiency of urban communities.

REFERENCES

[1] Sandanayake, Malindu, Guomin Zhang, and Sujeeva Setunge. "Impediments affecting a comprehensive emission assessment at the construction stage of a building." International Journal of Construction Management 22, no. 3 (2022): 453-463. https://doi.org/10.1080/15623599.2019.1631977

[2] Darko, Amos, Albert Ping Chuen Chan, Ernest Effah Ameyaw, Bao-Jie He, and Ayokunle Olubunmi Olanipekun. "Examining issues influencing green building technologies adoption: The United States green building experts' perspectives." Energy and Buildings 144 (2017): 320-332. https://doi.org/10.1016/j.enbuild.2017.03.060

[3] Santamouris, Mattheos, and Jie Feng. "Recent progress in daytime radiative cooling: is it the air conditioner of the future?." Buildings 8.12 (2018): 168. https://doi.org/10.3390/buildings8120168

[4] Acevedo-De-los-Ríos, Alejandra. Building Materials and the Climate: Constructing a New Future. No. UCL-Université Catholique de Louvain. 2023. https://wedocs.unep.org/handle/20.500.11822/43293

[5] Giannetti, Biagio F., Jorge CC Demétrio, Feni Agostinho, Cecília MVB Almeida, and Gengyuan Liu. "Towards more sustainable social housing projects: Recognizing the importance of using local resources." Building and Environment 127 (2018): 187-203. https://doi.org/10.1016/j.buildenv.2017.10.033

[6] Doan, Dat Tien, Ali Ghaffarianhoseini, Nicola Naismith, Tongrui Zhang, Amirhosein Ghaffarianhoseini, and John Tookey. "A critical comparison of green building rating systems." Building and Environment 123 (2017): 243-260. https://doi.org/10.1016/j.buildenv.2017.07.007

[7] Dong, Ya Hong, and S. Thomas Ng. "A life cycle assessment model for evaluating the environmental impacts of building construction in Hong Kong." Building and Environment 89 (2015): 183-191. https://doi.org/10.1016/j.buildenv.2015.02.020

[8] Catalano, Chiara, et al. "Smart sustainable cities of the new millennium: towards design for nature." Circular Economy and Sustainability 1.3 (2021): 1053-1086.

[9] Catalano, Chiara, et al. "Smart sustainable cities of the new millennium: towards design for nature." Circular Economy and Sustainability 1.3 (2021): 1053-1086. https://link.springer.com/article/10.1007/s43615-021-00100-6

[10] Subhi Sharaf El-Din, Nourhan Mohamed, et al. "Compatibility of renewable energies with the standards of energy management system and environmental design of green buildings." Journal of Al-Azhar University Engineering Sector 15.55 (2020): 527-537. Doi: 10.21608/AUEJ.2020.87841

[11] Tizot, Jean-Yves. "Ebenezer Howard's Garden city idea and the ideology of industrialism." Cahiers victoriens et édouardiens 87 Printemps (2018). https://doi.org/10.4000/cve.3605

[12] Bayulken, Bogachan, and Donald Huisingh. "A literature review of historical trends and emerging theoretical approaches for developing sustainable cities (part 1)." Journal of Cleaner Production 109 (2015): 11-24. https://doi.org/10.1016/j.jclepro.2014.12.100

[13] Caragliu, Andrea, Chiara Del Bo, and Peter Nijkamp. "Smart cities in Europe." In Creating Smarter Cities, pp. 65-82. Routledge, 2013. https://www.researchgate.net/publication/46433693

[14] Bibri, Simon Elias, and John Krogstie. "On the social shaping dimensions of smart sustainable cities: A study in science, technology, and society." Sustainable Cities and Society 29 (2017): 219-246. https://www.sciencedirect.com/science/article/abs/pii/S2210670716305881

[15] Ockwell, David, and Rob Byrne. Sustainable energy for all: Innovation, technology and pro-poor green transformations. Taylor & Francis, 2016. https://doi.org/10.4324/9781315621623

[16] Salati, Maryam, Luis Bragança, and Ricardo Mateus. "Sustainability assessment on an urban scale: Context, challenges, and most relevant indicators." Applied System Innovation 5, no. 2 (2022): 41. https://doi.org/10.3390/asi5020041

[17] Hiyama, Kyosuke, Tatsuya Hayashi, and Ryutaro Kubo. "Trend analysis of CASBEE Wellness Office certified properties." Japan Architectural Review 6, no. 1 (2023): e12403. https://doi.org/10.1002/2475-8876.12403

[18] Kacyira, Aisa Kirabo. "Addressing the sustainable urbanization challenge." UN Chronicle 49, no. 2 (2012): 58-60. https://doi.org/10.18356/f813137d-en.

[19] Zellner, Moira, and Scott D. Campbell. "Planning for deep-rooted problems: What can we learn from aligning complex systems and wicked problems?." Planning Theory & Practice 16, no. 4 (2015): 457-478. https://doi.org/10.1080/14649357.2015.1084360

[20] Heerwagen, Judith, and Bert Gregory. "Biophilia and sensory aesthetics." Biophilic Design: The theory, science, and practice of bringing buildings to life. New Jersey: John Wiley & Sons (2008): 227-241.

[21] Beatley, Timothy. Biophilic cities: integrating nature into urban design and planning. Island Press, 2011.

[22] Hernández-Palacio, Fabio. "Urban Densification and the Sustainable City in Norway: A Study of Drivers and Barriers." (2018).

[23] Beatley, Timothy. Green urbanism: Learning from European cities. Island press, 2012.

[24] Zhong, Weijie, Torsten Schröder, and Juliette Bekkering. "Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review." Frontiers of Architectural Research 11.1 (2022): 114-141. https://doi.org/10.1016/j.foar.2021.07.006

[25] Andreucci, Maria Beatrice, et al. "Exploring challenges and opportunities of biophilic urban design: Evidence from research and experimentation." Sustainability 13.8 (2021): 4323. https://doi.org/10.3390/su13084323

[26] Totaforti, Simona. "Emerging biophilic urbanism: the value of the human–nature relationship in the urban space." Sustainability 12.13 (2020): 5487. https://doi.org/10.3390/su12135487

[27] Tabb, Phillip James. Biophilic urbanism: Designing resilient communities for the future. Routledge, 2020. https://doi.org/10.4324/9781003034896

[28] Xue, Fei, et al. "From biophilic design to biophilic urbanism: Stakeholders' perspectives." Journal of Cleaner Production 211 (2019): 1444-1452. https://doi.org/10.1016/j.jclepro.2018.11.277

[29] Omrany, Hossein, and Abdul Kadir Marsono. "Optimization of building energy performance through passive design strategies." British Journal of Applied Science & Technology 13.6 (2015): 1-16.

[30] ALI, PESHWAZ ABDULLAH. Energy reduction through architectural passive designs in sulaymaniyah, Northern Iraq: Building's material assessment. Diss. Doctoral dissertation, NEAR EAST UNIVERSITY, 2021.

[31] Capolongo, Stefano, et al. "Healthy design and urban planning strategies, actions, and policy to achieve salutogenic cities." International Journal of Environmental Research and Public Health 15.12 (2018): 2698.

[32] Elshafei, Ghada, et al. "Towards an adaptation of efficient passive design for thermal comfort buildings." Sustainability 13.17 (2021): 9570.

[33] Croce, Silvia, and Daniele Vettorato. "Urban surface uses for climate resilient and sustainable cities: A catalogue of solutions." Sustainable Cities and Society 75 (2021): 103313.

[34] Li, Bin, et al. "Sustainable passive design for building performance of healthy built environment in the Lingnan area." Sustainability 13.16 (2021): 9115.

[35] Zheng, Lina, Huanyu Wu, Hui Zhang, Huabo Duan, Jiayuan Wang, Weiping Jiang, Biqin Dong, Gang Liu, Jian Zuo, and Qingbin Song. "Characterizing the generation and flows of construction and demolition waste in China." Construction and Building Materials 136 (2017): 405-413. https://doi.org/10.1016/j.conbuildmat.2017.01.055

[36] Liu, Yansui. "Research on the urban-rural integration and rural revitalization in the new era in China." Acta Geogr. Sin 73, no. 4 (2018): 637-650.

[37] Jansson, Åsa. "Reaching for a sustainable, resilient urban future using the lens of ecosystem services." Ecological Economics 86 (2013): 285-291. https://doi.org/10.1016/j.ecolecon.2012.06.013

[38] Derkzen, Marthe L., Astrid JA van Teeffelen, and Peter H. Verburg. "Quantifying urban ecosystem services based on high-resolution data of urban green space: an assessment for Rotterdam, the Netherlands." Journal of Applied Ecology 52, no. 4 (2015): 1020-1032. https://doi.org/10.1111/1365-2664.12469

[39] Jaradat, Haytham, Omar Adeeb Mohammad Alshboul, Islam Mohammed Obeidat, and Mohammad Kamal Zoubi. "Green building, carbon emission, and environmental sustainability of construction industry in Jordan: Awareness, actions and barriers." Ain Shams Engineering Journal 15, no. 2 (2024): 102441. https://doi.org/10.1016/j.asej.2023.102441

[40] Golić, Kosa, Vesna Kosorić, Tatjana Kosić, Slavica Stamatović Vučković, and Kosara Kujundžić. "A platform of critical barriers to socially sustainable residential buildings: Experts' perspective." Sustainability 15, no. 9 (2023): 7485. https://doi.org/10.3390/su15097485

[41] Ershad Sarabi, Shahryar, Qi Han, A. Georges L. Romme, Bauke de Vries, and Laura Wendling. "Key enablers of and barriers to the uptake and implementation of nature-based solutions in urban settings: A review." Resources 8, no. 3 (2019): 121. https://doi.org/10.3390/resources8030121

[42] Shafique, Muhammad, Reeho Kim, and Muhammad Rafiq. "Green roof benefits, opportunities and challenges–A review." Renewable and Sustainable Energy Reviews 90 (2018): 757-773. https://doi.org/10.1016/j.rser.2018.04.006

[43] Prendeville, Sharon, Emma Cherim, and Nancy Bocken. "Circular cities: Mapping six cities in transition." Environmental innovation and societal transitions 26 (2018): 171-194. https://doi.org/10.1016/j.eist.2017.03.002

[44] De Jong, Martin, Simon Joss, Daan Schraven, Changjie Zhan, and Margot Weijnen. "Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization." Journal of Cleaner production 109 (2015): 25-38. https://doi.org/10.1016/j.jclepro.2015.02.004

[45] Jim, Chi Yung. "Sustainable urban greening strategies for compact cities in developing and developed economies." Urban Ecosystems 16 (2013): 741-761.

[46] Seto, Karen C., Galina Churkina, Angel Hsu, Meredith Keller, Peter WG Newman, Bo Qin, and Anu Ramaswami. "From low-to net-zero carbon cities: The next global agenda." Annual review of environment and resources 46 (2021): 377-415. https://www.annualreviews.org/doi/abs/10.1146/annurev-environ-050120-113117

[47] Hess, David J., and Haley Gentry. "100% renewable energy policies in US cities: strategies, recommendations, and implementation challenges." Sustainability: Science, Practice and Policy 15, no. 1 (2019): 45-61. https://doi.org/10.1080/15487733.2019.1665841

[48] Obersteg, Andreas, Alessandro Arlati, Ariane Acke, Gilda Berruti, Konrad Czapiewski, Marcin Dąbrowski, Erwin Heurkens et al. "Urban regions shifting to circular economy: Understanding challenges for new ways of governance." Urban Planning 4, no. 3 (2019): 19-31.

[49] Lehmann, Steffen. "Conceptualizing the urban nexus framework for a circular economy: linking energy, water, food, and waste (EWFW) in Southeast-Asian cities." In Urban energy transition, pp. 371-398. Elsevier, 2018.

[50] Pojani, Dorina, and Dominic Stead. "Sustainable urban transport in the developing world: beyond megacities." Sustainability 7, no. 6 (2015): 7784-7805. https://doi.org/10.3390/su7067784

[51] Schwartz, Emily K., and Moncef Krarti. "Review of adoption status of sustainable energy technologies in the US residential building sector."

Energies 15, no. 6 (2022): 2027.

[52] Dadzie, John, Goran Runeson, Grace Ding, and Francis K. Bondinuba. "Barriers to adoption of sustainable technologies for energy-efficient building upgrade—semi-Structured interviews." Buildings 8, no. 4 (2018): 57.

[53] Yeatts, Dale E., Dana Auden, Christy Cooksey, and Chien-Fei Chen. "A systematic review of strategies for overcoming the barriers to energy-efficient technologies in buildings." Energy research & social science 32 (2017): 76-85.

[54] Bouramdane, Ayat-Allah. "Optimal water management strategies: paving the way for sustainability in smart cities." Smart Cities 6, no. 5 (2023): 2849-2882.

[55] Solá, Ana Gil, Bertil Vilhelmson, and Anders Larsson. "Understanding sustainable accessibility in urban planning: Themes of consensus, themes of tension." Journal of Transport Geography 70 (2018): 1-10.

[56] Pupphachai, Umaporn, and Christian Zuidema. "Sustainability indicators: A tool to generate learning and adaptation in sustainable urban development." Ecological Indicators 72 (2017): 784-793.

[57] Carley, Michael, Harry Smith, and Paul Jenkins. Urban development and civil society: The role of communities in sustainable cities. Routledge, 2013.

[58] Coaffee, Jon, Marie-Christine Therrien, Lorenzo Chelleri, Daniel Henstra, Daniel P. Aldrich, Carrie L. Mitchell, Sasha Tsenkova, Éric Rigaud, and Participants. "Urban resilience implementation: A policy challenge and research agenda for the 21st century." Journal of Contingencies and Crisis Management 26, no. 3 (2018): 403-410.

[59] Lee, Jung Hoon, Marguerite Gong Hancock, and Mei-Chih Hu. "Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco." Technological Forecasting and Social Change 89 (2014): 80-99.

DOI: https://doi.org/10.15379/ijmst.v10i5.3627