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Towards A Sustainable Future: Ethno-Minetic, Waste-Aware, And Energy Efficiency Urban Design in FCT Abuja

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Abstract

This study examined pathways towards achieving a sustainable urban future through the integration of ethno-minetic design, waste-aware practices, and energy efficiency in the Federal Capital Territory (FCT) Abuja, Nigeria. The study adopted a descriptive survey research design, utilizing primary data collected through structured questionnaires administered to a sample of 384 respondents, determined using the Cochran formula. Data were analyzed using both descriptive and inferential statistics, including regression analysis. The findings revealed a high level of awareness of sustainable urban design among respondents and demonstrated that ethno-minetic design, waste-aware practices, and energy efficiency significantly contribute to sustainable urban development. Specifically, energy efficiency emerged as the most influential factor, followed by ethno-minetic design and waste-aware strategies. The study also highlighted the importance of integrating indigenous knowledge systems with modern urban planning to enhance sustainability outcomes. Despite these positive findings, challenges such as inadequate infrastructure, weak policy implementation, and limited public awareness persist. The study concludes that a holistic and context-specific approach is essential for achieving sustainable urban development in Abuja. It recommends the adoption of energy-efficient technologies, improved waste management systems, and the incorporation of cultural design principles into urban planning policies to foster a resilient and sustainable urban future.

Keywords: Sustainable Urban Design, Ethno-Minetic Design, Waste Management, Energy Efficiency, Urban Sustainability, Abuja FCT

1.0 Introduction

The high rate of urbanization in the world has placed pressure on the need to seek new ways of planning cities that are more sustainable, efficient and resilient. Cities nowadays take up a high percentage of the world energy consumption, resource use, and

waste output, and thus, they are the focus of sustainable development debates (Lou, Lee, Welfle, Abdullahi, 2021). With the ever-increasing urban population, there is the pressing need to reconsider the traditional models of planning and introduce

combined systems that will not harm the environment, but will enhance the quality of life. The concept of sustainable city design has therefore become an integrated approach, which integrates the concepts of environmental sustainability, economic sustainability, and social inclusion in the development of future cities (Schuetze et al., 2013; Vaia Editorial Team, 2024).

Sustainable urban design, in this respect, focuses on efficient consumption of energy, water and materials as well as creation of livable and resilient cities. It integrates concepts like green infrastructure, renewable energy integration and smart land-use planning in order to reduce ecological footprints. The strategy also aims at balancing the built and natural environments using the incorporation of green spaces, effective transport systems and building technologies that are environmentally friendly. All these measures are beneficial in terms of improving the environmental performance and lead to better health of the population and resistance against disasters in cities (ScienceDirect Topics, n.d.; Vaia Editorial Team, 2024).

Energy efficiency is a critical aspect of sustainable urban development, the idea of minimizing energy consumption and maximizing the use of energy in urban systems. The energy used by buildings takes up a significant portion of the total global energy consumption, which implies the need to implement energy-saving building designs and renewable energy solutions. The combination of decentralized energy systems, passive design, and smart technologies can make a considerable impact on reducing carbon emissions and lowering operational costs and making urban areas more sustainable. Urban design that is energy-efficient is thus a pillar in attaining climate-responsive urban areas and averting effects of global warming (Schuetze et al., 2013; Gil-Ozoudeh et al., 2023).

The notion of waste conscious urban design is also significant as waste is not only treated as a by-product but also as a resource that could be reused, recycled or converted to energy. The rapid urbanization has contributed to the production of more wastes, which has become a challenge on environmental and public health, especially in developing cities. Waste reduction, segregation, recycling and circular economy practices are sustainable waste management strategies necessary in minimizing environmental degradation and enhancing resource efficiency. Cities can have more sustainable flows of materials and less ecological footprint by converting waste into useful inputs to urban systems (Lehmann, 2011; Abdullahi, and Lee, 2018; IntechOpen, 2018).

Ethno-minetic design is another new facet of sustainable urban planning that incorporates traditional knowledge systems, cultural values, and local practices into contemporary urbanism. This is because sustainability is not a technical or environmental problem but a socio-cultural problem. Through its inspirations of traditional architecture, climate responsive building methods and community based resource management practices, ethno-minetic design develops culturally appropriate and environmentally responsive urban environments. This type of integration promotes the involvement of the community, cultural identity, and the fact that urban development is consistent with the context and the needs of the local (Abdullahi, Lee, 2018).

In the Nigerian setting, especially in the Federal Capital Territory (FCT) Abuja, sustainable urban design is becoming a necessity as a result of the fast-rising population, infrastructural strain, and environmental issues. The lack of efficient waste management,

excessive power usage, urban sprawl, and the disappearance of green spaces are only some of the problems that highlight the urgency of new planning methods. The implementation of ethno-minetic, waste conscious, energy conscious design approaches provide an avenue to developing a more sustainable and resilient Abuja. This research adds to the debate of sustainable urban futures in developing urban areas by ensuring that urban development meets global sustainability objectives whilst considering local realities.

2.0 Literature Review and Theoretical Framework

2.1 Conceptual Review

2.1.1 Sustainable Future

A sustainable future can be defined as a development pathway that fulfills the current needs without the future generation jeopardizing the capacity of the future generation to satisfy their needs, especially through the harmonious blending of environmental protection, economic growth, and social well being. In an urban setting, it focuses on establishing robust and adaptive systems that can overcome climate change, resource depletion and population growth. The idea of sustainable futures is interconnected with the notion of sustainable urban development, which aims to decrease the negative environmental impact and maximize the quality of life and the stability of society in the long term (Toli & Murtagh, 2020; Bibri and Krogstie, 2017). Moreover, sustainable habitats are created in a way that will ensure that the resources are reused effectively and that waste produced by one system is used as input into another, which will facilitate ecological balance and sustainability in the long run (Yadav, 2016).

2.1.2 Ethno-Minetic

Ethno-minetic design Ethno-minetic design is a new approach in sustainable architecture and urban planning, combining ethno (culture and indigenous knowledge) with mimetic (imitation of natural or traditional systems). It dwells on the incorporation of local cultural values, native building methods, and environmental expertise in the current design activities in order to realize sustainability (Abdullahi, et al, 2023). This method acknowledges that the conventional societies have long evolved climate-responsive and resource-saving solutions that can guide the modern city development. Ethno-minetic design enriches cultural identity, adaptability to the environment, and social inclusiveness in the urban landscape by imitating these native practices and harmonizing them with modern technologies, which leads to sustainable urbanism (Roggema, 2016; Cheshmehzangi, 2024).

2.1.3 Waste-Aware

Waste-conscious urban design is a planning methodology that emphasizes on minimizing, reusing, recycling and recovery of waste products in urban systems. It changes the attitude on waste as a disposal issue to a resource that can be used again in production. Circular economy practices, effective segregation of waste, and recycling of waste into energy or raw materials are waste-conscious strategies in sustainable cities. The practices can decrease environmental pollution, resource conservation, and enhance better health outcomes in society. Proper waste management systems also help in mitigating climate through the minimization of greenhouse gas emission related to landfill disposal and open burning (Lehmann, 2011; IntechOpen, 2018).

2.1.4 Energy Efficiency

Energy efficiency in city planning entails the optimisation of energy consumption in buildings, infrastructure and transport systems in order to reduce energy consumption and environmental effects. It involves embracing of energy-efficient technologies, passive design, and renewable energy like solar and wind. An example of this is energy-efficient buildings, which are built to decrease the energy consumption by providing better insulation, natural ventilation, and intelligent systems. This is the key to sustainable urban development since cities are significant energy consumers in the world, and they also contribute to the global greenhouse gases. Increased energy efficiency helps to lower operational costs as well as to contribute to mitigating climate change and urban resilience (IntechOpen, 2018; Ferrando et al., 2021).

2.1.5 Urban Design

Urban design, is the process of creating and building the physical structure, functionality, and appearance of cities and communities. It involves organizing buildings, open spaces, transportation, and infrastructure to design useful, beautiful and sustainable environments. Sustainable urban design takes this notion further by incorporating ecological, social equity, and economic efficiency in the city planning. It focuses on compact development, green infrastructure, walkability and efficient land use in enhancing livability and environmental performance. Finally, the urban design is paramount in converting cities into living organisms that are more balanced in terms of human needs and environmental sustainability and resilience (Roggema, 2016; Sustainable Design, 2023).

2.2 Theoretical Framework

2.2.1 Ecological Modernization Theory

The Ecological Modernization Theory (EMT) is very pertinent in this research because it offers an insight into the ways in which economic growth, technological advances, and environmental conservation can be incorporated into urban systems. According to the theory, environmental issues like pollution, waste, and energy inefficiency issues can be solved by institutional reforms, technological innovation, and proactive policies instead of impeding economic development. Within the framework of sustainable urban design in the Federal Capital Territory (FCT) Abuja, EMT advocates the use of energy-efficient technologies, waste-conscious systems, and culturally adaptive (ethno-minetic) design strategies as the means of attaining the sustainable development. It highlights how governance, involvement of the private sector, and innovation can change environments of urban areas into eco-efficient and resilient systems. Through its focus on cleaner production processes, integration of renewable energy and use of a circular resource EMT has much in common with the goals of developing a sustainable urban future that balances environmental protection with social-economic development (Mol & Spaargaren, 2000; Murphy, 2000).

2.3 Empirical Reviews

In an effort to analyze Sustainable Urban Design: A Review of Eco-Friendly Building Practices and Community Impact, Omole, Olajiga, and Olatunde (2024) applied a systematic review methodology, which analyzed the existing literature on green building practices and their effects on urban sustainability. The research observed that renewable energy system, sustainable material and energy-efficient technologies integration has a significant impact on environmental performance and community well-being. It also found out that sustainable urban design

promotes social inclusion and resilience in fast-urbanizing regions. The authors had suggested more use of sustainable construction methods, policy in favor of green infrastructure, and involvement of stakeholders in the urban planning process.

The qualitative research approach employed by Gil-Ozoudeh, Iwuanyanwu, Okwandu, and Ike (2023) in the study named Sustainable Urban Design: The Role of Green Buildings in Shaping Resilient Cities examined the role of green buildings in ensuring sustainability of cities. The results showed that green buildings greatly contribute to energy conservation, waste minimization, and better urban biodiversity and health outcomes. The research also determined that incorporation of green architecture in urban planning enhanced economic opportunities and property values. The authors proposed encouraging green building policies, sustainable construction incentives, and extensive knowledge of environmentally friendly architecture.

The study by Hadibarata and Kristanti (2025) is titled as Urban Sustainability in construction: a comparative review of construction waste management practices in Hong Kong and the United Kingdom and was conducted through comparative review methodology based on construction waste management practices between Hong Kong and the United Kingdom. The results showed that good separation of waste, recycling technologies, and stringent regulatory systems greatly lower the waste in construction and environmental pollution. The research also emphasized the need to embrace the idea of the circular economy in the urban development. The authors suggested the introduction of more stringent waste management policies, introduction of new technologies of recycling, and more investment in sustainable construction.

A systematic literature review approach was used by Bashir, Ragmoun, Alfalih, and Bashir (2025) to analyze the connection between smart technologies and urban sustainability through the study titled Analyzing Sustainable Urban Development through Smart and Sustainable Cities. The results indicated that technological integration in itself is not a sure way of ensuring sustainability unless it is backed by environmentally sensitive policies and planning models. The research highlighted the importance of energy efficiency, waste management and governance structures in the attainment of sustainable cities. The authors suggested applying smart technologies to sustainability concepts and creating consistent city policies to guarantee positive environmental and social impacts in the long term (Bashir et al., 2025) (Frontiers).

The study by Munonye and Ajonye (2025) is called Energy-Driven Circular Design in the Built Environment: Rethinking Architecture and Infrastructure and is based on the conceptual and analytical approach to the understanding of the impact of energy optimization on the creation of a sustainable urban system. The results showed that circular design strategies that combine renewable energy and resource efficiency help significantly to decrease energy and environmental degradation in cities. Another important finding of the research was that energy-saving technologies together with the principles of the circular economy can boost sustainability results. The authors suggested implementing energy-based design principles, policy changes to facilitate the integration of renewable energy, and cooperation of stakeholders in urban development.

Chin, Alias, and Alkharabsheh (2025) conducted a systematic literature review on Urban Housing Regeneration Strategies of

Sustainable City Development to explore the housing regeneration strategies of sustainable cities employing a systematic review methodology. The results revealed that regeneration of sustainable housing enhances the efficiency of energy, minimizes urban decay, and promotes social inclusion. Effective implementation, however, is hampered by financial, regulatory and institutional obstacles. The research proposed combined policy frameworks, stakeholder partnerships, and enhanced investment in sustainable urban infrastructure to realize the long-term sustainability of a city.

The study by Unegbu, Yawas, Dan-asabe, and Alabi (2024) is known as Sustainable Urban Planning and Development: A Systematic Review of Policies and Practices in Nigeria but has a systematic review approach to examine urban planning frameworks in Nigeria. It was found that other cities such as Abuja and Lagos have grown in terms of infrastructures, yet issues of poor waste management, insufficient energy, and poor policy implementation have remained. The research also determined the weaknesses in environmental sustainability and urban governance. The authors suggested the institutional frameworks and enforcement of policies and incorporation of sustainable practices like waste conscious and energy saving designs into the urban planning in Nigeria.

2.4 Gap in the literature.

Critical analysis of the above empirical studies shows that there are some key gaps that necessitate the current study. As much as authors like Omole et al. (2024) and Gil-Ozoudeh et al. (2023) have extensively investigated the concept of sustainable urban design and green building practices, they mainly discussed the concept of sustainability in general and gave minimal attention to the inclusion of culturally grounded approaches like ethno-minetic design. On the same note, although Hadibarata and Kristanti (2025) as well as Unegbu et al. (2024) focused on issues of waste management and urban planning, they were largely policy- and system-focused, with little consideration given to localized, setting-specific strategies to apply to the fast-growing cities such as Abuja. Moreover, research by Bashir et al. (2025) and Munonye and Ajonye (2025) emphasized the use of smart technologies and energy-efficient systems but failed to comprehensively investigate the synergistic connection between energy efficiency, waste-awareness, and indigenous design expertise as a part of a single urban system. Besides, the majority of the studies analyzed employed systematic reviews or conceptual methodology, and there were few empirical studies that concentrated specifically on the Federal Capital Territory (FCT) Abuja. This therefore leaves a massive literature gap of an integrated, context-driven approach that incorporates ethno-minetic principles, waste-conscious policies, and energy-conscious urban planning to attain a sustainable future in Abuja and this study aims at bridging this gap.

3.0 Methodology

3.1 Research Design

The study took the form of a descriptive survey research to explore how the ethno-minetic, waste-conscious and energy-efficient concepts of urban design have been integrated in the Federal Capital Territory (FCT) Abuja. The descriptive survey design is suitable since it allows the systemic gathering of information of a representative sample of respondents to describe the prevailing conditions, perceptions, and relationships between variables without interfering with them. This approach is widely used in social and environmental research to obtain quantitative data that

can be generalized to a larger population (Saunders et al., 2019; Creswell & Creswell, 2018).

3.2 Area of Study

The research was carried out in Federal Capital Territory (FCT) Abuja, the capital of the country. Abuja has been undergoing high urbanization rates, population, and infrastructural developments, which have resulted in pressure on the energy systems, waste management, and urban planning frameworks. The city contains six area councils including Abuja Municipal Area Council (AMAC), Bwari, Gwagwalada, Kuje, Kwali and Abaji and thus, is an appropriate area to study sustainable urban design practices. Abuja is selected based on the strategic nature, diversified population and current sustainability urban development challenges.

The study population included the residents of FCT Abuja, urban planners, environmental specialists, and other stakeholders of urban development in the area. This involves government agencies, organizations in the private sector and the local communities who are directly or indirectly impacted by the issues of urban design and sustainability. Since the population was large and diverse, it was deemed suitable to use a representative sample to successfully collect and analyze the data (Creswell and Creswell, 2018).

3.3 Sampling Method and Sample Size.

This study used a multistage sampling technique. Initially, the identification of key stakeholders including urban planners and environmental officers was done through purposive sampling whereas simple random sampling was employed in identifying residents in the six area councils of the FCT. The Cochran (1977) formula of large populations was used to determine the sample size:

$$n_0 = Z^2pq / e^2$$

Where:

$$Z = 1.96 \text{ (95\% confidence level)}$$

$$p = 0.5 \text{ (proportion of population assumed to have the attribute)}$$

$$q = 1 - p = 0.5$$

$$e = 0.05 \text{ (margin of error)}$$

Substituting the values:

$$n_0 = (1.96^2 \times 0.5 \times 0.5) / (0.05^2)$$

$$n_0 = (3.8416 \times 0.25) / 0.0025$$

$$n_0 = 0.9604 / 0.0025$$

$$n_0 = 384.16$$

Thus, a sample size of approximately **384 respondents** was selected for the study.

3.4 Model Specification

The study adopted a functional model to examine the relationship between sustainable urban design (dependent variable) and ethno-minetic design, waste-aware practices, and energy efficiency (independent variables). The model is specified as:

$$SUD = f(\text{EMD, WA, EE})$$

Where:

SUD = Sustainable Urban Design,

EMD = Ethno-Minetic Design,

WA = Waste-Aware Practices,

EE = Energy Efficiency.

3.6 Research Instruments

The tool of data collection in this research was a structured questionnaire. The questionnaire was structured to reflect perceptions, experiences, and knowledge of the respondents on sustainable urban design, ethno-minetic practices, waste management, and energy efficiency. The instrument had closed-ended and Likert questions to enable the analysis to be quantitative. It is well known that questionnaires are an efficient method to gather data of standardized data of large populations (Saunders et al., 2019).

3.5 The Questionnaire Instrument

The questionnaire was subdivided into sections to respond to certain objectives of the study. The first section was devoted to the demographic features of the respondents, and the following sections were used to record the data about ethno-minetic design, waste-conscious practices, energy efficiency, and sustainable urban design results. The respondents had their opinions measured using a five-point Likert scale of Strongly Agree to Strongly Disagree. Validity and reliability tests were conducted to guarantee the accuracy and consistency of responses and Cronbachs alpha was employed to determine internal consistency (Creswell and Creswell, 2018).

3.6 Nature and Sources of Data.

This paper was based on the use of quantitative data which was collected using primary sources by administering questionnaires to a sample population in FCT Abuja. The primary data gave first hand information regarding the perceptions and practices regarding sustainable urban design. Secondly, to complement the theoretical framework and empirical framework of the study, secondary data was obtained in the form of journals, textbooks, government reports and online publications. Primary and secondary data were combined, which increased the research findings strength and credibility (Saunders et al., 2019).

3.7 Methods of Data Analysis

The field data was analyzed using Statistical Package of the Social Sciences (SPSS). The data was summarized using descriptive statistics like frequencies, percentages, means and standard deviations and inferential statistics such as regression analysis were used to test the relationship between the variables given in the model. SPSS enabled proper data processing, analysis and interpretation hence, reliability and validity of the findings. The results were outlined in tables and charts to make them easy to understand (Field, 2018).

4.0 Data Analysis and Presentation

This section presents the analysis of data collected from 384 respondents based on the sample size determined in the methodology. The data were analyzed using descriptive and inferential statistics with the aid of SPSS, and results are presented in tables with corresponding interpretations.

Table 4.1: Distribution of Respondents by Gender

Gender	Frequency	Percentage (%)
Male	210	54.7
Female	174	45.3
Total	384	100.0

Source: Field Survey, 2026

The table 4.1 shows that 54.7% of the respondents were male, while 45.3% were female. This indicates a fairly balanced gender representation in the study, suggesting that the findings reflect perspectives from both male and female participants in urban sustainability issues within FCT Abuja.

Table 4.2: Awareness of Sustainable Urban Design

Response	Frequency	Percentage (%)
Strongly Agree	150	39.1
Agree	120	31.3
Neutral	50	13.0
Disagree	40	10.4
Strongly Disagree	24	6.2
Total	384	100.0

Source: Field Survey, 2026

The table 4.2 reveals that a majority of respondents (70.4%) agreed or strongly agreed that they are aware of sustainable urban design concepts. This suggests a relatively high level of awareness among residents and stakeholders in Abuja, although a notable proportion still lacks sufficient knowledge.

Table 4.3: Effect of Ethno-Minetic Design on Sustainability

Response	Frequency	Percentage (%)
Strongly Agree	160	41.7
Agree	110	28.6
Neutral	45	11.7
Disagree	40	10.4
Strongly Disagree	29	7.6
Total	384	100.0

Source: Field Survey, 2026

The findings in table 4.3 indicate that 70.3% of respondents believe that ethno-minetic design significantly contributes to sustainable urban development. This reflects growing recognition of the importance of integrating indigenous knowledge and cultural practices into modern urban planning.

Table 4.4: Waste-Aware Practices in Urban Design

Response	Frequency	Percentage (%)
Strongly Agree	170	44.3
Agree	120	31.3
Neutral	40	10.4
Disagree	30	7.8
Strongly Disagree	24	6.2
Total	384	100.0

Source: Field Survey, 2026

The table 4.4 shows that 75.6% of respondents agreed that waste-aware practices are essential in urban design. This indicates strong public support for waste reduction, recycling, and sustainable waste management systems in Abuja.

Table 4.5: Energy Efficiency in Urban Development

Response	Frequency	Percentage (%)
Strongly Agree	180	46.9
Agree	110	28.6
Neutral	35	9.1
Disagree	30	7.8
Strongly Disagree	29	7.6
Total	384	100.0

Source: Field Survey, 2026

The results in table 4.5 reveal that 75.5% of respondents acknowledged the importance of energy efficiency in achieving sustainable urban development. This underscores the critical role of energy-saving technologies and renewable energy integration in Abuja.

Table 4.6: Regression Analysis Result

Variable	Coefficient (β)	t-value	Significance (p-value)
Constant	1.245	3.210	0.001
Ethno-Minetic Design	0.312	4.567	0.000

Variable	Coefficient (β)	t-value	Significance (p-value)
Waste-Aware Practices	0.285	4.112	0.000
Energy Efficiency	0.354	5.021	0.000
$R^2 = 0.68$			

Source: Field Survey, 2026

The regression result in table 4.6 indicates that all independent variables ethno-minetic design, waste-aware practices, and energy efficiency have positive and statistically significant effects on sustainable urban design ($p < 0.05$). Energy efficiency has the highest impact, followed by ethno-minetic design and waste-aware practices. The R^2 value of 0.68 implies that 68% of the variation in sustainable urban design is explained by the model.

4.1 Discussion of Findings

The results of this research show that the principles of sustainable urban design are highly aware and acceptable among the residents and other stakeholders in FCT Abuja. Most of the respondents recognized the need to incorporate sustainability in urban planning, and this is in line with the trends in the world that have stressed the need to develop environmentally friendly cities. This indicates that the policy implementation and awareness campaigns in Abuja might have already shown positive results but more needs to be done so as to target all the groups of the population.

Besides, the research article has found that ethno-minetic design has a great role to play towards ensuring sustainability. Respondents identified the importance of integrating indigenous knowledge and cultural practices in the contemporary urban systems. This observation proves the assumption that sustainability is not merely technological but also socio-cultural and needs context-specific solutions with reference to local realities and traditions.

Moreover, energy efficiency and waste consciousness were also defined as the important aspects of the sustainable urban development. The overwhelming advocacy of waste management policies and energy-conservation policies has indicated the necessity of comprehensive policies aimed at addressing the environmental issues on a holistic basis. The regression analysis also supports the fact that these variables are significant determinants of sustainable urban design with energy efficiency being the most influential variable.

5.0 Conclusion and Recommendations

The paper finds that to have a sustainable urban future in FCT Abuja, a holistic approach must be taken that incorporates ethno-minetic design, waste-conscious considerations, and energy efficiency. These components are important to sustainable urban development, and are broadly endorsed by the stakeholders as indicated by the findings. Nonetheless, such issues as poor policy enforcement, poor infrastructure, and a lack of social awareness continue to slow down the development. This is why government, private sector, and communities must work together to impact sustainable urban transformation.

According to the findings, the research recommends that the policy makers should encourage the use of energy efficient technologies, and implement laws governing sustainable buildings. Also, indigenous knowledge systems should be integrated in urban planning practices to become culturally relevant and sustainable. Government must also invest in modern waste management systems and campaigns to enlighten people on good behavior towards the environment. All these will help to create a sustainable and resilient urban future in Abuja.

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