

Plastic Sand Bricks as an Alternative Sustainable Building Material: Panacea to Affordable Housing for Low Income in Nigeria

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Abstract

Housing shortages are one of the key issues in Nigeria, low-income earners are disproportionately affected. The majority of the low cost housing designed for this population is out of reach because of high cost of construction materials, among other things. This study examined bricks made of plastic sand as a substitute for building materials. A questionnaire was used to gather data for the study utilizing both quantitative and qualitative methodologies. A total of 169 questionnaires were systematically disseminated to professionals in the built environment to acquire their opinions on the sustainability principles and the idea of plastic sand brick. The information gathered was then analyzed using tables and percentages. The study's findings indicate that the majority of respondents 40.5% and 16.0%, respectively strongly agree and agree that the material will address Nigeria's housing predicament, while only 8.0% and 5.5%, respectively, strongly disagree and disagree. 30% remain neutral. The study recommends, among other things, that Nigeria's government at all levels establish a domestic technology-driven economy, especially in the area of alternative building materials like plastic sand bricks.

Keywords: Housing shortage; plastics sand brick; low-cost housing; low-income; affordable housing.

1. Introduction

In developing nations like Nigeria, affordable housing is a major problem. Low-income earners, whose earnings are often low compared to the high cost of living, have particular housing issues. The Nigerian Federal Government has further confirmed this by introducing residences in the Federal Capital Territory (Damilola A 2023). The Federal Mortgage Bank of Nigeria has launched a number of projects to address the issue of cheap housing for the workforce, a move that the government acknowledged was necessary. Nevertheless, because these initiatives are unable to satisfy the public's demand for housing, their influence has been negligible or nonexistent.

In many parts of Nigeria, plastic sand bricks are still mostly unutilized despite their obvious advantages. According to the United Nations Environment Programme, Nigeria produces millions of tons of plastic garbage each year, of which very little is recycled or used for other purposes. Like many other countries in the world, the country is currently experiencing a significant housing shortfall; according to UN-Habitat (2019), 23% of people in sub-Saharan Africa live in sub-standard housing. Adoption and use of plastic sand bricks offer a dual benefit: they provide a workable solution to the pressing housing issue in addition to providing an environmentally friendly substitute for conventional building materials. Despite their potential, plastic sand brick acceptance has been slow, mostly because of a lack of knowledge, a restricted supply, and skepticism concerning their durability and strength.

As such, this study sets out to review plastic sand bricks as an alternative sustainable building material in Ilorin, Kwara State, Nigeria. The research intends to illuminate the factors that either encourage or impede the use of plastic sand bricks and examine how these materials could help mitigate the housing shortage and environmental concerns associated with traditional construction practices in the area.

A wide variety of materials that are obtained, produced, and used in an environmentally conscious manner are included in the category of sustainable building materials (Adu-Ampong and Kimbu, 2019). These materials are designed to preserve the structural integrity and performance of buildings while minimizing energy consumption, lowering carbon emissions, and conserving natural resources (Hossain et al., 2019; Nasir et al., 2019). These can include low-impact goods with negligible negative consequences on the environment and public health, as well as renewable resources, recycled or salvaged materials (Ali et al., 2021). The construction sector can play a vital role in attaining global sustainability targets and fostering a more ecologically conscious built environment by implementing sustainable building materials into their processes. (UN-Habitat, 2019).

Nigeria, as a rapidly urbanizing and densely populated nation, is experiencing significant growth in construction activities (Weisheng et al., 2021). However, the widespread use of conventional building materials, such as fired bricks and concrete blocks, has raised environmental concerns, including heightened energy consumption and carbon emissions (Olanipekun and Adedokun, 2020).

Additionally, the extraction of raw materials for these conventional materials contributes to environmental degradation and land depletion. Given this context, there is an urgent imperative to explore alternative sustainable building materials that align with Nigeria's unique requirements and challenges.

Plastic sand bricks have emerged as a potential alternative sustainable building material that addresses both environmental concerns and waste management issues (Mazen A. Al-Sinan, 2022). These bricks are made by mixing plastic waste, such as high-density polyethylene (HDPE), with sand and a binding agent to form solid blocks (Naraindas *et al.*, 2022). Plastic sand bricks have shown promising properties, including high compressive strength, thermal insulation, and resistance to water absorption. Moreover, the utilization of plastic waste in construction reduces its accumulation in landfills and contributes to the circular economy concept.

Nigeria, a country with a high population density and fast urbanization, is seeing a notable increase in construction activity. However, there are now environmental problems due to the extensive use of conventional building materials like fired bricks and concrete blocks, including increased energy consumption and carbon emissions (Olanipekun and Adelokun 2020). Additionally, the mining of raw materials for these conventional materials depletes land and worsens environmental conditions. In light of this, it is vital to investigate substitute sustainable building materials that meet Nigeria's particular needs and difficulties.

2. Literature Review

2.1 Sustainable Building Materials

Sustainable building materials are acknowledged in the context of construction and design for their effective resource conservation, low negative environmental effects, encouragement of energy efficiency, and attention to the health and well-being of occupants (Adu-Ampong and Kimbu 2019). Ali *et al.* (2021) have highlighted several attributes of them, such as their low embodied energy levels, renewability, recyclability, and eco-friendliness. Many Researchers were of the opinion that the goal of sustainable building materials is to decrease the carbon footprint that comes with construction operations and to lessen reliance on non-renewable resources (Amen, 2021; Amen *et al.*, 2023; Jacob, 2023; Moretti, 2023; Afara *et al.*, 2024; Amen *et al.*, 2024)

. Environmentally responsible practices are used at every stage of the life cycle of a sustainable resource, from extraction or harvesting to disposal or reuse. This all-encompassing method takes into account the environmental impact of every activity, giving rise to a full understanding of sustainability in relation to building materials.

In order to do this, the use of eco-friendly building materials is growing, including bamboo, rammed earth, straw bales, recycled steel, and bio-based composites. Innovative approaches, such as plastic sand bricks, have recently been investigated as a viable sustainable substitute. This is especially important considering the numerous environmental problems that plastic trash poses. The application of circular economy principles is a prominent issue in the field of sustainable development. A circular economy places emphasis on the 'reduce, reuse, and recycle' idea, which Furthermore, as demonstrated by the projects included in the GEF Small Grants Programme, sustainable building materials also support community-based initiatives and solutions, which boost the local economy. By redefining the connection between sustainable building methods and the environment, these materials have the potential to completely transform the construction sector. Therefore, encouraging their wider implementation in the industry and building a more resilient and sustainable built environment would require an awareness of their definition and characteristics.

is commonly known as the '3Rs.' These guidelines align with the qualities of sustainable construction materials and are essential to the economical and sustainable use of resources. One of the waste that can be recycle in to a sustainable building materials is Plastic waste which according to Awoyera and Adesina, (2020) is extremely threatening to the environment due to their high quantities generated which pose serious harm to both the environment and its inhabitants.

Sustainable projects including plastic management by recycling, reducing, and reusing plastics for new goods have been proposed, drawing on lessons learnt from the UNDP-run GEF Small Grants Programme. Thus, the idea of "plastic sand bricks" embodies the ideas of sustainable building materials and the circular economy. (UNDP, 2019) The ability of sustainable building materials to lessen the negative environmental effects of the construction sector emphasizes their significance overall. These materials support the overall sustainability of the built environment by drastically lowering energy use, carbon emissions, and waste production. Additionally, they support international sustainability objectives like the Sustainable Development Goals (SDGs) of the United Nations. (2019, UN-Habitat) Moreover, sustainable building materials also contribute to the local economy by promoting community-based actions and solutions, as illustrated by the cases included in the GEF Small Grants Programme. These materials can potentially revolutionize the construction industry by redefining the relationship between building practices and environmental sustainability. Therefore, understanding their definition and characteristics is crucial to promoting their wider adoption in the industry, thereby fostering a more sustainable and resilient built environment.

2.2 Importance of Sustainable Building Materials in Construction

Reducing energy use, cutting carbon emissions, and improving indoor environmental quality are just a few advantages of using sustainable construction materials (Hossain *et al.*, 2019; Nasir *et al.*, 2019). Sustainable materials

support the circular economy's tenets, encourage waste reduction, and preserve natural resources (Thomson et al., 2022; Lavy et al., 2020). In addition, the use of sustainable construction materials supports international sustainability objectives, including the Sustainable Development Goals (SDGs) of the United Nations (UN-Habitat, 2019).

2.3 Plastic Sand Bricks as an Alternative Sustainable Building Material

Plastic sand bricks, which provide an affordable and eco-friendly substitute for sustainable building materials, have gained attention as a possible solution to the world's housing crisis. This creative technique makes use of plastic waste, which is widely accessible and usually takes a very long time to decompose. Bricks made of plastic sand have the potential to be a viable substitute for conventional sustainable building materials. However, a number of obstacles have prevented them from being fully embraced. The notable disparity between the rates of plastic generation and recycling is one of the main obstacles. The production of plastic waste has been rising quickly, yet the recycling rate is still not very high. The main causes of this include the complexity of managing plastic trash, which includes a variety of plastic types and compositions, a lack of infrastructure for recycling, a lack of awareness, and insufficient regulations.

Due to the poor recycling rate, a sizable portion of plastic trash ends up in landfills or the environment instead of being recovered and turned into useful items like plastic sand bricks. It is imperative to make investments in efficient plastic waste management systems, upgrade recycling infrastructure, increase public awareness, and put supportive laws in place in order to address this problem and encourage the use of plastic sand bricks.

To promote the adoption and use of plastic sand bricks, cooperation between governmental entities, businesses, and the building industry is crucial. Stakeholders may cooperate to develop a sustainable and circular economy where plastic trash is effectively recycled and turned into useful building materials by emphasizing their durability, affordability, and environmental benefits.

2.4 Composition and Manufacturing Process of Plastic Sand Bricks

One potential solution to the increasing issue of plastic pollution is the use of plastic waste in the production of construction bricks. Because plastic products are used so widely in both home and industrial settings, plastic garbage is currently expanding at a rate never seen before. According to Chandrappa and Das (2021), plastic sand bricks are a new sustainable building material that tackles waste management and environmental concerns. In order to create solid bricks, plastic waste—such as high-density polyethylene (HDPE)—is combined with sand and a binding agent Petrella *et.al*, (2022). There are multiple steps in the production of plastic sand bricks.

The gathering and classification of plastic garbage is the initial stage. This garbage can originate from a number of places, such as used bottles, cans, and packing supplies as shown in figure 1 below. To make the mixing process easier, the waste plastic is then cleaned and shred into smaller bits.



Figure 1: Shredded plastic waste. *Source:* (Chandrappa and Das, 2021).

Sand is then combined with the shreds of plastic garbage. Sand provides strength and stability to the brick composition as it is the main aggregate. The ratio of plastic waste to sand can change based on the bricks' intended use. A binding agent is added to the mixture to help it stick together. In order to hold the plastic and sand particles together, common binding agents are cement or lime. The bricks' overall strength and durability are further enhanced by the binding agent. After the slurry is ready, brick moulds are filled with it and crushed to the

appropriate size and form. After that, the compacted bricks are cured to enable the binding agent to solidify and harden. The process of curing could entail air drying or the application of heat, depending on the specific requirements of the binding agent used.

According to Almeshal et al. (2020), plastic sand bricks have shown promise in terms of their high compressive strength, thermal insulation, and resistance to water absorption. These characteristics allow them to be used in a variety of construction applications and provide a substitute for traditional building materials.

In addition to addressing the environmental issues brought on by plastic trash, plastic sand bricks help conserve resources. The bricks support the idea of a circular economy and lessen the need for natural resources by using plastic trash as a raw material.

2.5 Affordable Housing in Nigeria

In order to address the nation's housing issues, the Nigerian government has continuously put policies and initiatives into action. But it has become clear that there is no evaluation process in place to evaluate how effective these policies are. Previous initiatives to offer cheap housing, especially for the low-income people, have not succeeded because of insufficient implementation and a lack of political will. Therefore, it is evident that these measures have not successfully addressed Nigeria's housing crisis despite the government's attempts (John, O.I et al 2023). But according to (Oni-Jimoh. et al. 2018), by carefully looking at every element of a strong housing policy, as described in the National Housing Policy 2012.

Nigeria can effectively address the difficulties of urbanization and make substantial progress in providing affordable housing. Many advantages will result from giving Nigerians access to enough inexpensive housing, including shelter for the populace and a significant boost to infrastructure development, which will help to meet some of the people's social demands. In addition, it will promote expansion in the building and housing industries, resulting in a multitude of employment prospects for labourers with and without skills. The construction industry is experiencing a spike in employment, which is expected to lead to increased productivity and ultimately promote economic development by raising the country's GDP.

It has been established, according to (Moore 2019), that between 17 and 20 million Nigerians do not have adequate housing. Furthermore, a plethora of studies has consistently demonstrated that the housing problem disproportionately impacts individuals with lower incomes. According to the findings, low-income earners in developing nations like Nigeria face an even more dire shortage and inadequate housing crisis. In addition, plastic sand bricks have a number of beneficial qualities that make them a great option for low-cost housing solutions. These bricks have a strong crushing strength, are lightweight, and are long-lasting. They are also excellent thermal conductors with little water absorption, which makes them effective at controlling temperature and lowering energy usage in buildings. Plastic sand bricks have the potential to completely transform the construction sector and it can offer a sustainable and cost-effective solution to the housing crisis

3.0 Materials and Methods

3.1 Study Area

Ilorin is the capital city of Kwara State in Nigeria. It has a rich history that dates back centuries and has undergone various transformations over time. It is located between longitude 4° 27' 38.05" E and 4° 39' 15 11" E, and latitude 8° 23' 05.57"N and 8" 34 09.39"N. It has a population of 908,490 as at 2011 making it the 13 largest city in Nigeria with a land area of 765 kilometre square and density of 1,188/kilometre square (Oladimeji, et. Al 2024) It is situated on the crossroads between the northern and southern parts of Nigeria, making it a strategic trading and cultural hub. The city has a diverse population, with a mix of ethnic groups, including Yoruba, Fulani, Nupe, and Hausa people. Ilorin is situated within the savannah climatic region, and is characterized by its geographical location, encompassing three distinct local government areas—namely, Ilorin East, Ilorin West, and Ilorin South, all of which are depicted in Figure 1.1.

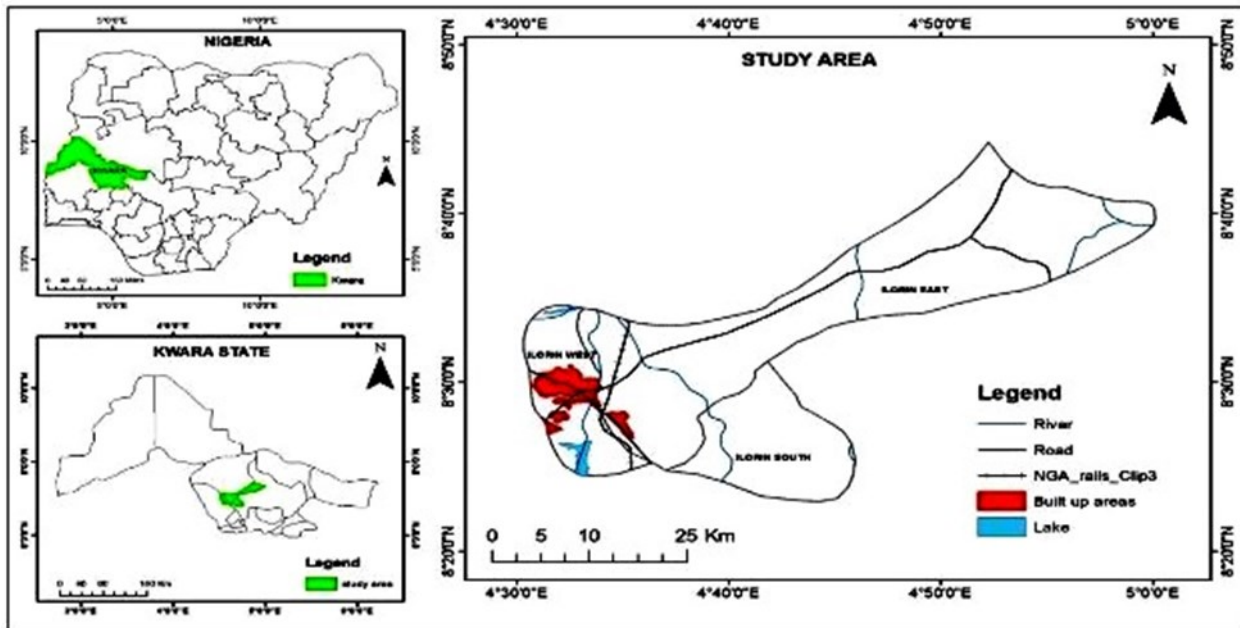


Figure 2: Maps showing the study area. GIS Laboratory, Department of Urban and Regional Planning University of Ilorin (2021).

Ilorin being the state capital of Kwara state has the highest percentage composition of plastic waste in the state. There are several plastic collection point in the city, one of the point is as shown in figure 2.



Figure 2: Plastic waste collection point in the study area. Source: Authors Field Survey 2024

3.2 Method of data collection

Sample population consists of specific group of individuals which are construction professionals within Ilorin, Kwara State, Nigeria. These professionals encompass a variety of roles, including architects, builders, engineers, and quantity surveyors. The selection criteria have been thoughtfully established, considering their involvement in the construction industry and geographical location within Ilorin.

In this study, a mixed-methods research design has been thoughtfully selected. This design seamlessly blends both quantitative and qualitative research approaches to provide a comprehensive understanding of the research problem.

This conceptualization serves as the foundation for the subsequent phases of the research, aiding in the precise identification and selection of participants for data collection. It enables the study to effectively target the key stakeholders whose perceptions and opinions will contribute to a comprehensive understanding of the adoption

and awareness of plastic sand bricks as an alternative sustainable building materials within the designated study area.

sample frame is all the 307 Built environment professionals registered in Kwara state under their respective professional bodies. This includes 53 Architects, 38 Builders, 66 Quantity surveyor and 150 Engineers as shown in Table 1. below. Using the Krejcie and Morgan (1970) table for determining sample size of known population, a sample size of 169 professionals out of the 307 registered professionals was determined. This sample size (169) was considered sufficient as similar researchers like work of Ofori ., (2015) and Nduka & Ogunsanmi, (2015) respectively determined sample sizes of 100 and 150.

Table 1: Sample of Construction Professional Bodies in Ilorin, Nigeria. Source: Authors Compilation, 2024.

S/N	Professional bodies	Total Number of registered Professionals	Sample size
1.	NIA - Nigerian Institute of Architects.	53	29
2.	NIQS – Nigerian Institute of Quantity Surveyors.	66	36
3.	NSE – Nigerian Society of Engineers.	150	83
4.	NIOB – Nigerian Institute of Builders.	38	21
	Total	307	169

3.2 Method of Data Analysis

Data obtained from the Professionals bodies in built environment were critically analyzed using descriptive statistics such as frequency counts and percentages to find out the level of awareness of plastic sand bricks as an alternative sustainable building materials and as a solution to affordable housing in Ilorin, Nigeria. This is done by attaching ratings of aware and not aware to rating of level of awareness and strongly Agree, agree, indifferent disagree and strongly disagree to sand brick as alternative sustainable building materials and a solution to affordable housing in Ilorin Nigeria.

4. Result and Discussion

4.1 Awareness of Plastic Sand Brick amongst Respondents

Table 2 presented below provides insights into the level of awareness of plastic sand bricks as alternative sustainable building materials among building professionals. The data clearly indicates that a significant majority, more than two thirds (77.5%) of the respondents, were well aware of plastic sand bricks before participating in this survey while 22.5% of the professionals in built environment in the study are not aware of plastic sand bricks. This suggests that there is a growing awareness of these innovative building materials within the construction industry in the study area.

Table 2: Building Professionals awareness of Plastic Sand Bricks as an Alternative building Materials. Source: Author's Field Study, (2024)

S/N	Plastic Sand bricks as building materials	Frequency (N)	Percentage (%)
1.	Aware	131	77.5
2.	Not aware	38	22.5
Total		169	100

4.2 Sustainability Aspect of Plastic Sand Bricks

Based on the discussion above, the dependent variables were in line with global sustainability goals such as the United Nations Sustainable Development Goals (SDGs). (UN-Habitat, 2019) the reducing energy consumption, carbon emissions, contribution to economic growth and waste generation. The variables on ranking scale of strongly Agree, agree, indifferent, disagree and strongly disagree to seek information from professionals in built environment on their perception of plastic sand bricks as an alternative building materials. This as shown in table 3 below.

Energy Consumption

The study shows that highest percentage of professionals in built environment in the study area strongly agree (62.5%) and agree (28.0%) that plastic sand bricks will reduce energy consumption in building compared to

conventional building materials while, 5.0% of the respondents were indifferent and 4.5% disagree with that opinion as shown in Table 3.2. The result of the finding also corroborates the findings of Hossain et al., 2019; Nasir et al., 2019; that emergency of plastic sand bricks as alternative building materials only environmentally friendly but also cost-effective in terms of energy consumption of building.

Carbon Emissions

Based on carbon emission reduction, the result revealed that the highest percentage 34.5% and 27.5% of built environment professionals strongly agree and agree that plastic sand bricks tend to reduce the carbon emissions due to the fact that instead of burning the plastic, it will be recycled to bricks. On the other hand, 25.0% of the respondent strongly disagree with the that plastic sand bricks will reduce carbon emissions while, 2.5%, 10.5% of respondent were indifferent and disagree with the opinion that the materials can help in reducing carbon emissions respectively. fact

Waste reduction

As regard waste reduction, the finding shows that majority of the respondent 62.5%, 18.0% strongly agree and agree that recycling of plastic into plastic sand bricks will reduce plastic waste and assist in waste management, while 7.5%, 8.5% of the respondents in the study area disagree and strongly disagree respectively. The result also corroborate Thomson et al., 2022 study that conversion of plastic waste to plastic sand brick will reduce waste in environment and will help in waste management.

Contribution to Economic Growth

The result revealed that 38.5%, 20.0% of the professionals in built environment in the study area agree and strongly agree respectively that adoption of plastic sand bricks as an alternative building material will contribute largely to economic growth of Nigeria. This is thereby encapsulating the principles of circular economy and sustainable building materials. (UNDP, 2019). While 13.5%, 12.5% of the respondents strongly disagree and disagree reespectively with the view that plastic sand brick will contribute to economic growth of Nigeria.

Solution to Housing Shortage

Finding from the study show that highest percentage of 40.5% of the respondent strongly agree that adoption of plastic sand bricks is a solution to housing shortage in Nigeria while, 16.0% agree. The result also revealed that 8.0%, 5.5% strongly disagree and disagree respectively that adoption of plastic sand bricks is a solution to the problem. Meanwhile, about 30.0% of the professionals in built environment in the study area were indifferent in their opinion.

Table 3: Perception of Professionals on Sustainable Benefits of Plastic Sand Bricks

S/N	Variables	Percentage Distributions					Total
		Strongly agree	Agree	Indifferent	Disagree	Strongly disagree	
1.	energy consumption reduction	62.5%	28.0%	5.0%	4.5%	0	100%
2.	carbon emissions reduction	34.5%	27.5%	2.5%	10.5%	25.0%	100%
3.	Waste reduction	65.0%	18.0%	1.0%	7.5%	8.5%	100%
4.	Contribute to economic growth	20.0%	38.5%	15.5%	12.5%	13.5%	100%
5.	Solution to housing shortage	40.5%	16.0%	30.0%	5.5%	8.0%	100%

5. Conclusions and Recommendation

5.1 Conclusions

This study has shown plastic sand bricks as an alternative sustainable building materials that offers several benefits which includes reduced energy consumption, minimized carbon emissions, improved indoor environmental quality, contribute to the conservation of natural resources, promote waste reduction, support the principles of a circular economy and a solution to housing shortages in Nigeria.

Furthermore, the research has identified key sources of plastic waste in the study area, emphasizing the need for targeted waste management strategies. These findings collectively provide a foundation for informed decision-making and policy development aimed at promoting the adoption of plastic sand bricks as a sustainable building solution. Also, this study not only contributes to the existing body of knowledge but also serves as a catalyst for the broader implementation of plastic sand bricks in construction projects, fostering environmental sustainability and economic viability within the Nigerian construction landscape.

5.2 Recommendations

Based on the insightful findings of this study, several recommendations emerge, aimed at harnessing the potential of plastic sand bricks for sustainable construction practices in Ilorin Metropolis:

Needs for technical knowledge among respondents, there is a need for targeted training and workshops by governments at all levels to enhance understanding of plastic sand bricks' specifications, advantages, and applications. The government should put more effort and be more intentional about developing a home-grown technology driven economy in Nigeria particularly in alternative building materials like plastic sand bricks. Also, intensify awareness campaigns regarding the environmental benefits of plastic sand bricks to engage both professionals and the broader public.

Again, there is need for more collaboration among professionals, researchers, and manufacturers to develop standardized guidelines and best practices for the use of plastic sand bricks in construction. Encouragement of the integration of plastic sand bricks into sustainable building practices by offering incentives or subsidies for projects employing this innovative material.

Plastic sand bricks is a potential means of converting our wastes to wealth, it will go along way in creating jobs for people ranging from plastic waste collecting to the level of skilled engineers and technicians and with advantage of making our environment a cleaner place to live.

Housing shortages is prevalent in Nigeria due to the explosion of population and cost of construction escalation as a result of economic meltdown, plastic sand bricks have been identified as an alternative to traditional building materials. Since building materials also constitute a huge percentage in the cost of construction, converting plastic

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Conflict of Interests

The authors declare no conflict of interest.

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