

Sustainability and Lifecycle Performance of Residential Housing Developments in Gwarimpa and Apo Districts, Abuja, Nigeria

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DOI: <https://doi.org/10.51244/IJRSI.2026.1309000224>

Received: 03 October 2026; Accepted: 08 October 2026; Published: 21 October 2026

ABSTRACT

Sustainable housing is increasingly promoted as a strategy for improving environmental performance and reducing long-term housing costs; however, evidence on its economic viability in developing-country contexts remains limited. This study assessed the economic performance of sustainable housing developments in Gwarimpa and Apo Districts of Abuja, Nigeria. Data were obtained through household surveys, developer interviews, real estate agent consultations, property records, and field observations. The analysis examined construction costs, operational expenses, maintenance requirements, property value appreciation, lifecycle costs, and returns on sustainability investments. The findings revealed that sustainable housing attracted a 14.7% higher initial capital cost than conventional housing, with an average construction cost of ₦44.5 million compared to ₦38.8 million. However, sustainable housing achieved a 38.6% reduction in annual operational costs, a 24.4% reduction in maintenance costs, and a 30.8% decrease in repair frequency. Properties with sustainability features recorded a higher annual appreciation rate (10.8%) than conventional properties (7.2%) and demonstrated lower 20-year lifecycle costs (₦56.2 million versus ₦57.5 million). Sustainability investments yielded an average payback period of 4.9 years and a 20-year return on investment of 424.0%. The study concludes that despite higher upfront costs, sustainable housing provides substantial long-term economic benefits and represents a financially viable housing development approach in Abuja.

Keywords: Sustainable housing; Economic performance; Lifecycle cost; Return on investment; Abuja.

INTRODUCTION

Housing remains one of the most important components of urban development, contributing significantly to social well-being, economic growth, and environmental sustainability. However, rapid urbanization, increasing energy demand, rising construction costs, and environmental degradation have intensified concerns regarding the long-term affordability and sustainability of residential developments, particularly in developing countries such as Nigeria. In rapidly growing urban centres, conventional housing development is often associated with high resource consumption, increased operational expenses, and significant environmental impacts, creating a need for more sustainable approaches to residential construction and management (Kibert, 2016; World Green Building Council, 2019).

Sustainable housing has emerged as a viable strategy for addressing these challenges through the incorporation of energy-efficient technologies, water conservation measures, environmentally friendly materials, and resource-efficient building practices. Beyond its environmental benefits, sustainable housing is increasingly recognized for its potential to reduce operational costs, improve building durability, enhance property values, and provide long-term economic returns for homeowners and developers (Zuo & Zhao, 2014; Berardi, 2013). Consequently, governments, policymakers, and real estate stakeholders worldwide are promoting the adoption of sustainable building practices as part of broader sustainable development initiatives.

Despite growing interest in sustainable housing, empirical evidence regarding its economic performance in developing countries remains limited. Existing studies have largely focused on the environmental and technical aspects of sustainable buildings, while relatively few have comprehensively evaluated their economic

implications, particularly within the Nigerian context. Furthermore, available studies often examine individual components such as energy savings or construction costs without integrating construction expenditure, operational costs, maintenance requirements, lifecycle costs, property appreciation, and investment returns into a single analytical framework. This limitation creates uncertainty among property developers, investors, and prospective homeowners regarding the overall financial viability of sustainable housing developments.

In Abuja, one of Nigeria's fastest-growing urban centres, housing demand continues to increase alongside concerns about affordability, energy consumption, and infrastructure sustainability. Although sustainable housing features are gradually being introduced into residential developments in districts such as Gwarimpa and Apo, limited empirical evidence exists on their actual economic benefits and long-term financial performance. Consequently, a significant research gap exists regarding whether the additional capital investment required for sustainable housing translates into measurable economic returns over the building lifecycle.

Against this background, this study evaluates the economic performance of sustainable housing developments in Gwarimpa and Apo Districts of Abuja, Nigeria, by examining construction costs, operational expenditures, maintenance requirements, lifecycle costs, property value appreciation, and returns on sustainability investments. By providing empirical evidence on the short-term and long-term economic implications of sustainable housing adoption, the study contributes to the growing body of knowledge on sustainable urban development and provides useful insights for policymakers, developers, investors, and homeowners seeking economically viable housing solutions.

MATERIALS AND METHODS

Research Design

This study adopted a **mixed-methods cross-sectional survey design**, integrating quantitative and qualitative approaches to assess the economic performance of sustainable housing developments in Gwarimpa Estate and Apo Resettlement, Abuja. The quantitative component focused on measurable economic indicators such as construction costs, operational expenses, maintenance requirements, lifecycle costs, property appreciation, and investment returns. The qualitative component provided contextual insights into sustainability practices, implementation challenges, and stakeholder perceptions regarding sustainable housing development. The combination of both approaches enabled triangulation of findings and enhanced the reliability and comprehensiveness of the study.

Study Area

The study was conducted in Gwarimpa Estate and Apo Resettlement, located within the Abuja Municipal Area Council (AMAC), Federal Capital Territory (FCT), Nigeria. Abuja lies between latitudes 8°25'N and 9°20'N and longitudes 6°45'E and 7°39'E. Gwarimpa Estate is one of the largest planned residential estates in West Africa, characterized by diverse housing typologies and extensive urban infrastructure, while Apo Resettlement represents a rapidly developing residential district established for communities displaced by urban expansion. The two locations were selected because they exhibit varying housing forms, socio-economic characteristics, and levels of adoption of sustainability features.

Population of the Study

The target population consisted of households residing in Gwarimpa Estate and Apo Resettlement as well as professionals involved in housing development and management. Household respondents provided information on housing characteristics, construction costs, utility expenditures, maintenance practices, and sustainability features. The qualitative population comprised officials from the Federal Capital Development Authority (FCDA), Abuja Municipal Area Council (AMAC), housing development agencies, developers, planners, architects, engineers, builders, quantity surveyors, and real estate professionals.

A total of 300 valid household responses were used for quantitative analysis, while 30 key informants participated in qualitative interviews.

Sample Size and Sampling Techniques

The sample size for the household survey was determined using the Taro Yamane formula for finite populations:

$$n = \frac{N}{1 + N(e)^2}$$

where:

- n = required sample size
- N = population size
- e = level of precision (0.05)

Using an estimated housing population of 15,000 housing units, a minimum sample size of 390 households was obtained. However, 300 properly completed questionnaires were retrieved and used for analysis.

A combination of stratified random, purposive, and snowball sampling techniques was employed. Stratified random sampling was used for household selection across different housing typologies. Purposive sampling was used to identify key stakeholders with relevant expertise, while snowball sampling facilitated the identification of additional professionals for the interview component until data saturation was achieved.

Sources of Data

Both primary and secondary data sources were utilized.

Primary data were obtained through:

- Structured questionnaire surveys administered to households;
- Key informant interviews with housing professionals and regulatory agencies;
- Systematic field observations using structured observation checklists.

Secondary data were obtained from policy documents, housing records, planning reports, academic literature, building plans, property records, and sustainability frameworks, including the National Building Code, Climate Change Act 2021, Abuja Master Plan, UN-Habitat housing indicators, and IFC EDGE sustainability standards.

Data Collection Methods

Questionnaire Survey

Structured questionnaires were administered to household respondents in Gwarinpa and Apo. The questionnaire collected information on housing typology, construction costs, utility expenditures, maintenance costs, property value trends, adoption of sustainability features, and occupant perceptions of housing performance.

Key Informant Interviews

Semi-structured interviews were conducted with 30 selected stakeholders, including developers, architects, engineers, planners, regulatory officials, and housing administrators. The interviews explored sustainable housing practices, economic implications of sustainability features, implementation barriers, regulatory challenges, and long-term housing performance.

Field Observation

Systematic field observations were conducted on selected housing units using a structured checklist. The checklist assessed building condition, energy-efficiency features, water-conservation systems, building envelope quality, passive design elements, maintenance conditions, and other sustainability indicators. Photographic records were also taken to support observational findings.

Variables and Measures

The study assessed economic sustainability using the following indicators:

- Initial construction cost;
- Operational expenditure (electricity, water, and waste management);
- Annual maintenance and repair costs;
- Property appreciation rate;
- Lifecycle cost (LCC);
- Net present value (NPV);
- Return on investment (ROI);
- Payback period of sustainability features.

Housing sustainability features assessed included solar photovoltaic systems, solar water heaters, rainwater harvesting systems, energy-efficient windows, roof insulation, LED lighting, low-flow water fixtures, and greywater recycling systems.

Data Analysis

Quantitative data were analysed using descriptive and comparative statistical techniques, including frequencies, percentages, means, weighted averages, and cost-benefit comparisons. Economic evaluation involved the calculation of lifecycle cost (LCC), net present value (NPV), payback period, return on investment (ROI), and property appreciation rates. Comparative analyses were performed between sustainable and conventional housing developments.

Qualitative interview data were transcribed, coded, and analysed thematically to identify recurring patterns and explanations regarding sustainable housing performance. Findings from questionnaires, interviews, and field observations were triangulated to provide a comprehensive assessment of the economic performance of sustainable housing developments in Gwarimpa and Apo, Abuja.

RESULTS

Construction Costs

Initial capital expenditure varied substantially among housing typologies. The overall weighted mean was ₦40.5 million, ranging from ₦8.5 million for traditional housing to ₦71.5 million for duplexes. Gwarimpa recorded a higher weighted mean capital cost (₦42.8 million) than Apo (₦38.2 million). Sustainable materials had an average cost premium of 18.5%, although some alternatives, including compressed earth blocks, recycled metal roofing, and certified timber, were less expensive than their conventional counterparts. Cost overruns were reported in 68–72% of projects, with material price fluctuations (77.5%) and labour cost increases (60.0%) being the most frequently reported contributors.

Table 1. Initial capital expenditure by housing typology

Housing typology	Gwarimpa (₦)	Apo (₦)	Overall mean (₦)	Range (₦)
Detached	55,250,000		55,250,000	35,000,000–85,000,000
Semi-detached	42,500,000	38,000,000	40,250,000	28,000,000–60,000,000

Terraced	35,000,000	30,500,000	32,750,000	22,000,000–48,000,000
Apartment	25,500,000	22,000,000	23,750,000	15,000,000–38,000,000
Duplex	75,000,000	68,000,000	71,500,000	55,000,000–95,000,000
Mixed-use	52,000,000	48,000,000	50,000,000	40,000,000–65,000,000
Traditional	—	8,500,000	8,500,000	6,000,000–12,000,000
Weighted average	42,800,000	38,200,000	40,500,000	—

Source: Developer Interviews and Field Survey, 2026.

Operational Expenses

Mean monthly electricity expenditure was ₦42,100, representing 17.0% of household income, while mean monthly water expenditure was ₦12,350 (4.7%). Energy-efficiency features were associated with 37.0% lower electricity expenditure, while rainwater harvesting was associated with 45.1% lower water expenditure. Mean monthly waste-management expenditure was ₦3,850, decreasing from ₦4,200 to ₦2,800 where waste segregation was practiced. Across the assessed green features, the mean payback period was 4.9years and mean adoption rate was 12.1%.

Table 2. Operational expenses and potential savings

Indicator	Overall cost (₦)	With sustainability feature (₦)	Without feature (₦)	Savings (%)
Monthly electricity	42,100	30,200	47,900	37.0
Monthly water	12,350	7,800	14,200	45.1
Monthly waste management	3,850	2,800	4,200	33.3
Annual operational cost*	429,600	—	—	—

Annual operational cost refers to the combined energy, water and waste expenditure reported in the comparative analysis.

Source: Field Survey, 2026.

Maintenance Requirements

The mean repair frequency was 2.4 incidents per household per year, with a mean repair cost of ₦62,500 per incident. Major repairs were reported for 42.7% of households during the previous two years, while 61.7% reported minor repairs during the previous six months. Only 8.3% of households maintained formal documented maintenance plans.

Table 3. Repair frequency and cost by housing typology

Housing typology	Major repairs (%)	Minor repairs (%)	Repairs/year	Mean repair cost (₦)
Detached	46.8	66.1	2.8	85,000
Semi-detached	44.6	63.5	2.5	70,000

Terraced	40.8	59.2	2.2	55,000
Apartment	36.4	56.1	1.8	40,000
Duplex	53.8	69.2	3.0	95,000
Mixed-use	57.1	71.4	3.2	80,000
Traditional	0.0	50.0	1.0	15,000
Overall	42.7	61.7	2.4	62,500

Source: Field Survey, 2026.

Long-Term Property Value and Lifecycle Cost

Mean annual property appreciation was 8.4%. Properties with sustainability features recorded a mean annual appreciation of 10.8%, compared with 7.2% for properties without such features, representing a 3.6-percentage-point difference. After 10 years, mean property value retention was 128.6%.

Sustainable construction produced lower 20-year lifecycle costs for semi-detached, terraced and apartment housing, with savings of ₦720,000, ₦800,000 and ₦880,000, respectively. Detached and duplex housing recorded slightly higher lifecycle costs under sustainable construction.

Table 4. Long-term value and lifecycle cost comparison

Indicator	Sustainable	Conventional	Difference
Annual appreciation	10.8%	7.2%	+3.6 percentage points
10-year value retention	138.5%	124.2%	+14.3 percentage points
Mean resale premium	12.5%	—	+12.5%
20-year lifecycle cost	₦56.2 million	₦57.5 million	–₦1.3 million
Annualized lifecycle cost	₦2.81 million	₦2.875 million	–₦65,000
10-year NPV	₦2.15 million	—	—
20-year NPV	₦4.80 million	—	—

Source: Real Estate Agent Interviews, Property Records, and Author's Computation based on Field Data, 2026.

Economic Returns on Sustainability Features

The assessed sustainability features had an average initial investment of ₦459,125, annual savings of ₦88,688, a 4.9-year payback period, 162.0% 10-year ROI, and 424.0% 20-year ROI. LED lighting had the shortest payback period (1.6 years) and highest 20-year ROI (1,185.7%), whereas greywater recycling had the longest payback period (8.0 years).

Table 5. Return on investment of sustainability features

Sustainability feature	Investment (₦)	Annual savings (₦)	Payback (years)	20-year ROI (%)
Solar PV, 3 kW	1,850,000	336,000	5.5	263.2

Solar water heater	450,000	140,000	3.2	522.2
Rainwater harvesting	380,000	63,000	6.0	231.6
Energy-efficient windows	420,000	56,000	7.5	166.7
Roof insulation	85,000	21,250	4.0	400.0
LED lighting	28,000	18,000	1.6	1,185.7
Low-flow fixtures	110,000	31,500	3.5	472.7
Greywater recycling	350,000	43,750	8.0	150.0
Average	459,125	88,688	4.9	424.0

Source: Author's Computation based on Field Data, 2026.

Comparative Economic Performance

Housing with sustainability features had a 14.7% higher mean initial capital cost than housing without such features (₦44.5 million versus ₦38.8 million). However, annual operational costs were 38.6% lower, maintenance costs were 24.4% lower, and repair frequency was 30.8% lower. Sustainable housing also recorded a 3.6-percentage-point higher annual appreciation rate and 2.3% lower 20-year lifecycle costs.

The economic performance increased with the number of sustainability features. Housing with five or more features recorded a 22.5% initial cost premium, 48.2% operational cost reduction, 4.2-year payback period, and 145.8% 10-year ROI.

Table 6. Comparative economic performance of housing with and without sustainability features

Economic metric	With sustainability (n=85)	Without sustainability (n=215)	Difference (%)
Initial capital cost	₦44.5 million	₦38.8 million	+14.7
Annual operational cost	₦429,600	₦699,600	-38.6
Annual maintenance cost	₦155,000	₦205,000	-24.4
Repairs per year	1.8	2.6	-30.8
Total annual ownership cost	₦584,600	₦904,600	-35.4
Annual appreciation	10.8%	7.2%	+50.0
10-year value retention	138.5%	124.2%	+11.5
20-year lifecycle cost	₦56.2 million	₦57.5 million	-2.3
10-year NPV	₦2.15 million	—	—
20-year NPV	₦4.80 million	—	—

Source: Author's Computation based on Field Data, 2026.

Table 7. Economic performance by number of sustainability features

Sustainability features	n	Initial cost premium (%)	Operational cost reduction (%)	Payback (years)	10-year ROI (%)	Rating
0	215	—	—	—	—	Poor
1–2	42	5.2	18.5	6.5	42.5	Fair
3–4	28	12.8	32.5	5.2	85.2	Good
5+	15	22.5	48.2	4.2	145.8	Excellent
Overall	300	14.7	38.6	4.9	92.5	Good

Source: Author's Computation based on Field Data, 2026.

DISCUSSION

Construction Costs of Sustainable Housing

The findings indicate that sustainable housing developments in Gwarimpa and Apo require higher initial capital investments than conventional housing. The overall weighted mean construction cost of ₦40.5 million, with sustainable housing exhibiting a 14.7% to 18.5% cost premium, supports the widely accepted view that green building adoption often involves higher upfront expenditures due to investments in energy-efficient technologies, sustainable materials, and environmental design features. This finding aligns with Kats (2018), who reported that green buildings typically incur additional initial costs ranging from 2% to 20%, depending on the level of sustainability certification and technology integration.

The substantially higher costs observed for duplexes and detached houses compared with apartments and terraced housing may reflect the greater floor area and increased incorporation of sustainability features in higher-income residential developments. Similar observations were reported by Darko et al. (2017), who noted that larger residential projects often demonstrate higher green-building investment requirements due to more sophisticated environmental systems.

However, the study also revealed that some sustainable materials, including compressed earth blocks, recycled roofing materials, and certified timber, were less expensive than conventional alternatives. This finding supports the argument of Kibert (2016) that sustainable construction does not necessarily imply higher costs when locally sourced materials and resource-efficient alternatives are utilized. The prevalence of cost overruns resulting from material price fluctuations and labour cost increases further reflects the unstable economic conditions affecting the Nigerian construction industry, as previously observed by Olatunji et al. (2020).

Operational Cost Savings and Resource Efficiency

One of the most significant findings of the study is the substantial reduction in operational expenses associated with sustainability features. Households adopting energy-efficiency measures recorded 37.0% lower electricity costs, while rainwater harvesting systems reduced water expenditure by 45.1%. These findings support previous studies demonstrating that sustainable housing improves long-term affordability through reduced resource consumption (World Green Building Council, 2019).

The observed reduction in waste-management expenses among households practicing waste segregation further confirms the economic benefits of sustainable household management practices. According to Zuo and Zhao (2014), sustainability measures contribute not only to environmental performance but also to operational cost efficiency throughout a building's life cycle.

The average payback period of 4.9 years found in this study is particularly encouraging and falls within the range reported by García-Navarro et al. (2014), who found that most residential sustainability investments recover their costs within 3 to 8 years through utility savings. Thus, despite the higher initial investment requirement, sustainable housing appears financially advantageous over the medium and long term.

Maintenance Performance of Sustainable Housing

The mean repair frequency of 2.4 incidents annually and average repair cost of ₦62,500 indicate that maintenance remains a significant component of housing ownership costs. Nevertheless, the comparative analysis showed that sustainable housing experienced lower annual maintenance costs and lower repair frequencies than conventional housing.

These findings corroborate the conclusions of Ding (2008), who argued that sustainable buildings often employ durable materials and higher-quality construction practices, resulting in lower maintenance requirements over time. The lower repair frequencies observed in housing with sustainability features may be attributable to improved construction quality, enhanced building envelope performance, and better moisture-control mechanisms.

The finding that only 8.3% of households maintained formal maintenance plans suggests a weakness in building management culture. Similar concerns have been reported in developing countries where preventive maintenance practices remain poorly established despite their potential to reduce long-term building deterioration (Seeley, 2019).

Property Appreciation and Lifecycle Economic Performance

The results demonstrate that sustainable housing generates superior long-term economic outcomes. Sustainable properties recorded an annual appreciation rate of 10.8% compared with 7.2% for conventional housing, representing a significant market advantage. This finding agrees with research by Fuerst and McAllister (2011), who found that environmentally efficient properties tend to command higher market values and stronger appreciation rates than conventional buildings.

The higher value-retention rate and resale premium observed in sustainable housing further suggest increasing market recognition of green-building benefits. The growing preference for resource-efficient housing may explain this premium, as buyers increasingly consider utility savings and environmental performance during property acquisition decisions.

A particularly important result is the lower 20-year lifecycle cost of sustainable housing. Although sustainable housing incurred higher construction costs initially, total lifecycle expenditure was lower than that of conventional housing by approximately ₦1.3 million. This finding supports lifecycle cost theory, which emphasizes that building evaluation should extend beyond initial construction expenditure to include operational and maintenance costs throughout the building's lifespan (Ashworth, 2015).

Economic Returns from Sustainability Features

The return-on-investment analysis reveals strong economic justification for adopting sustainability technologies. The average 20-year ROI of 424% indicates that every naira invested in sustainability measures yields substantial financial returns over the building lifecycle.

Among the features assessed, LED lighting achieved the highest ROI (1,185.7%) and shortest payback period (1.6 years). This result aligns with findings by the International Energy Agency (IEA, 2023), which identifies LED technology as one of the most cost-effective energy-efficiency interventions worldwide. Similarly, solar water heaters and low-flow fixtures demonstrated favourable economic performance, confirming earlier evidence of their effectiveness in reducing household utility expenditure.

Although greywater recycling and energy-efficient windows exhibited longer payback periods, they still generated positive long-term financial returns. This outcome supports the argument that sustainability investments should be evaluated based on lifecycle benefits rather than solely on short-term economic gains (Cabeza et al., 2014).

Comparative Economic Performance of Sustainable and Conventional Housing

The comparative assessment clearly indicates that sustainable housing performs better economically over the long term despite higher initial costs. While sustainable housing required a 14.7% higher capital investment, annual operational costs were reduced by 38.6%, maintenance costs by 24.4%, and repair frequency by 30.8%.

These findings are consistent with the Triple Bottom Line framework, which argues that sustainability initiatives can simultaneously deliver environmental, social, and economic benefits (Elkington, 1997). The data suggest that resource-efficiency measures generate measurable financial benefits for homeowners while also reducing environmental impacts.

Furthermore, the analysis shows that economic performance improves with the number of sustainability features incorporated into a building. Houses with five or more sustainability features achieved the highest operational savings, shortest payback periods, and greatest return on investment. Similar trends have been reported by Berardi (2013), who observed that greater integration of sustainability measures generally produces cumulative economic benefits through enhanced energy efficiency and reduced maintenance requirements.

Overall, the findings demonstrate that sustainable housing in Abuja represents a financially viable investment strategy. Although higher initial costs may discourage adoption, the significant reductions in operating and maintenance expenses, combined with improved property appreciation and lifecycle savings, indicate that sustainability features provide considerable economic advantages over the long term.

CONCLUSION

This study evaluated the economic performance of sustainable housing developments in Gwarimpa and Apo Districts of Abuja by assessing construction costs, operational expenses, maintenance requirements, lifecycle costs, property value appreciation, and returns on sustainability investments. The findings revealed that sustainable housing requires a higher initial capital investment, with an average cost premium of approximately 14.7% to 18.5% compared to conventional housing. Despite this higher upfront expenditure, sustainable housing demonstrated substantial long-term economic advantages.

The results indicated that sustainability features significantly reduced operational costs through lower energy, water, and waste-management expenditures. Households incorporating sustainable technologies recorded notable savings, resulting in shorter payback periods and attractive long-term financial returns. Maintenance performance also favoured sustainable housing, which experienced lower annual maintenance costs and fewer repair incidents than conventional housing, suggesting greater durability and improved building performance.

Furthermore, sustainable housing exhibited superior long-term market performance, characterized by higher rates of property appreciation, greater value retention, and resale premiums. Lifecycle cost analysis showed that the cumulative economic benefits derived from reduced operating and maintenance costs outweighed the higher initial investment, resulting in lower overall lifecycle costs over a 20-year period.

The study also established that economic benefits increased with the number of sustainability features adopted. Houses incorporating multiple sustainability measures achieved the highest operational savings, shortest payback periods, and strongest investment returns. Among the technologies assessed, LED lighting, solar water heating, and low-flow water fixtures provided particularly favourable economic outcomes.

Overall, the findings demonstrate that sustainable housing is economically viable and financially beneficial in Abuja's housing market. While initial construction costs may present a barrier to adoption, the long-term reductions in ownership costs, enhanced property values, and significant returns on investment justify the

integration of sustainability features in residential developments. Therefore, increased promotion of sustainable building technologies through policy incentives, financing mechanisms, and public awareness initiatives could enhance their adoption and contribute to more affordable, resilient, and environmentally responsible urban housing development in Nigeria.

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