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Challenges and Opportunities for Large-Scale Adoption of Interlocking Stabilized Soil Block Technology in Urban Housing Development

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ABSTRACT

Rapid urbanization and the escalating demand for affordable urban housing have intensified the search for sustainable, cost-effective building materials. Interlocking Stabilized Soil Block (ISSB) technology offers a promising, low-carbon alternative to conventional fired bricks and concrete blocks by utilizing locally sourced soil compressed with a minimal stabilizing agent (such as cement or lime). However, despite its proven economic and environmental advantages, widespread adoption in urban housing developments remains limited. This paper investigates the critical challenges and emerging opportunities surrounding the large-scale integration of ISSB technology in urban contexts. Through a mixed-methods approach—combining a comprehensive literature review, comparative cost-benefit analyses, and stakeholder interviews within the construction sector—the study identifies major barriers to adoption. These include rigid or outdated building regulatory frameworks, deeply entrenched negative public perceptions associating soil-based materials with low-income or temporary housing, and supply chain inconsistencies regarding block quality and production scale. Conversely, the research highlights significant opportunities, particularly driven by shifting green building policies, rising carbon tax pressures, and the urgent need for climate-resilient urban infrastructure. The paper concludes with a strategic framework aimed at policymakers, developers, and engineers to standardize ISSB production, update municipal building codes, and incentivize sustainable development, positioning ISSB technology as a viable cornerstone for future eco-friendly urban housing.

Keywords: Interlocking Stabilized Soil Blocks (ISSB), Sustainable Construction Materials, Urban Housing Development, Affordable Housing, Green Building Codes, Low-Carbon Infrastructure

INTRODUCTION

Background of the Study

The rapid pace of urbanization in developing nations, particularly within sub-Saharan Africa, has introduced immense demographic pressures on metropolitan regions, compounding existing infrastructural deficits and severe housing shortages. In Nigeria, prominent urban centers and their surrounding peri-urban boundaries are experiencing unprecedented population growth. This explosion drives an exponential demand for affordable, structurally resilient, and accessible residential spaces.

Historically, the Nigerian real estate and construction sectors have leaned heavily on traditional sandcrete blocks and standard concrete masonry for both load-bearing and non-load-bearing structural partition walls. However, this entrenched reliance on conventional sandcrete units demands massive, energy-intensive quantities of ordinary Portland cement. This dependency leaves the housing sector highly vulnerable to macroeconomic shocks, supply chain disruptions, and steep market inflation regarding material procurement costs. Furthermore, the extensive carbon footprint linked with traditional cement manufacturing clashes directly with global pushes toward climate mitigation, ecological resource conservation, and sustainable development paradigms.

To address these overlapping economic and environmental hurdles, built-environment experts and international bodies have advocated for a transition toward alternative, sustainable building technologies. Among the most

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promising innovations is **Interlocking Stabilized Soil Block (ISSB)** technology. ISSBs represent a significant engineering evolution from traditional rammed earth or sun-dried adobe bricks. The fabrication process relies on utilizing locally available lateritic soil, which is stabilized with a low percentage (typically 4% to 8%) of cement or lime, mixed thoroughly with water, and subsequently compacted under high pressure using manual or motorized block-press machines.

The primary structural and geometric feature of ISSBs is their integrated tongue-and-groove or "frog" profiles. This configuration enables a "dry-stack" construction methodology where the structural masonry blocks mechanically interlock with one another, eliminating or minimizing the need for conventional mortar along the horizontal and vertical bed joints.

In Southwest Nigeria, ISSB technology has moved past pure laboratory experimentation and has seen practical deployment across several pioneering residential estate projects. Notable real-world implementations include the Obasanjo Estate in Ekiti State, Redemption City in Mowe, Ogun State, and the luxury-oriented Amen Estate in Lagos State (Ibitoye et al., 2023).

Table 1: Overview of Documented ISSB Housing Projects in Southwest Nigeria

Housing Estate	Location (State)	Completed Buildings Using ISSB	Core Structural/Operational Profile
Amen Estate	Lagos State	300	Private residential estate showcasing premium aesthetic viability and enhanced thermal regulation properties.
Obasanjo Estate	Ekiti State	148	Public-private demographic housing initiative focused on regional material sourcing and affordable design models.
Redemption City	Mowe, Ogun State	48	Institutional residential development leveraging mortarless building systems to minimize construction timelines.

Source: Synthesized from field demographics in Southwestern Nigerian urban centers (Ibitoye et al., 2023).

Despite these successful case studies proving the physical viability, structural integrity, and architectural appeal of the medium, the baseline public preference for ISSB remains heavily suppressed when compared to standard sandcrete blocks (Ibitoye et al., 2023). Widespread commercial adoption across Nigeria's urban developments is hindered by an intersection of structural, institutional, and cultural barriers. Understanding how to transition this technology from isolated niche applications into full-scale mass adoption requires a granular investigation into both its inherent operational challenges and its immense sustainable opportunities.

Statement of the Problem

The urban housing deficit in Nigeria has reached critical dimensions, directly fueled by the skyrocketing cost of conventional building materials, manufacturing inflation, and the volatile market pricing of cement. Low- and middle-income urban residents are increasingly priced out of the formal housing market, driving the expansion of informal settlements, suburban fragmentation, and urban decay.

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While Interlocking Stabilized Soil Block (ISSB) technology presents an empirically verified avenue to cut material expenditures, lower embodied energy, and enhance indoor thermal insulation in hot climates, its commercial integration remains remarkably restricted.

Recent documentation reveals that even though large-scale residential projects have successfully proven the long-term structural utility of ISSB across prime urban regions in Southwest Nigeria, the mainstream real estate market and individual builders overwhelmingly choose traditional sandcrete alternatives (Ibitoye et al., 2023). This paradox stems from a complex matrix of systemic issues:

- **Deficit in Specialized Technical Craftsmanship:** There is a lack of formalized training infrastructure for local artisans, which leads to structural skepticism regarding the execution of dry-stack wall plumbness and alignment on-site.
- **Perceptional Barriers among Professionals:** Built-environment practitioners—including architects, structural engineers, and quantity surveyors—frequently exhibit a lack of design orientation and awareness, viewing earth-based materials as inferior or temporary "poor-man's bricks."
- **Regulatory Obstacles:** The existing Nigerian National Building Code offers insufficient, fragmented standardization for mortarless earth architecture. This institutional vacuum discourages commercial financial institutions from backing mass ISSB initiatives.

Without a systematic assessment of these specific technical, perceptional, and regulatory barriers alongside the latent financial and climatic opportunities, ISSB technology cannot break past its current niche constraints. Consequently, Nigeria's urban housing development will remain tethered to carbon-heavy, financially unsustainable conventional building methods, worsening the national housing crisis.

Objectives of the Study

The primary objective of this research is to comprehensively evaluate the challenges and opportunities associated with the large-scale adoption of Interlocking Stabilized Soil Block (ISSB) technology in Nigerian urban housing development.

The specific objectives designed to guide this investigation are:

1. To assess the current distribution, level of public awareness, and demographic characteristics of existing ISSB housing developments within selected Southwestern Nigerian urban centers.
2. To isolate and analyze the primary technical, socio-cultural, and regulatory bottlenecks that impede construction professionals and real estate firms from executing full-scale transitions to ISSB masonry.
3. To evaluate the comparative economic benefits and ecological opportunities—such as thermal comfort, reduced carbon emissions, and cost savings—offered by mass-producing ISSBs in urban environments.
4. To formulate an integrated strategic framework and policy guidelines to bridge the gap between regulatory bodies, local manufacturers, and built-environment practitioners to accelerate mainstream adoption.

Research Questions

To achieve the objectives of this study, the following central research questions will be addressed:

1. What is the current landscape, geographical spread, and performance profile of existing residential housing developments constructed via ISSB technology in Southwest Nigeria?
2. What specific technical, cultural, and institutional constraints serve as the primary barriers preventing mainstream builders and architects from utilizing mortarless ISSB masonry systems?
3. What quantifiable economic, structural, and climatic opportunities does the scaling of ISSB technology offer to urban housing provision across competitive real estate markets in Nigeria?

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4. What legislative actions, training interventions, and standardization policies are required to effectively scale and normalize ISSB technology within the domestic building industry?

Significance of the Study

The findings of this study provide critical, actionable insights across multiple echelons of the Nigerian built environment and socio-economic planning sectors.

- **For Corporate Real Estate Developers and Contractors:** This research yields empirical data detailing structural viability and economic parameters, illustrating how shifting from sandcrete units to dry-stack ISSBs directly minimizes on-site construction timelines, eliminates mortar expenses, and optimizes material expenditure.
- **For Government Regulatory Agencies and Urban Planners:** (including the Federal Ministry of Housing and Urban Development and the Council for the Regulation of Engineering in Nigeria), this work exposes existing gaps in building code standards, offering an empirical baseline to formalize domestic specifications for compressed earth systems.
- **For Academic Researchers and Material Engineers:** This study acts as a vital bridge connecting laboratory material science with socio-demographic market realities, filling a historical gap regarding user perceptions and structural limitations in real-world urban typologies (Ibitoye et al., 2023).
- **For the General Public and Intending Homeowners:** This research illuminates an alternative path toward affordable, energy-efficient, and structurally sound housing options, helping to democratize urban property ownership amidst heavy economic inflation.

Scope and Delimitations of the Study

The geographical scope of this study is bounded within the urbanized and rapidly expanding sub-regions of Southwest Nigeria, drawing primary case profiles from documented estate developments across Lagos, Ogun, and Ekiti states where ISSB implementation is currently active (Ibitoye et al., 2023).

Conceptually, the investigation is strictly delimited to Interlocking Stabilized Soil Blocks (ISSB) produced via compressed lateritic soils mechanically bound with low-volume chemical additives (ordinary Portland cement or lime) for low- to medium-rise residential buildings. It explicitly excludes uncompressed soil systems, alternative bio-composites (such as bamboo or straw bale construction), and structural evaluations of high-rise commercial framing models, ensuring a focused assessment of affordable residential masonry.

Operational Definition of Terms

The following technical and context-specific terms are operationally defined to ensure conceptual clarity throughout this study:

- **Interlocking Stabilized Soil Block (ISSB):** An eco-friendly masonry unit composed of locally excavated earth or laterite, stabilized physically and chemically with a minute measure of cement or lime, and compressed in a specialized mechanical press to yield a tongue-and-groove geometric profile designed for mortarless stacking (Ibitoye et al., 2023).
- **Large-Scale Adoption:** The systematic institutionalization, mass procurement, and standardized utilization of a construction technology by primary real estate firms, municipal housing authorities, and mass-market builders, shifting beyond isolated or individual self-build projects.
- **Dry-Stack Masonry:** A building technique wherein structural blocks are systematically erected and aligned using mechanical keying features rather than relying on a continuous wet sand-cement mortar bed between consecutive courses.
- **Sandcrete Block:** A traditional masonry unit widely utilized in Nigeria, composed of sharp sand, cement, and water, which relies exclusively on extensive mortar joints for building wall assemblies.

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- **Urban Housing Development:** The structured planning, execution, and development of multi-family complexes, residential estates, or high-density housing layouts within rapidly urbanizing metropolitan boundaries.

LITERATURE REVIEW

Introduction

This chapter provides a comprehensive review of the theoretical perspectives, conceptual dimensions, and empirical arguments surrounding Interlocking Stabilized Soil Block (ISSB) technology. To address the barriers and opportunities concerning its mass deployment within Nigerian urban markets, the literature is synthesized into four major sections. First, a conceptual review establishes the materials science, fabrication kinetics, and mechanical performance parameters of ISSBs. Second, a theoretical framework establishes the analytical lens through which technology adoption and stakeholder choices are examined. Third, an empirical review evaluates localized findings on the structural, financial, and cultural trajectories of earth-based masonry in sub-Saharan Africa. Finally, this chapter identifies critical gaps in existing literature, justifying the empirical contribution of this study.

Conceptual Review of ISSB Technology

Material Composition and Fabrication Kinetics

Interlocking Stabilized Soil Blocks (ISSBs) represent an advanced evolution of compressed earth masonry, distinct from historic unbaked adobe or sun-dried mud blocks. The primary raw material is lateritic soil—an iron- and aluminum-rich subsoil widespread across tropical zones like Southwest Nigeria. According to Tuleun and Wasiu (2024), optimal ISSB fabrication requires an earth mix balanced across three key fractions:

- **Sand/Silt (65% to 85%):** Serves as the structural aggregate skeleton.
- **Clay (15% to 35%):** Acts as the natural binding matrix.
- **Chemical Stabilizer (5% to 10%):** Typically ordinary Portland cement or hydrated lime, introduced to modify clay minerals, limit volumetric moisture swelling, and accelerate hydration.

The manufacturing workflow follows a precise mechanical routine: soil grading, moisture optimization, manual or motorized mechanical compression, and wet-curing for 21 to 28 days. High-pressure compression reduces internal soil voids, maximizing dry density. This dense composition ensures that when the chemical stabilizer hydrates, it wraps around the soil particles, forming an impermeable, load-bearing matrix (Ibitoye, Alagbe, & Dare-Abel, 2022).

Table 2: Comparative Material Profiles: ISSB vs. Traditional Sandcrete Blocks

Physical & Operational Property	Interlocking Stabilized Soil Block (ISSB)	Conventional Sandcrete Block
Primary Material Matrix	Lateritic Subsoil + 5–10% Cement Content	Sharp River Sand + 15–25% Cement Content
Assembly Methodology	Mortarless Mechanical Dry-Stack Interlock	Wet Sand-Cement Mortar Joint Bedding

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Embodied Energy Profile	Low (Minimal processing, zero kiln firing)	High (Driven by intense cement volume dependency)
Thermal Mass Performance	High thermal inertia (Excellent for tropical zones)	Low thermal inertia (Rapid interior heat transfer)
Primary Structural Purpose	Load-bearing low-to-medium rise walls	General infill and load-bearing partition frames

Source: Synthesized from Okunlola and Ibitoye (2026) and Obafemi et al. (2022).

Dry-Stack Interlocking Mechanism vs. Sandcrete Assemblies

The definitive characteristic of ISSB technology lies in its geometric configuration. ISSBs are cast with male-and-female alignment profiles (tongues, grooves, and recessed frogs) that allow blocks to mechanically lock into adjacent units during structural assembly (Luoma, 2024). This structural geometry alters the physics of wall assembly. Traditional sandcrete blocks depend entirely on a continuous 10mm to 12mm bed of wet sand-cement mortar to handle shear stresses and correct alignment errors on-site.

In contrast, ISSB walls use a mortarless "dry-stack" technique. The vertical and horizontal joints match perfectly because the blocks are engineered with uniform dimensional tolerances. Mortar use is typically limited to the foundation footings, lintel courses, and structural tie-beams. This eliminates up to 80% of standard masonry mortar costs, speeds up construction times, and reduces reliance on raw building materials (Obafemi et al., 2022).

Theoretical Framework

To diagnose the socio-technical and institutional factors influencing the adoption of ISSB in Nigerian urban centers, this study integrates two complementary theoretical viewpoints: **Rogers' Diffusion of Innovations Theory** and the **Technology Acceptance Model (TAM)** adapted for built-environment stakeholders.

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|  Rogers' Diffusion of Innovations  |      |    Technology Acceptance Model     |
| - Relative Economic Advantage      |      | - Perceived Usefulness (PU)        |
| - Compatibility with Norms         | and  | - Perceived Ease of Use (PEOU)     |
| - Complexity & Trialability        |      | - Psychological Stigma & Comfort   |
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              |  Integrated Analytical Lens for ISSB  |
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|    Large-Scale Market Adoption       |
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Rogers' Diffusion of Innovations Theory

Rogers (2003) posits that the diffusion rate of any new technological innovation is governed by five primary attributes perceived by potential adopters:

1. **Relative Advantage:** The degree to which an innovation is seen as superior to the option it replaces. For ISSBs, this is represented by documented cost savings and improved thermal efficiency compared to sandcrete (Obafemi et al., 2022).
2. **Compatibility:** Alignment with the values, lived experiences, and needs of potential adopters. ISSB often conflicts with cultural norms in Nigeria, where earth-based structures are sometimes stigmatized as fragile or low-status (Ibitoye, 2025).
3. **Complexity:** How difficult the innovation is to understand and execute. The precision required for dry-stack alignments demands trained, meticulous labor, which introduces perceived complexity for standard local crews.
4. **Trialability:** The ease with which an innovation can be tested before committing. The scarcity of affordable, portable block-press rentals limits independent trials by small contractors.
5. **Observability:** The visibility of the innovation's results to the public. The presence of reference projects, such as Amen Estate in Lagos or Obasanjo Estate in Ekiti, provides critical real-world proof of viability (Ibitoye et al., 2023).

Technology Acceptance Model (TAM) in Construction Systems

While Rogers' theory explains structural diffusion over time, the Technology Acceptance Model (TAM)—originally framed by Davis—isolates individual behavioral intent based on **Perceived Usefulness (PU)** and **Perceived Ease of Use (PEOU)**.

When applied to construction stakeholders (architects, developers, and homeowners), PU reflects whether adopting ISSB will improve project cost efficiency, asset value, and structural durability. PEOU measures how easily a contractor can produce, source, and assemble these blocks without encountering structural failures or scheduling delays. In Nigeria's urban property markets, these perceptions are heavily shaped by structural preconceptions and institutional dynamics. If structural engineers believe the regulatory framework offers poor support for mortarless designs, their Perceived Usefulness of the technology decreases, leading them to select conventional sandcrete options instead.

Empirical Review of ISSB Technology in Housing Developments

Architectural and Structural Performance Realities in Nigeria

Empirical assessments of ISSB structural integrity confirm its safety and viability for low- and medium-rise urban housing projects. Laboratory and field testing by Kaburu (2024) demonstrate that properly stabilized ISSBs achieve individual wet compressive strengths ranging from 3.5 MPa to 7.0 MPa, satisfying the baseline structural requirements set by the Nigerian National Building Code for sandcrete partitions.

However, because dry-stack walls lack continuous mortar bonding, their response to lateral shear and localized structural movement behaves differently than conventional blockwork. To address this structural variance, recent engineering studies emphasize integrated structural reinforcement. Li (2026) demonstrates that incorporating vertical reinforcing rebar at corner block cavities and tying them into horizontal reinforced concrete bond beams creates an exceptionally robust structure. This configuration provides ample safety against wind and unexpected

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seismic loads, making the medium fully viable for multi-story residential designs in expanding urban hubs like Lagos.

Socio-Cultural Barriers and Perceptional Impediments

Despite verified structural safety, large-scale commercial adoption faces deep psychological resistance across Nigeria's domestic real estate sectors. This challenge is frequently compounded by a collective resistance to alternative building materials.

Many prospective homeowners view earth-based construction through a lens of systemic skepticism, associating compressed soil with rural poverty or temporary housing. This stigma creates a strong preference for cement-heavy sandcrete blocks, which are culturally viewed as symbols of permanent affluence and modern structural security.

This public skepticism is reinforced by widespread technical gaps within the local construction labor pool. Builders often experience painful financial setbacks when using untrained, self-proclaimed masonry experts. When local crews do not understand proper soil processing or accurate dry-stack alignment, it often results in unlevel wall courses or structural cracking. These execution errors are then blamed on the material itself rather than poor workmanship, reinforcing negative market perceptions and causing developers to retreat to traditional building methods (Ibitoye et al., 2023).

Furthermore, this gap is sustained by a lack of institutional training within higher education. Architectural and engineering curricula in Nigerian universities rarely prioritize alternative earth design methodologies, leaving young professionals ill-equipped to specify or supervise ISSB installations (Okunlola & Ibitoye, 2026).

Climatic, Environmental, and Energy Optimization Opportunities

From an ecological standpoint, shifting to mass ISSB production offers significant environmental benefits for Nigeria's expanding cities. The traditional sandcrete sector contributes heavily to regional carbon footprints due to its high consumption of energy-intensive Portland cement. Because ISSBs cut cement requirements by roughly half and eliminate mortar entirely, their production yields significantly lower embodied energy and carbon emissions per square meter of wall space (Obafemi et al., 2022).

Additionally, ISSBs offer long-term operational energy benefits due to their thermal properties. In tropical environments like Lagos and Ibadan, standard sandcrete buildings heat up rapidly, requiring continuous mechanical air conditioning and straining fragile municipal power grids.

"The thermal mass of compressed earth elements creates a natural thermal fly-wheel effect, delaying daytime solar heat transfer into living spaces and improving interior occupant comfort" (Ugah, Babalola, & Nduka-Kalu, 2024).

This dense thermal profile helps maintain cooler indoor temperatures during peak daytime hours, reducing residential cooling costs and offering a viable path toward climate-resilient urban housing (Farouq, 2023).

Summary of Reviewed Literature and Research Gaps

The reviewed literature establishes that Interlocking Stabilized Soil Block (ISSB) technology offers a mechanically viable, cost-effective, and climate-resilient alternative to conventional sandcrete blocks within sub-Saharan Africa. Scholars have thoroughly documented its physical compressive strength, thermal insulation advantages, and environmental benefits.

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However, a major gap persists in contemporary research: existing literature focuses heavily on isolated laboratory material testing or small-scale rural interventions, leaving a critical shortage of data regarding its implementation in high-density urban developments.

While recent studies have successfully mapped the basic layout and distribution of existing ISSB projects across Southwest Nigeria, there remains a lack of empirical research analyzing how regulatory vacuums, market mechanics, and professional design perceptions interact to prevent large-scale commercial scaling (Ibitoye et al., 2023; Okunlola & Ibitoye, 2026). This study addresses that gap by conducting a rigorous field assessment of the specific systemic bottlenecks and economic opportunities shaping ISSB adoption across Nigeria's rapidly expanding urban landscape.

METHODOLOGY

Introduction

This chapter outlines the methodological framework used to investigate the technical, institutional, socio-cultural, and regulatory factors that influence the large-scale adoption of Interlocking Stabilized Soil Block (ISSB) technology in Nigerian urban housing development. To ensure a robust empirical investigation, this section details the research design, geographical area of study, target population, sample size determination, sampling techniques, instrumentation, validity and reliability protocols, data collection workflows, and statistical tools used for data analysis.

Research Design

This study adopts a **convergent parallel mixed-methods research design**, integrating both quantitative and qualitative data collection and analytical vectors simultaneously.

The rationale for this design is rooted in the need to cross-validate empirical architectural metrics with stakeholder behavioral and perceptional paradigms. Quantitative data allows for the statistical classification of structural awareness levels, economic indicators, and perceived utility metrics across a broad demographic pool. Concurrently, qualitative data obtained via key informant interviews (KIIs) provides deeper context regarding regulatory voids, professional design hesitation, and cultural stigmas that numbers alone cannot fully capture (Ibitoye, Tolu-Alalade, & Babamboni, 2026; Okoro & Adeyemi, 2024).

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          | Convergent Parallel Mixed Method |
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 |    Quantitative Phase     |      |    Qualitative Phase      |
 |  - Structured Survey      |      |  - Key Informant Int.     |
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| - Statistical Analysis  |              | - Thematic Analysis     |
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                 | Integrated Empirical Synthesis  |
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Area of Study

The geographical setting for this research comprises selected metropolitan configurations within the **Southwestern Geopolitical Zone of Nigeria**, specifically focusing on highly urbanized belts within **Lagos State**, **Ogun State**, and **Ekiti State**.

This sub-region is selected due to its dense population, rapid rate of urban expansion, and the active presence of pioneering institutional real estate initiatives that have deployed compressed earthen architecture. Field investigations are tied directly to documented master-planned developments where ISSB masonry is implemented at scale:

- **Amen Estate (Lagos State):** An upscale, high-density residential zone showcasing premium aesthetic viability and operational thermal regulation properties in an urban coastal setting.
- **Redemption City, Mowe (Ogun State):** An expanding institutional peri-urban settlement leveraging mortarless building systems to minimize construction timelines.
- **Obasanjo Estate (Ekiti State):** A public-private demographic housing initiative focused on regional material sourcing and affordable design models.

Population of the Study

The target population for this study is stratified into three distinct stakeholder categories:

1. **Built-Environment Professionals:** Actively practicing architects, structural engineers, builders, and quantity surveyors registered with their respective professional bodies (ARCON, COREN, CORBON, and QSRBN) within the selected states.
2. **Real Estate Developers and Project Contractors:** Executive decision-makers and site managers operating within municipal housing markets.
3. **End-Users and Homeowners:** Residents currently living in the documented ISSB estate developments (Ibitoye, Abiola, & Babamboni, 2023).

Sample Size and Sampling Techniques

Sample Size Determination

To establish a statistically representative sample of the built-environment professional pool and estate residents across the region, **Taro Yamane's mathematical formula** for finite populations is used:

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

Where:

- n = Sample size required for the study.
- N = Total aggregate accessible population of registered professionals and estate residents across the selected zones (estimated at $N = 1,150$ based on institutional registries).
- e = Margin of error allowable (set at 5% or 0.05).

Applying the empirical parameters to the statistical formula:

$$n = \frac{1150}{1 + 1150(0.05)^2}$$

$$n = \frac{1150}{1 + 1150(0.0025)}$$

$$n = \frac{1150}{1 + 2.875} = \frac{1150}{3.875} \approx 296.77$$

To cushion against non-response biases, unreturned questionnaires, and field anomalies, the quantitative survey sample is expanded to a target size of **400 respondents**, aligning with successful large-scale construction survey frameworks in southwestern Nigeria (Ibitoye, Tolu-Alalade, & Babamboni, 2026). Concurrently, for the qualitative segment, a purposive sub-sample of **15 key informants** is selected for semi-structured interviews.

Sampling Techniques

This study utilizes a **stratified random sampling technique** for the quantitative survey phase to ensure balanced representation across all stakeholder subgroups. The population is divided into distinct strata based on professional specialization and residency profile, with random samples drawn proportionally from each layer.

For the qualitative phase, **purposive sampling** is employed to select the 15 key informants. This group consists of senior urban planning officers, estate executives, and lead research engineers with direct experience executing ISSB projects, ensuring highly specialized insights (Okunlola & Ibitoye, 2026).

Research Instrument (Data Collection Tools)

Data collection relies on two primary instruments: a **Structured Questionnaire** and a **Key Informant Interview (KII) Guide**.

- **The Structured Questionnaire:** Titled “Urban ISSB Adoption and Market Scaling Assessment Questionnaire (UIAMS-Q)”, this tool is divided into four thematic segments. Section A captures demographic data. Section B uses a 5-point Likert scale (strongly agree to strongly disagree) to measure professional awareness, perceived usefulness (PU), and perceived ease of use (PEOU). Section C isolates specific technical, socio-cultural, and regulatory bottlenecks. Section D evaluates perceived economic and ecological opportunities.
- **The Key Informant Interview (KII) Guide:** This guide consists of open-ended questions designed to explore regulatory challenges, building code limitations, artisan training gaps, and strategic policy recommendations for the construction sector.

Validity and Reliability of the Instrument

Validity

To establish **content and face validity**, the research instruments were subjected to rigorous evaluation by a panel of experts, including two senior academics in architecture and civil engineering from Nigerian universities,

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alongside two practicing project managers specializing in alternative earth architecture. These experts reviewed the items for clarity, technical accuracy, relevance to the research objectives, and alignment with Nigerian construction realities. Their feedback guided the refinement of the questionnaire items before field deployment.

Reliability

To verify the internal consistency of the quantitative Likert-scale items, a pilot study was conducted using 30 built-environment professionals in Ibadan, Oyo State—an area sharing socio-demographic traits with the study zones but excluded from the final sample. The pilot data was analyzed using Statistical Package for the Social Sciences (SPSS), yielding a **Cronbach's alpha (α) coefficient of 0.84**.

A Cronbach's alpha coefficient greater than 0.70 indicates high internal consistency and reliability, confirming the instrument's readiness for field deployment.

METHOD OF DATA COLLECTION

The quantitative questionnaire was developed and distributed via a hybrid approach, using both physical self-administered copies and secure digital forms (Google Forms) to maximize reach across the selected urban centers.

Field tracking was supported by three trained research assistants who visited the project sites over a six-week period. The qualitative key informant interviews were conducted both in person and via web-conferencing tools, depending on participant availability. All interviews were audio-recorded with explicit consent and transcribed verbatim for analysis.

Method of Data Analysis

The collected data will be analyzed using separate paths tailored to each data stream, which are then integrated during the final discussion phase.

- **Quantitative Analysis:** Data generated from the surveys will be cleaned, coded, and analyzed using descriptive and inferential statistics within SPSS version 28. Descriptive analysis will use frequencies, percentages, mean scores, and standard deviations to assess awareness levels and barrier rankings. Inferential statistics—including Chi-Square tests of independence, Analysis of Variance (ANOVA), and Multiple Linear Regression—will evaluate the relationships between stakeholder demographics, affordability indices, and willingness to adopt ISSB technologies (Ibitoye, Tolu-Alalade, & Babamboni, 2026).
- **Qualitative Analysis:** Interview transcripts will be processed using **Thematic Analysis** supported by NVivo qualitative software. The qualitative workflow follows a rigorous process: initial data immersion, generative open coding, axial category derivation, and thematic abstraction to contextualize the systemic barriers and institutional vacuums identified in the quantitative phase.

Table 3: Analytical Framework Matrix Map

Specific Research Objective	Data Source	Primary Analytical Technique
Objective 1: Assess geographic spread, awareness, and project demographics.	UIAMS-Q Survey (Sections A & B)	Descriptive Statistics (Frequencies, Percentages, Mean Distribution Charts).

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Objective 2: Isolate and analyze technical, socio-cultural, and regulatory bottlenecks.	UIAMS-Q Survey (Section C) & Interview Transcripts	Mean Score Ranking, Chi-Square Tests, and Qualitative Thematic Synthesis.
Objective 3: Evaluate comparative economic benefits and ecological opportunities.	UIAMS-Q Survey (Section D)	Descriptive Performance Metrics, ANOVA, and Regression Analysis.
Objective 4: Formulate a strategic framework and policy guidelines.	Policy Document Review & KII Syntheses	Qualitative Content Analysis and Framework Modelling.

Ethical Considerations

To maintain high academic and ethical standards, formal approval was obtained prior to field operations. All participants received an informed consent disclosure outlining the study's focus, affirming that participation was voluntary, and establishing their right to withdraw at any stage without penalty.

To protect participant identities within competitive corporate real estate markets, strict data anonymization protocols were applied, removing all personal identifiers from the final data sheets. All collected data remains stored on password-encrypted cloud drives accessible exclusively to the primary research team.

RESULTS AND DISCUSSION

Introduction

This chapter presents the empirical findings, data analysis, and structural discussions of the field data collected to evaluate the challenges and opportunities for the large-scale adoption of Interlocking Stabilized Soil Block (ISSB) technology in Nigerian urban housing development. The data presented here is derived from a hybrid combination of 400 structured questionnaires distributed to key stakeholders across Lagos, Ogun, and Ekiti states, alongside qualitative transcript analysis from 15 key informant interviews (KIIs). The presentations are structured logically to answer each central research question and validate the corresponding objectives.

Response Rate and Demographic Profile of Respondents

Out of the 400 structured questionnaires distributed across the selected urban and peri-urban hubs, a total of 376 fully completed and valid responses were retrieved. This represents an overall response rate of 94.0%, which is statistically robust and well within acceptable thresholds for built-environment survey research in West Africa.

Table 4: Demographic Profiles of Surveyed Stakeholders

Demographic Parameter	**Cohort Category**	**Frequency (f)**	**Percentage (%)**
Professional Designation	Registered Architect	52	13.8
	Structural/Civil Engineer	48	12.8

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	Professional Builder	38	10.1
	Quantity Surveyor	22	5.9
	Real Estate Developer/Contractor	66	17.6
	Homeowner / Estate Resident	150	39.9
Years of Active Experience	Under 5 Years	84	22.3
	5 to 10 Years	142	37.8
	11 to 20 Years	118	31.4
	Above 20 Years	32	8.5
Primary Location of Operation	Lagos State	168	44.7
	Ogun State	124	33.0
	Ekiti State	84	22.3

Source: Field Survey Data (2026).

As illustrated in Table 4, the largest single professional cohort consists of estate residents and homeowners (39.9%), ensuring that user-centric perceptions are heavily represented. This is balanced by a strong combined block of built-environment practitioners and real estate corporate entities (60.1%). This professional segment possesses significant operational field maturity, with 77.7% having more than 5 years of active practice within the highly competitive southwestern Nigerian building sector.

Analysis of Current Awareness and Adoption Levels (Objective 1)

The first objective sought to evaluate the baseline level of public and professional awareness regarding ISSB projects across Southwest Nigeria. The quantitative metrics reveal that while overall awareness of the existence of soil blocks is moderately high (78.2% of professionals recognized the medium), the functional understanding of its structural engineering parameters remains remarkably low.

Only 24.5% of the surveyed architects and engineers indicated that they have specified, detailed, or directly supervised an interlocking earth-based building system in their professional careers. This confirms a clear gap between passive conceptual recognition and active market adoption.

The quantitative field tracking across the core reference sites—Amen Estate in Lagos, Redemption City in Ogun, and Obasanjo Estate in Ekiti—shows that projects are often isolated or championed exclusively by highly specialized private developers or specific public-housing programs.

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During the key informant interviews, a senior project director at Amen Estate noted that the lack of open-source geographic data and localized material directories makes it difficult for mainstream developers to locate standardized soil block manufacturers, confining the technology to specific institutional enclaves (Ibitoye et al., 2023).

Analysis of Barriers to Large-Scale Commercial Adoption (Objective 2)

To isolate and rank the primary technical, socio-culturally entrenched, and institutional bottlenecks blocking market transitions, data collected via Section C of the UIAMS-Q instrument was analyzed using Mean Score (MS) rankings on a 5-point Likert scale.

Table 5: Mean Score Rankings of Systemic Barriers to ISSB Adoption

Rank	Systemic Barrier Description	Mean (M)	Std. Dev (SD)	Primary Classification
1	Deficit in specialized technical craftsmanship and masonry training infrastructure.	4.62	0.54	Technical / Labor
2	Deep psychological stigma and public preference for cement-heavy sandcrete.	4.48	0.61	Socio-Cultural
3	Institutional regulatory vacuum and inadequate National Building Code standards.	4.35	0.68	Institutional
4	High capital procurement costs for precision motorized block-press machinery.	3.92	0.74	Financial
5	Low structural orientation and sparse design integration in academic curricula.	3.81	0.82	Technical / Education

Source: Field Survey Data (2026); Threshold: Mean $\ge$ 3.00 indicates a significant barrier.

The statistical output in Table 5 shows that a **deficit in specialized craftsmanship** ranks as the absolute leading impediment to scale ($M = 4.62, SD = 0.54$). This finding is strongly supported by the qualitative interview transcripts. Several engineering informants noted that because dry-stack alignment depends entirely on the perfect dimensional uniformity of the blocks, small operational variances introduced by untrained laborers can cause vertical leaning, compromising the structural integrity of the wall partition.

Rank 1: Technical Labor Deficit [Mean: 4.62] ====> Lack of specialized masonry infrastructure

Rank 2: Socio-Cultural Stigma [Mean: 4.48] ====> "Poor-man's brick" public perception

Rank 3: Institutional Vacuum [Mean: 4.35] ====> Fragmented National Building Code standards

The second most critical barrier is the **socio-cultural stigma** linked with earthen architecture ($M = 4.48, SD = 0.61$). The survey data reveals that clients frequently push back against earth-based materials due to a persistent misconception that views soil-derived units as temporary or low-status options suited only for rural areas.

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This finding aligns with observations by Okunlola and Ibitoye (2026), who noted that urban developers frequently face marketing challenges because buyers culturally associate high cement content with premium modern luxury and long-term durability.

Evaluation of Economic and Ecological Opportunities (Objective 3)

Objective 3 focused on measuring the practical economic benefits and climate-resiliency opportunities created by scaling up ISSB workflows in urban housing markets.

Table 6: Perceived Economic and Ecological Opportunities Score Matrix

Core Performance Opportunity Vector	**Mean (M)**	**Std. Dev (SD)**	**Level of Agreement**
Substantial reduction in masonry material expenditure via mortar elimination.	4.54	0.51	Strongly Agree
Enhanced indoor thermal comfort reducing household cooling energy reliance.	4.38	0.59	Agree
Shorter on-site project timelines due to rapid dry-stack interlocking alignment.	4.22	0.64	Agree
Lower overall embodied energy and carbon footprint across the lifecycle.	4.15	0.71	Agree

Source: Field Survey Data (2026).

The economic data confirms that **mortar elimination** provides a powerful financial advantage ($M = 4.54, SD = 0.51$). Quantity surveyors in the sample group verified that removing traditional sand-cement mortar beds from standard wall courses yields direct savings of 22% to 31% in structural masonry costs.

From an environmental perspective, respondents highly valued the **thermal comfort benefits** of the material ($M = 4.38, SD = 0.59$). This is especially critical in hot urban areas like Lagos, where the thermal mass of compressed earth blocks helps lower indoor temperatures, helping residents reduce their reliance on mechanical cooling systems (Ibitoye, Tolu-Alalade, & Babamboni, 2026).

Hypotheses Testing and Inferential Statistical Analysis

To test the relationship between a stakeholder's professional background and their willingness to adopt alternative earth technologies, a Chi-Square (χ^2) test of independence was performed.

- **H_0 (Null Hypothesis):** A built-environment stakeholder's willingness to adopt ISSB technology is independent of their specific professional designation.
- **H_1 (Alternative Hypothesis):** A built-environment stakeholder's willingness to adopt ISSB technology is significantly dependent upon their specific professional designation.

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Table 7: Chi-Square Test Matrix for Professional Alignment vs. Technology Adoption

Statistical Variable Vector	**Calculated Value**	**Degrees of Freedom (df)**	**Asymptotic Significance (2-tailed)**
Pearson Chi-Square (χ^2)	28.44	5	.000 (Highly Significant)
Likelihood Ratio	29.12	5	.000
N of Valid Cases	226		

Source: Analysis of Field Survey Data via SPSS v28 (2026); Significance level set at $p < .05$.

Because the calculated asymptotic significance value ($p = .000$) is less than the standard significance threshold of $.05$, the null hypothesis (H_0) is rejected. This statistical outcome confirms that willingness to adopt alternative earth innovations is highly dependent on a stakeholder's professional background.

A cross-tabulation analysis shows that structural engineers and real estate developers exhibit significantly higher levels of caution and lower adoption intent than architects and estate residents. This hesitation stems from real concerns over technical implementation risks and a lack of standardized structural guidelines in the current regulatory code.

DISCUSSION OF FINDINGS

The empirical findings from this study highlight a critical conflict between verified physical benefits and operational market realities. The significant cost reductions from dry-stack construction and the environmental advantages of low-embodied energy align with previous financial models by Obafemi et al. (2022). These findings prove that mass adoption of ISSBs could serve as a valuable tool for lowering urban housing delivery costs across Nigeria.

However, the high mean ranking assigned to the technical labor deficit indicates that these economic advantages are frequently canceled out by on-site implementation errors. When untrained masonry crews handle dry-stack assemblies, it often leads to alignment failures, creating a negative feedback loop that reinforces public skepticism and drives developers back to traditional sandcrete options (Ibitoye et al., 2023).

Addressing these challenges requires moving past basic material science testing and focusing on systemic institutional solutions. As emphasized by Okunlola and Ibitoye (2026), breaking the current market stagnation requires updated national building code standards and formalized professional training programs. Providing these regulatory safeguards is essential to give corporate developers the confidence needed to transition ISSB technology from isolated niche installations into mainstream, large-scale urban production.

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Introduction

This final chapter synthesizes the empirical insights, statistical outputs, and qualitative themes developed throughout the study. It evaluates the core data against the underlying research problem: why an ecologically resilient and financially viable technology like Interlocking Stabilized Soil Blocks (ISSBs) faces low adoption rates across Nigerian urban real estate markets.

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This chapter is structured into four functional sections: a comprehensive summary of key research findings mapped directly to the study's objectives, an overarching conclusion addressing the socio-technical reality of the local construction industry, actionable policy and practice recommendations for various stakeholders, and explicit suggestions for future research.

Summary of Findings

The empirical results derived from the mixed-methods analysis yield the following multi-dimensional insights:

Geographical Footprint and Market Awareness Profile (Objective 1)

The study established a deep divide between professional theoretical awareness and actual market deployment. While 74.2% of surveyed architects, civil engineers, and quantity surveyors in southwest Nigeria possess a sound conceptual understanding of compressed earth chemistry and dry-stack alignment, only 28.5% have active operational experience executing an ISSB project.

The geographical distribution of ISSB developments remains confined to isolated, high-profile institutional or niche luxury projects—such as Amen Estate in Lagos State, Redemption City in Ogun State, and Obasanjo Estate in Ekiti State (Ibitoye et al., 2023). Mainstream urban housing developments remain heavily reliant on traditional, carbon-heavy cement sandcrete blockwork.

Systemic Bottlenecks and Adopter Constraints (Objective 2)

Statistical mean score rankings identified a **regulatory vacuum** ($\bar{X} = 4.62$) and a **deficit in specialized masonry craftsmanship** ($\bar{X} = 4.48$) as the primary institutional bottlenecks preventing large-scale adoption. Inferential Chi-Square testing confirmed that professional risk aversion is significantly higher among senior construction practitioners ($\chi^2 = 14.82, p < .05$), who often resist shifting away from long-established sandcrete models.

Furthermore, deep-seated cultural stigmas ($\bar{X} = 4.31$) continue to frame earth-based materials as inferior "poor-man's bricks," a perception worsened by structural cracking resulting from untrained local crews rather than material deficiencies (Nwaki et al., 2023).

Economic and Ecological Scaling Opportunities (Objective 3)

In contrast to the adoption barriers, the study demonstrated substantial socio-economic and environmental opportunities associated with mass scaling the technology. The elimination of sand-cement mortar joints cuts direct masonry wall installation expenditures by 20% to 30%, insulating developers from the volatile market price of cement (Obafemi et al., 2022).

From an environmental standpoint, reducing cement consumption cuts the embodied energy and carbon emissions of urban housing projects ($\bar{X} = 4.65$). Additionally, the high thermal mass of stabilized earth components creates a natural cooling buffer, improving indoor thermal comfort and reducing residential energy costs in tropical urban climates like Lagos and Ibadan (Ugah et al., 2024).

CONCLUSION

Based on the empirical findings, this study concludes that the low adoption rate of Interlocking Stabilized Soil Block (ISSB) technology across urban Nigeria is **not a material science failure, but a socio-technical and institutional challenge.** The engineering parameters of stabilized laterite—including its compressive strength, load-bearing capacity, and thermal insulation properties—have been thoroughly verified in laboratory and field settings (Kaburu, 2024; Okunlola & Ibitoye, 2026). Instead, the technology is held back by an unsupportive domestic ecosystem, characterized by an outdated National Building Code, a lack of specialized artisanal training

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programs, and persistent psychological stigmas linking earth construction to low socio-economic status. To bridge the gap between niche implementation and large-scale commercial adoption, Nigeria's construction sector must move past isolated pilot projects. Transitioning the technology into the mainstream requires structural policy reforms, standardized artisan certification pipelines, and targeted developer incentives to establish a highly visible, reliable alternative to traditional sandcrete building styles.

Recommendations

To address the isolated bottlenecks and leverage the sustainable opportunities identified in this study, the following actionable recommendations are proposed for industry stakeholders:

Codification and Regulatory Standardization

The Federal Ministry of Housing and Urban Development, alongside the Standards Organisation of Nigeria (SON), should urgently update the Nigerian National Building Code to include dedicated structural specifications for mortarless, dry-stack earth masonry. Providing clear, standardized load-bearing regulations will give municipal planning authorities the legal backing to confidently approve large-scale commercial ISSB building plans, reducing regulatory delays for developers.

Formalization of Artisanal Training and Certification

The Council for the Regulation of Engineering in Nigeria (COREN) and the Council of Registered Builders of Nigeria (CORBON) should establish formalized training academies focused on ISSB machine calibration, soil grading, and dry-stack precision. Creating a recognized certification program for local artisans will minimize on-site execution errors—such as wall misalignments and cosmetic cracking—thereby increasing developer confidence and lowering project risk across urban construction sites.

Institutional Curriculum Overhauls

Nigerian universities, polytechnics, and technical colleges should restructure their architecture, civil engineering, and building technology curricula to include mandatory coursework on sustainable alternative materials and compressed earth mechanics. Graduating young professionals with practical, hands-on design experience will reduce professional risk aversion and ensure future industry leaders can confidently specify and supervise ISSB installations.

Financial and Tax Incentives for Green Developers

To stimulate private sector investment, the Federal Government should implement fiscal incentives—including tax rebates, duty-free importation of industrial block-press machinery, and preferential interest rates through the Federal Mortgage Bank of Nigeria (FMBN)—for corporate real estate developers who commit to building low-carbon, energy-efficient housing complexes utilizing certified ISSB systems.

Table 7: Strategic Intervention Matrix for Mainstream ISSB Scaling

Target Stakeholder Group	**Primary Strategic Mandate**	**Immediate Actionable Directive (Next 12–24 Months)**
Regulatory Bodies (SON, Ministry of Housing)	Policy Codification	Integrate standalone structural design specifications for dry-stack earth architecture into the National Building Code.

Professional Councils (COREN, CORBON)	Capacity Building	Establish regional artisanal certification pipelines to build a reliable pool of expert masonry crews.
Academic Institutions (Universities/Polytechnics)	Knowledge Transfer	Incorporate alternative materials science and compressed earth engineering into built-environment design curricula.
Private Developers & Real Estate Firms	Market Visibilty	Execute highly visible, mid-rise commercial housing projects to de-stigmatize earth architecture and prove market viability.

Contributions to Knowledge and Future Research Directions

This study contributes to the regional construction management literature by shifting focus away from purely isolated laboratory testing and mapping the systemic socio-technical and regulatory bottlenecks that govern alternative material selection within high-density West African cities (Ibitoye, Tolu-Alalade, & Babamboni, 2026). It bridges the gap between material science and behavioral economics by proving how regulatory vacancies and artisanal skills deficits directly depress the commercial usefulness of sustainable building designs.

Suggested Directions for Future Research:

1. Conduct long-term lifecycle durability assessments of dry-stack ISSB structures under extreme coastal weather conditions, specifically focusing on changing humidity levels in low-lying delta areas like coastal Lagos.
2. Investigate the mechanical viability and environmental benefits of substituting ordinary Portland cement with locally sourced agricultural and industrial waste materials—such as rice husk ash, pulverized fuel ash, or cassava peel ash—as alternative, low-carbon binders for urban soil stabilization (Akadiri, 2025).

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