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The Evaluation Of The Circular Economy Potential Of Machine-Pressed Earth Blocks In Affordable Housing Delivery In Lagos, Nigeria

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Abstract- The urbanization in Lagos has significantly increased the demand for affordable housing and aggravated environmental degradation, largely as a result of dependence on energy-intensive construction materials. he prevailing linear take, make, and dispose model in the construction industry is a major contributor to material waste and carbon emissions, indicating the pressing requirement for a transition to circular construction systems. This study uses a mixed-method approach, in-tegrating an organised literature review, comparative material analysis, and lifecycle assessment of machine-pressed earth blocks (MPEBs) relative to conventional building materials used in Lagos. The research shows that MPEBs have significant circular-economy potential, as evidenced by local material sourcing, low embodied energy (0.45–1.5 MJ/kg), full end-of-life recyclability, and notably diminished construction costs. Comparative analysis shows that MPEBs pro-duce up to 85% fewer carbon emissions than reinforced concrete and are 45–55% less expensive per unit than sandcrete blocks in the current Lagos market. The proposed CE-MPEB integration framework delineates six strategic pillars for adoption: material sourcing, production standardization, regulatory reform, community capacity building, lifecycle de-sign, and economic incentivization. The study shows that MPEBs represent a viable and scalable strategy for promoting circular construction in Lagos, mainly within low- to middle-income housing schemes. Policy support, technical stand-ardization, and public and community awareness initiatives are identified as essential enablers for expanding the adop-tion of earth-based construction technologies.

Keywords Affordable Housing, Circular Economy, Machine-Pressed Earth Blocks, Sustainable Construction, Embod-Ied Energy, Material Lifecycle

I. INTRODUCTION

Rapid urbanization in Lagos has intensified the demand for affordable housing, contributing significantly to Nigeria's housing deficit, estimated at over 17 million units (Adebayo, 2019; World Bank, 2020). The increasing cost of conventional construction materials such as cement and steel has further limited access to affordable housing for low- and middle-income populations (Olotuah & Bobadoye, 2019). Consequently, there is a growing need for alterna-tive building materials that can reduce construction costs while maintaining acceptable performance standards (Ib-itoye & Olaleye, 2022; Ibitoye et al., 2023).

At the same time, the construction industry largely oper-ates within a linear economic model characterized by re-source extraction, consumption, and waste generation, contributing significantly to environmental degradation and carbon emissions (UNEP, 2022). Circular economy principles offer a sustainable alternative by promoting re-source efficiency, material reuse, and lifecycle optimiza-tion within the built environment (Boulding, 1966; Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017).

Machine-pressed earth blocks (MPEBs) have emerged as a promising sustainable building material due to their low embodied energy, local availability, affordability, recycla-bility, and favourable thermal performance (Walker et al., 2005; Houben & Guillaud, 1994). Studies in Southwest Nigeria have demonstrated their economic viability and suitability for residential construction (Ibitoye et al., 2022; Ibitoye et al., 2023), while evidence also suggests satisfac-tory indoor environmental performance in earth-based housing developments (Asaju et al., 2025).

However, adop-tion remains limited due to negative perceptions, regula-tory constraints, inadequate technical expertise, and weak institutional support (Olotuah & Bobadoye, 2019; Ibitoye & Olaleye, 2022). This study therefore evaluates the circu-lar economy potential of machine-pressed earth blocks in affordable housing delivery in Lagos and proposes a framework for their effective integration into sustainable urban construction practices.

1.1. Problem Statement

Despite the urgent need for affordable housing in Lagos, rising construction costs and dependence on conventional building materials continue to hinder housing delivery (Adebayo, 2019; World Bank, 2020). Furthermore, the construction sector's reliance on a linear production model contributes to resource depletion, waste generation, and environmental degradation (UNEP, 2022).

Machine-pressed earth blocks offer significant advantages including low embodied energy, affordability, local sourc-ing, reduced waste generation, and end-of-life recyclability (Walker et al., 2005; Maini, 2010). Studies have demon-strated their cost-effectiveness and suitability for residen-tial construction in Nigeria (Ibitoye et al., 2023). However, adoption remains constrained by negative public percep-tions, inadequate technical knowledge, limited standardi-zation, and weak policy support (Ibitoye & Olaleye, 2022).

Although previous research has examined the performance and economic benefits of earth-based construction tech-nologies, limited attention has been given to their integra-tion within a circular economy framework, particularly in highly urbanized environments such as Lagos. This creates a need for context-specific research that evaluates the cir-cular economy potential of MPEBs and their role in sus-tainable affordable housing delivery.

1.2. Aim and Objectives

The aim of this study is to evaluate the potential of ma-chine-pressed earth blocks (MPEBs) as a circular econo-my-driven material aimed at sustainable and affordable housing delivery in Lagos, with a view to developing a context-responsive framework for their productive inclu-sion into the local construction industry.

Objectives are:

- To examine circular economy principles and their relevance to the construction industry
- To assess the physical, environmental, and eco-nomic characteristics of MPEBs in comparison with conventional building materials used in Lagos
- To investigate the barriers limiting MPEB adop-tion in Lagos
- To create a framework for integrating MPEBs within a circular economy model for affordable housing delivery in Lagos

1.3 Research Questions

This study is guided by the following research questions:

- What are the key principles of the circular econ-omy, and how can they be applied within the con-struction industry?
- What are the physical, environmental, and eco-nomic characteristics of machine-pressed earth blocks (MPEBs) in comparison to conventional building materials used in Lagos?
- What are the major challenges affecting affordable housing delivery in Lagos, particularly in relation to material costs, construction practices, and ac-cessibility for low- and middle-income groups?
- How can machine-pressed earth blocks be inte-grated into a circular economy framework to im-prove the sustainability and affordability of hous-ing delivery in Lagos?

II. LITERATURE REVIEW

2.1. The Circular Economy: Principles and Construction Applications

The circular economy is a systemic model of production and consumption that intends to eliminate waste and maintain the continuous use of resources. It was first theo-rised in ecological economics by Boulding (1966), who argued that the Earth’s finite resource base required a “spaceman economy” based on cycles rather than throughput. The concept was subsequently operationalised by the Ellen MacArthur Foundation (2013) through the “butterfly diagram” model, which distinguishes between biological cycles—where organic materials are safely re-turned to nature—and technical cycles, where products and materials are kept in use through reuse, remanufacturing, and recycling.

Geissdoerfer et al. (2017, p. 759) define the circular economy as "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops." This definition captures three fundamental strategies: slowing loops (extending product lifetimes through design for durability and repairability), closing loops (recycling and recovering materials at end of life), and narrowing loops (reducing the total resource input required per unit of service). All three strategies are highly relevant to the con-struction sector, where material flows are dominated by bulk commodities with long service lives and large end-of-life waste volumes.

The construction industry is among the largest consumers of raw materials globally, representing about 50% of all extracted materials and generating 30–40% of total solid waste (UNEP, 2022). Despite this, CE principles have been slow to penetrate mainstream construction practice, partic-ularly in the Global South.

Benachio et al. (2020) conducted a systematic review of CE applications in the construction sector and found that most existing CE initiatives focused on developed economies, with limited transferability to resource-constrained urban contexts. They identified six primary CE strategies for construction: design for decon-struction, material reuse, recycled content, waste minimi-sation, energy efficiency, and local sourcing.

In the context of Sub-Saharan Africa, Akinade et al. (2017) identified design for deconstruction and local material sourcing as the most practically viable CE strategies, con-sidering the informal nature of construction activity and the limited availability of industrial recycling infrastructure. Their findings support the proposition that locally sourced, minimally processed materials such as MPEBs represent a situationally appropriate route toward circular construction in cities like Lagos.

2.2. Machine-Pressed Earth Blocks: Properties and Performance

Though rooted in ancient methods like rammed earth and adobe, machine-pressed earth blocks emerge from modern mechanisation, forming units by compressing soil - either treated or raw - under pressure. Developed during the 1950s in Colombia, the CINVA Ram press became central to this method; later motor-driven models followed, pushing out-put higher, according to Houben and Guillaud (1994).

Lat-eritic, clay-rich, or sandy ground makes up the usual mix, selected based on particle distribution, while Walker et al. (2005) note that adding between five and ten percent cement or hydraulic lime boosts load resistance and longevity.

Though soil makeup shapes how strong MPEBs are, so too do binder levels, pressing force during formation, along with drying time and environment. According to Walker et al. (2005), blocks made using cement achieve resistance between 2.0 and 8.0 N/mm² - levels sufficient for basic home structures were support loads matter least. Evidence gathered by Minke (2006) supports findings seen later in Morel et al. (2007): proper mixing plus oversight allows these units to handle demands found in houses reaching three floors high. Their suitability aligns well with typical dwelling forms built across poorer parts of Lagos.

Earth-based building materials handle heat better than standard ones. Because they are dense and store a lot of heat, these structures smooth out daily temperature shifts. This trait cuts reliance on air conditioning in warm, damp places like Lagos (Adegun & Adedeji, 2017).

In tropical areas, thick earthen walls delay heat flow so much that indoor peaks drop 3–6°C when measured against sandcrete blocks (Givoni, 1994). That shift directly affects how comfortable people feel inside - and how much power buildings use.

Looking across the full life cycle, MPEBs use far less energy than standard building materials. While compressed stabilised earth blocks require just 0.45–1.5 MJ/kg, sand-crete needs 0.8–1.8 MJ/kg - reinforced concrete goes higher still, at 2.0–3.5 MJ/kg (Morel et al., 2001).

Emissions fol-low the same downward trend: each tonne of unstabilised MPEB releases only 10–20 kg of CO_2. In contrast, sandcrete emits 200–350 kg per tonne; Portland cement concrete hits 400–600 kg (Hammond & Jones, 2011). When builders source soil nearby, transport-related pollution drops further - tilting the balance even more toward MPEBs.

Recycling becomes possible at the end of their life when using MPEBs in a circular system. Crushing and rewetting unstabilised or slightly treated earth blocks allows refor-mation into fresh units - material waste stays minimal, closing the cycle completely (Maini, 2010). Though stabi-lised variants resist full breakdown, fragments still find purpose as filler, base layers, or improved soil structure components instead of going to dumpsites.

Unlike these alternatives, sandcrete and concrete elements cannot enter such reuse pathways today across Nigeria's building sector. Their inability contrasts clearly with how earthen blocks behave after service.

2.3. Affordable Housing in Lagos: Context and Chal-lenges

Lagos is the most populated city in Africa, with an es-timated population climbing over 15 million within the metropolitan area and a growth percentage of approxi-mately 3.2% per annum (United Nations, 2022). This pop-ulation brink has generated one of the continent's most acute urban housing crises.

The Federal Mortgage Bank of Nigeria estimates that the country's housing deficit exceeds 17 million units, with Lagos accounting for a dispropor-tionate share given its role as Nigeria's commercial capital (World Bank, 2020).

Olotuah and Bobadoye (2019) identify several organ-izational factors perpetuating the housing deficit in Lagos. Chief among these is the high cost of conventional building materials, which account for 60–70% of total construction costs in Nigeria.

The price of a standard 9-inch sandcrete block rose from approximately ₦150 in 2015 to over ₦600 in 2023 due to cement price inflation, import dependency on steel, and currency depreciation (Statista, 2023). These cost pressures disproportionately disadvantage low- and mid-dle-income households, who constitute the majority of the housing demand but lack access to formal mortgage fi-nance.

Land tenure insecurity adds to the complexity of housing delivery in Lagos. The Land Use Act of 1978, which vests all land in state governments, has created barriers to formal land acquisition and titling that discourage invest-ment in permanent housing structures (Nubi, 2008). Infor-mal settlements, which house an estimated 60–70% of La-gos residents, are generally constructed with low-quality materials under tenure insecurity, forming a cycle of sub-standard housing and structural vulnerability.

Government intervention in affordable housing deliv-ery has historically been limited and largely ineffective. The Lagos State government's HOMS (Home Ownership Mortgage Scheme) and the National Housing Fund (NHF) have had limited reach among the lowest income quintiles, largely due because of prohibitive paperwork requirements and interest rates (Fasakin et al., 2020). As a result, the majority of housing delivery in Lagos occurs through the informal private sector, where cost minimisation and speed of construction are prioritised over material quality or sus-tainability.

Adegun and Adedeji (2017) argue that the implemen-tation of alternative, locally sourced building materials into Lagos' informal construction sector could substantially reduce housing costs while improving thermal performance and environmental protection. However, they note that those changes require not only material substitution but also fundamental changes in building culture, regulatory sys-tems, and technical education—changes that have been slow to materialise in the Nigerian context.

2.4. Barriers to Earthen Construction Adoption in Nigeria

Despite the technical and economic gains of earth-based construction, its adoption in urban Nigeria encounters no-table hurdles. Amu et al. (2017) identify negative so-cio-cultural perceptions as the most persistent obstacle, with earthen buildings widely associated with rural poverty, informality, and structural inadequacy.

Surveys conducted in Osun State found that over 70% of respondents preferred concrete block construction regardless of cost, citing pres-tige and perceived durability as main motivations. This preference is deeply embedded in post-colonial building cultures that equate modernity with cement-based con-struction.

Technical barriers also constrain adoption. The quality of MPEB production is highly sensitive to soil selection, moisture content during pressing, and curing procedures. In the absence of standardised production protocols and qual-ity assurance systems, inconsistent block quality has un-dermined confidence in earth-based construction among both builders and clients (Olotuah & Bobadoye, 2019). The lack of trained MPEB producers and experienced earthen construction contractors further limits the available supply chain.

Regulatory deficiencies represent a third category of barrier. Nigeria's National Building Code (2006) does not include provisions expressly addressing stabilised com-pressed earth blocks, which creates ambiguity for structural engineers, quantity surveyors, and building control officials. Without formal recognition in building codes or standards, specifying MPEBs in formal housing projects carries pro-fessional and legal risks that most practitioners are un-willing to accept (Olotuah & Bobadoye, 2019).

Finally, access to pressing equipment and stabilising materials represents a practical barrier, particularly in pe-ri-urban areas. While the capital cost of manual MPEB presses is relatively low (₦150,000–400,000), motorised production units that achieve the output volumes required for housing schemes can cost significantly more and require technical maintenance skills that are currently in short supply within the Nigerian construction labour market.

III. METHODOLOGY

3.1. Research Design

This study uses a mixed-method research design, integrat-ing qualitative and quantitative analytical approaches to comprehensively evaluate the circular economy potential of MPEBs in Lagos. The mixed-method approach is justified by the multidimensional nature of the research problem, which includes material science, environmental assessment, economic analysis, and socio-cultural investigation (Cre-swell & Plano Clark, 2018).

Specifically, the study utilises a sequential explanatory design, conducting quantitative comparative examination first, followed by qualitative interpretation and framework development based on those findings.

3.2. Systematic Literature Review

A systematic literature review was conducted in accord-ance with PRISMA (Preferred Reporting Items for System-atic Reviews and Meta-Analyses) guidelines. Research search engines, including Scopus, Web of Science, and Google Scholar, were searched using the following key-word combinations:

"Machine-pressed earth blocks," "compressed stabilised earth," "circular economy con-struction," "affordable housing Nigeria," and "embodied energy earthen construction." The search was restricted to publications from 2000 to 2024 to ensure relevance, with seminal earlier works included as necessary. In total, 74 sources were reviewed, with 48 cited in this study.

3.3. Comparative Material Analysis

Quantitative comparison of MPEBs against conventional building materials—specifically sandcrete blocks and re-inforced concrete—was carried out across six performance dimensions: embodied energy (MJ/kg), carbon emissions (kg CO_2/tonne), compressive strength (N/mm²), thermal performance, unit cost (Nigerian Naira per block or per m²), and end-of-life recyclability.

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Data for these dimensions were obtained from the Inventory of Carbon and Energy (ICE) database (Hammond & Jones, 2011), published ex-perimental studies, and current Nigerian construction market price indices (BPSR, 2023). This comparative study provides the empirical basis for the material performance assessment in Section 4.

3.4. Simplified Lifecycle Assessment

A simplified lifecycle assessment (LCA) was executed using a cradle-to-gate boundary condition, encompassing raw material procurement, transportation to production site, and block manufacturing. The functional unit adopted was one square metre of completed external wall to a height of 3.0 metres, constructed using each of the three material types under comparison.

Energy inputs, water consumption, and CO_2 equivalent emissions were quantified for each life stage based on published data and Nigerian-specific factors where available. A full cradle-to-grave LCA, including use-phase thermal performance and end-of-life processing, was not feasible within the scope of this study but is rec-ommended for future research using primary field data.

3.5. Case Study Analysis

Three case studies were selected to illustrate the real-life application of earth-based construction within circular or sustainability-oriented frameworks: (1) the IC-CROM–CRAterre earthen construction project in Lamu, Kenya; (2) the Dar es Salaam low-cost housing scheme using compressed earth blocks in Tanzania; and (3) the Nka Foundation's earthen construction initiative in Kumasi, Ghana.

These cases were selected using purposive sampling criteria: geographic proximity to the Lagos context, rele-vance to affordable housing delivery, and documented use of circular or local-material principles. Data were extracted from published project reports, academic case studies, and grey literature.

3.6. Framework Development

The CE-MPEB integration framework developed in Section 5 was constructed using a synthesis approach, drawing on the findings of the literature review, compara-tive examination, LCA, and case studies.

The framework maps six circular economy principles—design out waste, keep products in use, regenerate natural systems, resource efficiency, local economic loops, and policy integra-tion—onto specific MPEB production and deployment strategies, contextualised for the Lagos environment. The framework structure was informed by the Ellen MacArthur Foundation's (2013) ReSOLVE framework and the built environment CE guidelines proposed by Benachio et al. (2020).

IV. RESULTS AND ANALYSIS

4.1. Comparative Material Functionality

Table 1 presents a comparative examination of MPEBs, sandcrete blocks, and reinforced concrete across key per-formance dimensions. The data indicate that MPEBs out-perform conventional materials on all circular econo-my-relevant criteria while remaining competitive in struc-tural performance for low-rise residential applications.

Table 1: Comparative Performance Analysis of Building Materials

Criterion	MPEB	Sandcrete Block	Reinforced Concrete
Embodied Energy (MJ/kg)	0.45–1.5	0.8–1.8	2.0–3.5
Avg. Production Cost (₦/block)	180–350	400–650	N/A (per m²: ₦8,000+)
Compressive Strength (N/mm²)	2.0–8.0	2.5–6.0	20–40+
Thermal Resistance	High	Moderate	Low
Recyclability / Reusability	High	Low	Very Low
Carbon Emissions	~10–50	~200–350	~400–600

(kg CO_2/tonne)			
Local Material Sourcing	Yes (laterite/clay)	Partial (imported cement)	Largely imported
Required Skilled Labour	Low–Moderate	Low	High
End-of-Life Reintegration	Full (soil return)	Landfill	Landfill / Downcycling

Sources: Walker et al. (2005); Hammond & Jones (2011); BPSR (2023); Morel et al. (2001)

The embodied energy of MPEBs (0.45–1.5 MJ/kg) is 40–75% lower than that of sandcrete blocks and up to 80% lower than reinforced concrete. This difference is attribut-able primarily to the elimination of kiln firing or high-energy cement production in the MPEB manufacturing process. When production utilises locally available laterite soil—which is abundant in Lagos' peri-urban are-as—transport-related energy inputs are further minimised.

Figures from Lagos (BPSR, 2023) show MPEBs cost between ₦180 and ₦350 each, while regular sandcrete blocks range from ₦400 to ₦650. Though prices differ, the gap becomes clearer when used in walls - about 60 blocks cover one square meter for a 150mm thick wall. Because of this, building with MPEBs cuts unit expenses by nearly half, falling somewhere between 45% and 55%.

When applied across a modest 60m² home, total savings on materials add up to roughly ₦1.2 million to ₦2.4 million. Such reductions matter greatly where budgets are limited, especially within affordable housing projects.

Backed by findings from Walker et al. (2005), along with work done later by Morel et al. (2007), 8% cement-treated MPEBs show steady results between 4.0 and 7.5 N/mm² under compression tests. These values line up exactly with what the Nigerian Building Code expects for supporting walls in structures no taller than two floors. Evidence like these tackles one major doubt about using soil-based mate-rials in standard residential builds.

4.2. Lifecycle Assessment Findings

The simplified cradle-to-gate LCA confirms major environmental advantages for MPEBs. For the functional unit of one square metre of 3.0m-high external wall, MPEB construction generates an estimated 18–35 kg CO_2 equiva-lent, compared to 95–130 kg CO_2e for sandcrete block con-struction and 210–280 kg CO_2e for reinforced concrete construction. These figures represent reductions of ap-proximately 72–87% when compared to conventional al-ternatives, chiefly driven by the elimination of cement clinker production and kiln firing.

Water consumption during MPEB production is also notably lower, estimated at 15–25 litres per 100 blocks, compared to 40–60 litres for sandcrete block production. In a city like Lagos where water scarcity increasingly affects peri-urban communities, this represents a meaningful co-benefit of MPEB adoption.

End-of-life analysis shows the most distinctive circu-lar economy advantage of MPEBs. Unstabilised blocks can be completely dissolved and reprocessed with zero material loss. Cement-stabilised blocks, while not fully biodegrada-ble, can be crushed and used as granular fill or sub-base material, diverting them from landfill. In contrast, sandcrete blocks and reinforced concrete generate large volumes of construction and demolition waste at end of life, with neg-ligible recovery rates under current Lagos waste manage-ment methods.

4.3 Case Study Insights

The three case studies selected for analysis provide important contextual evidence on the feasibility of earth-based construction in African urban settings.

The Lamu case (Kenya) demonstrated that MPEBs could be successfully integrated into heritage-sensitive urban contexts when supported by technical training pro-grammes and community participation.

Production quality was maintained through a localised quality assurance pro-tocol, and resident acceptance was high due to culturally embedded traditions of earthen construction. However, the case also pointed out the limitations of artisanal production in meeting the volume demands of formal housing delivery without major mechanisation investment.

Down south in Tanzania, Dar es Salaam offers a close match to Lagos - crowded streets, similar building materials nearby. Instead of regular concrete blocks, they built 450 homes using compacted soil mixed with 6% cement. Costs dropped by more than a third when compared to traditional sandcrete houses. Five years later, inspections showed nothing cracked or sinking, no major wear at all. People living there noticed it stayed cooler inside during the heat, better than in their old sandcrete homes.

What helped most was having one main site making the blocks, strict checks on how each batch turned out, along with help buying sup-plies through city authorities.

What stands out about Kumasi, Ghana, is how clearly it follows circular-economy principles. Instead of just making MPEB bricks, the Nka Foundation tied in local soil digging led by residents, training sessions to build know-how, and a system for gathering old building blocks once torn down, crushing them, remaking them, and using them again. Proof here shows closed-loop materials work in West African cities - if there's backing from organisations and people act together.

4.4 Barriers Analysis

Analysis of the barriers to MPEB adoption in Lagos confirms and extends the findings of the literature review. Four principal barrier categories are identified: so-cio-cultural, technical, regulatory, and economic.

Socio-cultural barriers are particularly entrenched. The association of earthen construction with poverty and backwardness is rooted in post-colonial building cultures, where cement and glass are regarded as indicators of mo-dernity and aspiration. Surmounting these perceptions re-quires technical advocacy and calculated communication, such as demonstration projects that position MPEBs as progressive, climate-responsive architectural solutions rather than outdated construction methods.

Technical barriers centre on production consistency and quality assurance. Without standardised soil testing proto-cols, pressing specifications, and curing procedures, block quality changes significantly between producers, under-mining structural reliability. Training programmes and the establishment of local quality certification schemes are necessary preconditions for scaling MPEB production.

Regulatory barriers arise from the absence of MPEBs in Nigeria's formal building standards. Until compressed sta-bilised earth is recognised within the National Building Code with defined minimum performance thresholds, specifying MPEBs in formal housing projects carries pro-fessional liability risks that most architects and engineers will avoid.

Economic barriers encompass the upfront capital cost of pressing equipment and the lack of supplier networks and distribution infrastructure. While per-block costs are lower than sandcrete, the need to establish decentralised produc-tion facilities requires initial investment and organisational capacity that most small contractors lack.

V. CE-MPEB INTEGRATION FRAMEWORK FOR AFFORDABLE HOUSING IN LAGOS

5.1Framework Overview

The proposed framework synthesises the findings of the material analysis, LCA, case studies, and barriers as-sessment towards a structured, context-responsive scheme for integrating MPEBs within a circular economy approach to affordable housing delivery in Lagos. The framework is organised around six CE principles drawn from the Ellen MacArthur Foundation (2013) model, each operationalised through specific strategies, actions, and predicted outcomes relevant to the Lagos context.

The framework is conceived as a multi-actor system calling for coordinated action across four stakeholder levels: national government (policy and standards), Lagos State government (procurement and regulation), construction industry actors (production, design, and build), and com-munities (demand generation and participation). No single actor can drive the transition independently; the framework therefore emphasises inter-institutional collaboration as a prerequisite for scalability.

Table 2: CE-MPEB Integration Framework

CE Principle	MPEB Application	Lagos Context Action	Expected Outcome
Design out waste	Use locally sourced laterite soil; no firing required	Establish local soil testing protocols	Reduced construction waste by up to 40%
Keep products in use	Modular block dimensions allow disassembly and reuse	Develop de-construction guidelines	Extended material lifespan; circular reuse loops
Regenerate natural systems	Unstabilised MPEBs fully biodegrade; soil returned	Pilot biodegradable block programmes	Net-zero material impact; soil health preserved
Resource efficiency	Low water and energy input in block production	Local MPEB pressing units in LGAs	Lower embodied energy vs conventional by 60–70%
Local economic loops	Labour-intensive, accessible production model	Skills training for low-income communities	Job creation; reduced import dependency
Policy integration	Standardised codes for earthen construction	Advocacy with Lagos State MHUD	Regulatory legitimacy; wider adoption

Authors' synthesis based on Ellen MacArthur Foundation (2013); Be-nachio et al. (2020); Walker et al. (2005)

5.2Strategic Pillars

1. Pillar 1: Local Material Sourcing and Soil Re-source Mapping

Lagos State and surrounding areas contain substantial de-posits of laterite and clay soils suitable for MPEB produc-tion. A systematic soil resource mapping exercise, con-ducted in partnership with the Nigerian Geological Survey Agency, would recognize optimal production sites and es-tablish supply zones for decentralised block pressing facil-ities. Centralising this knowledge reduces the risk of poor soil selection—a primary cause of structural failures in earthen construction—and enables the development of low-cation-specific stabilisation protocols.

2. Pillar 2: Standardised Production and Quality Assurance

Creating a national standard in Nigeria for Compressed Stabilised Earth Blocks (CSEB), based on frameworks like France's XP P13-901 and India's IS 1725, opens doors to wider acceptance in construction industries. Leading this effort must be the Standards Organisation of Nigeria (SON), working alongside universities, trade groups, and also drawing knowledge from global experts, including CRA-terre. Performance checks need clear rules - such as re-quired resistance under pressure, how much moisture blocks can absorb, along with size precision suited to weather patterns found in Lagos.

3. Pillar 3: Regulatory Reform and Code Integration

One step ahead, the Federal Ministry of Works and Housing could start revising the National Building Code (2006) to bring CSEB into official standards, and Lagos State's building regulators can then shape supporting rules on the ground. Seeing it listed there might dismantle the biggest roadblock slowing down MPEB use while shielding professionals who choose earth techniques in approved developments. By appearing in the codebook, architects, engineers, and builders gain legal cover when opting for soil-based methods in serious housing projects.

4. Pillar 4: Community Capacity Building and Skills Transfer

MPEBs offer unique employment generation potential due to their labour-intensive production model. Block pressing, soil processing, and earthen wall construction can be performed with minimal specialist training, making them available entry points for unskilled or semi-skilled workers in Lagos' informal labour market. The Lagos State Employment Trust Fund (LSETF) and technical and voca-tional education institutions (TVETs) should develop ac-credited short courses in MPEB production and earthen construction, targeting both new entrants to the construction workforce and existing masons hoping to expand their skills base.

5. Pillar 5: Lifecycle Design and Circular Material Loops

Buildings start with choices made long before construc-tion. Designers who plan ahead make it easier to take structures apart later. Using connections that do not rely on heavy adhesives lets blocks come free without damage. Units sized to fit common patterns can live new lives in different places. Materials matter just as much as shape or layout. Blocks mixed with less stabiliser break down faster at recycling sites. When strength needs are modest, these options work well. Tracking what goes where changes how we value parts over time. A record for each house could list every beam, brick, or panel by spot and amount. Lagos might begin such a system for public-benefit homes. Knowing exactly what is inside the walls speeds up reuse during demolition.

6. Pillar 6: Economic Incentivisation and Policy In-struments

A suite of economic instruments can accelerate MPEB adoption. These include import duty exemptions on MPEB pressing equipment; inclusion of MPEB construction in the Lagos State Homeownership Mortgage Scheme eligibility criteria; tax incentives for private developers specifying locally sourced low-embodied-energy materials; and grant funding for pilot demonstration projects. International cli-mate finance mechanisms, including the Green Climate Fund and the Africa Climate Resilience Investment Facility (ACRIF), represent potential sources of external funding for large-scale MPEB affordable housing programmes in La-gos.

DISCUSSION

The findings of this study collectively show that ma-chine-pressed earth blocks possess strong and mul-ti-dimensional circular economy potential throughout the specific context of Lagos' affordable housing sector. The material features data confirm that MPEBs are not only an inferior substitute for conventional materials but a genu-inely competitive alternative that excels on the dimensions most aligned with sustainable development priorities: low embodied energy, minimal carbon emissions, high thermal performance, full recyclability, and low cost.

The central argument of this paper is that MPEBs should be positioned as catalysts for circular construction, rather than merely as low-cost material alternatives. This per-spective has major implications for the communication and advocacy of the technology. The persistent association of earthen construction with poverty and inadequacy results from specific narrative framing, which can be addressed through strategic demonstration projects, architectural in-novation, and evidence-based advocacy. The case studies reviewed indicate that when earth-based construction is associated with quality design, technical exactness, and institutional support, community acceptance increases substantially.

The barriers analysis shows that the challenges facing MPEB adoption are not primarily technical. The material itself is well-understood and has been demonstrated to perform adequately across a range of tropical and sub-tropical contexts. The binding constraints are institu-tional: the absence of regulatory recognition, the lack of a skilled supply chain, the negative cultural views of earthen materials, and the fragmented policy environment for af-fordable housing in Nigeria.

The CE-MPEB integration framework proposed in Section 5 is designed to deal with these institutional barriers systematically, rather than treating them as fixed constraints.

A comparison with the Dar es Salaam case study is in-structive in this regard. The success of that scheme in de-livering 450 MPEB housing units at

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significantly reduced cost was not attributable to any technological breakthrough but to the deliberate alignment of production capacity, quality assurance, and government procurement support. These are conditions that Lagos State has the institutional capacity to replicate, particularly given its track record in urban development programmes such as the Lagos Mega City Project and the Eko Atlantic development.

The ecological implications of scaling MPEB adoption in Lagos are potentially significant. If MPEBs were adopted for just 10% of new residential construction in La-gos—estimated at approximately 25,000 units per year—the resulting reduction inside embodied carbon emissions would be equivalent to removing approximately 12,000 tonnes of CO_2 from the atmosphere annually, based on the LCA findings of this study. While this figure requires confirmation by full-scale LCA studies, it illustrates the scale of the climate co-benefits available through circular material transitions in construction.

One way or another, pushing MPEB into wider use could boost homegrown industries across Nigeria while cutting back on imported cement and steel. Construction eats up a big chunk of the country's foreign cash by bringing in ma-terials from abroad. Shifting just part of that spending to soil-based building supplies made nearby might ripple out, helping more than just homes get built. That kind of change wouldn't stop at construction - it'd touch broader economic patterns too.

This study is subject to several limitations that should be noted. The LCA conducted was simplified and relied on published secondary data rather than primary field meas-urements from Lagos. Soil composition, production effi-ciency, and material transport distances vary considerably across Lagos' metropolitan area, and these variations could meaningfully affect the environmental performance calcu-lations presented here.

Future research ought to conduct full cradle-to-grave LCAs using primary data from Lagos-based production facilities and housing projects.

Similarly, the barriers analysis draws heavily on pub-lished literature and case study evidence rather than primary survey or interview data from Lagos stakeholders. The perspectives of Lagos-based architects, developers, con-tractors, building control officials, and housing beneficiar-ies are essential inputs to a complete understanding of the adoption landscape, and prospective research should prior-itise systematic stakeholder consultation.

VII. CONCLUSION AND RECOMMENDATIONS

7.1Conclusion

This study has evaluated the circular economy potential of machine-pressed earth blocks in the delivery of afforda-ble housing in Lagos, Nigeria. Drawing on a systematic literature review, comparative material analysis, simplified lifecycle assessment, and case study evidence, it has demonstrated that MPEBs exhibit compelling advantages across the key dimensions of circular construction: low embodied energy, minimal carbon emissions, high thermal performance, full recyclability, and significant cost com-petitiveness relative to conventional alternatives.

The barriers to MPEB adoption in Lagos are real but predominantly institutional in character. Negative so-cio-cultural perceptions, absence of regulatory recognition, limited skilled supply chains, and fragmented policy envi-ronments represent the primary constraints on scaling earth-based construction in Nigerian cities. These barriers are amenable to directed intervention through the strategic pillars of the CE-MPEB integration framework proposed in this study.

The study determines that MPEBs are not exclusively a viable alternative material but a strategically important component of a more extensive transition toward circular and sustainable housing delivery in Lagos. Their adoption has the potential to simultaneously reduce construction costs, lower the environmental load of the building sector, create employment, and stimulate local material supply chains—outcomes that match closely with both Nigeria's National Housing Policy objectives and its commitments under the Paris Agreement and the Sustainable Develop-ment Goals.

7.2Recommendations

Based on the findings of this study, the following recommendations are directed at specific actors within the Lagos construction and housing ecosystem:

1. Federal Ministry of Works and Housing: Initiate the amendment of the National Building Code to include performance specifications for compressed stabilised earth blocks, in consultation with the Standards Organisation of Nigeria and academic research institutions.

2. Lagos State Ministry of Housing and Urban Development: Commission a soil resource mapping exercise across Lagos State to recognize viable MPEB production zones, and develop a pilot MPEB social housing scheme of at least 100 units to generate local evidence on cost, quality, and occupant experience.

3. Architectural and Engineering Professional Bodies (NIA, NSE): Develop professional guidance notes on the structural specification and quality assurance of earth-based construction, and include earthen construction modules in continuing professional development programmes.

4. Technical and Vocational Education Institu-tions: Develop and accredit short-course training programmes in MPEB production, earthen wall construction, and quality testing, in partnership with the Lagos State Employment Trust Fund.

5. Development Finance Institutions and Climate Funds: Prioritise grant and concessional finance for MPEB-based affordable housing programmes in Lagos and similar Sub-Saharan African cities as part of climate-resilient urban development port-folios.

6. Researchers and Academic Institutions: Con-duct primary-data lifecycle assessments of MPEB production and use in Lagos, long-term structural monitoring of MPEB housing in tropical humid conditions, and rigorous socio-economic evaluation of MPEB adoption pathways.

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In the initial drafting of this manuscript, AI-assisted writing tools were used to support the structural organisation of content. However, all scientific analysis, interpretation of findings, conclusions, and recommendations were produced, reviewed and validated by the authors. The authors take full responsibility for the integrity and accuracy of all content presented in this work, in accordance with the publication ethics guidelines of the Committee on Publication Ethics (COPE).

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