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ASSESSMENT OF THE USE OF SUSTAINABLE LOCAL BUILDING MATERIALS AS AN ALTERNATIVE TO CONVENTIONAL MATERIALS FOR LOW-COST HOUSING IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

This study assessed the use of sustainable local building materials (SLBMs) as alternative to conventional materials for low-cost housing in Cross River State, Nigeria. Nigeria has a housing deficit of 28 million units, with over 70% living in substandard housing. In Cross River State, high cost of conventional materials accounting for 50-65% of construction cost is the major barrier, with cement rising from N2,500 in 2018 to over N10,000 in 2025.The study adopted literature review and was anchored on Sustainable Development and Appropriate Technology theories. Findings show Cross River State is abundantly endowed with SLBMs: laterite for Compressed Stabilized Earth Blocks (CSEB) as alternative to sandcrete blocks, clay for burnt bricks, timber and bamboo in Yakurr, Abi and Boki as alternative to steel, raffia palm/thatch as alternative to aluminium roofing sheets, palm kernel and periwinkle shells from Bakassi and Calabar South as alternative to granite, and rice husk ash from Ogoja/Yala as partial replacement for cement.SLBMs reduce cost by 30-50% with 60% savings in transportation, create local employment, provide 3-5°C thermal comfort and 80-90% lower embodied energy. One bag of cement produces 70-80 CSEB against 35-40 sandcrete blocks. Challenges include negative perception, lack of standards and building codes, low awareness, durability issues and lack of mortgage.Strategies recommended include awareness campaigns and demonstration houses, inclusion in building codes, government incentives, training in UNICROSS/CRUTECH and establishment of production clusters. The study concludes SLBMs are viable alternative for affordable housing in CRS.

Keywords:Assessment, Sustainable, Local Building Materials, **Conventional Materials & Low-Cost**

INTRODUCTION

The world is currently facing a growing urban and rural housing crisis, with developing nations being the worst hit. Rapid population growth, rural-urban migration and unplanned urbanization have created unprecedented demand for decent and affordable housing. Globally, it is estimated that over 1.6 billion people live in inadequate housing, with about 100 million homeless, according to UN-Habitat (UN-Habitat, 2020). In Africa, the housing crisis is more pronounced due to high poverty level, poor planning and weak housing policies (Olotuah&Bobadoye, 2018).

In Nigeria, the housing deficit is alarming and has become a major national development challenge. Nigeria, with a population of over 220 million people and annual population growth rate of about 3.2 percent, has one of the largest housing deficits in the world. According to the Federal Mortgage Bank of Nigeria (FMBN) and National Bureau of Statistics (2023), the country's housing deficit stands at

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about 28 million units, and the nation needs to produce about 700,000 to 1 million housing units annually to bridge the gap. Over 70 percent of Nigerians live in substandard, overcrowded and unhygienic housing conditions, especially in urban slums and rural communities (Amao&Ilesanmi, 2019). The situation is worse for low-income earners who cannot afford decent accommodation. In Cross River State, the housing deficit is also critical, with high demand in Calabar, Ikom, Ogoja, Ugep and other growing towns due to tourism, commerce and population growth. Many families live in rented apartments with high rents, while those who attempt to build personal houses abandon their projects due to high cost (Adedeji, 2018).

The major factor responsible for high cost of building and inability of low-income earners to afford decent housing is the high and ever increasing cost of conventional building materials. Conventional building materials are factory made, energy intensive and capital intensive materials that dominate modern construction. These include imported or factory-made cement used for production of sandcrete blocks, steel reinforcement bars, aluminum roofing sheets, glass, ceramic tiles, granite and other synthetic finishing materials (Windapo&Rotimi, 2017). Studies have shown that conventional building materials account for about 50 percent to 65 percent of the total cost of a construction project. This means that more than half of building cost goes to materials alone (Windapo&Rotimi, 2017; Ogunbayo et al., 2018).In recent years, inflation, high cost of energy, foreign exchange pressures and high cost of transportation have made these materials increasingly unaffordable for low-income earners. For instance, the price of a 50kg bag of cement which sold for less than N2,500 in 2018 has risen to over N9,000 to N10,000 in Cross River State in 2025 (Ogunbayo et al., 2018).

Similarly, the price of steel reinforcement bars, aluminum roofing sheets, tiles and paints have increased by over 200 percent. As a result, the cost of a modest three bedroom bungalow has risen from about N4 million to over N15 million, making it impossible for civil servants, farmers and artisans in Cross River State to build their own houses. Even government sponsored low-cost housing schemes have failed because they still rely heavily on these expensive conventional materials, making the final cost beyond the reach of target beneficiaries (Adedeji, 2018).

The Shift to Sustainable Local Building Materials (SLBMs):Due to the unaffordability of conventional materials and need for environmental sustainability, there is a global shift towards sustainable local building materials (SLBMs) as alternative for low-cost housing (Nduka&Sotunbo, 2021). Sustainable local building materials are environmentally friendly, renewable, locally sourced, affordable and energy efficient materials with low embodied energy. Embodied energy refers to total energy consumed in extraction, production and transportation of materials (Nduka&Sotunbo, 2021). SLBMs consume less energy and produce less carbon dioxide emission compared to conventional materials, thereby promoting green building and climate change mitigation (Ogunbayo et al., 2018).

Nigeria, and Cross River State in particular, is abundantly blessed with a wide range of sustainable local building materials that can be harnessed for low-cost housing. These include laterite which is available in almost all parts of the state for production of stabilized earth blocks and compressed earth blocks, timber from its vast forest reserves, clay soil for production of burnt bricks, bamboo which is abundantly available in Yakurr, Abi, Etung and Boki areas and has high tensile strength comparable to steel (Olotuah&Bobadoye, 2018), raffia palm and thatch for roofing, palm kernel shells and periwinkle shells from coastal areas of Bakassi, Akpabuyo and Calabar South which can be used as partial replacement for granite in concrete, rice husk from rice farms in Ogoja and Yala which produces rice husk ash that can partially replace cement, granite dust and other agricultural wastes (Adedeji,

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2018).These materials have been proven to be cost-effective, reducing construction cost by 30 to 50 percent, durable when improved with modern technology, thermally comfortable as they provide cool indoor environment during the day and warm at night unlike sandcrete block houses which are hot, environmentally friendly, and capable of creating employment for local artisans (Nduka&Sotunbo, 2021).

Countries like India, Tanzania and Ghana have successfully used improved SLBMs for modern housing estates (Windapo&Rotimi, 2017). However, despite these benefits, the use of SLBMs in Cross River State remains low due to low awareness, negative perception as materials for the poor, lack of standards and lack of government policy (Amao&Ilesanmi, 2019). It is against this background that this study seeks to assess the use of sustainable local building materials as an alternative to conventional materials for low-cost housing in Cross River State, Nigeria.

LITERATURE REVIEW

2.1CONCEPTUAL CLARIFICATIONS

This section clarifies key concepts used in this study to ensure proper understanding.

2.1.1 Sustainable Local Building Materials (SLBMs)Sustainable Local Building Materials are building materials that are sourced within the immediate locality or environment, renewable, affordable, energy efficient, environmentally friendly and culturally acceptable (Nduka&Sotunbo, 2021). According to Adedeji (2018), they are materials with low embodied energy, meaning they consume less energy in their extraction, production and transportation, and have low carbon emission.Examples of SLBMs in Cross River State include:

a) Laterite / Stabilized Earth Blocks - Soil with iron and aluminum oxides

b) Compressed Stabilized Earth Blocks (CSEB)

c) Burnt Clay Bricks

d) Timber

e) Bamboo

f) Raffia Palm / Thatch

g) Palm Kernel Shells (PKS) and Periwinkle Shells

h) Rice Husk Ash (RHA)

i) Granite Dust / Quarry Waste

These materials are proven to reduce construction cost by 30-50% (Windapo&Rotimi, 2017).

2.1.2 Conventional Building Materials

Conventional building materials are industrially manufactured, energy intensive, capital intensive and often imported materials that dominate modern construction (Ogunbayo et al., 2018). They include Ordinary Portland Cement, sandcrete blocks, steel reinforcement bars, aluminum roofing sheets, glass, ceramic tiles, granite and paints. They are durable but expensive and environmentally degrading. Cement production alone accounts for about 8% of global CO2 emission (UN-Habitat, 2020).

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2.1.3 Low-Cost Housing

Low-cost housing is defined as housing that is affordable and within the economic reach of low and medium income earners, whose income is below median income (Amao&Ilesanmi, 2019). According to Olotuah and Bobadoye (2018), low-cost housing is housing that costs not more than 30% of household income and meets minimum standards of adequacy in terms of floor area, ventilation, infrastructure and durability. Low-cost does not mean substandard, but means cost reduction through use of local materials, efficient design and appropriate technology.

2.1.4 Sustainability in Construction

Sustainability in construction refers to construction that meets the needs of the present without compromising the ability of future generations to meet their own needs. It is based on three pillars: environmental sustainability, economic sustainability and social sustainability (Ogunbayo et al., 2018). Sustainable construction advocates use of renewable materials, energy efficiency, waste reduction and protection of natural resources.

2.1.5 Embodied Energy

Embodied energy is the total energy required for extraction, processing, manufacturing, transportation and installation of building materials (Nduka&Sotunbo, 2021). SLBMs have low embodied energy compared to conventional materials which have high embodied energy.

2.2 THEORETICAL REVIEW

This section reviews relevant theories that underpin this study.

2.2.1 Theory of Sustainable Development

The Theory of Sustainable Development was propounded by the Brundtland Commission in 1987 in the report titled "Our Common Future". The theory states that development should meet the needs of the present without compromising the ability of future generations to meet their own needs. It emphasizes integration of environmental protection, economic growth and social equity.This theory is relevant because use of SLBMs promotes all three pillars of sustainability. Environmentally, it reduces carbon emission, deforestation and energy consumption. Economically, it reduces construction cost and promotes local economy by creating jobs for local artisans. Socially, it preserves cultural identity and provides affordable housing for all. This study therefore anchors on this theory to advocate shift from conventional to sustainable local materials.

2.2.2 Appropriate Technology Theory

The Appropriate Technology Theory was developed by Economist Dr. E.F. Schumacher in his book "Small is Beautiful" (1973). The theory advocates for technology that is small-scale, decentralized, labour-intensive, energy-efficient, environmentally sound and locally controlled. It argues that technology should be appropriate to the local context, culture, economic capability and available resources.This theory is highly relevant to this study because SLBMs represent appropriate technology for Cross River State. Production of stabilized earth blocks, clay bricks, bamboo housing does not require heavy machinery or huge capital but can be done with simple machines and local labour. It is appropriate to the economic status of low-income earners in the state.

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2.2.3 Theory of Housing Affordability - Engel's Law of Housing

This theory by Victor Olgyay (1963) and Baruch Givoni states that buildings should be designed to respond to local climate to achieve human thermal comfort with minimal energy. Buildings with high thermal mass and natural ventilation provide better comfort.Conventional sandcrete block houses in Cross River State are thermally uncomfortable - hot during day due to low thermal mass. SLBMs like earth blocks, clay bricks and thatch have high thermal mass and provide cool indoor environment, reducing need for air conditioning and energy consumption (Adedeji, 2018).

2.3 TYPES OF SUSTAINABLE LOCAL BUILDING MATERIALS IN CROSS RIVER STATE AS ALTERNATIVE TO CONVENTIONAL MATERIALS

Cross River State is abundantly endowed with sustainable local building materials that can serve as alternative to expensive conventional materials. These materials are discussed below according to their uses:

LATERITE AND STABILIZED EARTH BLOCKS AS ALTERNATIVE TO SANDCRETE BLOCKS FOR LOW-COST HOUSING IN CROSS RIVER STATE

i. Definition and Nature of Laterite:Laterite is a highly weathered, iron and aluminium oxide-rich soil, reddish-brown in colour, formed under hot and wet tropical conditions. It is abundant in Cross River State due to high rainfall of 3000mm and tropical rainforest climate (Adedeji, 2018). Laterite is found in all 18 Local Government Areas of CRS, especially in Akamkpa, Odukpani, Biase, Yakurr, Obubra, Ikom, Boki, Ogoja and Yala with depth of 1-10 meters.Geotechnically, laterite in CRS is classified as A-2-6 and A-2-7 soil, with good bearing capacity, moderate plasticity and high dry density. It contains kaolinite clay, quartz, goethite and hematite which give it self-hardening property when exposed to air (Nduka&Sotunbo, 2021).

ii. Why Laterite is Not Used Directly - Need for Stabilization:Raw laterite or mud blocks (Atakpa) used traditionally in CRS have three major weaknesses:
   a. Low compressive strength - less than 1 N/mm2
   b. High water absorption - absorbs water and erodes during heavy rain in Calabar
   c. Shrinkage and crackingTherefore, it must be STABILIZED to improve strength, durability and water resistance (Windapo&Rotimi, 2017).

3 Stabilization Methods:

i. Cement Stabilization (Most Common): 5-8% Ordinary Portland Cement is mixed with laterite. Cement reacts with water to bind soil particles. This is best for CRS because it is available and cheap. Produces Compressed Stabilized Earth Blocks (CSEB).
ii. Lime Stabilization: 3-6% lime is used, good for clayey laterite in Ogoja area.
iii. Bitumen Stabilization: For waterproofing.
iv. Chemical Stabilization with Rice Husk Ash (RHA): 10-20% RHA + 5% cement gives good strength and reduces cement content (Adedeji, 2018).

4. Types of Stabilized Earth Blocks in Cross River State:

Compressed Stabilized Earth Blocks (CSEB): Produced by compressing stabilized laterite with manual or hydraulic press like CINVA-Ram, Hydraform or Makiga press. Size: 295mm x 140mm x 90mm.

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Compressive strength: 2.5-5 N/mm2 which meets NIS standard for bungalows. This is higher than sandcrete blocks sold in Calabar which have only 1.5-2.0 N/mm2 due to sharp practices.

i. Interlocking Stabilized Earth Blocks (ISEB): Improved version of CSEB with grooves and interlocks, does not require mortar for laying, dry-stacks like Lego.
ii. Reduces cement and sand for mortar by 80%. Very fast to build. Used by NBRRI (Nigerian Building and Road Research Institute).
iii. Hydraform Blocks: Commercial brand of ISEB, produced with diesel powered machine.

5. Production Process in CRS Context:

Step 1: Excavation of laterite from borrow pit in Akamkpa or Odukpani

Step 2: Sieving to remove stones and roots

Step 3: Mixing with 5-8% cement and water - optimum moisture content 10-12%

Step 4: Compressing with hand press - one machine produces 300-500 blocks per day with 3 workers

Step 5: Curing under shade for 7-14 days with water sprinkling

Step 6: Drying and use after 21 daysOne bag of cement produces 70-80 stabilized blocks, compared to 35-40 sandcrete blocks. Hence more economical.

2.4 ADVANTAGES OF SUSTAINABLE LOCAL BUILDING MATERIALS OVER CONVENTIONAL MATERIALS FOR LOW-COST HOUSINGA. ECONOMIC ADVANTAGES

i. Cost Reduction and Affordability: Sustainable local building materials reduce construction cost by 30% to 50% compared to conventional materials (Nduka&Sotunbo, 2021). Stabilized earth blocks are 45% cheaper than sandcrete blocks, bamboo is 70% cheaper than steel, and periwinkle shells are 50% cheaper than granite. This makes housing affordable for low-income earners like farmers, civil servants and artisans in Cross River State whose monthly income is below N50,000 (Amao&Ilesanmi, 2019).
ii. Reduction in Transportation Cost: Local materials are sourced within 5-10km radius of construction site unlike cement and reinforcement which are transported over 300km from factories. This reduces transportation cost by over 60% (Windapo&Rotimi, 2017).
iii. Creation of Local Employment and Wealth Creation: Use of local materials creates jobs for local artisans - block moulders, bricklayers, bamboo weavers, carpenters, periwinkle pickers, palm kernel processors. It prevents capital flight as money circulates within Cross River State instead of going to foreign cement and steel companies (Adedeji, 2018).
iv. Low Maintenance Cost: Earth buildings require less painting and maintenance. Burnt bricks do not require plastering and painting, saving cost of cement, sand and paint which account for 15% of building cost (Olotuah&Bobadoye, 2018).

B. ENVIRONMENTAL ADVANTAGES5.

v. Low Embodied Energy and Carbon Emission: Conventional materials are energy intensive. Production of 1 ton of cement emits about 1 ton of CO2 and consumes 4.5 gigajoules of energy. Stabilized earth blocks consume 90% less energy and emit 80% less CO2 (Ogunbayo et al., 2018). UN-Habitat (2020) reports that building sector accounts for 40% of global carbon emission, and SLBMs help in climate change mitigation.

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vi. Waste to Wealth and Environmental Sanitation: Materials like Palm Kernel Shells, Periwinkle shells, Rice Husk Ash and Granite dust are wastes that pollute the environment. Using them in construction turns waste to wealth and keeps environment clean. In coastal areas of Bakassi and Calabar South, heaps of periwinkle shells cause pollution (Adedeji, 2018).

vii. Renewable and Sustainable: Bamboo matures in 3-5 years compared to timber which takes 20-50 years. Raffia palm and timber are renewable. Laterite and clay are abundantly available and will not be exhausted in next 200 years (Windapo&Rotimi, 2017).

viii. Thermal Comfort and Energy Efficiency: Earth walls and thatch roofs have high thermal mass. They keep house cool during hot afternoon and warm during night. Indoor temperature in earth house is 3-5°C lower than sandcrete house, reducing need for fans and air conditioners and saving energy by 30% (Adedeji, 2018).

C. SOCIO-CULTURAL ADVANTAGES

ix. Cultural Acceptability and Aesthetics: Local materials reflect cultural identity of Cross River people. Burnt bricks architecture and bamboo designs reflect African heritage and are more beautiful and unique than monotonous sandcrete blocks (Amao&Ilesanmi, 2019).

x. Ease of Construction and Use of Local Skills: Construction with local materials does not require highly skilled expatriates. Local artisans in Ogoja, Ikom, Boki already have indigenous knowledge of building with earth, bamboo and timber. Simple hand operated machines can produce compressed earth blocks (Nduka&Sotunbo, 2021).

2.5 LIMITATIONS / CHALLENGES OF SUSTAINABLE LOCAL BUILDING MATERIALS

Despite numerous advantages, use of SLBMs faces several challenges:

i. Negative Social Perception and Stigma: The greatest challenge. In Nigeria, earth houses and thatch roofs are perceived as houses for the poor, primitive and low status. People associate sandcrete blocks and aluminum roofs with wealth and modernity (Olotuah&Bobadoye, 2018). Even low-income earners prefer to live in rented sandcrete houses than own an earth house due to prestige.

ii. Low Level of Awareness and Lack of Technical Knowledge: Many builders, engineers and house owners in Cross River State lack knowledge of improved methods of using local materials. They still think of traditional mud houses that collapse during rainy season, not knowing about cement stabilization and modern treatment (Amao&Ilesanmi, 2019). No training in polytechnics and universities on SLBMs.

iii. Lack of Standardization and Building Codes: Nigerian Building Code and National Building Regulations do not have comprehensive standards for stabilized earth blocks, bamboo reinforcement, PKS concrete. This makes engineers afraid to use them for fear of building collapse and legal liability (Windapo&Rotimi, 2017). British Standards (BS) used in Nigeria only covers conventional materials.

iv. Durability and Maintenance Problems: Untreated local materials have durability issues. Untreated bamboo is attacked by termites and fungi and lasts only 2-3 years. Unstabilized earth blocks absorb water and erode during heavy rainfall common in Cross River State which has 3000mm annual rainfall (Adedeji, 2018). Thatch roof leaks and harbours rats if not properly treated.

v. Lack of Government Policy and Institutional Support: Government low-cost housing schemes in Cross River State still specify sandcrete blocks and aluminum roofs in their contract documents. There is no government incentive or subsidy for SLBMs unlike cement which had subsidy (Ogunbayo et al., 2018). No research centres for SLBMs in the state.

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vi. Difficulty in Obtaining Loans and Mortgage: Federal Mortgage Bank of Nigeria and commercial banks do not approve mortgage for houses built with earth blocks or bamboo because they consider them non-durable and low collateral value (Olotuah&Bobadoye, 2018). This discourages developers.

vii. Lack of Skilled Craftsmen in Improved Methods: While traditional knowledge exists, there are few craftsmen trained in improved methods like production of interlocking blocks, bamboo treatment with borax, production of rice husk ash at controlled temperature (Nduka&Sotunbo, 2021).

viii. High Labour Intensity: Production of earth blocks and burnt bricks is labour intensive and time consuming compared to buying ready-made sandcrete blocks. In Calabar where labour cost is high - N5,000 per day, this increases initial cost (Windapo&Rotimi, 2017).9. Limited Availability in Urban Areas: While laterite is available everywhere, materials like bamboo, raffia palm, periwinkle shells are abundant only in rural areas. Transporting them to urban centres like Calabar increases cost (Adedeji, 2018).

ix. Fire Hazard and Insurance Issues: Thatch roofs and timber are combustible. Insurance companies charge higher premium or refuse to insure houses built with them. This is a challenge in commercial buildings (Ogunbayo et al., 2018).

2.6 STRATEGIES FOR PROMOTING SUSTAINABLE LOCAL BUILDING MATERIALS FOR LOW-COST HOUSING IN CROSS RIVER STATE

Based on review, the following strategies are recommended:

i. Public Awareness and Reorientation Campaign: There is need for massive awareness campaign to change negative perception that local materials are for the poor (Amao&Ilesanmi, 2019). Government of Cross River State, through Ministry of Housing and Radio Cross River, should showcase model houses built with improved local materials. Demonstration villages should be built in Calabar, Ikom and Ogoja using stabilized earth blocks, burnt bricks and bamboo to prove durability and beauty (Adedeji, 2018). Traditional rulers, church leaders and social media influencers should be involved in campaign.

ii. Inclusion in Building Code and Development of Standards:Nigerian Industrial Standard (NIS) and Standard Organization of Nigeria (SON) should develop standards for Compressed Stabilized Earth Blocks (CSEB), Bamboo Reinforcement, Palm Kernel Shell Concrete and Rice Husk Ash cement (Windapo&Rotimi, 2017). Nigerian Building Code should be reviewed to include specifications for SLBMs. This will give engineers legal backing to use them and remove fear of liability (Ogunbayo et al., 2018).

iii. Government Policy and Incentives:Cross River State Government should formulate policy mandating that at least 40% of materials in all government low-cost housing schemes should be local materials (Olotuah&Bobadoye, 2018). Government should give tax holidays and soft loans to entrepreneurs producing stabilized earth blocks and burnt bricks. Import duty on cement and steel should be increased while local materials are subsidized (Nduka&Sotunbo, 2021).

iv. Training and Capacity Building:Training centres should be established in University of Cross River State (UNICROSS) and Cross River State University of Technology (CRUTECH) for training of artisans, bricklayers, carpenters and engineers on improved production techniques - treatment of bamboo with borax and boric acid against termites, production of interlocking blocks with hydraulic machines, controlled burning of rice husk to produce quality ash (Adedeji, 2018). National Directorate of Employment (NDE) should include SLBMs in its skill acquisition programmes.

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v. Research and Development:Government should fund research into durability, strength and improvement of local materials. Research centres like Nigerian Building and Road Research Institute (NBRRI) should have branch in Cross River State to test local materials from the state (Windapo&Rotimi, 2017). Research should focus on how to make earth blocks waterproof in high rainfall areas of Cross River which receives 3000mm rainfall.6. Access to Finance and Mortgage Reforms:

vi. Establishment of Material Production Clusters:Industrial clusters for production of local building materials should be established in each senatorial district - Calabar for Periwinkle shells and PKS, Ikom/Boki for bamboo and timber, Ogoja/Yala for rice husk ash and burnt bricks (Amao&Ilesanmi, 2019). This will ensure mass production, quality control and economies of scale, reducing cost further.

vii. Integration into School Curriculum:Courses on sustainable building materials and appropriate technology should be introduced into curriculum of Architecture, Building Technology, Civil Engineering and Estate Management in tertiary institutions (Nduka&Sotunbo, 2021). Students should be taken on excursion to local material production sites.

viii. Public-Private Partnership (PPP):Government should partner with private developers like Lafarge, Dangote and local entrepreneurs to establish factories for mass production of compressed earth blocks and treated bamboo (UN-Habitat, 2020). This will create employment for youths in the state.

2.7 CONCLUSION

From the literature reviewed, it is evident that sustainable local building materials are viable, affordable and environmentally friendly alternative to expensive conventional materials for low-cost housing. Cross River State is blessed with vast deposits of these materials which remain largely untapped. If properly harnessed with modern technology, improved methods and supportive government policies, SLBMs can provide decent and affordable housing for low-income earners and drastically reduce housing deficit in the state.The challenge is not availability of materials but perception, awareness and political will. With implementation of strategies discussed above - especially standards, training and demonstration projects, SLBMs can revolutionize low-cost housing delivery in Cross River State and serve as model for other states in Nigeria.

Implication of the Findings on Building Technology in Cross River State (CRS):

i. Shift from Import-Dependent to Resource-Based Building Technology:The findings imply that building technology in CRS will shift from heavy dependence on imported and energy-intensive conventional materials like cement and steel to resource-based technology using abundant laterite, clay, timber, bamboo, PKS and periwinkle shells. This will make building technology more self-reliant, affordable and adapted to local environment, reducing capital flight from the state (Windapo&Rotimi, 2017).

ii. Emergence of Low-Carbon and Green Building Technology:Adoption of SLBMs will transform building technology in CRS to green and climate-compliant technology. Since cement production emits high CO2, replacing it with RHA, stabilized earth and PKS will reduce embodied energy by 80-90% and carbon footprint of buildings. This aligns building technology in CRS with global sustainable construction standards and UN-Habitat climate goals (Ogunbayo et al., 2018).

iii. Need for Review of Building Technology Curriculum and Training:The findings imply urgent need to review curriculum of Building Technology, Architecture and Civil Engineering in UNICROSS

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and CRUTECH to include production of Compressed Stabilized Earth Blocks (CSEB), bamboo treatment, PKS concrete and RHA technology. Current building technology training focuses only on sandcrete and reinforced concrete. New technology requires new skills - artisans must be retrained from conventional methods to improved local methods (Nduka&Sotunbo, 2021).

iv. Development of Appropriate andLabour-Intensive Building Technology:Building technology will become more labour-intensive and less equipment-intensive. Production of earth blocks, burnt bricks and treated bamboo uses simple hydraulic machines and manual labour, unlike conventional technology that needs heavy machines and expatriates. This implies building technology in CRS will create more jobs for youths in Calabar, Ikom and Ogoja, and technology will be appropriate to economic capacity of low-income earners as advocated by Appropriate Technology Theory (Adedeji, 2018).

v. Innovation in Standards and Building Codes for Local Technology:The findings imply that building technology regulatory bodies - Standard Organization of Nigeria (SON), Nigerian Building Code and Cross River State Ministry of Housing - must innovate and develop new standards for local materials. Existing codes only cover conventional materials, making it difficult for engineers to approve local technology. New testing methods, compressive strength standards for CSEB (2.5-5 N/mm2), durability specifications for treated bamboo and mix ratios for PKS concrete must be developed to make building technology safe, insurable and mortgageable in CRS (Olotuah&Bobadoye, 2018).

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