RESEARCH ARTICLE

JENER Journal of Empirical and Non-Empirical Research
Volume 2, Issue 8, Page 151-160 | Article No. 26
DOI: 10.4898/jener.v2i8.a26
ISSN: 7895-9216
Journal homepage: https://jenerjournal.com
Journal email: editor@jenerjournal.com

JENER Journal
JENER Journal of Empirical and Non-Empirical Research

Evaluation of the Sustainability of Machine-Pressed Earth Blocks for Healthy Learning Environments – Gando Primary School as a Case Study.

Ajala Timileyin I., Farinde Adedapo, Oluwole Opefoluwa, Ibitoye Obafemi & Opeyemi Asaju.

ARTICLE INFORMATION

Article history:
Published: August 2026

Keywords:
Machine-Pressed Earth
Machine-Pressed Masonry
Sustainable Construction
Embodied Energy
Thermal Mass
Indoor Comfort
Higher Education
Low-Carbon Materials

ABSTRACT

Machine-pressed earth blocks are commonly referred to as Compressed Earth Blocks. They are emerging as a technically credible and environmentally friendly alternative to conventional fired clay bricks and concrete masonry in construction. They are usually produced on-site using mechanical or hydraulic presses. Machine-pressed earth blocks consume up to 90% less energy than concrete block manufacturing, generate minimal carbon emissions, and are fully recyclable back into subsoil at the end of life. Their dense earthen composition delivers strong passive thermal performance, natural humidity regulation, and resistance to fire and pests, qualities that are especially valuable in enclosed academic learning environments. This paper evaluates the sustainability of Machine-pressed earth across environmental, structural, economic, and indoor comfort dimensions, with specific attention to its application in higher educational buildings such as Gando Primary School, Burkina Faso.

1. Introduction

The building and construction industry contributes significantly to global carbon emissions; it accounts for an estimated 37% of energy-related CO_2 emissions annually (GlobalABC,2026). The construction sector, particularly the production of materials such as cement and steel, is a major contributor to global CO2 emissions, with cement alone accounting for about 8%. (Shiferaw,2025). Traditional building materials such as fired clay bricks and concrete blocks require significant energy to produce and transport, making them harmful to the environment overall. The use of sustainable building materials (SBMs) has been advocated to minimize the environmental impacts of construction activities, including resource depletion, ecosystem imbalances, and global warming and climate change (Eze et al., 2021a). Machine-pressed earth blocks provide a more sustainable alternative by compressing locally available soil with a small amount of cement or lime, reducing the need for firing, transportation, and excessive mortar use, resulting in much lower carbon emissions and embodied energy.

Apart from being environmentally friendly, Machine-pressed earth blocks offer several health and comfort benefits. MPEBs are particularly well-suited for hot, dry climates due to their thermal mass and hygroscopic properties, which help stabilize indoor temperatures and humidity, reduce reliance on air conditioning, and lower heating requirements (Imane et al.,2025). They are also resistant to fire, insects, and mould, creating healthier learning environments for students and staff. With compressive strengths of about 4.5–7 MPa, these MPEBs are increasingly used for load-bearing walls in low to medium-rise buildings, as well as non-load-bearing external and interior walls in residential and educational buildings (Imane et al.,2025). Studies show that they can produce over 90% less carbon emissions than conventional concrete blocks and can maintain indoor temperatures 5–7°C lower, reducing the need for mechanical cooling. This paper examines the suitability of Machine-pressed earth blocks for higher education buildings by evaluating their environmental sustainability, health, thermal performance, and economic viability. It also discusses challenges affecting their adoption, including moisture sensitivity, public perception, and limited regulatory support.

1.1 Aim

The aim of this study is to evaluate the sustainability performance of Machine-Pressed Earth Blocks in creating healthy learning environments, using Gando Primary School in Burkina Faso as a case study, and to assess their suitability for application in school buildings in Nigeria.

1.2 Objective of the Study

- To evaluate the impact of Machine-Pressed Earth Blocks on indoor environmental quality and thermal comfort within the learning spaces of Gando Primary School.
- To examine the material properties, composition, and construction characteristics of Machine-Pressed Earth Blocks used in Gando Primary School.
- To develop design and construction recommendations for the use of Machine-Pressed Earth Blocks in sustainable school infrastructure in Nigeria.
- To analyse the durability and climatic responsiveness of Machine-Pressed Earth Blocks under conditions of heat, rainfall, humidity, and wind exposure.

1.3 Scope of the Study

The study will specifically examine the sustainability performance, benefits, and limitations of Machine-Pressed Earth Blocks in relation to the creation of healthy learning environments in school buildings. The study focuses on Gando Primary School in Burkina Faso as a case study to evaluate how MPEBs perform under hot climatic conditions and to inform their potential application in educational buildings.

The scope of this study is limited to the analysis of thermal comfort, indoor environmental quality, durability, and environmental sustainability of Machine-Pressed Earth Blocks in school construction. The study also considers how climatic factors such as temperature, rainfall, humidity, solar radiation, and wind influence the performance of Machine-pressed Earth Blocks in the selected case study.

1.4 Significance of the Study

The study is beneficial to the general public, educational stakeholders, government agencies, private developers, and professionals within the building industry, particularly architects and construction engineers. It provides relevant insights into the potential of Machine-Pressed Earth Blocks (MPEBs) as a sustainable alternative construction material that can improve the environmental performance, affordability, and overall quality of educational buildings in Nigeria.

The study will also serve as a valuable reference for students, researchers, and educators in the fields of architecture and construction technology, particularly on sustainable construction practices and the use of earth-based materials to deliver climate-responsive, energy-efficient learning environments. By assessing the performance of MPEBs in terms of thermal comfort, environmental sustainability, and cost-effectiveness, the research contributes to the expanding body of knowledge on low-carbon and environmentally responsible building technologies. Furthermore, this study investigates the sustainability performance of MPEBs in creating healthy learning environments, using Gando Primary School as a case study. By addressing this critical issue, the research seeks to inform architectural practice, construction decisionmaking, and policy formulation, particularly regarding the development of sustainable school infrastructure in Nigeria and similar developing contexts.

2. Literature Review

2.1 Preamble

This chapter presents a review of relevant literature on sustainable building materials, compressed and machine-pressed earth blocks, and their thermal performance in relation to indoor environmental quality in learning environments. The construction industry plays a critical role in global environmental change due to its high consumption of energy, natural resources, and raw materials. It is widely reported that buildings and construction activities account for approximately 34–37% of global energy-related carbon dioxide emissions, driven largely by conventional materials such as cement, fired clay bricks, and concrete (UNEP & IEA, 2021). As urbanization continues to accelerate, particularly in developing regions, the environmental pressures associated with construction activities have intensified, necessitating a transition to more sustainable material alternatives. In response to these challenges, sustainable building materials have gained increasing attention in contemporary research and practice. These materials aim to reduce environmental impact across their life cycle while maintaining structural performance, durability, and occupant comfort.

Research indicates that sustainable materials are typically characterized by low embodied energy, reduced carbon emissions, recyclability, and the utilization of locally available resources, all of which contribute to a more circular and resource-efficient construction system (Kibert, 2016).

2.2 Concept of Sustainable Building Materials

The construction industry plays a significant role in global resource consumption, energy use, and environmental degradation. The production, transportation, and use of conventional building materials such as cement, concrete, and fired clay bricks contribute considerably to embodied energy and greenhouse gas emissions. According to the International Energy Agency (IEA) and the United Nations Environment Program (UNEP), the building and construction sector is the largest contributor to global energy-related carbon emissions, accounting for approximately 38–40% of total emissions, driven by both operational energy use and embodied carbon from building materials (UNEP & IEA, 2021). The use of sustainable construction materials not only addresses environmental problems but also contributes to the production of healthier, more energy-efficient, and durable structures. The building sector promotes sustainable practices, conserves natural resources, and reduces the environmental impact of construction operations (Yonatan, 2024). Buildings consume energy throughout their life cycle, including construction, operation, renovation, and demolition, with environmental impacts arising from both direct operational energy use and indirect embodied energy in materials (Cabeza et al., 2014).

Sustainable building materials are generally characterized by low embodied energy, reduced carbon emissions, recyclability, durability, and local availability (Bribián, Capilla & Usón, 2011). Local sourcing is particularly important because it reduces transportation energy and associated emissions while supporting regional economies. Furthermore, materials with long service life and high durability reduce the frequency of maintenance and replacement cycles, thereby lowering cumulative environmental impacts over a building's lifespan (Kibert, 2016).

2.3 Machine-Pressed Earth Blocks

Compressed earth blocks (CEBs) are a low-cost, low-carbon construction product that is well-suited for masonry infill in the Global South (Hisham et al.,2023). Machine -Presses earth blocks, made using mechanically operated or hydraulic press machines to compact soil into uniform, standardized blocks, have been developed in recent decades. The compression process yields higher strength and durability than Adobe (Adam & Agib, 2001). Its production does not require skilled labour, as the production process goes through three simple phases: soil preparation, compression, and curing (Riza et al., 2011). Machine-Pressed Earth Blocks can therefore be viewed as a desirable middle ground between adobe and fired bricks for infill masonry – they have greater strength and durability than adobe but with lower embodied energy and better hygro-thermal performance than fired bricks.

Compressed Earth Blocks (CEBs) represent a modernized approach to one of humanity's oldest building materials: earth. These durable blocks are formed by mechanically compacting a mixture of soil, water, and sometimes a stabilizer, into uniform, dense units (Cope,2025). The constituent materials are thoroughly mixed with water, either manually or with mechanical equipment such as a pan mixer, to ensure a uniform consistency. The prepared mixture is then placed into a mould and compacted under hydraulic pressure, thereby increasing the block's density and improving interparticle bonding. This compaction process produces a freshly formed block with sufficient strength to be handled and transported to a curing area. The blocks are then cured for approximately 7–14 days, allowing gradual strength gain and improved durability through controlled hydration of the stabilizing cement (PMSA, 2026).

Fig 1.1: Machine-pressed earth block production process in operation(blockmachine1,2024)

2.4 Thermal Performance and Healthy Learning Environments

Healthy learning environments require appropriate thermal conditions because excessive heat can negatively affect student concentration, comfort, and academic performance. Classroom environments are often densely occupied and naturally ventilated, making them highly sensitive to external climatic conditions. As a result, maintaining stable indoor temperatures is essential for ensuring both comfort and effective learning outcomes. According to Zeiler and Boxem (2009), thermal conditions in classrooms significantly influence students' cognitive performance, concentration, and overall learning outcomes, particularly in naturally ventilated buildings. Therefore, thermal comfort is a critical component of indoor environmental quality in educational facilities, especially in hot and humid climates where overheating is common.

Building materials also play an important role in regulating indoor thermal conditions. Earthbased materials can contribute to passive cooling strategies when combined with appropriate ventilation and building design. Recent studies in tropical regions have shown that earth-based construction materials, such as compressed earth blocks, can improve indoor thermal comfort in educational buildings compared to conventional sandcrete block systems. These materials have been reported to reduce indoor temperature fluctuations due to their high thermal mass and thermal buffering capacity.

Therefore, thermal performance is a critical component of healthy learning environments, particularly in warm climates where classrooms are highly vulnerable to overheating. The use of earth-based materials, such as compressed and machine-pressed earth blocks, offers a practical passive design solution for stabilising indoor temperatures, improving thermal comfort, and enhancing student concentration and learning outcomes in educational buildings.

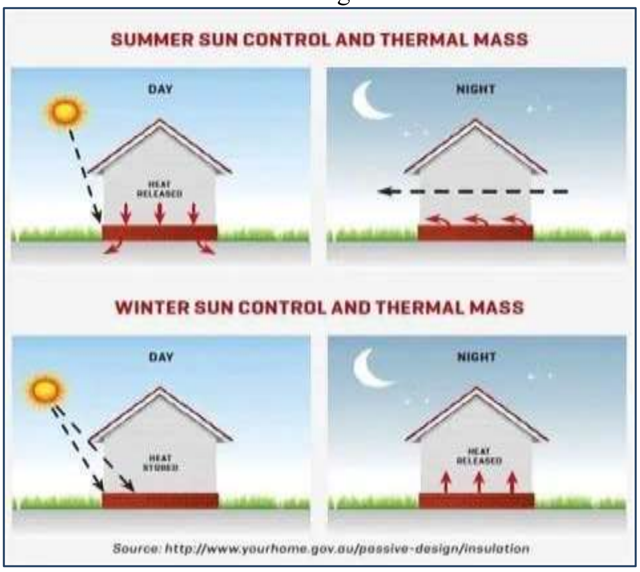


Fig 1.2: Thermal Performance Mechanism of Earth-Based Materials (buildingconnection,2018).

2.5 Challenges Affecting the Adoption of Sustainable Building

Materials: Despite the growing recognition of sustainable building materials such as compressed and machine-pressed earth blocks, their widespread adoption in the construction industry remains limited due to several technical, economic, institutional, and socio-cultural challenges. The use of sustainable building materials (SBMs) has been advocated for minimizing the impact of construction activities on the environment, resource depletion, imbalance in the ecosystem, and global warming and climate change (Eze et al., 2021a). SBMs are regarded as

'friends of the environment because they are recyclable, reusable, and have low environmental impact (Onyegiri and Ugochukwu, 2016). (Häkkinen et al.,2011) established a link between GBM knowledge, awareness, and adoption of sustainable construction. Most stakeholders are either ignorant of or lack knowledge about GBMs, which impedes implementation. The lack of awareness and knowledge of GBM by professionals, the misunderstanding of the sustainability concept, the lack of clients' awareness of the benefits of Sustainable building materials, and the poor education of sustainable design are factors that inhibit the attainment of sustainability. Studies have shown that limited education and exposure to sustainable construction technologies significantly slow down their acceptance in developing construction markets (Kibert, 2016).

Another barrier is the lack of standardization and integration with building codes. In many developing countries, including Nigeria, sustainable earth-based materials are not fully integrated into national building regulations or standardized construction guidelines. This absence of clear code creates uncertainty in design approval processes and discourages professionals from specifying such materials in formal construction projects (Kibert, 2016). Economic constraints also play a major role in limiting adoption. While raw earth materials are often locally available and inexpensive, producing stabilized compressed earth blocks may require mechanical presses, stabilizers such as cement or lime, and quality control systems. The initial cost of setting up production facilities and acquiring equipment can discourage smallscale contractors and informal builders from adopting these technologies (Minke, 2012). Furthermore, policy and institutional limitations hinder widespread adoption. Weak enforcement of environmental regulations in the construction sector, combined with limited government incentives for green building technologies, reduces stakeholders' motivation to adopt sustainable alternatives. Where incentives exist, they are often insufficient to offset the perceived risks associated with non-conventional materials. In many countries, sustainability policies exist; however, their implementation is often limited by weak institutional capacity, inadequate enforcement mechanisms, and insufficient support systems, resulting in slow largescale adoption of sustainable construction practices (UNEP, 2021)

3. Methodology

3.1 Research Methodology

This research uses a case study approach to evaluate the sustainability performance of Machine Pressed Earth Blocks (MPEB) in terms of indoor environmental quality and learning comfort at Gando Primary School. Case study methodology can be used to evaluate an existing building in which earth structures have been constructed and used in an actual learning environment.

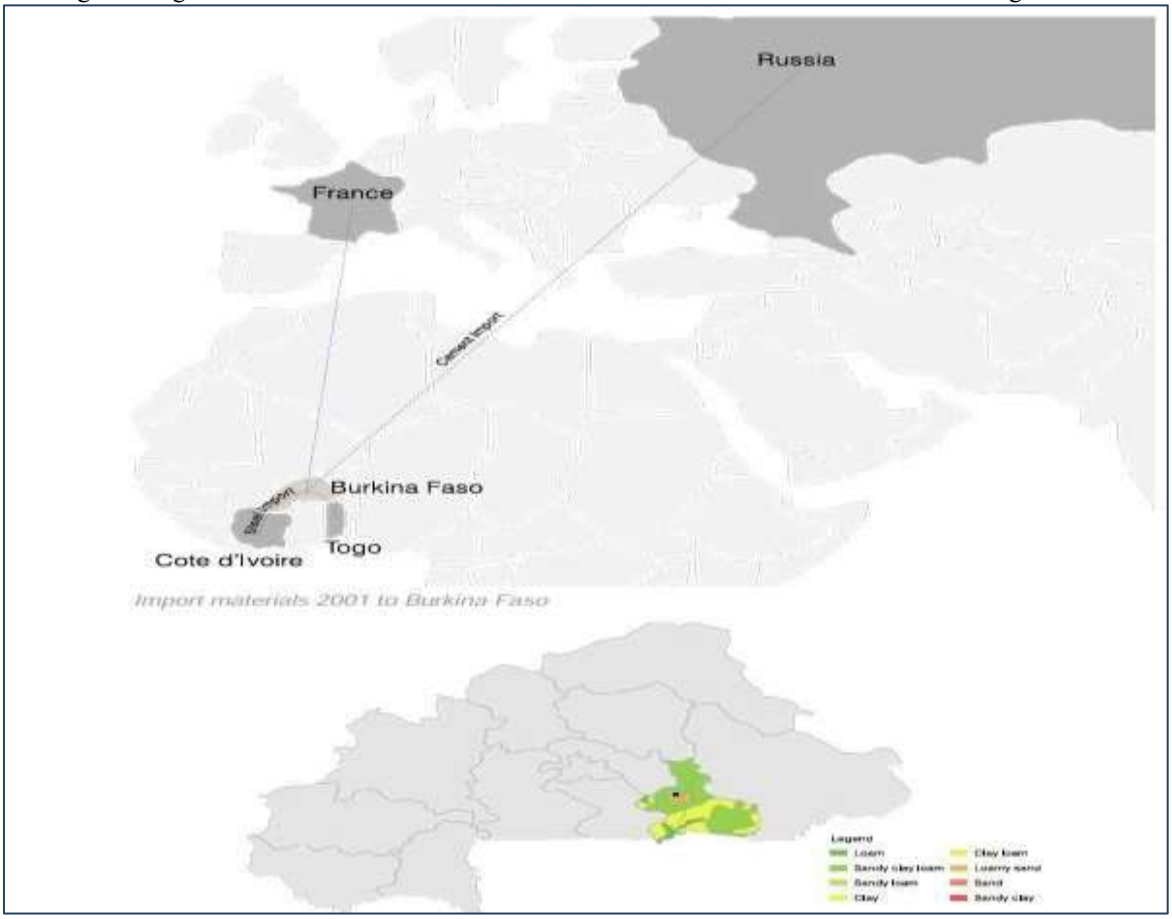


Fig 1.3: Location map of Gando Primary School, Burkina Faso

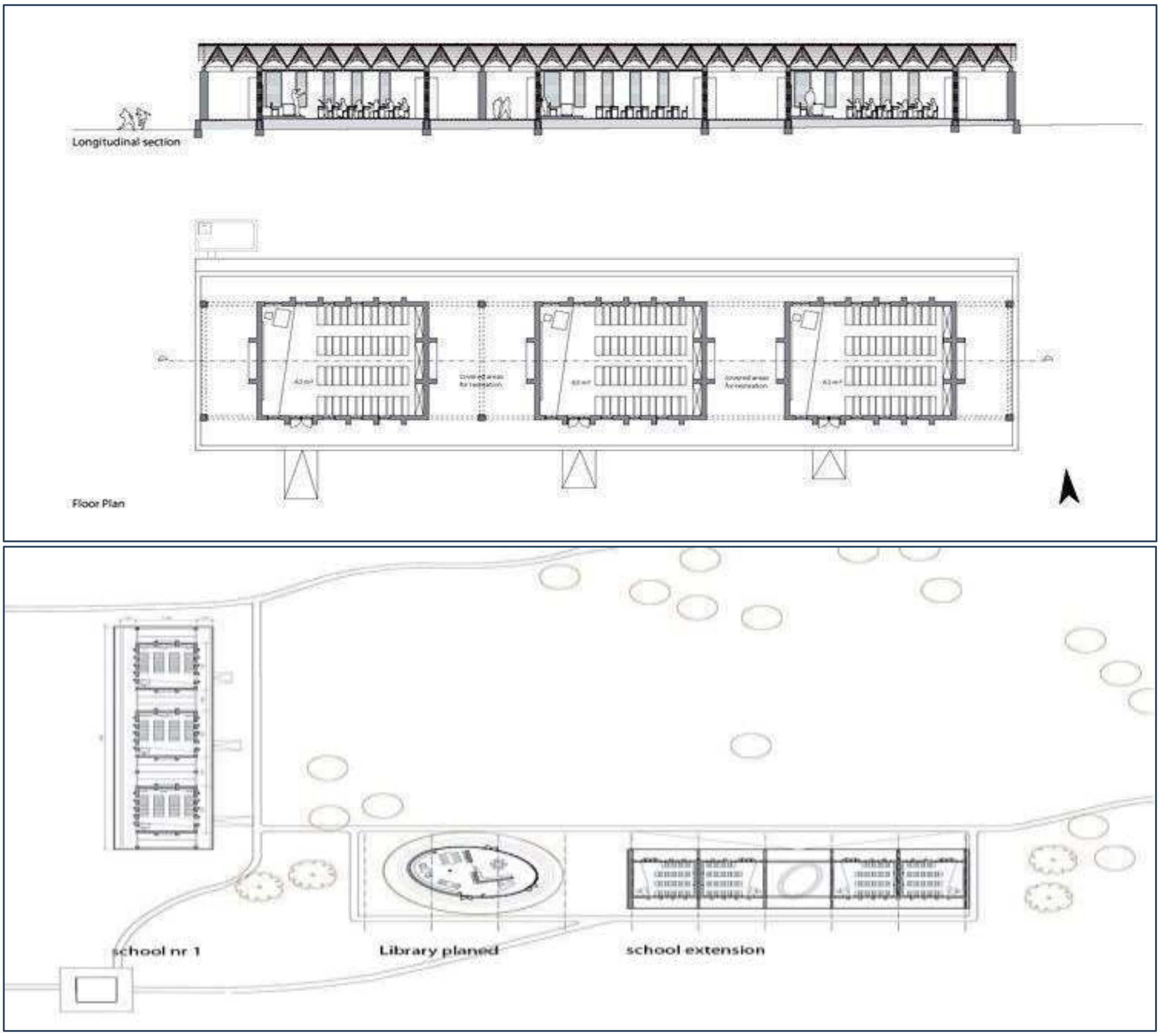
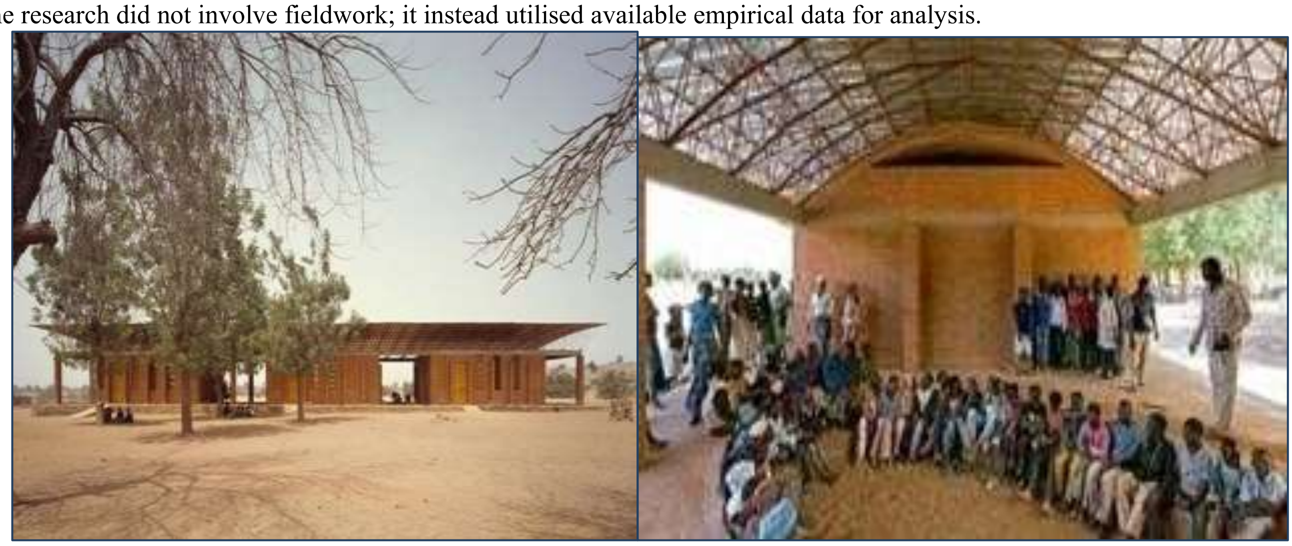
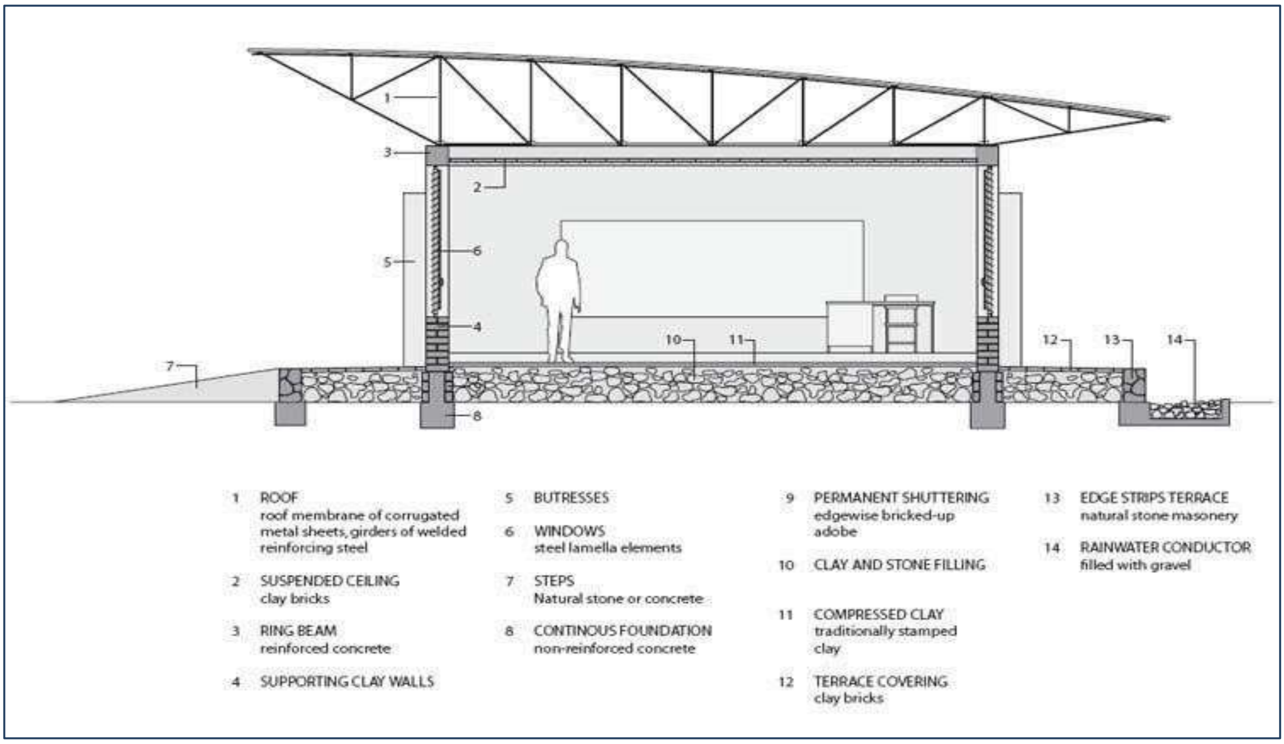


Fig 1.3. Site location and spatial layout of Gando Primary School.

3.2 Data Collection Method
The research relies on secondary data collection, which includes the following:
Climate data published for Burkina Faso (Sahel), Architectural Documentation of Primary School Gando
Peer-reviewed literature from academic journals on earth architecture

- Sustainability performance data on compressed earth blocks
- The research did not involve fieldwork; it instead utilised available empirical data for analysis.





3.3 Variables of Analysis

Variables to be used in analysing the link between environmental conditions and the Performance of MPEB includes the following:

Category	Variables	Description in Relation to MPEB Performance
Independent Variables (Environmental Conditions)	Heat Index	Influences thermal stress on MPEB walls and indoor temperature levels
	Rainfall	Affects moisture absorption, erosion risk, and structural durability
	Relative Humidity	Impacts moisture content, material stability, and indoor comfort
	Solar Radiation	Determines heat gain through walls and overall thermal load
	Wind	Affects evaporative cooling, heat dissipation, and moisture drying rate
Dependent Variables (Performance of MPEB)	Thermal Comfort Performance	Measures indoor temperature regulation and occupant comfort level
	Durability of Earthen Walls	Assesses resistance to weathering, erosion, and structural degradation
	Indoor Air Quality Performance	Evaluates ventilation effectiveness and pollutant regulation
	Learning Environment Suitability	Assesses overall comfort, usability, and cognitive support in classrooms

3.4 Methodology of Data Analysis and Presentation

The collected data were presented in a descriptive statistical table and analyzed for comparative efficiency. The analysis focuses on identifying the influence of climatic conditions in Burkina Faso on MPEB efficiency in schools.

3.5 Data Analysis

Climate Conditions and MPEB Performance in Gando Primary School:

Environmental Factor	Measured Condition	Effect on MPEB Performance	Impact on Learning Environment
Average Temperature	30°C – 42°C	High thermal storage requirement	Prevents overheating of classrooms
Night Temperature	18°C – 25°C	Heat release from wall mass	Improves indoor cooling balance
Annual Rainfall	600 – 900 mm/year	Requires protective design	Ensures structural durability
Humidity Level	20% – 60%	Supports fast block curing	Reduces dampness and mold growth
Solar Radiation	5.5 – 7.0 kWh/m²/day	High heat gain control needed	MPEB reduces indoor heat stress

Wind (Harmattan)	3 – 6 m/s	Surface erosion risk	Requires protective plaster finish
Soil Availability	70% – 85% lateritic soil	Supports local MPEB production	Reduces construction cost
Wall Thickness	300 – 400 mm	High thermal mass performance	Stabilizes indoor temperature
Indoor Temperature Reduction	2°C – 6°C lower	Passive cooling effect	Improves student comfort

3.6 Data Interpretation
Based on the analysis, the climatic conditions in Burkina Faso are most conducive to the use of Machine-Pressed Earth Blocks in school construction. Due to high daytime temperatures ranging from 30°C to 42°C, there is a need to employ building materials with thermal mass, which MPEBs offer effectively.
The thick earth blocks (300-400 mm) at Gando Primary School act as heat insulators, thereby keeping internal temperatures about 2-6°C cooler than external temperatures. Passive cooling contributes significantly to thermal comfort within the classroom.
Humidity levels of 20-60% improve the block curing process, but seasonal rainfall requires protection against erosion and heavy-rain-induced deterioration.

3.7 Findings of the Analysis
The findings of this study demonstrate that Machine-Pressed Earth Blocks (MPEBs) offer significant potential for improving the sustainability performance of educational buildings in hot and semi-arid climates. The results confirm that climatic conditions similar to those in Burkina Faso play an important role in enhancing the effectiveness of earth-based construction systems, particularly by enabling them to respond to high diurnal temperature variations. The observed improvement in indoor thermal comfort indicates that MPEBs, owing to their high thermal mass, can stabilize indoor temperatures and reduce overheating in classroom environments. This is particularly important in learning spaces, where thermal discomfort has been shown to negatively affect students' concentration, productivity, and overall academic performance. The implication is that material choice is not only a structural decision but also a direct contributor to educational quality.
The case of Gando Primary School further reinforces the relevance of climate-responsive design strategies that integrate locally available materials. The project demonstrates that sustainable architecture can be achieved through simple, context-sensitive solutions without compromising functionality or aesthetics. It also highlights the importance of integrating local knowledge systems and material resources into contemporary architectural practice.

3.8 Summary of Methodology
This chapter presented the research design, data collection methods, and analytical framework used to evaluate the performance of Machine-Pressed Earth Block (MPEB) in sustainable building construction. A case study approach was employed to enable an in-depth assessment of the material within a real-life architectural context.
The case study of Gando Primary School provided empirical evidence for examining the climatic responsiveness and environmental performance of earth-based construction in educational facilities. The analysis focused on key sustainability indicators, including thermal comfort, material efficiency, and environmental suitability, in a hot, semi-arid climate. Findings from the methodological process confirmed that earth-based construction systems are both climatically appropriate and ecologically sustainable for educational buildings in Sahelian regions. This validates the potential of MPEBs as a viable alternative to conventional construction materials in similar environmental contexts, particularly for improving the sustainability of learning environments.

4. Data Presentation, Analysis
4.1 Introduction
This chapter presents and discusses the results obtained from the analysis of secondary data
Concerning the sustainability of Machine Pressed Earth Blocks (MPEB) at Gando Primary School. The analysis focuses on the relationship between climatic conditions and the performance of the buildings and the quality of the learning

4.2 Presentation of Findings
Climate Conditions and MPEB Performance

Variable	Value / Range
Average Temperature	30°C – 42°C
Night Temperature	18°C – 25°C
Annual Rainfall	600 – 900 mm
Relative Humidity	20% – 60%
Solar Radiation	5.5 – 7.0 kWh/m²/day
Wall Thickness	300 – 400 mm
Indoor Temperature Reduction	2°C – 6°C
Average Temperature	30°C–42°C
Night Temperature	18°C–25°C

4.3 Analysis of Findings
4.3.1 Climatic Context of the Study Area

The climatic conditions of Gando are characterized by high solar radiation, elevated daytime temperatures, and moderate humidity levels. With temperatures reaching up to 42°C and solar radiation between 5.5–7.0 kWh/m²/day, buildings in this region experience significant thermal stress. These conditions make passive design strategies essential, particularly in educational buildings where thermal comfort directly affects learning performance.

4.3.2 Thermal Comfort and Indoor Environmental Performance

The indoor environmental performance of Gando Primary School shows a significant improvement compared to outdoor conditions. While external temperatures reach 42°C, indoor spaces constructed with Machine-Pressed Earth Blocks experience a reduction of approximately 2°C to 6°C. This improvement is attributed to the high thermal mass of MPEBs, which allows them to absorb heat during the day and release it slowly at night. As a result, indoor spaces maintain more stable temperatures, reducing heat stress and improving comfort.

4.3.3 Material and Construction Characteristics of Machine-Pressed Earth Blocks

Machine-Pressed Earth Blocks (MPEBs) used at Gando Primary School are produced by mechanically compacting locally sourced lateritic soil under controlled pressure. This process significantly improves the density, uniformity, and structural integrity of the blocks compared to traditional sun-dried earth bricks. The use of a mechanical press ensures consistent block geometry, which enhances construction accuracy and overall building performance. The wall system in Gando Primary School typically consists of thick earth walls ranging between 300 mm and 400 mm. This thickness is critical to the building's thermal performance, as it increases the structure's thermal mass. High thermal mass allows the walls to absorb heat during periods of high solar exposure and release it gradually when temperatures drop, particularly at night. This process contributes significantly to indoor thermal stability.

4.3.4 Architectural Performance Analysis

The architectural design of Gando Primary School plays a critical role in enhancing environmental performance and indoor comfort. The analysis is based on the drawings presented in Chapter 3, including the site plan, floor plan, section, and elevations.

4.3.4.1 Site Plan Analysis

The site layout demonstrates a strong response to climatic conditions through building orientation. As shown in Figure 1.3, the buildings are positioned to optimize prevailing wind direction and minimize direct solar exposure, thereby improving natural ventilation and reducing heat gain.

4.3.4.2 Floor Plan Analysis

The floor plan indicates a linear classroom arrangement that supports cross ventilation and efficient airflow distribution. As shown in Figure 1.3, openings are strategically positioned to enhance daylight penetration and reduce dependence on artificial lighting.

4.3.4.3 Section Analysis

The sectional drawing reveals the use of thick 300–400 mm Machine-Pressed Earth Block walls. As shown in Figure 1.4. These walls act as thermal mass elements, slowing down heat transfer from the external environment into interior spaces. This results in improved thermal stability throughout the day.

4.3.4.4 Elevation Analysis

The elevation demonstrates controlled window openings and shading strategies that reduce direct solar radiation. The façade design balances daylight access with thermal protection, contributing to overall indoor comfort.

4.3.5 Environmental Sustainability / Embodied Carbon Analysis

The environmental performance of the building materials used at Gando Primary School was assessed through an embodied-carbon analysis of the façade system. This evaluation considers the quantity of materials used and their corresponding carbon dioxide equivalent (CO_2eq) emissions, providing insight into the overall sustainability of the construction. The analysis is based on the Material Pyramid (CINARK, BK TU Delft), which compares the environmental impact of different construction components within the building envelope.

The results indicate that the total carbon footprint of the analysed façade is approximately 1254.2 kg CO_2eq. Among the materials assessed, clay-based components such as compressed earth blocks (CEBs) exhibit a moderate environmental impact due to their local sourcing and low-energy production. In contrast, steel and reinforced concrete elements contribute significantly higher CO_2 emissions due to their energy-intensive manufacturing processes.

Material Component	Material Type	Group	CO_2 Emission Factor (kg CO_2eq/m^3)	Volume (m^3)	CO_2 Result (kg CO_2eq)
Roof panel (steel lamella)	Steel	Metal	21,509.0	0.006	129.1
Structural steel (ring beam)	Steel	Metal	5,403.2	0.005	27.0
Brick roof tiles	Fired brick	Mineral	624.4	0.017	10.6
Compressed Earth Blocks (CEB)	Clay / Earth bricks	Mineral	297.0	0.200	59.4
Concrete C20/C25 (ring beam)	Concrete	Mineral	215.0	0.108	23.2
Clay plaster	Plaster	Mineral	98.2	0.050	4.9

4.4 Discussion of Findings

This chapter presented and analyzed the sustainability performance of Machine-Pressed Earth Blocks (MPEBs) at Gando Primary School, with particular emphasis on climatic response, material characteristics, architectural performance, indoor environmental quality, and embodied carbon analysis.

The findings reveal that the study area is characterized by a hot, semi-arid climate with high daytime temperatures up to 42°C and strong solar radiation. These climatic conditions impose significant thermal stress on buildings; however, the use of MPEBs with thick wall construction (300–400 mm) significantly improves indoor thermal stability, reducing indoor temperatures by approximately 2°C to 6°C.

The material analysis indicates that MPEBs are produced from locally sourced earth through mechanical compression, resulting in improved density and structural strength, and reduced embodied energy compared to conventional building materials. This contributes positively to both thermal performance and environmental sustainability.

The architectural analysis shows that the building design, including orientation, spatial layout, and wall construction, enhances passive cooling, natural ventilation, and daylight access. The use of thick earth walls and controlled openings ensures effective heat regulation and improved indoor comfort for learning activities.

Furthermore, the sustainability assessment confirms that MPEBs perform well across environmental, economic, and social dimensions. The embodied carbon analysis further demonstrates that earth-based materials produce significantly lower CO_2 emissions than steel and concrete components, with a total façade carbon footprint of approximately 1254.2 kg CO_2eq.

Overall, the study confirms that Machine-Pressed Earth Blocks offer a sustainable, climate responsive construction solution that improves indoor environmental quality and supports effective learning environments in hot, semi-arid regions.

5. Summary, Conclusion, And Recommendations

5.1 Summary of the Study

This study evaluated the sustainability performance of Machine-Pressed Earth Blocks (MPEBs) in creating healthy learning environments, using Gando Primary School in Burkina Faso as a case study. The research focused on the relationship between climatic conditions, material characteristics, architectural design, and indoor environmental quality.

The study found that the climatic conditions of the study area are characterized by high temperatures (30°C–42°C), strong solar radiation, and moderate humidity levels. These conditions create significant thermal stress on buildings, making passive design strategies essential.

The analysis revealed that MPEBs with wall thicknesses of 300–400 mm significantly improve indoor thermal comfort by reducing indoor temperatures by approximately 2-6°C. This demonstrates the effectiveness of earth-based materials in regulating indoor environments in hot climates.

Material analysis showed that MPEBs are locally sourced and mechanically compacted, resulting in improved strength and durability, and lower embodied energy compared to conventional materials such as concrete and steel. The embodied carbon analysis further confirmed that earth-based materials contribute significantly less CO_2 emissions, supporting their environmental sustainability.

The architectural analysis demonstrated that building orientation, spatial layout, and passive design strategies such as natural ventilation and shading contribute to improved indoor environmental performance and learning conditions.

5.2 Conclusion of the Study

The study concludes that Machine-Pressed Earth Blocks are a highly sustainable and climate-responsive construction material suitable for educational buildings in hot semi-arid regions.

The findings confirm that MPEBs effectively enhance thermal comfort, reduce indoor heat gain, and improve learning environments through passive design principles. Their use also contributes to environmental sustainability by reducing embodied carbon emissions and promoting the use of local materials.

Furthermore, the study establishes that earth-based construction systems can serve as viable alternatives to conventional materials such as concrete and steel, especially in regions facing high temperatures and limited access to energy-intensive building technologies.

Overall, the research demonstrates that MPEBs provide a balanced solution that integrates environmental, economic, and social sustainability in school building design.

5.3 Recommendations

Based on the findings of this study, the following recommendations are made:

5.3.1. Adoption of MPEBs in School Construction

Governments and educational authorities should promote the use of MachinePressed Earth Blocks in the construction of school buildings in hot and semiarid regions due to their thermal and environmental benefits.

5.3.2. Integration of Passive Design Strategies

Architects should incorporate passive cooling strategies such as proper orientation, shading devices, and natural ventilation when designing earthbased buildings.

5.3.3. Improvement of Material Technology

Further research and development should be conducted to improve the durability and water resistance of MPEBs, particularly in areas with seasonal rainfall.

5.3.4. Use of Local Materials
Construction projects should prioritize locally available earth materials to reduce transportation costs and carbon emissions.

5.3.5. Policy Support for Sustainable Construction
Governments should develop policies that encourage low-carbon and sustainable construction practices, particularly in public infrastructure such as schools.

5.3.6. Training and Awareness
Builders, architects, and engineers should be trained on modern earth construction techniques to improve acceptance and implementation of MPEBs.

5.4 Contribution To Knowledge
This study contributes to the body of knowledge by demonstrating that Machine-Pressed Earth Blocks can significantly improve indoor environmental quality while reducing environmental impact. It also provides empirical evidence linking climatic conditions, material performance, and the quality of the learning environment in earth-based school construction.

5.5 Suggestions For Further Studies
Future research should focus on:
- Long-term durability performance of MPEBs in different climatic zones
- Structural performance under extreme weather conditions
- Cost-benefit analysis compared to conventional materials
- Integration of modern construction technologies with earth architecture

References

[1] Adam, E. A., & Agib, A. R. A. (2001). *Compressed stabilized earth-blocks: Manufacture and properties*. United Nations Educational, Scientific and Cultural Organization (UNESCO).
[2] Abera, Y. A. (2024). Sustainable building materials: A comprehensive study on ecofriendly alternatives for construction. *Composites and Advanced Materials, 33*. https://doi.org/10.1177/26349833241255957
[4] Block Machine 1. (2024). *Machine-pressed earth block production process in operation*. BlockMachine1. https://engineerfix.com
[5] Building Connections. (2018). *Thermal performance mechanism of earth-based materials*.
[6] Bribián, I. Z., Capilla, A. V., & Usón, A. A. (2011). Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. *Building and Environment, 46*(5), 1133– 1140. https://doi.org/10.1016/j.buildenv.2010.12.002
[8] Cabeza, L. F., Rincón, L., Vilariño, V., Pérez, G., & Castell, A. (2014). Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review. *Renewable and Sustainable Energy Reviews, 29*, 394–416. https://doi.org/10.1016/j.rser.2013.08.037
[10] Cope, L. (2025). *How compressed earth blocks are made and used*. EngineerFix. https://engineerfix.com/how-compressed-earth-blocks-are-made-and-used/
[11] Eze, E., Sofolahan, O., & Omoboye, O. (2023). Assessment of barriers to the adoption of sustainable building materials (SBM) in the construction industry of a developing country. *Frontiers in Engineering and Built Environment, 3*. https://doi.org/10.1108/FEBE-07-2022-0029
[13] GlobalABC. (2026). *Global status report for buildings and construction*. Global Alliance for Buildings and Construction. https://globalabc.org
[16] Gharbage, I., Benmahiddine, F., & Sebaibi, N. (2025). Mechanical, thermal and hydric properties of compressed earth blocks: A review. *Journal Building* Engineering*, 104*, 112387. https://doi.org/10.1016/j.jobe.2025.112387
[18] Hafez, H., El-Mahdy, D., & Marsh, A. T. M. (2023). Barriers and enablers for scaledup adoption of compressed earth blocks in Egypt. *Building Research & Information,* 51(7), 783–797. https://doi.org/10.1080/09613218.2023.2237133
[19] Häkkinen, T., & Belloni, K. (2011). Barriers and drivers for sustainable building.
[20] *Building Research & Information, 39*(3), 239–255.
[21] Kibert, C. J. (2016). *Sustainable construction: green building design and delivery* (4th ed.). John Wiley & Sons.
[22] Minke, G. (2012). *Building with earth: Design and technology of a sustainable architecture* (3rd ed.). Birkhäuser.
[23] Onyegiri, I., & Ugochukwu, I. B. (2016). Traditional building materials as a sustainable resource and material for low-cost housing in Nigeria: Advantages, challenges and the way forward. *International Journal of Research in Chemical,*
[24] *Metallurgical and Civil Engineering, 3*(2), 247–252.
[25] Project Management South Africa. (2026). *About PMSA*. https://www.projectmanagement.org.za
[27] Riza, F. V., Rahman, I. A., & Kamarudin, N. (2011). A study of compressed earth block (CEB) production process and properties. *Construction and Building Materials, 25*(1), 375–380. https://doi.org/10.1016/j.conbuildmat.2010.07.026
[30] Shiferaw, A. T. (2025). Carbon conscious construction: Evaluating compressed stabilized earth blocks. *Buildings, 15*(23), 4362. https://doi.org/10.3390/buildings15234362
[32] UNEP & International Energy Agency. (2021). *Global status report for buildings and construction*. https://globalabc.org
[33] Zeiler, W., & Boxem, G. (2009). Effects of thermal activated building systems in schools on thermal comfort in winter. *Building and Environment, 44*(11), 2308–2317. https://doi.org/10.1016/j.buildenv.2009.05.005