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Evaluating the Economic Impact of Alternative vs. Conventional Construction Materials for Residential Projects in Tanzania: Integrating Environmental and Social Criteria

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Abstract

Previous research in Tanzania has focused on comparing the mechanical and environmental properties of sustainable building materials (SBMs) with those of their conventional counterparts; however, there remain limited contributions in assessing the economic impacts associated with this trend. This significantly hinders the adoption of SBMs in residential construction, as economic viability remains a critical factor in material selection in developing countries, such as Tanzania. Using cost-benefit analysis (CBA), this study addresses this gap by evaluating the economic viability of SBMs in comparison to conventional materials for residential building projects in Tanzania, while considering environmental and social factors. To achieve this aim, a comparative analysis of two material alternatives, namely compressed stabilised earth blocks (CSEBs) and conventional concrete blocks, was conducted based on predefined criteria, including cost, local availability, and ease of use. Findings reveal that CSEB walls are approximately 18% more cost-effective than concrete blocks, offering enhanced constructability and reducing environmental impact, rendering them a highly recommended option for sustainable residential construction. The novelty of this study lies in the application of CBA, which is predicated on developing unit rates per unit scale through a cost breakdown, enabling stakeholders to adjust cost components at a granular level for informed decision-making. Practically, this study provides a cost-based decision-making framework for selecting SBMs in Tanzania while promoting awareness through suggesting an improved format of price list that integrates sustainable alternatives. However, the study is limited by its focus on a specific region and materials, as well as the qualitative treatment of environmental and social criteria. Future research should expand the analysis to include broader aspects, thereby better elucidating the overall suitability of SBMs in diverse contexts.

Keywords: Alternative building materials, Cost-Benefit Analysis, Residential Building Projects, Social and Environmental Criteria, Tanzania

1. Introduction

The construction industry faces an urgent mandate to adapt in response to global climate change and rapid urbanisation, two challenges that collectively put pressure on resources and escalate environmental impacts (UNEP, 2022). Climate change manifests in rising global temperatures, resource scarcity, and increasingly severe weather events, all of which underscore the need for sustainable construction practices. Simultaneously, urban populations are projected to grow significantly, with an estimated 68% of the global population living in urban areas by 2050, up from 55% in 2017 (The World Bank, 2021). This rapid urbanisation is intensifying housing demand, especially in the fast-growing cities of developing countries, revealing the limitations of traditional, resource-intensive construction methods that contribute

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approximately 39% of global CO_2 emissions and consume over 40% of the world's raw materials each year (UNEP, 2022). As nearly 2 billion new homes are anticipated by 2100 to accommodate urban growth, adopting innovative, eco-friendly building materials has become a priority (UN, 2017).

In East Africa, efforts to promote sustainable materials are emerging. For instance, Rwanda has adopted adobe bricks for urban housing (RHA, 2022), demonstrating how locally sourced materials can balance economic, social, and environmental considerations (MDG, 2019). Similarly, Tanzania has demonstrated its commitment to improving living standards and promoting sustainable housing solutions through various initiatives. The establishment of the Institute of Building Research (IBR) exemplifies this effort, with a mission to provide innovative, cost-effective construction technologies suited to local needs (IBR, 2024).

However, while previous studies in Tanzania have explored the mechanical and environmental properties of various sustainable and conventional building materials such as concrete blocks, volcanic rocks, and CSEBs (Hatibu *et al.*, 2015; Jung *et al.*, 2019; Moses *et al.*, 2020; Sabai *et al.*, 2013), there remain limited contributions in assessing their economic impacts relative to conventional building materials. This limitation hinders the broader adoption of sustainable materials in residential construction, as economic viability remains a critical factor in material selection in developing countries like Tanzania (Mahame *et al.*, 2024). Although alternative materials cover a variety of options, this study focuses explicitly on Compressed Stabilised Earth Blocks (CSEBs) as the primary alternative, and concrete blocks as the conventional counterpart, due to their widespread use and relevance in Tanzanian residential construction.

This study addresses this gap by evaluating the economic viability of alternative building materials in comparison to conventional materials for residential building projects in Tanzania, while balancing environmental and social factors. The specific objectives of the study are to:

1. Assess the suitability of selected alternative building materials for residential building projects.

2. Compare cost variance between conventional and alternative materials

3. Suggest an enhanced building materials price list format that implements alternative materials and reflects sustainability criteria

Using cost-benefit analysis (CBA), the study integrates environmental and social criteria to provide a comprehensive economic evaluation. The findings aim to inform policymakers, enhance awareness, and propose an elaborate price list of materials to the National Construction Council (NCC) to support the implementation of sustainable materials.

2. Literature review

2.1. Overview of alternative building materials

Historically, building materials have undergone significant evolution. According to Kibert (2016), vernacular architecture primarily relied on simple, locally available natural resources that required minimal processing, such as adobe, bamboo, and timber. These locally sourced materials were abundant, cost-effective, and well-suited to the cultural and environmental contexts of their regions. Ross and Dru (2010) further note that these materials offered a sustainable construction approach, characterised by low energy demands and minimal ecological disruption. However, with the arrival of industrialisation, the landscape of construction materials transformed dramatically, as Gann and Barlow (1996) observed.

The industrialisation and urbanisation of the 19^{th} and 20th centuries marked a significant shift in construction practices, favouring modern materials such as concrete, steel, and plastics (Vagtholm *et al.*, 2023). While these materials enabled rapid urban development and large-scale infrastructure projects, their energy-intensive production processes and dependence on non-renewable resources significantly contributed to global carbon emissions and waste generation, raising concerns about their environmental sustainability (Gann & Barlow, 1996). In response to these challenges, growing concerns over climate change, resource depletion, and environmental degradation have reignited interest in alternative building materials. These materials, characterised by renewability, recyclability, and low embodied energy, offer promising solutions for sustainable construction (Ngowi, 2001). For example, CSEBs, made from locally sourced soil, reduce transportation emissions and resource depletion (Waziri *et al.*, 2013), while bamboo, with its rapid growth cycle, provides an efficient renewable substitute for timber (Patil & Patil, 2017).

In the Tanzanian context, prior studies have explored the environmental benefits of alternative building materials but have mainly overlooked their economic implications. For instance, Hatibu *et al.* (2015) analysed the energy and carbon intensities of mud bricks (adobe bricks) and soil cement interlocking bricks compared to conventional materials like burnt clay bricks and solid concrete blocks, concluding that the alternatives significantly reduce carbon emissions and environmental degradation. However, the study did not assess the cost implications of these materials relative to their conventional counterparts. Similarly, Jung *et al.* (2019) investigated the geochemical properties of volcanic rocks from Oldoinyo Lengai, highlighting their ability to recycle carbon and mitigate emissions. However, like Hatibu *et al.* (2015), this study also failed to examine the economic feasibility of incorporating volcanic rocks into construction. These gaps underscore the need for integrated assessments that combine environmental and cost-benefit analyses to facilitate the practical adoption of sustainable materials. This study seeks to address this gap by evaluating both the economic and environmental impacts of alternative building materials in Tanzania, providing a comprehensive foundation for informed decision-making.

2.2. Economic Viability of Building Materials

The cost of building materials plays a pivotal role in material selection, particularly in low- and middle-income countries where affordability often dictates decision-making (Ernest *et al.*, 2022). Conventional materials, such as concrete blocks, are frequently regarded as cost-effective due to their widespread availability and well-established supply chains (Nilimaa, 2023). However, this perception shifts when lifecycle costs are considered, as SBMs like CSEBs can offer significant long-term savings (Elahi *et al.*, 2021). Unni and Anjali (2022) argue that the economic viability of SBMs stems from their ability to reduce operational costs and enhance building resilience. While these materials may involve higher upfront expenses, they are shown to yield substantial long-term benefits, including lower maintenance costs and extended durability.

Globally and regionally, the economic evaluation of building materials has emphasised cost-effectiveness, lifecycle costs, and resource efficiency. For instance, Ohemeng and Ekolu (2020) conducted a comparative analysis in South Africa, demonstrating that recycled concrete aggregates could achieve cost savings of approximately 40% while reducing environmental impacts by 97% compared to natural aggregate concrete. Similarly, Puri *et al.* (2016) assessed cost trends in bamboo construction. They found that it can be 40% less expensive compared to partition brick walls, positioning bamboo as an affordable alternative for budget-conscious builders.

Despite their contributions, these studies reveal notable gaps in context-specific applicability. Ohemeng and Ekolu (2020) do not address the generalizability of their findings beyond South Africa, where factors such as material availability, labour costs, and supply chain efficiencies may differ significantly from other contexts, such as Tanzania. Likewise, although Puri *et al.* (2016) highlight the affordability of bamboo construction, the study lacks specificity regarding the traditional wall materials used as a basis for comparison, leaving uncertainties about the precise magnitude of its cost advantages.

To bridge these gaps, this study undertakes a comprehensive cost assessment of alternative building materials within the Tanzanian context. By evaluating their comparative cost benefits relative to conventional options and incorporating environmental and social considerations, this research aims to provide a more nuanced understanding of the economic viability of sustainable materials in a low-income, resource-constrained setting.

2.3. Environmental and Social Criteria in Material Selection

Globally, the discussion on SBMs tends to prioritise environmental metrics such as carbon footprints, embodied energy, and resource efficiency (Pham *et al.*, 2020). The latter author continues that factors dominate sustainability assessments due to their measurability and widespread standardisation. In contrast, social criteria—such as cultural acceptance, local availability, and community empowerment—are often marginalised in material selection discussions, despite their importance in achieving holistic sustainability (Mahame *et al.*, 2024 and Phoya and Nyange, 2022). This imbalance restricts the ability to address broader human-centred dimensions of sustainability, particularly in contexts like Tanzania, where construction practices are closely tied to socio-economic dynamics.

In Tanzania, materials such as soil-cement interlocking bricks and earth bricks have demonstrated significant potential for social impact (Moses *et al.*, 2020). By promoting local job creation, skill development, and self-reliance, these materials reduce dependence on expensive, energy-intensive imports, offering a pathway to community-based economic empowerment (IBR, 2024; Moses & Mosha, 2020; Hatibu *et al.*, 2015). However, these social benefits are frequently overshadowed by the dominance of environmental considerations in material evaluation frameworks (Mba *et al.*, 2024). While studies often emphasise the carbon savings and resource efficiency of such materials, there remains a critical need for research that evaluates their cultural acceptance and ability to address the diverse needs of marginalised groups (Mahame *et al.*, 2024). As Ramos (2024) highlights, social benefits—such as inclusivity, affordability, and alignment with local practices—are inherently more complex to quantify and integrate into standardised evaluation frameworks. Consequently, their consideration in material selection processes is inconsistent and context-dependent. This study seeks to address this gap by integrating both social and environmental criteria into material selection processes. By considering factors like cultural acceptance, local availability and accessibility, and community empowerment alongside carbon and resource efficiency, this research aims to offer a more comprehensive framework for sustainable construction in Tanzania.

2.4. Cost-Benefit Analysis as a Framework

Cost-Benefit Analysis (CBA) is widely recognised as a valuable tool for evaluating the feasibility of projects by comparing their projected costs and benefits. According to Hayes (2024), CBA provides a structured approach to determining whether a decision is worthwhile, particularly in construction, where resource allocation and financial efficiency are critical. Butković *et al.* (2023) emphasise that over the past two decades, CBA has become a primary tool in both academic literature and business practices for evaluating large-scale infrastructure and construction projects. Similarly, Landau (2023) highlights its utility in enabling project managers and stakeholders to make informed decisions about project viability. Vindana (2024) further elaborates that CBA can help assess direct and indirect financial gains, as well as intangible benefits such as enhanced productivity and environmental sustainability.

In the context of SBMs, CBA plays a crucial role in evaluating both initial and long-term financial implications. While these materials often have higher upfront costs, their long-term benefits—including lower energy consumption, reduced maintenance, and extended lifespan—frequently offset the initial investment (TheBuildChain, 2023). For example, sustainable materials with superior thermal insulation properties can significantly reduce heating and cooling expenses over a building's lifecycle (Dickson & Pavía, 2021). As Unni and Anjali (2022) argue, a comparative cost-benefit analysis of sustainable and conventional materials is essential for achieving both affordability and sustainability in housing.

Numerous studies have explored the cost-effectiveness of SBMs. Orekanti (2013) analysed the production costs of stabilised soil blocks compared to burnt bricks, positing that the local availability of soil could reduce construction costs by minimising transportation expenses. However, this study focused solely on production costs and did not extend to the costs of constructing entire buildings with these materials. In a separate analysis, Unni and Anjali (2022) demonstrated that houses built with CSEBs were 13% cheaper than those constructed with red-fired bricks. While insightful, this study relied on fixed construction costs and did not provide a detailed cost breakdown, limiting its practical applicability for budget adjustments.

In Tanzania, Moses and Mosha (2020) found that constructing a building with soil-cement interlocking bricks and sisal concrete roofing tiles reduced costs by 40% compared to using sand-cement blocks and corrugated iron sheets. Similarly, NHBRA (2016) reported a 40% cost reduction when using soil-cement interlocking bricks. However, these studies did not specify the basis of comparison or provide detailed rate build-ups, raising questions about the reliability of their conclusions.

This study builds upon these findings by employing a detailed cost-benefit analysis to evaluate the economic impacts of commonly used sustainable materials compared to conventional counterparts in residential projects. By addressing the limitations of previous studies, such as the lack of comprehensive cost breakdowns and context-specific data, this research aims to provide more actionable insights for construction stakeholders.

2.5. Limitations in NCC Material Price Lists for Sustainable Construction

In Tanzania, the absence of local building standards and certification systems to assess the environmental compliance of building materials (Nkini *et al.*, 2024), coupled with low levels of awareness and knowledge about sustainable alternatives (Mushi *et al.*, 2023), hinders the effective utilisation of alternative building materials. This challenge was further highlighted by Mahame *et al.* (2024), who identified a lack of awareness and limited knowledge as particularly significant barriers to the effective selection of SBMS. These barriers, alongside regulatory and policy constraints, continue to impede the broader adoption of SBMs in residential construction projects.

Similarly, Nidhin *et al.* (2023) and the United Nations (2009) assert that weak policies and regulatory frameworks are frequently linked to lower levels of awareness and knowledge among stakeholders in the construction industry. Kibert (2016) confirms this relationship, noting that regions with inadequate environmental policies often exhibit limited understanding and adoption of sustainable building materials. The interplay of these factors suggests that addressing awareness and regulatory barriers is critical to improving the selection and use of SBMs.

One practical challenge is the presence of ineffective or insufficiently comprehensive tools or databases to guide stakeholders in understanding and comparing material alternatives. Such tools are critical for providing detailed insights into the sustainability attributes of materials, such as their environmental impact, lifecycle costs, and social benefits (Thormark, 2002). For instance, the most recent price list of materials published by the NCC in 2019 (NCC, 2019) exclusively focuses on conventional materials, offering limited to no guidance on sustainable alternatives. This list, widely used by builders, developers, and policymakers, primarily emphasises financial aspects—specifically initial costs—while neglecting broader considerations of material sustainability. Without robust tools or databases that integrate both financial and other sustainability metrics, stakeholders are left with incomplete information, limiting their ability to make informed, forward-looking decisions.

Table 1: Sample format of the actual price list (Source: NCC, 2019)

Region	Unit	Price (TZS)		
		450mm*250mm*100mm	450mm*250mm*125mm	450mm*3250mm*150mm
Iringa	pc	1,000	1,200	1,500
Mbeya	pc	1,300	1,500	1,500
Songwe	pc	1,200	1,500	1,700
Rukwa	pc	1,000	1,200	1,500
Katavi	pc	1,000	1,200	1,600
Ruvuma	pc	1200	1,400	1,600
Lindi	pc	900	1,000	1,500
Mtwara	pc	900	1,000	1,500

It is important to note that not all materials listed in the NCC price list are entirely unsustainable. However, the exclusion of explicit sustainability metrics or alternative materials limits stakeholders' ability to make informed decisions based on comprehensive evaluation criteria. Table 1 illustrates the existing format of the price list, which primarily focuses on cost factors, offering limited insight into other sustainability attributes of listed materials.

To address these limitations, this study proposes an enhanced framework for the NCC's price list that integrates sustainability metrics alongside financial data. By broadening the scope of the price list to include environmental and social dimensions, stakeholders can make decisions that prioritise long-term benefits, such as resource efficiency, reduced environmental impact, and local community empowerment, rather than solely focusing on initial costs.

3. Methodology

3.1. Introduction

This study adopts a quantitative research approach to evaluate the economic impacts of selecting SBMs compared to conventional materials for residential building projects in Tanzania. This approach facilitates evidence-based decision-making by providing measurable and comparable numerical data, such as costs, environmental and social benefits (Lim, 2024).

3.2. Research Design

A cost-benefit analysis (CBA) framework was selected as the primary method due to its systematic approach to comparing material alternatives based on direct and indirect costs, environmental impacts, and social benefits (Boardman *et al.*, 2011). This framework aligns with Goel and Sharma's (2022) assertion that CBA enables data-driven evaluations to inform stakeholders' decision-making processes. The descriptive research design supports the study's objective by focusing on measurable criteria such as cost and by assessing local availability and ease of use through qualitative and semi-quantitative proxies. Moreover, a comparative analysis of two material alternatives—compressed stabilised earth blocks (CSEBs) and conventional concrete blocks—was conducted, based on pre-defined criteria such as cost, local availability, and ease of use within the specific contexts of Dar es Salaam. This location was selected due to its significance in urbanisation, housing demand, and resource availability (Komu & Ramparsad, 2022). This ensures the analysis captures local nuances relevant to Tanzania's construction industry.

3.3. Steps in Cost-Benefit Analysis

In assessing the economic viability of SBMs (CSEBs) compared to conventional materials within the Tanzanian construction sector, the study adopted a systematic approach based on the methodology outlined by Mishan and Quah (2007). This approach is visually summarised in Figure 1, which illustrates the sequential steps undertaken in the Cost-Benefit Analysis (CBA) process.

The key steps include:

1. Defining scope and objectives– The study examines the economic feasibility of SBMs (CSEBs) compared to conventional materials (concrete blocks) in the Tanzanian construction sector. To this, social and environmental criteria are integrated into the material selection process.

2. Identifying relevant costs and benefits– Relevant factors include material, labour, and plant costs, alongside benefits such as reduced embodied energy, local availability and accessibility, durability, and energy savings. Existing local findings were integrated to evaluate energy and carbon intensities as well as social impacts.

3. Quantifying costs and benefits
   i. Data collection: Conducted in May 2024, materials prices were gathered from local suppliers in Dar es Salaam. The saturation principle ensured adequate representation of variability in costs.

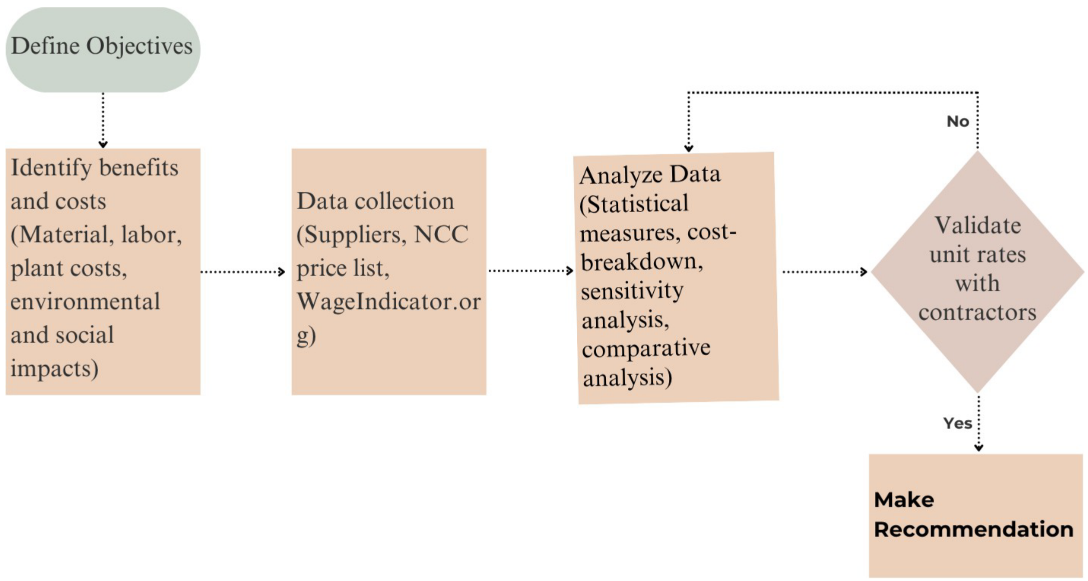

Figure 1: CBA flowchart (Authors)

The saturation principle ensured adequate representation of variability in costs. Labour costs were derived from the updated minimum wage data for construction services in Tanzania, as provided by WageIndicator.org (WageIndicator, 2025). This platform offered consistent and reliable baseline rates applicable to both Dar es Salaam. To account for potential variations, inflation-adjusted plant costs were calculated using the 2019 NCC Price List as a reference. The adjustment process involved applying the annual average inflation rates for Tanzania, sourced from the National Bureau of Statistics (NBS, 2024), ensuring the figures reflect present-day market conditions. This process ensured consistent and representative patterns reflecting the prevailing market conditions. Moreover, it leveraged the 2019 price list report from the National Construction Council of Tanzania (NCC, 2019).

i. Statistical measures: Statistical measures, including mean, median, range, and standard deviation, were employed to assess cost variability, providing insights into the reliability and distribution of data (Moore *et al.*, 2021; Olsen *et al.*, 2010; Newbold *et al.*, 2013).

4. Comparing costs and benefits– The analysis standardises comparisons on a per-square-meter (1 m²) or per-cubic-meter (1 m³) basis (Ashworth & Perera, 2015).

5. Validate unit rates with contractors– This step involved cross-checking the calculated unit rates with local building contractors in Dar es Salaam. This ensured alignment with market practices and validated the practicality of the rates.

6. Making recommendations– Findings inform policy, building practices, and the development of updated price lists incorporating sustainability criteria.

3.4. Material Selection Criteria

Key criteria for material selection included cost, local availability, and ease of use. Lower material costs can significantly enhance housing affordability for middle- and low-income populations (Carpino *et al.*, 2018 and Oyebanji *et al.*, 2017).

Local availability sourcing reduces transportation costs, supports local economies, and minimises environmental impacts (Mahame *et al.*, 2024). While ease of use improves project timelines and reduces labour costs, it offers practical benefits in resource-constrained settings (Falco *et al.*, 2020).

Based on these criteria, the comparative analysis focuses on CSEBs and conventional concrete blocks.

Concrete blocks dominate the market, comprising 70% of all building materials in Dar es Salaam (Sabai *et al.*, 2013).

CSEBs, which are gaining popularity in sub- Saharan Africa, are increasingly recognised for their cost efficiency, sustainability, and ease of use (ARSO, 2018).

3.5. Analysis

To ensure transparency and precision, the study employs a cost breakdown approach (Brook, 2017), which allows for detailed estimation of initial costs and precise identification of cost-saving opportunities. This approach addresses the higher upfront costs often associated with sustainable materials by highlighting their long-term economic and other benefits *(Mahame et al.*, 2024). Additionally, a sensitivity analysis examined the impact of variations in material and labour costs on total costs. The analysis considered adjustments of ±10% and ±20%, commonly used ranges that reflect the stability of labour/material costs and price fluctuations in Tanzania's construction sector (NCC, 2020a, 2020b). This analysis ensures the reliability of decision-making and accounts for market volatility (Kermanshachi & Pamidimukkala, 2023).

4. Results

This section presents a detailed analysis and interpretation of the study's findings, covering descriptive statistics, unit rates build-up, sensitivity analysis, and comparative evaluation of concrete blocks and CSEBs.

4.1. Descriptive Analysis

The descriptive analysis of this study provides insights into the distribution and variability of unit prices for concrete blocks and CSEBs, based on data collected

Table 2. Descriptive statistics for initial prices of concrete blocks and CSEBs (Authors)

Prices (TZs)	**Frequency (f)**	$x \times f$	**Deviation from mean (x_i−μ)**	**Squared deviation ((x_i−μ)^2×f)**
1. Concrete Blocks				
1,650	3	4,950	(50)	7,500
1,700	9	15,300	0	0
1,750	3	5,250	50	7,500
Total	**15**	**25,500**		**15,000**
Mean (μ)= Σ i/n		1,700		
Standard deviation (σ)= %Σ i$n (xi&μ)² / n				31.62
2. CSEBs				
650	1	650	(60)	3,600
700	2	1,400	(10)	200
750	2	1,500	40	3,200
Total	**5**	**3,550**		**7,000**
Mean (μ)= Σ i/n		710		
Standard deviation (σ)= %Σ i$n (xi&μ)² / n				37.41

from a total of 15 suppliers for concrete blocks and five suppliers for CSEBs (Table 2).

These descriptive statistics were instrumental in determining the initial prices of the materials, which were subsequently used to calculate their respective unit rates per Square Meter of walling. This approach ensures that the analysis reflects real market conditions and supplier pricing trends, thereby enhancing the reliability of the study's cost comparisons.

Observation: The mean price for concrete blocks is 1,700 TZs with a standard deviation of 31.62 TZs, indicating relatively minor variability across supplier prices and market stability (Agyekum *et al.*, 2018). By contrast, CSEBs have a mean price of 710 TZs, with a slightly higher standard deviation of 37.41 TZs. This reflects a more pronounced price variability, potentially attributable to factors such as variability in raw material composition (e.g., soil and cement ratios) and less mature supply chains (Dominguez *et al.*, 2013). Despite the differences in pricing patterns, both materials share a comparable price range of 100 TZs, highlighting that both markets exhibit a similar price dispersion.

4.2. Unit Rates Build-Up

Apart from considering the standard factors of estimation for materials, labour, and plant inputs for construction works provided in the book 'Estimating and Tendering for Construction Work' by Brook (2017), the following additional considerations were applied to accomplish the estimation task:

1. Size
   i. Concrete blocks: 450 x 200 x 150mm
   ii. CSEBs: 230 x 220 x 115mm

2. Mortar ratio
   i. Concrete block: (1:3)
   ii. CSEBs: (1:4)

3. Material market prices
   i. Portland cement: 25,000TZs/50Kg (Bag)
   ii. Sand: 30,000 TZs/ton`
   iii. Semi-skilled/Mason: 1,641TZs/hour (WageIndicator, 2025)
   iv. Concrete mixer (10/7):
   v. Concrete block: The mean value of 1,700 TZs per block was used due to its representativeness of the market prices (Refer to Table 2).
   vi. CSEBs: The higher price of 750 TZs per block was adopted instead of the mean value of 710 TZs. This decision reflects risk mitigation, such as supply chain variability or increased production costs, particularly as CSEBs are still in the early stages of adoption in Tanzania (Refer to Table 2).

4. Assumptions
   i. The cost of materials includes transportation costs.
   ii. Assume that one mason and one helper can handle 5-7 sq m per day of concrete blocks.
   iii. Assume that a helper works half as long as a mason.
   iv. For CSEBs, mortar is only used on the lowest course and vertical joints, thus requiring a lesser mortar quantity.
   v. Assume the labour cost is equal for both concrete blocks and CSEBs
   vi. Assume all works are carried out without the services of a subcontractor
   vii. All currencies are in Tanzanian Shillings
   viii. Standard allowances for waste, contingency (5%), overheads (15%), and profits (15%) were used.

From Table 3, the calculation of the unit rate for concrete block wall began by determining the rate of $1m^3$ of mortar (1:3), which was 284,365 TZs/m^3, factoring in material costs, labour, and plants. For $1m^2$ of concrete block walling, 12 blocks were required at 1,700 TZs each, with an additional 10% for waste.
The total labour required included 1.1 hours for a mason and 0.55 hours for a helper, resulting in a final unit rate of 39,960 TZs/m^2, including contingency, overheads and profit allowances.

Similarly, the unit rate for $1m^2$ of CSEBs walling (Table 4) was built upon the rate of $1m^3$ of mortar (1:4), calculated as 241,043 TZs/m^3, including the material waste allowance. For $1m^2$ of walling, 23 blocks were required at 750 TZs each with a 10% allowance for waste. Labour requirements included 0.9 hours for a mason and 0.45 (rounded to hours for a helper, resulting in a final unit rate of 32,747 TZs/m^2, including contingency, overheads and profit percentages.

The overall observation reveals significant economic advantages of CSEBs over concrete blocks. The base unit rate of CSEBs (32,747 TZs/m^2) is 18.05% lower than that of concrete blocks (39,960 TZs/m^2). While this cost advantage exceeds the 13% reported by Unni and Anjali (2022), it is substantially lower than the 40% reported by Moses *et al.* (2020) and NHBRA (2016), and the 41% reported by Orekanti (2013). The latter three studies, however, did not specify the source of their reported percentage advantage or provide the basis of comparison or detailed rate build-ups, which raises questions regarding the reliability of their conclusions. In contrast, Unni and Anjali (2022) conducted their CBA for CSEBs against masonry bricks rather than concrete blocks, as used in the present study, and relied on prevailing field unit rates instead of the cost breakdown methodology employed in this research.

An additional trend observed between Tables 3 and 4 is that the labour required is at least a quarter-hour less to complete one square of CSEB's wall compared to concrete blocks. This observation aligns with broader findings in the literature indicating that sustainable materials often incorporate designs that facilitate ease of use (Falco *et al.*, 2020). Furthermore, this reduced construction time has significant economic implications, as it directly translates into lower labour costs, a crucial consideration for resource-constrained projects.

1.1. enitivity Analysis

To assess the impact of possible price volatility, a sensitivity analysis was performed using adjustments of ±10% and ±20% on key cost components, including cement, sand, concrete blocks, CSEBs, and labour. It is noteworthy that due to the extensive number of tables illustrating the implications for each scenario of potential variation, the manuscript detailing unit-rate tables for all ranges is available in the supplementary files (Sensitivity Analysis) provided for reference. Subsequently, the authors present the summary data and key findings (Figure 1).

For concrete blocks, a 10% cost decrease reduces the unit rate to 35,988 TZs/m^2, whereas a 20% reduction To assess the impact of possible price volatility, a sensitivity analysis was performed using adjustments of ±10% and ±20% on key cost components, including cement, sand, concrete blocks, CSEBs, and labour. It is noteworthy that due to the extensive number of tables illustrating the implications for each scenario of potential variation, the manuscript detailing unit-rate tables for all ranges is available in the

Table 3: Cost breakdown for 1m^2 of solid concrete block wall (Authors)

200 mm thick solid concrete block walling; in cement and sand (1:3) mortar......m 2									
ITEM DETAILS					**ANALYSIS**				**Net Unit Rate (TZs)**
Ref	**Description**	**Qty**	**Unit**	**Rate (TZs)**	**Lab**	**Plt**	**Mat**	**s/c**	
Mat	Mat for 1 m3 of mortal 1:3								
Mat	Cement	0.52	t	400,000			208,000		
Mat	Sand	1.35	t	30,000			40,500		
Mat	Add Waste (7.5% of Mat)						18,638		
Mat	Semi-skilled	3.7	Hr	1,641	6,072				
Plt	Concrete mixer (10/7)	0.5	Hr	22,313		11,156			
Rate for 1:3 mortar					6,072	11,156	267,138		284,365
Now consider the walling.									
Mat	Blocks	12	nr	1,700			20,400		
Mat	Waste 10%	1.2	nr	1,700			2,040		
Mat	Mortar	0.014	m3	284,365			3,981		
Mat	Waste 15%	0.0021	m3	284,365			597		
Lab	Mason	1.10	Hr	1,641	1,805				
Lab	Helper (1:2)	0.55	Hr	821	451				
Sub 1					**2,256**		**27,018**		**29,275**
Add Contingency 5%					113		1,351		1,464
Sub 2					**2,369**		**28,369**		**30,738**
Add overheads 15%					355		4,255		4,611
Add Profit 15%					355.38		4,255.38		4,611
Unit Rate per m2					**3,080**		**36,880**		**39,960**

Note(s): Ref= Reference; Qty= Quantity; Lab= Labor; Plt= Plant/Equipment; Mat= Materials; S/C: Sub-contractor.

Table 4: Cost breakdown for 1m2 of CSEBs wall (Authors)

230mm x 190mm x 115mm CSEB walling; with (1:4) mortar only laid under the lowest course...... m 2									
ITEM DETAILS					**ANALYSIS**				**Net Unit Rate (TZs)**
Ref	**Description**	**Qty**	**Unit**	**Rate (TZs)**	**Lab**	**Plt**	**Mat**	**s/c**	
Mat	Mat for 1 m3 of mortal 1:4								
Mat	Cement	0.39	t	400,000			156,000		
Mat	Sand	1.74	t	30,000			52,200		
Mat	Add Waste (7.5% of Mat)						15,615		
Mat	Semi-skilled	3.7	Hr	1,641	6,072				
Plt	Concrete mixer (10/7)	0.5	Hr	22,313		11,156			
Rate for 1:4 mortar					6,072	11,156	223,815		241,043
Now consider the walling.									
Mat	CSEB	23	nr	750			17,250		
Mat	Waste 10%	2.3	nr	750			1,725		
Mat	Mortar	0.008	m3	241,043			1,808		
Mat	Waste 15%	0.0011	m3	241,043			271		
Lab	Mason	0.90	Hr	1,641	1,477				
Lab	Helper (1:2)	0.45	Hr	821	369				
Sub 1					**1,846**		**21,054**		**22,900**
Add Contingency 10%					184.61		2,105.40		1,145
Sub 2					**2,031**		**23,159**		**24,045**
Add overheads 15%					305		3,474		3,607
Add Profit 15%					304.61		3,473.91		3,607
Unit Rate per m2					**2,640**		**30,107**		**32,747**

Note(s): Ref= Reference; Qty= Quantity; Lab= Labor; Plt= Plant/Equipment; Mat= Materials; S/C: Sub-contractor.

in the supplementary files (Sensitivity Analysis) provided for reference. Subsequently, the authors present the summary data and key findings (Figure 1).

For concrete blocks, a 10% cost decrease reduces the unit rate to 35,988 TZs/m², whereas a 20% reduction lowers it further to 32,017 TZs/m².

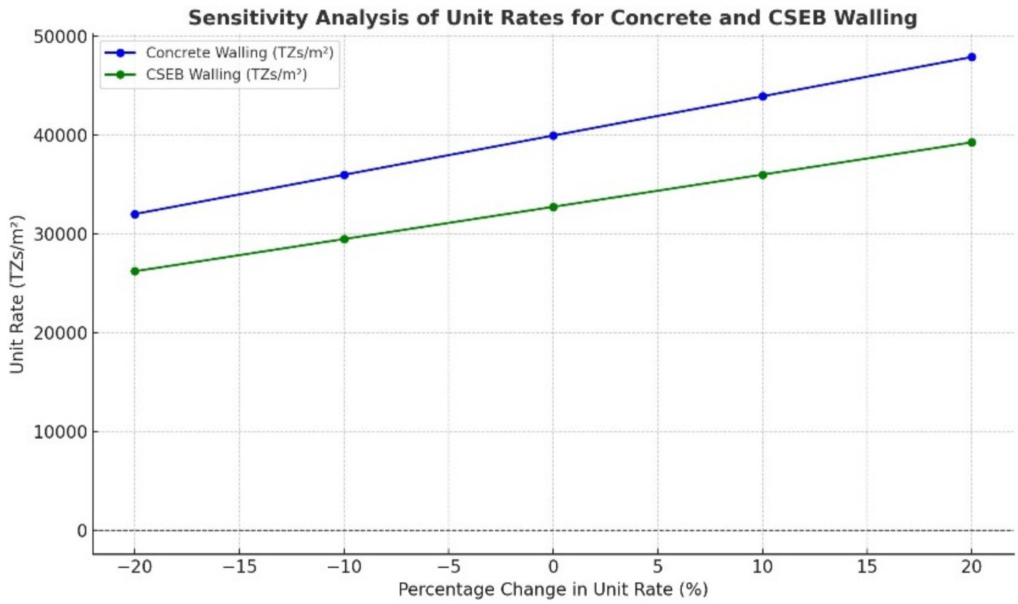

Figure 1: Sensitivity analysis of unit rates for concrete block and CSEBs (Authors)

Conversely, a 10% increase increases the rate to 43,931 TZs/m², and a 20% increase elevates it to 47,903 TZs/m². For the CSEBs, the unit rate decreased to 29,666 TZs/m² (-10%) and 26,386 TZs/m² (-20%). However, a 10% cost increase raises the rate to 36,225 TZs/m², and a 20% increase pushes it up to 39,505 TZs/m².

The findings indicate that CSEBs generally demonstrate greater economic viability compared to concrete blocks, exhibiting lower unit rates across all scenarios examined.

This observation aligns with the research conducted by Islam *et al.* (2020), which concluded that CSEBs are more cost-effective and may provide enhanced price stability in volatile markets, potentially attributable to the utilisation of locally sourced materials and waste products as stabilising agents.

1.2. Summary, Interpretation, and Implications

The findings indicate that:

1. CSEBs are cost-effective: The consistent cost advantage across sensitivity ranges demonstrates their economic viability.

2. Impact of price volatility: Materials and labour prices significantly influence unit rates, suggesting the need for cost control measures in these areas.

3. Policy and practice implications: The adoption of CSEBs can contribute to more economical and sustainable construction practices, aligning with Tanzania's objectives for sustainable housing development.

Furthermore, in a review of the existing literature, multiple studies support the idea that CSEBs offer significant environmental and social advantages compared to concrete blocks. According to Hatibu *et al.* (2015), the embodied energy of concrete blocks is three to four times higher, and their carbon emissions are four to six times greater than those of CSEBs. These disparities are attributed to the localised production of CSEBs and the avoidance of energy-intensive processes such as high-temperature firing (Paul *et al.*, 2024). Moreover, CSEBs yield energy savings of 1.0–2.0 MJ/m² compared to 0.5–1.0 MJ/m² for concrete blocks.

Durability is another notable characteristic of CSEBs, which, when stabilised with cement, lime, or geopolymers, can meet international standards and withstand various environmental conditions (Bogas *et al.*, 2018 and Sore *et al.*, 2018). A minimum cement content of 4% ensures water resistance, while natural fibres such as areca further enhance strength and longevity (Paul *et al.*, 2024). Although concrete blocks can last over 100 years under ideal conditions (Franks, 2023), CSEBs have a lifespan of up to 70 years, rendering them a durable option for sustainable construction (Malkanthi & Perera, 2018).

From a social perspective, CSEBs provide environmentally friendly and cost-effective building solutions that align with global sustainability goals. Their production supports local economies, reduces construction costs, and creates employment opportunities (Latha *et al.*, 2023 and Sadouri *et al.*, 2024). Furthermore, the aesthetic appeal of red soil CSEBs eliminates the necessity for painting, as noted by Hydraform Tanzania (2024).

Although CSEBs may require further optimisation to suit specific project conditions, their lower embodied energy and carbon emissions, coupled with their notable economic and social advantages, make them a promising alternative to conventional concrete blocks in sustainable construction (Table 5).

Table 5: Comparative analysis between concrete blocks and CSEBs (Authors)

S/No.	Parameter	Concrete blocks	CSEB
1	Sizes (mm)	450x250x150mm	230x220x115mm
2	Volume (m^3)	0.016875	0.005819
3	Initial Cost (Tsh/m^2)	39,960	32,747
4	Average Lifespan (years)	100	70
5	Availability	High	Moderately High
6	Ease Of Use	Easy	Easier
7	Energy Savings (Annually)	Moderate	Moderately High
8	Environmental Impact	High	Low
	Recommendation	**Advised with Environmental Caution**	**Highly Recommended**

On the other hand, apart from understanding the economic impacts of sustainable materials compared to conventional construction materials while integrating environmental and social criteria, this study aimed to utilise its results to propose an enhanced format of the price list of materials to the NCC. The proposed price list format (Table 6 in Appendix 1**)** integrates sustainability metrics with financial data, thereby promoting awareness and facilitating informed decision-making for stakeholders.

According to Albarbary *et al.* (2023), integrating sustainability into cost build-up encourages the use of greener materials by highlighting their long-term financial benefits, driving demand for sustainable options, and potentially leading to economies of scale. Myint and Shafique (2024) reported that incorporating sustainability metrics into cost information enables stakeholders to make more environmentally conscious decisions in various sectors, particularly in construction and manufacturing. By considering factors such as embodied energy, carbon footprint, and recyclability potential alongside traditional cost metrics, decision makers can better align their choices with environmental goals (Trappey *et al.*, 2012). Moreover, Robichaud and Anantatmula (2010) expressed that, given the growing emphasis on sustainability, there is a clear need to integrate sustainability considerations into building material pricing guides. Therefore, the incorporation of sustainability aspects into price lists would not only promote a more holistic approach to cost estimation but also ensure that the actual value of materials is considered in building projects.

The following is what to see about the proposed format of the price list:

1. The new format includes both conventional and sustainable materials, clearly labelling each material type. This will;
   i. Enable users to distinguish between conventional and sustainable options easily
   ii. Broaden the range of materials considered, making it easier for stakeholders to explore sustainable alternatives.
2. The new format retains the region-specific approach while ensuring that the information is relevant and accurate for local contexts. This comprehensive view could help list all materials available in a region and indicate their categories.
3. The new format includes crucial information on environmental and social factors. With this comprehensive approach, stakeholders will be able to consider not just the immediate cost but also the long-term benefits and environmental implications.

1.3. Study Limitations

Despite achieving the objectives, this study acknowledges some limitations. The investigation was limited to Dar es Salaam and a specific set of building materials, with a focus on CSEBs and concrete blocks. All of these considerations limit the generalizability of the findings to other materials or contexts beyond the scope of this study. Therefore, future research should expand the range to include a wider variety of materials. Moreover, they should focus on diverse geographical regions of Tanzania to assess how regional differences in material availability, labour costs, and construction practices influence the suitability of sustainable materials. Lastly, future studies should incorporate more robust quantitative data on environmental and social impacts. A more holistic evaluation, such as LCA, would allow for a better understanding of the overall sustainability of alternative building materials.

5. Conclusion

This study aimed to assess the economic viability of SBMs in comparison to conventional materials for residential building projects in Tanzania, while considering environmental and social factors. Through the application of CBA, the study assessed the economic advantages of using CSEBs compared to conventional concrete blocks. These materials were selected based on key criteria including cost, local availability of resources, and ease of use. Moreover, the cost breakdown per 1 Sq.m. was utilised in order to ensure more precise estimations, helps in setting realistic budgets, enables stakeholders to adjust plans to stay within budget, and enhances transparency.

The findings revealed that CSEB walls are approximately 18% cheaper than concrete blocks, easier to construct, and offer significant energy savings with a reduced environmental footprint. Consequently, CSEBs emerged as a highly recommended option for sustainable residential construction, while concrete blocks, although commonly used, are advised with environmental caution due to their higher impact. Beyond understanding the economic implications of sustainable materials, the study used the findings to suggest an enhanced format for the price list of materials to the NCC. By incorporating the cost-efficiency and sustainability of materials like CSEBs, the revised price list could help increase the awareness of sustainable materials, hence promoting more environmentally conscious decisions.

This study offers substantial contributions to advancing sustainable construction practices in Tanzania. By identifying alternative building materials, the research promotes awareness and deepens knowledge of sustainable options, which is crucial for fostering more environmentally conscious decision-making. The proposed enhanced price list of materials not only supports this awareness but also serves as a comprehensive tool for comparing various alternatives, aiding stakeholders in selecting the most suitable materials for their projects. The cost-benefit analysis conducted provides a valuable guide for future research, suggesting the need to expand the range of sustainable materials analysed and explore additional alternatives. Furthermore, the detailed cost breakdown per Sq.m. is highly recommended, as it enables precise budget estimations and helps stakeholders adjust plans while staying within budget.

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Appendix 1

Table 6: Proposed enhanced price list format (Authors)

REGION: DAR ES SALAAM												
S/No.	**Description**	**Unit**	**Price (TSh)**			**Material Type**	**Lifespan (Years)**	**Availability**	**Ease Of Use**	**Energy Savings**	**Environment Impact**	**Remark**
			450x250 x150mm	**450x250 x125mm**	**450x250 x100mm**							
1	Concrete Block	PC	1,500	1,400	1,300	Conventional	100	High	Highly Usable	Moderate	High	Advised with Environmental Caution
2	CSEB	PC	750	750	750	Sustainable	70	Moderately High	Moderately Usable	Moderately High	Low	Highly Recommended