Sustainable block production in developing countries

A case study in Tanzanian construction industry

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Abstract

This study investigates the potential for sustainable building practices in the sub-Saharan regional context, using small- and medium-scale sandcrete block production in Tanzania as a case study. The research combines a literature review on sustainability challenges in the region with insights from two semi-structured interviews. One with a local practitioner who regularly collaborates with small-scale producers, and one with an engineer with long-term experience in sandcrete production in sub-Saharan Africa. It also includes an evaluation and comparison of three environmental assessment systems, BREEAM, Green Star SA and BSAM, regarding their relevance for material sourcing, usage and efficiency in the region.

Findings indicate that the adoption of sustainable practices faces financial, cultural, educational, and infrastructural barriers. High costs of materials, limited access to training and the prioritization of short-term profit hinder implementation, while traditional building practices using local resources are undervalued despite potential environmental and cost benefits. International assessment systems such as BREEAM and Green Star SA both provide comprehensive material categories, that are, however, often not applicable to the sub-Saharan area, whereas regional frameworks like BSAM also contain social and economic dimensions and may offer an approach more appropriate in the geographical context.

The discussion highlights the potential for governmental policies and international support to address and overcome financial and educational gaps. Future research should further explore practical methods for incorporating local materials and supplementary cementitious products and ways for assessment systems to support small-scale production while aligning with regional standards.

Sammanfattning

Denna studie undersöker potentialen för hållbara byggmetoder söder om Sahara i Afrika, med en fallstudie som behandlar små- och medelskaliga producenter av sandcrete i Tanzania. Forskningsarbetet kombinerar en litteraturstudie om hållbarhetsutmaningar i regionen med insikter från två semistrukturerade intervjuer: en med en lokal yrkesverksam som regelbundet samarbetar med småskaliga producenter och en med en ingenjör med lång erfarenhet av sandcreteproduktionen i Afrika söder om Sahara. Studien inkluderar även en utvärdering och jämförelse av tre miljöcertifieringssystem, BREEAM, Green Star SA och BSAM, med avseende på deras relevans för materialinköp och användning, samt hur effektiva de potentiellt hade varit i området.

Resultaten visar att införandet av hållbara byggmetoder möter ekonomiska, kulturella, utbildningsmässiga och infrastrukturella hinder. Höga materialkostnader, begränsad tillgång till utbildning och prioritering av kortsiktig vinst försvårar genomförandet, samtidigt som traditionella byggmetoder som använder lokala resurser underskattas trots potentiella kostnads- och miljömässiga fördelar. Internationella certifieringssystem som BREEAM och Green Star SA har båda omfattande materialkategorier men är ofta svåra att tillämpa i området, medan regionala ramverk som BSAM inkluderar sociala och ekonomiska aspekter som upplevs mer passande i kontexten.

Diskussionen betonar potentialen av statliga policyers och internationellt stöd för att underlätta och överkomma ekonomiska och utbildningsmässiga hinder. Framtida forskning föreslås utforska vidare kring praktiska metoder för att integrera lokala material och alternativa bindemedel samt hur certifieringssystem kan stödja småskalig produktion samtidigt som de anpassas till regionala standarder.

Acknowledgements

This thesis is one of the final parts of my master’s degree in civil engineering at Lund University. The thesis reflects both interests born though my long academic journey and my personal interest for work in sustainability. My interest reached new heights through realising that sustainability can be understood in many different aspects, and through many different contexts and conditions that can differ greatly than what is seen in Western society.

Writing this thesis has allowed me to explore how sustainability can be defined in growing economies and to connect and compare theoretical perspectives with real-world practices. I hope that this study will challenge the way that sustainability is perceived, highlighting that there are many connected reasons why assessment systems cannot be applied directly without any geographical adaptation.

I would like to thank my supervisor, Stefan Olander, for his guidance and support throughout the process of writing this thesis. I am grateful for the interview respondent wanting to share his valuable experiences, as well as thank Raine Isaksson at Engineers Without Borders Sweden for not only making the introduction but also for the discussions that led to the aim of this thesis.

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1 Introduction

This thesis focuses on sustainable building practices in developing countries, with a particular emphasis on block production in Tanzania. The main objective is to understand, define, and measure sustainability within the building block production process in the sub-Saharan context.

Although building blocks are widely used across sub-Saharan Africa, clear and context-adapted guidelines for how sustainability should be assessed in their production are lacking. Existing assessment systems are either designed for Western contexts or are not implemented in practice, which creates uncertainty regarding how sustainability can be measured in low-income construction environments. This makes block production both a critical and insufficiently studied component of sustainable building development in Tanzania.

1.1 Background

One of the reasons why it is important to be able to produce sustainable housing in Tanzania and other developing countries is due to an expected population growth, as can be seen in figure 1. The sub-Saharan countries are overrepresented regarding percentual population growth, with 33 of the 45 least developed countries being in the region (UNCTAD, 2024). In the case of Tanzania, the population is expected to grow to roughly 81 million by 2030 (PopulationPyramid, 2025), which is an increase by 15 million within a seven-year period.

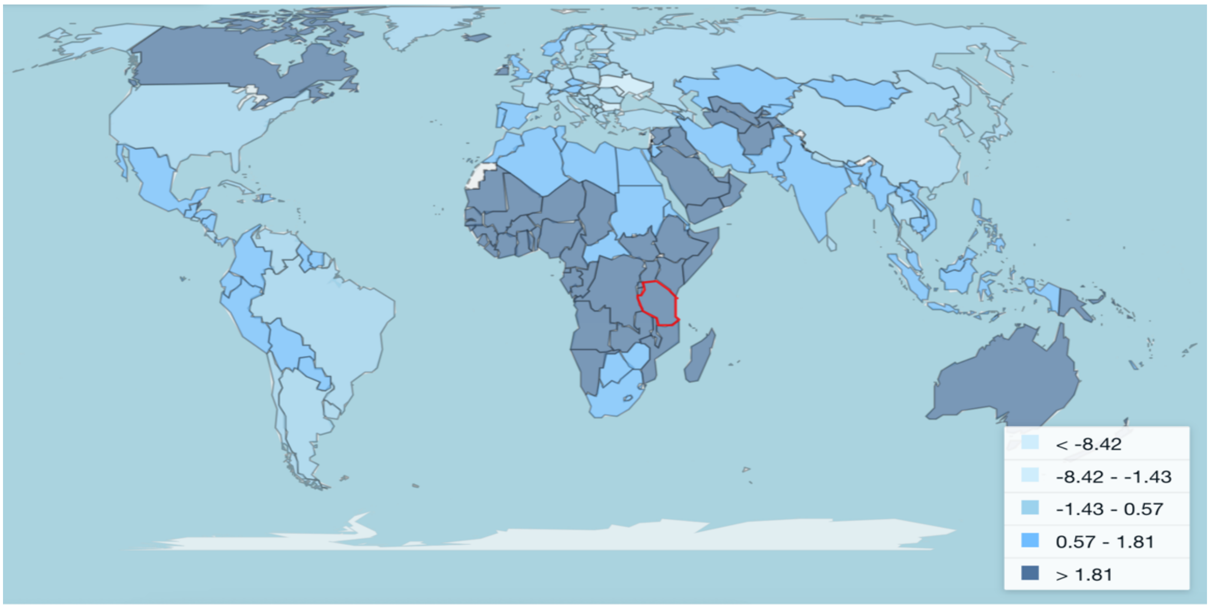

Figure 1. Population growth (%) 2023 Tanzania lined in red (World Bank Group, 2023).

The population growth will lead to an increased need of housing and amenities in both rural and urban areas. UNDP (2025) reports that 4.2 billion people, which is more than half of the world's population, currently lives in cities and that number is expected to grow. In Tanzania, 70 % of the urban population live in informal or unplanned settlements, also known as slums (Mussa, 2020). These citizens lack basic services, such as water and sewage. Due to regulations concerning how long a building permit is issued and the widespread poverty, many low-income households in Tanzania simply cannot afford either a house or a plot to build on. As the population grows, these are among the many challenges currently facing Tanzania.

The UN's Sustainable Development Goals, also known as the Global goals, are 17 goals that were adopted by the UN in 2015 to protect the planet and to ensure that people were to enjoy peace and prosperity by 2030 (UN, 2015). The goals are integrated in each other, covering and balancing economic, social and environmental sustainability. This study is primarily guided by the 11^{th} goal, named "Sustainable cities and communities", even if the other goals also will be considered. The goal includes ten specific targets that outline how to achieve and ensure sustainability within cities and communities (UN, 2015). The targets strive to ensure affordable housing and basic services to all, as well as safe and affordable transport systems though improved roads and expansion of public transport. This must be done by a sustainable urbanization and settlement planning, which must also protect and safeguard natural and cultural heritage sites. Sustainable cities must also be adaptable to climate change and natural disasters, with a focus to be able to protect societies' most vulnerable. Urban cites must be able to ensure healthy air quality, waste management and be able to provide its citizens with green and public spaces. The goal also encourages to support economic, social and environmental links between urban and rural areas to strengthen both regional and national development. The final goal target is very relevant for the study, saying *"Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials"* (UN, 2015)

Isaksson and Babatunde (2019) reports that 5% of global carbon emission originated from cement production. Since the global usage of cement is growing rapidly, even quicker than global carbon emissions, there is a need to lower cement usage. As a normal-size 50 kg bag of cement costs more than most low-income households in developing countries earn in one day, the economic implications of building with concrete become particularly significant. Many Africans are paying with more hours of labour for their cement that western parts of the worlds are. In 2014, the African continent consumed about 200 kg/person per year, which is lower that the world average of 600 kg/person per year. The African number is expected to increase to the world average, which would raise the global consumption from 200 Mton per year to 1400 Mton per year. (Isaksson & Babatunde, 2019)

The most common way to build houses in sub-Saharan Africa and Tanzania is by using cement-based building blocks. These blocks are made with Portland cement and since the cement is, by far, the most expensive ingredient in relation to the salary, the building block becomes very expensive (Isaksson et al., 2023). The high prices are both due to high cost related to long transport and a high energy cost. Portland cement, as mentioned, also drives the carbon footprint of the building block and therefore, the building as a whole. As an alternative, cement blocks with a part of the Portland cement replaced with sand are used. These blocks are called sandcrete blocks and have a low compressive strength, they are used for building both formal and informal settlements. The sandcrete blocks are often produced with simple methods using a mixer and a vibrating unit to compact the block (Isaksson et al., 2023). Their affordability and availability make them a key focus when planning future sustainable building development. Due to the low strength requirements, the Portland cement could further be replaced with supplementary cementitious materials, such as local material as agricultural waste ashes and natural pozzolanic materials. This would lower the carbon footprint even further and lower the costs. Pozzolanic materials require a chemical binding with cement to become cementitious and usable to become concrete or sandcrete blocks (Isaksson et al., 2023).

1.2 Definition of sustainability

Given the urgent need for affordable and environmentally responsible building solutions, it becomes essential to define what sustainability means within this context, especially for building block production process in developing countries. The term sustainable development was introduced in the Brundtland Commission (WCEP, 1987) and defined by *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*. The UN clarifies that the term sustainability is today balanced on three distinct perspectives: economic, environmental and social. It is these three that the 2030 Agenda where the Sustainable Development Goals are described are built upon. (UN, 2015)

Economic sustainability aims to promote economic growth, as it is essential for prosperity. This is to be done by building economies centred around people, particularly promoting youths' employment and female economic empowerment. Forced and child labour is to be eliminated if a nation's economy and its citizens are to prosper (UN, 2015). The economic perspective in this study will focus on the affordability of the materials, production process and employment. Factors such as cost-effectiveness and potential for local economic development are considered.

Climate change is named as the key threat against environmental sustainability. The UN hopes to be an international and intergovernmental forum for discussion in the fight against climate change (UN, 2015), as global cooperation is needed to reduce greenhouse emissions. Environmental sustainability is however a wider spectrum than just climate change. It includes protection of natural resources and biodiversity as well as protecting against drought and desertification. It also aims to reduce hazardous environments where both human health and the planets health are concerned. This study's environmental perspective addresses the carbon footprint of the entire building block production and the efficiency of resources used.

Social sustainability relies on peace from war, disease and poverty (UN, 2015). Education, welfare and healthcare are needed is a society where life can thrive. Water safe to drink, acceptable sanitation and sufficient and affordable food is also needed for prospering welfare. The 2030 Agenda (2015) also highlights the need for human rights and dignity, where there is respect for ethnical and cultural diversity, as well as gender equality. The social perspective in this study will be related to local employment and the broader social impact on communities affected by the production.

The term "green" is often used alongside and have become a synonym to sustainable. However, a "green" building often only refers to ecological environmental aspects, such as being resource and energy efficient that reduce the impact made by carbon footprints (Ng'eno Chelang'at & Lawrence, 2024). "Green" buildings do not consider the social and economic aspects that the term sustainability also entail. This study will use the term sustainable is the broader meaning where all three dimensions are considered.

1.3 Previous research

Previous studies on sandcrete production have primarily focused on material properties (Isaksson & Babatunde, 2019), including the use of local or alternative materials as partial replacements for Portland cement (Korankye & Danso, 2024; Ikeagwuani et al., 2020; Isaksson et al., 2023), as well as the widespread lack of quality control and the resulting high variation in block strength (Alejo, 2020; Akpokodje et al., 2021) Much of the same research has examined how supplementary cementitious materials can improve material performance or reduce carbon dioxide emissions, as well as costs.

At the same time, research addressing sustainability assessment is irregular. International sustainability assessment systems often overlook local production conditions, and their criteria do not fully correspond to the realities of low-income contexts (Olawumi et al., 2020; Ng'eno Chelang'at & Lawrence, 2024). Regional systems, while sometimes more aware of local context, are rarely used in practice and their use remain limited (GBCSA, 2016). Existing studies tend to discuss environmental impacts or technical improvements in isolation, while few attempt to integrate material performance with broader sustainability considerations such as affordability, local resource availability or labour conditions (Isaksson & Buregyeya, 2020; Isaksson & Babatunde, 2019; Mahame et al., 2024).

Therefore, a clear knowledge gap remains regarding how sustainability in sandcrete block production can be assessed in a cohesive and context-appropriate way. Previous research has not combined technical insights, local practical experience and a structured comparison of international, regional and local assessment systems. This study addresses that gap by integrating a literature review with practical interviews and an evaluation of selected assessment systems, with a specific focus on the Tanzanian context.

1.4 Aim of thesis

Despite the extensive use of sandcrete in both Tanzania and the rest of the sub-Saharan countries, clear guidelines regarding how sustainability in the industry should be measured are lacking. The purpose of this thesis is to investigate how sustainability in building block production can be assessed and measured in Tanzania and comparable developing countries. The study begins with an analysis of current block building production methods, followed by an evaluation using selected criteria regarding materials from international and regional sustainability assessment systems. Based on this, the thesis aims to define relevant sustainability indicators and propose benchmarks tailored for building block production in sub-Saharan Africa. Tanzania was selected partly due to it represents a typical sub-Saharan country and partly due to having contact with a local practitioner who could be interviewed as well as an engineer with extensive knowledge of the local conditions. By identifying sustainability indicators for the sub-Saharan context and integrate theory, local insight and assessment systems comparison, this study aims to support a more climate-conscious construction process in fast-growing developing countries.

The following research questions are used to concretize the focus of this study:

1. What challenges does sustainable building practises face in sub-Saharan Africa?

2. How relevant are the selected sustainability assessment systems when applied to the building process in sub-Saharan Africa, particularly Tanzania?
3. What practices can ensure future sustainable building block production in this context?

1.5 Limitations

The study is geographical limited by the area south of Sahara in Africa. Regarding what materials will be studied, analysed and discussed, only sandcrete as a building material will be included, even if different alternatives to supplementary cementitious materials will be brought up. The choice of material and geographical context was chosen as sub-Saharan Africa is an area where sandcrete is very frequently used, and a lot of research is being done to make the material more environmentally sustainable.

1.6 Disposition

The methodology chapter will discuss different methods of approach, as well as their validity and reliability within the context in which they are applied. This is to ensure that the appropriate approach is chosen and to present how the study will be conducted.

In the chapter *Building Process in sub-Saharan Countries*, the study will review literature concerning the challenges of implementing sustainable building practices in developing countries. It will then proceed to examine sandcrete production by reviewing literature both on the production process itself and on potential materials that could supplement cement. The findings from the interviews will be presented in the *Interviews* chapter to provide a practical connection to the theoretical findings. The chapter *Assessment Systems* will present the results of the document study of the selected assessment systems, to clarify what aspects these systems credit and value.

The findings from the literature review will be analysed to identify challenges related to sustainability and how they correspond with the interview results in the analysis chapter. The findings from the document review will be compared to identify similarities and differences between the various assessment systems.

Finally, the findings of the analysis will be discussed and linked to the aim of the study in the discussion chapter.

2 Methodology

The thesis applied multiple methods of approach to perform a qualitative research where both practical and theoretical provided insight into how the sandcrete block production can be assessed and understood in a sub-Saharan context. Creswell & Creswell (2018) state that qualitative approaches are especially useful when the research question involves social, cultural or economic dimensions that are difficult to quantify, as they provide more context and a refined understanding that quantitative methods might overlook and miss.

According to Säfsten (2024) the choice of research approach should be based on the nature and aim of the study. Since this thesis seeks to understand the complexity of sustainable building practises in a geographic context, a qualitative approach was chosen as it considers social and cultural aspects that a quantitative research approach could risk potentially overlooking. To support this approach, this thesis combined multiple methods of gathering data, which increased both the credibility and the relevance of the findings.

This study applied a case study design to enable an in-depth examination of sandcrete block production within a specific local context. A case study is a qualitative research approach that focuses on gaining a detailed understanding of a bounded system, such as a process, organisation or community, by collecting and analysing multiple forms of data. (Säfsten, 2024) In this study, the case consisted of small- and medium-scale sandcrete block production in the area around Dar es Salaam, Tanzania.

To analyse the case study, a unit of analysis is needed. The unit of analysis defines what the case actually is and specifies the level at which the phenomenon is examined. (Säfsten, 2024) The unit of analysis was the sandcrete block production process, including material sourcing, mixing practices and quality variations. This focus made it possible to explore how sustainability-related challenges manifest in everyday production routines. The case study approach was considered appropriate because it allowed the study to combine literature findings with insights from interview respondents who had extensive experience with this specific production. The insights gained from the case provided a practical complement to the theoretical frameworks assessed in the study.

The first part of the study consists of a literature review of academic research papers. The second part consists of two semi-structured interviews with a local practitioner in Tanzania and a Swedish engineer. The third part is an analysis of three different environmental assessment systems, each representing a different perspective. BREEAM provides an international perspective, Green Star SA offers a regional perspective, and BSAM gives a local perspective. Combined, these three components provided both width through a theoretical foundation and depth through local insights and contextual knowledge. This triangulation of methods strengthened the study by combining theoretical understanding with practical insight (Säfsten, 2024).

2.1 Literature review and document study

The literature review provided a theoretical base for the analysis to later be complemented with practical insight. A literature review focuses on systematically locating and evaluating existing research to build an overview of current knowledge and identify gaps relevant to the study (Creswell & Creswell, 2018; Säfsten, 2024). To achieve this, academic research papers focusing on the building block construction process, as well as case studies describing practical examples were systematically reviewed.

In addition, a document study was conducted. A document study refers to a systematic examination of materials, such as manuals, reports and guidelines. This is to understand how a certain topic is presented and regulated (Creswell & Creswell, 2018). In this study, the technical manuals and guidelines from different environmental assessment systems were analysed to understand their categories, criteria, and scoring methods, since these documents represent the official frameworks that guide how sustainability is assessed in practice.

The review focused on materials used in sandcrete production, specifically where the materials are from, how they are sourced and whether there are regional challenges connected to their use. Studies that examined and evaluated the use of environmental assessment systems in developing countries were included as well to insights into how international frameworks can be applied in local contexts. Particular attention was given to the role of supplementary cementitious materials. These supplements are a central part in reducing Portland cement usage, thereby reducing the environmental impact while also responding to cost-related challenges in the sub-Saharan region.

To ensure that the review reflected recent developments and relevant research, literature search was limited to publications from 2019 and forward. This was to avoid outdated production methods. The search included and combined keywords such as “sustainability”, “developing countries”, “sub-Saharan Africa”, “sandcrete”, “supplementary cementitious materials” and “assessment systems”. Mainly Google scholar was used to reach out to as many international studies in as many scientific journals as could be found. While international reports, research and technical manuals offer a valuable insight, studies conducted by researchers based in the region where preferred. This ensured regionally grounded knowledge and practise-based insights that international reports might miss.

The analytical process was carried out in several steps according to Säfsten (2024) where data is presented and then organised, after which patterns are identified, and conclusions can be drawn. First, the findings from the literature review were examined and summarised with a focus on sustainable building practices, sandcrete production, the use of supplementary cementitious materials and challenges related to sustainability assessment in sub-Saharan Africa. The material was then organised around recurring themes such as material sourcing, environmental impacts and obstacles to implementing sustainable building practices. These themes provided the initial analytical structure and served as a basis for comparing the remaining empirical material.

The interview data were subsequently analysed using the same thematic structure. Statements from both interviews were read repeatedly and grouped according to the themes identified in the literature review. This approach made it possible to identify where the respondents' practical experiences aligned with or differed from the theoretical findings, and it ensured that the interview material could be compared systematically with existing research.

After this, the selected assessment systems were analysed. Each system was reviewed to identify categories and scoring criteria relevant to the themes generated from the literature and interviews. Particular attention was given to material-related criteria, since they directly address sourcing, efficiency and environmental impact. The systems' primary focus areas, meaning those categories awarded the highest credit points, were identified to clarify which sustainability dimensions could be prioritised internationally, regionally and locally. By examining what each system rewarded most, it became possible to evaluate how applicable the systems were in a sub-Saharan context and to understand why certain sustainability issues were emphasised more strongly than others.

By comparing findings across all three the analysis provided both depth and coherence. This integrated approach made it possible to identify practical challenges, evaluate the relevance of existing sustainability frameworks and highlight where the systems aligned with or diverged from the conditions observed in Tanzanian block production.

Finding research on sandcrete blocks and the use of supplementary cementitious materials was not difficult, as quite a substantial amount of work exists. Among the regionally focused research articles, Nigeria was somewhat more frequently represented than other countries. This is assumed to be due to Nigeria being is the largest economy in the region and not only sub-Sahara's most populated country, but the most populated on the entire African continent. Relevant research articles from Ethiopia, Ghana, Tanzania, and Uganda were also included, particularly those that tested different supplementary cementitious materials such as rice husk ash, volcanic ash and fly ash. Including these studies allowed the review to move beyond one nations context and instead capture a broader regional perspective.

The literature review and the document study therefore provides both a broad and a deep knowledge base. It formed the foundation for evaluating the applicability of different assessment systems, while also offering insight into how sustainability is defined and understood in practice in a sub-Saharan setting.

2.2 Interviews

To complement the literature review and provide a deeper understanding of local sandcrete block production, two semi-structured interviews were conducted with practitioners who had relevant experience in Tanzanian block production and sustainable construction. The interviews were carried out in different formats depending on what was practically possible for each respondent, which reflects the varying conditions under which they work.

The first interview was conducted with a local practitioner in Tanzania, who worked closely with several small- and medium-scale block producers in the area surrounding Dar es Salaam. During regular visits, the respondent assisted producers in collecting important data on block weight, bulk density and the ratio between water, cement and compaction. The respondent has collaborated with a Swedish engineer from Engineers without borders for approximately ten years, and through learning by doing has developed extensive practical expertise in block production.

Although self-employed, the Tanzanan respondent has gained a level of technical knowledge that today exceeds that of most small block producers in the region, where many production teams follow routine practices and lack formal theoretical training. This long-term involvement in the industry, combined with practical experience, made the respondent a suitable source for providing detailed insights into local methods, real-world challenges and constraints that might not be fully captured in academic literature.

Due to geographical distance and logistical limitations, this interview was conducted via email. Even though the format did not allow immediate follow-up questions, it enabled access to valuable information and provided an overview of production practices around Dar es Salaam.

A second interview was carried out with the same Swedish engineer from Engineers without borders who had introduced the Tanzanian respondent. The Swedish respondent has worked with sandcrete block production and related sustainability challenges for approximately fifteen years and has extensive experience from development-related construction projects in several sub-Saharan countries. With a background as a chemical and process engineer and more than twenty years of industrial work within cement production combined with academic research in sustainability and quality management, the Swedish respondent contributed broader technical and organisational perspectives compared to the local insights provided by the first interview.

The second interview took place through a digital meeting and was conducted in Swedish, according to the respondent's preference. This live format made it possible to ask follow-up questions and clarify responses in real time, which added additional depth to the empirical material and complemented the written format used for the Tanzanian interview.

Both interviews followed a semi-structured format, chosen because it provides a balance between structure and flexibility. The format allows ensures that key themes are covered while at the same time providing the flexibility for examples or insights of what the interview respondent considers important or relevant to the discussion (Creswell & Creswell, 2018). The interviews were structured around five main themes to guide the discussion: sustainability and awareness, production and development, customer perspective, collaboration and competition and material sourcing. Each of these themes was explored in detail, with several questions each to address different aspects of the theme in order to gain a deeper understanding of local practices and production dynamics.

Ethical considerations were observed throughout the process. Both respondents were informed about the purpose of the study and consent was obtained prior to the interviews.

2.3 Environmental assessment systems as analytic tools

The findings of the literature review and the interview were assessed using selected and relevant criteria from three different assessment systems. BREEAM was included because it is a well-known international assessment system, providing a widely recognised benchmark and a basis for comparison between local sandcrete block production and internationally established sustainability criteria. Its way with a clear scoring system, which assigns points to various categories such as materials, energy and water, allows for structured comparison with other systems.

Green Star SA is the only assessment system in this study that was developed within sub-Saharan Africa, although it is originally based on the Australian Green Star framework. It has been adapted to a South African context and is included to provide a regional perspective. Like BREEAM, it uses a points-based system with categories and sub-categories like materials, water, energy and indoor environmental quality. This allows for easier direct comparison. Its inclusion also ensures that locally developed criteria are considered, reflecting regional priorities and practices that international systems might overlook.

BSAM is a system specifically developed for building in sub-Saharan Africa. It was chosen both to enable comparison with BREEAM and Green Star SA and to relate directly to the actual building processes observed in the region. BSAM's scoring structure is similar to BREEAM and Green Star SA which makes it possible to analyse and compare performance across systems while also comparing it to local conditions. The system is designed to consider the economic and social realities of developing countries in sub-Sahara and have been developed to fit the region and recognises that local and informal building processes often exist. It is intended to support practices when they are beneficial and to provide guidance or discourage them when they are unsustainable or risky, thereby encouraging improved building practices.

All three systems are presented in tables with categories and sub-categories. This provides an overview perspective, showing both how the systems differ from one another and where possible similarities can occur. The selected systems were specifically chosen because they represent international, regional and local perspectives while also using comparable scoring approaches that enables a structured analysis. Only one assessment system was selected to represent each geographical level, while other assessment systems were not included either because they did not focus on the relevant regional context or because their scoring structures were not compatible for comparison.

2.4 Validity and reliability

The case study through the interviews focused on medium- and small-scale sandcrete block production in the area around Dar es Salaam, Tanzania and the producers that the Tanzanian interview respondent has direct contact with. As a consequent of this, the insights of the interview may not be directly representable to other regions in sub-Sahara or even to large-scale sandcrete production within Tanzania.

Two interviews were conducted for this study. While the respondents together provided both local, hands-on perspectives and broader organisational insights, the limited number of interviews restricted the range of individual experiences included. Including additional perspectives from several interviewees from producers, governmental representatives or other relevant occupations, would have provided a broader scope of practical experiences.

The interviews were conducted using two different formats, one via email due to geographical and logistical constraints, and one through a digital meeting. These formats allowed participation under the practical circumstances of each respondent, but they also introduced certain limitations. The email format did not allow for immediate follow-up questions or clarifications, which may have affected the depth of the responses. Furthermore, the Tanzanian interview was conducted in English, which if not being the first language of the respondent, may have influenced the level of detail or nuance in some answers.

The literature review was limited to studies concerning sub-Saharan Africa. This geographical focus was motivated by the fact that the majority of the global low-income countries are situated in this region, and they often share similar characteristics in terms of population growth, climate conditions, available material resources and socio-economic context. Even if they are similar, it will not be directly appliable to other areas in the region as local dynamics presumably differ.

Moreover, the study was constrained by the time and resources available in the scope of a master's thesis. Site visits, interviews with producers themselves or more extensive fieldwork were not possible to carry out.

Despite these limitations, the study's credibility was strengthened by triangulation across three data sources, a literature review, two interviews and a document study of assessment systems. By comparing insights from different empirical and theoretical materials, the study sought to provide a more balanced understanding of sustainability challenges in Tanzanian sandcrete block production.

3 Building process in sub-Saharan countries

3.1 Sustainable building

Building with sustainable materials presents significant challenges in sub-Saharan Africa. Mahame et. al (2024) identify six categories that act as barriers that hinder sustainable building materials from being used. Regulatory and policy barriers, financial barriers, knowledge and awareness barriers, technical barriers, market and supply chain barrier as well as cultural and social barriers are identified. The study emphasizes that understanding and analysing the causes of why these obstacles exist is crucial to successfully integrating sustainable materials in the building process in Tanzania as well as the rest of the region.

Similarly, Genovese & Zoure (2023) identify five primary causes for why technology transfers from developed Western countries to developing countries often fails, listing government, people, knowledge, market and cost. These findings highlight the importance of adapting methods and technologies to local contexts rather than applying them unchanged. The barriers identified by both studies are interdependent. For instance, financial challenges often stem from regulatory limitations and technical barriers may be addressed through targeted education and training (Atafo Adabre et al., 2021).

By addressing and implementing sustainability considerations early in the design process can reduce the resistance projects teams can face from clients. Integrating sustainable practices at the initial design stage helps lower costs and preserve the final profit, as material expenses and project timelines tend to increase if sustainability measures are introduced later in the construction phase (Ayarkwa et al., 2022).

3.1.1 Education and awareness

The lack of knowledge and awareness about sustainable materials is identified and widely recognized as one of the most significant obstacles (Mahame et al., 2024). Both clients and professionals within the building industry often appears unaware of the potential benefits of sustainable materials, as well as the specific characteristics and applications of these materials. This knowledge gap is largely attributed to the absence of education regarding sustainability in construction is the main factor, as well as limited connection between academic research findings and practical implementation in the building industry.

In the absence of reliable and accessible information regarding environmentally sustainable materials, producers and developers rely on conventional, less sustainable options. Practical examples of building projects with sustainable materials can serve as effective tools of demonstration and to inspire building developers to use alternative materials beyond traditional choices. For instance, the Tanzanian National Construction Council features a price list of material, including only traditional materials, excluding newer, sustainable options. This exclusion reinforces the status quo and limits the visibility of sustainable options to professionals and the wider industry.

To be able to integrate sustainable building strategies into the local communities, comprehensive education programs are needed across multiple professions. Designers, manufacturers, suppliers, researchers and entrepreneurs all would require targeted training programs that addresses both theoretical knowledge and practical application (Genovese & Zoure, 2023). Nkini et al. (2024) reports that a higher level of formal education seems to corelate with a high level of greater stated awareness of sustainable building practices, highlighting the importance of education in many professions throughout the building process.

There exists a persistent gap in collaboration between research institutions and the building industry, which slows progress towards more sustainable construction practices and energy-efficient buildings (Stephen & Aigbavboa, 2025). The causes are indicated to be too few partnerships and limited funding for research leading to challenges in effectively transferring knowledge between the universities and the industry. By aligning academic research with real-world industry needs, universities can support the development of practical solutions and help improve the adaptability of the construction sector to new materials. This can lead to advance innovation in design and construction techniques of which the industry gains from.

Raising awareness among local communities and building clients is a necessity for future sustainable practises to take hold. By using multiple demonstration projects that can complement formal education, practical experience and evidence of the benefits of sustainable constructions is provided. Increasing the understanding across the entire building ecosystem, these efforts can encourage the adoption of sustainable materials and practices. This will be done while also gradually shifting cultural and professional norms toward a more environmentally responsible building process.

3.1.2 Policies and regulations

Regulatory obstacles and the absence of supportive policies from governments are also a reason for sustainable materials not more widely used in the sub-Saharan region. Several studies highlights that stronger governmental provisions together with a clearer enforcement mechanism are essential in order to promote sustainable building practices and to ensure policies translate into actual change. When regulatory frameworks are vague or inconsistently applied, the incentives to adopt sustainable materials remain weak. By introducing policy support and regulatory frameworks adopted to local conditions could substantially increase the motivation to utilize sustainable materials both among developers and material producers.

Further weakness lies in an absence of locally developed assessment systems, as mostly international certification system are used to assess environmental compliance, of which often are not fully aligned with regional realties (Mahame et al., 2024). This gap risks making such systems feel detached from local practices, limiting their uptake and effectiveness. Genovese & Zoure (2023) emphasises the importance of construction trends and policies specifically suited to the climate conditions, local culture practises and economic capacity. By accounting for geographical and social context when regulatory frameworks are developed, they can seem less distant and easier to adopt as they are practical. Establishing a formal platform for communication and knowledge exchange between government agencies, industry professionals and users would enable information sharing regarding policies and technological advances.

Stephen & Aigbavboa (2025) lists several projects in Mozambique, Botswana, Tanzania, Rwanda, Ghana and Namibia where targeted policy interventions to encourage collaboration between universities and building projects have yielded positive results. These initiatives not only benefited the local communities by improving construction quality and sustainability but also created opportunities for research institutions to try new knowledge in real-world projects. This demonstrates how carefully designed policies can function as mediators between research, industry and society.

Despite these promising cases, there remain significant gaps. On the African continent, only around 30 % of the countries have established green building councils (Nkini et al., 2024). Most of these councils are non-governmental organizations, NGO’s, rather than being fully integrated into governmental structures. This might lead to that their capacity to enforce policies are limited. In Tanzania, the Tanzanian Green Building Council was established 2014 and have yet to introduce policies or regulations from the government mandating any sustainable building practices. Tanzania even lacks a clear national definition of what a sustainable building is, which can lead to uncertainty around the concept.

Atafo Adabre et al. (2021) further caution that policies are vulnerable of being discontinued or changed as governments change due to elections. To counter this instability, national development plans should be established and accepted by all political parties present. Such plans would need to be designed as long-term strategies that remain independent from short-term political cycles, ensuring continuity and reliability in policy direction. Importantly, the study also identifies that several of the most pressing issues hindering the growth of the sustainable building market, including corruption, bribery and the lack of fair competition, can ultimately be traced back to weak or absent policies and regulations. Strengthening the regulatory environment do not only enable the uptake of sustainable construction materials but also reduces systemic risks that can compromise the integrity of the construction industry.

3.1.3 Financial constraints

Financial barriers are consistently identified as one of the most significant obstacles to the adoption of sustainable building practices. The costs are multifaceted and often extend beyond the mere price of materials. Transportation costs, additional labour requirements and the expenses linked to new construction techniques are repeatedly emphasised as key financial challenges (Nkini et al., 2024). These costs are particularly clear in areas where infrastructure is underdeveloped, leading to fragmented supply chains for sustainable materials.

One commonly suggested solution to these challenges is targeted government support toward the sustainable building industry. Subsidies and tax reduction are listed as possible solutions and could help offset the higher initial costs of sustainable construction and encourage developers to make the transition (Mahame et al., 2024). Without government support, sustainable alternatives are often perceived as uncompetitive when compared to conventional materials. Local mass production and joint import initiatives between producers may reduce material costs over time and are strategies not only make materials more affordable but also help stabilise supply chains by reducing dependency on small-scale or fragmented production. This enables the production to increase and the material costs to reduce.

Financial barriers are not only an issue in developing contexts. Even in developed countries, the additional costs associated with sustainable construction remain a primary reason for resistance. Nkini et al. (2024) conclude that the focus on short-term profit is amplified by the limited awareness of long-term financial benefits that sustainable building practices can provide. If cost-benefit analyses could be provided to prove the long-term gain, these practices could be more attractive to both producers and developers.

Interestingly, financial considerations are not always the definitive factor behind the decision to adopt to more sustainable construction process. Stephen and Aigbavboa (2025) reports that regulations, certifications and social expectations often act as stronger drivers of change than profit motives alone. This suggests that financial incentives may need to be paired with normative or regulatory pressure to achieve widespread impact, even if in the case of hinderance of using local materials seem nonetheless to be the high cost (Nkini et al., 2024).

Sustainable construction is still perceived by many as a risky investment. The transition often requires new equipment, machinery and training programmes for workers (Addy et al., 2019). Given that much of the work in the construction industry in developing countries relies on manual labour, a substantial number of workers must be trained. As a result, sustainability is therefore frequently framed as an added budget cost with uncertain rewards. This furthers the reluctance among both private companies and public actors to engage with it.

3.1.4 Technical challenges

The technical challenges that can occurs represent another major barrier to the wider adoption of sustainable building practices. A lack of expertise and practical experience in working with the new, sustainable materials significantly limits their use across the sub-Saharan region. Mahame et al. (2024) emphasises that many construction professionals in the industry are not sufficiently trained in the area of using sustainable building methods or sustainable materials. This discourages both the industry to use the materials and the clients reluctant from investing in them. Limited technical skills often result in poor-quality outcomes, reinforcing scepticism towards sustainable materials and contributing to a cycle where low adoption further limits the usage. The industry is hesitant to take financial risks investing in unproven methods and materials when insufficient expertise could compromise both project quality and profit.

There are, however, notable regional differences (Mahame et al., 2024), as some projects in other countries in sub-Sahara has seen the opposite results where sustainable material performed better than the conventional materials due to the producers being highly skilled and well trained. By effectively training producers and professionals in green building practises and material production, this could be achieved in the rest of the region as well. These cases suggest that when professional skills and technical systems are sufficiently developed, sustainable construction can become not only an option, but even a preferable one. The providence of referral projects and demonstration buildings could therefore play an important role by serving as practical examples of how sustainable materials can be successfully integrated.

Technology must be designed to be accessible, user-friendly and aligned with the practical needs of the industry if it is to be used more frequently in the region (Stephen & Aigbavboa, 2025). Offering guidance through supportive systems by trained professionals can help in the early stages of implementation. If training is incorporating at the design stage, it can enable project teams to adapt new practices from the beginning rather than implementing them in later in the process.

Another obstacle identified by Ibrahim et al. (2024) is the reliance on imported technology and machinery new construction practices could entail. Newer equipment often requires specialised service and spare parts that might not be available locally. If the new machinery were to break down, delays in time schedule and cost could escalate due to parts requiring time to be imported, sometimes with high tariffs. Depending on external technical support enhances hesitancy among stakeholders, as it adds another layer of uncertainty and financial risk. By strengthening regional capacity for maintenance and repair, reliance on imported technologies lessened. This could potentially encourage more sustainable building practices.

3.1.5 Market

Frequent inconsistency in supply chains present a significant barrier to the implementation of sustainable building materials. Delays in project completion, budget disruptions and slower construction processes are often the result of unreliable delivery and limited availability (Addy et al., 2019). As the demand for sustainable materials carries on being comparatively low in the region, the market is hindered from growing which leads to materials still being expensive and remaining both less attractive and accessible to use. This cycle of low demand and limited supply further discourages producers from investing in the sector, reinforcing the dominance of traditional building materials.

Local production is proposed as a solution since it has the potential to shorten the supply chains and reduces transportation cost. It also holds the potential to provide a more stable and predictable supply of materials. By improving consistency in availability, local production of materials could increase the willingness of developers and contractors to use more sustainable options. Strengthening regional markets may further reduce developers need to depend on material import and over time the increased production could help to lower costs and making sustainable materials more attractive in the construction industry.

3.1.6 Cultural and social factors

Cultural adaptation to a more sustainable way of building is slowed by the social resistance to change (Mahame et al., 2024). In many communities, building with conventional materials are seen as a symbol of wealthy, prestige and social status, since these materials aligns with the Western standard which are widely perceived and promoted as superior. Mahame et al. (2024) highlights a certain contradiction, as many of the building practices today promoted as sustainable actually draw on traditional methods that were commonly used in the region in the past, before Western-like methods were seen as desirable. Despite being resource-efficient and environmentally sound, the traditional methods can unfortunately be undervalued as they are seen as old-fashioned or less prestigious. However, this historical perspective shows that cultural knowledge can offer practical and sustainable solutions if supported by modern scientific understanding.

As a result of the social perception, “new” and sustainable ways of building are seen as something unfamiliar and regarded with scepticism, of which local communities rarely adapt to. Research done by Mahame et al. (2024) does however suggest that if local communities were involved and invited to make decisions in the design processes, attitudes could potentially shift to become more positive. When people can participate actively in the development of building projects, they may understand that sustainable solutions as more culturally relevant and thereby accepting the transition towards more sustainable construction practices.

According to Nkini et al. (2024) there seems to be certain parts of the construction industry that remain doubtful towards the concept of sustainable or green buildings, perceiving them primarily as a business label rather than a meaningful environmental strategy. Ayarkwa et al. (2022) further argue that informing and educating property owners or clients is just as critical as training architects, engineers and project managers. Because property owners make the final decisions, project teams can have a difficult time promoting new approaches in situations where sustainable practices are not a priority (Ibrahim et al., 2024). Having these key decision-makers informed of long-term benefits of sustainable construction is therefore important for a wider adoption.

The unreliable electricity supply that much of sub-Saharan African countries experience also present a challenge to the social and cultural acceptance (Ibrahim et al., 2024). New technologies in buildings often require stable power supply to work, placing additional strain on already unstable power grid. The strain could make local communities hesitant to embrace construction practices, as people may perceive sustainable construction as impractical or disruptive to daily way of life. The technical solutions required to solve this issue must also be sensitive to engage community trust and highlight the practical advantages of using sustainable methods.

3.2 Sandcrete block production

Across the sub-Saharan region, a masonry unit called sandcrete is utilized in the building industry. In countries such as Kenya, Ghana (Ikeagwuani et al., 2020), Tanzania and Uganda (Isaksson & Buregyeya, 2020) all rely on sandcrete as their main building material. In Nigeria it is estimated that as much as 90% of building infrastructure are constructed using sandcrete blocks (Akpokodje et al., 2021). The rapid urbanization and the growing demand for housing, amenities and industries, cites are growing have further increased the need for sandcrete blocks.

According to Alejo (2020), the Nigerian Industrial Standard defines a sandcrete block as a "*composite material made up of cement, sand and water, moulded into different sizes*". The blocks can be produced in both solid and hollow forms and can be used as both load bearing and non-load bearing elements. Typical dimensions are 450 mm in width and 225 mm in height while the depth can vary, it is usually 225 mm or 125 mm. For the most part, Ordinary Portland Cement is used as the binder, though marketed different brand names.

A study by Akpokodje et al. (2021) where 18 major block producers in Delta State, Nigeria found that most of the sourced sand used was either white sand, also called ordinary dredge, or sharp sand obtained from riverbeds. While some producers used manual labour for mixing, others relied on mechanical methods. In Uganda, a company called Eco Cement Limited has introduced mobile production units which manufactures sandcrete blocks at the building site, reducing material transport which can save costs. These units typically source sand and water used for the mixture from the area surrounding the building site area (Isaksson & Buregyeya, 2019).

Despite its widespread use, the quality of sandcrete is highly inconsistent. Akpokodje et al. (2021) report that almost every one of the block producers participating in the study did not follow recommended standards for water-cement ratios. Instead, batching is often carried out through volume, not by measuring weight. Water was added as needed until the mixture was deemed done when the right consistency was obtained. This imprecise method leads to significant variation in compressive strength, but even though volume batching is less precise than measuring, it is faster and easier as it required simpler methods.

The variation caused by volume batching is also the biggest drawback of the sandcrete block. The blocks have a high variation in compressive strength, and few producers perform quality controls. In Tanzania, none of the medium- or small-sized block producers have any systematic quality control (Isaksson & Buregyeya, 2019). This lack of quality control makes it hard for the producers to improve their blocks compressive strength and therefore their performance. The lack of compressive strength and performance is apparent when an increase of sandcrete building collapses is seen. Due to lower costs, lower quality sandcrete block are more likely to be sold and therefore build with. Weak sandcrete blocks have been identified as a major factor in building collapses in Nigeria (Akpokodje et al., 2021).

At the same time, sandcrete blocks offer several advantages that explain their dominance in the region. They can be produced relatively cheaply with minimal technical expertise, more so than other construction material. They are also often produced locally, supporting local employment, local economy and reducing transportation costs and the blocks do not rust or attract any pests or insects (Alejo, 2020).

Some producers, however, demonstrate that higher standards and innovation are possible. Eco Cement Limited in Uganda have gotten recognition for their technological and process innovation in the housing industry with the mobile production unit as well as organisational innovations in the way that employees are managed (Isaksson & Buregyeya, 2019). The employees are all well acquainted with and trained in production process, product development, machine operation, record-keeping, work ethics and concrete material manufacturing which leads to higher quality product. The company also employs marginalised youths who have been excluded from educational systems, offering them skills development and livelihood opportunities. These youths can create even more jobs and know-how with the help from the company. The company producers both solid and hollow sandcrete blocks, as well as other concrete construction parts.

Eco Cement Limited has since 2021 been experimenting with zero-cement binder to reduce the carbon dioxide emission, as well as lower the cost of the building blocks, as the ordinary cement is what drives up the costs (Eco Cement Limited, 2024). By using local material that are in abundance in the area, such as volcanic ash and kaolinite clays, the company hopes to ensure higher quality housing with lower cost in Uganda, both rural and urban parts, which are more climate resilient and environmentally sustainable. Most of rural Uganda today is built by temporary materials as mud or soil blocks.

Recent research has also highlighted the potential of agricultural by-products as supplementary cementitious materials in sandcrete production. Isaksson et. al (2023) concluded that waste by-products can be used as supplementary cementitious materials. Ashes derived from corn cobs, rice husks, sugarcane, bamboo leaves, banana leaves, and corn husks could serve as partial cement replacements after controlled incineration. They all are dried and then incinerated from 550°C and up to 900°C to produce ash. Most of the by-products would only end up at landfills or they would become animal feed.

Similar studies in Ghana evaluating other supplementary cementitious materials have found that cashew apple ash, a waste by-product from the highly exported cashew fruit, can replace up to 5% of cement while meeting pozzolanic requirements (Korankye & Danso, 2024). The study also lists cocoa pod husk ash and millet husk ash as potential supplements. The nutshell itself has been studied and could make a cement supplement but as the shells are exported with the nut, are not waste by-products. Unlike cashew shells, the fruit is typically discarded rather than being exported. This means its reuse in block production could support local farmers as well as the construction sector. Research innovations like this demonstrate the potential for integrating circular economy practices into sandcrete block production, enhancing both sustainable and local economic development.

3.3 Tanzanian standards

Concrete block, and therefore sandcrete blocks are formally regulated by the draft national standard DTZS 283:2022 (2022) which is issued by the Tanzania Bureau of Standards. DTZS 283:2022 specifies technical requirements for both hollow and solid masonry units made entirely or partly of concrete. The units can be used for both load-bearing and non-load-bearing building elements. Even if it does not mention sandcrete explicitly, it is the closest available national guideline for block performance and quality.

The standard defines block dimensions, material requirements and performance criteria, which includes regulations on density and compressive strength (Tanzania Bureau of Standards, 2022). Even if the standard is purely technical and mentions nothing of sustainability it is still comprehensive. However, the literature review shows that the small- and medium scale producers seldom adhere to this standard. The existence of the standard therefore does not necessarily translate into consistent block performance in practice. Instead, DTZS 283:2022 primarily functions as a formal benchmark that highlights the gap between recommended production methods and the informal or semi-formal practices that dominate the Tanzanian market. Including the standard is important for understanding the regulatory context of sandcrete production. It shows that formal quality requirements exist, but that implementation is limited.

3.4 Environmental assessment systems

Sustainability assessment systems were first developed during the latter part of the 20th century in the UK and the US. According to Ng'eno Chelang'at & Lawrence (2024), it is estimated that more than 600 systems have been developed and were in use by 2017.

The main goal of an assessment system is to define, guide and measure sustainable impacts done by building projects, both during the design phase and for the completed building. The typical system, and the ones assessed in this study, works based on having different categories and sub-categories, rating the projects with credit points from the presented criteria (Ng'eno Chelang'at & Lawrence, 2024). These assessment systems thus provide a rating on a scale of what is an accepted standard in the cultural and geographical context in which they are developed.

Comparing systems to each other can sometime cause confusion rather than clarification, as buildings being evaluated by different frameworks can receive highly contrasting results (Ng'eno Chelang'at & Lawrence, 2024). Buildings that receive the highest rating within BREEAM is unlikely to be directly comparable to a building that attains a high rating in Green Star.

For the purpose of this study, three environmental assessment systems were selected. They represent different levels of international, regional and local adaptation. These systems were chosen based on their relevance to sub-Sahara, and Tanzania in particular, as well as their comparable scoring structures, which allow for a structured analysis. The systems are presented by highlighting their categories and sub-categories, with an emphasis on how the corresponding material category is presented and which criteria generate the most credit points.

3.4.1 BREEAM

Building Research Establishment Environmental Assessment Method, or BREEAM for short, is a system developed in United Kingdom during the early 1990's. It is primarily adapted to a Western building practises where it's also mostly used, though it is non-mandatory. BREEAM was the first assessment tool to be developed, followed by the development of LEED in the US (Ng'eno Chelang'at & Lawrence, 2024).

BREEAM is divided into ten different sections, each are evaluated separately and then combined into a final rating for the new construction. The sections and what they assess are presented in Table 1.

Table 1. BREEAM sections and assessment issues (BREEAM, 2021).

Management	- Project brief and design - Life cycle cost and service life planning - Responsible construction practices - Commissioning and handover - Aftercare
Health and wellbeing	- Visual comfort - Indoor air quality - Thermal comfort - Acoustic performance - Accessibility - Hazards - Private space - Water quality
Energy	- Reduction of energy use and carbon emissions - Energy monitoring - External lightning - Low carbon design - Energy efficient cold storage - Energy efficient transport systems - Energy efficient equipment - Drying space - Flexible demand side response
Transport	- Public transport accessibility - Proximity to amenities - Alternative modes of transport - Maximum car parking capacity - Travel plan - Home office
Water	- Water consumption - Water monitoring - Water leak detection - Water efficient equipment
Materials	- Life cycle impacts - Hard landscaping and boundary protection - Responsible sourcing of materials - Insulation - Designing for durability and resilience - Material efficiency
Waste	- Construction waste management - Recycle aggregates - Operational waste - Speculative floor and ceiling finishes - Adaptation to climate change - Functional adaptability
Land use and ecology	- Site selection - Ecological value of site and protection of ecological features - Minimising impact on existing site ecology

	- Enhancing site ecology - Long term impact on biodiversity
Pollution	- Impact of refrigerants - NO_x emissions - Surface water run-off - Reduction of nighttime light pollution - Reduction of noise pollution
Innovation	- Innovation

For residential dwellings, the sections weighted most heavily in the final score are Health and Wellbeing, Energy, and Materials, which together account for 50–55% of the total score, depending on whether the dwelling is single or multiple, partially or fully fitted. The Innovation category is not part of the total score but can contribute up to 10% additional credit to the final score. BREEAM does allow some adaptation to cultural, economy, climatic and work practices conditions in the final scoring (BREEAM, 2021). The adaptation to location is based on five different climate zones: equatorial, arid, warm temperate, snow and polar while adaptation in the Water category is based on precipitation zones.

Section 2, Health and wellbeing is the most influential when the final score is determined. This category encourages to prioritize comfort and wellbeing for residents and visitors. Hea 01 Visual comfort is the issue that rewards the most credits, followed by Hea 02 Indoor air quality and Hea 05 Acoustic performance (BREEAM, 2021). Visual comfort aims to control what light affect the occupants, both natural light and artificial light. The more daylight the occupants get, the more credits the building receives. Hea 02 Indoor air quality has a minimum requirement of the building not containing asbestos. The main goal of the credit is to take measurements towards minimizing sources of air pollution during both during and after the construction and ensure a healthy indoor quality. A plan for indoor air quality as well as potential for natural ventilation is also rewarded (BREEAM, 2021)

Section 6 treats materials and how they are sourced, resourced and recycled and is particularly of interest for this study. This category promotes efforts to minimise the environmental impact of construction materials across the stages of design, construction, maintenance and repair. The category itself is divided into six issues, where they are assessed and weighted different (BREEAM, 2021). The issue which is weighs most is the life cycle impacts and is summarised as *"Reduction in the building´s environmental life cycle impacts through assessment of the main building elements"*.

Mat 01 Life impacts cycle aims to assess how low the environmental impact is of the construction material during the full life cycle of the building (BREEAM, 2021). It requires that a life cycle analysis has been made and presented in detail. For every product of different material used an environmental product declaration must made. The declarations classification must be made in accordance with Mat 03 Responsible sourcing of construction products, which is the issue that's more interesting for this study. To comply with BREEAM, the chosen LCA tool must be one that has already received approval.

Mat 03 aims to encourage responsibly and sustainable sourced construction parts. It consists of three parts that can be assessed and give credits towards a final score. The category has one minimum standard concerning any timber-based products. If the building project contains any, all of these must be legally harvested. If the timber is correctly procured, or if the project does not contain any, the next step is to present a sustainable procurement plan.

The sustainable procurement plan must state the certification of the material. In the case of cement, the material must be certified by Concrete sustainability council, or CSC for short. CSC certifies in four levels: bronze, silver, gold and platinum (BREEAM, 2023). The key chain production of the material must also be presented and accounted for. Where bricks or clay-based products are concerned, where the clay has been extracted must be presented. Sand is also mentioned, however in relation where it is used in glass production, not sandcrete production.

CSC also provides a technical manual on how they rate and certify concrete. The manual contain management, environmental, social and economic aspects (CSC, 2024). To even be eligible to receive certifications from CSC, producers must demonstrate compliance with human rights legislation, ethical and legal requirements, as well as traceability of materials. CSC is not formally a part of BREEAM, but BREEAM awards credit points that nevertheless rely on CSC certifications.

BREEAM category Mat 05 Designing for durability and resilience aims to encourage protection of exposed elements of the construction and by doing that, reducing the need for replacements. By reducing the need for replacements, the need for new material is eliminated. It can be applied to foundations, walls, roofs, stairs or landscaping. It should protect against UV radiation, variations in temperature, moisture and wind. It should also protect against pests or insects, as well as corrosion, rotting and swelling or shrinking (BREEAM, 2021). To receive points in this criterion the building elements at risk of being targeted must be identified and assessed how they are at risk. Design drawings illustrating how they will be protected and made durable will have to be provided and documented is the design stage, as well photographic evidence after the construction is completed.

BREEAM builds upon the idea of optimizing material use through the category Mat 06 Material efficiency, which encourages measures to optimise material usage to reduce environmental impact of material use and waste. This includes to both use fewer materials and also reuse existing demolition materials. Using materials with high level of recycled content is also rewarded, however mentioned to do so only when appropriate. In the technical manual this is mentioned to be a new issue and as it is under development, would welcome any feedback from project management teams. (BREEAM, 2021).

Reuse and recycle of construction material is mentioned again in the waste category, Wst 01 Construction waste management, in the way that it awards credit points if reusable construction parts are identified and diverted from landfill. It is seen to be one of the steps to promote recourse efficiency when managing construction waste. Wst 02 Recycled aggregates promote the use of recycled aggregates (BREEAM, 2021). It does however only include industrial waste and recycled materials, not agricultural by-products.

3.4.2 Green star South Africa

Green Building Council South Africa was established in South Africa in 2007 (GBCSA, 2025) and promotes the use of Green Star SA as one of its assessment systems. Green Star itself was originally developed in Australia, but some alterations and modification has been made to suit it for a South African context, which is reflected in the SA addition. The impact categories and credits used in Green Star SA is presented in Table 2. The criteria that are presented are used specifically for residential buildings.

Table 2. Impact categories and criteria (GBCSA, 2011).

Management	- Accredited professional - Commissioning - Occupants user’s guide - Environmental management - Waste management - Airtightness testing - Common property rules
Indoor Environment Quality	- Ventilation - Daylight - Thermal comfort - Hazardous materials - Internal noise levels - Volatile organic compounds - Formaldehyde minimisation

	- Private outdoor space - Universal access
Energy	- Greenhouse gas emissions from heating and cooling - Energy sub-metering - Lighting energy use - Maximum electrical demand production - Hot water energy use - Common property energy use - Low emission energy generation - Energy efficient appliances
Transport	- Provision of car parking - Fuel efficient transport - Cyclist facilities - Commuting mass transport - Local connectivity
Water	- Occupant amenity water - Water sub-metering - Landscape integration - Fire system water consumption - Portable water efficient appliances - Swimming pool/spa efficiency
Materials	- Recycling wate storage - Building reuse - Recycled content and reused materials - Concrete - Steel - Sustainable timber - Dematerialisation - Local sourcing - Efficient dwelling size - Masonry
Land use and ecology	- Topsoil - Reuse of land - Reclaimed contaminated land - Change of ecological value - Urban heat island - Outdoor communal facilities - Urban consolidation
Emissions	- Refrigerant/gaseous ozone depletion potential - Refrigerant global warming potential - Insulant ozone depletion potential - Watercourse pollution - Discharge to sewer - Light pollution - Boiler and generator emissions
Innovation	- Innovative strategies and technologies - Exceeding Green Star SA benchmarks - Environmental design initiatives

In Green Star SA, Energy is the category that rewards the most credit points. The category has conditional requirements that the building being constructed, the "actual case", must emit lower greenhouse gases than a standard reference construction, a "notional case". This must be demonstrated before any credits can be awarded. The sub-category that rewards the most is the Ene-1 Greenhouse gases emissions – heating and cooling which aims to encourage new construction designs that minimize greenhouse gas emissions associated with energy consumption for heating and cooling. Credit points are awarded on a scale from 0 to 10, based on the difference between the “notional case” and the “actual case” (GBCSA, 2011).

The material category fucuses on the use of newly sourced resources while also promoting the use of recycled steel, concreate and sustainably sourced timber. Emphasis is placed on the lifecycle and overall lifespan of materials and other building components, which is reflected throughout the category’s credit aims. The credit that generates the most points is the Mat-2 Building reuse, which encourages to reuse already existing buildings or large building components, like façades, rather than relying solely on using new resources. The more of the existing building that is reused, the more points the project is rewarded. The primary aim of this credit is to reduce the volume of demolition waste that ends up in landfills, thereby conserving raw resources and reducing the amount of water and energy as well as the impacts of by-products connected to extraction, manufacturing and transportation (GBCSA, 2011).

Another sub-category, Mat-3 Recycled content and reused materials, promotes the integration of secondary building components that have already been used in previous projects. Examples include recycled windows, doors and flooring which can be directly incorporated in new building projects. By encouraging reuse, this sub-category aims to reduce the demand for raw materials not connected with load bearing elements, therefore minimizing the waste associated with demolition. Mat-3 highlights the potential environmental benefits or reusing components as their lifespan can be prolonged, reducing construction waste and lessen the environmental strain. Important note is that major building materials for load bearing element, such as steel, timber, masonry and concrete are excluded from Mat-3 as they are all covered separately by their own sub-category which generate credit points.

Mat-5 Concrete aims to encourage reducing the need for conventional concrete by replacing a portion of the Portland cement with alternative materials. Sub-categories acknowledges that cement is one of the most carbon-intensive construction materials, making it a significant contributor to the combined environmental impact of the building process. Up to three points can be rewarded by reducing the use of Portland cement and substituting it with other materials, such as industrial waste, recycled or reclaimed aggregate (GBCSA, 2011). If industrial waste product is used, such as fly ash, silica fume or slag, it must be from industry facilities that does not burn hazardous waste, ensuring that the substitute does not create new environmental risks.

To be awarded credit points, project management teams must provide detailed documentation, including proportions of all the concrete used in the project and proof that structural requirement is met. It must also be clearly demonstrated the percentage reduction in Portland cement. A statement of confirmation from the contractor must be presented: "*...in the form of signed correspondence demonstrating, through calculations, the total quantity and material value of the actual new concrete used in the project...*" (GBCSA, 2011). By demanding such evidence, Mat-5 not only incentivises substitution but also enforces accountability and transparency in reporting.

Mat-13 Masonry addresses carbon footprint of concrete bricks and blocks, both of which are widely used in both residential and commercial building construction in the sub-Saharan region. The sub-category requires that the blocks or bricks contain at least of 30% recycled aggregate and a minimum of 10% Portland cement replacement. This requirement directly targets the carbon footprint made by masonry production, which although individually smaller than structural concrete elements, can represent a substantial share of material use due to the sheer volume of blocks in a building.

Steel and timber are also specifically targeted in separate categories. Mat-6 Steel encourages the use of recycled steel, thereby reducing the reliance on energy intensive steel production. Mat-7 Sustainable Timber requires that all timber and timber-composite material used in projects and must be either reused or recycled timber or carry a Forest Stewardship Council, FSC, certification.

Mat-11 Local sourcing encourages the use of sourcing materials from within the local area, aiming to reduce the environmental impact of long transport routes, as well as supporting local economies. One point is awarded when 20% of the project's total value represented in materials have been sources within a 400 km radius of the project site. An additional credit point is awarded when 10% of the same value have been sources with a 50 km radius. Only materials permanently installed on the project site are eligible, hence temporarily materials used only in the construction process itself cannot generate credit points. By promoting local sourcing, not only greenhouse gas emissions from transport is reduces but local supply chains are strengthened.

3.4.3 BSAM

Building Sustainability Assessment Method, or BSAM, is an assessment system developed by Olawumi, Chan, Chan and Wong, researcher affiliated with both Hong Kong Polytechnic

University and University of Technology Sydney. BSAM was developed to address the need for an assessment system tailored in a sub-Saharan context, as assessment systems from developed countries tend to prioritize indoor comfort and energy issues instead of social and economic issues (Olawumi et al., 2020). The system uses Nigeria, due to being the largest economy in the region, as case study for both building projects and expert consultation. BSAM aims to provide contextually relevant guidance for sustainable building practices, considering local economic, social and environmental conditions while promoting measurable improvements in sustainability performance. Its indicators and attributes that are used as criteria are presented in Table 3.

Table 3. Indicators and attributes (BSAM, 2020)

(A) Sustainable Construction Practises	- Project site and design - Societal engagement - Safety and health - Ethics and equity - Construction material and waste - Project management
(B) Site and ecology	- Site selection - Site management - Reduction of heat island effect
(C) Energy	- Energy performance - Energy management - Energy efficient systems and equipment
(D) Water	- Water efficiency - Water management - Water efficient systems and equipment
(E) Material and waste	- Sustainable purchasing practice - Efficient use and selection of materials - Waste management practice - Ease of conversation of building functions
(F) Transportation	- Alternative means of transport - Community accessibility - Transport management
(G) Indoor environmental quality	- Visual comfort - Indoor air quality - Thermal comfort - Acoustic performance - Hygiene - Building amenities
(H) Building management	- Operation and maintenance - Security - Risk management - Green innovation

The 189 experts from Nigeria involved in establishing BSAM represented a wide range of relevant professions, including architects, engineers, project managers and urban planners, all with significant time spent in the industry, gaining experience. Approximately 92% of these experts have been involved in making decisions regarding sustainability and over half of them have worked in the industry for over eleven years (Olawumi et al., 2020). The system is built up by eight indicators which is divided into 32 attributes, which in turn is divided into 136 sub-attributes. Among these sub-attributes, 73 are classified as “required” and 63 are classified as “optional”. In cases where criteria overlap, the required sub-attributed will be addressed before the optional ones in the final assessment. To ensure objectivity and reliability in the final credit score, an independent third-party assessor must act as the evaluator.

In the BSAM technical manual, it is not immediately clear which indicators, attributes or sub-attributes contribute the most credit points. The overview only lists the indicators along with their corresponding attributes and sub-attributes but does not provide information or specify on their respective credit values. To determine how many points a particular sub-attribute offers, one must consult the detailed description of each of the 136 sub-attributes individually. Additionally, the overview does not indicate whether a sub-attribute is classified as required or optional, making it more challenging than needed to understand which elements the assessment system prioritizes. Overall, the sub-attributes reward between one to four points and there is no apparent correlation between whether a sub-attribute is marked as required or optional and the number of credits it awards. Both required and optional sub-attributes can yield either high or low point values, suggesting that the classification “required” does not necessarily reflect the importance of the sub-attribute in terms of credit allocation.

The indicator that rewards the most credit points is (A) Sustainable building practices, with a total of 69 credit points available through both required and optional sub-attributes. Within this indicator, the attribute that allocates the highest credit points is Project site & design, which emphasizes the importance of selecting construction methods that are appropriate for both the building or structure and the project site. Documentation must include an expert report prepared by a multidisciplinary team of architects, engineers, project manager and land surveyor to verify and ensure the suitability of the site and planned structure (BSAM, 2020). In addition, the documentation should provide a detailed description of the construction method, building plans and site layout.

BSAM promotes local engagement in the indicator (A) Sustainable building practices through the attribute A2 - Societal engagement. This attribute emphasizes the involvement of local firms and the promotion of local employment, awarding credits when these criteria are met. Additionally, sustainable local economic practices and public participation are recognized and rewarded with credit points (BSAM, 2020).

Another high rewarding attribute is A4 - Ethics and equity. The attribute can be summarized as promoting the ideals of social equity by emphasizing both economic and social engagement in the local communities (BSAM, 2020). The sub-attributes are all classified as required and include compliance with labour, social and safety standards, education and skills development and environmental statutory requirements. By classifying the sub-attributes required while also allocating a high number of credit points, the attribute is assumed to central in the system to achieve sustainability. This prioritization highlights that social responsibility is regarded not as an optional enhancement but as a fundamental requirement within BSAM.

The attribute A5 - Construction material and waste focus on promoting the use of locally sourced and sustainably managed materials. In BSAM, "local" is defined as resources sourced within a 160 km radius of the project site. To be awarded credits, the documentation must not only confirm the distance but also demonstrate that the sourcing process is sustainable and does not compromise environmental or social standards (BSAM, 2020). A5 does also emphasizes material use efficiency by awarding credits for reusing materials through sub-attribute A54 - Reuse of construction material. This encourages practices like salvaging usable components from demolition or renovation projects, thereby reducing construction waste and the demand for new. raw resources.

Indicator (E) Material and addresses both sustainable purchasing practices and the efficient use and selection of materials. Within the sub-attributes to E1 - Sustainable purchasing practice, the system highlights the importance of developing a procurement plan that integrates not only environmental concerns but also social and economic aspects. In practice, this means that the project's purchase plan must ensure that no materials or products are sourced from supply chains associated with corruption or forced labour (BSAM, 2020). Beyond purchasing, the indicator also encourages resource efficiency through standardized and modular design. The sub-attributes reward up to two points to projects that can demonstrate the use of standardized designs. However, the technical manual does not specify which standards these designs should follow, leaving it to the assessor and project team to interpret and justify their chosen approach. This vagueness may reduce comparability between assessments but also gives flexibility to adapt standardization practices to local contexts.

3.5 Challenges with environmental assessment systems

Assessment systems are, according to Ng'eno Chelang'at and Lawrence (2024), developed on the assumption that environmental concerns exist on a global scale and can be addressed in the same way everywhere. This assumption tends to overlook environmental issues on a local level, as well as fail to consider local variables such as the availability of material, energy resources and construction methods. Western assessment systems also tend to focus on primarily the environmental aspect of sustainability, which makes them less applicable in a developing country, where greater emphasis on social and economic dimensions is needed. Particularly, by recognising the social aspects with categories such as social justice, equity, education and culture, assessment systems could become more relevant in developing countries.

Ng'eno Chelang'at & Lawrence (2024) further criticize the way assessment systems appear to evolve, arguing they are guided more by market and political trends, rather that scientific research. They also claim that in the developing world, assessment systems are often perceived as a business tool to make projects appear more "Western-like," thereby increasing the market value. When considering sandcrete production, the critique becomes particularly relevant. Western assessment systems are developed based on building materials common in Western contexts, such as concrete, timber or steel, and therefore fail to account for locally available materials like sandcrete. By failing to consider sandcrete, the idea of it being undervalued could be increased. The production is closely linked to the economic dimension through efforts to make it more affordable, and to the social dimension by providing employment opportunities within local communities, as it largely relies on manual labour.

4 Results from the interviews

Contact with the first interview respondent was made through Engineers without borders. The respondent does not produce any blocks directly but regularly visits small- and medium-scale block producers and assists in conducting tests regarding bulk density, block weight and the ratio between water, cement and compaction. With more than ten years of practical experience from working alongside producers, the respondent has developed extensive insight into everyday production routines and the challenges associated with maintaining consistent block quality.

To complement this local perspective, a second interview was conducted with a Swedish engineer from Engineers without borders. With approximately fifteen years of experience working with sandcrete block production and sustainability-related construction challenges in sub-Saharan Africa, this respondent contributed more global organisational and technical perspectives. Together, the two interviews provided both local, hands-on insights and contextual understanding relevant for analysing sustainability considerations in Tanzanian block production.

Both interviews were included to complement the literature review and to provide practical, context-specific knowledge for analysing the assessment systems. As described in the methodology chapter, the interviews followed a semi-structured format, allowing flexibility while maintaining a clear focus on key themes. The questions addressed production methods, customer views on sustainability, local sourcing practices and collaboration within the industry.

In the interviews, the term *fundi* is used by the Tanzanian respondent. *Fundi* typically refers to a craftsman or carpenter and implies a high level of competence and skill but may more broadly denote any experienced technical specialist. The Tanzanian currency, Tanzanian shilling, is mentioned and is abbreviated as TSH.

Sustainability and awareness

Both respondents stated that environmental impact is not considered in the sandcrete block production process around Dar es Salaam. Production is driven primarily by cost, and sustainability does not influence decision-making. According to both respondents, small-scale producers are generally unfamiliar with international assessment systems such as BREEAM or regional ones like Green Star SA. BSAM is also not known locally. The Swedish respondent added that these systems rarely appear in the residential sector, where most blocks are used.

Neither respondent observed consistent use of quality standards. Although standards exist, both respondents expressed doubt that they are used in practice, as they do not hold the same perceived value in the Global South. Customers do not ask for standards, and producers therefore have little incentive to follow them.

When asked whether an assessment system could increase environmental awareness, both respondents noted that this would only be possible in theory. In practice, it would require education, governmental support or international projects. According to both respondents, the local market is not driven by environmental considerations, and customers would need greater awareness of sustainability issues for any assessment system to have an effect.

Production and development

Both respondents emphasised that financial conditions are the key challenge for future production. According to both, the market is driven entirely by money, and production cannot expand unless financial resources improve. Rising cement prices and the increasing scarcity of sand were highlighted as major limiting factors. Sand is currently sourced from areas increasingly distant from Dar es Salaam and Zanzibar as local quarries are depleted.

Regarding the possibility of scaling up production using current materials and techniques, both respondents described resistance among *fundi* and company owners. The Tanzanian respondent explained that because *fundi* are paid per bag of cement, there is little incentive to change established routines. A team of three to four *fundi* typically needs to process at least ten bags per day for each worker to earn approximately 10,000 TSH (about 3.5 USD), leaving limited room for adjustments to the production process.

When asked about replacing part of the Portland cement with supplementary materials, both respondents stated that producers would consider such changes only if they could save money. Although it is uncertain whether the blocks would become cheaper, both respondents noted that profit margins could increase. They also stated that customers would continue to buy the blocks as long as the price remained low.

Customer perspective

Both respondents observed that customers rarely discuss or prioritise ecological sustainability. According to the Swedish respondent, awareness of environmental issues appears primarily among individuals with formal education. Although collecting sand from riverbeds is prohibited, this information does not significantly influence purchasing decisions.

Most customers rely on their *fundi* to select blocks, which means that the preferences of the *fundi*, which is typically based on price, largely determine what is purchased. When asked what would be required for customers to begin considering sustainability, both respondents noted that price and awareness are closely connected. They explained that sustainable alternatives would need to be cost-competitive and that broader education would be necessary for customer attitudes to change.

Collaboration and competition

According to both respondents, sandcrete block producers collaborate very little. The Tanzanian respondent described the competition as "*It's like war*." Customers purchasing from small-scale producers almost always prioritize low prices, especially in areas with low incomes. Only when customers have higher purchasing power does quality become a factor in their decision.

The Tanzanian respondent also emphasised the strong influence of the *fundi*, as many customers rely on this specialist to select blocks. The *fundi* typically choose suppliers offering the lowest price or discounts, regardless of quality. This dynamic reinforces competition based solely on cost and discourages producers from investing in improved quality or sustainable practices.

Sandcrete block materials

Both respondents provided similar descriptions of material sourcing in Tanzanian block production. Portland cement used in sandcrete blocks is primarily produced locally in Tanzania, based on limestone cement and clinker. Water is typically sourced from municipal supply, on-site wells or, in some cases, nearby seasonal rivers.

Sand sourcing was identified by both respondents as an increasingly serious challenge. The Swedish respondent claimed that sand collection from riverbeds is prohibited, and coastal sand contains higher chloride levels. While this is less problematic for non-reinforced sandcrete blocks, both respondents noted that the environmental consequences are significant. Heavy vehicles transporting sand over long distances contribute to road degradation. Sand is currently sourced from Bagamoyo, Mkuranga and Kimbiji, located approximately 50 km, 80 km and 110 km from Dar es Salaam, respectively.

Neither respondent reported widespread use of recycled materials in local block production. The Tanzanian respondent noted that many blocks break during the manufacturing process due to variations in compaction and curing. The Tanzanian respondent also mentioned having seen examples from Turkey where crushed demolition waste was reused as aggregate but stated that this practice is not used locally. According to both respondents, there are no standards regulating what materials can be reused in Tanzanian sandcrete production, which limits the potential for more circular practices.

5 Analysis

The analysis is divided into two parts. The first part presents the findings from the literature review within a sub-Saharan context, complemented by insights from the interview on small- and medium-scale block production in Tanzania. This part focuses on the challenges associated with sustainable building practises in the region and examines how these relate to the handling of construction materials with the assessment system.

The second part compares the assessment systems with each other, focusing on which criteria are most highly rewarded through credit allocation and identifying similarities and differences in how they approach material sourcing, usage and efficiency. The analysis also considers the structure of the systems, including their categories and sub-categories, to provide a comprehensive comparison.

5.1 Challenges with sustainability

A recurring theme in the literature review is the high expenses associated with introducing sustainable practices. This includes not only the direct costs of new materials or technologies but also the loss of profit when production is slowed down for training, longer planning phase or certification processes. The interview supports this perspective, as the interview respondent emphasized that any time or money invested in sustainability is ultimately measured against short-term profit.

The connection between government policies and the financial strain becomes particularly evident, since Stephen and Aigbavboa (2025) argue that the combination of regulations, certifications and social expectations has the potential to outweigh profit margin alone. Government-funded education can help strengthen the social standing of sustainability, particularly if combined with efforts to involve local communities in the decision-making during the design phase of building projects. The cultural and social attitude toward sustainability that were identified as a major barrier in the literature review were confirmed in the interviews. Established practices and familiar materials guide decision-making just as much as financial considerations. Involving communities, especially in the construction of public buildings, can also influence private stakeholder to adopt more sustainable practices in their own projects.

Governmental regulations and financial support to cover the initial costs of transitioning towards sustainable building practices are often mentioned in the literature review as a necessity. However, for certification to play a meaningful role in a developing country, it will require incorporation of social and economic dimensions. This aligns with the argument made by Ng'eno Chelang'at and Lawrence (2024) who stress that these dimensions are often overlooked in existing, western-developed, systems. The authors mention BSAM as an alternative, more appropriate framework in the sub-Saharan region, since it accounts for social and economic aspects alongside environmental ones.

If a national government in a developing country lack the resources to provide sufficient financial support, international organizations may need to interfere. This would also be consistent with the UN's Sustainable Development Goals, which highlight the importance of supporting developing countries and help to implement sustainable practices in goal 11, Sustainable cities and communities.

There is a clear contradiction in how materials are addressed in the literature review. On the one hand, when barriers for the implementation of sustainable materials are discussed, local materials are often seen as less desirable and sustainable materials as more expensive, especially compared to conventional, sometimes imported products. On the other hand, multiple studies regarding supplementary cementitious materials stress that using locally available resources could in fact generate significant costs saving by reducing transport and lowering purchase costs, while simultaneously supporting a local supply chain and promoting local economies.

The interview further confirmed that sand and cement transportation is one of the main expenses in block production. However, it also clarified that these materials are not imported internationally but are produced within Tanzania. This adds another layer of complexity to the discussion. Although the resources are manufactured nationally, the costs of logistics still make them a financial burden for small- and medium-scale producers. This emphasizes the need for a definition of how "local" is defined and how supply chains are organized. This also highlights that the believed cost and actual costs of local resources are not only by production, but also by transportation, availability and market structures.

Traditional building practices in sub-Saharan Africa seem to unintentionally align with environmental sustainability by using local materials and not relying on imported materials. As highlighted in the literature review, the growing aspiration to imitate Western construction methods led many of these practices to be abandoned or undervalued while the result is higher environmental impacts. Ironically, Western countries later introduced assessment systems like BREEAM and LEED, which framed sustainability as a modern and desirable attribute in building projects. This creates a contradiction, the image of being modern in developing countries has often meant moving away from local materials, whereas in developed countries, using sustainable methods and materials is increasingly regarded as a necessity for a modern building. If Western building practices and materials are perceived as the benchmark of modern construction, it raises the question of why Western assessment systems they have not become more popular in sub-Saharan Africa.

5.2 BREEAM, Green Star SA and BSAM in a sub-Saharan context

Ng'eno Chelang'at & Lawrence (2024) report that the use of assessment systems in sub-Saharan African countries is in the early stages of being implemented but does not currently have any widespread use. This correlates with what the respondent from the interview, as none of the assessment systems from this study had been heard of. Understanding the reasons for this limited adoption is crucial for evaluating how assessment systems could realistically influence sustainable building practices in the region.

BREEAM is the most internationally established of the three assessment systems chosen in this thesis. The system emphasizes the use of already established tools to plan material usage, as well as material certifications to evaluate the environmental performance of these materials. It encourages efficient use of materials to minimize waste and reduce excess consumption. BREEAM requires documentation at all stages of a building project, from design to post-construction, fostering an environmentally aware mindset throughout the entire production process. The material certifications are sourced from external organizations, such as the Concrete Sustainability Council, which assumes that such systems already exist and are in active use.

Attempting to apply BREEAM's criteria in a sub-Saharan context does however have its limitations as it is not only rare in the region, but it is practically non-existent, as can be seen in Figure 2. Analysing the literature used in this thesis, any certifications on the Portland cement used is not named or seem to be of any particular interest, as the interview confirms. In the case of cement, cost appears to be the main consideration often outweighing any environmental aspects. BREEAM does not explicitly address the use of supplementary cementitious materials, although it does encourage the use of recycled aggregates in the waste category. In the material guidance note (BREEAM, 2023) sand is only mentioned in relation to the glass production supply chain, and bricks are assumed to be clay-based, as the brick supply chain exclusively addresses clay sourcing. Given that some countries in Africa report that 90% of current construction is carried out using sandcrete (Akpokodje et al., 2021) the relevance of BREEAM in this context becomes limited, as the system does not appear to specifically address or accommodate the use of sandcrete, its supply chain or any alternative binders in its criteria.

Figure 2. The number of certified BREEAM projects by location with focus on the African continent (BREEAM, 2025).

When discussing the sourcing of materials in BREEAM, the *how* seems more important than *where*. Local sourcing is not directly mentioned and the system emphases more on traceability and certifications. In the literature used, transportation of materials in the sub-Saharan context are seen as an expense to be minimized if possible. By using nearby materials as sand and alternative binders, the cost of transport is reduced as well as cutting the supply chain shorter. Transport of materials is not directly approached in BREEAM, as the transport category relates to commuting and parking spaces rather that material transport.

Compared to BREEAM, Green Star SA places a stronger emphasis on the reuse and recycling of building materials and construction components. The system awards more credit points when larger and less reworked building elements are used. The literature review, however, primarily focuses on producing sandcrete with new, unused materials. Supplementary cementitious materials, which are often waste by-products from agricultural processes, could be considered recycled, even if not in the traditional sense or as originally intended by Green Star SA. These waste by-products might be better classified as materials with substitution potential rather than reused building components. Furthermore, the limited structural strength of sandcrete raises questions about whether this material can be reused at all without compromising safety.

This raises the concern on how applicable Green Star SA is the Sub-Saharan region as reusable or recycled construction materials is scarce. The issue the region is facing is how to produce more building and more homes as the need is not yet met. As has been mentioned in the introduction, a large part of Tanzania's urban residents lives in informal housing (Mussa, 2020), where the materials used are often of low durability and limited structural integrity. Such materials may not meet the standards for safe, long-term use initially, let alone be suitable for reuse in future construction projects. According to a project brief by Eco Cement Limited (2024) in Uganda, 56% of housing was constructed using temporary materials such as unburnt bricks and mud. While this highlights the need for improving the housing situation, it also indicates that the reuse of these building materials is not advisable.

Green Star SA does, however, mention and reward the substitution of part of the cement used in concrete, provided that the structural integrity is not compromised. Both industrial and agricultural waste by-products are mentioned as possible substitutes which increases the potential relevance of the system for the region. The system has a separate category for masonry, where credit points are generated if supplementary cementitious materials are used. While sandcrete is not explicitly named in this category, credit points would be rewarded depending on the ration between cement, sand and water. However, the credit criteria clearly state that to receive the points for reducing Portland cement the sandcrete must perform the same strength as reference cases (GBCSA, 2011). According to Isaksson et al. (2023), the compressive strength requirements for sandcrete blocks are only around 10% of those applied to concrete. This large gap in performance standards suggests that the category in question could only generate credit points if national guidelines specifically regulating sandcrete compressive strength exist. In such a case, these standards could serve as reference cases in the assessment, thereby aligning local practices with the requirements of the system. Without such nationally defined benchmarks, however, the potential for sandcrete to contribute to credits would remain limited.

In addition to national guidelines on compressive strength, it is also necessary to have reliable data on the actual cement content of sandcrete blocks to award credit points. Since the reference cases in the systems assume a certain percentage of cement replacement, documentation is required to verify that the mixture used in the actual building corresponds to these assumptions. In practice, however, such data is rarely collected in sandcrete production, especially in small-scale or informal settings. This lack of documentation makes it difficult to assess sandcrete against the criteria, which in turn limits its potential to generate credits despite its widespread use.

Agricultural waste products, that currently are of interest to use in sandcrete blocks, are mentioned in Mat-3 Recycled Content & Reused Materials, not as a mentioned substitute in when addressing concrete. By explicitly mentioning organic matter a substitute, Green Star SA could become more relevant in the region. Its relevance increases by discussing and rewarding materials that are locally resourced within 400 km of the project site. Even more points are rewarded if the material source is within 50 km. Some 20 projects are certified in Africa outside of South Africa, with one example being in Tanzania (GBCSA, 2025).

In contrast to BREEAM and Green Star SA, BSAM does not any mention any specific building materials such as cement, concrete, masonry or alternative binders and how to handle them. Instead, methods and practices are promoted to ensure that the whole building process is sustainable. Sustainable methods are described quite detailed and require documentations and reports from a team of engineers, architects, project managers and land surveyors. Regarding materials BSAM promotes the use of local sources ones from within 160 km of the project site. This shows understanding of the expenses and difficulties that transporting materials in the region entails, even if the availability of materials differs based on regional infrastructure and local agriculture, if alternative binders are to be considered. However, the use of supplementary cementitious materials derived from local agricultural by-products could increase, or at the very least be explored to assess their usability, which would be a positive development.

Many of the methods described in BSAM involves some kind of social engagement, both job opportunities and engaging a whole community in the production, which can indirectly promote and support local material sourcing and production as well as skills and knowledge within different parts of the material production stages.

However, by only having 6 of the 18 sub-attributes in the materials and waste indicator required, the category might not be prioritized (BSAM, 2020). The total rewarded credit points are 23, which is not the lowest, but not the highest either. By only focusing on material use and sourcing, BSAM will not yield a high credit score. If the system wanted to promote and focus on material use, acknowledging the different building materials and specifying material sub-attributes is one way to increase the focus. Making the sub-attributes required might not be necessary, but rewarding high credit points is. Since BSAM is developed in and for the sub-Saharan region, explicitly including the widely used building material sandcrete would strengthen its relevance. By also aligning with existing national compressive strength standards, quality and strength testing could increase. Additionally, incorporating supplementary cementitious materials into the system would not only encourage the use and development of alternatives to Portland cement, but also promote sustainability in the region. No buildings have been assessed or certified with BSAM, which indicates that it is not yet in use.

In both Green Star SA and BSAM the materials category also includes waste. BREEAM has its own waste category which is where the system addresses recycled building materials. This demonstrates that demolition waste of materials is part of the construction and should have a proper plan than just ending up at a landfill.

5.2.1 Tanzanian context

Based on the answers from the interviews, getting the small-scale construction block industry interested in environmental assessment systems seems like a challenge. The interview respondents both explained that profit is the dominant driving force in the market. It is noted that customers, through their fundi, tend to base their purchasing decisions almost exclusively on price, while aspects such as product quality or environmental considerations are lowly or rarely prioritized. Since none of the assessment systems brought up in this study directly focuses on price of the materials used, implementing any of them into the Tanzanian sandcrete block production could prove to be difficult.

However, by assessing how the systems indirectly address money-saving actions, some parts can be relevant. Both Green Star SA and BSAM rewards points for using locally sourced materials. This criterion reflects the both the benefit of minimizing transportation distances and thereby reducing environmental burdens, while also lowering construction costs and thereby the cost of the finished product. According to the Tanzanian interview respondent, even if the sand used in production is sourced from a quarry within 160 km, it is still expensive. The Swedish respondent nots how the heavy traffic wears down the roads. BREEAM rewards points for using construction products efficiently, meaning reducing the amount of material needed. Using less materials would also lower costs. BSAM has a sub-attribute to promote modular and standardized construction to also promote material efficiency.

None of what the Tanzanian interview respondent mention in how the materials are procured and where they are purchased suggests the materials are not environmentally sustainable. The Swedish respondent does however mention that taking sand from riverbeds are prohibited and is still being done. Still, the supply chains that do not take sand from riverbeds seems traceable and within what BSAM deems as local and within the 160 km radius to allocate credit points.

This could lead to some points being rewarded if the producers could procure a sustainable purchasing plan.

The Tanzanian respondent mentions that in other countries, for example Turkey, demolished or broken sandcrete block are being sold to be crushed and used again in new blocks. If this could be implemented in Tanzania, or anywhere across the sub-Saharan region, sandcrete blocks could be repurposed and recycled, generating some credit points in Green Star SA, BSAM and even in BREEAM.

A part of Green Star called Green Star Africa have released local context reports regarding how appliable the different requirements are in countries throughout Africa. In the newest Tanzanian local context report (2016), each credit is reviewed and assessed by contacting and having a discussion with Tanzanian professionals as well as looking at what resources Tanzania has in term of manufacturers, suppliers and consultants. The credits are ranked for the changes needed to be applicable in Tanzania with three ranks. If the credit is marked as green the credit will be kept in its current form. If yellow, credit required adaptation and red, credit should be omitted for the Tanzanian application.

Some credits are marked yellow as the Tanzanian professionals uses another standard than the one in Green Star SA. In the material category some adaptation is recommended to give additional if the materials are not only sourced within the radius given in the criteria, but within Tanzanian borders to favour the Tanzanian market. None of the credits used for residential buildings are marked as red (GBCSA, 2016). Since the interview respondent noted that the small-scale producers have not even heard of Green Star, it is unsure how established the system is in the country.

A study done with Tanzanian professionals showed however that using local materials were seen as the least important feature of a sustainable building (Nkini et al., 2024). The study also finds that even though local materials are accessible, more than 80% is imported in the construction of multi-level buildings.

5.3 Comparing the systems

By comparing the systems to each other it becomes clear on how the systems differ and how they are similar. What the different systems prioritize by highly rewarding and what can be seen as not as prioritized, however important, also becomes clear. An overview of the systems is presented in table 4.

Table 4. An overview of the assessment systems.

	BREEAM	Green Star SA	BSAM
Local adaptation	Limited Only climate based	Medium Local context reports	High Region specific indictors
Rewards highest	Indoor climate	Energy	Sustainable management
Material category	Material efficiency	Reuse	Procurement
Strengths regarding materials	Clear structure, reference buildings exist	Cement substitution, awards local sourcing	Aligns with socioeconomic realities
Limitations regarding material	Assumes third-party certification exists	Required testing	No material-specific guidance

5.3.1 BREEAM to BSAM

Compared to BSAM, BREEAM appears significantly more developed and refined. Its technical manual is more professionally presented and offers a clearer overview of the sections and issues that are prioritized and highly rewarded. It is evident that BREEAM has had more time to evolve and improve its structure, making the system more user friendly and pedagogically accessible. In BSAM it's more difficult to directly understand what the system values high and not as high, meaning the reader must read though each of the over a hundred sub-attributes to know what is prioritized.

Looking through the literature regarding sustainability assessment systems the sub-Saharan region, BSAM is only mentioned by name in the developers' own articles. Although BSAM was developed in 2020, there is no evidence of its practical usage or broader regional application in any sub-Saharan country. The system lacks an official website where readers can access further information or updates. In contrast, BREEAM provides and maintains both national and international websites. Furthermore, it is difficult to find any publicly available information regarding the system's development since its initial development in 2020, if any such progress has occurred.

BSAM relied on both BREEAM and Green Star as inspiration when developing attributes and sub-attributes (Olawumi et al., 2020), as well as professionals from the Nigerian construction industry. By relying solely on these experts, its applicability across other countries in the sub-Saharan region may be limited. While the countries are similar, national variations in construction practices, regulations and financial capacity can differ. Including at least some experts from neighbouring countries would expand the system's regional relevance and enhance its ability to reflect the diverse practices and priorities found across sub-Saharan Africa, however similar they may appear.

The systems differ in what they reward the highest credit points. BREEAM rewards the health and wellbeing category the highest while BSAM rewards the sustainable building practises category. This suggests a difference where BSAM can be interpreted to prioritizes mostly on the early stages and how the building is produced and constructed with special focus on social engagement while BREEAM appears more interested in the finished building itself and how it is perceived.

BREEAM does assess responsible construction practises, but it is named as an assessment issue in the Management section and not as a main category is it in BSAM. The issue handles more of the environmental management practises where how energy, water and transport will affect the building site. Consideration for neighbours are also assessed in the issue. BSAM however addresses and rewards aspects such as social engagement, ethics and equity, and health and safety. Notably, all sub-attributes under the ethics and equity attribute are classified as required, making it the only attribute in which every sub-attribute holds this status. In contrast, BREEAM does not include assessment issues that directly correspond to this or anything similar. However, concerning concrete and cement, BREEAM relies on the Concrete Sustainability Council, CSC, to certify concrete in order to award credit points. While BREEAM itself does not assess aspects such as ethics, social engagement, or economic responsibility, these dimensions are indirectly included through CSC's certification criteria.

BSAM have an indicator named indoor environmental quality where the same issues as the health and wellbeing category in BREEAM are being addressed. BREEAM's category is at first glance more extensive and includes hazards, accessibility and private space. However, accessibility for persons with disability is addressed in the attribute G6 – Building amenities, in a required sub-attribute and Hazards are addressed in the G5 – Hygiene, which makes the categories more equivalent.

The initial impression that BREEAM's categories appear more extensive remains when examining the full scope of both systems. For categories that address the same issues, however, the sub-categories are largely comparable. BSAM presents the attributes in broader terms, while the sub-attributes are more detailed in their formulation, which results in a structure that requires a more thorough reading to fully understand and comprehend.

5.3.2 BREEAM to Green Star SA

The systems are alike in how they are presented on their websites and in their technical manual, even if BREEAM's technical manual was easier to find. Green Star SA was more beginner friendly to those new to environmental assessment systems in the aspect of understanding the basics of how the system is built up. By summarizing what the systems require as documentation to be awarded credit points the work amounts to about the same. Reports from the different building stages are required as well as plan drawing and photographic evidence.

The systems differentiate greatly when addressing materials and how they are to be procured in the material section. Green Star SA's first recommendation is to assess if parts of existing buildings can be reused to minimize the need for raw resources. The second recommendation is to re-use materials and use materials with recycled content. After this, new materials are recommended to be used, preferably partly containing recycled aggregates. BREEAM does not emphasize reuse as explicitly. Instead, it is addressed more indirectly in a relatively recent section that discusses material efficiency in general. Within this context, reuse is mentioned alongside broader strategies for optimizing material use, which makes it less of a focal point. In addition, BREEAM highlights the importance of ensuring that generated waste can be reused, but the emphasis on reuse is not as central or systematic as in Green Star SA.

The energy category is the highest rewarding in Green Star SA. The category does not only aim to lower energy usage in residential houses but to also lower greenhouse gases emissions related to energy consumption. This is to be done through mainly the sub-category greenhouse gas emissions – heating and cooling which awards 10 credit points. Other issues being addressed in the category are limit energy and electric use, as well as monitoring hot water usage. BREEAM weighs categories differently depending on the type of house, and while health and wellbeing is the highest weighted for residential, the energy category is slightly higher weighted when regarding non-residential buildings. In its energy category, BREEAM addresses the same issues that Green Star SA does, making the systems very similar in that aspect.

As previously noted, BREEAM places the greatest emphasis on health and wellbeing. Green Star SA includes a comparable category, referred to as indoor environmental quality. While the sub-categories largely overlap, they differ slightly in terminology. For instance, BREEAM's sub-category acoustic performance corresponds to Green Star SA's internal noise levels.

Overall, the categories and sub-categories are largely similar in intention. The main difference lies in the terminology, with BREEAM tending to use more technical and engineering oriented language, while Green Star SA applies terminology that is comparatively less technical and more accessible.

5.3.3 BSAM to Green Star SA

One of the differences between BSAM and Green Star SA is that Green Star SA addresses all the different building materials in separate categories with credit to be rewarded for each separately whereas BSAM addresses none directly. BSAM focuses more on sustainable purchasing practices regarding materials acquisition and supply chains.

As has been mentioned, Green Star SA emphases heavily on reusing and recycling both entire building elements and materials throughout their material category. BSAM has an optional sub-attribute which can rewards up to two credit points for using recycles materials. The systems measure the amount of recycled materials in different ways. While BSAM award credit points by percentage of content of the materials that are from recycled materials, 1 point if the total is below 40% and 2 points if the total is more than 40% (BSAM, 2020). BSAM also rewards points if strategies for reusing materials are adopted. Green Star SA awards three points, one point if 1% of projects contract value is represented by reused materials and up to two mote points if the projects contract value is represented by either 1% or 2% of recycled content of materials (GBCSA, 2011). However, in Green Star SA the credit excludes steel, timber, concrete and masonry. The materials are addressed in their respective categories, whereas this credit addresses other building elements. Green Star SA technical manual (2011) states "*Examples of reused materials include, but are not limited to windows, cladding, pre-cast concrete panels, flooring, doors, sanitary and lighting fixtures/fittings.*"

Both systems reward credit points for local resourcing of raw materials. Green Star SA rewards one point for if the material is sourced within 400 km, and another if the sourcing is within 50 km. BSAM one rewards one credit point which is rewarded if the material is sourced within 160 km of the project site. The Green Star SA Tanzania local context report suggestion that materials resourced with in certain trading area (GBCSA, 2016), such as within the Tanzanian borders, could be a good application here as well to promote and favour the Tanzanian market.

The systems prioritize differently on where they reward the most credit points. While BSAM promotes sustainable construction practises, Green Star SA prioritizes the energy category. Green Star SA does not have a category that directly translates to BSAM's sustainable construction practises, the management category covers some of the same content. BSAM's category is however more extensive with ethics and equity as well as societal engagement.

The energy category in BSAM does not seem to cover the sub-category of greenhouse gas emissions – heating & cooling, which is the most rewarding in Green Star SA. Otherwise, the systems address similar issues related to energy, such as monitoring consumption and managing performance.

5.4 Concluding the analysis

The analysis demonstrates that while al the three systems include a material category, how they are weighted, documented and used differ. BREEAM relies heavily on third-party certifications, and credits life-cycle assessment tools, which limits its relevance in a Tanzanian sandcrete context where such systems are absent and documentation is minimal. Green Star SA provides a more flexible structure and rewards local sourcing and cement substitution, but its credit requirements still assume strength testing and performance verification that are rarely present in small-scale sandcrete production. BSAM aligns most closely with regional realities through its emphasis on social and economic considerations and its focus on local procurement. Still, it lacks material-specific guidance and does not explicitly address widely used building materials such as sandcrete, or even concrete or any other material.

Taken together, the systems illustrate three different approaches to material use. BREEAM is certification-driven, Green Star SA a more focused on reuse and recycle and BSAM is the most context-adapted, focused on the building process. What BREEAM treats as a matter of documentation and certification becomes in Green Star SA a question of substitution and reuse, while BSAM frames material sustainability through local sourcing and procurement ethics. This synthesis highlights that no existing system fully captures the challenges of sandcrete production, especially the lack of quality control, the dominance of manual labour and the financial limitations steering sourcing decisions. These gaps indicate that a system adapted for Tanzanian block production would need to combine the process-based approach of BSAM with some of the material-specific clarity found in BREEAM and Green Star SA.

Taken together, these findings address the research aim by clarifying both the practical challenges facing sustainable building practises and sandcrete production and the extent to which international, regional and local assessment systems align with these realities. The comparison also highlights which aspects of the systems could support future improvements.

6 Discussion

One of the primary barriers to implementing sustainable building practices in sub-Saharan Africa is financial. According to the interview respondent, producers earn approximately 3.5 USD per day. This highlights why cost considerations are important, especially when viewed from a Western perspective. Customer priorities further reinforce this, as low purchase price is often the main concern making strategies that increase costs, even to improve sustainability, difficult to implement.

While governmental policies and regulations could be used to promote sustainability, both financial constraints and cultural resistance have the potential to limit how effective they are in practice. Insufficient project budgets can limit initiatives in sustainable construction and trust in conventional practices can slow the adoption of new methods. With financial aid, technical expertise and project initiatives from international organizations such as Engineers Without Borders or the United Nations, developing countries can receive support to overcome economic boundaries, while hopefully the sustainable awareness that follows can change cultural norms. Such support would also align with the Sustainable Development Goals by enabling the adoption of environmentally responsible building practices and at the same time promoting local economic development.

The interview respondent highlights that many customers rely on their *fundi* to buy sandcrete blocks. As the *fundis* are respected professionals with established social authority in the construction process, providing targeted education and training to this group on sustainable practices could facilitate the adoption of environmentally responsible methods in actual projects.

Despite the few weaknesses that BSAM has, an assessment system specifically for low-income developing countries seems to be needed where priorities may differ from more international frameworks such as BREEAM, as it feels at times difficult to apply in the sub-Saharan context.

BSAM incorporates important issues in the attributes such as ethics and equity and societal engagement into the system, which Green Star SA only addresses similar issues, however more indirectly through other categories such as the management category. BREEAM does not include a dedicated category neither economic or social responsibility nor ethics. Instead, it relies on third-party material certifications where social, ethical and economic aspects are assessed as part of the certification process. Example of this is the use of CSC when awarding credit points regarding concrete use. This reliance ensures that the issues are considered even if it also removes direct control from BREEAM itself, creating potential variables between materials and could limit the system's consistency and control in addressing social and economic aspects.

One possible explanation for this approach is that in many Western countries, where BREEAM was developed and is most used, social and economic aspects are already regulated by existing national legislations structures. As a result, BREEAM places greater emphasis on environmental performance and implementing sustainable work plans into both the design stage and construction stage, while delegating social and economic considerations to existing legal frameworks and complementary certifications.

BSAM places greater emphasis on the planning stage and building practises being sustainable rather than putting any significant focus on material acquisition. This could be to implement sustainable thinking early into the construction which would permeate the rest of the process. The building practises also involve the treatment of worker and involvement local communities and economic growth. BSAM prioritizes the integration of economic and social sustainability alongside environmental aspects, a focus that is less pronounced in BREEAM and Green Star SA.

The different assessment systems all have strengths and weaknesses and would reward varying amounts of points to the material procurement part of a building process in sub-Saharan Africa. Since the purpose of this thesis was primarily to address the material aspects and production of sandcrete, large parts of the different assessment systems are not studied in detail. This means that a comprehensive image of how applicable the systems are cannot be given by this study alone. However, by only assessing the adaptability of the systems to sandcrete production and the potential use of supplementary cementitious materials, some adjustments are needed.

BREEAM relies on third-party certifications to certify materials, to include a certification on sandcrete as a material could increase the relevance. This would however require that a third-party sustainability certification system of sandcrete exists, which it does currently not. Green Star SA could make it clear to include sandcrete in either the concrete or masonry category or add a new sandcrete category. By adding agricultural by-products as a supplementary cementitious material, the system could become more relevant in the region, both by generating credit points and by promoting a more sustainable supplement to cement. BSAM focus is not on specific materials, but on how they are acquired and from where. The system's largest weakness is unfortunately that it's unheard of and no users.

Another indication of Green Star SA's local relevance, not only in South Africa but across the African continent, can be seen in its scoring structure. The system allocates the highest number of points to the energy category, which aligns with the country's ongoing challenges in energy production and supply (Trace, 2020). Trace states that the South African government-owned company Eskom has planned blackouts, called load shedding, to be able to handle the pressure on the electricity grid. In the same article, it is mentioned that only 43 % of Africans have a reliable supply of electricity. This could explain why an African based system would value energy-saving measures highly.

This suggest that local variation or local systems should be explored and used. One system cannot possibly be applied to every construction process, national or local contexts, opportunities offered by local geography and the availability of regional materials should be leveraged. This approach could promote the adoption of sustainable practices globally and enhance knowledge and engagement with sustainable building.

6.1 Conclusions

The aim of this study was to investigate how sustainability in developing countries in sub-Saharan Africa could be assessed. By identifying the challenges sustainable building methods face, why they exist and possible ways to overcome, a clearer way towards a more sustainable building process is recognized. The primary challenges are identified as financial constraints, limited awareness, an absence of political regulations, difficulties with adapting to new technology and a social and cultural resistance. The challenges are interloped and depending on each other, as are the solutions. By introducing policies from governments, financial help can improve awareness and ease the way toward new technology. Though education, cultural resistance can also lessen, as the positive impact of sustainable methods are learned and seen.

The study sought to find ways to measure sustainability in sub-Sahara through three possible assessment systems and analyse how relevant the systems are in the local context. locally

By having a relevant and widespread known assessment system that include relevant materials such as sandcrete, working towards more sustainable building methods in this context could be easier achieved. Supporting and developing national and local variant that support local farmers, and local economies could further ease the way. By demonstrating the long-term financial gain through examples, future sustainable sandcrete production could be achieved.

6.2 Future research and development

Future research should include to continue exploring the potential of agricultural by-products and other available as partial substitutes for cement in sandcrete production. A key part for this is the ability to measure compressive strength accurately, as any substitution could change the structural integrity of the blocks. Developing simple, low-cost testing methods suitable for small- and medium-scale producers could enable testing on site. Previous studies, such as those by Isaksson et al (2023) have suggested practical approaches for such testing.

In addition to material substitution, research could investigate ways to integrate sustainability into the small-scale production processes in a manner that also considers the financial concerns. This includes demonstrating how sustainable practices can reduce material waste and lower production costs, for example the reuse of demolished or broken blocks. Standardized guidance on sandcrete production, like the national compressive strength benchmarks in Tanzania and Nigeria, provides a foundation for further studies to explore effective implementation strategies for these standards in small- and medium-scale production.

Finally, future research could examine how to adapt sustainable frameworks could be aligned with local realities concerning economy. By explicitly linking sustainable practices to budget savings and potential profit, these frameworks could become more relevant and appealing to producers and consumers in sub-Saharan contexts. Combining technical solutions with locally adapted guidance and education could support wider adoption of environmentally responsible building practices. As the BSAM framework has been developed specifically for this region partly with the economic aspect in mind, testing and using it could be the next step towards a more sustainable sub-Saharan Africa.

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Appendix A – Interview guide

Sustainability and awareness

- Is environmental impact something that is considered in the production process?
- Have you or the producers heard about the building assessment systems BREEAM, BSAM or Green Star?
- Do any of the producers follow or relate to any kind of assessment system or standard?
- Do you think using an assessment system could help increase awareness about environmental sustainability?

Production and development

- What are the main challenges you see for increasing production in the future?
- Do you think it is possible to scale up with the materials and techniques currently in use?
- How do the producers feel about replacing part of the Portland cement?
    - Do they think it would make the blocks cheaper?
    - Do they think customers would still want to buy the blocks?

Customer perspective

- Do customers ever talk about or care about ecological sustainability?
- If not, what do you think would be needed for them to start thinking about it?

Collaboration and competition

- Do producers cooperate and share knowledge, or is there strong competition between them?
- If there is competition, what do you think customers value most when choosing which blocks to buy?

About sandcrete block materials

- Where does the Portland cement mainly come from?

- Where does the water mainly come from?
- Where does the sand mainly come from?
- Are any of the materials reused or recycled?