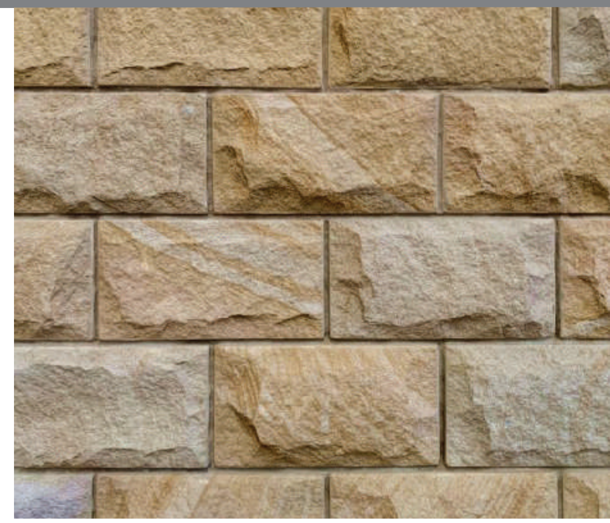
CLIMATE ACTION IN LEAST DEVELOPED COUNTRIES



ADDRESSING LESOTHO'S GAPS IN RESEARCH, PRODUCTION AND USE OF SUSTAINABLE LOCALLY SOURCED CONSTRUCTION MATERIALS

rise relationships inspiring social enterprise

ACTION IRELAND TRUST WORKING TO CHANGE THE FUTURE

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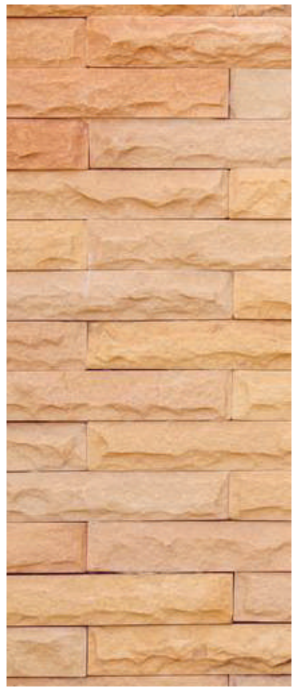
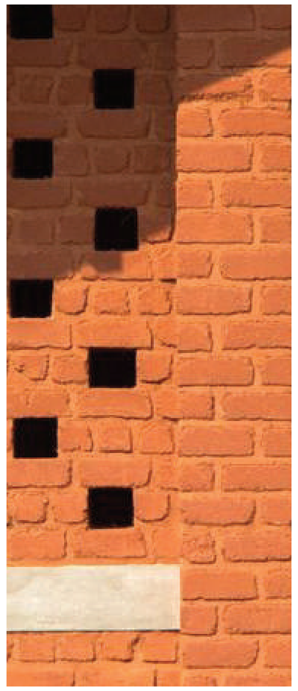
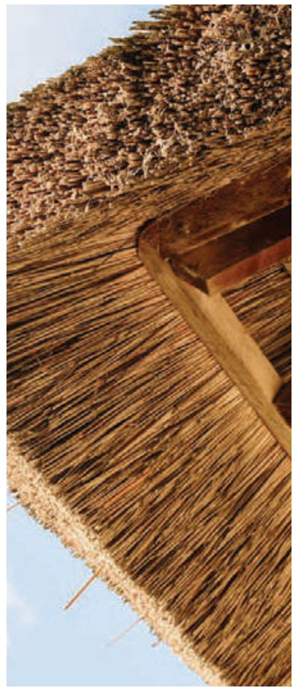

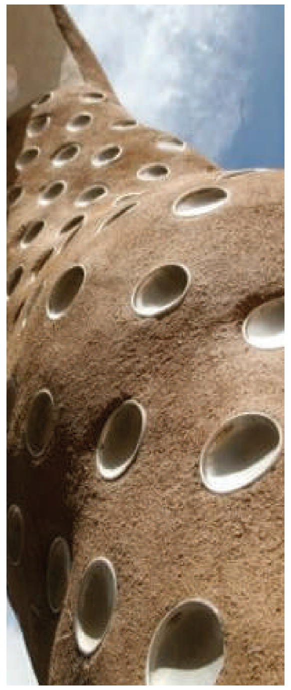



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PROJECT DESCRIPTION

This document is part of the EFICA-funded project on Capacity Building and Knowledge Exchange on Climate Action in Least Developed Countries.

The main project's objective is to explore the utilisation of local building techniques and repurposed materials in Lesotho to gather evidence that can support the expansion and promotion of their utilisation and commercialization. It is hoped that this will lead to the adoption of eco-friendly building practices and the creation of more employment opportunities. The research findings will be shared with policy-makers, private sector practitioners, and relevant government ministries.

This catalogue of locally sourced materials, and indigenous building echniques is the result of 6 months of research that resulted in the compilation of a research document of 6 building materials; 3 traditional-locally sourced and 3 recycled or repurposed materials. The main objectives of this activity was to identify the sources and availability of the materials, determine their cost and accessibility, evaluate the environmental impact ofextracting or reusing, explore the local knowledgeand techniques used when building with them, assess the durability of these materials in comparison to modern materials and in relation to the local climate conditions. The main document is a comprehensive paper where the reader can find the details of the undertaken desk research and findings from the interviews. This catalogue is not an exhaustive document of all the completed research, it is however one component, designed with lots of visuals forease and speed of reference.

The catalogue is in fact organised in short descriptive sections reporting the main findings regarding knowledge gaps, cultural barriers, accessibility as well as icons representing advantages or disadvantages of each material. In this way the reader can have a general understanding of the findings and then if interested in reading in more detail about each material, can refer to the main research document.

ICON LEGEND

Decription

Advantages

Disadvantages

Comparison with modern materials

Accessibility & Availability

Preservation

Unmet needs

Sandstone

Sandstone is a sedimentary rock composed of sand-sized grains of mineral, rock or organic material abundant on the earths surface. Lesotho is home to a rich variety of sandstone sediments classified in to three types : Molteno, Clarens and Elliot, which have been used as a building material for centuries. The sandstone found in Lesotho comes from the Clarens formation type of sandstone.

One of the most well-known examples of sandstone architecture in Lesotho is the historic town of Morija, which was founded by French missionaries in the19th century. The town features many buildings constructed of sandstone, including the Morija Museum and Archives, which houses a collection of artifacts and documents related to Lesotho's history.

Soft

Easy to shape

Durable

Erodes over time

Knowledge Gap

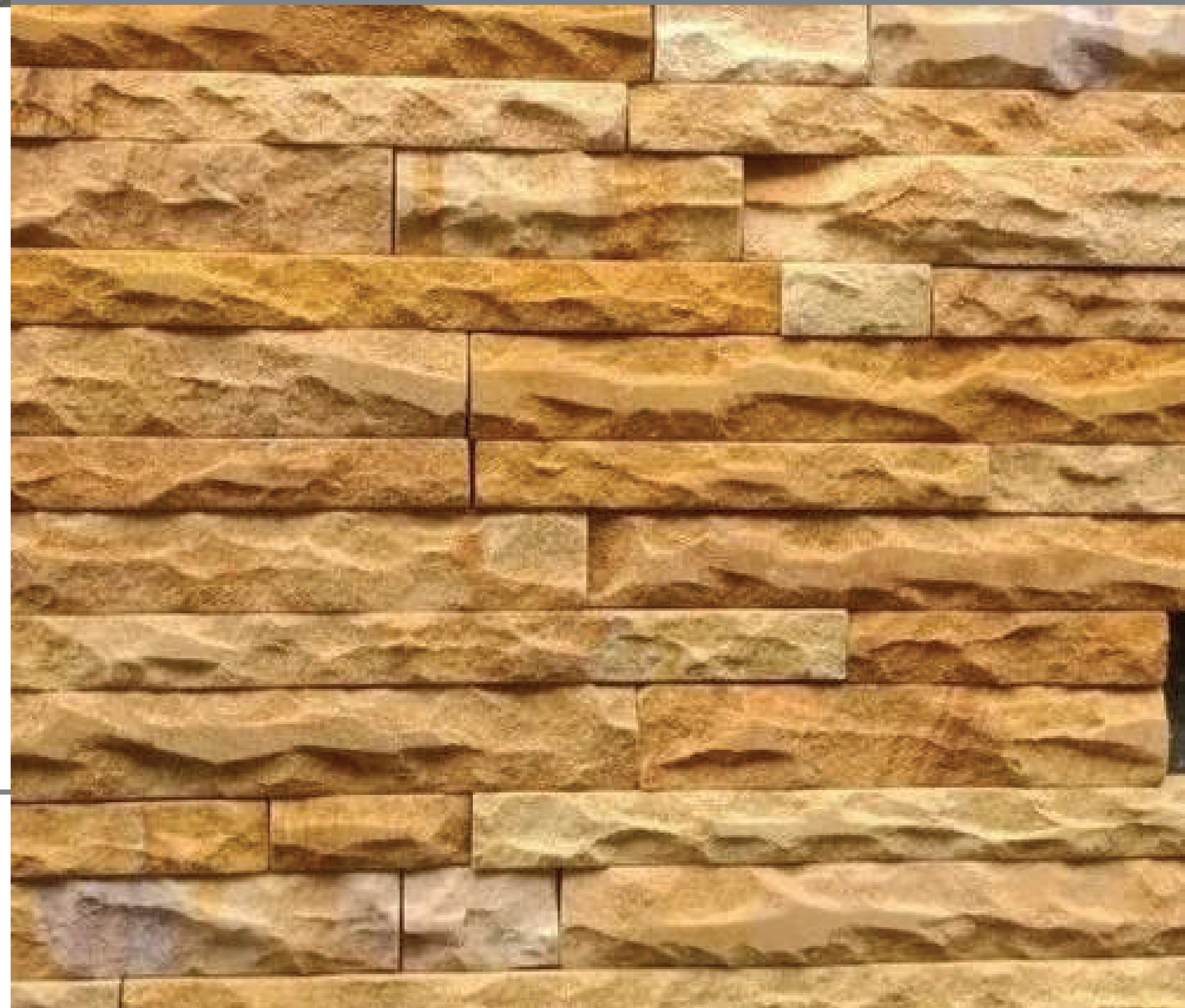
In Lesotho, the main area where sandstone is mined at a large scale is Berea. It comes from the Clarens formation type of sandstone. However, the geological map shows that there are several places of sandstone deposits from Elliot, Molteno and Clarens formations in other districts that have not yet been explored.

Properties	Sandstone
Texture	Rough, granular
Grain Size	Coarse or Fine
Luster	Dull
Porosity & Permeability	Highly porous
Colour	Grey, yellow, red to white

Cultural barriers

Basotho believe the use of cut and dressed local sandstone to be expensive and can only be afforded by wealthy households, hence the material is not being exploited in the country and the majority of it is exported to South Africa due to limited demand in Lesotho.

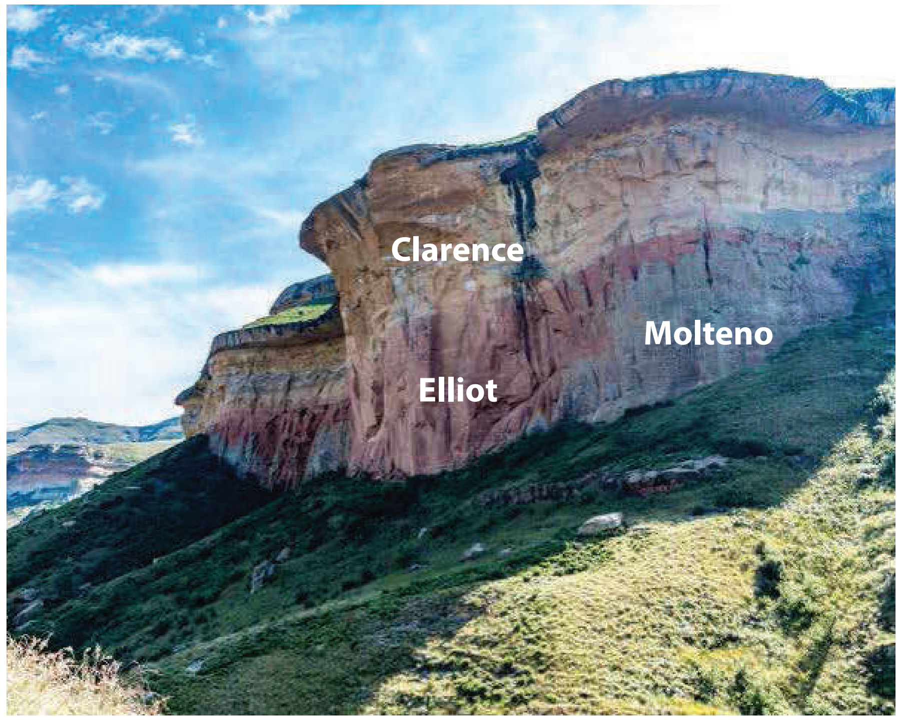
> *The best sandstone comes from the Clarens formations which has lower viscosity than Elliote and Molteno*
>
> - Lesotho Sandstone expert



- Low carbon footprint associated with the transportation and processing of the material
- Abundant local material
- Good thermal insulation properties
- Minimal maintenance required
- Aesthetically pleasing
- It is versatile, it can be cut and shaped to fit a wide range of design styles
- Fire resistant
- Durable
- It has a cultural significance as it has been used in Lesotho for centuries

- It is expensive
- Possible environmental impacts such as soil erosion, habitat destruction, and water pollution

- It is a natural product which means there are no harmful substances added to form or enhance it like in concrete blocks and bricks.
- Unlike burned bricks, sandstone is not burned in a furnace, a practice which contributes to the accumulation of greenhouse gases in the atmosphere.
- Compared to concrete blocks, sandstone's colour/appearance never fades. Even the patina that develops over time can be sanded to make the structure look new again.
- Sandstone is biodegradable, which makes it one of the ideal durable materials in the fight against climate change.



One sandstone company quarries on a large scale while 4 others on a small scale.The quarries are further from urban areas causing high transportation costs. One block is sold M27.34/ €1.41 which is the same size 6 concrete blocks. Not immediately readily available, since extraction is done according to customer demand.

Lesotho government has developed an environmental impact assessment tool to ensure that the present & future developments are socio-economically and environmentally sustainable. However, the government has failed to monitor the enforcement hence unable to monitor damage to the environment.

The country still hasn't mapped out potential areas where sandstone can be mined, other than in Lekokoaneng, hence there is insufficient knowledge of the country's mineral resources endowment and mineral exploration is inadequate. There is an absence of strategies for developing industrial clusters and general economic diversification through infrastructure development and planned connectivity of the mining sector to other economic sectors such as manufacturing and wholesale companies. To fully leverage these benefits, there is a need for innovation in sandstone construction techniques, such as modular designs and prefabricated building components, to increase efficiency and reduce costs.

Traditional use

King Moshoeshoe's two-roomed European house on the top of the Thaba-Bosiu plateau.

A 1912 Mill in Lesotho, Mafeteng.

The house of Chief Lerotholi Letsie in Makeneng, built in 1893.

St Michaels Cathedral, Lesotho, built in 1867

The Old Parliament building, Maseru, built in 1909 and extended in 1959

The Thomas Mofolo Library at the National University of Lesotho, built in 1964

Modern use

Thaba-Bosiu cultural village at Thaba-Bosiu, Lesotho

Government Office Complex, Finance house, Maseru

High Court of Lesotho in Maseru

Mofumahali oa Tlholo Cathedral in Maseru. It was designed by Morisset and construction completed in 1960.

Sandstone facade on the Lesotho Communications Authority building.

Avani Lesotho Hotel and Casino

Compressed Earth Blocks

Compressed Earth Blocks (CEB) are made from a mixture of soil, sand. If the mixture has cement or lime then they are called stabilized compressed earth blocks. The soil used for CEBs should have a clay content of at least 15% to ensure the blocks have good compression strength. The mixture is then compacted into a block shape using a machine or manually using a mold, and then cured by air-drying or baking in a kiln. There are several techniques for building with CEB. One technique involves using mortar to join the blocks together, similar to traditional masonry construction. Another technique, known as "dry stacking," involves placing the blocks without mortar, using the interlocking shapes of the bricks to create a stable structure.In both techniques, reinforcement can be added to the walls in the form of steel bars or mesh to improve their strength.

CEBs can be used for a variety of building types, including houses, schools, and other community buildings. With the growing awareness of sustainability and environmental concerns, CEB are also gaining popularity as a modern, eco-friendly building material in urban areas.

Higher tensile strength

Low water absorption

Higher impact & abrasion resistance

Knowledge Gap

Despite the benefits of CEBs, there is a significant knowledge gap in their use as a building material. Many people are not aware of the benefits, how to properly use them, or how to maintain and repair CEB buildings. Additionally, there is a lack of trained professionals who can design and construct CEB buildings, which can limit their adoption in the construction industry.

Properties	Soil
Texture	Sandy, clay, loamy
Consistency	Hard, loose, sticky
Structure	Granular, Blocky, Platy
Porosity & Permeability	Depends on the soil type
Colour	Depends on the soil

Cultural barriers

CEBs have the potential to be a cost-effective and environmentally friendly alternative to traditional building materials in Lesotho. However, there are cultural barriers to their adoption. One such barrier is a preference for more modern building materials such as concrete blocks or fired bricks, which are often seen as a symbol of social status.

There is also a lack of awareness and knowledge about the benefits of CEBs and how to properly use them. Additionally, the perception that CEBs are associated with rural and informal construction may hinder their use in more formal and urban building projects.

“Compressed Earth Blocks are a natural building solution for general building”

- CEB Expert in South Africa

Good thermal insulation

Sourced locally, no transportation costs

Biodegradable

Eco-friendly & sustainable

Durable

Cost-effective in the long run

Creates job opportunities

Aesthetically pleasing

Weak blocks: Failure to mix soils correctly may lead to weak blocks which crack easily

There is risk of erosion by the rain

Looses strength and dimensional stability when in contact with water for a long period of time.

Low technical performance in comparison to concrete

- CEBs are generally cheaper than modern building materials such as concrete blocks or bricks.
- CEBs have a lower carbon footprint than modern building materials as they are made from locally sourced materials and do not require high-energy manufacturing processes.
- CEBs have good thermal insulation properties, which can help to keep buildings cool in hot climates and warm in cold weather.
- CEBs are durable and long-lasting, but may not be as resistant to moisture and weathering as some modern materials.
- CEBs have a unique and attractive appearance that can add a natural and earthy aesthetic to buildings, but may not be as versatile in design as modern materials.
- CEBs can be made on-site from locally sourced materials, making them more accessible in areas where modern building materials may be scarce or expensive.
- CEBs are strong and can be engineered to meet specific structural requirements, but may not be as strong as some modern materials such as steel or reinforced concrete.
- CEBs are not as fire-resistant as some modern materials, which can be a concern in areas with a high risk of fires.
- CEBs require skilled labor and proper installation techniques to ensure structural integrity, which may be more complex than installing modern building materials.
- CEBs are generally low-maintenance but may require periodic repairs or replacements due to weathering or erosion.

Compressed Earth Blocks (CEBs) can be readily available and accessible in Lesotho due to their cost-effectiveness and sustainability. They are produced on-site, where soil is readily attainble therefore saving on transportation costs. CEBs can be widely used for building homes, particularly in rural areas where traditional building materials are scarce.

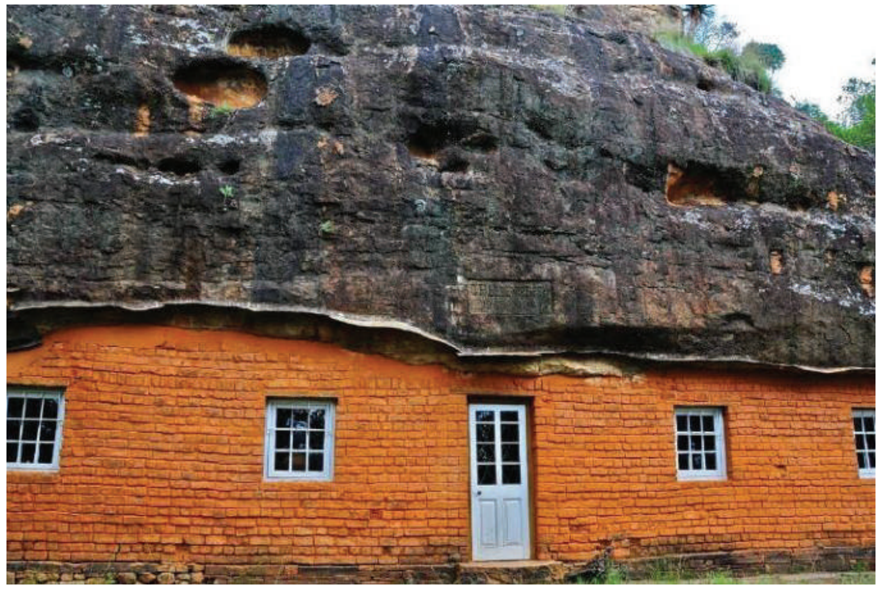
Earth (Soil) is the most abundant material available on the planet and the section of earth used for construction is not detrimental to agricultural needs because topsoil is not used

The market of CEBs is untapped in Lesotho. Some of the main challenges are the lack of awareness among potential users about CEB and its benefits. However there are houses built from adobe bricks in Lesotho. In fact, the oldest buildings were built from adobe, dating back to1843. There is also a need for better training on how to properly produce, install, and maintain CEB structures. Finally, there is a need for more research on how to improve the strength and quality of CEBs to meet the demands of modern construction.

Traditional use (Lesotho) There are no traditional Compressed Earth Block structures in Lesotho

Lesotho Evangelical Church in Southern Africa, located in Morija,
built in 1833. (Clay bricks)

The Morija Sesutu Book Depot built in 1862, supplied books and other materials to schools and churches (Clay bricks)



Masitise Cave House Museum in Quthing, built in 1866 by Rev. David Frederic Ellenbergeras his home. He lived there for 55 years. (Clay bricks)

Traditional use (International)

Located in Mali, the Djenne mosque was constructed in the thirteenth century. It is the largest mud brick building in the world. (Adobe bricks)

The Great Ziggurat of Ur of ancient Mesopotamia c. 2100 B.C.E. Contracted of mud brick covered with baked bricks laid with bitumen

Itchan Kalal walls in Khiva, Uzbekistan. The 10 m clay wall encompasses the this ancient city which is said to have been founded by Noah's eldest s on Shem.

Modern use (International)

EIM Tech campus building in West Africa

The Mwabwindo School in Zambia by Selldorf Architects

Children's library in Muninga in Burundi, built from compressed earth blocks. Designed by BC Architects

Center for Earth Architecture in Mopti, Mali by Kere Architecture.

H2OS eco village in Keur Baker, Senegal by TAMassociati.

A house in South Africa by Dwell Earth

Straw and grass

Thatching is a traditional roofing technique that has been used for centuries in Lesotho. Thatch is a roofing material made from dried vegetation, such as straw, reeds, and grasses. In Lesotho, there are two types:

(1) Agricultural thatch which is wheat straw (Seteroi) - a byproduct of an agricultural cash crop, which is more widely available in the country,especially in two mountainous districts in Lesotho: Thaba-Tseka and Mokhotlong; the top regions for wheat production.

(2) Natural thatch consists of a wild thatch (Mohlomo) which is found in the lowlands and foothills where is warmer and water reed (Lehlaka) - a naturally occurring indigenous vegetation that is mostly available in wet lowlands in the northern parts of Lesotho. The grass is grown in communal gardens, and the thatching process is often a community effort.

Thatch is durable and can last for up to 20 years with proper maintenance. Despite its many benefits, thatch has become less common in Lesotho in recent years, as more modern roofing materials, such as corrugated metal, have become available. However, thatch remains an important part of Lesotho's cultural heritage, and efforts are underway to promote its use and preserve the traditional thatching techniques.

Organic

Flammable

Good Insulator

Knowledge Gap

Thatch is mostly used in rural areas, historical buildings, and lodges. Basotho associate thatch with being a historical roofing material so is often sidelined from the modern architectural world. A shortage of skilled thatchers means that it's a dying trade. Due to its informal nature, little information is known about its availability and no database of thatchers exists.

Properties	Thatch
Weight	Light
Insulation	Good for air and sound
Fire resistant	Highly flammable
Porosity & Permeability	Medium to good
Colour	Mid-tone yellow to brown

Cultural barriers

There are two polarising beliefs associated with with thatch. On the one hand, it is seen as a roofing material used by poor households in rural areas. While on the other hand, others, especially in urban areas think it is used by rich families who can afford to transport it to town and buy it in bulk. Both these points of views have led to a reduction in its use.

“*From all the 4 different types of thatches available in the country , Mohlomo has proven to have the best quality and its durable*”

Thatch roofing expert in Lesotho

Excellent insulation

Durable and lasts for 20 years or more

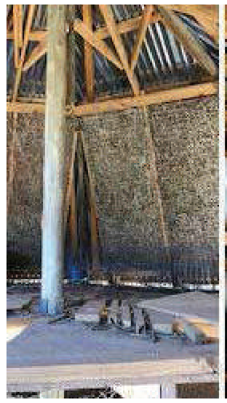
Ages well, blending with the surrounding landscape when it darkens

Adds warmth and character to buildings

Renewable resource

Waterproof

Good sound insulator



Flammable

More expensive to install compared to other roofs

It is organic, which means it is susceptible to decay if not maintained.

It needs to be replaced regularly depending on quality

Animals looking for food and nest material can cause damage.

- Thatch is made from locally available grass and reeds as opposed to other modern materials that are made from imported metal, concrete and clay tiles
- The material is expensive and also labour intensive to install, compared to other modern roofing materials such as metal, which is very fast to install.
- It provides good insulation and thermal efficiency, as opposed to other materials such as metal that are very hot in Summer and cold in Winter
- It requires frequent maintenance and replacement compared to other materials.
- Thatch is prone to fire, pests, and weather damage whereas other roofing materials are often fire and pest resistant.
- Gives traditional aesthetic to buildings
- It is difficult to source during dry seasons, whereas other imported roofing materials are available throughout the year.


Not easily attainable due to laws put in place by local chiefs on who can harvest it. Relatively affordable: one hand bundle is M10/€0.50, but labour is expensive. A 38.5m^2 rondavel uses 13,475 bundles. The quality is a cause for concern due to climate conditions. Only available in a particular season: in Spring.

Land is held communally, with the use of resources regulated by chiefs and village councils. The policy towards biodiversity is very emphatic in protecting wild genetic resources. Its unregulated use has become unsustainable through erosion due to overgrazing.

Insufficient knowledge of the country's resources and geological mapping result in thatch exploration being inadequate. Elderly thatchers are dying without passing on their skills, hence techniques of roofing with thatch are becoming rare. There is an opportunity for young unemployed to get skilled in this dying trade and help increase the demand for this indigenous material. Due to reduced demand for roofing using thatch, there is a strong belief that there are no skilled thatchers left in Lesotho and that there are few employment opportunities as a thatcher.

Traditional use (Lesotho)

The rear view of a mohlongoa-fat'se hut, located at Thaba-Bosiu cultural village

A typical Basotho hut (Mokhoro)

A more modern rectangular Basotho house with a thatched roof.

A Matsitsi and Matebele hut constructed entirely of thatch, located at Thaba-Bosiu cultural village

A hut at Thaba-Bosiu cultural village, Lesotho

Mohlongoa-fat'se at Thaba-Bosiu cultural village, Lesotho

Modern use (Lesotho)

The monumental Mokorotlo building in Maseru, Lesotho

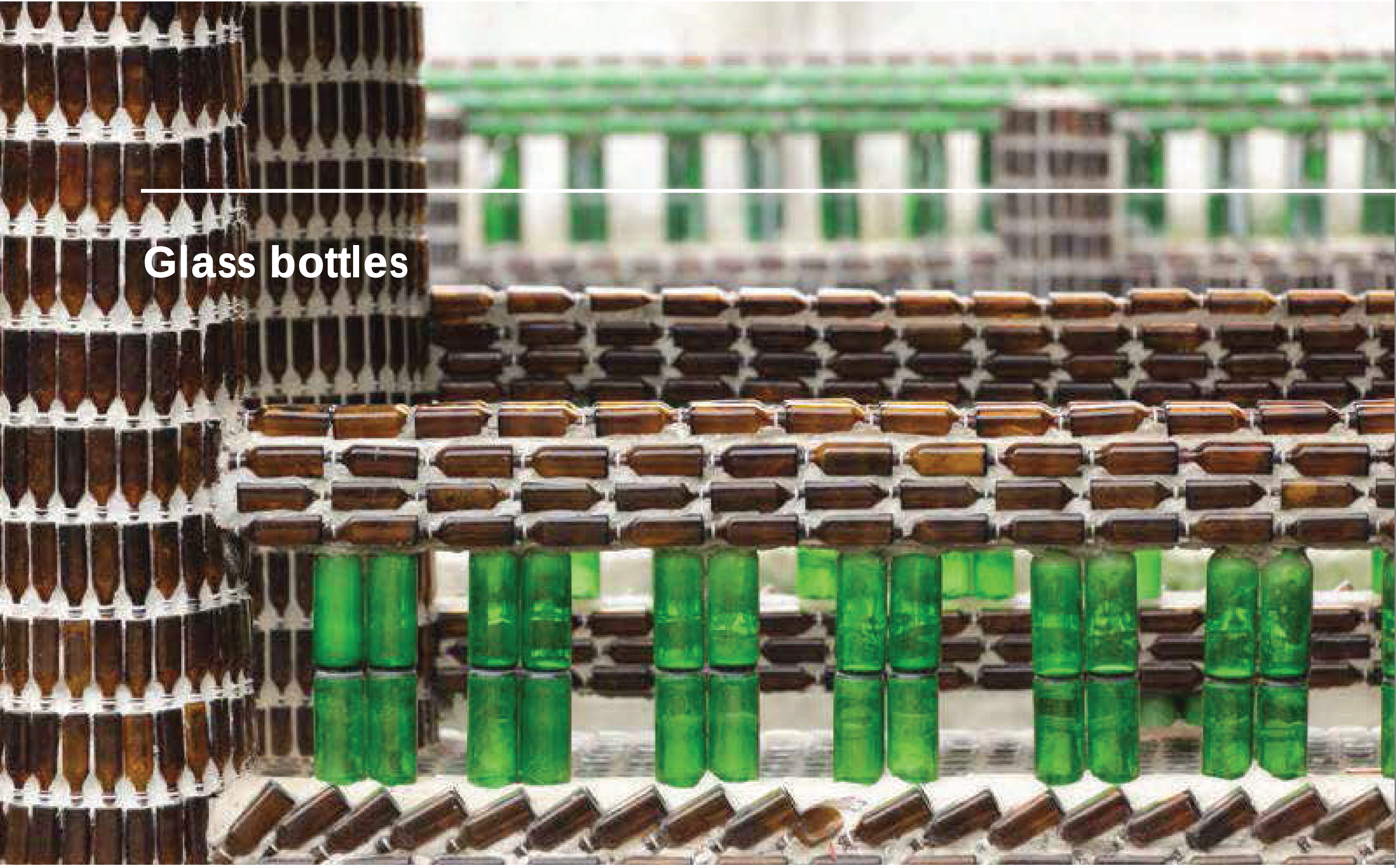
The luxury Maliba Lodge in Tsehlanyane National park, Butha-Buthe, Lesotho

The amphitheatre at Thaba-Bosiu Cultural Village

Mmelesi Lodge at Thaba-Bosiu, Lesotho

Thatch building at Thaba-Bosiu cultural village, Lesotho

Ha Kome Cave Information centre in Berea, Lesotho



Glass bottles

Bottle walls are made from glass or plastic bottles and are joined with a binding mixture using adobe, sand, cement, stucco, clay or mortar. This way of building helps reduce landfills and promotes the reuse of waste materials. The benefits of this way of building are that it is low cost, aesthetically pleasing and sustainable. The technique of using empty vessels dates as far back as ancient Rome, in the Circus of Maxentius. This method was used to lighten the load of upper levels of structures and reduce concrete usage.

The first bottle house to be constructed using this technique is believed to be one by William F. Peck, built in 1902 using 10,000 bottles and was demolished in the early 1980s. In 1905, using 51.000 beer bottles and adobe, Tom Kelly constructed his house in Rhyolite, Nevada. Since trees were scarce, he used beer bottles collected from 50 bars.

These walls can be made in many different ways. The walls are usually one or two bottles thick. A two finger separation is typically used. This wall functions as a thermal mass when the glass bottles are filled with dark liquid or other dark materials so as to absorb the solar radiation during the day and radiate it into the interior at the night (This feature is only pleasent for cooler climates). Research shows that there are no examples of glass bottle buildings in Lesotho.

Aesthetically pleasing

Durable

Reduces polution

Knowledge Gap

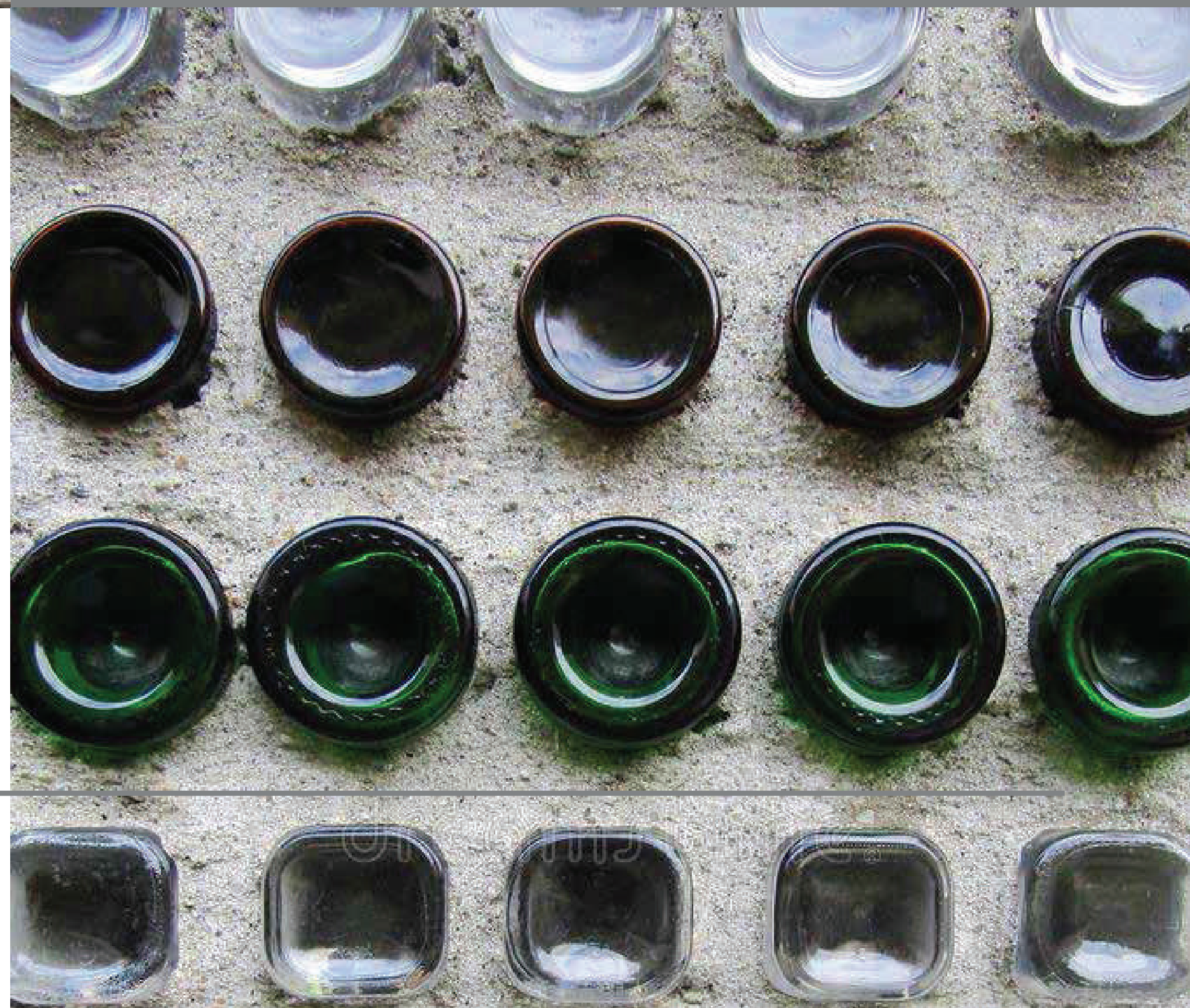
There's limited knowledge on the availability and cost of the necessary materials for constructing glass bottle buildings. There's a lack of research on the structural integrity and thermal insulation properties of glass bottles as a building material.
Lastly, there's a need for information on the potential environmental impacts and sustainability of using glass bottles as a building material in Lesotho.

Properties	Glass
Clarity	Transparent, Opague
Rigidity	High
Impact resistance	Poor to fair
Stress resistance	Fair to good
Moisture barrier	Good to excellent

Cultural barriers

Cans, plastic and glass share the same cultural barriers. Waste is viewed as trash that needs to be burned or sold to recycling companies. Conventional building methods and materials, such as concrete blocks, are preferred due to their availability and familiarity. There is a perception that using waste materials is unhygienic and low-quality. There is a lack of awareness and understanding of the benefits of using waste materials, as well as a lack of technical expertise in how to use them effectively. Finally, there may be resistance from the government and regulatory bodies due to concerns around safety and quality control.

"*The idea is to use a material that is already accessible, also available to the community and use that to show through design a better use or increased value of the material*" - Community Architect in South African



Sustainable

Aesthetically pleasing

Cost-effective waste management

Structurally sound and stable

Good thermal insulation properties

Durable

Provides natural light in the interior

Low tech and easy to reuse

Additional costs arise when opting for vermiculite instead of sand, which is better when reducing the weight of the glass

Not architectural grade material so they are non load bearing

High thermal conductivity leading to unwanted heatlosses

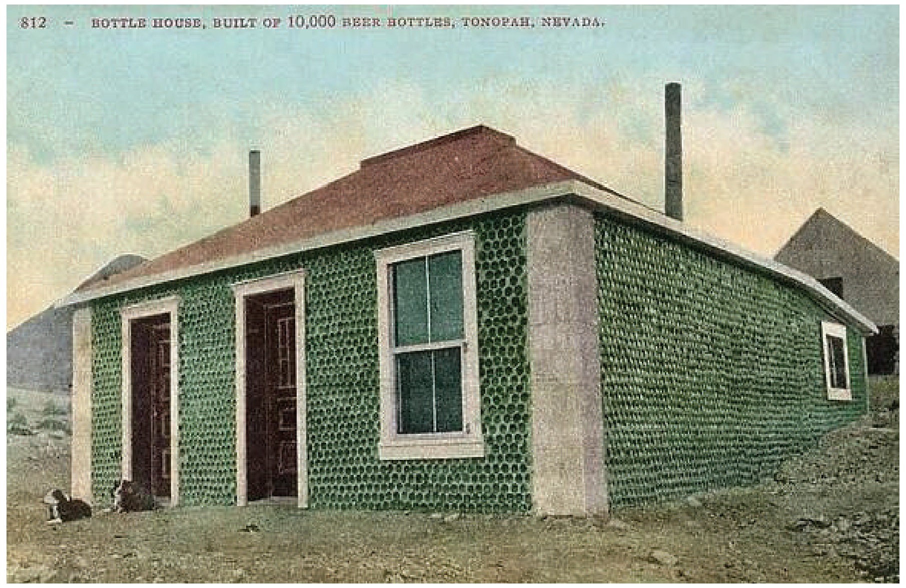
- Reduce the amount of pollution by being upcycled into a construction material.
- Low carbon footprint unlike concrete and burned bricks.
- Glass walls are not as strong as concrete bricks walls.
- Unlike other materials such as cans, concrete blocks, and bricks, bottle glass walls create natural light indoors.
- They have stained glass effect which most building materials do not have.
- Bottle glass walls reduce the weight of structures unlike solid walls made from bricks and block
- They reduce construction costs compared to other construction materials like bricks and stone.
- Costs are reduced when it comes to plastering and painting the interior walls made from glass bottles.

Waste amounts to 137,510 tonnes/year. 20% ends in collection systems, 80% is dumped illegally. It's easily attainable and free from illegal dumpsites. The amount of available waste may vary depending on location. Feasibility depends on the availability of technical expertise, regulatory and cultural acceptance of using waste materials in construction.

Currently, there are no recycling facilities in Lesotho. However, there are several waste reclaimers who collect, separate and either sell recyclables locally or transport them for sale to recycling companies in the Republic of South Africa (RSA).

Using waste as a building material in Lesotho has not been fully explored. A few unregistered companies have started using waste in the building industry, therefore its has potential to be used and seen as a viable building material has yet to be explored. Additionally, the lack of data with regard to the exact number of plastic bottles, cans, and glass bottles in dumpsites remains undocumented. Lastly, accessing the unaccounted 80% of waste, will play a role in the ability to use waste as a construction material on a larger scale in order to ensure enough packaging waste is available.

Traditional use (International)



William F. Peck's house in Tonopah, built in 1902.

Tom Kelly's Glass bottle house Rhyolite, Nevada,1906.

Masitise Cave House Museum in Quthing, built in 1866 by Rev. David Fredric Ellenbergeras his home. He lived there for 55 years.

Wat Pa Maha Chedi Kaew in Si Kaeo Thailand, 1986

Boswell Embalming house in Boswell Canada,1952.

The John J. Makinen bottle house in Michigan, 1941.

Modern use (International)

Silindokuhle creche in Joe Slovo township, South Africa by Kevin Kimwelle

The Bottle Chapel in North Carolina

Glass bottle construction in Wamatu

Beer Bottle Houses in Tamil Nadu, India.

Kawakawa men's toilets in New Zealand by Friedensreich Hundertwasser

The pivoting bottle doors at the Blatz, by Johnsen Schmaling Architects

Cans

The production of packaging waste has become an environmental problem for the world. Products like cans have either ended up in oceans or landfills. Lesotho is no exception, with 137,510 tonnes of waste produced annually, of which, 80% is unaccounted for while 20% falls within the collection system . The need to divert cans from landfill is apparent, and re-purposing them into a construction material is a viable solution.

Can walls are non-structural walls made from aluminium or steel cans by stacking them on their side like bricks with mortar or concrete holding them together. Tin can walls are not as popular as glass bottle wall construction since the cans by themselves do not provide the compressive strength essential for load bearing walls. Another reason could be that glass bottle walls provide a stained glass window effect.

Architect Michael Reynolds has been spearheading the development of can wall buildings for years. He uses re-purposed materials in all his earthship projects. A German man by the name of Michael Hönes moved to Lesotho and started working with cans. He has built several soda can structures as a way to do something positive for people there.

Affordable

Reduces Pollution

Simple technique

Knowledge Gap

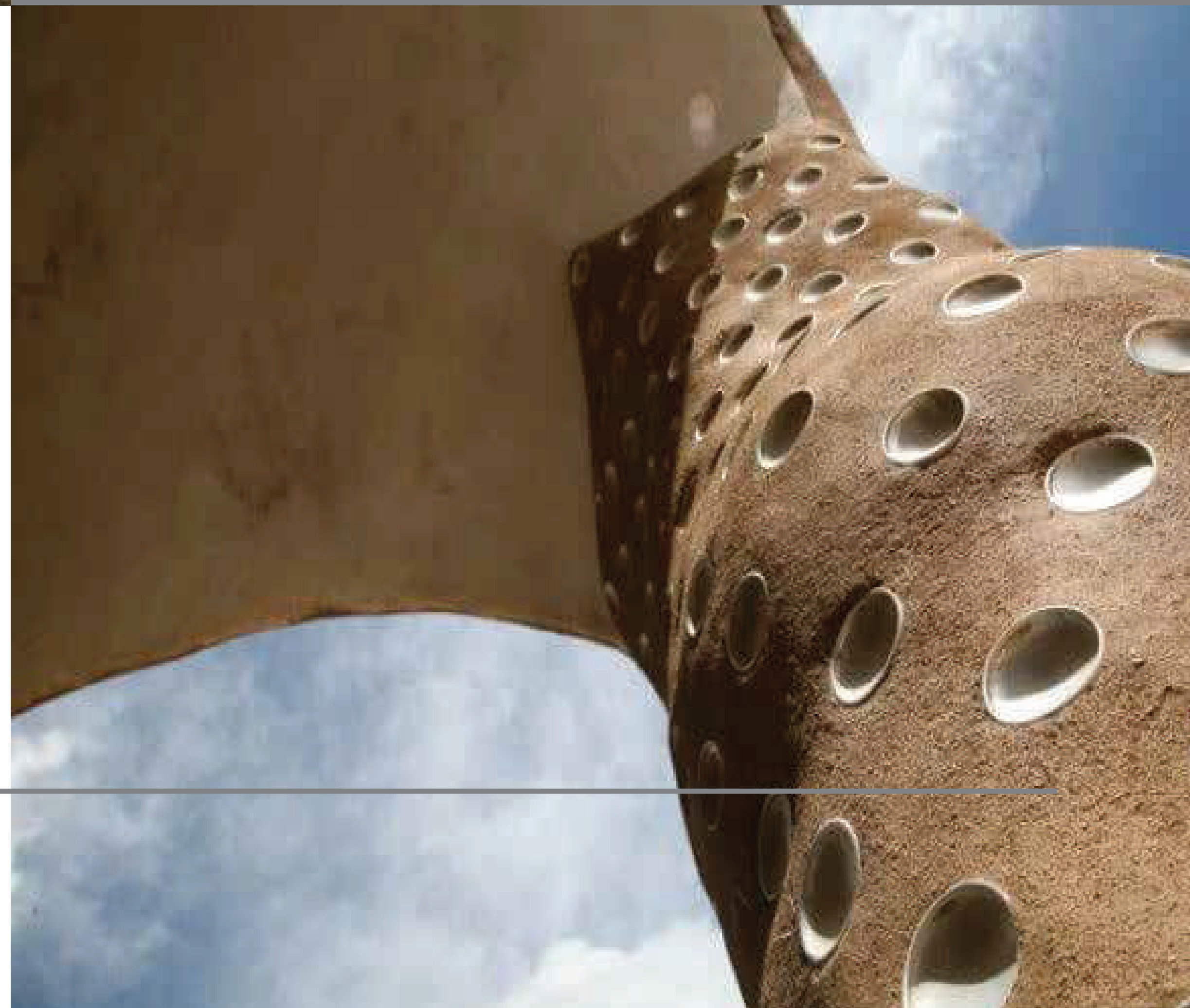
Cans, plastic and glass share the same knowledge gap. Lack of awareness of the possibility of waste being used as a building material. The main issue is not with packaging materials, but the linear economic model: goods are produced, consumed, then disposed. The model assumes endless economic growth and doesn't consider the environment. However, waste can be set on a different lifecycle, turning disused waste into sustainable building material.

Properties	Cans
Weight	Light weight
Corrosion	Non corrosive
Durability	Very durable
Thermal conductivity	High
Ductility	Ductile

Cultural barriers

Cans, plastic and glass share the same cultural barriers. Waste is viewed as trash that needs to be burned or sold to recycling companies. Conventional building methods and materials, such as concrete blocks, are preferred due to their availability and familiarity. There is a perception that using waste materials is unhygienic and low-quality. There is a lack of awareness and understanding of the benefits of using waste materials, as well as a lack of technical expertise in how to use them effectively. Finally, there may be resistance from the government and regulatory bodies due to concerns around safety and quality control.

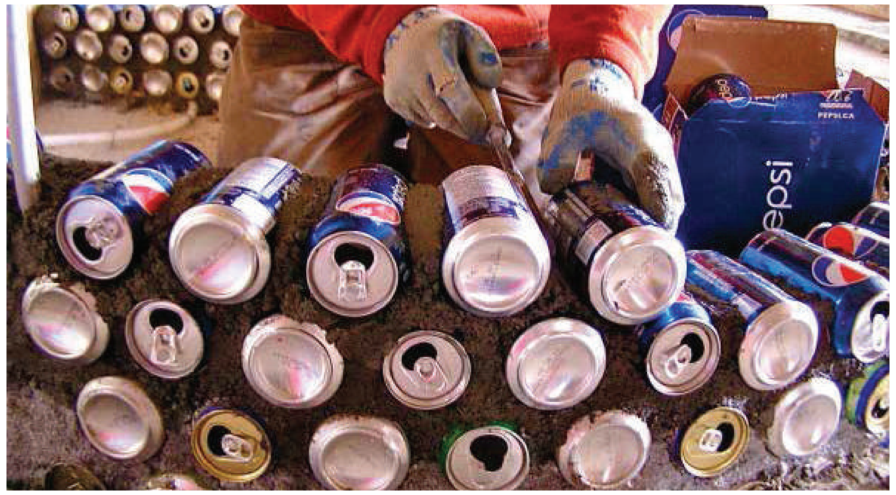
"The most valuable waste materials are the cans because a can is a high-tech product, durable, and lightweight and it has a lot of properties, not just as a valuable material for recycling but also as a form ." Energy Technology Engineer



- Recycled material
- Lightweight
- Durable
- Tin can walls do not require complex skills in terms of construction
- Affordable
- Versatality: they can easily be cut, shaped and combined to form a variety of structures, including walls, roofs and even entire buildings

- Tin can wall method is considered to be non-load bearing
- May not be aesthetically pleasing to everyone

- Not as strong as other walls such as concrete and stone walls, which is why they are non-load bearing.
- A low carbon footprint unlike concrete and burned clay bricks
- Made from repurposed materials unlike concrete walls.
- Can walls have low thermal properties compared to traditional building materials
- Minimise pollution by preventing cans from going to landfill.
- They do not require any complex skills unlike concrete blocks and stone blocks.



Waste amounts to 137,510 tonnes/year. 20% ends in collection systems, 80% is dumped illegally. It's easily attainable and free from illegal dumpsites. The amount of available waste may vary depending on location. Feasibility depends on the availability of technical expertise, regulatory and cultural acceptance of using waste materials in construction.

Currently, there are no recycling facilities in Lesotho. However, there are several waste reclaimers who collect, separate and either sell recyclables locally or transport them for sale to recycling companies in the Republic of South Africa (RSA).

Using waste as a building material in Lesotho has not been fully explored. A few unregistered companies have started using waste in the building industry, therefore its has potential to be used and seen as a viable building material has yet to be explored. Additionally, the lack of data with regard to the exact number of plastic bottles, cans, and glass bottles in dumpsites remains undocumented. Lastly, accessing the unaccounted 80% of waste, will play a role in the ability to use waste as a construction material on a larger scale in order to ensure enough packaging waste is available.

Modern use (Local)

Soda can structure in Lesotho, built in 2002, designed by Michael Hönes

House at the border post Van Rooyans gate, Mafeteng, by Michael Hönes

Soda can structure located in Maseru, built in 1995

Modern use (International)

House of Budweiser in Florida

Broadway Housing, Santa Monica, CA by Brooks and Scarpa Architects

Cans were used in the walls of this Public school in Jaureguiberry, Uruguay. Built in 2016 by Michael Reynolds

Plastic

Plastic waste is increasing day by day and becomes an eyesore and in turn pollutes the environment, especially in urban areas. In Lesotho plastic bricks are already being produced. During the process of making the bricks, plastic waste is collected and it is separated according to the different types of plastic. Furthermore, it is cleaned to remove any kind of waste and dried up to remove water content. After the separation stage the plastic bags and bottles are dropped one by one into a furnace and allowed to melt. It is done in a closed vessel to prevent the toxic gasses being released into the atmosphere.

The burning temperature is 120-150 degrees centigrade. When the plastic turns into molten state, river sand is added to the mixture. After the completion of proper mixing the mixture is placed into the required mould, and it is cured for 2 days before removing it from the mould.

Moreover, plastic bottles can work as bricks when filled with soil they form a framework for walls or pillars.

Lightweight

Durable

Water resistant

Knowledge Gap

Some entrepreneurs are experimenting with the fabrication of plastic bricks but are using methods that aren't environmentally-friendly since toxic fumes are emitted when melting the plastic. There are also some rondavel structures being built using plastic bottles as an integral part of the walls. Training is needed to demonstrate environmentally-friendly ways of converting plastic packaging waste into building materials.

Properties	Plastic
Impact resistance	Good
Moisture barrier	Good
Weight	Lightweight
Corrossion	Non corrosive
Chemical resistance	Good

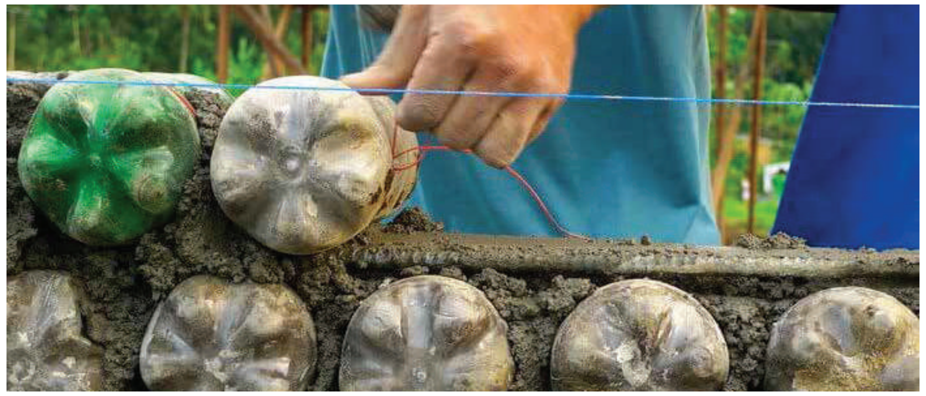
Cultural barriers

Basotho tend to view waste materials as low quality and unsuitable for use in buildings. There's a perception that traditional building materials are more durable and there is a stigma associated, as well as a lack of awareness about the benefits and feasibility of plastic waste as a building material. Additionally, there may be resistance to using plastic waste due to concerns about its safety. Addressing these cultural barriers requires education and awareness campaigns, as well as efforts to demonstrate the safety, durability, and sustainability of building with plastic waste.

> “*Bricks made from plastic are less permeable than concrete bricks making them the best solution for making bridges*”
>
> -Plastic bottle builder in Lesotho

- Long lasting
- Water resistant
- Bullet proof
- Durable
- Resistant to corrosion
- Affordable

- They reduce the mount of pollution by being upcycled into a contruction material.
- They have a low carbon footprint unlike concrete and burned bricks.
- They reduce construction costs compared to other construction materials like bricks and stone.



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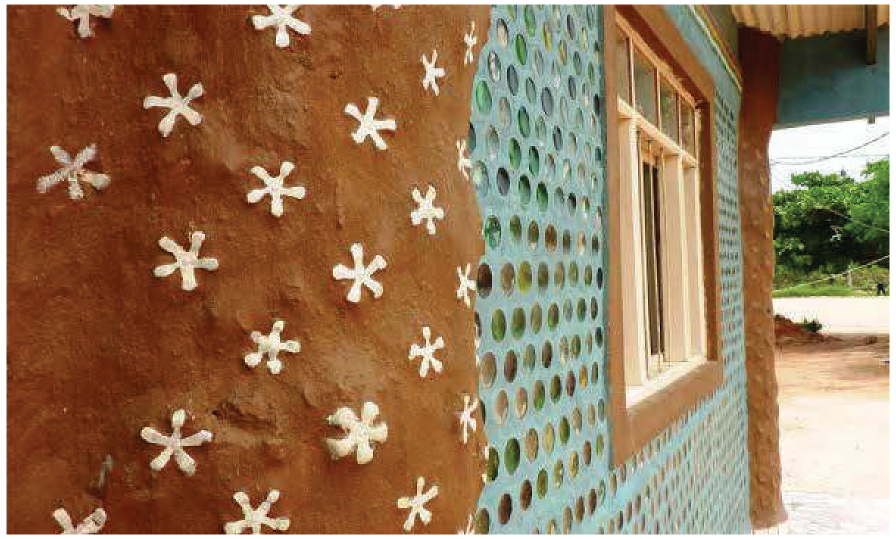
- There are those who believe that this way of building will be harmful in the long term
- Many consider this method short term solution, it's merely delaying the problem for a few more years
- Non recyclable plastics leak into the natural environment when the plastic bricks are exposed to the sun



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Modern use (National)

Tiles made from recycled plastic by Pheha plastic in Lesotho

Plastic bricks made from recycled plastic by Moeketsi Motantsi in Lesotho

Plastic bottle house in Lesotho, Mokhotlong.

Modern use (International)

Plastic bottle school in Greyton South Africa by Nicola Vernon

Eco bottle house in Nigeria, Sabon Yelwa

Sahrawi refugee camps in Algeria

Hempcrete

Hemp is a type of cannabis known as cannabis sativa. Unlike cannabis, hemp contains very low levels of THC. It is one of the most versatile plants in the world. The stalk of a hemp plant offers many different uses including alternative building materials such as hempcrete. Hempcrete is a sustainable building material made from a mixture of hemp hurds (the woody inner core of the hemp plant), lime, and water. The combination of these materials results in a durable concrete-like material that is about one-eighth the weight of concrete and can be used for walls, floors, and roofs; or moulded, sprayed, or precast into hemp bricks or panels.

Hemp is a fast-growing crop that requires relatively little water or pesticides, making it an attractive option for eco-conscious builders. Additionally, the carbon dioxide absorbed during the growth of the hemp plant is sequestered within the hempcrete, making it a carbon-negative building material.

Overall, hempcrete is a versatile and sustainable building material that offers a range of benefits for both builders and occupants. However, its use is still relatively uncommon due to regulatory barriers and the relatively high cost of production compared to more traditional building materials.

Durable | Light weight | Energy efficient | Pest resistant

Knowledge Gap

In Lesotho, it is common knowledge that a license for producing medicinal cannabis is very expensive M500,000 / €24,000 per year, so is renewing it. This makes venturing into hemp cannabis production and creating by-products such as hempcrete an almost non-existent venture.

Properties	Hemp
Durability	Highly durable
Abrasion resistant	Very poor
Tensile strength	3 times stronger than cotton
Elasticity	Poor
Colour	Light sand, dark greyish beige

Cultural barriers

Cannabis is currently known for its recreational use, and is often planted and sold illegally because there is a common perception that the laws prohibit the planting of cannabis; this, therefore, brings a halt to the development of cannabis by-products such as hempcrete

> *Advantage of hempcrete is that that one can grow their own house, it is a healthy home - with lots of theurapetic benefits to it and, better thermal properties.*
>
> - Builder & independent contractor

- Good thermal insulation properties
- Durable
- Disaster resistant
- Light weight
- Fire resistant
- Easy and quick construction
- Breathable walls
- A carbon-negative material
- Waterproof

- Expensive
- Not readily available due to seasonal production
- Blocks take 6 -8 weeks to dry and are affected by weather change
- Not load-bearing

- Hemp is a building material that has the ability to remove carbon from the air. Other building materials such as cement have a significant carbon footprint.
- It is also possible to spray hempcrete for floor insulation and roof ceilings, this means that hempcrete is a flexible building material with many construction advantages.
- Hempcrete's low density is also advantageous, as it is resistant to cracking unlike concrete blocks.
- Hempcrete provides excellent insulation properties, which can reduce energy consumption for heating and cooling.
- It is naturally fire-resistant and can provide better fire protection than some modern building materials.
- It is breathable and can regulate moisture, which can reduce the risk of mold and other moisture-related issues.

Hemp is not currently grown in Lesotho and so is not locally available. The Ministry of Health has recently instituted the production of cannabis for use in by-products, which is not well known. Once there is demand, the availability of hempcrete will largely depend on the take-up of its production.

The Drugs of Abuse (Cannabis) regulations, 2019 have control measures that promote the conservation of cannabis, which could be used under the Licence for Manufacturing.

Lack of public knowledge about the opportunities of the production of hemp is the greatest hindrance to development. It would be an advantage for Lesotho to use hemp as a building material that can be produced quickly and its thermal efficiency would help improve against the cold Basotho Winters. Ultimately, a local hempcrete industry would stimulate the economy and reduce the reliance on South Africa's construction material industry. The emergence of a new industry would also introduce new job opportunities for people living below the poverty line, especially in rural areas where employment opportunities are non-existent.

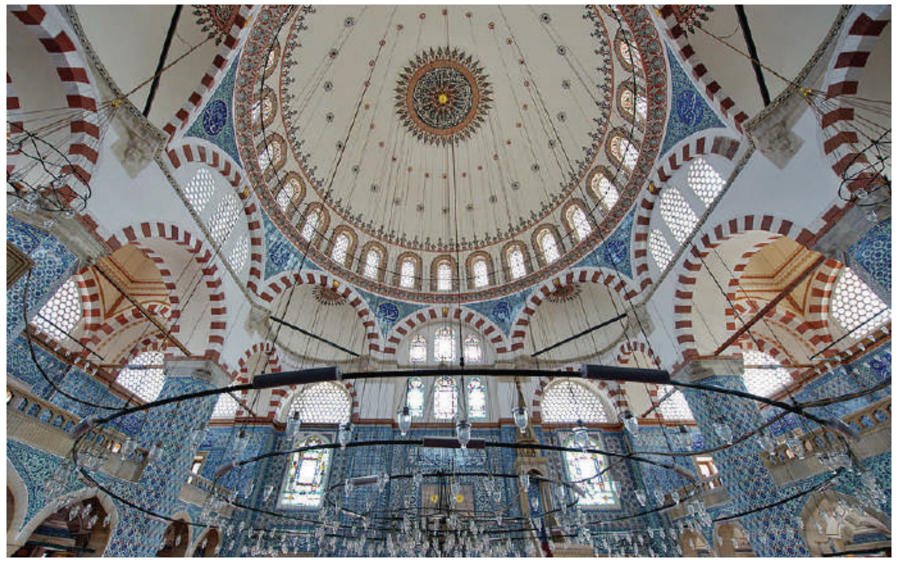
Traditional use (International) No historical hempcrete buildings exist in Lesotho

Ellora caves in India, 6the Century. Hemp is used here as plaster for the walls and ceilings

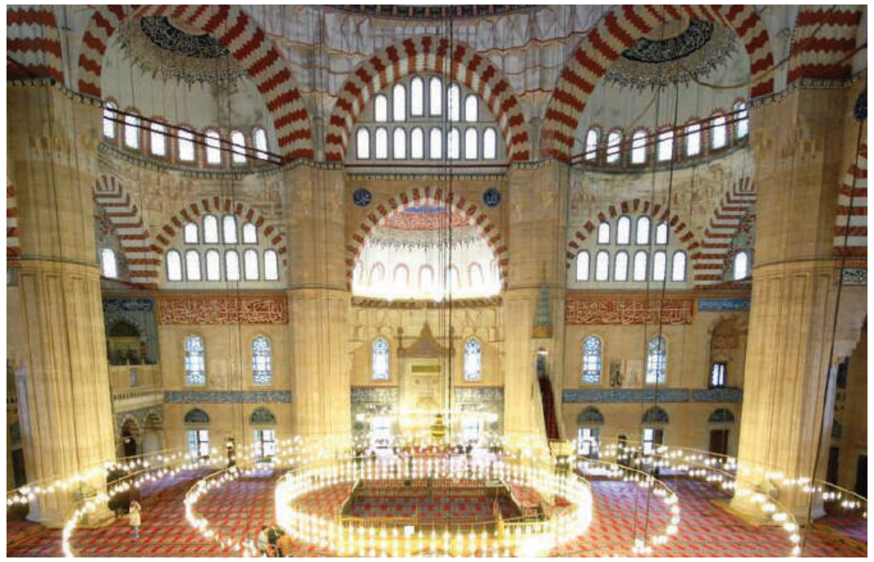
Hemp house in Japan built in 1698

Sarthe River Bridge in Saint Ceneri le Gerei, 500 AD, France. Hemp mortar was used for construction

Maison d'Adam in Angers, France, built in 1491 from hempcrete



Hemp was mixed with mortar the construction of the dome of the Rustem Pasha Mosque, 1555-1561, located in Turkey. Built by Mimar Sinan



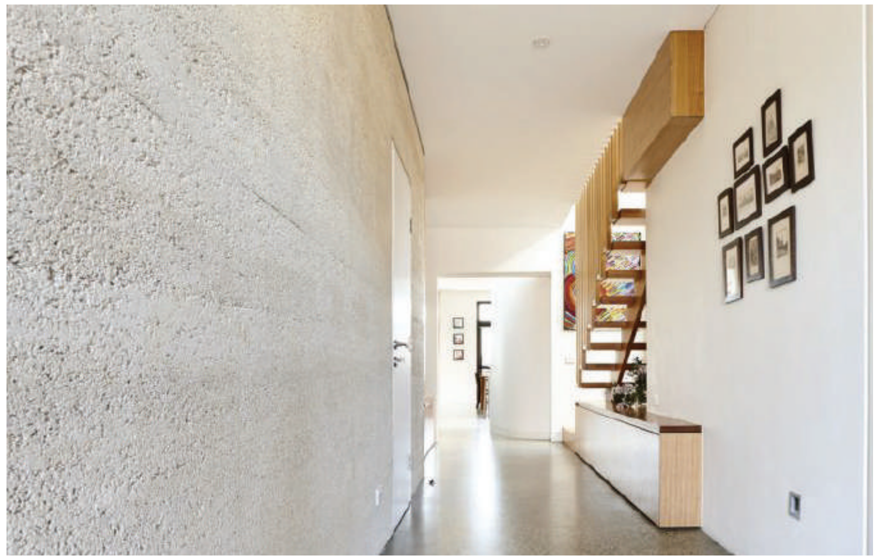
Selimiye Mosque in Turkey, built between 1568-1575 by Mimar Sinan. The interor walls have a hemp motif

Modern use (National & International)

Hempcrete walls in this Zero-carbon Flat house in Cambridgeshire, UK by Practice Architecture

The first hemprecete house in America, owned by Russ Martin and constructed by Push Design in Asheville, North Carolina

Case di Luce by Pedone Studio in Italy built from hemp



Hemp house in Australia by Steffen Welsch Architects

The first hempcrete house in Morija, Lesotho

84 Harrington Street building in Cape Town South Africa. It is the world's tallest hempcrete building

Wool

Sheep wool is a natural and renewable building material that has been used for insulation in buildings for centuries. In Lesotho, where sheep farming is a common agricultural activity, wool is currently exported but can be a valuable resource for the local manufacture of building insulation.

One of the main building techniques used with sheep wool is blown-in insulation. This involves shredding the wool and blowing it into cavities or between joists in walls, roofs, or floors. Blown-in insulation is an effective method of insulation as it fills gaps and crevices, creating a thermal barrier that helps to maintain a comfortable living environment.

Another technique used with sheep wool is batt insulation. Wool batts are sheets of wool that can be placed between studs or rafters in walls, roofs, or floors. This technique is particularly effective in areas where a consistent thickness of insulation is required.

Sheep wool insulation is a sustainable and eco-friendly building material. It is particularly well-suited to Lesotho where sheep farming is a common agricultural activity and can help to promote more sustainable building practices in the region.

Fire resistant | Elastic | Durable | Soft

Knowledge Gap

Wool is currently seen as a commodity that is exported for guaranteed cash, without taking into consideration that it has many other properties, including its use as an insulation material. Insulation made from sheep wool does not currently exist in Lesotho as most people do not understand the advantages sheep wool can offer over other materials.

Properties	Wool
Resiliency	Excellent
Abrasion resistance	Good
Dimensional stability	Bad

Cultural barriers

Wool is generally seen as a commodity that can be exported for use in the clothing industry. Moreover, the utilisation of insulation is not common practice in Lesotho. An additional cultural barrier may be a perception that modern building materials are more desirable than traditional ones, leading to a lack of interest in exploring alternative options such as sheep wool.

Overcoming these cultural barriers would require education and awareness campaigns that promote the benefits of using sheep wool as a sustainable and effective building material.

> *"There is no rejected wool..every grade of wool that can be considered as bad is sold."*
>
> \- Department of Marketing (Wool & Mohair Association)

Natural, renewable and sustainable

Low embodied carbon

Soundproof

Assists in controlling temperature

Easy to install

Good insulator

Fire resistant

Expensive, almost 4 times more expensive to install than mineral insulation

Needs to be treated with chemicals to make it insect reistant

It can absorb and retain moisture, which can lead to mold growth and reduce insulation properties

- Wool is a renewable sustainable product that has no negative footprint on the ecosystem.
- Sheep's Wool insulation has an R-value of approximately 3.5 to 3.8 per inch of material thickness. 0.3 to 0.6 points higher than fiberglass, cellulose, or mineral wool. The higher the R-value, the better the material is at resisting the flow of heat.
- The sustainable and natural insulation type is available in slabs, batts and rolls of varying size and thickness. This makes it suitable for several insulation purposes.
- It is a 100% natural product that requires 15% less energy to manufacture than glass wool insulation.
- Sheep's wool has a naturally high nitrogen content making it one of the only fibres that are flame resistant and self-extinguishing. As a result of the wool's high nitrogen content, it will simply smoulder and singe away instead of bursting into flames

Wool isn't attainable in Lesotho. After shearing all the wool (including the lowest grade) is brokered and auctioned in South Africa. Unless there's an increase in wool production, accessibility will continue to remain a problem. Additionally, no manufacturing facilities to process the wool into an insulation material.

Sustainable growth of wool production is key to ensuring the possibility of sheep wool being used as an insulation material for the built environment. To achieve that, it's crucial to address land degradation issues due to uncontrolled animal overgrazing.

Sheep wool presents an opportunity as a locally sourced, renewable, and environmentally friendly building material.The use of wool for insulation would improve the energy efficiency of buildings and reduce energy costs. However, Lesotho's wool is all exported in its raw form with no processing facilities in the country. The lack of technical expertise and knowledge on how to process and manufacture wool into a building material, as well as challenges related to supply chain management would have to be addressed in order to create opportunities for the development of a sustainable and locally sourced building materials industry in Lesotho.

Uses in construction

Wool insulation in the walls.

Sheeep wool insulation for the floor.

Sheep wool insulation in the ceiling.

Wool insulation legging.

Sheep wool insulation in the attic.

Wool brick samples.

Cover page
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