ACP-EU DEVELOPMENT MINERALS PROGRAMME

Implemented in partnership with UNDP

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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UNDP

# BUILDING A GREENER FUTURE: LOW-CARBON AND CIRCULAR USES OF MINERALS AND MATERIALS

## *NON-TECHNICAL SUMMARY*

# INTRODUCTION

Development Minerals, known as common minerals, are mined, processed, manufactured, and used mostly domestically in construction, manufacturing, infrastructure, and agriculture. They include industrial minerals, construction materials, dimension stones, and semi-precious stones. The vast majority of Development Minerals mined globally – such as sand, stone, gypsum, lime and dimension stones - are used as construction materials.

In the Global South, Development Minerals, largely produced by artisanal and small-scale enterprises, generate important domestic economic linkages and have an important impact on poverty reduction. Eight of the top ten produced mineral commodities in the world are Development Minerals, and they account for over 80% of the global mineral production.

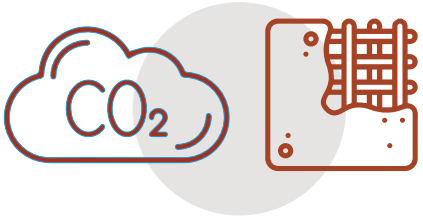
To date, little progress has been made in achieving Sustainable Development Goal 11 (SDG11), 'Make cities and human settlements inclusive, safe, resilient, and sustainable'. Despite the abundance of minerals and materials in the Global South, it faces huge housing and infrastructure deficits, with increasingly growing needs for construction. It is estimated that only about 20 percent of the infrastructure needed by the Global South is in place. Sub-Saharan Africa and Asia will continue to see high population growth and increased urbanisation. Urbanisation in Africa is growing at the highest rate and Africa is expected to account for about 75% of global urban growth by 2050.

Population growth and urbanization in the Global South are driving the demand for minerals and construction materials needed for housing, infrastructure, agriculture, and energy production. At present, approximately 1.1 billion people around the world live in slums and other informal settlements that are not climate resilient, nor suitable for safe and resilient human development, and many more live in disaster-prone settings. Climate change places additional demands on construction materials. Housing and infrastructure destroyed by natural disasters need to be rebuilt – ideally to withstand disasters. Housing in tropical, subtropical, and desert regions of the world needs to be built in a way that enables people to endure temperatures exceeding 40°C.

However, mining and the transformation of construction materials have large environmental and climate impacts. Though the construction of highways, dams and large building projects undergo environmental
and social impact assessments, the impact of the earlier stages of construction including mining of Development

Minerals, and transformation of minerals into construction materials remain largely unaccounted for.

Concrete is the most commonly used construction material because of its durability, ease of production, and low lifetime cost. Its global annual consumption is estimated to increase from 4.6 gigatons currently to an estimated 6-13.5 gigatons by 2050. Though concrete has relatively lower carbon emissions compared with other construction materials like steel, glass, and plastic in relative terms, the sheer amount of concrete consumed is one of the most carbon-emitting construction materials. Cement, the principal ingredient of concrete, makes up most of its carbon emissions. For every tonne of cement produced, 1.5 tonnes of materials are mined and about one tonne of carbon is emitted.




**Globally, the production of cement is responsible for more than 8% of all greenhouse gases released by human activity.**

Earth materials such as clay and laterite are also used in vast quantities to produce bricks and building materials. Artisanal and small-scale miners and operators do the majority of mining and brick production in the Global South. Due to the dominance of informal activities in this sector, national or global statistics on mining of earth materials and brick-making are not produced. The environmental and climate impacts of brick-making are mainly caused by two processes: the mining of earth materials and the burning of trees to fuel kilns. For every 5,500 bricks produced, about one tonne of wood–trees and shrubs–are burned to fire the bricks in kilns. This makes burnt brick-making a major cause of deforestation and land degradation in developing countries.

## Can construction in the Global South meet the needs of its growing population-and can it be more sustainable?

Given the sheer scale of construction materials used, even small improvements in reducing emissions and improving the environmental impact will result in large gains. For a greener and more sustainable future, there is an urgent need to change how the Global South meets its current and future needs for construction by using minerals in low-carbon and environmentally sustainable ways.

Developing countries have an enormous potential to foster circular economy approaches and develop low-carbon alternatives. They have the natural and human resources, and ingenuity to meet this challenge. Moreover, a vast majority of mineral resources needed for housing and infrastructure resilient to climate change are available locally. This study by the ACP-EU Development Minerals Programme, implemented by UNDP, explores opportunities for the production of low-carbon, circular, and greener materials in the Global South to:

- Meet the growing needs for housing and infrastructure
- Scale up emerging innovations
- Source minerals and other materials sustainably
- Create green jobs

# METHODOLOGY

The study :

- Reviews minerals and circular materials for low-carbon, sustainable construction materials and the availability of these materials globally
- Examines existing value chains of construction materials
- Source minerals and other materials sustainably
- Compares costs and carbon emissions of different types of construction materials in selected countries

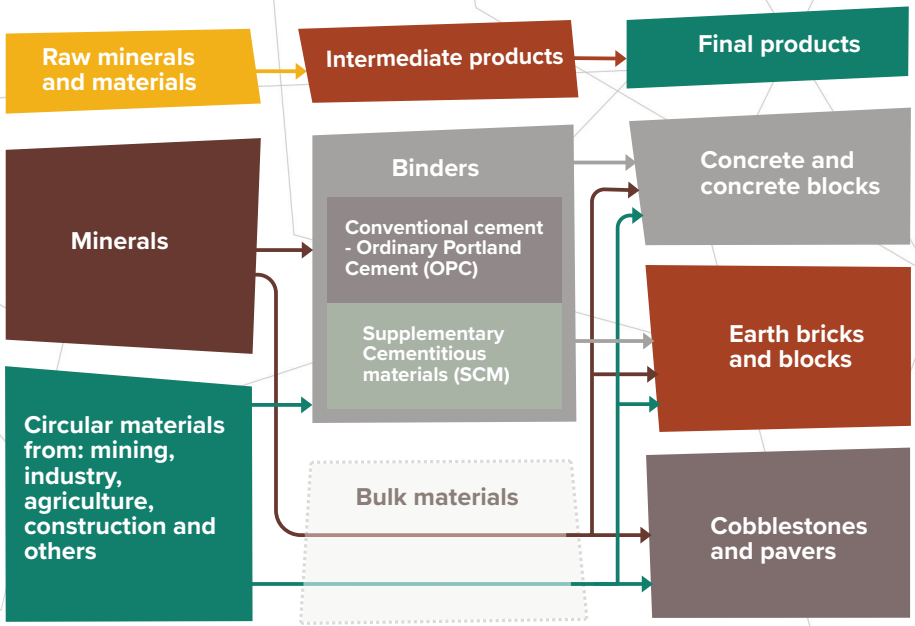
## MATERIALS REVIEWED

| MINERALS | CIRCULAR MATERIALS | | |
|---|---|---|---|
| MINERALS | MINERAL AND INDUSTRIAL BY-PRODUCTS | AGRICULTURAL BY-PRODUCTS | POST-CONSUMER MATERIALS |
| Clay and laterite<br>Stone and aggregates<br>Volcanic rock<br>Limestone<br>Sand | Mine tailings<br>Ore-sand<br>Quarry dust<br>Fly ash<br>GGSB | Rice and coffee husks<br>Cassava peels<br>Sugarcane straw and bagasse<br>Palm kernel shell<br>Corn cobs | Recycled aggregates<br>Recycled glass |

The study covers the Global South while delving deeper into the cases of Cameroon, Uganda, Tanzania, Zambia, and Fiji.

This study reviewed minerals and materials across the construction materials value chain, including raw materials, intermediate products, and final products. Each stage—from raw mineral or circular material extraction, through transformation into intermediate products, to final construction materials—has environmental, social, and climate impacts. The study assesses the impacts for broad classes of materials - minerals and circular materials (by-products of mining, industry, agriculture and post-consumer products).

## CONSTRUCTION VALUE CHAINS



# FINDINGS: MATERIALS

There are abundant minerals and circular materials, especially agricultural by-products, available in the Global South for production of low-carbon construction materials.

**Minerals:** Common minerals used in construction materials are distributed widely, with some differences. For instance, clays and rocks are available around the world, while laterite, another versatile earth material, is prevalent in the tropics. Limestone, pozzolan have more limited availability.

**Circular materials:** Using circular materials helps avoid extraction of new minerals, enabling to keep land, water bodies and biodiversity intact.

- **Industrial by-products**, such as fly ash and GGBS (Ground granulated blast-furnase slag), are already used widely in production of cement and concrete. However, these by-products are mostly available in the Global North.
- **Mining by-products**. There are also recent innovative initiatives in mining that produce manufactured ore-sand as a by-product of mining of iron ore and copper-gold, that can be used as a substitute for natural sand.
- **Agricultural by-products** are widely available in the Global South and have been investigated by researchers for producing supplementary cementitious materials that can be low-carbon alternatives to conventional cement. Such by-products of agriculture include rice husks, sugarcane bagasse, cassava peels, and coffee husks, which are otherwise left to rot or burnt.
- **Post-consumer materials**. Recycled aggregates and recycled glass can also be used as substitutes for bulk materials. Construction waste from demolition and building collapse accounts for about 50 percent of the volume of waste generated on earth. The use of recycled aggregates can reduce the need for mining. Its use is more standardized in the Global North, while in the Global South, opportunities for this are growing.

## How to make construction materials more environmentally sustainable?

This study reviewed minerals and materials across the construction materials value chain, including raw materials, intermediate products, and final products. Each stage—from raw mineral or circular material extraction, through transformation into intermediate products, to final construction materials—has environmental, social, and climate impacts. The study assesses the impacts for broad classes of materials - minerals and circular materials (by-products of mining, industry, agriculture and post-consumer products).

- **At the mining stage:** Sustainable sourcing of minerals reduces the environmental impact.
- **At the transformation stage:** Substitution of conventional cement with some Supplementary Cementitious materials lower emissions. Stabilized Earth Bricks have less environmental impact compared with burnt bricks, which consume large quantities of wood. Moreover, transformation or value-addition locally allows substitutes for imports, and correspondingly, lowers emissions from the transportation of materials over long distances.
- **At the stage of using bulk materials:** Substitution of new minerals with circular materials helps prevent environmental degradation of land and water sources.
- **At the construction stage:** Materials with higher thermal insulation properties such as clay and earth bricks allow for more climate-adapted living, reducing the need for energy for cooling.

## KEY TERMS

**Supplementary Cementitious Materials (SCM)** are materials that can be used as a partial replacement of Ordinary Portland Cement, or conventional cement, to improve properties of cement-based products. SCMs are a key ingredient in low-carbon materials–serving as a binder, they enable to replace and reduce the conventional cement, which is a high-emitting ingredient.

Replacing some conventional cement in construction materials with Supplementary Cementitious Materials allows to reduce the content of cement and, correspondingly, carbon emissions. Limestone calcined clay, fly ash, GGBS, silica fume, geopolymer and natural pozzolan (volcanic ash) are examples of SCM that are already on the markets. Research identifies a good potential to use plant-based SCMs, such as rice husk ash, sugar cane bagasse ash, cassava peel ash and coffee husk ash.

**Stabilized Earth Bricks** are a type of bricks made from earth materials such as clay or laterite and hardened through a process called "cold stabilization", by addition of a small amount of cement (typically 8%). The production method is thus different from that of burnt bricks which are fired, or mud bricks which are sun-dried.

### How to make construction materials more socio-economically inclusive?

Substituting concrete blocks with Stabilized Earth Bricks has the potential to expand income generation and employment opportunities. Stabilized Earth Bricks are produced using more abundant earth materials, such as clay and laterite, and their production requires smaller initial investment. Production of Stabilized Earth Bricks has lower barriers to entry and are therefore more suited to small and middle-sized enterprises.

Using agricultural by-products will create employment opportunities for women, since women dominate employment in the agricultural sector. By using both minerals and agricultural by-products, production of low-carbon materials is within the reach of artisanal and small-scale miners, who often work in both small-scale mining and smallholder agriculture sectors.

In the context of fast-growing construction markets in the Global South, production of low-carbon construction materials presents substantial business opportunities for small- and middle-sized enterprises–and job creation. Investments to catalyze low-cost financing, combined with skills training in low-carbon materials can not only create green jobs, but also contribute to reducing carbon emissions and the environmental impact of the construction sector.

## FINDINGS: COUNTRIES

The study reviews the availability of materials, the needs for construction materials and the opportunities for low-carbon material production in five countries with different geographical, ecological and socio-economic context.

**Cameroon** has a diverse geography and a young and growing population. It has abundant Development Minerals suitable for construction, including sand, clay, laterite, stone, limestone, and pozzolan. Construction with bricks is more common in Cameroon compared with concrete, especially in the Sahelian arid zones, because brick buildings provide better insulation and comfort in hot climate.

**Uganda** is a landlocked country with a young and rapidly growing population, facing high demand and high deficit of housing. While traditional materials such as timber and earth bricks are used in construction, there is a shift towards concrete. Uganda has rich resources of volcanic rock and pozzolan that can be used as low-carbon materials.

In Uganda and Cameroon, ACP, EU and UNDP interventions fostered entrepreneurship, creating jobs and empowering women and youth, through training in production of Stabilized Earth Bricks.

**Tanzania** is a large and populous country with varying geography and significant resources of industrial minerals. Tanzania has extensive Development Minerals such as aggregates, dimension stones, sand, clay, laterite, and pozzolana and a rapidly growing construction market.

**Zambia** is a landlocked country with a fast-growing mining sector. In addition to housing, mining and infrastructure are important sources of demand of construction materials.

The four African countries reviewed in this study are also large agricultural producers. Thus, agricultural waste materials can be utilized in production of low-carbon materials.

**Fiji** is an archipelago in the Pacific. Similar to other small island countries, its needs for construction materials are compounded by frequent natural disasters and sea level rise. Fiji also supplies quarry materials to other Pacific Island countries. The need for sustainable sourcing of minerals for construction is therefore substantial.

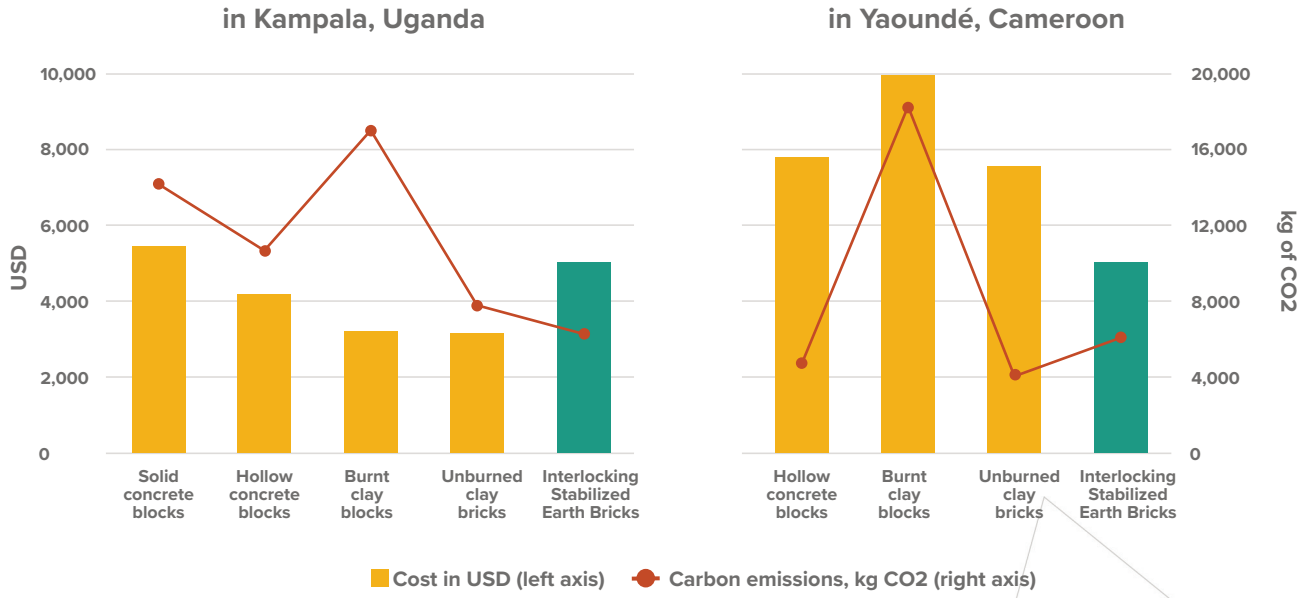
The Government of Fiji, along with partners, promotes domestic production of low-carbon materials (LC3 cement, a type of Supplementary Cementitious Material) through the Blue Concrete Initiative.

## What is the potential for market adoption of low-emitting materials?

Based on field work with market and value chain analysis in Uganda and Cameroon, the study compares costs and emissions of common construction materials on the market vis-à-vis Stabilized Earth Bricks. The comparison was made using equivalent amount of material needed to build a house with dimensions 7m x 14m. [1]

[1] Two units of 2-bedroom apartments, for a typical income earner in a developing country.

## COST V. EMISSIONS OF CONSTRUCTING A TYPICAL HOUSE




Source: author's calculations

Cement blocks

Stabilized Earth

Burnt bricks

The study found that Stabilized Earth Bricks are one of the lowest-emission material compared to other materials. The only exception is unburnt bricks (mud bricks), which in the case of Yaoundé have the lowest emissions. However, mud bricks are poor quality and are not resistant to extensive rains and floods. In contrast, burnt clay bricks are the highest emitting material-this is due to their large impact on deforestation.

Relative costs differ significantly in Uganda and Cameroon. In Kampala, Stabilized Earth Bricks are the second most expensive material after solid concrete blocks. In Yaoundé, Stabilized Earth Bricks are the least expensive construction material.

The study findings indicate that to scale up and commercialize the adoption of Stabilized Earth Bricks, different approaches are needed, depending on relative costs. In Uganda, incentives through less costly and more accessible finance for small- and middle-sized enterprises, combined with extensive awareness and promotion of Stabilized Earth Bricks, can make SEBs more competitive. In Cameroon, the relative costs make SEBs suitable for wide commercialization. But it will be necessary to overcome public perception of bricks as inferior building materials.

There are significant opportunities for the development and use of low-carbon materials in construction. These materials can reduce the carbon footprint of the construction industry, promote sustainable development, and create economic benefits.

# CONCLUSIONS AND RECOMMENDATIONS

**Low-carbon and circular materials offer a promising solution to the triple challenge of providing shelter for a growing global population, creating jobs, and reducing the environmental and carbon footprint of construction.**

This scoping study provides a high-level review of the availability of minerals and circular materials in the Global South, delving into cases of five countries.

Many countries in the Global South are experiencing continued growth in population and urbanisation. The need for housing, schools and built environment is increasing rapidly. For growing construction and infrastructure in the context of a climate change, urgent action is required to shift to a low-carbon, environmentally sustainable path that allows to meet and adapt to the needs in a changing climate.

Traditional knowledge of building with earth materials, which have lower carbon emissions and enable better resilience to climate change, needs to come full circle, with modernized and improved production technologies. Circular materials that are in abundance in the Global South, especially in agricultural-producing countries, can be used to reduce the need to mine new minerals. The added advantage is that these innovative technologies require modest investments and rely on abundant minerals and materials, making them suitable for localized production by small- and medium-scale enterprises, with the opportunity to create many jobs, especially for youth.

The study makes recommendations to capitalize on the opportunity to develop low-carbon, circular and greener construction value chains:

- **Spread awareness and knowledge.** Education and training on why and how construction sector needs to reduce its emissions and improve its environmental impact is required at every level from policy makers to civil engineering and vocational education students. Training programs should be designed and delivered.
- **Establish guidelines and standards, and leverage public procurement and green finance.** Governments need to set expectations to increase the use of low-carbon materials, through strategies, guidelines and incentives. Standards for low-carbon materials should be established based on evidence and laboratory testing.

- **Identify and map minerals and materials for sustainable sourcing.** Geological data coverage should be expanded to include minerals used for low-carbon materials. Baseline studies of Development Minerals available in some countries, conducted by the ACP-EU Development Minerals Programme implemented by UNDP, should be replicated. Country-specific studies on circular economy of materials should be conducted to enable more sustainable sourcing of materials.
- **Collaborate with the private sector, artisanal miners and actors across the value chains.** Backing by industry and artisanal and small-scale miners' communities is crucial. A series of 'green building' information sessions is needed. Cooperatives in artisanal mining, agriculture, construction and other sectors along the value chain should be supported with training and low-cost, 'green' financing to purchase simple equipment such as brick presses and stone crushing machines.
- **Build circularity.** Make the best use by-products–investigate the potential of ore-sand as mineral by-product in countries and locations with extensive mining, and that of various agricultural by-products in agricultural areas. Promote and incentivize research and development using circular materials widely available in the Global South, and encourage cross-country knowledge exchange by universities and research centers.

Low-carbon and circular materials offer a promising solution to the triple challenge of providing shelter for a growing global population, creating jobs, and reducing the environmental and carbon footprint of construction.

Since most of the construction in the future will be happening in the Global South, this is where the biggest opportunity for greening construction is present. Public action is needed to catalyze investment in and commercialization of low-carbon, circular construction materials to bring down its cost and accelerate its market adoption–in much the same way like they brought down the cost of renewable energy. We can then, quite literally, build a greener future.






This non-technical summary accompanies a report of the scoping study:
UNDP (2025), BUILDING A GREENER FUTURE: LOW-CARBON AND CIRCULAR USES OF MINERALS AND MATERIALS. Study report

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**Abbreviations and acronyms:**

ACP - African, Caribbean and Pacific
ASME - Artisanal and Small-Scale Mining and Mineral Processing Enterprise
ASM - Artisanal and Small-Scale Miner or Artisanal and Small-Scale Mining
SCMs - Supplementary Cementitious Materials
SEBs - Stabilized Earth Bricks
SDGs - Sustainable Development Goals

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## About the Programme

The ACP-EU Development Minerals Programme is an initiative of the Organisation of African, Caribbean and Pacific States (OACPS), coordinated by the Secretariat of the OACPS, financed by the European Commission and the United Nations Development Programme (UNDP) and implemented by UNDP.

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