CiCoSA Handbook

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Circular Construction and Housing in Sub-Saharan Africa (CiCoSA) Handbook

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This Handbook is part of the CiCoSA Action Toolkit (Circular Construction & Housing in Sub-Saharan Africa). It was developed by UN-Habitat with the support of the Federal Ministry for Economic Cooperation and Development (BMZ), the Federal Republic of Germany to strengthen the sustainable building and construction sector, while also improving access to affordable housing and reducing the ecological footprint of cities.

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Preface

Africa is the world's second largest continent after Eurasia. 49 of these 54 nations are located in Sub-Saharan Africa. Africa is urbanizing faster than other regions. The urban growth in Africa is at around 3.55 % per year with the urbanization rate expected to reach 59% by 2050. The populations of countries in the Sub-Saharan African region are expected to continue growing rapidly, with projections indicating that they will almost double between 2022 and 2050, surpassing 2 billion inhabitants by the late 2040s. Although the current level of urbanization growth rate is one of the lowest worldwide, the region is experiencing rapid urban growth due to a high rate of urbanization.

Urbanization and rapid expansion of cities are creating visible environmental and social challenges. The generation and management of waste is one of the central concerns in urban agglomerations, particularly in the global South. Globally, waste is expected to grow to 3.40 billion tonnes by 2050. In Sub-Saharan Africa, the total waste generation is expected to more than triple in the same period which will have vast implications for the environment, health, and economy if no action is immediately taken.

At the same time, the region is also struggling to provide adequate housing to its population. The Sustainable Development Goals Report 2022 states that in 2020, 23% of urban dwellers in Sub-Saharan Africa (230 million out of over 1 billion people) lived in slums or informal settlements. The issue of affordability of housing becomes especially relevant for Africa. It is estimated that 75% of buildings needed in Sub-Saharan Africa by 2050 have yet to be built.

However, if waste and resources are effectively and efficiently managed, they represent an opportunity to transit to a circular economy, creating new jobs opportunity, saving precious resource and innovate affordable housing approaches.

CiCoSA, Circular Construction and Housing in Sub-Saharan Africa, project aims to strengthen the sustainable building and construction sector by applying circular economy and low-carbon principles (waste wise approach) to the housing value chain, improving access to affordable housing and reducing the ecological footprint of cities in Sub-Saharan Africa.

The CiCoSA Action Toolkit includes a **CiCoSA Handbook** and a **CiCoSA Implementation Guide**, dealing with circular solutions and resources efficiency in the building and construction sector in Sub-Saharan Africa, with a particular focus on Kenya, Namibia, and South Africa.

The CiCoSA Handbook delves into circular construction material options with a waste management perspective, within the Sub-Saharan African context. It examines benefits and risks of circular economy approaches to the building and construction sector, providing practical case studies that could be scaled up in the region as part of a sustainable urbanization strategy.

The CiCoSA Implementation Guide serves as a roadmap to navigate challenges on circular construction. This comprehensive resource is specifically tailored for policymakers in Sub-Saharan Africa. The guide outlines the various stages of a circular construction life cycle, from product manufacture and design to construction, operation, and ultimately, building's deconstruction.

Recommendations emphasize the crucial role of empowering local communities and fostering collaboration across sectors. By working together, policymakers, industry leaders, waste management professionals, and local communities can unlock the full potential of circular construction in Sub-Saharan Africa.

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Executive Summary

A significant body of literature addresses circular solutions in the construction sector, focusing on applying resource-efficient construction practices, reducing floor space or using renewable materials as well as low and renewable energy solutions for buildings. What is missing still is a comprehensive analysis of options and the role of waste (re) use and recycling as a sustainable resource for the construction sector. Therefore, the Circular Construction in Sub-Saharan Africa (CiCoSA) Action Toolkit aims to provide insights into circular construction from the waste management sector perspective.

Based on prevailing practical experiences, three waste streams of interest are being looked at. These are fractions derived from the Municipal Solid Waste (MSW) stream, the Construction and Demolition Waste (CDW) stream and Agricultural Waste (AW). It is demonstrated that fractions of MSW might be used as a construction material under certain conditions. The options are, however, limited and require extensive sorting and processing to allow sustainable use. CDW offers the biggest potential for reuse and recycling, however, efforts regarding identification and separation of pollutants and unwanted materials that impede the sustainable reuse and recycling of CDW are still paramount. Raising the acceptance of secondary materials is crucial in this context, with various options for AW highlighted and discussed.

The use and recycling of specific wastes or fractions thereof have in common that sorting and processing tasks need to be performed to allow a sustainable implementation and the acceptance of the construction sector to make use of secondary materials. While these operations entail certain costs, they offer significant opportunities for creating meaningful employment.

When assessing the overall potential of secondary waste-derived construction materials, it becomes evident that the volume of construction activities far exceeds that of demolition. As a result, only a relatively small portion of construction materials can be replaced with secondary waste-derived alternatives. Still, all avenues for the reuse and recycling of waste fractions need to be considered as a matter of waste management priorities, as defined by the waste hierarchy.

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List of Abbreviations

AW	Agricultural Waste
BMZ	Federal Ministry for Economic Cooperation and Development
CDW	Construction and Demolition Waste
CiCoSA	Circular Construction and Housing in Sub-Saharan Africa
DRC	Democratic Republic of Congo
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
EPS	Expanded Polystyrene
GHG	Greenhouse Gases
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit – German Development Cooperation
HBCD	Hexabromocyclododecane
HFCs/CFCs	Hydro-Chlorofluorocarbons
IEK	Institution of Engineers of Kenya
IIED	International Institute for Environment and Development
ISO	International Standard Organization
KGBS	Kenya Green Building Society
MEFT	Ministry of Environment, Forestry and Tourism
MURD	Ministry of Urban and Rural Development
MSW	Municipal Solid Waste
MWT	Ministry of Works and Transport
NCA	National Construction Authority
NCAQS	Namibia Council of Architects and Quantity Surveyors
NCR	National Capital Region Delhi
NEMA	National Environment Management Authority
NHAG	Namibia Housing Action Group
NIA	Namibia Institute of Architects
NPC	Namibia Planning Comission
NSI	Namibia Standard Institution
NUST	Namibia University Science and Technology
ODS	Ozone Depleting Substances
PCB	Poly-Chlorinated Biphenyl
PET	Polyethylene terephthalate
POP's	Persistent Organic Pollutants
PVC	Polyvinyl Chloride
RDF	Refuse Derived Fuel
ROAf	Regional Office for Africa
SBC	Sustainable Building and Construction
SDI	Slump Dweller International
SLCP	Short-Lived Climate Pollutants
SSA	Sub-Saharan Africa
UBSS	Urban Basic Services Section
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
WEEE	Waste of Electrical and Electronic Equipment
XPS	Extruded polystyrene

1. Introduction

1.1 Urbanization, Housing and Waste in Sub-Saharan Africa

Africa is the world's second-largest continent after Eurasia with a total surface area of 30,365,000 km2. It comprises 54 sovereign nations, with 48 on the mainland and 6 island nations [1]. The focus of this handbook is mostly on on Sub-Saharan Africa (SSA), which encompasses the 49 countries located partly or entirely south of the Sahara Desert.

The population of countries in the SSA region is expected to continue growing through 2100 [2]. Between 2022 and 2050, the population of this region is projected to almost double, surpassing 2 billion inhabitants by the late 2040s. In 2022, the population in this region was growing at an annual rate of 2.5 per cent, more than three times the global average of 0.8 per cent per year [2].

More than half of the projected increase in the global population between 2022 and 2050 is expected to be concentrated in just eight countries: the Democratic Republic of Congo (DRC), Egypt, Ethiopia, India, Nigeria, Pakistan, the Philippines and the United Republic of Tanzania [2]. Notably, five of these eight countries are on the African continent, with four belonging to the SSA region.

While the population in SSA used to be mainly rural (40 % as of 2014 [3]) Africa is urbanizing faster than other regions. The urban growth in Africa is at around 3.55 % per year with the urbanization rate expected to reach 59% by 2050 [3]. The growth of the number of cities with more than 5 million inhabitants will grow fastest in SSA between the 2020 and 2070 [4]. At the same time, the SSA region is also struggling to provide adequate housing to its population living in slums or informal settlements, representing approximately half of the SSA population 50.2% in 2020 [2].

On the other hand, unless urgent action is taken, waste generation in the region is also expected to triple by 2050 [4], meaning more waste to be handled and more secondary material that can be generated from that waste. According to the Sustainable Development Goals Report 2022 [5], in 2020, one in four global urban dwellers lived in a slum or an informal settlement. This represents over 1 billion people worldwide, with 230 million residing in SSA. A one per cent increase in urban population growth is expected to increase the incidence of slums by 2.3 per cent in Africa [5]. The World Cities Report 2022 [4]. states that based on data from the UNDP and Oxford Poverty and Human Development Initiative (2020) the urban population of multidimensionally poor individuals in SSA amounts to 92.3 million people. In that context, the issue of affordability of housing and the need for sound waste management becomes especially relevant for Africa.

Figure 1-1 shows the correlation between the population growth rate and the percentage of the population living below the international poverty line. It is noticeable that the SSA region faces significant challenges related to poverty. Most of the SSA countries show a comparable high annual growth rate of the population and a comparably high percentage of people living below the international poverty line.

Although per-capita waste generation is currently lower in Africa than in the rest of the world, SSA is forecasted to become the dominant region globally in terms of total waste generation, if current generation trends persist. Meanwhile, waste collection services in most African countries are inadequate and a lack of consistent and reliable data is a major issue for planning municipal solid waste (MSW) services for all. Indeed, the average MSW collection rate in 2012 across Africa was only 55%, and in SSA, it was on average as low as 44%. It is expected that the average collection rate of waste in Africa will increase by almost 40% and will be as high as 69% by 2025 [1].

125 million tonnes of MSW were generated in Africa in 2012, 81 million tonnes of which were from SSA. The recently published Global Waste Management Outlook 2024 [6] states an MSW collection rate for SSA at 36%, indicating a downward trend from previously re-ported numbers by UNEP in 2018 [1]. Nevertheless, the actual collection rate varies very much between individual cities and can be as low as 20% or as high as 90%. Without any intervention, it is projected, that MSW generation will increase to almost 500 tonnes in 2050 in SSA, of which more than 400 tonnes would be managed in an uncontrolled manner.

Concerning the end-of-life of MSW, open dumping and open burning are still the main prevailing forms of waste treatment at a share of 47% and 9% respectively [1]. 19 of the world's 50 biggest dumpsites are in SSA [1].

FIGURE 1-1 **Population growth rate, 2015-2020, by the proportion of the population living below the international poverty line, 2003-2021. Source: World Population Prospects 2022: Summary of Results. UN DESA[2]**

Source: Based on the most recent data available for the period 2003-2021, SDG Indicators Database, available at https://unstats.un.org/sdgs/dataportal/database/. Accessed on 2 June 2022. Note: SDG indicator 1.1.1 is the proportion of the population living below the international poverty line, which the World Bank has defined as a per capita incarne of U.S.dollars 1.90 per day in terms of purchasing power parity (PPP).

The above-mentioned aspects of population growth and the state of waste management systems put high pressure on local authorities managing waste in urban areas in the African region on the one hand and high demands for establishing adequate housing in the urban centres on the other hand. This pressure is likely to intensify as the urbanization rate and per capita waste generation are increasing.

1.2 CiCoSA contributing to a Sustainable Urbanization Strategy in the Region

Considering the region has the world's fastest urbanization rate, the need for new construction works including housing and urban infrastructure will grow rapidly in the decades to come. Buildings and the construction sector are the single largest source of greenhouse gases (GHGs) emissions both at the time of production as well as during the use-phase, accounting to 37% of global emissions in 2022 [7]. With the current baseline with most of the waste being neither collected nor managed in an environmentally sound manner, the dimensions of this challenge become clear. Applying circular economy and low-carbon principles in the sustainable building and construction (SBC) sector especially looking at the housing sector could help to tackle the challenges imposed by rapid urbanization and poor waste management in the region.

There are many publications dealing with decarbonization and circularity in the building and construction sector. The Global Status Report for Buildings and Construction [8], Circular Built Environment – Highlights from Africa [9] and the Circularity and Sustainability in the Construction Value Chain [10] reports focus on the design of buildings and the use of sustainable materials. However, the utilization of waste as a secondary resource in the building and construction sector is not discussed in depth.

The CiCoSA Handbook examines the benefits and risks of circular economy approaches to a SBC sector from the waste management perspective, providing practical case studies that could be scaled up in the region as part of a sustainable urbanization strategy. It also provides an overview of the current legislative landscape in the region and snapshots of the regulatory frameworks from Kenya, Namibia, and South Africa. These examples serve as the foundation for the implementation guide, which offers policy recommendations and practical guidelines for execution.

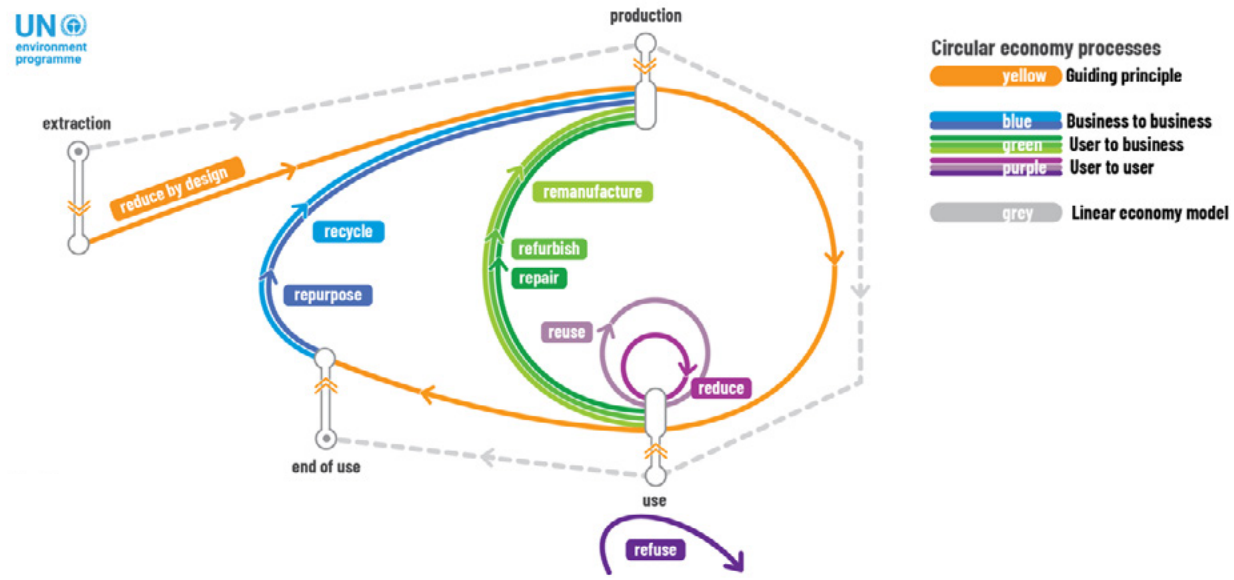
2.

Waste Management and the Circular Economy

Concepts and principles of waste management and circular economy share similar values and objectives. However, seeking circularity while neglecting basic waste management principles could pose risks to human health and nature in the long term while also prevent ing sustainable practices from evolving. This section will deep dive into the two similar yet different concepts, highlighting key complementarities towards a safe and circular economy with a special focus on the construction sector.

The circular economy is an inclusive economic paradigm that aims to minimize pollution and waste, extend product lifecycles, and enable broad sharing of physical and natural assets [1]. The life cycle of products and materials is extended, and natural resource extraction should thereby be reduced as much as possible. As per the UNEP concept of circularity, the guiding principle of “reduce by design” is accompanied by eight value retention loops (8Rs) that allow for achieving the establishment of a circular economy [11] as shown in Figure 2-1.

FIGURE 2-1 UNEP Circularity concept [11]



1 https://unece.org/trade/CircularEconomy

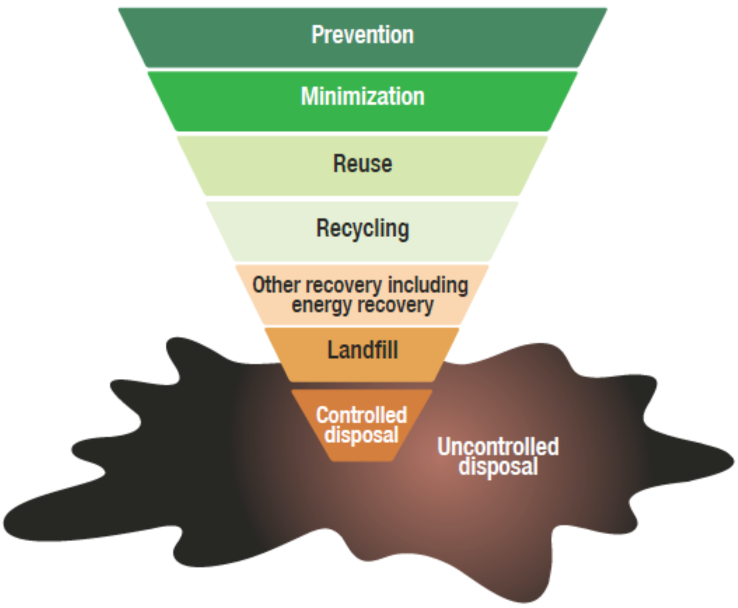
While “circular economy” is a concept of production and consumption, “waste management” focuses predominantly on the downstream solutions for managing end-of-life products and materials minimizing environmental pollution and protecting public health (Note: although waste avoidance is a top priority within the waste hierarchy, however, the action to avoid waste is taken outside the realm of “waste management”, see text below). Although waste management focuses on downstream solutions, the concept of “waste management hierarchy” [12] (compare Figure 2-2) recommends “prevention”, “minimization” and “reuse” to avoid waste generation as much as possible. These overlap with “reduce by design”, “refuse”, “reduce”, “reuse”, “repair”, “refurbish” and “remanufacture” under the concept of circular economy. “Recycle” under the waste management hierarchy overlaps with both “repurpose” and “recycle” in the circular economy model in Figure 2-1. However, the concepts of “other recovery including energy recovery”, “landfill” and “controlled disposal” in the waste management hierarchy are not covered under the concept of circular economy. Those elements of the waste hierarchy are important since they are relevant for materials that must not be kept in the anthroposphere but need to be treated and disposed of in order to protect humans and the environment.

While it is important to close material loops and allow the establishment of a circular economy, it must be acknowledged that only products or materials that will not pose any risks to human and public health should be reused or recycled. Indeed, a clean and safe circular economy should not create pollutant cycles, causing the accumulation of pollutants in products on the market.

In addition, it is also important to consider the “recyclability” of products and materials during the product design stage, as well as the development of a secondary resource market. The latter very much depends on environmental legislation as well as its enforcement in a specific region. For example, globally, only 9% of all plastic waste is recycled [13]. Low recycling rates of plastics are largely due to the lack of a market for specific types of secondary plastics, which still lack sustainably operated and economically viable recycling models. Currently, a lot of discussions, as seen for instance during the intergovernmental negotiations committee for a treaty on plastic pollution, are also directed at increasing the recyclability of products [14]. This is of high importance as any product that enters the consumption cycle will turn into waste at one point in time. Therefore, it is paramount to make the right choices during the product design phase following the waste hierarchy as well as the circularity principles.

The same applies to other products and materials. Recycling loops can only be economically viable when there is a market for the specific recycled products and materials. This implies that recyclability can vary across geographical locations, as it depends on factors such as available infrastructures, market development for recyclables, and other local context-specific conditions. The lack of market for many materials results in a large portion of

FIGURE 2-2 Waste Management Hierarchy [12]



products and materials being mismanaged (e.g. open dumping and open burning) or managed according to a different – economically more attractive – waste management route such as utilization as Refuse Derived Fuel (RDF), incineration for energy recovery or disposal at landfill sites.

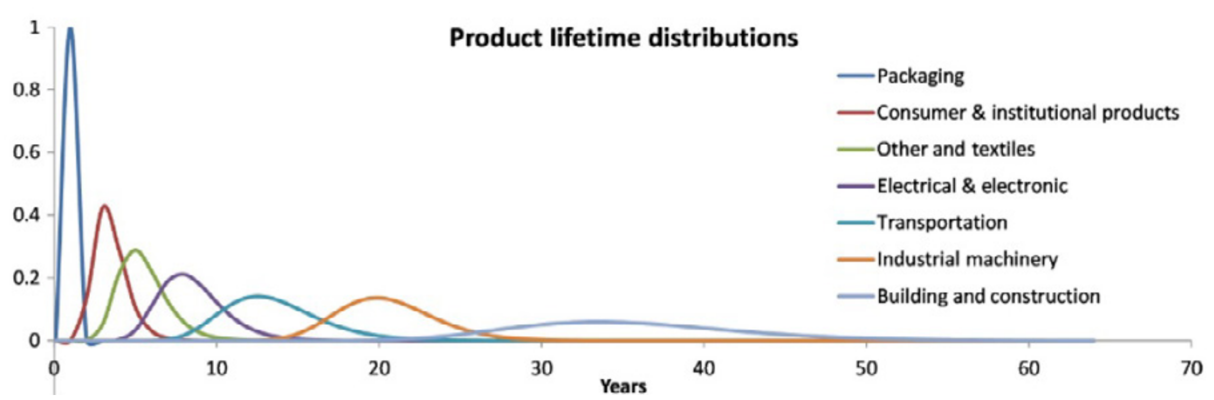
In addition, it should be mentioned that the management of waste is always a matter of alternative availability. Recycling loops that are economically viable are relatively rare. Indeed, while recycling highly valued metals is often economical, this is not the case for many materials. The economic viability of recycling and recovery activities depends on the existence of alternative management options. As long as open dumping, open burning or low-level recycling is tolerated, sustainable waste management options will not evolve due to the higher costs to be borne by the responsible waste management authority or the producers in case of systems of Extended Producer Responsibility (EPR) put in place. However, it is important to note that such assessments fail to consider the costs to society and the environment when waste is not managed sustainably.

Products and materials that cannot be recycled, recovered or contain pollutants which pose human health risks need to be managed accordingly. Especially products containing pollutants should not be fed into a recycling loop, since this can lead to their accumulation. Consequently, these must be managed in an environmentally sound way, such as the incineration of organic pollutants or the disposal of inorganic compounds in a safe and sound sanitary landfill.

The essential element of "sinks" is missing in Figure 2-1. The concept of "sinks" in order to avoid accumulation of pollutants is largely acknowledged by several international conventions, such as the Stockholm Convention for Persistent Organic Pollutants (POPs) [15] and the Montreal Protocol for Ozone Depleting Substances (ODS) [16] [17] that prevents specific substances from the economic cycle, to treat and destroy them or safely retain them. The element of preventing inappropriate substances from entering the circular economy is one of the important aspects to consider for circular construction materials.

The need to prevent pollutants from re-entering the economic cycle is especially relevant wherever long-lived products are involved. This is particularly valid in the building and construction sector where the lifespan of products, including those made from plastics, typically exceeds 20 years and can extend to 50 years or more (see Figure 2-3). Due to these long lag times from production to end-of-life of a product, there is a great risk for products to be contaminated with legacy substances once they become waste. This is especially true concerning any demolition and refurbishing activities resulting in waste arisings of such "old" products.

FIGURE 2-3 Product lifetime distribution for plastic products [18]



The risk of accumulation of toxic contaminants in products through inappropriate recycling can be prevented through the implementation and enforcement of strong institutional frameworks and environmental regulations with the appropriate controlled infrastructure. However, when these preconditions are lacking, there is a high risk that circular economic activities retain toxic products and materials in use, possibly affecting human health and the environment.

The Circularity Gap Report 2024 [19] revealed that in 2023, secondary materials accounted for only 7.2% of the global economy, a significant drop from the 9.1% reported in 2018. To address this, this series of reports has consistently presented circular construction as a key solution to addressing climate change and achieving a circular economy. In the 2022 report [20], 21 circular solutions were presented for a 1.5-degree pathway, including the use of circular construction materials (see Figure 2-4). It suggests that through the implementation of these circular strategies, such as using recycled construction materials and diverting construction and demolition waste from final disposal sites, 1.14 Gt of emissions and 3.55 Gt of material use could be saved.

FIGURE 2-4 Circular solutions and their impact to resource consumption reduction as well as climate control [20]

CiCoSA Handbook aims to delve into possible circular construction material options that are applicable in the SSA context, paying careful attention to remove the toxic products and materials, through the waste management perspective.

This is important as disrespecting these fundamental guiding principles will prolong practices harmful to humans and the environment, preventing the evolution of sound waste management and circular economy model in the construction sector.

3.

Circular Construction Cases According to Different Waste Streams

This chapter gives a brief overview of the current status of the generation and management of specific waste streams. Each stream is assessed based on its significance for circular construction, both in terms of quantities generated and the potential of (partial) recovery. The focus is on three key waste streams: **MSW**, **CDW**, and **AW**.

» Municipal Solid Waste (MSW)

» Construction and Demolition Waste (CDW) as well as

» Agricultural Waste

Apart from a few publications addressing MSW and providing some overview, there is limited systematically recorded data on CDW and AW generation and disposal. Therefore, only a brief overview based on available data and case studies can be provided.

3.1 Municipal Solid Waste

MSW includes waste generated from households, commerce and trade, small businesses, office buildings and institutions (schools, hospitals, government buildings). It also includes bulky waste (e.g. white goods, old furniture, mattresses) and waste from selected municipal services, e.g. waste from park and garden maintenance, waste from street cleaning services (street sweepings, the content of litter containers, market cleansing waste), if managed as waste. The definition excludes waste from municipal sewage network and treatment, and municipal construction and demolition waste [2].

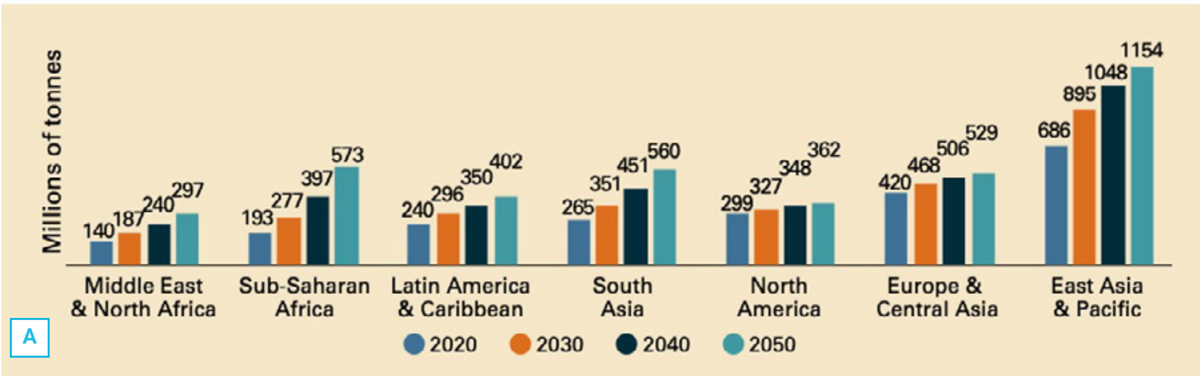
2 Waste Wise Cities Tool step by step guide, UN-Habitat 2021, available at https://unhabitat.org/sites/default/files/2021-10/Waste%20wise%20cities%20tool%20-%20EN%2013.pdf

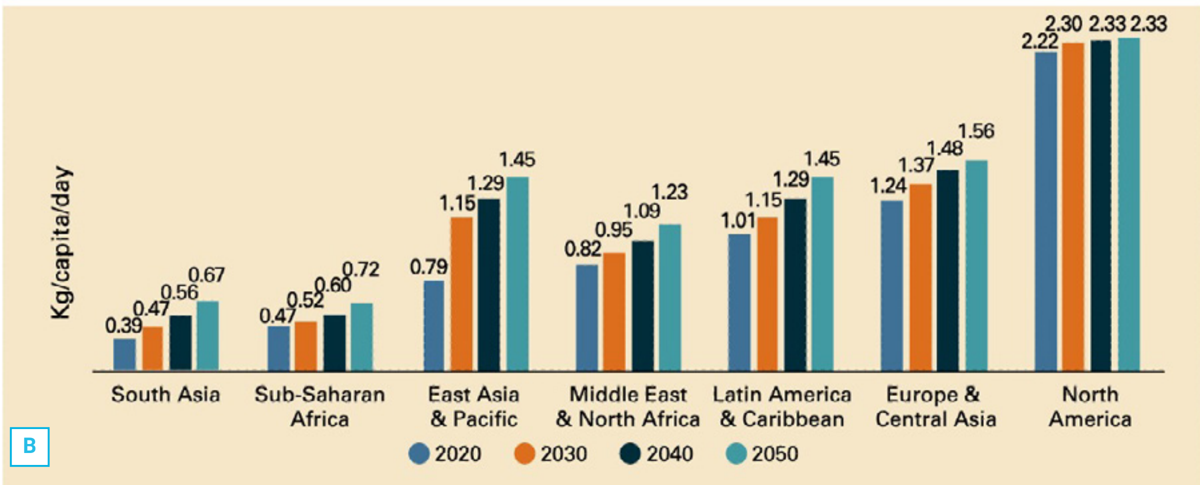
3.1.1 Estimated MSW generation and management in Sub-Saharan Africa

When researching qualitative and quantitative data on MSW, the primary finding that emerges is that data is limited. The estimations focus on MSW generation in urban areas in Africa, as rural MSW data is almost non-existent. Nevertheless, it is clear that waste generation is set to increase substantially in the coming years.

Recent projections of waste generation by World Bank, based on 2020 data, predict that, without any action, waste generation in SSA is set to almost triple by 2050 [21]. Increasing from 193 tonnes in 2020 to 573 tonnes in 2050, making it the second biggest waste generating region. However, when looking at the daily generation rates per capita, it becomes apparent that SSA has the second lowest generation rate per capita compared to all other regions.

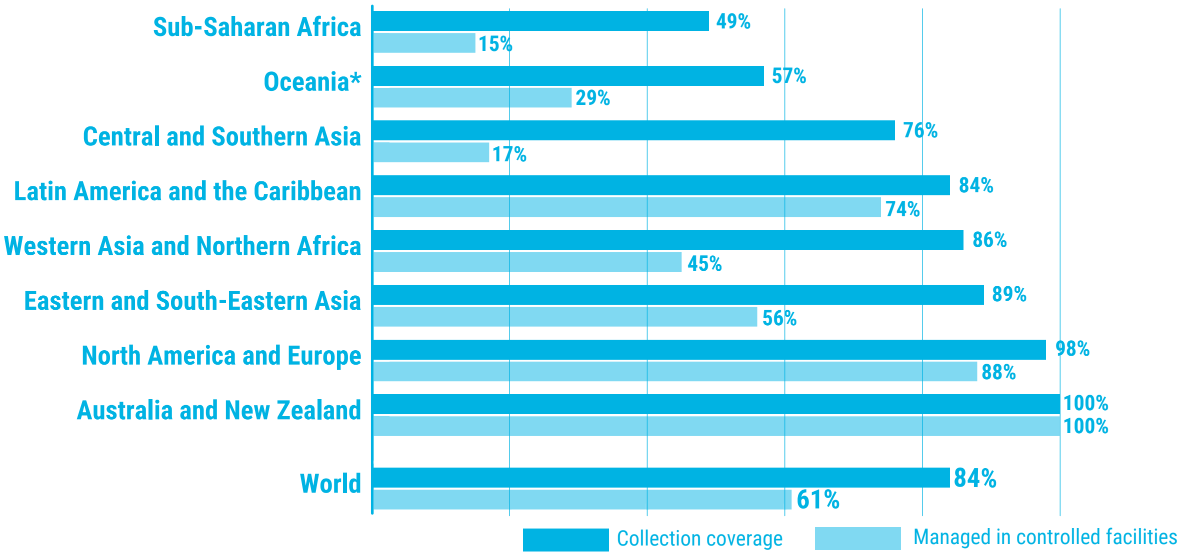
FIGURE 3-1 A - Projected Total Waste Generation by region and B - Projected Daily Waste Generation Per Capita [21]





Recently published data showed that of a little more than 200 million tonnes of MSW in SSA, 90% is uncontrolled [6]. Unless urgent action is taken the figures for SSA will increase to almost 500 million tonnes by 2050, with more than 80% being mismanaged [6]. The collection rate refers to the total waste collected in relation to the total quantity of waste generated. In 2022, the average collection rate for MSW in SSA lies at 49% and is the lowest globally [22], together with the share of MSW managed in controlled facilities, standing at 15% (See Figure 3-2) [22].

FIGURE 3-2 MSW collection rate and percentage of treatment in controlled facilities in 2022 [22].



A household-based survey conducted by UN-Habitat in the cities of Nairobi, Kenya, and Kampala, Uganda, revealed that the population with access to the basic MSW collection service differs from 10% in slum areas to 70% in formally planned residential areas [22]. It is especially true in underserviced areas where the informal sector plays an important role in resource collection and recovery.

Open burning and open dumping are the most prevalent "management" options of MSW in SSA, as similarly seen in Asian countries. This leads to a high emission of short-lived climate pollutants (SLCP) such as methane and carbon black as well as the emission of plastics and microplastics to the natural environment. SLCP emissions have a much higher impact on near-term global warming when compared with CO2-emissions. Both, collection, and environmentally sound downstream management of MSW entails a huge potential for improvement on GHGs, including SLCP, reduction.

03.1.2 Municipal Solid Waste composition

According to The Global Waste Management Outlook 2024, the most recent publication on this subject matter, around 68% of the MSW in SSA is comprised of food and garden waste, around 6 – 7 % are represented by paper and cardboard, 6 – 7 % by plastic and 2 % by glass [6]. The balance is represented by other materials that cannot be attributed to one of the mentioned ones.

However, while there has been some progress in recent years, reliable data and information on MSW composition is lacking globally, especially in low- and middle-income countries, due to limited data availability, inconsistent data quality and lack of harmonised data collection methodology.

3.1.3 Toxic and Hazardous Substances in MSW

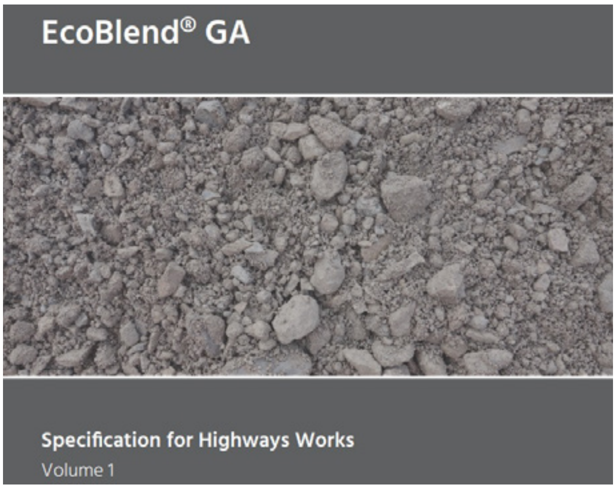
Untreated MSW should not be considered an appropriate resource for the construction sector. This is due to the inhomogeneity of this waste stream. This waste stream often contains problematic substances, more precisely hazardous waste. Apart from Waste of Electrical and Electronic Equipment (WEEE), batteries and medical products are problematic substances that might also entail potentially infectious items. The use of MSW containing problematic substances could result in leaching and setting free of substances of high health concern, posing hazards to mankind and ecosystems.

Apart from items considered as problematic substances, hazardous waste items made of plastics contain additives such as plasticizers, UV-stabilizers, and flame retardants, which pose hazards to mankind and the environment. This aspect is discussed in more detail in Chapter 3.1.4.

3.1.4 Cases for the Utilization of MSW derived materials for Construction Materials

MSW can be considered a sustainable source of construction material in certain cases. One of these cases being if the MSW is treated thermally. In that case incinerator bottom ash can be used for selected construction purposes. Countries such as Germany and the Netherlands have applied this technology [23]. In these cases, the hazard potential of problematic waste components as well as the organic fraction that also poses a problem, due to the properties needed for construction products, is destroyed during the thermal treatment. In addition, the incineration residue is much more homogeneous in its composition. Still, a lot of preconditions regarding the quality of the bottom ash must be met to allow for its sustainable use for construction purposes [24]. These preconditions involve operating parameters of incinerators, practices of ash and slag management that might involve processing and quality assurance measures.

FIGURE 3-5 MSW-incinerator ash as a potential secondary material for the construction sector needs to meet quality specifications [25]]



Another option for retrieving resources for construction purposes from the MSW stream is source separation of individual materials such as 1) glass, 2) paper and 3) plastics from the MSW stream. In the context of SSA, the separation of these materials could be practiced during the collection or the sorting phase.

Glass that cannot be recycled for bottle production, can be used to produce :

Bricks/plaster stones : glass can be used to produce bricks/ plaster stones. However, for quality reasons, scrap glass needs to meet certain quality criteria that require sorting (at source or afterwards) as well as processing (e.g. removing labels, washing, drying, etc.). Keybricks from South Africa is one example here [26].

In these proposed cases, glass and potentially also fine aggregates (such as bed ash from fluidized bed incinerators) derived from MSW streams, must comply with certain specifications, such as grain size and mineralogy, in order to ensure bricks/plaster stones of a decent quality. Otherwise, the durability of the product will be compromised, and pollutants might be leached into the environment.

FIGURE 3-6 Scrap glass as secondary material for construction products [26]

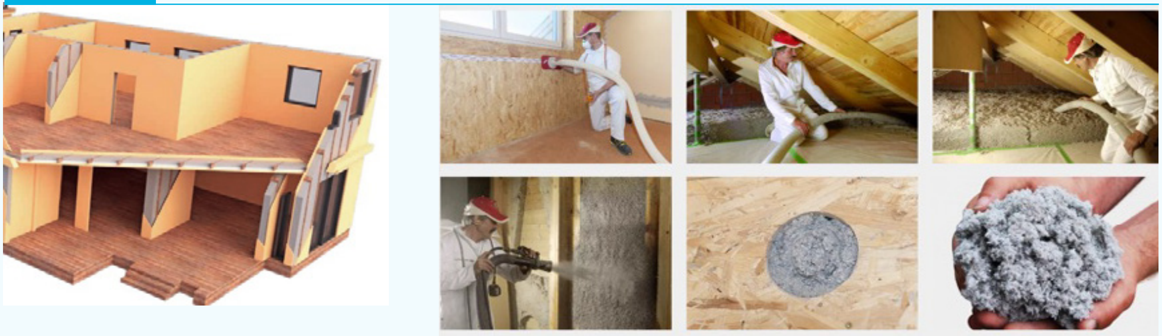
Glass foam and glass wool : glass can also be used to create glass foam or glass wool which are used as insulation materials as well as to prepare a geotechnical stable sub-base for buildings [27].

The quality requirements for scrap glass (e.g. grain size) in this specific application are less strict than the ones for scrap glass recycling to produce new bottles. Thereby such practices might allow for an increase of its recycling rate.

FIGURE 3-7 Glass foam as an option to use glass as a secondary material

Paper can be used as insulation material [28] ; however, it must be treated to increase its durability (e.g. drying, pesticide treatment, etc.).

FIGURE 3-8 Paper as possible secondary material for construction purposes – as insulation material [28]



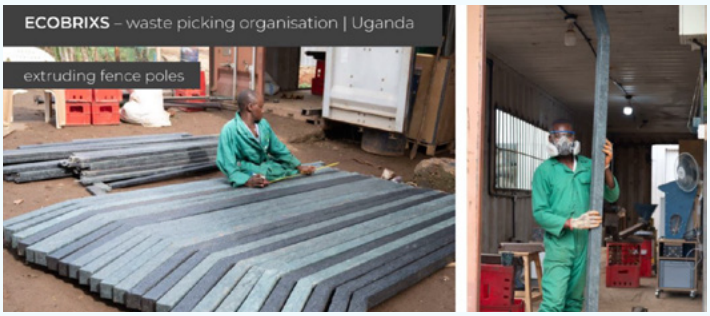
For such applications, wastepaper must be sorted and processed to make it resistant to biological degradation and rodents who might feed on and nest in biologically based insulation material, compromising the integrity of the product.

Plastics are sometimes repurposed for construction applications, such as producing plastic wood, pavers, furniture, and fence poles, particularly in areas lacking sufficient collection and recycling infrastructure. [29], [30], [31]. Considering sustainability and guiding waste management principles, such approaches can only be seen as bridging technologies. Indeed, the wear and tear of construction products made from waste plastic pose potential risks due to the release of microplastics and the chemical additives contained in plastics, which may harm humans and the environment.

Another crucial aspect of the sustainable use of secondary materials is the end-of-life phase of the products, particularly those made from waste-derived materials. If the altered properties of a product due to the use of waste-derived materials make recycling difficult or impossible, it cannot be considered a truly sustainable practice.

In the case of plastic, the highest priority should be put on closed-loop recycling which means recycling plastics into new plastic products. However, this requires significant investments in sorting and recycling facilities. In the absence of funding for such practices, recycling options using plastic as an ingredient in construction products might be an option. Particularly, in cases where wear and tear can be kept to an absolute minimum, such as plastic paving of pedestrian ways instead of motorized roads, and if waste management practices can ensure that these types of products are kept separately from mineral construction waste at the end-of-life phase. If the latter is not feasible, the practice is unsustainable, as it not only prevents further recycling of the plastic but also that of the minerals of CDW.

FIGURE 3-9 Plastic as secondary material for construction products [29]



3.1.5

Benefits of using MSW-derived materials for Circular Construction

It is difficult to quantify the benefits of using MSW-derived materials as construction materials. Any assessment must consider the boundary conditions given in a specific context and must also take into consideration possible alternative options to manage MSW and to manufacture building products.

Activities are needed in the realm of collection, sorting and treatment of MSW, in order to enable the use of fractions from MSW as a resource for sustainable construction. Therefore, there is significant potential to create new jobs, thus, generating social benefits. It is believed that this will outweigh the potential job losses in the industry for producing building products from raw materials.

Environmental benefits

From an environmental perspective, the recovery of resources such as discussed in Chapter 3.1.4 can be seen as beneficial as long as due consideration is given to the collection, sorting and treatment of the MSW. It secures an appropriate quality of the fractions to be recovered as well as to avoid adverse effects on mankind and to environment.

Economic benefits

In terms of economic benefits, we must differentiate between benefits for society at large and for the waste owners. It must be clearly stated that for waste owners, any activity needed to process the waste involves costs. As long as there are less expensive alternative waste management options (controlled or uncontrolled), available or tolerated, any recovery-oriented option might not be beneficial in economic terms. These costs may not be offset by revenues from selling fractions of the MSW as construction material. However, from a societal perspective, reducing externalities ultimately leads to economic benefits.

In settings where waste is not managed in a controlled manner, informal activities of retrieving material fractions such as glass, paper or plastics, to be sold as a secondary material for the manufacturing of building products, might create a positive business case for these informal sector actors.

Social benefits

From a societal viewpoint, the avoided future costs of mitigating environmental damages must also be considered. There is a consensus that controlled waste management is economically beneficial for societies. This has been demonstrated in the Global Waste Management Outlook 2024 [6]. The direct costs for the global MSW management as usual scenario in the year 2050 have been stated as USD 417.3 billion $ whereas the costs for the Circular Economy Scenario have been stated as USD 254.6 billion $.

3.1.6 Stakeholder Mapping for the Increased and Safe Use of MSW-derived Materials for Construction Materials

In the context of MSW, there is a multitude of stakeholders involved: starting with citizens, offices, small businesses, and tourists who generate MSW, formal public or private waste management companies, informal sector stakeholders in the construction industry, and residents utilizing housing options and infrastructure built with secondary materials. Also, governments and municipal administrations must be seen as stakeholders influencing and being affected by circular economy activities in the construction sector.
A thorough discussion of various stakeholders and their roles is conducted in the CiCoSA Implementation Guide.

3.1.7 Concluding Remarks on the use of fractions of MSW for the construction sector

MSW is a material stream with a very heterogeneous composition. The composition varies across regions due to factors such as the type of waste collection and coverage and it also varies throughout the year. Construction products must adhere to clear specifications and demonstrate high durability. Taking these two aspects into account it already becomes clear that any use of fractions from the MSW stream for construction purposes requires extensive efforts during the collection, sorting and processing phases.

In addition, any use of recycled plastic material in the construction sector must account for the potential for material degradation, and wear and tear based on aspects such as direct sunlight, heat, and physical stress. All these phenomena result in the potential breakdown of the product in microplastic particles which can enter waterways and ultimately the food chain, as they are consumed by fish and other species.

In conclusion, it can be stated that there is a small potential for recovering fractions of the MSW stream for use in the construction sector, however, it necessitates extensive efforts in collection, sorting and processing and the applications to do so must be chosen wisely in order to achieve long-term sustainability.

3.2 Construction and Demolition Waste

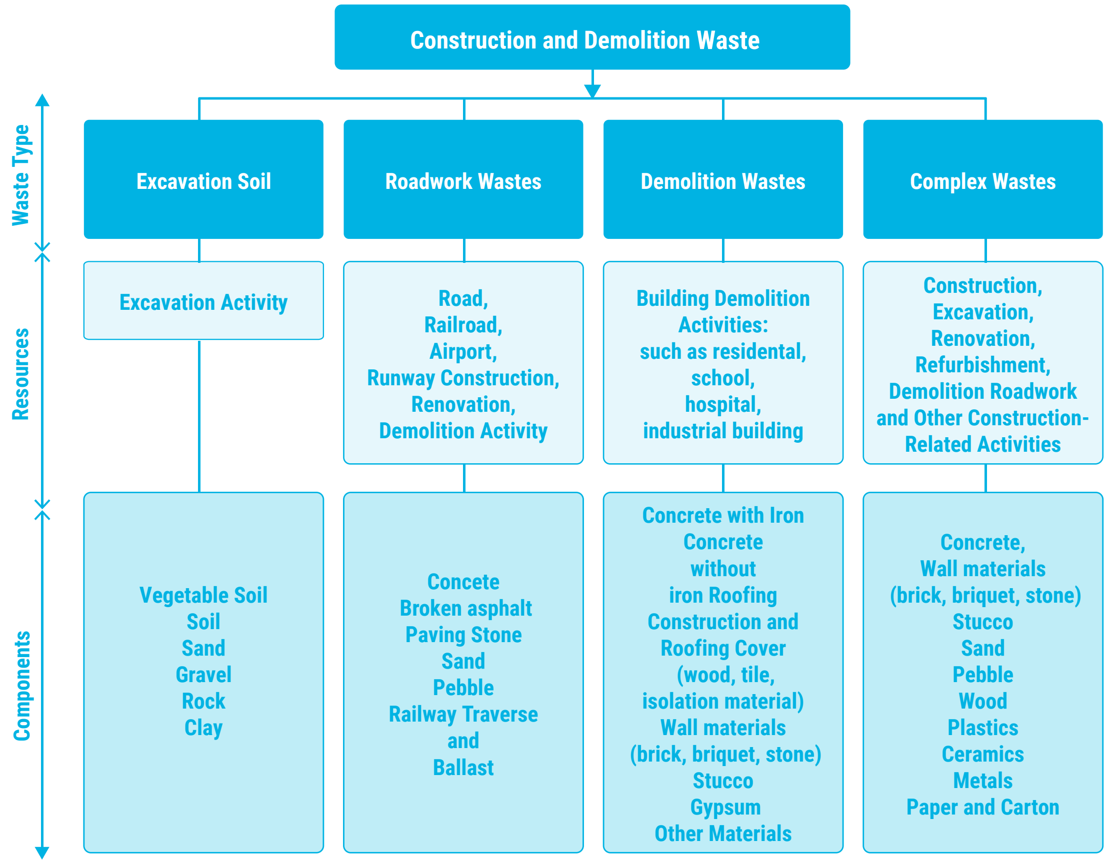
3.2.1 What is Construction and Demolition Waste?

CDW is generated during the construction phase of buildings, during refurbishments and at the end-of-life phase of buildings when they are demolished.

CDW, generally, consists of timber, metal, concrete, glass, gypsum, asphalt, clay bricks, tiles, and other building materials potentially bearing pollutants such as asbestos. CDW is one of the major waste streams in terms of weight and volume. Studies have shown that in some countries the CDW represents up to 50% of the total volume of waste landfilled [32]. Concrete, globally, is the second most consumed material after water.

Figure 3-10 gives an overview of the typical CDW types and the embedded resources which could be recovered. The actual quantity of CDW also depends on the legislation, its actual implementation and enforcement in respective countries. For example, excavation soil is not always seen as a waste in legal terms.

FIGURE 3-10 Various types of CDW based on components [33]



3.2.2 Estimated CDW Generation in Sub-Saharan Africa

Studies examining CDW quantities in South Africa showed that CDW is believed to be significantly under-reported. This was largely attributed to a lack of reporting by municipalities and public statistics. Moreover, the use of CDW for informal constructions of residential buildings and informal recycling also makes it difficult to understand the scale of CDW reuse and recycling on the ground. Nevertheless, most of the CDW is disposed of. In the best-case scenario, it is landfilled; however, in many cases, it is dumped into illegal dumpsites or riverbeds. Therefore, leaving the materials out of reach for reuse and recovery.

Most of the materials in the CDW stream are long-lived products, which are hardly bio-degradable and most of the time not burnable. As the products are long-lived there is a high potential of legacy substances. Some substances have been used in the past, for which negative impacts on mankind and the environment have been proven in the meantime, which led to bans on the use of those substances. Product lifetime of some part of CDW is having similar pattern as plastic product (Figure 2-3). This poses a major challenge to environmentally sound practices for a circular construction sector. Legacy substances must be kept out of CDW that is to be recycled or reused to secure a sustainable and safe approach. This is best done by identifying and removing these substances before demolition: sorting of mixed CDW may not allow the removal of these substances to the degree needed.

A quantitative understanding of CDW generation is essential to plan and establish an effective waste management system where CDW is used as a resource to substitute new construction materials [34]. The volume of demolition waste in general is much higher than the volume of construction waste. Globally, it is estimated that up to 75% of the waste generated by the construction industry may have a positive economic value and currently is not reused or recycled [35]. To improve data availability about the CDW generation and composition as well as to identify construction components containing pollutants and legacy substances, waste audits should be conducted before the demolition of buildings starts. Besides significantly improving data availability, it could be used for a meaningful deconstruction strategy. It would also ensure that construction parts containing legacy substances and pollutants are not reused or recycled, and reusable and recyclable construction components are used as secondary resources to the highest possible degree [36].

While it can be assumed that CDW generation per capita in SSA is still lower than in other regions, the current rapid urbanization will lead to an increase in this waste stream in the near future. Additionally, reuse and recovering CDW has a positive climate impact due to the high embodied energy and thereby ecological footprint of new construction products.

3.2.3 Toxic and Hazardous Substances in Construction and Demolition Waste

As shown in Figure 3-10, a wide variety of building products can ultimately become waste. Some of those contain legacy substances that have negative impacts on people and the environment when mismanaged. Moreover, if these wastes are not managed properly, they will also contaminate other wastes, such as concrete and rubble, which could otherwise easily be recycled.

The most urgent issues related to poorly managed CDW are the following [37]:

- Illegal open dumping of CDW in areas such as wetlands, riverbeds, and drainage systems which can cause major environmental and health issues, including flooding caused by clogged drains and water channels; increased particulate matter pollution; serious threats to valuable ecosystems; and contamination of water bodies, including ground-water.
- Health risks and risks of injury for residents and animals.
- The mixing of CDW with other waste streams, such as MSW, makes the recovery of recyclable fractions technically more challenging.
- CDW, due to its bulky shape, consumes a lot of volume in landfills and results in the need for more landfills

Critical in the CDW composition is the use of environmentally questionable substances, including legacy substances, which make deconstruction and proper treatment or recycling of CDW very challenging. In the second half of the 20th century, the replacement of traditional building materials with new and synthetic alternatives has been seen as an important part of economic development, in order to improve diverse material properties like durability, insulating properties, weight reduction or cost reduction. However, these new materials have not always undergone a detailed examination regarding their health impacts during the use period or the environmental risk associated with their final disposal.

The use of some of these substances has already been prohibited based on international law (i.e. Stockholm Convention for POPs [15] and the Montreal Protocol for ODS [16]), but some are still being used. In any case, these materials are part of the existing building stock and thereby become relevant once buildings are deconstructed.

These materials and contaminants still pose a danger to human health as part of the continuously generated CDW in the long term.

Some of the major pollutants which were historically prevalent in building products include Asbestos, flame retardants such as Hexabromocyclododecane (HBCD), ozone-depleting substances such as Hydro-Chlorofluorocarbons (HFCs/CFCs) as well as plasticizers such as Poly-Chlorinated Biphenyl (PCB) [38]. While this is not an exhaustive list, as there are many more relevant contaminants to be considered and taken care of, i.e. wood preservatives such as Pentachlorophenol; the focus here is on contaminants most relevant to the SSA region.

• Asbestos

Asbestos is perhaps the most well-known example. It was used worldwide in the 20th century as an affordable material for thermal insulation, and roof covering. Additionally, Asbestos was also used for fire-protection purposes in spray coatings, flooring, pipes, ducts, and paints, among other applications. In industrialized countries, its use was largely banned during the last century due to the related health dangers. However, in some SSA countries, its utilization remains common (compare Figure 3-11) [39].

Due to its durability, Asbestos products are still widely spread in existing building stock even though many of the products have been banned decades ago (Figure 3-11). Indeed, Amphibole Asbestos is listed in Annex III of the Rotterdam Convention which lists chemicals that are banned or severely restricted due to environmental or health reasons, while Chrysotile Asbestos has been recommended for inclusion. [41]. Figure 3-12 shows an application example of Asbestos-containing corrugated sheets.

FIGURE 3-11 Asbestos Consumption 2016 (provisional and national bans 2019 [40]

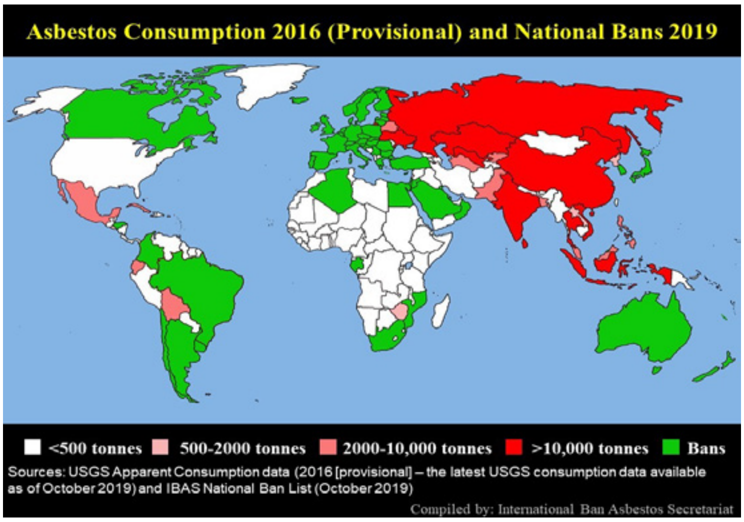


FIGURE 3-12 Corrugated Asbestos Sheets in use (photo credits: Arne Ragossnig)

• Flame retardants such as HBCD

Flame retardants such as HBCD have been and continue to be commonly used, especially in polymer products, such as expanded polystyrene (EPS) and extruded polystyrene (XPS) as well as textiles. In a recent comprehensive risk assessment, the US Environmental Protection Agency (EPA) concluded, that HBCD in XPS/EPS insulation foam poses unreasonable risks to the environment at all life cycle stages (i.e. manufacture, use, disposal and recycling) [42]. Figure 3-13 shows an application example of HBCD containing insulation material.

FIGURE 3-13 EPS / XPS / PU sheets in use as insulation for flat roofs [43]]

One of the main paths of exposure to this contaminant is through plastics released into the environment (e.g. being washed off by rain, reaching rivers and oceans, and eaten by aquatic animals) where they degrade into microplastics that enter the food chain, and are subsequently ingested by human beings. Figure 3-14 gives information about human exposure to micro- and nano-plastic particles. Figure 3-15 explains the effect of flame retardants and plasticizers that have been and are used as additives on the human body.

FIGURE 3-14 Human exposure to micro- and nano-plastic particles [44]

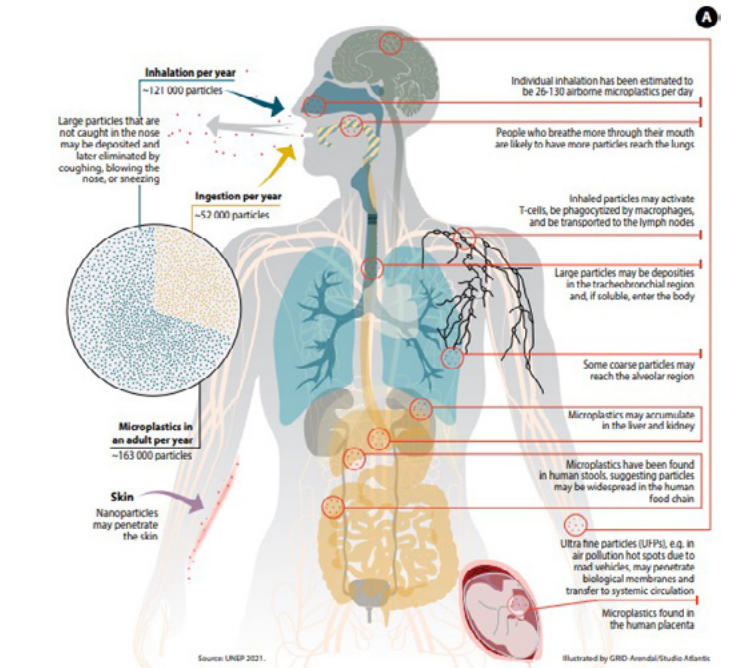
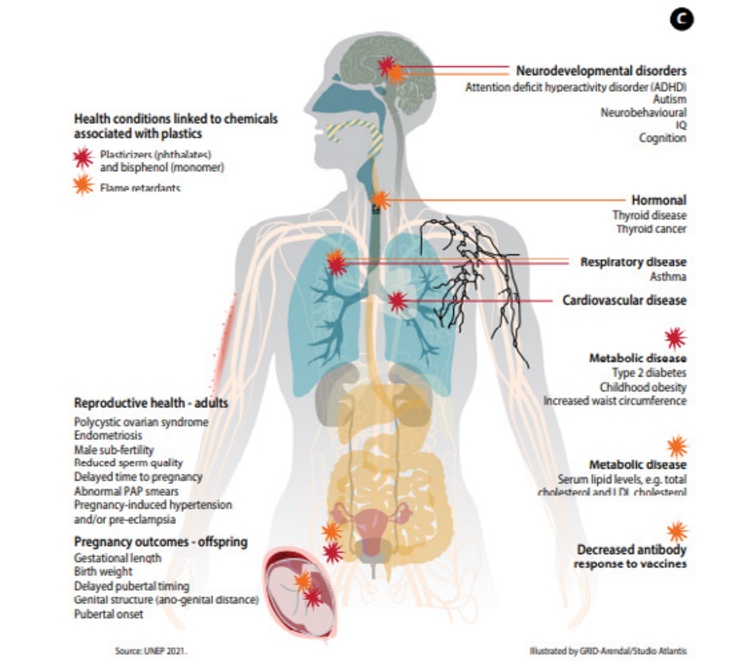


FIGURE 3-15 The effect of plasticizers and flame retardants on the human body [44]



• Ozone-depleting substances such as HFCs

Amongst other applications, HFCs have been widely used as blowing agents for foam products. Most relevant in the building and construction sector are XPS and PU panels, used for insulation or as a composite sandwich component for construction purposes. These foaming agents were banned from use in Europe in 2005 and have not been brought to market in Europe since 2009. However, keeping in mind the lifecycle of such products, these substances are widely used in existing buildings. If demolition is not conducted thoroughly and following international standards, ODS will be set free during the demolition process. Figure 3-16 shows an application example of ODS containing sandwich panels.

FIGURE 3-16 Sandwich elements in use [45]

• Plasticizer

This category of additives has been used in plastic products for construction such as Polyvinyl Chloride (PVC) flooring or for expansion joints at building facades. The effects of plasticizers are explained in Figure 3-15. Figure 3-17 shows an application example of a plasticizer containing expansion joints.

To avoid any negative health and environmental risks, hazardous substances must be detected as early as possible in the CDW stream and diverted to avoid such substances contaminating other fractions, which are suitable as a resource for the construction industry. Pre-demolition audits, selective demolition practices as well as a separate collection of different materials at source are, therefore, vital elements for circular construction practices.

FIGURE 3-17 Expansion joints in use [46]

3.2.4
Barriers to Circularity of CDW

There are some key reasons why CDW are not properly used as a resource for building materials in the construction sector [47]:

Lack of suitable policy, governance, and enforcement

The lack of policy-related incentives to recycle CDW back into the construction sector as well as lack of monitoring, enforced rules on proper disposal, and enforced penalties on improper CDW management are some of the principal barriers to promoting such alternative and sustainable uses..

Lack of quality and performance

The proper quality of CDW is key to returning these material streams to become high-quality resources for the construction industry again. This requires efforts before and during the construction or demolition activity, as well as skilled manpower for the orderly separation of the different waste fractions and the timely detection of contaminated materials, such as with chemically treated wood.

Lack of Information, know-how and technology

A lack of knowledge and information in the construction industry about the benefits and the potential of recycled CDW materials is a main factor which is limiting the exploitation of that resource.

Lack of competitiveness

In cases where improper dumping practices are not criminalized and where no adequate landfill levy is imposed, open dumping or landfilling tends to be more cost-effective than recycling the materials. Thus, discouraging the reuse and recycling of such materials..

Lack of acceptance

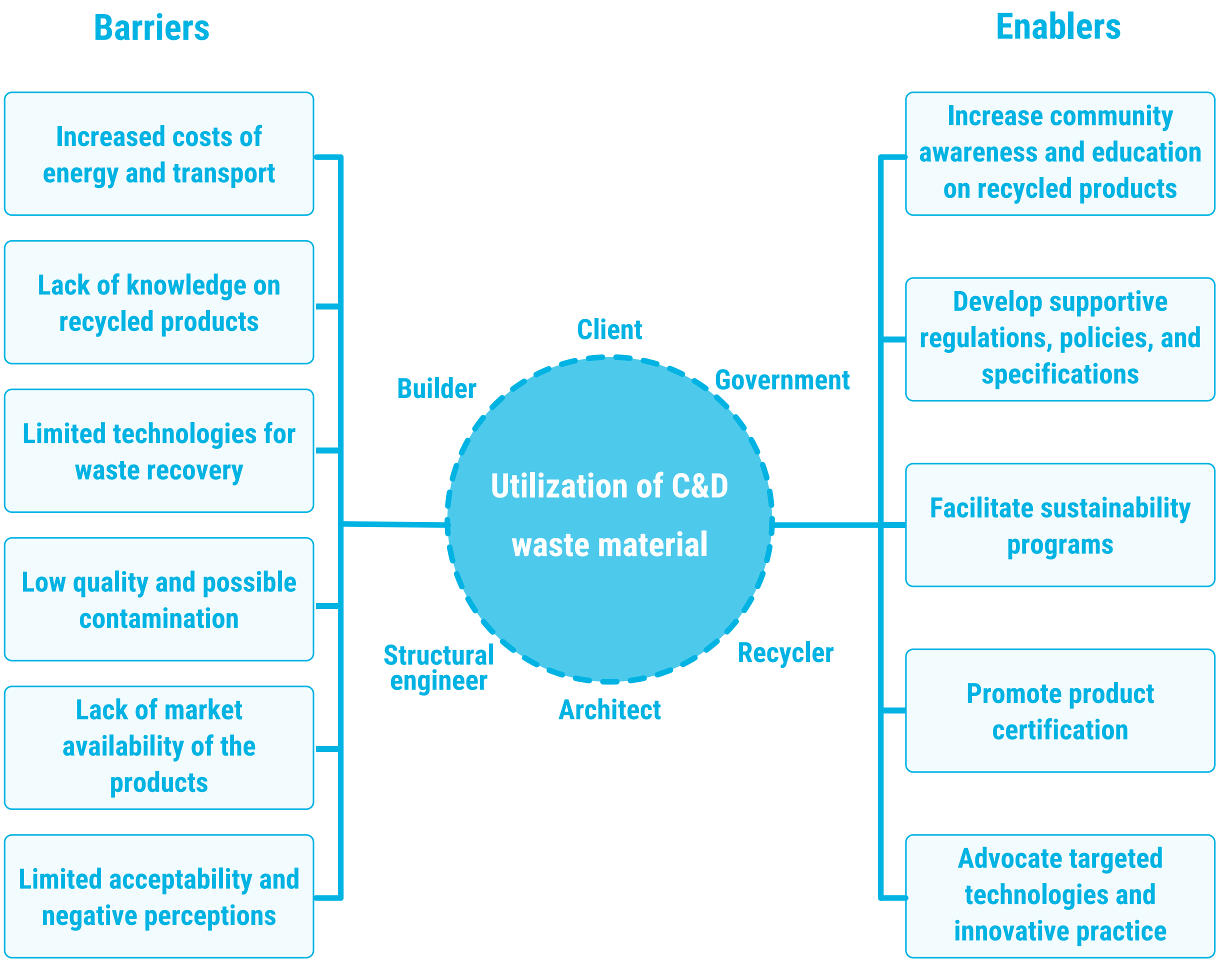
In the construction sector, waste is commonly perceived as a material without value, limiting its acceptance within the industry. To overcome this barrier, quality criteria and standards for recycled CDW need to be established, ensuring that all recycled materials meet specific performance and safety requirements. This effort should be accompanied by awareness-raising and sensitization activities.

Permits and specifications

The lack of material specifications and legal provisions permitting the use of such recycled materials is a major limitation for its increased adoption. Furthermore, contractual arrangements with construction companies as well as applicable standards that form the basis of these agreements, can pose an obstacle to reuse and recycling..

The following illustration summarizes these barriers and shows the enablers, which can support the use of CDW as resource in the construction industry. In addition, this illustration shows very clearly that there are many stakeholders involved in the realization of buildings. All of them in different roles and with different boundary conditions such as contractual arrangements, standards, guidelines, and laws to respect; so circular construction therefore also encompasses very often a redesign of prevailing processes and interfaces in the construction sector in order to actually allow for a broader implementation.

FIGURE 3-18 Barriers and enablers of CDW as building material [48]



3.2.5

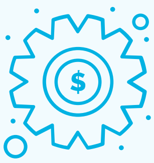
Benefits of using CDW for Circular Construction

Because of the large quantities of natural resources which are consumed by the construction sector, the application of the circularity for CDW concept has several benefits which are highlighted in this chapter.

Environmental benefits

The landfilling of CDW provokes a series of environmental problems which can be reduced if more of this waste stream is diverted and used again for the construction of buildings. Organic materials, like timber, if openly dumped, potentially have high methane emissions that contribute to climate change. In addition, CDW, due to the high quantities, contributes to an accelerated filling up of scarce landfill space. The diversion of CDW towards a circularity-orientated use reduces harmful environmental and health effects and pollution.

Economic benefits



The recovery and recycling of CDW in SSA could contribute to the development of new employment and entrepreneurship opportunities. The processing of such waste streams into useful materials for the construction industries can contribute to the formation of new companies to offer these types of services. Such companies will create a variety of new formal job opportunities for skilled and unskilled labour opportunities and can therefore contribute significantly to the improvement of economic conditions in SSA.

Additionally, the avoidance of CDW landfilling can reduce the financial burden due to waste levies, if applicable under the specific context, to demolition companies.

Social benefits

Most disposal sites in SSA are still uncontrolled dumpsites. Besides being an enormous source of pollution, they significantly deteriorate the living conditions of communities living nearby. These impacts range from contaminated water, soil, and air to the devaluation of the value of agricultural and residential land in and around the dumpsites. Therefore, the reduction of CDW landfilling can significantly contribute to lowering negative social impacts on adjacent communities.

3.2.6
Cases for the Utilization of CDW for Construction Materials

As CDW streams are composed of a multitude of different materials, the suitability of their use as input material in the construction industry is very much dependent on their actual separation at source. Quality assurance on a case-by-case basis is also a vital element for enabling circularity.

Below is an overview of cases for the circular use of CDW:

Aggregate replacement for concrete production

The use of typical aggregates in concrete, such as sand and gravel, is becoming an immense environmental problem due to its over-extraction in many places, contributing to the loss of complete ecosystems such as beaches and riverbanks. This global problem is growing fast in SSA, due to the booming construction industry and the demand for typical aggregates for large buildings and infrastructure construction. The reverse logistics model for product recovery of construction aggregates has been tested for real-life data for National Capital Region Delhi, India [49] and study conducted near metro Manila for reclaimed aggregate from debris [50].

The replacement of sand and gravel with inert fractions of CDW is an ideal way to alleviate the pressure on these non-renewable resources. For that purpose, waste fractions which typically are composed of materials like bricks, concrete, and ceramics, are processed in dedicated CDW processing plants, to generate usable material fractions that can be recycled.

In the academic literature, many different materials are discussed as alternative aggregates in concrete. These range from the use of glass, ceramics, clay bricks, concrete waste, fly ash, and agricultural waste up to fractions of the MSW like Polyethylene Terephthalate (PET) or rubber. Such usage must be evaluated on a case-by-case basis to make sure that the environmental benefits exceed potential negative effects.

It is important to consider the waste hierarchy and ensure that the use of aggregate replacement is conducted just for materials where no higher value-added use case exists. In addition, it is important to consider, the avoidance of future legacies, such as micro-plastic generation, emissions of pollutants or the impossibility of future recycling of the concrete. Therefore, the use of inert and stable fractions as concrete aggregates, like glass, tiles, clay bricks or ceramic might be an interesting use case for such materials.

Use for road surfacing

Another interesting use option for CDW is its utilization as input material for paving roads and replacing traditional aggregates like sand. The same preventive measures should be applied for aggregate replacement in concrete. No material should be used which could lead to an environmental legacy in the future.

Use of wood waste for scaffolding and formwork at construction sitesg

Suitable wood fractions from CDW, like boards, beams or poles can be used directly at construction sites for formworks and scaffolding. Such use allows the replacement of natural wood and helps to reduce deforestation.

Reuse of windows and doors

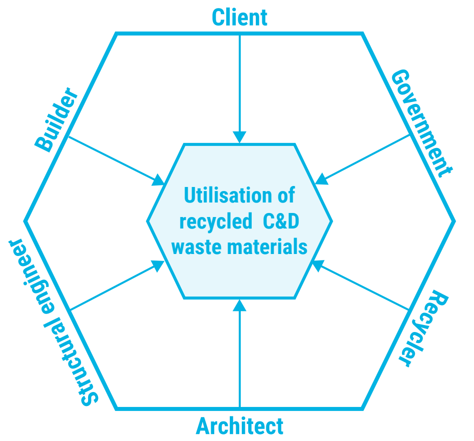
Windows and doors in good condition can be salvaged from demolition sites for donation or alternative uses, such as for greenhouses.

Use as filling material

Bricks or concrete can be processed onsite to be used as filling material for the new building or to stabilize the driveway bedding.

For all the proposed examples, it must be stated that there are quality criteria that need to be met according to the respective application. In addition, there might be standards, legislation, regulations, and contractual arrangements that must be complied with.

FIGURE 3-19 Stakeholders for increasing the use of CDW as construction material [48]



3.2.7 Stakeholder Mapping for the Increased and Safe Use of CDW for Construction Materials

To increase the CDW utilization rate to recover embedded resources as construction material, stakeholders involved in CDW must be addressed to improve waste management of this particular waste type. The following illustration shows the main stakeholders involved in such an improved waste management strategy for CDW.

3.2.8 Processing of CDW to Building Materials

For the processing of CDW, all the easily removable and reusable materials must be removed before the remaining waste enters a CDW processing line, where all the inert materials like stones, bricks, cement, ceramics, etc. are crushed and screened to produce aggregates of different sizes, which can be used as building materials. The following illustrations show a typical process and material flow at a CDW processing plant (compare Figure 3-20) and a waste concrete recycling plant (compare Figure 3-21).

FIGURE 3-20 Process flow for the processing of CDW to extract building materials [51]

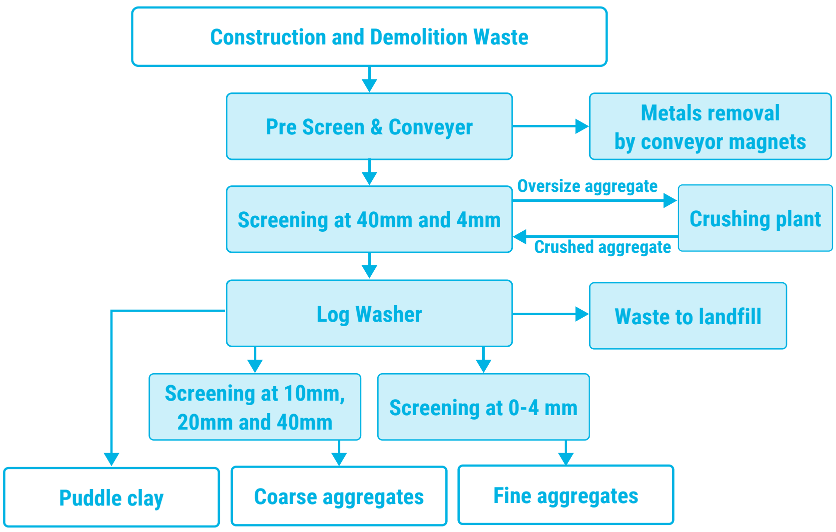
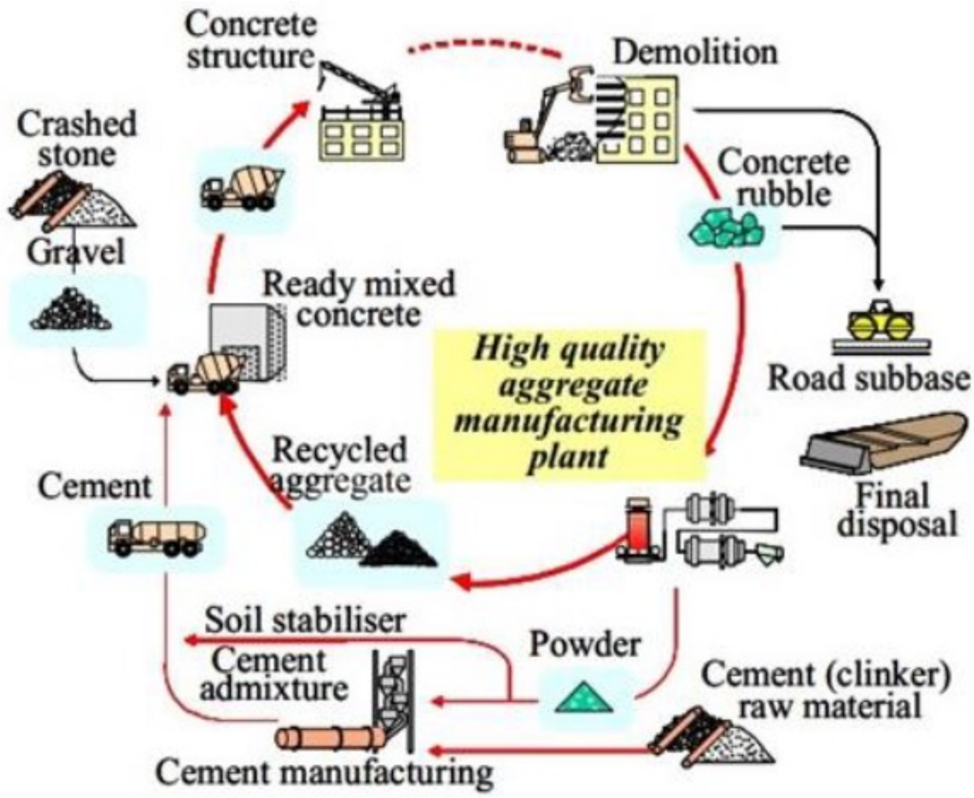


FIGURE 3-21 Process flow for waste concrete recycling [52]



3.2.9
Concluding Remarks on the use of CDW for the construction sector

Overall, the CDW poses the highest quantities of waste arisings. There is a multitude of materials used in the construction sector, many of which have long product lifespans - often extending for decades.

Due to that fact, the processes of demolition and recycling of CDW need to account for the identification and separation of legacy substances to prevent pollutants from accumulating in the anthroposphere.

The potential for recycling CDW is much higher than the potential to recycle (fractions) of MSW, but the demolition processes must be adapted accordingly and require a pre-demolition audit in order to identify products that need to be kept separate from the waste fractions to be recycled.

Another major challenge that needs to be addressed is to focus on the standardization of recycled construction materials as well as on quality assurance during the production of these recycled products. Only a focus on the quality of recycled products will allow for elevating the image of recycled construction waste.

3.3 Agricultural Waste

In contrast to CDW, AW streams are always biodegradable, and their occurrence is predominantly concentrated in rural areas, where agricultural production is happening. AW are diverse in their composition because these types of residues come from different crops and are cultivated and processed in diverse climate zones. In SSA, typical agricultural residues are among others, corn cobs, sugarcane bagasse, rice straw, rice husks, coconut shells, peanut husks, and cacao pods.

These types of waste, if not treated properly, will pose several environmental challenges, due to their biodegradability. Open dumping or open burning can result in air, soil and groundwater contamination, and GHGs formation (methane). However, the use of agricultural waste as input material in the construction sector can be seen as a beneficial opportunity to increase circularity by replacing unsustainable building materials.

The benefits of using agricultural residues in construction are not limited to the reduction of negative environmental impacts. The use of such types of materials can improve the quality of living by improving the air quality in buildings, supporting the natural management of moisture levels or reducing allergic reactions. In addition, the valorisation of agricultural residues can contribute to the economic viability of agricultural production, which could improve the living conditions in rural areas [53].

It should be noted that in SSA, the use of AW as construction materials has been a common practice. For example, in several rural communities, straw, reeds, and other plant fibres from crops like wheat, rice, and sugarcane have been used in construction. These materials are typically mixed with clay or mud to create natural, sustainable building materials for walls, roofing, or insulation. However, this practice declined with the introduction of more industrialized and modern construction materials like concrete, steel, and bricks. This shift occurred gradually during the 20th century, particularly as urbanization increased and more Western-style construction techniques were adopted. The decline of agricultural waste in SSA construction can be attributed to modernization, industrialization, and the cultural shift towards more durable and prestigious materials, the loss of traditional knowledge, among others.

3.3.1 Utilization of agricultural waste as input material in the construction industry

There are countless different types of agricultural wastes. Further, their availability and potential to use as construction material varies. This section gives a short overview of common practices and opportunities to use specific agricultural waste as a building material.

Use as aggregate or cement substitute in concrete mixtures and cement blocks

AW can be used as aggregate in concrete mixtures or cement blocks to achieve different material properties, such as weight reduction or altered thermal properties and binding carbon in a sink. Many agricultural residues, such as sugarcane bagasse, hemp fibres or jute fibres, have a high fibre content and can be used for this purpose. Other agricultural residues that can be used to replace non-renewable materials, such as gravel and sand, in concrete and cement blocks, are for instance coconut shells, and walnut shells. However, the agriculture residue must be evaluated on a case-by-case basis and is highly dependent on the actual use case and the prevailing static load.

For other types of AW, such as rice husk, once it has been transformed into inert ash, it can be used as a component in concrete mixtures – substituting natural aggregates [54] [54]. The resulting ash from rice husk has a high silica concentration, which has beneficial effects on the properties of concrete and allows the replacement of a fraction of cement in the concrete mix. Likewise, it has GHG emission reduction benefits [55]. However, considering the risk of reduced strength of the concrete which contains agricultural waste particles, the use of this type of material seems to be more suitable for non-load-bearing structures or low-storey buildings [56].

The conversion of AW into biochar presents a promising solution for utilizing this material in the construction sector. Biochar is produced through the pyrolysis process, where organic waste is thermally transformed into stable organic carbon under oxygen-free conditions.

Biochar can be mixed in concrete, replacing GHG-intense cement, up to a certain amount, without negatively affecting its static properties [57]. TThe use of biochar has a series of advantages. For instance, the thermal property of the resulting concrete improves the quality of life in concrete buildings. In addition, biochar is stable and allows long-term sequestration of carbon, which otherwise would have been emitted into the atmosphere. This advantage of biochar is an interesting instrument for carbon sequestration and climate mitigation.

The maximum amount of biochar which can be added depends on the occurring static load and must be assessed on a case-by-case basis. However, the operation of a pyrolysis unit and the production of a high-quality biochar that may be used in the construction sector demands infrastructure and know-how.

Production of panels, composites and other structural elements

Some AW can be used as raw material for the fabrication of building materials, like panels, cover plates, cladding, particle boards and similar structural elements. In SSA, large quantities of sugar cane bagasse are currently not being utilized. It is a suitable material to produce particle boards, which could reduce the pressure on natural resources such as wood [58]. Another interesting raw material for particle boards is peanut shells, which are highly resistant to biodegradation, which in turn makes them ideal for use in building materials.

FIGURE 3-22 Composite panel produced with organic waste [59]]

AW can also be used to produce bio-based composites, where processed agriculture residue is mixed with other materials, like resins or tannin-based adhesive, to produce solid composites for boards, cladding walls and other building materials.
Figure 3-22 shows such types of boards made by AW.

Insulation materials

AW can be used for thermal and noise-insulating materials, presenting a valuable application in the construction industry. Some AWs have excellent low thermal conductivity properties, which are ideal as insulating materials. For example, corn cobs have a low-density foam-like structure making them an ideal insulation material. [60] The biodegradability and inhomogeneity of AW require nevertheless proper processing and treatment of the waste, ensuring the material can fulfil its function without limitations, as a building material.

Direct use as building material

AW can be used directly for building purposes, without further processing or changing their physical or chemical properties. In this context, the use of straw bales for structural elements, such as walls, is a viable alternative for single-floor buildings. Buildings made from straw bales have excellent thermal, structural and acoustic properties. To use straw bales for structural buildings, the bales must be produced with a high density, which increases their static properties significantly [61]. When using straw bales, the roof should be completely watertight, and the foundations well carried out to keep the straw bales dry. Traditionally, agricultural residues are still in use for roof covering in the SSA region. Such examples are straw, palm fronds, and reeds.

Hempcrete

Agricultural by-products, like hemp fibres, can be used to produce hempcrete and replace concrete bricks. The hemp fibres are mixed with lime and sand to form blocks, which are air-dried. The material properties are excellent, especially a high vapour permeability contributes to a positive living quality in buildings. It is considered a carbon-negative material, thanks to its hemp fibre capacity to sequester carbon. Figure 3-23 below shows a sample of hempcrete bricks.

FIGURE 3-23 Hempcrete blocks [62]

3.3.2

Benefits of using agricultural residues as building material

Because of the immense climate protection benefits of diverting AW from open decomposition and its usage as a resource in the construction sector, many times (except when ash is used, and before thermal decomposition happening) the application of circularity to AW has benefits and is binding carbon in a sink.

The benefits are highlighted below:

Environmental benefits

When AW is not treated in an environmentally sound way, it can provoke a series of environmental problems. When agricultural wastes are landfilled or openly dumped, they contribute to an accelerated filling up of landfills and generate significant methane emissions. Another common practice for AW management is open burning. This practice is done in many countries with straw or bagasse and contributes to local air pollution and climate change. As such, the use of these waste streams in the construction sector would has the potential to significantly reduce such harmful practices.

Economic benefits

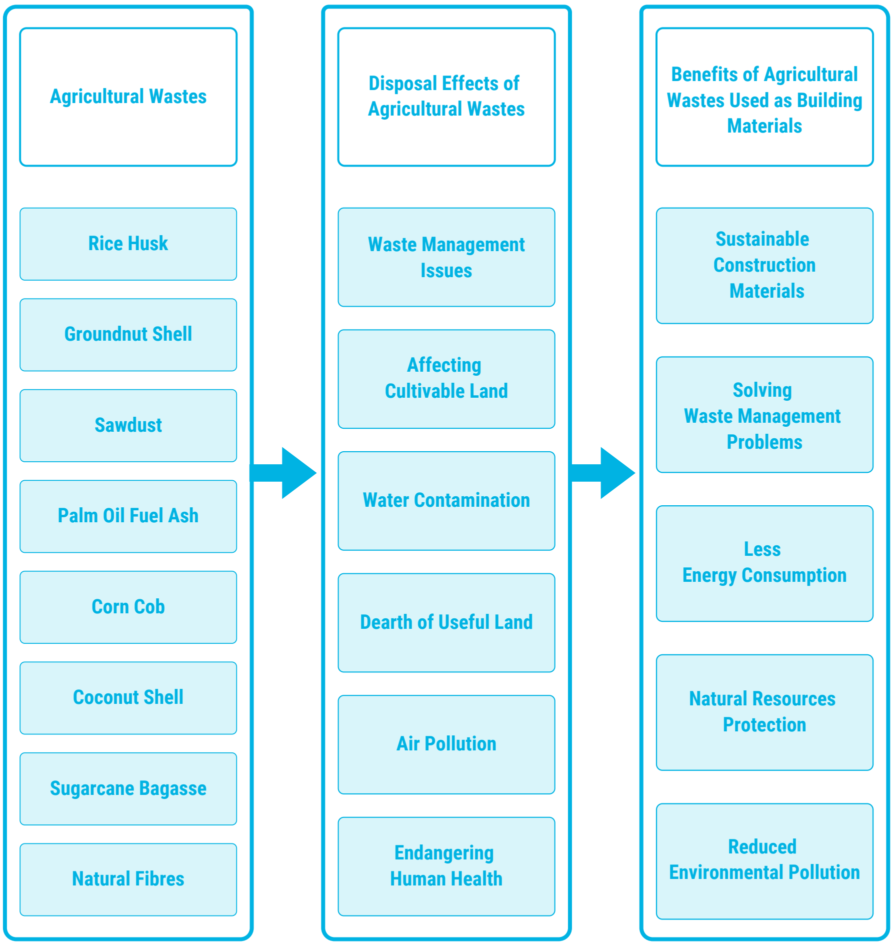
The transformation of AW into building materials provides residues with an economic value, which is one of the key instruments to support circularity. The valorisation of agricultural residues as building materials can make a meaningful contribution to peasants in the countryside and improve their living conditions, generating additional income. It also contributes to generating new job opportunities through the development of a new value chain, in urban context too.

Social benefits

Illegal dumping of AW has negative social impacts on communities living nearby. Bad odour, attraction of rodents and other animals, the propagation of flies and the spreading of infectious diseases are common impacts from untreated AW. Its valorisation as a construction material could play a role in reducing these negative impacts on the surrounding communities.

The following Figure 3-24 is summarizing the benefits of AW usage as a building material.

FIGURE 3-24 Disposal effects and benefits of agricultural wastes as building material [63]



3.3.3 Concluding Remarks on the use of fractions of AW for the construction sector

The use of fractions from AW in the construction sector offers two key benefits. First, if the AW used for construction purposes is usually burned openly, the negative effects of doing so can be prevented by providing a new use case for the AW.

Secondly, if AW is used without thermo-chemical conversion or if biochar is produced and further on used as an amendment to concrete, then carbon contained in the AW can be sequestered and thereby taken out from the carbon cycle and temporarily stored in the buildings that are constructed.

Also, in the case of the use of AW in the construction sector, focus must be laid on defining and complying with specifications in order to allow for a beneficial use and sustainable recycling.

While there are limiting factors to the use of AW in the construction sector, such as limited, fragmentated or lack of regulations, the revival of AW as a construction material in SSA is being driven by the need for sustainable, affordable, and locally sourced materials. With rising environmental concerns, the growing demand for affordable housing, and the advancement of eco-friendly construction technologies, agricultural waste is proving to be a viable and sustainable alternative in the construction sector. This movement also supports the preservation of traditional building knowledge while promoting innovative, modern approaches to green building.

4.

Comparative Analysis of Legislations Regulating and Impacting the Reuse of Secondary Materials in the Construction Sectors of Kenya, Namibia and South Africa

In SSA, several policies and legislative instruments are in place to address MSW management [64] [65]; while CDW and AW often lack regulations or they are not sufficiently detailed. Existing regulations tend to concentrate on related topics such as public health, hazardous materials control, and general environmentally sound waste management practices. For instance, South Africa has broader frameworks on solid waste management, but often only addresses CDW and AW indirectly, leaving gaps in how such waste streams are eventually handled.

One of the challenges in SSA is the inconsistency of these policies, which frequently govern only certain aspects of waste management. As a result, there is a lack of cohesive and comprehensive guidelines that could effectively govern CDW and AW, leading to poor enforcement and fragmented approaches. Some policies may emphasize hazardous waste or public health but provide little detail on the sorting, recycling, or disposal methods specifically needed for CDW or AW, creating a piecemeal regulatory landscape.

Namibia's most recent Environmental Management Act of 2007, which represents a corner-stone of the country's waste legislation, implicitly references CDW. However, specific regulations for managing CDW and promoting circular practices are not thoroughly detailed, as these aspects are incorporated into the broader framework of the integrated waste management system. Although the Act provides general guidelines for sound waste management, its implementation and enforcement remain insufficient.

In Kenya, CDW is mentioned in The National Solid Waste Management Strategy by the National Environment Management Authority. This waste is described to typically consist of materials like debris, steel, timber, tiles, and ceramics. The regulation calls for sorting to recover recyclable components for reuse. However, the common practice is still to repurpose some of the recycled materials for backfilling quarries or as fill in road construction rather than being reintroduced in the construction value chain. The remaining is disposed to the dumpsite or landfill. There are regulations related to the construction waste management that suggest the submission of Environmental

Impact Assessment, including a decommissioning plan, disposal of certain waste (including construction waste) by licenced waste provider, etc. However, similarly to Namibia, implementation as well as enforcement are still lacking.

In South Africa, the National Environmental Management Act and the Waste Act of 2008 provide a comprehensive framework for managing various waste streams, including CDW. These policies emphasize waste minimization, recycling, and environmentally sound disposal methods. However, regulations tailored to CDW management are less detailed, often integrated into broader waste management policies without clear directives on promoting circular construction practices. While there are general guidelines on managing construction waste, practical enforcement and implementation remain limited. This gap is particularly evident in the recycling infrastructure, where a lack of facilities and inconsistent oversight across municipalities hinder the proper sorting and reuse of CDW, ultimately affecting the transition to circular economy models within the construction sector.

Apart from the waste-related legislation mentioned in Table 4 1, it is clear that there are no provisions promoting waste reuse or recycling in the construction sector nor provisions that directly pose an obstacle to reuse or recycling in line with the waste legislation. Below is a comparison of examples of legislations regulating and impacting the reuse of secondary materials in the construction sector in Kenya, Namibia and South Africa.

TABLE 4-1 **Comparative analysis of legislations regulating and impacting the reuse of secondary materials in the construction sector in Kenya, Namibia and South Africa**

([K] ... Kenya; [N] ... Namibia, [SA] ... South Africa).

POLICY AND LEGISLATION	IMPACTS ON THE CONSTRUCTION SECTOR		
	KENYA	NAMIBIA	SOUTH AFRICA
CONSTITUTION			
[K] Constitution of Kenya 2010 [66] [N] The Namibian Constitution [67]] [SA] South African Constitution Act (No 108 of 1996) [68]	[K] Article 42 – states that every person in Kenya is entitled to a clean and healthy environment and must safeguard and enhance the Environment. [K] Articles 69 and 70: articulate the obligations of the state to the Environment and inclusive public participation in environmental protection and conservation [K] Fourth Schedule: Role of the county Governments in the waste management services	[N] Does not provide for an environmental clause directly relevant to pollution. However, the provisions are generally relevant for environmental protection, namely, Article 91(c). [N] Article 95 articulates the obligations of the state to promote and maintain the welfare of the people by adopting, inter alia, policies aimed at utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future;	[SA] Right to an environment that is not harmful to health or well-being, and to protection of the environment

POLICY AND LEGISLATION	IMPACTS ON THE CONSTRUCTION SECTOR		
	KENYA	NAMIBIA	SOUTH AFRICA
ENVIRONMENTAL REGULATIONS			
[K] The Environmental Management and Coordination Act (EMCA), 1999 [69] [N] The Environmental Management Act of 2007 [70] [SA] Environment Conservation Act (No 73 of 1989) [71]	[K] Every person shall cooperate with the authorities to protect and conserve the environment and to ensure the ecologically sustainable development and use of natural resources The delivery of this has been reinforced through various regulations to operationalise the law.	[N] Acknowledges responsibility to protect and maintain its own environmental and natural resources. The 2012 regulations guide the implementation of EMA 2007.	[SA] Provides for the protection of the environment, control of environ¬mental pollution, and control of activities which may have a detrimental effect on the environment
SOLID WASTE MANAGEMENT REGULATIONS			
[K] Solid Waste Management Act of 2022 [72] [N] Namibia`s Pollution Control and Waste Management Policy, 2003 [73] [SA] The National Environmental Management Act (No 107 of 1998) [74] & National Environmental Management Act: Waste Act 2008, (No 59 of 2008) [75]	[K] Identifies sustainable waste management promotion; improving the health of all Kenyans by ensuring a clean and healthy environment; ensuring the delivery of waste service	[N] Waste is closely related to pollution but not identical. Framework to enforce, promote and support the principles within the Solid Waste Management Policy. The regulations provide for storage, collection, transportation, treatment and disposal of various kinds of wastes, including household hazardous waste; construction and demolition waste; & recyclable waste;	[SA] Provides for cooperative environmental governance and for the enforcement of environmental management laws. Adopts a waste hierarchy, promotes cleaner production, waste minimisation, reuse, recycling and waste treatment, with disposal seen as a last resort
HEALTH REGULATIONS			
[K] The Public Health Act [Cap. 242] [76] [N] Public and Environ-mental Health Act, 2015 (No. 1 of 2015) [77]] [SA] National Health Act, 2003 (Act No. 61 of 2003) [78]	[K] for controlling the construction of buildings, and the materials to be used in the construction of buildings	[N] Promotes public health and wellbeing; prevents injuries, protects individuals and communities from public health risks; encourages community participation to create a healthy environment	[SA] Encourage individuals and communities to plan for, create and maintain a healthy environment. Provide for the prevention or early detection of diseases and other public health risks

POLICY AND LEGISLATION	IMPACTS ON THE CONSTRUCTION SECTOR		
	KENYA	NAMIBIA	SOUTH AFRICA
OCCUPATIONAL, SAFETY AND HEALTH REGULATIONS			
[K] The Occupational Safety and Health Act, 2007 [79] [N] The Occupational Safety and Health Policy,2021 [80] [SA] Occupational Health and Safety Act (No 85 of 1993) [81]	[K] Emphasizes the safety of all workers and safeguards the safety of all employees	[N] Employers, by law, must provide employees with a safe and healthy working environment. Occupational Health and Safety in Namibia is governed by the Labour Act Nr 11 of 2007 [82]	[SA] Provides for the health and safety of persons at work and the health and safety of persons in connection with the activities of persons at work
WASTE MANAGEMENT STRATEGIES AND VISIONS			
[K] National Waste Management Strategy 2015 [83] [K] Kenya Vision 2030 [84] [N] National Solid Waste Management Strategy 2018 Namibia [85] [N] Namibia Vision 2030 [86] [N] Local Authorities Act, 1992 Namibia (Act. No. 23 of 1992) [87]: Waste Management Regulations for different Municipalities and Town Councils [88] [SA] National Waste Management Strategy 2020 [89]	The strategy specifically recognises construction and demolition waste noting the waste is classified as non-hazardous though mixed that will require separation for reuse and recycling while the vision encourages the development of material recovery facilities in major urban areas and municipalities	The objectives and targets of the strategy are for waste minimisation and expand recycling systems; and to enforce improvements in municipal waste disposal standards. The main types of solid waste covered in the strategy include domestic, industrial, construction waste and commercial waste. Section 30 (1) (C) of the local authority act, mandates the local authorities to provide waste management services for all kinds of waste. In doing this, the different local authorities have developed their waste management regulations for their respective towns. These regulations prescribe how each town is managing construction and recyclable waste.	The Strategy is aligned with the National Environmental Management Act and is a comprehensive strategy to reduce waste generation, promote recycling, and foster sustainable waste management practices. While the NWMS emphasizes the importance of recycling and reuse across various waste streams, examples of reuse of CDW refer to its use after treatment to improve its use as raw material input for landfill cover, crushing and recycling to create bricks, aggregate in the construction of roads.

POLICY AND LEGISLATION	IMPACTS ON THE CONSTRUCTION SECTOR		
	KENYA	NAMIBIA	SOUTH AFRICA
NATIONAL BUILDING CODES			
[K] National Building Code 2022 [90] [SA] National Building Regulation and Building Standards Act, No. 103 of 1977 [91] [SA] South African National Standards (SANS 10400) [92] [93]	Emphasizes sustainable construction but lacks specific frameworks for circular economy practices. While it includes provisions for waste segregation on construction sites, it offers limited guidance on recycling MSW into construction processes. References to CDW management exist, though they fall short of incentivizing material reuse. AW is not addressed, missing opportunities to incorporate biomass into building materials and taking advantage of traditional building techniques.	Namibia relies on South African building codes and standards for regulatory alignment.	Provides a comprehensive framework for building safety, environmental performance, and waste management (with SANS 10400 acting as a guiding document). However, circular construction concepts, particularly regarding waste streams, are not yet fully mainstreamed. While the standards promote waste reduction and recycling, specific regulations for MSW and CDW recycling remain underdeveloped. Provisions for AW usage in construction are notably absent.

The legal frameworks governing circular construction and waste management vary across Kenya, Namibia, and South Africa. Each country has developed policies and strategies aimed at regulating MSW, CDW, and, to a limited extent, AW. However, there are significant differences in the extent of these regulations, with notable gaps in implementation, especially concerning circular construction practices.

In Kenya, the Environmental Management and Coordination Act and the Solid Waste Management Act of 2022 provide a solid regulatory foundation, promoting sustainable waste management and ecological conservation. The country's focus on waste minimization is reinforced through Kenya Vision 2030, which aims to expand recycling systems and establish material recovery facilities. Notably, the recognition of CDW as a separate waste stream supports circular construction by encouraging recycling and reuse. However, a significant gap is the lack of policies addressing the integration of AW into construction practices. While county governments are tasked with waste management, challenges in local-level implementation hinder the operationalization of these policies. For example, the UN-Habitat SDG indicator 11.6.1 monitoring, conducted through the Waste Wise Cities Tool survey, highlighted significant gaps in waste management across Nairobi, Mombasa, and Kiambu. The survey revealed that only 15%, 5%, and 3% of MSW in these cities, respectively, is collected and managed in controlled facilities. Meanwhile, the overall MSW collection rates stand at 65% in Nairobi, 56% in Mombasa, and 52% in Kiambu. These shortcomings are primarily attributed to insufficient financial resources allocated to the waste management system, preventing comprehensive and environmentally sound MSW management. As a result, this limits the potential for reuse of MSW in circular construction practices.

In Namibia, the Pollution Control and Waste Management Policy (2003) and the National Solid Waste Management Strategy (2018) form the backbone of the country's waste management framework. The Local Authorities Act empowers municipalities to develop their own waste management regulations, including those for CDW. Namibia's long-term development agenda, articulated in Vision 2030, emphasizes sustainable resource use. Despite these efforts, the absence of comprehensive environmental clauses in the constitution creates fragmented policy enforcement. Furthermore, AW remains largely unregulated within construction policies, and uneven implementation across municipalities weakens Namibia's efforts toward circular waste practices. This suggests that waste in Namibia is often not regarded as a valuable resource, and there is a significant lack of awareness regarding the benefits of proper waste management, limiting prospective circular construction practices.

South Africa offers a comprehensive legal framework for waste management, through its National Waste Management Strategy 2020, anchored in the National Environmental Management Act and the Waste Act of 2008. These policies adopt a waste hierarchy that prioritizes reduction, reuse, and recycling over disposal, promoting cleaner production across sectors. The country's cooperative governance structure facilitates municipal waste management, but practical challenges persist in scaling up the use of secondary material in the construction sector. Additionally, AW is not directly addressed in the policies' realm of South Africa, limiting opportunities to integrate biomass by-products into the construction industry.

It is worth mentioning, that the identified lack of circularity considerations in the construction sector is not exclusive to SSA but rather reflects a global missed opportunity. Circular construction has only recently gained traction, with many countries beginning to integrate it into their regulatory frameworks. This shift highlights the emerging awareness of sustainability related to the built environment, but widespread implementation remains a challenge worldwide. However, there is significant potential also to integrate traditional knowledge into circular construction in SSA, where resource recovery and efficiency practices have long been part of local building techniques. For example, earth-based construction, such as adobe or rammed earth, exemplifies sustainable methods that emphasize local materials and reuse. Some of these practices have also been documented in the CiCoSA Good Practices Booklet, providing a useful resource for policymakers seeking to develop sustainable construction policies and frameworks.

Recognizing and explicitly incorporating these practices into formal frameworks, such as national building codes, is essential to bridge traditional knowledge with modern policies. For circular construction to succeed, it is therefore crucial to address the absence of enabling provisions. In the current context, where infrastructure and public services are often inadequate in SSA, decentralized solutions are further essential in driving short-term progress.

Ultimately, establishing supportive frameworks within legislations will be key to fostering sustainable construction aligned with local realities and stakeholders' engagement. Stakeholders involved in the circular construction transition range from government bodies and policymakers to private sector players, including developers, contractors, architects, material suppliers, etc. A comprehensive approach to stakeholder engagement and step-by-step on circular construction implementation are detailed at the Implementation Guide of the CiCoSA Action Toolkit.

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Annex A :

Circular construction good practices

Good Practices Booklet

Circular Construction & Housing in Sub-Saharan Africa

Prepared by

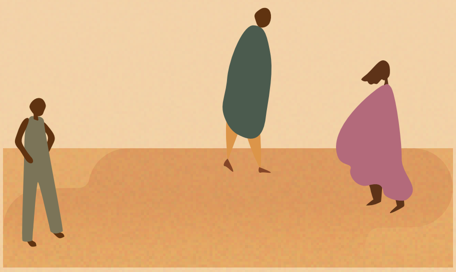
UN-HABITAT

With financial support of

Federal Ministry
for Economic Cooperation
and Development

Good Practices Booklet

Circular Construction & Housing in Sub-Saharan Africa



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This compilation of good practices booklet is part of the CiCoSA toolkit (Circular Construction & Housing in Sub-Saharan Africa), which also includes an handbook and implementation guide on waste wise approaches to sustainable building and construction in Sub-Saharan Africa. It was developed by UN-Habitat with the support of the Government of Germany to strengthen the sustainable building and construction sector, while also improving access to affordable housing and reducing the ecological footprint of cities.

DISCLAIMER

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1. Introduction

Introduction

Climate change, resource depletion, rapid and un-planned urban growth, as well as delivering adequate and sustainable housing are amongst the greatest challenges of the 21st century. One billion people live in inadequate housing conditions and housing shortage is common across many countries.

Building industry is energy and resource intensive

The building and construction sector is a key area that has significant impacts on the economy and environment as one of the main consumers of resources: about 50% of the total use of raw materials and 36% of the global final energy use. With the construction industry accounting for 39% of the greenhouse gas (GHG) emissions related to process and energy use, any effort to mitigate global climate change requires considerable interventions in construction practices[1].

Conservation of resources and energy require rethinking

The 2022 Circularity Gap Report[2] highlighted that only 9% of the global economy is circular, leaving a gap of resources that are not reused or reintroduced to the environment of over 90%. While reducing GHG emissions associated with housing and construction is high on the agenda to mitigate climate change, the global planetary resources boundaries also demand rethinking housing construction with the objective of managing resources optimally.

Housing has a major role to play in resource and energy use

Housing is with 13.5 billion tons the second largest contributor to global GHG emissions[2]. This is due to the vast extraction, transport and construction activities it entails, as well as the energy used to light, heat and cool homes. Further, the housing construction sector, homes' operations and maintenance represent the largest resource and energy footprint among lower- income nations.

1 2021 Global Status Report for Buildings and Construction
2 The Circularity Gap Report - 2022

The African context

Population is growing in Africa

As the continent with the fastest population growth, it is predicted that by 2050 there will be 1.3 billion more people in addition to the current population [1]. This means that the continent will have to be able to host double its present population.

Rapid urbanisation is inevitable

Africa also features the highest urbanisation rate with an annual average of 4%. By mid-2030, 50% of the population in Africa is anticipated to live in urban areas. As of now, there are only three megacities in Africa with a population of over ten million. Eleven more cities are expected to join this category by 2050 [1].

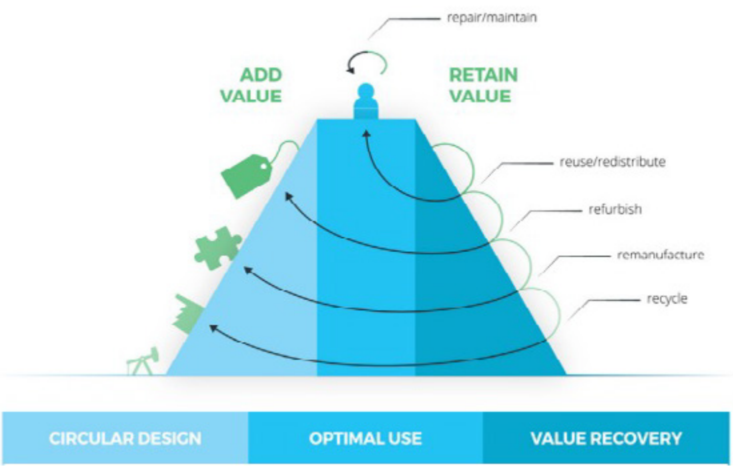
There is a need for affordable and sustainable houses

It is estimated that 75% of buildings needed in Sub-Saharan Africa by 2050 have yet to be built. The region already faces an acute housing shortage – a shortfall of at least 51 million housing units - sparked by urbanisation and population growth, leaving governments to struggle to meet the increasing demand for affordable housing [1].

Resource and energy footprint of buildings continue to grow in Africa

According to the United Nations Environment Programme (UNEP), buildings in Africa had used 57% of the total energy produced in the region in 2019. This has resulted in 32% of the process-related CO2 emissions and makes the building sector the single most significant industry in terms of CO2 emissions2[2].

Circular Construction Principles and 5R



Refuse wasteful use of resources

Reduce energy consumption and waste

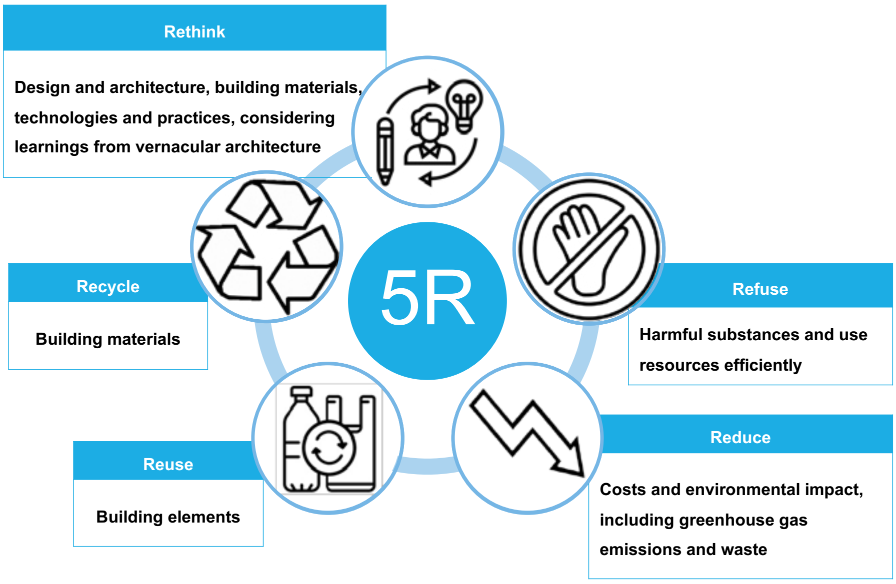
Reuse building elements

Rethink Design and architecture, building materials, technologies and practices

Recycle building materials

1 Global State of Play for Circular Built Environment - One Planet Network
2 UNEP Circularity Platform

The waste wise approach to sustainable building and construction (SBC)



There is a need for a revised approach

1. **Focus on local climate conscious design, which is also resource and culture aware**
   African climate ranges have a large variation. Inefficient design combined with poor understanding of thermal comfort, passive building principles and energy conscious behaviour, has led to energy wastage in buildings. Adopting design approaches that align with local climatic conditions and resource availability is therefore crucial, as much as respecting local heritage and traditional knowledge associated with buildings and architecture.

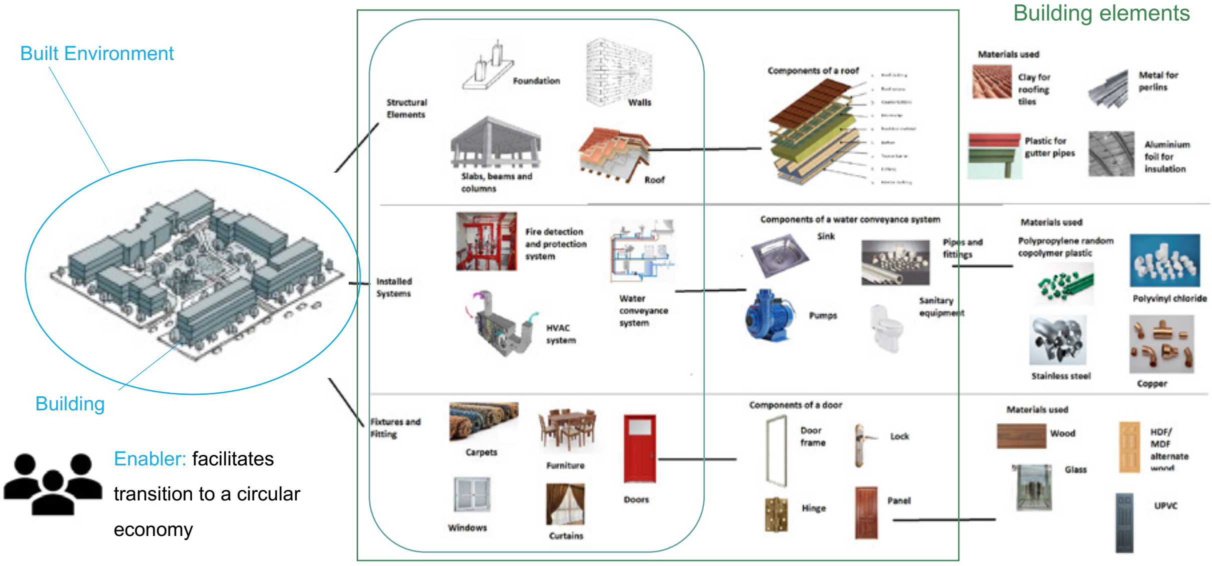
2. **Special consideration to the selection of components and materials**
   The construction industry in Africa mainly utilises raw materials and produces construction materials with intensive energy use. Further, when the building reached its end of life such materials are discarded as waste. Transitioning to a circular approach where resources are kept in use for as long as possible or are designed to regenerate within the life of the built environment is therefore needed.

3. **Making buildings affordable and cater to a large proportion of the population**
   The provision of affordable land and housing at scale remains a challenge for most countries. While the African continent is the most rural region in the world, it is urbanising fast, straining affordable urban land and housing provision in the coming decades. With 40,000 people moving to African cities every day, many of them cannot afford basic formal housing or access mortgage loans.

※ Africa Housing Forum in Nairobi – Habitat for Humanity

What are we talking about?

A building or built environment, is a product system, which is built with a range of construction products. Each of these are made of different components and these components are made of materials.



2. Good Practices

About this booklet

This booklet presents good practices of the waste wise approach to built environments, construction products, components and materials. Good practices on enablers of circular economy and low-carbon design principles, such as marketplaces and information exchange platforms are also included in the guide.

The booklet presents a hand-picked selection of case studies reflecting the African built environment context, presented together with similar good practices observed globally. Global practices applicable to the entire built environment, which employ life cycle thinking and regenerative principles at an early stage of design are presented in the first part of the guide. It then further presents good practices that apply to specific building components and materials.

The presented 22 good practices were selected from 62 case studies through careful evaluation. The focus of the booklet has been to provide the reader a comprehensive and holistic idea on how the journey towards a waste wise approach to the built environment could look like. Good practices that represent different 5R principles have been chosen, considering their ability to be replicated and scaled-up in Sub-Saharan Africa.

Circular economy and low-carbon principles are optimally applied when considered at early design stages of a built environment and when duly combined with life cycle thinking and the resulting environmental footprint. The good practices presented emphasize effective design thinking and intend to promote effective design choices in the construction industry in Sub-Saharan Africa and globally.

Index

The selected good practices are providing information on the good practice, references and categorise them within the waste wise approach and the building environment.

NO.	NAME	LOCAL / GLOBAL	CATEGORY
1	Sunimplant: an eco-building combining hemp and solar energy	Morocco	Product
2	Venlo City Hall	Netherlands	Product
3	Buildings As Material Banks (BAMB)	Belgium	Enabler
4	Norrsken Kigali House	Rwanda	Product
5	Prefabricated houses	Pakistan	Product
6	Rwanda Green Building Minimum Compliance System	Rwanda	Enabler
7	Hotel Azalai	Burkina Faso	Product
8	Las Carolinas - Cohousing	Spain	Product
9	Jenga Green Library	Kenya	Enabler
10	Digital manufactured building system	Mongolia, UK, Austria, Netherland	Product
11	Capitec Bank headquarters: iKhaya	South Africa	Component
12	Houses constructed using compressed earth interlocking bricks	Uganda	Material
13	Zero carbon modular panels	Uganda	Material
14	Restado	Austria, Germany, Switzerland	Enabler
15	Standardisation of adobe blocks (Rukarakara)	Rwanda	Material
16	Circular cement called Susteno	Switzerland	Material
17	DigiYard	South Africa	Enabler
18	Rambricks	South Africa	Material
19	Ecopanel Structural Insulated Wall System	New Zealand	Material
20	Turning excavation waste into sustainable building material	Burundi, Belgium	Material
21	Elementerre factory in Mbour	Senegal	Material
22	100% recycled plastic lumber	Kenya	Material

01. Sunimplant

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Independent consultants	**Morocco**	**2020**	


Image Source https://urbannext.net/sunimplant/

DESCRIPTION

- A spherical building skin made from a hemp fiber bio-composite that integrates frameless photovoltaic-technology of crystalline silicon cells, whose output is optimized through the insulating carrier substrate.
- The modular, off-grid hemp home is inspired by the energy needs of remote regions like the Moroccan Central Rif.
- The vacuum-injection-made panels were resolved with plant-based resins.

CIRCULARITY ASPECT OF THE PRODUCT

- Uses agricultural waste to produce quality construction material, reducing waste and virgin resources extraction. Since the hemp panels are biodegradable, they are easily recyclable at its end-of-life.
- Use of off-grid renewable energy generation system that reduces burden on the national grid and lowers the reliance on non-renewable energy.

AWARDS AND ACCREDITATIONS

- Participated in the competition “Solar Decathlon Africa 2019”
- Nominated for “Hemp Product of the Year 2020”

IMPACT

- Environmental performance - Hemp material is known to be sustainable, recyclable, non-toxic and locally available, it additionally has a low carbon footprint.
- Socio-economic performance – Sunimplant could provide an affordable energy solution for households incorporating knowledge from vernacular architecture.
- Special product characteristics – It has high thermal isolation properties and adequate thermal conductivity.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Inspired by vernacular architecture and the use of local, waste-derived and bio-degradable materials.
- The house is powered by off-grid generated solar power.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology used for Sunimplant is replicable in the region provided that material such as hemp and technical know-how is locally available.
- Scalability of Sunimplant can be improved through collaborations that allow knowledge transfer and combining it with other possible renewable energy production systems such as bio-gas.

MORE INFORMATION

- SUNIMPLANT: An Avant-garde Off-grid Hemp Building
- MOROCCO: Groundbreaking eco-building combines hemp and solar energy

02. Venlo City Hall

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
The C2C Centre	Netherlands	2016	

Image Source http://www.c2c-centre.com/project/venlo-city-hall

DESCRIPTION

» The municipality of Venlo, The Netherlands, has built a new city hall inspired by the Cradle-to-Cradle (C2C) principles.

» It envisioned a healthy workplace for employees of the municipality that incorporates sustainability strategies and builds on the municipality principles: open, transparent, and accessible.

» Therefore, it considered C2C themes: Enhance air and climate quality; integrate renewable energy; define materials and their intended pathways; enhance water quality.

CIRCULARITY ASPECT OF THE PRODUCT

» The building is inspired by and employs Cradle-to-Cradle design thinking, where products, components and materials are designed to regenerate within industrial and biological cycles.

» The building has a living green façade that cleans indoor and outdoor air, uses upcycled materials that are recyclable and generates more renewable energy than it uses.

AWARDS AND ACCREDITATIONS

» C2C® certified

MORE INFORMATION

- Venlo City Hall
- City Hall from Cradle to Cradle: Venlo

IMPACT

» Environmental performance – The building improves indoor and outdoor air quality and increases biodiversity due to the green wall and landscaping, uses renewable energy and energy efficient systems with reduced carbon footprint. The building materials are cradle to cradle certified ensuring optimum utility and prevention of landfilling.

» Socio-economic performance – the buildings' good indoor environment quality improves occupant health and increases labor productivity. It boasts a positive business case with 16.8 million Euro net profit in 40 years and a return on investment of 11.5%.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» C2C ambitions can be transformed into measurable and practical goals. The use of C2C elements and materials can be mainstreamed across Sub-Saharan Africa with the use of certification and incentives.

» High emphasis was placed on water conservation and water stewardship during the use phase of the project.

» The design and procurement involved principles of performance economy from the start, focusing on "the total cost of ownership".

POTENTIAL FOR UPSCALING / REPLICABILITY

» Professionals with adequate technical expertise on Cradle-to-Cradle design thinking or circular design principles need to be involved during the design phase.

» High-level stakeholder involvement is needed to employ design thinking that is not conventional.

» Scalability of practice can be improved by regulating the construction activities via national regulations and standards, establishing circular building codes etc.

03. Buildings As Material Banks

CATEGORY
ENABLER

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
BAMB	Belgium and Germany	2020	

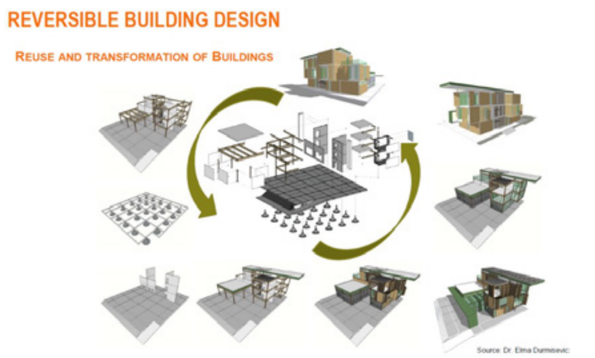


Image Source https://www.bamb2020.eu/about-bamb

DESCRIPTION

- In Buildings As Material Banks (BAMB) buildings will function as banks of valuable materials, instead of being designed to eventually be wasted
- BAMB aims to enable a systemic shift where dynamic and flexibly buildings are designed for deconstruction and disassembly, in order to reuse the elements.
- The project employs reversible building design techniques to enable design for reuse of elements and material passports to track and trace the elements along material pathways.

CIRCULARITY ASPECT OF THE PRODUCT

- The example highlights how to achieve regeneration of materials at the end of the buildings' life through conscious design and creating identity for structural elements through material passports.
- It enables effective deconstruction through disassembly, structural element reuse in other buildings and repurposing of materials.

IMPACT

- Environmental performance – BAMB prevents and reduces waste, using fewer virgin resources which overall reduces the carbon footprint of products, components and materials.
- Socio-economic performance – BAMB creates green job opportunities across the supply chain, new entrepreneurial opportunities and allows cost effective end-of-life management of building materials and components.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- BAMB promotes proactive and conscious design of a building, developing it as an integrated system of components that can be disassembled and reused in the future.
- Two complementary value adding frameworks, namely (1) materials passports and (2) reversible building design, can change conventional building design. This enables building design to be rethought as a set of components or material feedstock that can be upcycled in new constructions.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The scalability of BAMB can be improved by promoting regulations and standards that strengthen design for deconstruction and incorporation of used elements into new constructions.
- A system that monitors the material/component flows (such as material passports) can be applied to a locality where flows are tracked successfully to upscale data monitoring.
- Scalability of Sunimplant can be improved through collaborations that allow knowledge transfer and combining it with other possible renewable energy production systems such as bio-gas.

MORE INFORMATION

- BAMB

04. Norrsken Kigali House

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Norrsken	Rwanda	2018	

Image Source https://edit.massdesigngroup.org/work/design/norrsken-kigali-house

Image Source https://www.archdaily.com/999752/ norrsken-kigali-house-mass-design-group

DESCRIPTION

- Norrsken Kigali House is the largest innovation and entrepreneurship in East Africa, built on the old premises of the Ecole Belge in downtown Kigali.
- Instead of demolishing the old building from 1968, the structure and reinforcing walls were maintained. Almost all the materials were salvaged from demolished sections and reintegrated into the design of the building or used in the landscape.
- The existing landscape was maintained, with buildings designed around trees. New structures were designed in accordance with the principles of modularity and repurpose at the end of life.
- 100% of the roof space is covered with solar PV panels, rainwater harvesting systems were also incorporated. A passive cooling system reduces the need for mechanical cooling.

CIRCULARITY ASPECT OF THE PRODUCT

- The project has employed modular construction and therefore has considered designing for deconstruction and end-of-life management of construction products.
- The project has considered the use of low-environmental impact technologies for operational phase such as lowering energy use.

MORE INFORMATION	• Kigali House • Circular Built Environment - Highlights from Africa

IMPACT

- Environmental performance - Materials and building components are reused, avoiding waste. The landscape design also prevented tree cutting. The building has a low carbon footprint and saves resources with renewable energy use and rainwater harvesting.
- Socio-economic performance – Kigali house generates new green entrepreneurial opportunities, including technical training while empowering green business initiatives. Kigali house saves operation costs due to green features that reduce energy use, water use, and waste.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Focus on education, innovation and entrepreneurship during design and development of a building can generate scalable socio-economic growth.
- A sustainably designed space to nourish new businesses can also be used to promote circular economy and low-carbon concepts among local communities.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology used is replicable given that the structure is modular and or most of the materials have already been reused and are reusable or repurposed.
- Professionals with adequate technical capability, including capability on regenerative design and use of existing brownfield sites for innovative design can help conversion of similar sites.

05. Prefabricated houses

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
ModulusTech	**Pakistan**	**2017**	

Image Source https://modulus-tech.com

DESCRIPTION

» The modular houses designed by ModulusTech are flexible and can be constructed in a matter of days and assembled on-site. Additionally, they can operate off-grid with their own renewable energy and water purification systems.

» The flat-packed prefabricated homes consist of a steel structure with insulated sandwich panel walls and roofs, which are usually made of glass wool insulation, fibre cement composites and recycled polymers. These can be replaced by local materials.

CIRCULARITY ASPECT OF THE PRODUCT

» The modular housing technology facilitates disassembly and deconstruction.

» The product is flexible and relocatable, providing high-level of mobility for reuse in projects.

» The product is resistant to earthquakes and other natural disasters and supports a lifespan of over 50 years.

AWARDS AND ACCREDITATIONS

» Represented Pakistan at the G20 Global Solutions Summit in 2019

» Selected as one of 50 global Youth Solutions by the UN General Assembly for Social Business

» Transformer Award from the Islamic Development Bank

» Global Cleantech Innovation award from UNIDO

IMPACT

» Environmental performance – Autonomous and off-grid energy use makes the house a net zero energy building with a low carbon footprint. Modular construction results in 90%-time reduction and minimized environment impact during construction. The materials used have up to 90% less embodied carbon.

» Socio-economic performance – The product empowers low-income groups and women with affordable and durable housing solutions. The product is affordable, used for diverse purposes and cost effective due to the quick construction process.

» Special product characteristics – Product is customizable, flat-packed and easily relocatable.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» Collaborating with supply chain partners and regional partners can result in manufacturing quality products that are designed to integrate principles of circularity.

POTENTIAL FOR UPSCALING / REPLICABILITY

» The technology is replicable in the region with adequate research and the establishment of supply through a manufacturing partner.

» Prefabricated houses are scalable due to the affordability of the product and the ease and speed of construction.

» Knowledge transfer and training of local experts can increase the scalability of the product in the region.

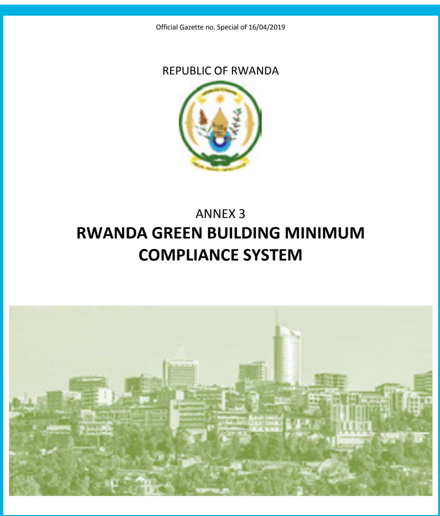
MORE INFORMATION

- Modulus Tech
- Reall Partnerships

06. Rwanda Green Building Minimum Compliance System

CATEGORY
ENABLER

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Rwanda Housing Authority	Rwanda	2017	


Official Gazette no. Special of 16/04/2019

REPUBLIC OF RWANDA

ANNEX 3

RWANDA GREEN BUILDING MINIMUM COMPLIANCE SYSTEM

Image Source https://gggi.org/report/rwanda-green-building-minimum-compliance-system/

DESCRIPTION

» The Rwanda Green Building Minimum Compliance System (GBMCS) is developed as a holistic system with a set of green building indicators to guide building designers and practitioners on integrating energy & water efficiency, environmental protection, better indoor environmental quality and green innovation in new buildings during the design, construction and operational stage.

» Buildings have to achieve at least 60 out of 190 points to comply with the Rwanda Green Building Minimum Compliance system to be granted permits to build and it applies to new buildings and major refurbishments of: Commercial buildings (excluding warehouses and retail shops); Public administrative and institutional buildings (excluding correctional services, police, fire department); Social, cultural & assembly buildings; Health facilities; Educational buildings (excluding living areas for students).

CIRCULARITY ASPECT OF THE PRODUCT

» This policy emphasizes circular principles such as wastewater recycling and use of recycled content in building materials.

» Policy, relevant guiding procedures and tools promote a more circular economy, allowing wide-spread incorporation of these principles in the construction industry.

IMPACT

» Environmental performance – Clauses are included in the system to ensure energy and water efficiency, and reduction of waste.

» Socio-economic performance – Clauses are included to ensure social wellbeing of the occupants and surrounding community. Capacity building programs organized to disseminate it among professionals and numerous awareness initiatives for civil society have also been implemented.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» Including mandatory and optional indicators together with making the compliance system detailed and easy to understand can help popularize it among industry professionals.

POTENTIAL FOR UPSCALING / REPLICABILITY

» The Rwanda Green Building Organisation is part of the World Green Building Council, a network with 36,000 members across 70 countries aiming to raise awareness on sustainability and circularity and to put them on public agendas.

» The compliance system is replicable given that it is designed to suit varying conditions in each country (e.g., climatic condition, locally available materials).

» The compliance system can be scaled-up to be applicable for all building categories. Continuous capacity building programs might be needed to successfully enforce the system and create more awareness among the public.

MORE INFORMATION

- Rwanda Green Building Minimum Compliance System
- Circular Built Environment - Highlights from Africa

07. Hotel Azalai

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Azalai Group	Burkina Faso	2021	

Image Source: https://www.readytotrip.com/hot... rovince/Ouagadougou/azalai-hotel-independance/

DESCRIPTION

- Hotel Azalai was constructed in Ouagadougou in 1960 and is regarded as an icon in the city. A significant part of the building was set on fire during the civil uprisings in 2014. After the uprising, it was deemed cheaper to repair and reuse the building, rather than rebuilding it.
- Hotel Azalai underwent its second major refurbishment since its construction. This renovation consisted of 45% of refurbishment and 55% of reinforcement of the existing building. The entire complex was reinforced with an additional structure to support the new floor slab.

CIRCULARITY ASPECT OF THE PRODUCT

- The refurbishment of Hotel Azalai has extended the useful life of the structure and its components by profiting from the original structure of the building.
- It has also allowed the adaptation of building space for a new purpose and flexibility.

IMPACT

- Environmental performance - Repair and reuse of existing structures reduces waste and raw material extraction. The building also reduces energy consumption due to thermal insulation.
- Socio-economic performance – The new design increased lifespan of the building allowing preservation of a local historical monument. It additionally created local job opportunities.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Careful selection of companies to carry out the project was integral in achieving the refurbishment goals.
- Government support for the project is an instrument to facilitate access to finance for construction projects.
- Engagement of foreign companies to work with local companies for technical guidance and capacity transfer strengthened knowledge exchange.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology and concepts are replicable provided that the initial development is suitable to undertake a similar refurbishment.
- Expertise gathered during Hotel Azalai refurbishment and other similar projects fosters a knowledge base associated with complex projects involving repair, reuse and refurbishment.
- National urban development guides and other standards could incorporate more guidance on refurbishmean affordable energy solution for households incorporating knowledge from vernacular architecture.

MORE INFORMATION

- Burkina Faso: start of rehabilitation work on the Azalaï Indépendance Hotel
- Circular Built Environment - Highlights from Africa

08. Las Carolinas - Cohousing

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Entrepatios	Spain	2019	

Image Source: https://www.facebook.com/people/RamBrick-Eco-Smart-Building-Materials/100057227179284/

DESCRIPTION

- Las Carolinas is the first collaborative housing building with the "right of use" as tenure system in the City of Madrid. Alternative to renting and buying, "right of use" enables occupants to enjoy a home for an indefinite period and to participate in making decisions about its design and its later life, but without acquiring it as property.
- It contains 17 apartments and was constructed using cross laminated timber (CLT) massive wood elements.
- The building has its own energy production and very low energy demand, as well as a community based mutual support.

CIRCULARITY ASPECT OF THE PRODUCT

- Modular and flexible design of the building allows for maximum utilization of building spaces and reduction of wasted resources in terms of materials, cost, time, energy, etc.
- Materials are carefully selected to be eco-friendly and allow easy recycling at the end of their usable life.

AWARDS AND ACCREDITATIONS

- Project is certified by ECOMETRO®

MORE INFORMATION

- Entrepatios

IMPACT

- Environmental performance – The building has reduced energy demand, uses renewable energy and optimizes water consumption. It is made of bio-degradable, reusable and non-toxic materials with low-carbon footprint, helping mitigate impacts associated with global warming.
- Socio-economic performance – The building contributes to the health of its occupants, promotes community participation and social wellbeing. It has a higher initial investment yet lower operational costs and impact of utilities for its inhabitants, which makes it more affordable in the long run.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- The participatory design model allows for better solutions in terms of climate adaptation of passive solutions, adaptability of spaces and common areas, etc.
- Tenure model of cooperative housing enables an affordable solution with decent rents for the local community.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology and the concepts used in Las Carolinas – Cohousing can be replicated provided that the design can use locally available materials and suits local climatic conditions.
- Scalability of the practice of these concepts can be improved by including them in regulations, building design, and construction standards.

09. Jenga Green Library

CATEGORY
ENABLER

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Kenya Green Building Council	Kenya	2022	

Image Source https://x.com/OfficialKGBS/status/1512311910292668419

Image Source https://jengagreenlibrary.com/directory

DESCRIPTION

» The green building materials and services directory Jenga Green Library is a one-stop-shop offered by the Kenya Green Building Council for displaying the entire supply chain of sustainable building materials and services for relevant stakeholders such as suppliers, dealers, retailers, service providers, and sustainable building consultants.

» Companies that provide environmentally beneficial services and/or products can share their data sheets with the Kenya Green Building Council, which assesses and potentially lists the products and services.

CIRCULARITY ASPECT OF THE PRODUCT

» The platform provides visibility for green products to relevant buyers and supply chain stakeholders. This allows inclusion of eco-friendly products in the building construction, which include recyclable, non-toxic and low-environmental impact products.

» The platform facilitates the connection of buyers and users and supports the exchange and purchase of low-carbon and recyclable materials. It also facilitates developers to find relevant professional services.

IMPACT

» Environmental performance – The library promotes green options for construction methodologies and materials allowing creation of living spaces that have a low environmental impact.

» Socio-economic performance – The library provides training to professionals and allows advertising of the environmental benefits of services and/or products.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» A digital platform that provides information on green services and products allows connection of environmental/green buyers and users to suppliers, acting as a marketplace.

» Developing hubs and networks connecting buyers and suppliers increases uptake of green/environmental products and services and their competitiveness, by improving the ability for these parties to find one another.

POTENTIAL FOR UPSCALING / REPLICABILITY

» The concept and technology behind Jenga Green Library are replicable in the region, especially for countries that already have an established green building council.

» The scalability of the platform can be further improved by ensuring the display of services and products that are accredited of their environmentally beneficial performance.

MORE INFORMATION

- Jenga Green Library

10. Digital manufactured building system

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
WikiHouse	Mongolia, UK, Austria, Netherland	2013	


Image Source https://www.wikihouse.cc/product

DESCRIPTION

- » The aim of WikiHouse is to provide open-source knowledge and tools to build beautiful, zero-carbon buildings into the hands of every citizen, community and business.
- » WikiHouse Skylark is a building system made up of interlocking timber blocks that are digitally fabricated to milimetre precision, and then assembled.
- » Building blocks can be delivered to site, then rapidly and accurately assembled by almost anyone, with minimal equipment and even without technical construction knowledge.

CIRCULARITY ASPECT OF THE PRODUCT

- » At the end of their life, structures can be disassembled instead of demolished, and blocks reused or recycled. The building system is designed for deconstruction and reuse of its components.

IMPACT

- » Environmental performance – WikiHouse is designed to reduce waste through 80% reusability, has negative upfront carbon cost, saves energy and its modular construction saves resources.
- » Socio-economic performance – It is cost effective due to the use of durable and local materials and its simple assembly, produces minimum waste and saves time.
- » Special product characteristics – The product is standardized, highly insulated and high in strength and allows multiple applications.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- » Collaborating on common, shared design solutions with a distributed network of small, local fabricators and assemblers can provide sustainable solutions for housing deficiency while creating entrepreneurial opportunities.

POTENTIAL FOR UPSCALING / REPLICABILITY

- » The technology behind WikiHouse is open source and can be replicated where raw materials can be sourced locally.
- » Collaboration and knowledge transfer opportunities for local experts and entrepreneurs can enhance the scalability of application.

MORE INFORMATION	• WikiHouse

12. Houses constructed using compressed earth

CATEGORY
MATERIAL

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Smart Havens Africa	Uganda	2018	

Image Source https://shafrica.org/what-we-do/

Image Source https://www.designindaba.com/articles/creative-work/smart-havens-africa-uses-human-centered-business-models-help-poor-build-homes

DESCRIPTION

» Smart Havens Africa (SHA) is a Ugandan social enterprise founded to provide low-cost eco-friendly and sustainable affordable housing solutions for low-income families in Africa.

» SHA houses are constructed using compressed earth interlocking bricks.

CIRCULARITY ASPECT OF THE PRODUCT

» UThe bricks are pressed onsite using local materials. There is less waste and no material is transported across large distances, which means pollution related to transportation is reduced. The bricks are made of bio-degradable materials and hence can be safely added back to the natural environment.

AWARDS AND ACCREDITATIONS

» Global Social Benefit Institute (GSBI) Alumni Winners of the Duke of York's Pitch at the Palace Africa award in 2018

» Africa Prize for Engineering Innovation in 2019

» 2020 Fellow of the Global Good Fund

MORE INFORMATION

- Smart Havens Africa
- Smart Haven Profile

IMPACT

» Environmental performance – BIM saves resources and minimizes waste, allows incorporating sustainable and circular principles in the design, construction, and operation phases of the building.

» Socio-economic performance – BIM allows remote working especially in the wake of a global pandemic and saves cost and time since it provides a common platform for on-time communication across departments.

» Special product characteristics – BIM can define standards and policies, provides a common data environment, an excellent platform for design and construction delivery and coordination. The model construction also enables visualization.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» Digital tools that allow detailed modelling of buildings can be effectively used in identifying, analyzing and choosing a building's products, components and materials in detail to allow regenerative/circular design.

POTENTIAL FOR UPSCALING / REPLICABILITY

» The practice is replicable, given the availability of necessary infrastructure such as information technology facilities.

» For the application to have wider use, training and capacity building of design professionals would be necessary.

» Pooling of design resources may need to be considered for similar applications to be used for small and medium scale construction projects, due to affordability.

13. Zero carbon modular panels 2019

CATEGORY
MATERIAL

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
IBS foundation	Uganda	2019	

Image Source https://ibs.foundation/local_manufacturing.htm

DESCRIPTION

- The company utilizes proven technology to convert agricultural waste in the form of rice straw into a high performance, zero carbon construction panel.
- This is intended as a solution to prevent the burning of rice straw in Uganda.
- The panels possess excellent physical properties and can therefore either be used as a load-bearing building panel or as cladding in combination with a structure made of lightweight steel, wood or concrete.

CIRCULARITY ASPECT OF THE PRODUCT

- Rice straw is biodegradable and the design of the panel enables modular construction, which helps to make the construction regenerative and low-impact.
- It is made of a highly compressed straw core covered in craft paper. The straw core enables load bearing and therefore can replace lightweight steel, wood and cement. With this, agricultural waste is upcycled to a high-quality construction material.

AWARDS AND ACCREDITATIONS

- Manufactured to British Standard BS 4046:1991.

MORE INFORMATION

- Zero Carbon Panels
- IBS Foundation

IMPACT

- Environmental performance – The panel reduces energy consumption during manufacturing, as their production requires no water and no wood (fuel) and they have a negative carbon footprint due to carbon sequestration.
- Socio-economic performance - Fast modular construction saves project delivery time and costs for stakeholders.
- Special product characteristics – Self-supporting wall modules do not require additional framing. The panels also enable good thermal insulation for a comfortable indoor-outdoor climate and good sound insulation.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Designing products suitable for the climatic conditions and socio-economic needs of the region results in lower resource consumption during operation.
- Training of professionals in using the material in design and construction can popularize the product among industry professionals.
- Good on-going partnerships with many parties enable building a strong local supply chain which facilitates the implementation of circular economy.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology can be replicated given that the specific locality has a viable and adequate source of the raw material.
- The product is scalable due to the time and cost benefit of modular construction that are integrated into the product design. It can further improve by standardizing the design and construction technology of the modular panels to be included in national building codes and local standards.

14. Restado

CATEGORY
ENABLER

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Restado	Austria, Germany, Switzerland	2017	

Image Source https://www.oneplanetnetwork.org/knowledge-centre/projects/restado-platform-reuse-construction-material

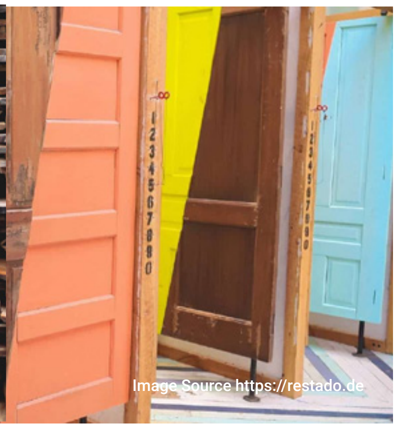


Image Source https://restado.de

DESCRIPTION

- IRestado is the largest marketplace for reclaimed construction materials in Europe.
- The materials include bricks, wood, tiles, windows, doors and façade elements and come from deconstruction, oversupply or are left over from projects.
- There are more than one million items, which are worth more than €40 million in stock. These can be matched to demand for any construction project.
- Restado offers specific product information together with building instructions, which enable non-professional and unskilled individuals to use them efficiently.

CIRCULARITY ASPECT OF THE PRODUCT

- Restado allows reuse of resources and avoids waste by enabling deconstructed/ oversupplied/ left over elements and materials to find a use.
- It enables information sharing that helps promote circularity.

MORE INFORMATION

- Restado - Marketplace for the reuse of construction material
- Restado - platform for the reuse of construction material

IMPACT

- Environmental performance – Restado reduces waste and extraction of raw materials while saving GHG emissions due to use of materials.
- Socio-economic performance - Items worth more than €40 million are available in the digital marketplace and they are matched to demand from construction projects.
- Special product characteristics – Restado links reclaimed resources with buyers (ease of access) and offers specific product information together with building instructions and making the resource suitable for both private and professional buyers (ease of use).

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- The digital platform provides information on materials as well as building instructions, making it suitable for both private and professional buyers.
- A blog on building practices promotes knowledge extension and raising awareness for the user and is beneficial for single purpose or DIY (do-it-yourself) users and industry professionals who lack the knowledge.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology is replicable provided that adequate infrastructure (e.g., internet facilities, smart phones etc.) is established or available in the locality and the application is calibrated to include local language(s).
- As a means of providing fast information for affordable construction materials, the application has high scalability.

15. Rukarakara

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Massdesign Group	Rwanda	2021	


Image Source https://inhabitat.com/incredible-modern-rwandan-education-center-made-with-local-materials/


Image Source https://www.oneplanetnetwork.org/sites/default/files/2021-12/211205_SBC%20CBE_Africa_highlights_final_0.pdf

DESCRIPTION

- Adobe blocks, also known as Rukarakara, are made of a mix of soil and water and sometimes with a mix of grasses depending on the type of soil.
- The Rwanda Housing Authority established the Local Building Materials Think Tank to bring together stakeholders with complementary expertise to review ways to standardize construction with adobe blocks.
- The Think Tank drafted the Rwanda Standard for Adobe Blocks and Technical Guidelines on Adobe Block Construction in Rwanda which is under review by Rwanda Standard Board.

CIRCULARITY ASPECT OF THE PRODUCT

- The product is bio-degradable and can be added to the natural environment safely.
- It saves non-renewable resources due to the simple manufacturing process that uses renewable energy (sun-dried bricks).

IMPACT

- Environmental performance – Rukarakara uses in situ local materials (clay and biodegradable fibre) and the brick is sundried. Hence, there are no carbon emissions in production.
- Socio-economic performance – It is cost effective since the raw material can mostly be found on site, the method of construction is simple and does not require non-renewable energy and uses local know-how and labour, creating jobs locally.
- Special product characteristics – The product is thermally efficient with good insulation qualities.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- The standard helps formalizing and standardizing the production and use of Rukarakara.
- Education and training leads to local capacity building, opening-up entrepreneurial opportunities.
- Collaborations and partnerships between the local communities and public authorities help create feasible and environment friendly solutions addressing construction technology-related challenges and at the same time allow knowledge transfer and innovation.

POTENTIAL FOR UPSCALING / REPLICABILITY

- Product is replicable if an adequate supply of suitable clays can be maintained. Due to the simple production process the replicability of the product is increased.
- Also, due to the simple production process and the cost effectiveness, the product has a higher scalability. It can be further improved by standardizing Rukarakara bricks to be included in national building codes and local standards.

MORE INFORMATION

- Circular Built Environment - Highlights from Africa
- Dignified rural home design in Rwanda using adobe block
- Adobe Block Construction in Rwanda

16. Susteno - Circular cement

CATEGORY
ENABLER

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Holcim	Switzerland	2021	

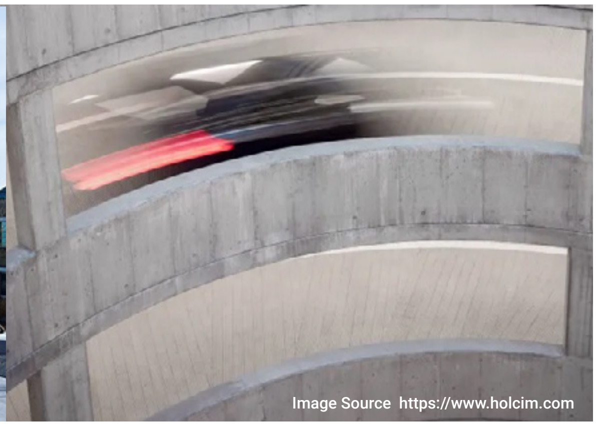



Image Source https://www.holcim.com

DESCRIPTION

- Susteno cement is made of high-quality processed mixed granulate from demolition projects
- Based on scientific evidence of the material's performance, Holcim began offering Susteno after 2021.
- This circular cement has been applied in landmark structures such as the soon-to-open HSG Learning Center at the University of St. Gallen, a 7,000 m2 work and study facility designed by Sou Fujimoto Architects.

CIRCULARITY ASPECT OF THE PRODUCT

- Upcycles waste materials (construction and demolition waste) by using them in high quality construction products.

AWARDS AND ACCREDITATIONS

- Approved for use in concrete for all exposure classes according to the SIA 262 and SN EN 206 standards.

IMPACT

- Environmental performance – Susteno reduces the clinker content of the cement and therefore CO2 emission by 10%, has a 30% lower carbon footprint compared to normal cement and uses 20% recycled C&D waste thereby ensuring 20% fewer resources drawn from nature.
- Socio-economic performance – The product is cost effective and can create entrepreneurial opportunities in C&D waste management.
- Special product characteristics – The product is approved for use by SIA 262 and SN EN 206 standards.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Susteno is a good solution for constructions where use of concrete is inevitable.
- Partnership and collaboration for knowledge transfer can improve the performance of the local cement production.

POTENTIAL FOR UPSCALING / REPLICABILITY

- With proper knowledge transfer and a viable supply of proper raw materials, the technology can be replicated in the local cement kiln.
- Due to the cost effectiveness of adding a waste product, the technology shows scalability.

MORE INFORMATION

- Susteno, resource-saving cement
- Switzerland: circular cement

17. DigiYard 2017

CATEGORY
ENABLER

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Arup	South Africa	2018	

Image Source: https://research.arup.com/projects/article-digiyard/

Image Source https://www.crown.co.za/construction-world/projects-and-profiles/10150-arup-incubates-a-digital-materials-transfer-platform

DESCRIPTION

» DigiYard is a digital platform that facilitates the flow of usable construction waste and surplus building material from construction sites to informal settlement upgrading projects.

» The platform aims to reduce construction waste whilst addressing the need for affordable, high quality building materials in the informal housing sector.

CIRCULARITY ASPECT OF THE PRODUCT

» DigiYard allows reuse of resources, thus preventing waste and extraction of virgin resources.

» It enables information sharing that helps circularity.

IMPACT

» Environmental performance - DigiYard reduces construction and demolition waste.

» Socio-economic performance – It is a marketplace for affordable and high-quality materials. It inspires a supply chain that optimizes material utilization and empowerment of small-scale builders via training and capacity building.

» Special product characteristics – DigiYard is a user-friendly application that is usable by a variety of audiences, including material traders in the construction and demolition industries.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» Technology makes information on waste accessible to potential users of this waste as resource. It facilitates resource recovery and reduces the cost of inventory and material waste.

POTENTIAL FOR UPSCALING / REPLICABILITY

» The technology is replicable provided that adequate infrastructure (e.g., internet facilities, smart phones etc.) are established or available in the locality.

» As a means of providing fast information for affordable construction materials, the application has high scalability. It can improve to include a mechanism for quality assurance, waste management service providers, consultants etc.

MORE INFORMATION

- DigiYard
- The Circular Economy: Our Journey in Africa So Far
- Circular Built Environment - Highlights from Africa

18. Rambrick

CATEGORY
MATERIAL

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
USE-IT	South Africa	2017	

Image Source https://www.facebook.com/people/RamBrick-Eco-Smart-Building-Materials/100057227179284/

DESCRIPTION

- RamBrick is a compressed earth block that uses waste soils from construction and demolition sites and crushed rubble to manufacture blocks for housing construction.
- The RamBrick is composed of a blended mixture of 70% waste soils, 25% crushed builders' rubble and 5% cement stabilizer.
- They are made without water, using a hydraulic compression system to press the waste materials into blocks that are subsequently air cured.

CIRCULARITY ASPECT OF THE PRODUCT

- The product uses a significant amount of waste resources (95%) and low environmental impact manufacturing method (waterless, sundried).
- Being thermally efficient, the environmental impact of the operational phase is expected to be low.
- Raw materials allow for recycling at deconstruction.

AWARDS AND ACCREDITATIONS

- The AfriSam-SAIA Sustainable Design Award
- Energy global awards (tbc)

MORE INFORMATION

- RamBrick Eco Smart Building Materials
- USE IT

IMPACT

- Environmental performance – Rambrick is a low carbon embodied building material (251kg CO_2/m^2 compared to concrete blocks at 760kg CO_2/m^2), requires zero water or fuel in manufacturing and reduces waste.
- Socio-economic performance – The product is 16% cheaper than concrete blocks and 45% cheaper than clay bricks. It is an affordable housing solution that can create local employment opportunities.
- Special product characteristics – Product is highly thermally efficient, sound-proof and bullet-proof.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Vernacular architecture combined with innovative technology can save resources and increase efficiency.
- Creating partnerships with local and international partners can ensure sustainable enterprises.
- Corporate Social Investment (CSI) is an opportunity to save money through appropriate waste management and to brand the company as a green and socially-responsible organization.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology can be replicated where there is a viable and appropriate supply of construction and demolition waste.
- The product is more affordable compared to other similar construction products, demonstrating higher scalability potential. It can further improve by standardizing Rambricks to be included in national building codes and local standards.

19. Ecopanel Structural Insulated Wall System

CATEGORY
PRODUCT

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
WikiHouse	Mongolia, UK, Austria, Netherland	2013	


Image Source https://www.ecopanel.co.nz

DESCRIPTION

- Ecopanel structural insulated wall system is a complete prefabricated wall solution, crafted in factory-controlled conditions in New Zealand.
- It provides a complete solution that delivers structural framing, insulation and exterior weather tightness in a solid, one-piece panelized wall, delivered and installed on site.

CIRCULARITY ASPECT OF THE PRODUCT

- The product is fabricated with local and safe materials, avoiding the use of plastics. This makes the product bio-degradable and easy to recycle.
- Ecopanel is standardized and allows modular and quick construction. This enables design for deconstruction and low-environmental impact.

AWARDS AND ACCREDITATIONS

- Certified for compliance with the New Zealand Building Code.

MORE INFORMATION

- Ecopanel

IMPACT

- Environmental performance – Ecopanel allows increased energy efficiency of the building. Modular construction reduces the environmental impact during construction and industrial and production waste due to factory-controlled production process. When used in local construction sites, it reduces carbon emissions from transport.
- Socio-economic performance – Ecopanel ensure indoor environmental quality and the modular construction lessens the social impact.
- Special product characteristics – Ecopanel is safe and non-toxic, strong and airtight with good insulation properties.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Sourcing materials from companies employing sustainable and regenerative practices is an effective way to establish a green procurement process.
- Use of local, bio-degradable materials and exclusion of plastic in the production make it easier to recycle at the end-of-life.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology is replicable provided that a viable supply chain is established for the provision of raw materials.
- Ecopanel has high scalability due to its diverse application, however, it may differ based on the climatic conditions of the region.

20. Turning excavation waste into sustainable building materials

CATEGORY
MATERIAL

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
BC Materials	Belgium	2018	


Image Source https://www.bcmaterials.org/en_354_negenoord.html


Image Source https://www.proptechlab.be/bc-materials-turns-excavation-waste-into-sustainable-building-material

DESCRIPTION

» Belgium excavates around 37 million tons of soil per year and 70% of it is being landfilled as waste.

» BC Materials transforms the excavated earth into clay plasters, compressed earth blocks and rammed earth.

» These are 3 different types of building materials that can replace conventional use of virgin resources for plasters, bricks, floors and walls.

CIRCULARITY ASPECT OF THE PRODUCT

» Upcycles excavation waste into building material.

» The material doesn't change chemically while being processed and at the end of their life cycle the blocks can be reused.

» These materials are sourced out of local excavations at construction sites to reduce transport and limit the depletion of resources.

AWARDS AND ACCREDITATIONS

» Tested for soil pollution and certified by Esher – Belgium

» Soil analysis by Het laboratorium géomécanique (BATir, ULB)

» Samples tested and certified by Techno Campus Gent (KUL)

MORE INFORMATION

- BC Materials turns excavation waste into sustainable building material
- BC Materials Concept

IMPACT

» Environmental performance – Materials are designed to reduce waste by upcycling a waste material. They are carbon neutral since raw material used is a local resource and production is not an energy intensive process.

» Socio-economic performance – Local jobs are created with opportunities for upskilling.

» Special product characteristics – Product improves indoor environmental quality, minimizes need for ventilation by buffering humidity and neutralizing odors. Product is non-toxic, standardized, allows multiple application and has good insulation properties.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

» Effective collaboration with standardizing institutes (e.g., national building authority) to formalize the use of building materials can popularize the product among industry professionals.

» Development of other value-added services such as workshops and trainings, together with production of diverse range of products improves the economic sustainability of the business.

POTENTIAL FOR UPSCALING / REPLICABILITY

» The technology is replicable if appropriate type and quality of raw materials are available and supply of said materials is viable in the locality.

» The technology is scalable since there is possibility of product diversification (e.g., bricks, plaster etc.). It can further improve by standardizing the products and technology to be included in national building codes and local standards.

21. Elementerre factory in Mbour 2010

CATEGORY
MATERIAL

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Elementerre	**Senegal**	**2010**	


Image Source http://www.elementerre-sarl.com

DESCRIPTION

- Elementerre makes prefabricated slabs and panels from mud and typha, which is an invasive water reed that grows aggressively in some of Senegal's freshwater bodies and clogs the flow of rivers and canals.
- These slabs, which are insulating better than compressed earth blocks, can be used in the construction of roofs, floors and walls and can even be installed in standard concrete buildings to reduce solar gain.
- There are further plans to commercialize the improved versions of traditional mud bricks, like theone used in northern Senegal.

CIRCULARITY ASPECT OF THE PRODUCT

- Use of mud and typha, an invasive water reed, for production lessen the burden on virgin resources.
- Both mud and Typha are bio-degradable.

MORE INFORMATION

- Elementerre
- Typha

IMPACT

- Environmental performance – The product uses less energy and water during the material production and building construction, compared to buildings constructed of concrete, iron and steel.
- Socio-economic performance – The product creates employment opportunities in manufacturing building materials and construction of buildings and uses traditional construction techniques. They are also affordable and cost-effective.
- Special product characteristics – The product has improved thermal efficiency and insulation properties.

LESSONS LEARNT APPLICABLE FOR SUB-SAHARAN AFRICA

- Building housing and other buildings with locally available materials, which are either derived from waste or help solve an environmental challenge creates multi-fold benefits.
- Opportunities of partnership and collaboration can empower local marginalized communities.

POTENTIAL FOR UPSCALING / REPLICABILITY

- The technology is replicable if similar or alternate raw material to typha can be found in the locality.
- The product is scalable since the production is cost effective and the application is diverse. It can further improve by standardizing the design and construction technology with mud and typha to be included in national building codes and local standards. Trialing bio-degradable materials with similar attributes may be an opportunity.

22. 100% recycled plastic lumber

CATEGORY
MATERIAL

COMPANY	COUNTRY OF IMPLEMENTATION	YEAR	5Rs
Ecopost	**Kenya**	**2009**	


Image Source https://www.ecopost.co.ke/index.php?page=products

DESCRIPTION

- Ecopost is a company in Kenya that manufactures plastic lumbers using 100% recycled plastics, addressing specific social concerns such as theft of wood fences as fuel.
- The lumber is widely used for outdoor decking with zero chemical treatment.
- Available in a variety of lengths and sizes. (5 to 11cm cross-section (square/round) & 4m length) and in black, grey, brown colour and can be painted to any preferred colour.

CIRCULARITY ASPECT OF THE PRODUCT

- Ecopost allows for plastic waste to be upcycled into durable, good quality construction materials that are long lasting. This prevents cutting of trees for fences.

AWARDS AND ACCREDITATIONS

- 2012 Energy Globe Awards
- 2010 WWF Nature Challenge Award by WWF (World Wildlife Fund)
- 2009 & 2010 Enablis Launch Pad Winners in the Green/ Ecological business category and many fellowships

MORE INFORMATION

- Ecopost Limited

IMPACT

- Environmental performance – 600 tones of plastic recycled from the environment, saving the lives of animals and plants. 60,000 wooden posts replaced, saving approximately 2,400 trees and helped mitigate climate change by saving acres of forest land that sequester CO2 emissions.
- Socio-economic performance – Product has a long-term cost effectiveness due to reduced maintenance and replacement. Income opportunities are provided for over 2,000 marginalized people while raising awareness about sustainable production and consumption in the community. The product addresses a specific social concerns which is theft of wooden fences for fuel.
- Special product characteristics – Ecopost is better than treated timber since there is no leaching of chemicals into underground water.

LESSONS LEARNT (APPLICABLE FOR SUB-SAHARAN AFRICA)

- Innovative waste wise approaches can be used to address specific social concerns such as theft of wooden fences for fuel, plastic pollution in slum areas etc.
- Collaboration with the local community is an ideal way to ensure a viable supply of raw materials.

POTENTIAL FOR UPSCALING / REPLICABILITY

- Since plastic waste is a common problem in Sub-Saharan Africa, the technology can be replicated provided that a viable supply can be maintained.
- The product is marketable and has good social benefits attached to its production. Hence it has good potential for scalability. It can further improve by standardizing and by being included in national building codes and local standards.

Good Practices Booklet
Circular Construction & Housing in Sub-Saharan Africa

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