Circular economy in Africa: examples and opportunities

BUILT ENVIRONMENT

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This article is part of a collection of insights on the circular economy in Africa. The goal of this collection is to explore the potential of the circular economy in a selection of key economic sectors in African countries and highlight examples of the circular economy in action. The sectors explored in this study are: food and agriculture; fashion and textiles; plastics; e-waste; automotive; and the built environment. The collection also considers the key role of public policy and the financial sector in creating the conditions needed for the transition to a circular economy.

The collection is the result of a joint effort led by four organisations: Chatham House; the Ellen MacArthur Foundation; ICLEI Africa; and the University of Lagos, who worked closely to combine their complementary knowledge and expertise on this broad topic. While the collection was curated by the Ellen MacArthur Foundation, it reflects a plurality of views and analyses.

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CHATHAM HOUSE

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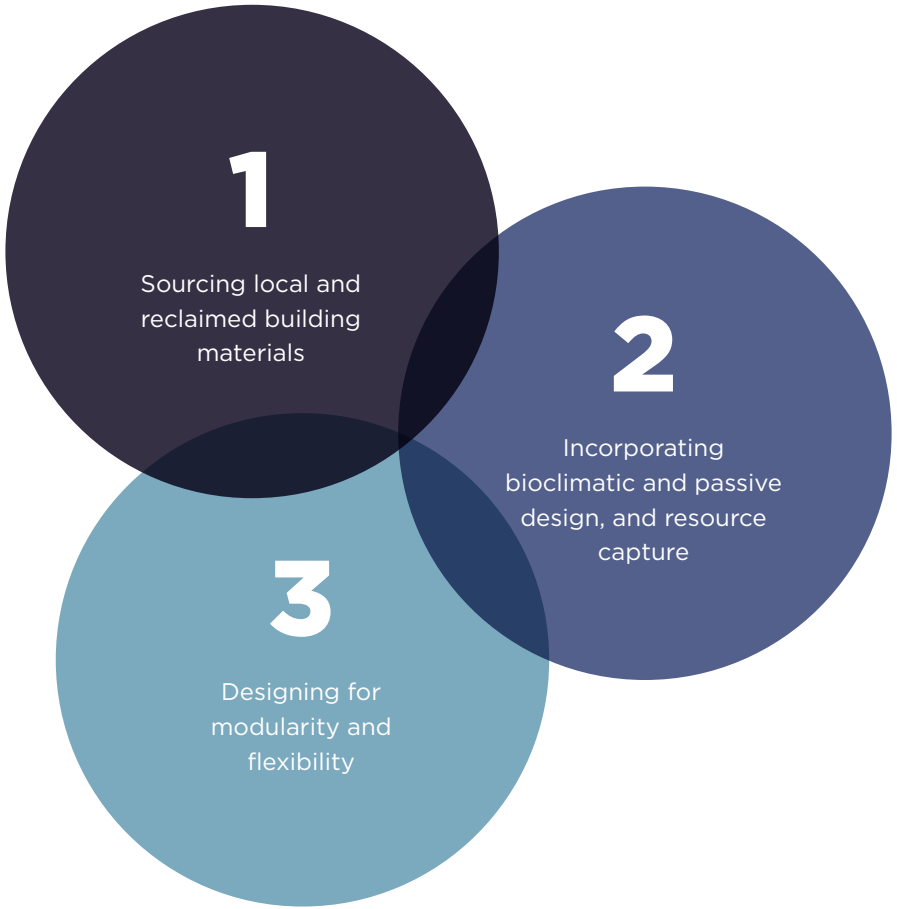
Introduction

Africa is the second most populous continent in the world and, according to forecasts, the urban population of African cities is expected to nearly triple by 2050 to 1.34 billion.[1] Cities often struggle to keep up with this growth, resulting in informal settlements with no, or limited, access to electricity, water, sanitation, and waste management. In 2015, about 190 million people in Sub-Saharan Africa (±17% of the total population) lived in informal settlements, and without investment in housing stock, it is expected that this figure could double every 15 years.[2] Added to this, due to a growing middle class, a spatial pattern of underserviced, unplanned settlements bordering elite, gated communities has become a prominent feature of many African cities.[3] Currently, most resources needed to service residents move linearly and infrastructure is not extensive. It is estimated that between 60% and 80% of the estimated built environment[4] that will be needed by 2050 to support growing populations across the continent has yet to be laid.[5],[6] ▶

▶ To ensure equitable access to services and improve quality of life, it will be vital to invest in housing and infrastructure to bridge this gap. This needs to be developed in a form that ensures sustainability, making efficient use of limited materials and using building processes that are less energy-intensive, in order to lower greenhouse gas emissions and stop environmental degradation. Governments, the private sector, NGOs, and the city residents themselves are trying to tackle the issue through various infrastructure and housing projects, and investments and policies, but the scale of the growth and lack of resources mean that conventional approaches will take many years to address infrastructure and service backlogs.

At the same time, where new infrastructure and buildings are being developed and constructed, they often rely on imported materials, which come with high costs for municipalities, and generate waste and pollution. Employing circular economy principles represents a valuable approach that leapfrogs conventional solutions and improves service delivery rapidly and cost-effectively, while creating employment and enterprises, and reducing waste and pollution. Given the limited extent of current infrastructure, expensive retrofits and upgrades of existing systems are not pertinent circular opportunities in Africa; rather the greatest circular opportunities lie in the design of buildings and infrastructure yet to be constructed.

This article first explores circular economy strategies for improved buildings and construction, however, while applying circular economy principles for buildings is important, consideration of the supporting infrastructure is needed to achieve a wider transition.



Circular economy strategies for buildings and construction

Applying circularity principles to buildings means looking at the whole life of a building, including the design, the construction and deconstruction[7] processes, as well as understanding the building as part of a wider physical and political space. The way a building is designed shapes how people use it, and can be valuable in supporting healthy lifestyles, but must also ensure that it caters to people's needs. A well-designed building can offer inspiration or the incentive to support the transformation of the neighbourhood in which it stands. Circular economy strategies for buildings in Africa include designing out waste and pollution by sourcing local and reclaimed building materials; incorporating bioclimatic and passive design, and resource capture; and designing for modularity and flexibility.

1

Sourcing local and reclaimed building materials

Photo credit:
Worofila

Using local materials in rural and urban construction

There is a diverse and evolving tradition of indigenous construction in Africa that creates comfortable, affordable buildings from local materials using local labour and generating limited waste.[8] Buildings which are widespread in many areas of rural Africa are typically constructed of earth block, timber, and thatch. They are built from locally sourced materials, which vary depending on geography, and are often highly thermally efficient. Designing a building to use locally available materials can actively support a local economy that sources, uses, and reuses materials locally. It also reduces the trade-associated impacts of transporting such materials and encourages local employment. There are examples of these approaches already being put into practice. Use-It in South Africa,[9] Worofila in Senegal,[10] and others are working to expand the use of earth blocks, while MycoTile in Kenya[11] are producing construction bricks from fungi. MMA Architect's Sandbag Houses in Cape Town, South Africa are promoting the use of locally available sand through the EcoBeam system that replaces bricks-and-mortar with sandbags.[12]

Historically, construction materials tended to be sourced locally, with only a few elements being imported. This, however, is changing, with the increased use of glass, concrete, and roofs made of corrugated iron. In informal urban settlements, construction typically consists of a timber frame to which corrugated iron sheets are attached as walls and a roof. Despite changes in the materials used, buildings in rural areas and in informal settlements are usually built by the occupants themselves and generate very little construction waste because they are aware of the affordability of materials.

This informal construction usually relies on the sourcing of local materials and using reclaimed building materials. This approach not only reduces waste from the building sector, but also ensures that these houses can be readily

repaired. However, homes in informal settlements are also often built hastily, given that the time of the residents is precious and needs to be devoted to deriving an income. Such dwellings are typically small, unsuitable for further extension due to having limited stability and space, and prone to fire risk due to settlement density. Work needs to be done to support the use of alternative local materials and building practices that can improve the longevity and stability of living space in currently informal areas – this requires demonstration of their value to informal builders, who need fast construction times, have limited access to equipment, and rely on cheap, available building materials.

Research on a range of construction materials is improving. For example, there is growing appreciation for new methods of using wood, and its value as a sustainable construction material is starting to be more fully recognised. Reinvesting in wood and timber for construction is valuable as many African countries have large stocks of timber that can provide a renewable, low-carbon source of building materials, if well managed. Many African countries are also using plastics and other municipal solid wastes to produce eco-bricks for construction. This may present a conflict to building a recycling industry, if recyclable materials are removed from circulation. Further, if these bricks are composites with timber and other materials, it becomes difficult to separate them at the deconstruction stage. However, if the eco-bricks are effectively made (not loose materials or composites), these materials can be stopped from entering the environment. Until recycling industries become mainstream, using compressed or converted waste for building may help to remove pollutants from the environment.

Local content policies, like those already in place in South Africa,[13] could be a powerful lever to accelerate the use of circular building materials. Local content policies that support the use of materials and products made in a country, as opposed to those that are imported, could be expanded to support the use of materials that contain reclaimed building materials and also reduce embodied energy. These policies would have other co-benefits – supporting local economies and job creation via production, repair, and maintenance.[14]

Repurposing buildings, reusing materials, and designing for deconstruction

Although much of Africa's buildings are yet to be built, repurposing existing buildings is also an important aspect to be considered. This approach is more directly relevant to urban rather than rural spaces, and it includes reforming warehouses and office blocks into mixed-use residence and commercial buildings or making use of demolition waste. A study in Tanzania indicated that concrete blocks could be formed from large proportions of demolition waste, and then used for new construction.[15] The El Mandara eco-resort in Egypt, which was a series of rundown buildings, has been renovated using local building materials including mud bricks and palm fronds.[16]

Reusing materials can save between 20% (e.g. glass products) and 95% (e.g. aluminium) of their embodied energy that would otherwise typically be lost.[17] Designing buildings carefully to incorporate separated or reprocessed demolition wastes is a valuable approach for reducing the amount of raw materials used. Designing buildings to use locally grown materials, while limiting synthetic or composite materials, can ensure ease of recycling and reuse at the deconstruction phase. Supporting these local building approaches to scale and ensuring they are compliant with certain building standards can aid public sector housing development efforts.

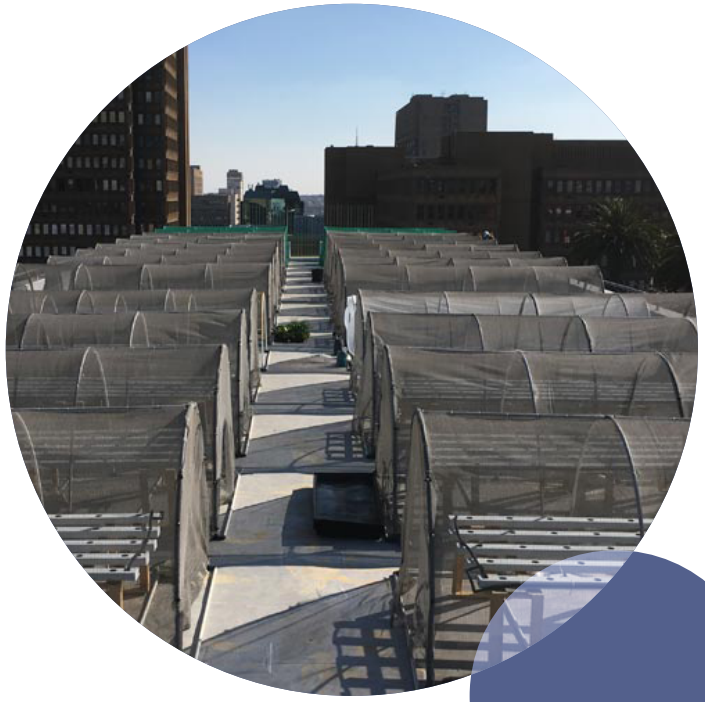


Photo credit:
myfoodgarden.co.za

2

Incorporating bioclimatic and passive design, and resource capture

At the design stage, selecting safe and healthy materials to be used in buildings can result in healthier living environments, as well as encourage the looping of materials at their end-of-use. Building approaches such as bioclimatic and passive design, which make use of natural conditions to cool, heat, light, and ventilate buildings, reduce energy demands. Such principles require attention to local climatic realities, the positioning of buildings in relation to the sun and wind tunnels, the length of overhangs to block or welcome sunlight, the size and position of ventilation ports, windows and doors, and more. The Africa Centre in South Africa and East Gate Mall in Zimbabwe are good examples of bioclimatic and passive design in action, using locally sourced materials and harnessing natural light and ventilation.[18]

Incorporating vegetation in the form of green roofs, rooftop food gardens, and green walls offers passive cooling to buildings and reduces energy needs,[19] while contributing to a natural aesthetic. Such approaches can further supplement food consumption in the building and surrounding areas.

The Kotze Rooftop Food Garden Project in Johannesburg[20] was set up on top of a homeless shelter and consists of 26 shade tunnels, with capacity for 1,950 plants. The garden uses hydroponics to reduce water loss and is producing spinach, swiss chard, cabbage, lettuce, and mustard greens, among other vegetation. In combination with, or instead of, green roofs, use of solar photovoltaic panels or solar water heaters can capture the light and heat for energy generation or reduction. This blocks the heat from entering buildings and captures useful energy. For example, Strathmore University in Kenya produced 0.6MW of electricity, resulting in energy cost savings of 51%,[21] and Almades Casino Supermarket in Senegal reduced its energy needs by 35% through harnessing such technology.[22] Finally, using the roof area as a watershed for capturing rainwater for storage and use in the building may be effective in places with consistent precipitation. This can support the irrigation of the building's vegetation. If coupled with a system for greywater cycling[23] or water treatment, such as a constructed wetland, the building can effectively reduce its reliance on external water sources. ▶

▶ **While sustainable buildings in isolation do not necessarily embody a system-wide transition to a circular economy, they are important demonstrations of what is possible.** They offer valuable lessons for other architects and businesses, and, if promoted effectively, provide inspiration and a competitive incentive for businesses to invest in their own sustainability principles. Using flagship buildings for embedded energy generation or water capture and cycling to provide energy, water, and sanitation services for their neighbouring settlements can reduce dependence on national grids and reduce costs. The widespread uptake of green roofs and walls can contribute to reducing the heat island effect in cities.[24] With almost half the urban population in need of improved, affordable housing there is a significant opportunity to incorporate circular design principles into the low-income and social housing markets in Africa.[25] Scaling this opportunity, means setting building standards and developing a certification system to award buildings based on their use of design principles. It will also require additional funding as the greatest gains will be made when taking a settlement-wide approach, and investing in sustainable precincts or neighbourhoods.

3

Designing for modularity and flexibility

Modular buildings can bring greater flexibility and resource-efficiency into residential and commercial buildings. Modular design can result in 80% of the components in a building's exterior being reused.[26] Ecomo Homes in Franschhoek, South Africa,[27] and EcoHomes in Kenya[28] are examples of design that uses low-maintenance materials and modular principles. The modular, prefabricated units are built off-site in a factory to minimise construction waste and then` installed on site. They can be installed at the same time as site work, reducing labour expenses and the environmental disruption typically associated with conventional construction.[29] Modular units can be easily joined together in a variety of arrangements to accommodate the living, play, or sleeping space requirements of the inhabitants.

Uptake of modular or prefabricated homes requires sensitisation around their benefits, as well as effective supporting infrastructure to enable their fabrication and transport to building sites. As with green building principles, publishing specific quality standards for prefabricated and modular homes can support their legitimisation as a construction approach and encourage their uptake in the market.

Photo credit:
Ecomo

Case study

Taking inspiration from nature and traditional building techniques

Eastgate Centre, Harare, Zimbabwe

Taking inspiration from nature and traditional Zimbabwean masonry techniques, the Eastgate Centre[30] is a great example of biomimicry in building design, and a good demonstration of how effective design can improve energy efficiency and save money. The building's ventilation system is modelled on termite mounds, which employ a series of vents that are opened and closed strategically throughout the day to generate an airflow current that sucks air into the ground, which may be warmer or cooler than the outside temperature, before sending it up to the higher parts of the mound. Similarly, the Eastgate Centre, a mostly concrete building, draws air in, where it is either warmed or cooled by the building's mass and then moved through the offices to replace stale air and vented through chimneys at the top of the building. This form of thermal regulation has replaced air conditioning and is estimated to cost only 10% of what a traditional regulation system in a building of the same size would cost. This lowers overall building management costs, and the Eastgate Centre owners have passed these savings on to the tenants, demonstrating shared value.

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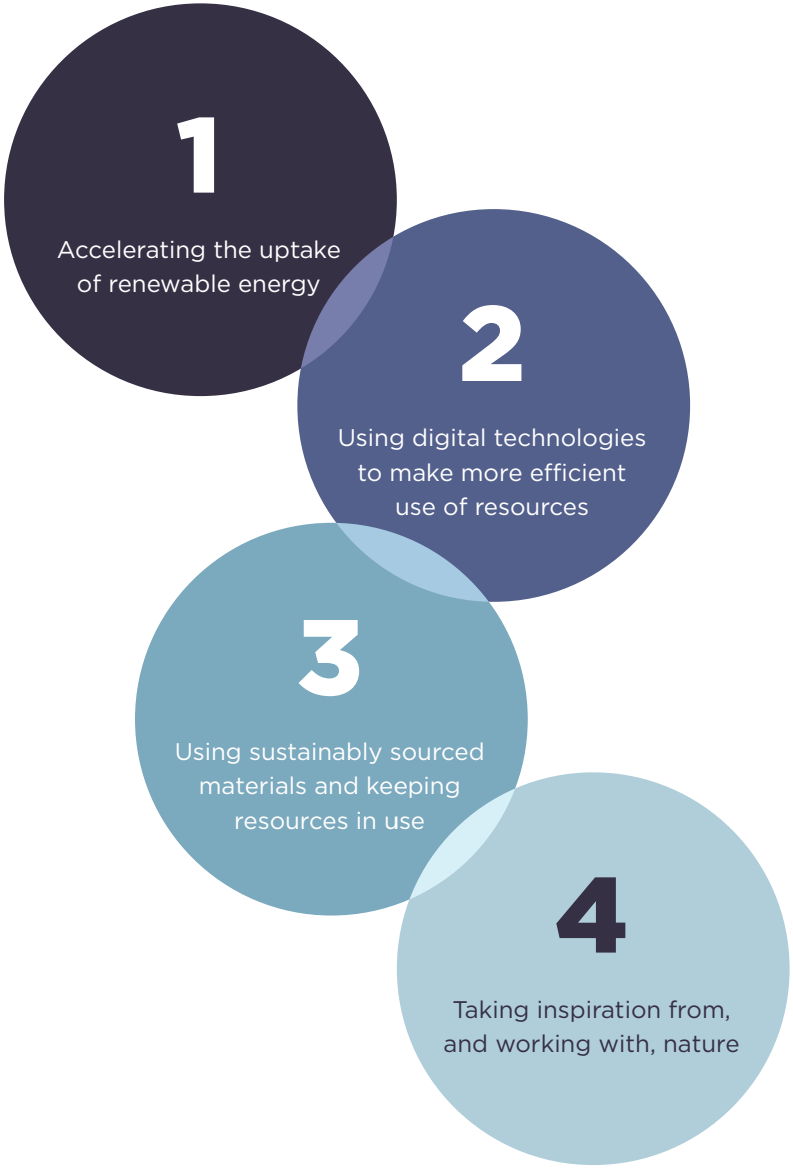
David Brazier - CC BY-SA 3.0



Circular economy strategies for infrastructure

Rapid urbanisation has resulted in the majority of networked infrastructure only being extended around an original colonial settlement or a new central district and a lack of access to bulk infrastructure services for the majority of urban Africans. Improving the circularity of energy, water supply and sanitation, transport infrastructure, and waste management can be done in a number of ways. For example, circularity can be built in by accelerating the uptake of renewable energy and digital technologies, using sustainably sourced materials and keeping these resources in use effectively, and making use of nature-based solutions. Across these three strategies is a need to decentralise infrastructure systems, employing micro-grids, supporting community-led precinct-level planning (even if still using national grids), and empowering private sector companies to contribute. Particularly as populations grow, these approaches can support resilience through a diversity of construction and infrastructure practices, keep prices appropriate through regulated competition, and support context-appropriate development.

1

Accelerating the uptake of renewable energy

African countries display a wide array of energy generation methods, with most being dependent on fossil-based energy. However, 12 countries[31] on the continent generate most of their energy needs from hydroelectric and/or geothermal sources. The growth in energy demand has typically been addressed through fossil-based thermal energy generation, contributing to increased carbon dioxide emissions. Wide uptake of (decentralised) renewable energy systems can improve access to clean energy, support resilient energy systems, and reduce greenhouse gas emissions. Governments can drive the uptake of renewable energy by supporting purchase agreements that guarantee purchase of renewable energy, improving the business climate for new companies, or setting fixed feed-in tariffs to make renewable energy more attractive for consumers than traditional energy. South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) is an example of how the country built a rapidly growing renewable energy market, through guaranteed purchase and fixed tariff agreements.[32]

2

Using digital technologies to make more efficient use of resources

The widespread uptake of Information Communication Technology (ICT), particularly mobile technologies, has enabled more effective monitoring of resource consumption to identify malfunctions, losses, and high consumption zones, which can enable rapid repair, indicate if demand-side management is needed, and support infrastructure planning where there are service shortfalls. Collecting consistent data across infrastructure networks, neighbourhoods, or in buildings allows city, precinct, or building managers to be more responsive in addressing issues. In the Western Cape, South Africa, a community development organisation called Violence Prevention through Urban Upgrading (VPUU)[33] has installed affordable mesh-networks and mobile sensors to monitor water leaks and the functionality of sanitation facilities in informal settlements; the placement of these systems has enabled the community to develop an intranet (an internal communications network) with resources accessible to residents. Service providers can sell data packages for people to access the internet through this network, improving the connectivity and agency of community residents. ICTs have also increased access to funds and livelihood opportunities for many. Mpesa in Kenya, Tigopesa in Tanzania, and the wider uptake of 'Mobile Money' has enabled people without bank accounts to send money using their mobile phone numbers as accounts. In Antananarivo, Madagascar, Mobile Information Systems have long been used to support peri-urban farmers with market knowledge, giving them access to niche or new markets and increased bargaining power.[34]

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3

Using sustainably sourced materials and keeping resources in use

Sourcing of local materials has been discussed above in relation to buildings, but many of the same approaches apply to networked infrastructure, particularly material reclamation. Supporting material reclamation from urban stock – such as from crushed rubble, construction and demolition wastes and municipal solid waste – ensures that these materials can have a second life in construction. The City of Cape Town, South Africa, has reused crushed asphalt waste and construction rubble from landfills in its road maintenance processes.[35]

When looking at the material flows – such as food, water, goods, and waste – cascading, or using a resource multiple times for lower quality work, is perhaps the most valuable strategy to consider for keeping a material in the system. It can be applied at many scales in building or precinct design, where ensuring that water is cycled can improve efficiencies; for example potable water, once used, can be captured and reused for flushing toilets or irrigating vegetation. If accompanied by artificial wetlands, the whole precinct could rely on water reuse. At utility scale, investing in effective water treatment can return used water to potable quality. Repurposing municipal wastes for useful work, instead of burning or sending them to a dump, is important for saving land area and avoiding environmental impacts. In the construction sector, reusing wood from old construction for lesser quality work, such as furniture, or conversion into fibre products or chips for energy supports further use. Reusing crushed rubble, such as from brick and stone, as described above, is part of this strategy.

Industrial symbiosis programmes, such as the Western Cape Industrial Symbiosis Programme (WISP),[36] South Africa, or Morocco's support for Industrial Ecosystems,[37] can further ensure that industrial material outputs are reinvested in material remanufacture for construction.

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4

Taking inspiration from, and working with, nature

Natural ecosystems provide valuable services.[38] However, most of the built environment has replaced nature and relegated it to specific parks or protected areas, reducing nature's benefits and increasing incidence of flood, urban heat island, air pollution, and more. Building infrastructures in ways that integrate and regenerate nature can have benefits for cost-reduction, population health, and providing a natural aesthetic. It can also enable nature to continue to provide the ecosystem services on which we depend – and indeed these ecosystems services can be considered part of our essential infrastructure.

Ecological regeneration can also be supported through hybrid green-grey infrastructures.[39] These can include green or agroforestry corridors for pedestrians and recreation, such as in Durban, South Africa,[40] or Dodoma, Tanzania, as well as constructed wetlands for purifying water, such as in Egypt[41] and Tanzania.[42] Porous pavements or sustainable urban drainage systems (SUDS) support water drainage infiltration or capture, and reduce flooding. These approaches have been used to good effect in the Biruh Tesfah precinct, Addis Ababa, Ethiopia,[43] and the Msimbazi River, Dar es Salaam, Tanzania.[44] These principles can be applied at building and precinct scale, as discussed above. The inclusion of more nature into built environments improves ecosystem connectivity and function.

Natural systems have many processes which have been improved over millennia. Learning from natural systems, through biomimicry,[45] can result in new innovations for circularity. A key example is the upcycling of organic wastes into compost which keep nutrients in the soil, or going further and using nature to convert these wastes into animal feed. Such an approach contributes to rethinking waste management, and reinforces the need for decentralised approaches and separation of waste streams to effectively recycle or treat, and avoid disposal. The use of black soldier flies, who feed on food waste and produce fertiliser and larvae which are a nutritious source of protein for animals, has become widespread across the continent. AgriProtein in South Africa,[46] Eco-Dudu in Kenya,[47] BioBuu in Tanzania,[48] and Cycle Farms in Ghana[49] have helped to divert organic wastes from landfill, reducing greenhouse gas emissions and offering livelihood opportunities. Planning and developing the built environment and infrastructure to incorporate these kinds of technologies and techniques is critical to supporting the use and value of resources.

Other factors

A number of enabling factors can support the realisation of the above opportunities. For example, data collection to track service access and quality needs to be scaled. Rapid skills development in the implementation of circular infrastructures, through technical schools and universities, needs to be promoted. Models for financing service delivery need to be rethought to ensure that there are adequate funds for incorporating circular economy principles in construction and infrastructure planning. Planning paradigms need to be re-examined to support the incorporation of informal economies and unplanned settlements. The economic, environmental, and societal benefits of bringing about this systemic shift will be significant, not least in a continent where the majority of the built environment that is projected to be needed by 2050 to support daily living is yet to be built.

Case study

Reuse of construction rubble in road building in Cape Town

In 2017, as part of the maintenance and extension of a highway in the City of Cape Town, about 13,000 cubic metres of concrete and 5,000 cubic metres of asphalt 'waste' was dug up. Instead of transporting this to landfill, the rubble was crushed and reincorporated into the highway. The intention was to make use of on-site crushing, but this was not possible due to the location, and instead the rubble was crushed in a nearby neighbourhood. It is estimated that this activity saved R 3.1 million (±USD 220,000). If the crushing had been done on site, the activity would have saved 36% of input costs compared to using raw materials.

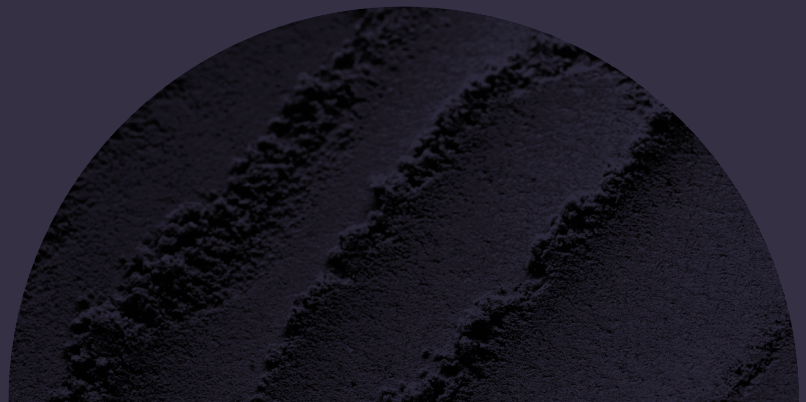
A GreenCape Report[50] estimated that 43,200 cubic metres of rubble are landfilled in the city each month, 25% of which could be used for road construction. This represents new input materials with a market value of R 1.1–1.5 million (USD 77,000–105,000) per month.

Case study

Restoring a healthy bioeconomy

Removing invasive vegetation and creating multiple economic benefits in Western Cape

This case study addresses two challenges: the prevalence of alien vegetation in a biodiversity hotspot, which is reducing the flow of water; and high levels of unemployment, with a lack of opportunities for economic participation. As part of the Working for Water Programme, the Western Cape Government has led a consistent effort to clear invasive Blue Gum and Black Wattle trees from the Garden Route District.[51] This programme supports ecological regeneration, creates temporary employment, and increases the available supply of water. It is coupled with programmes to enhance sustainable production of fynbos products – such as teas, bio-oils, and medicines – in ways that ensure ecological protection. The transport of the removed lumber is costly, so a charcoal production facility was recently launched to process this lumber. While the charcoal plant has been developed with export markets in mind, the Western Cape government is exploring opportunities for additional value creation and connection to other sectors. Activated charcoal is presently imported to South Africa for use in water treatment plants; locally produced activated charcoal would reduce this cost and the associated externalities of transport and increase local economic development.



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