CIRCULAR ECONOMIES AND AFFORDABLE HOUSING IN KENYA

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Executive Summary

The construction industry consumes more raw materials than any other sector in the global economy, accounting for more than 25% of the global total carbon emissions. Due to its current level of industrialization, Kenya does not have a large ecological footprint, having recorded a per capita CO2 emission of 0.31 metric tonnes in 2018, less than 2% of the United States' emissions for the same year. In fact, like other African countries, indigenous building practices, which have minimal adverse environmental impacts, are still present in much of the country. Nevertheless, in Kenya, strides have been made towards mitigating adverse effects on the natural environment by embracing practices and products towards circular economies. Much of this progress is due to the increased participation of stakeholders, e.g., state actors, private industries, and various interest groups.

In partnership with Habitat for Humanity, this research set out to identify sustainable housing solutions that enable circular economies in Kenya. This report provides a landscape analysis of main opportunities, trends, private initiatives, barriers, key stakeholders, and policy options to promote and develop the circular economy in affordable housing in Kenya.

To achieve this objective, secondary research was completed to identify main trends and solutions, combined with twelve interviews with experts of the sector, with representation from the public sector, private sector, NGOs, and academia. Guided by the ReSOLVE Framework, data were synthesized to assess barriers and recommendations categorized as follows: (1) Circularity within the construction value chain, (2) Natural Construction Materials, and (3) Enablers and Barriers to Circularity.

Overall, this report presents a variety of initiatives and technologies aimed at achieving a circular economy, with an emphasis on affordable housing. Important insights are discussed, including the importance of participatory community approaches to housing development. Further, there already exists a vast array of technologies suited for developing affordable housing and financial platforms that serve the bulk of the population in the informal sector; these require support to scale at feasible speeds.

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1 Circular economy in affordable housing in Kenya

In Kenya, "the right to accessible and adequate housing, and to reasonable standards of sanitation" is enshrined in the renewed constitution, which came into effect in 2010. Kenya is also positioned as the top shareholder (18.72%) in Shelter Afrique, a Pan-African housing financier co-owned by 44 African countries and the African Development Bank. Driven by this constitutional commitment, the government, through KENYA VISION 2030 program and BIG 4 Agenda, continues to make efforts to plug the existing housing deficit of 2 million units, a deficit that currently grows at about 10% annually as the estimated supply stands at about 50,000 units per annum. Overall, Kenya's construction sector contributes nearly 6% to the national GDP, experiencing annual growth of over 7% since 2015 (with the exception of 2020, due to the pressures of the global COVID-19 pandemic), employing over 200,000 workers.

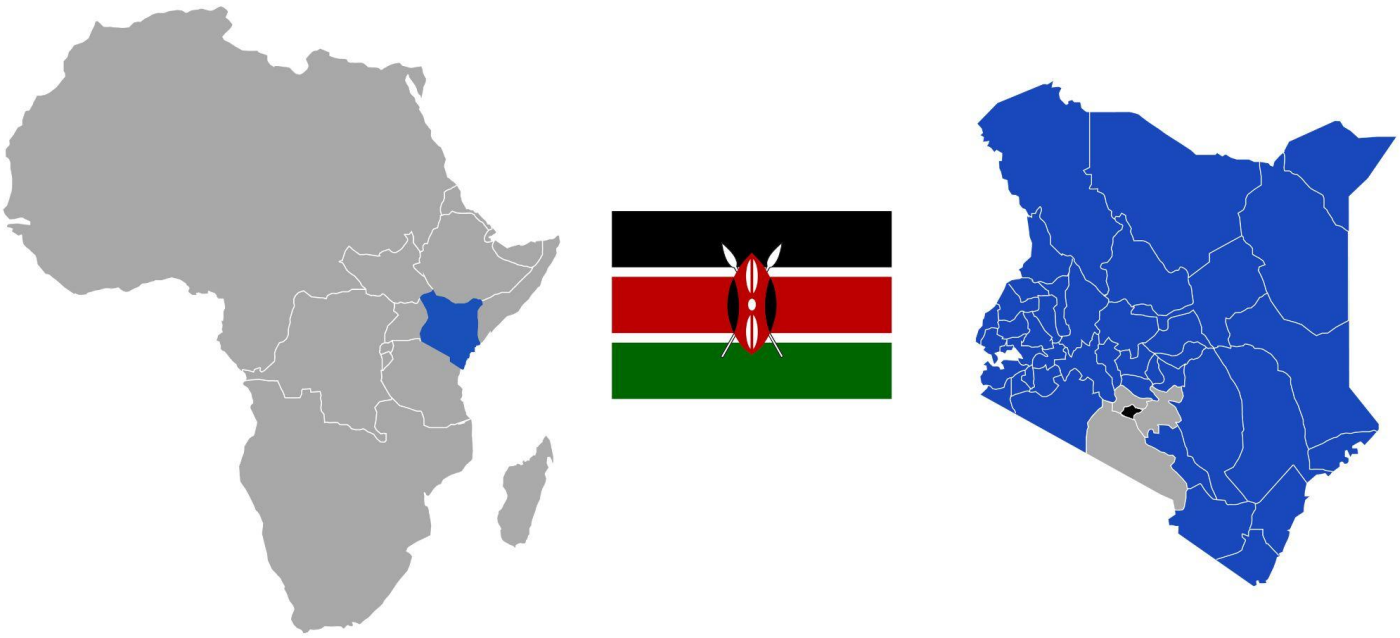

Figure 1. Kenya in the context of the African continent (left), and its capital, Nairobi (right, inset), in the context of the greater metropolitan area (grey) and the 47 semi-autonomous administrative countries. (Source: Author).

The character of Kenya's urban housing supply is such that most housing investments target the market component that can buy the units in supply. Ironically, the country only has about 40,000 mortgages out of an estimated population of over 52 million – with a median age of 19.9 years (Gibberd, 2020). Housing investments targeting young, low-income Kenyans with limited access to housing finance require further support; some promising ventures such as the Riverview Estate in Mavoko aim to provide home structures at a price of KSH 1.6M (about USD 9,100). The mass occupation of rented metal shacks and grass-thatched mud houses reflects the broader reality and plight, both in informal settlements and the peri-urban precincts of Kenyan cities, including Nairobi. Much improvement is required to provide dignified housing for families to thrive below the mortgage-able threshold.

Nearly 80% of total recorded employment in Kenya is in the informal sector, commonly called "Jua Kali" (UNDP, 2016), which includes unregulated small-scale enterprises spread across multiple sectors. A significant

proportion of this demographic works within the construction value chain. Kenya recorded a mortgage to GDP ratio of only 2.5% in 2019, falling deeper from already low rates recorded in previous years (Cytonn Report, 2019). Furthermore, 46.5% of Kenya's urban population live in slums and informal settlements (Reall, 2019).

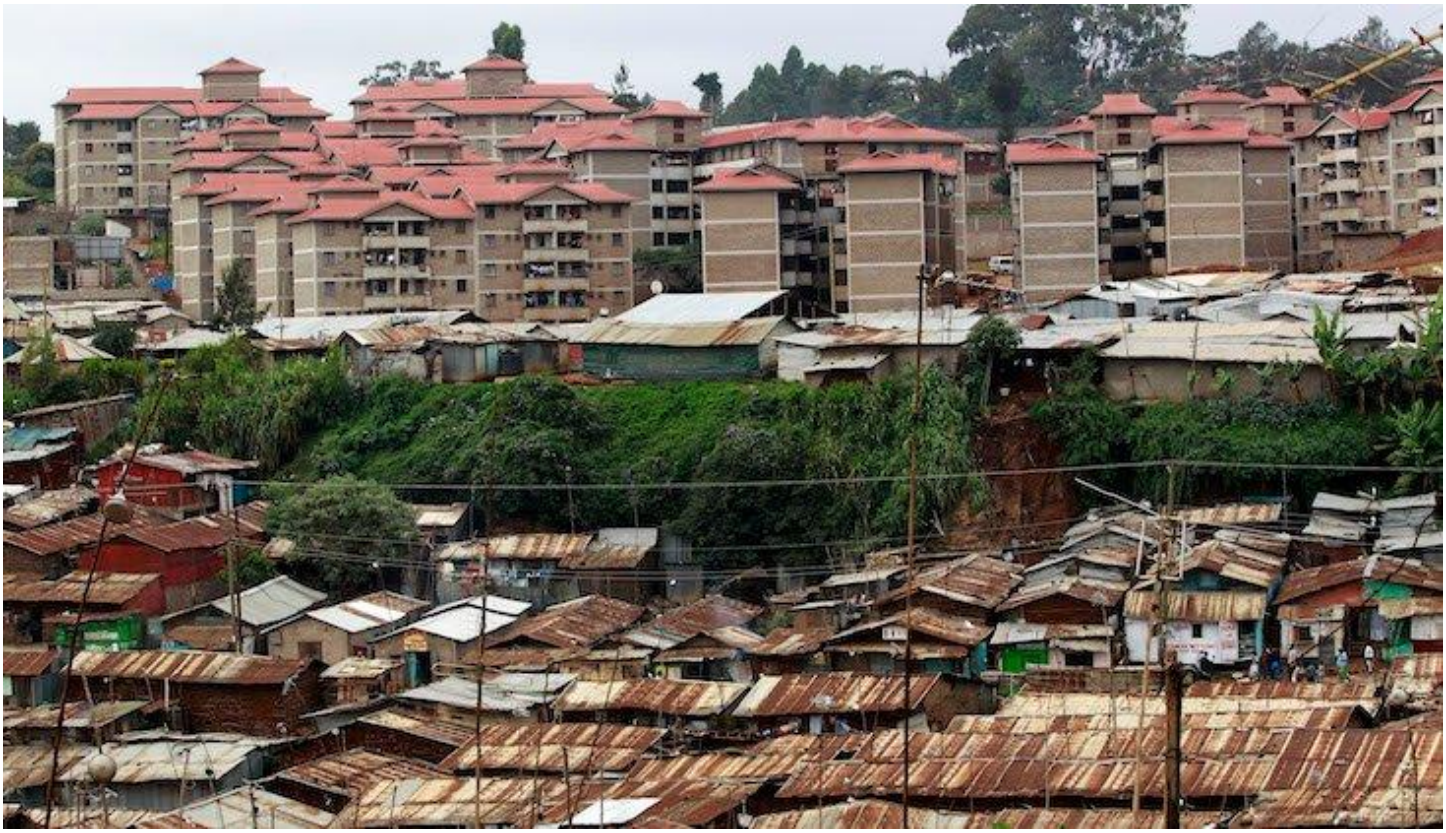

Figure 2. Dissonance: how typical state policies view affordable housing (background), and the reality (foreground) lived by millions of Kenyans who work in its capital. (Author: Reuters/Thomas Mukoya)

The construction industry consumes more raw materials than any other sector in the global economy, accounting for more than 25% of the global total carbon emissions (IFC, 2018). Due to its current level of industrialization, Kenya does not have a large ecological footprint, having recorded a per capita CO2 emission of 0.31 metric tonnes in 2018, less than 2% of the United States' emissions for the same year (World Bank, 2021). In fact, like other African countries, indigenous building practices that famously have almost no negative impact on the environment and have do-it-yourself maintenance practices built into them (contrary to the modern false impression of building permanence) are still present in much of the country in their sustainable glory. Nevertheless, in Kenya, strides have been made, with the participation of state actors, private sector, local and international interest groups, to mitigate adverse effects to the natural environment by embracing practices that tend towards circularity. Guided by the **Resolve framework** authored by the **Ellen McArthur Foundation**, emerging trends in the pursuit of **circular economies** in Kenya are summarily categorized as circularity within the construction value chain and natural construction materials.

2 Methods

In this study, we use the Ellen Macarthur Foundation's definition for *Circular Economy*; their methodology provides a broad approach to a circular economy based on a "take, make, dispose" model (Figure 3). The model relies on **three principles: preserving natural capital** by controlling the use of finite materials and using renewable resources; **optimizing resource yields** by circulating materials at the highest utility in both technical and biological flows; and **fostering system effectiveness** by eliminating negative externalities, like climate change (Ellen MacArthur Foundation, 2020).

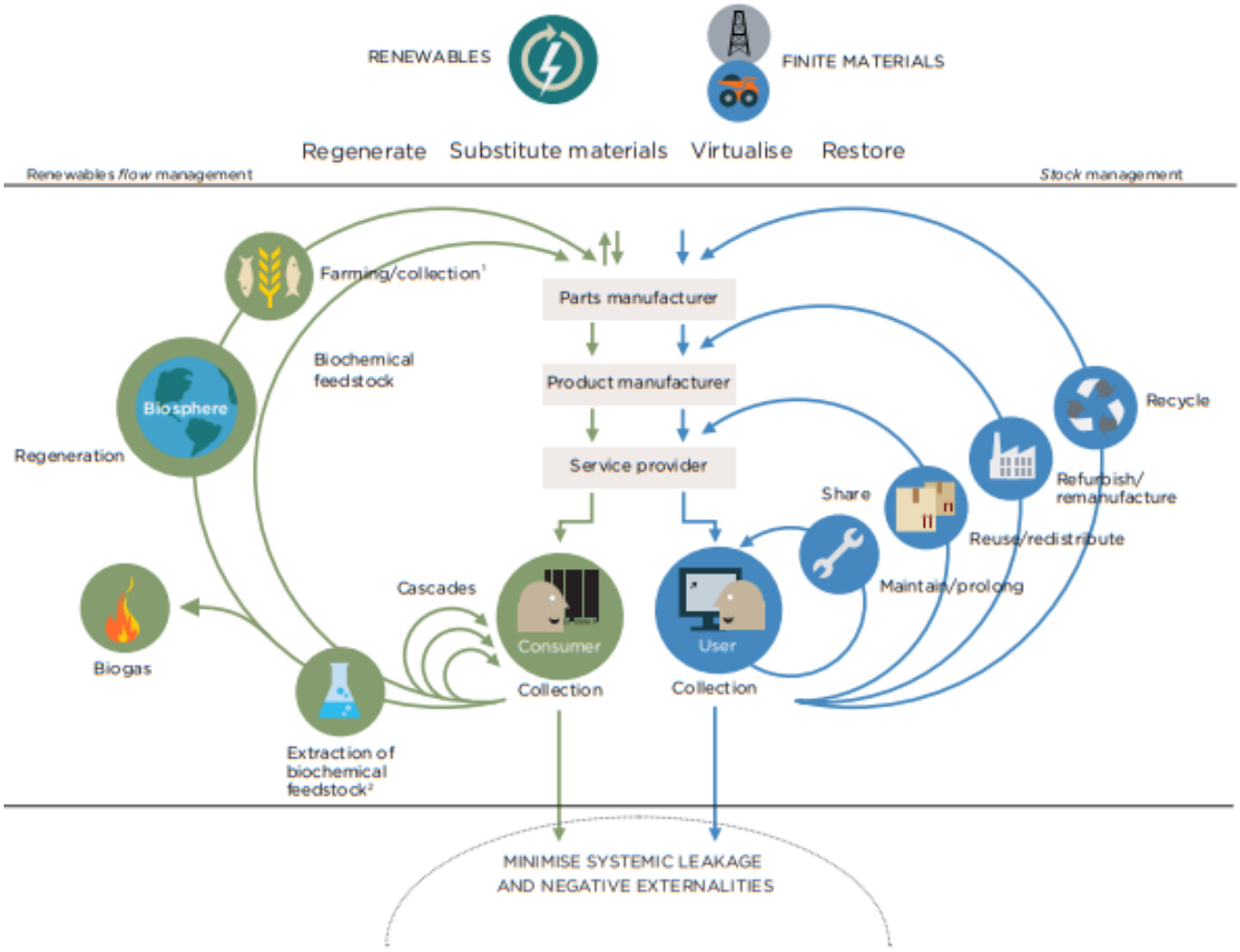

Figure 3. Circular economy system applied for the biological and technical flow of materials. Source: (Ellen MacArthur Foundation, 2020).

The ReSOLVE framework offers six different business actions to achieve a circular system, **REgenerate, Share, Optimise, Loop, Virtualise, and Exchange**, and provides a step-by-step guide for mapping opportunities, trends, barriers, and policy opportunities to enable the transition to a circular economy (Figure 4).

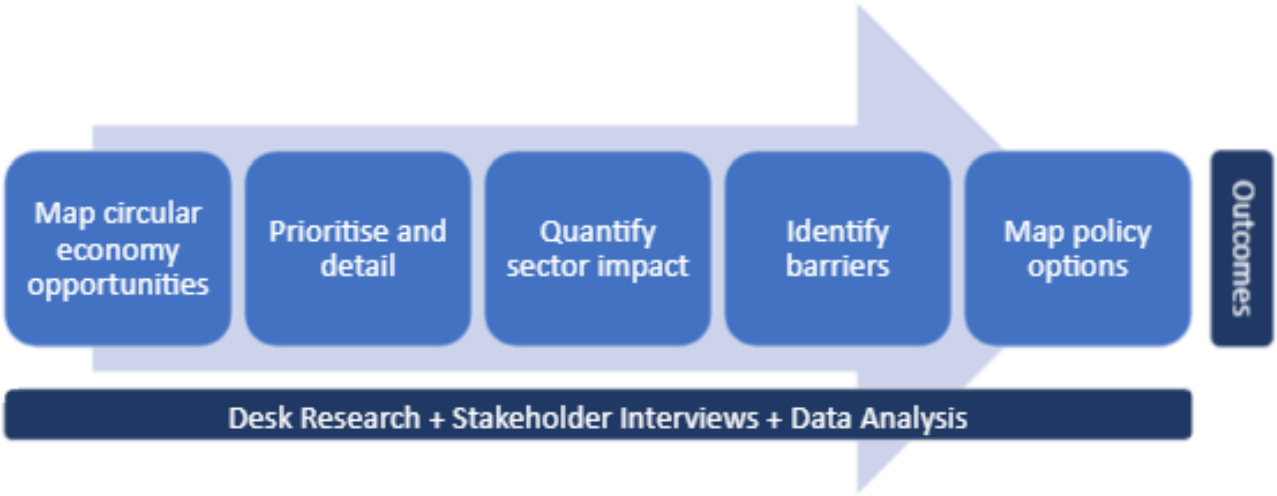

Figure 4. The process of the iterative methodology applied in the study. Source: Martín Ignacio del Pino.

3 Materials and Construction: Opportunities and Trends

3.1 Circularity within the construction value chain

The International Finance Corporation (IFC, 2018) describes the construction value chain as a process that transforms raw materials into manufactured materials that are made into final products, which are integrated into the built environment we commonly occupy. On this basis, the IRP (2020) propose a breakdown of the transformation process into the following components, which sustain dynamic relationships among themselves: finance; planning, design, and commissioning; extraction and/or processing of construction materials; logistics (mobilization); construction; property market; operation and/or maintenance of the resultant built environment; and end-of-life of the edifice. Each of these segments presents unique opportunities to enhance circularity in the development of affordable housing stock in Kenya and the broader region of East Africa, with significant examples already building momentum in the economy.

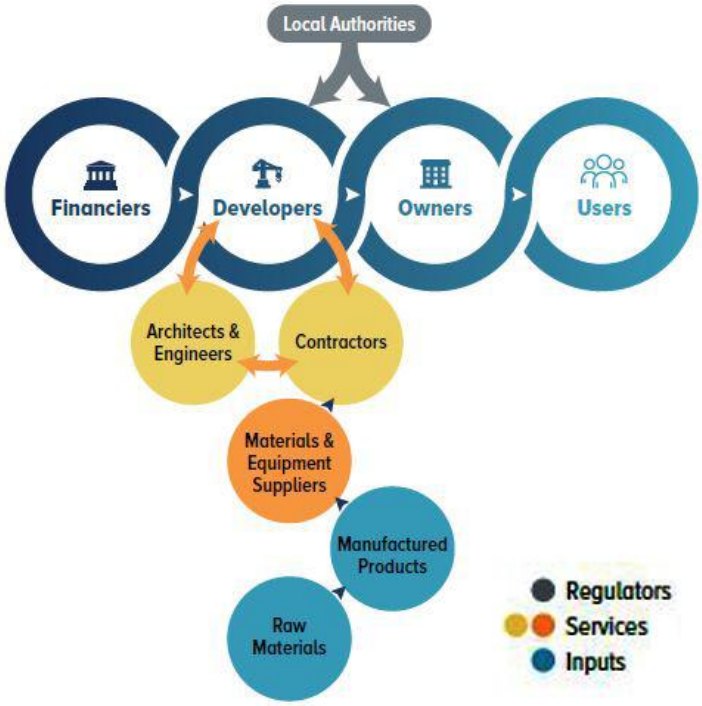

Figure 5. Construction value chain actors and interactors. (Source: IRP, 2020)

Table 1. Construction value chain.

Opportunity	Looping recycled plastics back into the built environment Rapid construction processes Leveraging existing building stock Recyclable and reusable building components Minimisation of resource wastage
Benefits	Cost saving in development Efficient use of materials Low-tech allows end-user participation and "financial circularity" Near "net-zero" carbon housing for repurposed spaces
Key Barriers	Building code doesn't reflect market reality High R&D costs limit further innovation Slow growth of market confidence Product data deficit inhibits EDGE & other green certifications
Policy options	Localised certification to improve impact assessment Incentivise developers to use green technology Facilitate access to tax breaks

3.1.1 Construction value chain: Opportunities and benefits

Raw material extraction for the construction industry presents unique opportunities to exercise circularity. Worldwide, the plight of plastic pollution has been rendered visible through successful multi-media global campaigns (Takada and Bell, 2021). Kenya has also risen to the challenge, with a coterie of innovators who have embarked on meeting the challenge by converting tonnes of plastic waste into various products for the housing enterprise. Leveraging the tons of plastic waste collected in Kenya, companies such as **Gjenge Makers**, **EcoTiles**, **Corec**, **EcoPost**, and **Green Pavers** are producing a wide range of building products, including paving blocks, roof tiles, and faux-lumber, all from sand-based recycled plastic.

Figure 6. Nzambi Matee of Gjenge Makers hold up paving blocks made of recycled plastics. (Source: africasustainabilitymatters.com).

In the same vein, SDG-sensitive corporate decisions by some companies have served to mitigate the demand (and therefore, supply) of virgin raw materials for the industry. For example, **Bamburi Cement** (the Kenyan arm of the global cement leader, **Lafarge**), through its subsidiary, **Geocycle**, recycles used tires, waste motor oils, and non-hazardous waste (e.g., rice husks) as fuel for cement kilns. Besides reducing the pressure and demand for virgin non-renewable fuels, this phenomenon also diminishes the pressure on existing landfills, allaying the development of new landfills in the name of sustainable waste management.

Resource efficiency is a hallmark of circularity. Participants in the housing value chain who occupy the planning design and commissioning segments and those who participate in construction have also found unique opportunities to contribute to the sector's circularity in several ways. Industrial and semi-industrial (offsite) production of building components and subsequent onsite assembly is a different construction model, unlike the traditional model in which processed raw materials are worked onsite, as in the case of typical masonry construction. Precast concrete construction has gained some traction in Kenya, with companies producing various products, including slabs, beams, columns, wall panels, hollow and solid blocks, and developing the capacity to deliver complete concrete homes.[1] Examples of companies employing precast concrete technology range in size and scope from large firms, such as **Erdemann Property**, which has built over 4,000 housing units in Kenya, to smaller developers such as **Kwangu Kwako**, who cater to smaller ticket developments targeting lower income urban dwellers, providing them alternatives to metal shacks and mud brick rentals that are common place in the slum areas.

Figure 7. Kwangu Kwako team installing precast concrete panels. (Source: kwangukwako.com)

The German-Kenyan built environment NGO, **Start Somewhere**, has contributed innovative precast concrete walling technologies to the Kenyan market. Having targeted the plight of unsafe built environments in Nairobi's largest slum, Kibera, the entity developed the *twistblock*, a precast hollow concrete block accessible enough to be manufactured inside of slums. The product has also been designed to be strong, durable, fire-resistant, seismic-resistant, and low-cost enough to compete favorably with typical masonry construction, metal shacks,

[1] Interview with Simon Dixon, *Kwangu Kwako*

and other "temporary housing" typologies, especially maintenance costs over ten years is factored in.[2] On top of its material-saving modular production and hollowness, including its dry-stackable profile, the design of the *twistblock* permits the construction around corners, thereby being uniquely suited to the space-tight landscape of informal settlements, maximizing already limited land in the efforts to provide affordable housing. As with **Kwangu Kwako**, the capacity of **Start Somewhere** to manufacture modular building materials using locally available materials sourced from within the context in which the development is coming up introduces much-needed economic opportunities for the served communities; a certain financial circularity.

Figure 8. A structure inside the Kibera slum built with dry-stacked twist-blocks. (Source: startsomewhere.eu).

In Kenya, other prefabricated industrial construction systems include expanded polystyrene (EPS) panels championed by the **National Housing Corporation (NHC)** and others. EPS technology allows for rapid construction processes and minimizes material waste during its industrial manufacturing. However, the product requires high embodied energy due to the importation of the primary raw materials. EPS is also a non-recyclable material bound to require landfill disposal at the eventual end of the building's life cycle. Another prefabricated material is cross laminated timber (CLT) panels, which have been championed by several specialized enterprises such as **Eurombao**. CLT construction, on top of the advantages of industrialized construction systems, bears the added benefit of encouraging reforestation and increasing the financial value of agroforestry. However, there is also potential for endangering food security as its scaling poses the risk of competition for arable land between growing trees and growing food crops.[3]

Nairobi has a spatial surplus of up to 52ha of unoccupied commercial and 54ha of unoccupied residential spaces. These surplus spaces are understood to have come about as a result of existing housing stock not

[2] Interview with Oliver Von Malm, Architect, *Start Somewhere*
[3] Interview with James Mitchell, Architect, *BuildXStudio*

meeting the market's needs. Specifically, young *Nairobians* entering the job market often do not have the financial capacity to individually rent whole apartments in the city, let alone the creditworthiness to buy at market price. Companies, such as **The Vlage**, have emerged with the vision to convert these surplus spaces into novel shared housing (i.e., co-living houses), subletting them to the unique target market constituted by Nairobi's young, single, employed workforce. Leveraging the advancements in ICT and mobile internet access across the country, this sub-sector provides house-mate pairing options, ultimately aspiring to charge residents only USD 150 - 250 per month in rent. By converting old homes into co-living spaces and repackaging existing shared infrastructure, this model (re)creates housing options in the city with a relatively small impact on the environment.

Figure 9. Autodesk is making efforts to enable greater fluidity among its software to best leverage the capacity of each to support modularisation in built environment design. (Source: Author).

The capacity for modular design and industrial manufacturing processes to help in the quest for circular economies in meeting affordable housing goals is at least, in part, partly reliant on the construction industry software. **Autodesk**, a global leader in engineering and architecture software, drives the idea of "housings as projects to housing as products," developing software linkages and modifications that facilitate modular building design, bridging architecture/engineering design with repeatability and fabrication features without stifling creativity. Autodesk products provide features that enable designers to simulate the environmental impact and reduce material waste automatically, among other features.[4]

However, most built environment professionals across Sub-Saharan Africa do not have access to genuine cutting-edge design and documentation software, primarily due to associated costs of user licenses. In a bid to improve access to its software, Autodesk has revised its perpetual license-based software model into a rentable, pay-as-you-go (i.e., metered) software access model in which users only pay for as much software time as they use. Furthermore, through leveraging the power of cloud computing, Autodesk software has attempted to mitigate the need for its users to have access to extraordinarily computing power, thus improving access to software via internet access.[5]

3.1.2 Construction value chain: Key barriers

Kenya's building code, adapted from the British code, was promulgated in 1968. Whereas a revised building code exists (2020) containing within it numerous considerations that would serve to enhance circular economies in

[4] Interview with Ryan McMahon, *Autodesk*
[5] Interview with Catherine Wolf, Autodesk.

the built environment and ultimately in affordable housing (including passive design requirements and solar water heating requirements), it has not been enacted, and therefore remains unenforceable.[6]

Built environment professions and building practices remain marred with tokenism concerning ecological sustainability. A culture of greenwashing of proposals as well as employing minor ecologically friendly attributes as design footnotes have become endemic in the industry, exhibiting a lack of depth of knowledge regarding sustainable built environments in the sector.[7]

Companies that continue to innovate towards greater circularity express that high costs of research and development strain their daily operations. Furthermore, consensus suggests that there appears to be little political incentive for fostering actual sectoral evolution due to conflicts of interests involving large corporations and some political figures.[8]

Consensus regarding the adoption of sustainable building practices and circularity points to the reality that most actors in the sector (including end-users and SME contractors) are too busy trying to survive economically to be particularly concerned for the environment. The conversation about the imbalance between economic realities and environmental ethics remains the proverbial elephant in the room. In contrast, echoes in the same room whisper, "the materials that are high carbon should not be the cheapest in the economy."

3.1.3 Construction value chain: Policy options

To bridge the construction value chain gaps, third-party entities and enterprises that help broker the same business linkages ought to be encouraged and developed. This would better situate the multiple and fragmented participant companies, most of them SMEs, to better participate in meeting national (and global) climate goals without going out of business.

Despite significant improvements in built environment education curricula over the years, there is still more room to deepen the principles of ecologically sensitive building practices in Kenya and the greater East Africa. Course modules that help revisit attitudes that foster the idea of "foreverness" of all buildings would help (re)introduce end-of-life-cycle conversation to future and present built environment professionals. Extending this conversation from the classroom to the continuous professional development series could finally yield the desirable end of learned professionals informing practice rather than practice informing specific professionals.

3.2 Natural construction materials

Kenya has a long tradition of using natural materials in construction, e.g., local wood, soil, and organic waste.The Kenyan capital, Nairobi, produces an estimated 2,400 tons of solid waste daily, more than half of which is domestic organic waste (World Bank, 2020). Beyond the domestic variety, organic waste also emerges in bulk from industry in the form of coffee husks, sugarcane bagasse, and sawdust. With the increasing focus on adopting sustainable practices in the construction industry, agricultural waste has emerged as an opportunity to innovate, serving as raw materials for the production of sustainable, locally sourced construction products that have low/zero impact on the environment.

[6] Interview with Jacob Simwero, *Habitat for Humanity TCIS Kenya*
[7] Interview with Prof. Alfred Omenya, Fellow, *Architectural Association of Kenya*
[8] Interview with anonymous source

Figure 10. Interlocking stabilised soil blocks bring dry stacked into a masonry wall. (Source: hytuganda.com).

In addition to the emergence of innovative agro-waste materials, Kenya has also witnessed the advancement of traditional construction methods and materials, e.g., mud walled hut construction, that reduce their impact on the environment while remaining technically sound. Vyncke et al. (2018) estimate that nearly 30% of the world's population live in earth construction. Advancements in masonry technology have been substituting burnt bricks and regular concrete blocks with interlocking stabilized soil blocks (ISSB) and natural stabilized compressed earth blocks (CEB). At the same time, industrially processed cross laminated timber (CLT) panels from sustainable agroforestry have also emerged in the industry.

Table 2. Natural construction materials.

Opportunity	Creating carbon negative construction materials Leveraging unsaturated state industrial research infrastructure
Benefits	Fuelling food production Incentivising agro-forestry Incentivising community waste management systems
Key Barriers	Low levels of finance available for SME innovators Scale of projects not conducive to capacity of production Existing product range serves niche market High product cost Unfavourable community perception of earthen construction
Policy options	Mass sensitisation to promote the durability of modern earth technology Facilitate access to tax breaks

3.2.1 Natural materials: Opportunities and benefits to circularity

Innovation and entrepreneurship have seen the exploration of agro-based construction materials manufactured in Kenya. Through collaborations with **Kenya Industrial Research and Development Institute (KIRDI),** companies such as **MycoTiles** have leveraged state-owned industrial incubation infrastructure to create and introduce new low carbon construction materials and building industry, potentially replacing existing high carbon imported varieties.

Figure 11. Kenyan-made hyphae based insulation panel by MycoTiles. (Source: knowledge-hub.circle-lab.com)

Hyphae-based building products, currently limited in range to ceiling panels and insulation, can be formidable competitors to ordinary masonry building blocks, ceramic tiles, and MDF panels. The capacity to absorb agricultural waste in the production of building components implies the utility of the growth of this sub-sector for efforts to manage organic waste, potentially curbing the growth of landfills as the production capacities in the sub-sector register growth.

UN-Habitat (2009) describes appropriate technology as referring to "materials, methods and/or practices which help protect the natural environment, take inspiration from the cultural values and practices in the area, make use of local resources, and contribute to local economic development." CEBs, ISSBs, and CLT panels, while presently serving various income brackets, satisfy the definition of appropriate technology. CEBs and ISSBs are often made with soils already available on site, lowering the carbon footprint of the walling component of the construction process. Further, using natural fibers as stabilizers, such as straw, sisal, elephant grass, or bagasse, sun-dried adobe blocks, have continued to perform well in Kenya without requiring energy-intensive curing during production (Namango and Starovoytova, 2014). Similarly, cement stabilized ISSBs allow dry stacking of the

blocks, thus eliminating the need for cement-based mortar. Meanwhile, rammed earth technology, indigenous to Kenya and the neighboring region, is also re-emerging as an alternative option for wall construction.

Figure 12. Kenyan made Makiga compressed earth press in use. (Source: hytuganda.com)

These innovative materials and sustainable raw material-based building methods have served to mitigate the importation of building raw materials and increased reliability on locally available raw materials for construction, thus reducing the embodied energy of the resultant housing. Additionally, various press typologies for the manufacture of innovative (as well as revised) masonry options have been successfully fabricated within the Kenyan manufacturing sector by companies such as Gearbox. In the process, these same materials and methods have served as catalysts for enhancing cash flow in micro-economies wherever the housing endeavors have been explored, thus achieving the goal of grass-root economic development and towards meeting SDG 1.

3.2.2 Natural materials: Key barriers

Some of the entities participating in this segment of the affordable housing sector identified access to suitably sized financing as one of their significant barriers to scaling. The market share occupied by clients able to put ecological goals and ideals above building costs is small (niche). The opportunities to explore the use of innovative agro-based construction materials have also been limited by extension. As a result, the market price of the same products struggles to compete with less ecologically sensitive alternatives in the market.

Unfavorable community perception of waste-based building components and the common cultural perception of earth-based building materials as symbolizing lower economic stature have affected the permeation of natural construction material and methods onto common urban housing typologies. The need for "higher value" investment (articulated in stone or concrete block) to reflect a socially accepted view of "permanence" continues to hold back the growth and scaling of products in this sector.

4 Enablers and Barriers to Circular Housing in Kenya

Implementing circular housing solutions faces both enablers and barriers in Kenya. As in all sectors of the economy, key stakeholders in the housing sector monitor and evaluate its performance, guiding it towards meeting established state policy and **Sustainable Development Goal #11**. Various stakeholders serve the sector by investigating its trends, challenges, and opportunities, fostering networks among actors, building channels for finance for both end-users and developers, and lobbying for change.

Table 3. Circular Housing in Kenya.

Opportunity & Benefits	Ongoing efforts towards organised open access sectoral data EDGE training available locally for built environment professionals and other sector participants Several local certified EDGE experts Ongoing development of a green building materials directory for Kenya
Key barriers	Affordable housing sector stunted due to limited data sharing eco - system Community needs/concerns inconsistent with interests of development partners Irreconcilable global M&E models for local housing realities Prohibitive interest rates leading to mortgage aversion in a mostly cash economy
Policy options	Localized certification & rating systems to improve impact assessment Prioritising local challenges in affordable housing development Advocacy for tax credits for developers and consumer protections Improvement of slum infrastructure and amenities

4.1 Circular housing: Opportunities and benefits

Availability of data advances a sector's knowledge of where opportunities for circularity improvements exist. Although data availability has previously been a well-articulated challenge for the construction industry, trends are suggesting advancement. The Market Shaping Indicator (MSI) dashboard was established to aggregate housing sector data in Kenya and a handful of other developing economies. The open-access dashboard, developed by **REALL** and the **Centre for Affordable Housing Finance in Africa (CAHF)**, categorizes a total of 115 market indicators, grouped under significant themes of land, construction and investment, sales and rental, maintenance and management, enabling environment, and demand. Of these, the collaborative effort has so far managed to populate over half of the 115 data points for Kenya's market.

While the housing sector in Kenya remains primarily dependent on carbon and traditional construction methods, efforts towards greening the sector are certainly underway, as displayed in the previous sections of this document. In order to facilitate access to the ecologically-sensitive initiatives, **Kenya Green Building Society (KGBS)**, together with its partners, are in the process of compiling a ***green building materials directory*** for Kenya.[9] KGBS is also conducting training programmes for **EDGE**, licensing local experts to help serve the industry in the region, which in turn raises the stock of licensed ecological stewards of the built environment.

[9] Interview with Roy Githaiga, *KGBS*

4.2 Circular housing: Key barriers

Many circular building solutions, such as natural and local materials, have been side-lined in favor of building technologies and materials that have come to be associated with wealth and progress. This dissonance has come to be enshrined in the building code, confirming in law the disdain for building traditions that are, in fact, ecologically sustainable and economically accessible to the majority of Kenyans.[10]

Community engagement has revealed that "better housing" is not strictly a priority for those currently dwelling in urban informal settlements and slums. Instead, challenges highlighted include food security for the families, safety, security, cultural integration in the informal settlements, access to clean water and sanitary facilities, and decent education for their children. Thus, improvements via circularity must incorporate these social and cultural needs, resulting in improved habitat rather than the merely improved quality of housing.[11]

Many developers and policymakers appear to conclude that there is adequate demand for homes to buy, as exemplified by the stock generated under the government's BOMA YANGU housing initiative. Although the affordable housing market is valued at $15 trillion (IFC, 2021), a housing deficit greater than 2 million units exists. There appears to be a mismatch in demand in the affordable housing market, which is constituted by a demographic which struggles to pay rental dues in the slums and informal settlements, be they metal shacks or mud houses.[12]

In the construction industry, negative attitudes are expressed towards homes not built with traditionally "hard" materials (e.g., stone, concrete blocks, burned brick), which then appear to lack a sense of permanence. This mentality has served to setback the market penetration of housing solutions that, while not promising 50-year durability, guarantee improved living conditions compared to the prevalent situations in Nairobi's slums. This is exacerbated by a general preferential treatment of specific building typologies over others.

Housing policymakers impose unreasonable demands upon private developers. Whereas the general industry goal is for homes to be classified as affordable when built for an equivalent of $10,000 or less, the price tag is generally unachievable as long as concessions are not made on housing typologies. Preferential treatment of particular housing typologies without evidence of acknowledgment has implications.

The provision of dignified, affordable housing has various challenges. Limited public WASH infrastructure and waste management systems both within informal settlements and in new housing developments impair the quality of life in contexts where the housing problem itself has already begun to be solved. Similarly, developers are sometimes required to fund extensive sewer systems on behalf of county governments without any subsidies in return.[13]

Some of the delays in the sector could be attributed to county-level graft, with those in positions to expedite decisions, permits, and/or licenses trading their official duties for favors or money.[14] Like all sectors of the economy, the housing sector experiences red tape. Duplicated responsibilities and authorities within state agencies and departments continue to breed both confusion and delay in decision making.

[10] Interview with Jacob Simwero, *Habitat for Humanity, TCIS*
[11] Interview with Roy Githaiga, *KGBS*
[12] Interview with Seeta Shah, *FSD - Kenya*
[13] Interview with Seeta Shah, *FSD - Kenya*
[14] Interview with Anonymous source

4.3 Circular housing: Policy options

As a sector that contributes between 14-17% to the GDP, the innovations in the housing sector ought to be supported with incentives to help mitigate the economic risks involved. Industry data indicates that providing affordable housing is more difficult than ecologically sustainable housing, which is a challenge in and of itself. Since these initiatives take time, experts recommend incremental changes, claiming that it is better to have quality housing stock with a 20-year expectancy than to not develop any housing unless the proposal has a 50-year expectancy. A mentality shift from "green" aspirations to "greener" ones would foster a culture of incremental change.

While development partners have backed archival data efforts and made great leaps towards increased data access, there is room to foster a local culture of project documentation, monitoring, and evaluation at the SME levels. Efforts should be made to improve calibration and measurement of informal construction sector practices and success in affordable housing provision, to make whole the "Housing Data bank" provided for in Part VI Section 22 of The Housing Bill, 2021.

There is a need to increase overall sectoral education to engender a mindset shift from mere "green buildings" as a monolithic goal to "green approaches" to housing development to acknowledge the enormity of value chains in affordable housing development. Deepening sectoral understanding and appreciation of the potential for EDGE and other standardization languages to impact the industry positively would contribute to a broader appreciation of circular economies.

Since Kenya has shallow mortgage penetration, alternative end-user finance is indispensable. Increasing access to alternative credit assessment for the informally employed would unlock the previously unserved demographic and increase affordable housing stock. Through leveraging existing community-led initiatives such as the trending Savings and Credit Society (SACCOs) and developing and encouraging rent-to-own schemes, more Kenyans would ultimately be able to access affordable housing.[15]

Standardizing tenancy and purchase contracts for the sector would help minimize red tape and protect consumers from the financial burdens of procuring decent legal representation. In a context where homeownership has been embraced as a cultural goal, deliberately broadening the sectoral perceptions of affordable urban housing by engaging end-users in communities would help migrate efforts and resources to reduce the current cost (3 million - 6 million KShs, approximately USD 27,200 - 54,400) to costs that are affordable.

5 Recommendations and next steps

Overall, the development of circular housing practices could benefit from a bottom-up community-based approach, prioritizing specific local challenges over globally defined goals. Benefactor communities' involvement in the definition, conception and planning of affordable housing initiatives has often been overlooked. Along similar lines, the combination of affordable and circular housing is still a vision that needs to be refined, as the greening process of the construction sector still requires support, and "decarbonization" will not happen overnight. The common conflation of the terms "affordable" and "low income" as applied to housing demonstrates a need for much more honest discourse and consultations within the sector. Technologies suited for developing actual affordable housing and financial platforms that serve the bulk of the informal sector already exist in Kenya; they need support to scale at feasible speeds.

[15] Interview with Laura Payne, *REALL UK*

Furthermore, the financial risks associated with green affordable housing are so high that it is unfavorable for private developers to carry the fiscal burden independent of the subsidies tax breaks are necessary. For practitioners in the industry, there exists a lack of knowledge of available circular solutions. Indeed, built environment education curricula could advance with additional modules to help change the outlooks of future professionals in the industry, who bear the primary role of educating prospecting property developers and homeowners about how to cause as little harm as possible upon the environment within their proposed budgets. There also exists a vast untapped enterprise and entrepreneurship in the Kenya economy and those of its neighbors already innovating in the construction industry. Increasing access to industrial incubators of the kind of KIRDI (state) or Gearbox (private sector) across counties (for Kenya) and the regions would serve to advance industry, alleviate poverty, and increase the capacity of more people to be concerned for the environment.

In terms of policy, access to equitable carbon finance can be improved for the Kenyan construction industry to benefit developers and manufacturers of building materials and components. Furthermore, policy can encourage systematic efforts to reintegrate traditional building techniques into legal use for "permanent" construction in the urban realm. Importantly, revision of the tax code could help mitigate development costs for green choices in the affordable housing sector and the construction industry

While our research presents an initial overview of opportunities and barriers to circular housing solutions in Kenya, we suggest various opportunities for future work and next steps. Further research on the links between affordable and circular housing in the country and surrounding region, including the role that close- and open-looped recycling processes could play in the sector.

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