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Building net-zero African cities

Decarbonization and structural transformation

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Abstract: This paper examines how African cities can reconcile rapid urbanization and development imperatives with urgent decarbonization goals through structural transformation. It begins by mapping key sources of urban carbon—energy poverty, inefficient buildings, poor planning, transport systems, waste management, and construction practices—and quantifies their contributions to emissions. Building on the concept of a 'latecomer advantage', the study argues that African cities can bypass legacy fossil-fuel systems by investing directly in decentralized renewables, net-zero energy buildings, green transport, and waste-to-energy technologies. It emphasizes how targeted green investment can simultaneously alleviate energy poverty, create skilled employment, and reduce carbon dioxide, while underscoring the critical roles of governance, finance, and policy coherence. Persistent barriers, constrained public and private finance, weak institutional capacity, skills gaps, policy fragmentation, and digital divides are analysed to highlight where interventions are most needed. The paper then proposes an integrated, cross-sectoral framework that aligns urban planning, energy, waste, and construction under coherent policies, supported by inclusive stakeholder engagement and innovative financing instruments such as green bonds and public-private partnerships. It concludes with recommendations for strengthening multilevel governance, formalizing informal sectors, and fostering South-South cooperation to accelerate a just transition towards low-carbon, resilient, and inclusive African cities.

Key words: decarbonization, African cities, structural transformation, urbanization, green investment, governance

JEL classification: O14, O18, O55 Q54

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1 Introduction

While Africa has been grappling with multiple entrenched challenges over the past decades, including chronic poverty, hunger, conflict, and widespread disease, the continent now faces climate change and its sweeping ramifications (Niang et al. 2014). Traditional practices in Africa such as reliance on fossil fuels, firewood, and bush-burning play a significant role in carbon dioxide emissions (Ernst et al. 2023; Oramah 2022). The burning of wood, for instance, which is a common practice, can generate sizable emissions, specifically when the wood is used in a way that exceeds the recovery rate of forests, thereby reducing their ability to isolate carbon (Flammini et al. 2023).

Within this context, Africa's urbanization rate is accelerating rapidly, with the urban population expected to increase from a modest, 400 million (in 2000) to 1.3 billion (in 2050), increasing the continent's urbanization rate to nearly 60% (Azubuike et al. 2022). This rapid urbanization brings its own social, economic, and environmental challenges (Combes et al. 2023). From the environmental perspective, this unprecedented urbanization experience aggravates several existing issues, which may perhaps be explained by the fact that many cities or even countries are unprepared for such an event. For example, rapid urban population growth is often associated with worsening air pollution due to increased use of transport and the birth of carbon-intensive industries (Cobbinah 2023; Ngcamu 2022). In fact, urban areas globally account for over 70% of energy-related carbon dioxide emissions (IEA 2023). Also, urbanization leads to loss of green spaces and environmental degradation, due to an increased demand for natural resources, thus resulting in biodiversity loss (Aronson et al. 2014). Further, urbanization intensifies waste management issues and water scarcity.

It follows that not only do African cities face multiple challenges because of the effect of climate change, but they are also faced with rapid urbanization, which further heightens climate-related issues. It is also worth stressing that African cities lack adequate infrastructure and planning to meet the demands of their growing populations and mitigate the effects of climate change. Yet, African governments have committed to the Paris Agreement to strengthen the global response to the threat of climate change by keeping the global temperature rise this century well below two degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (UNFCCC 2015: Article 2(1)(a)). In fact, some less-developed countries have committed to net zero by 2050.

Nevertheless, the urgency to address climate change has become ever more apparent, as recent estimates show that buildings alone consume as much as 45% of the world's primary energy supply and produce around 33% of global carbon dioxide emissions (Bongwirnso et al. 2023). Within sub-Saharan Africa specifically, the building sector can account for over a quarter of the region's total energy usage (Bongwirnso et al. 2023). Meanwhile, global atmospheric carbon dioxide concentrations continue to rise annually, reaching 423.75 parts per million in June 2023, up from 421.15 parts per million in June 2022 (Bongwirnso et al. 2023). These figures underline the pressing need to rethink development strategies in African cities, especially as they expand at a speed that outstrips the planning and infrastructural capacity of many nations.

Recent studies affirm that African countries are at a pivotal moment, either to pursue high-carbon, low-cost energy options that meet urgent development needs, or to leverage their 'latecomer advantage' by transitioning directly to clean energy systems, a strategy that involves bypassing outdated infrastructure and embracing emerging technologies such as hydrogen and decentralized renewables (French 2020). The growing appeal of solutions such as solar mini-grids and domestic wind or battery production lies in their dual capacity to boost economic growth while reducing emissions. Yet, the success of these technologies depends heavily on access to adequate finance and enabling policy environments. This leapfrogging potential is especially relevant for Africa, where many countries are not yet locked into legacy fossil-fuel systems and can move directly towards sustainable alternatives. As Ogaya and Okesanya (2024) argue, clean energy integration offers not only climate benefits but also development opportunities, particularly in off-grid and underserved areas. While Sayani et al. (2023) draw lessons from India's rural mini-grid initiatives, the parallels for Africa are evident and compelling.

Financial and institutional backing remains central. Green finance, public-private partnerships, and dedicated investment vehicles are repeatedly cited as essential enablers (Rasoulinezhad and Taghizadeh-Hesary 2022; Xing et al. 2022; Zhang 2024). Without these, investment is stifled and innovation constrained. Ogaya and Okesanya (2024) underline the critical role of regulatory frameworks in mobilizing capital for low-carbon projects. Ultimately, the latecomer advantage must be coupled with innovation in both finance and governance. Studies emphasize the need for cohesive stakeholder engagement, from governments to financial institutions and private actors, to drive lasting progress (Belgacem et al. 2023; Taridala et al. 2023).

In sum, Africa's energy future hinges on bold choices and coordinated action. Clean energy pathways are not only technically feasible but increasingly necessary for sustainable and inclusive development.

This brings several key questions. First, how can Africa achieve its goal of net zero and develop at the same time? This question is particularly important for African economies because of their heavy reliance on extractive industries that are carbon-based (e.g., fossil fuels, logging, and mining). These extractive industries not only drive economic growth and development, but they also offer employment prospects (Aladejare and Nyiputen 2023) and help to reduce poverty (UN 2021). At the same time, their detrimental environmental effects are considerable. The second question, which is somewhat related to the first, is: how can African cities address the challenging trinity of rapid urbanization, climate, and net zero? The next question is concerned with decarbonization: given the nature and complexity of the challenges faced by African countries and their cities, what practical decarbonization pathways can they adopt to achieve net zero without jeopardizing their growth prospects? Fourth, a central question in this paper relates to structural transformation. Can structural transformation play a crucial role in addressing the urbanization challenges and at the same time carry African cities on the decarbonization path? Finally, what are the key challenges faced by African cities on their path to a low-carbon society?

As highlighted in Nwokolo et al. (2023), advancing technology alone is insufficient without robust governance and effective financing measures to guide urban expansion onto a greener footing. African cities therefore face a critical juncture wherein they can combine local innovation (e.g., improved building codes, climate-smart infrastructure) with international support to foster inclusive, sustainable development.

Whereas many previous studies have tended to concentrate on isolated aspects of decarbonization, such as renewable energy technologies or individual urban planning strategies, this paper sets itself apart by presenting a comprehensive and integrated framework. Rather than viewing energy, urban planning, waste management, and building construction as separate challenges, it explores how these sectors can be transformed in synergy to accelerate decarbonization in African cities. In doing so, it builds on existing knowledge while advancing the conversation through a cross-sectoral lens and the use of contemporary case studies to chart a pathway towards sustainable and inclusive urban development.

This paper seeks to address these critical questions. It begins by outlining the primary sources of carbon emissions in African cities, followed by an exploration of how structural transformation may offer a valuable opportunity to accelerate progress towards decarbonization and the achievement of net-zero goals. Selected country case studies are then examined to illustrate these dynamics in practice. The paper continues with a discussion of the key challenges facing African cities, before concluding with final reflections and recommendations.

2 Sources of ‘carbonization’ in African cities

To implement practical policies on the road to achieving the net-zero goal, it is crucial to first understand the key sources of ‘carbonization’ in African cities. This section discusses some of the key factors behind carbonization for African cities, which include energy poverty, poor urban planning, and inadequate waste management systems.

One of the critical avenues for decarbonizing African cities is through the reduction of energy poverty, which is generally defined as the absence of satisfactory choice in accessing adequate, affordable, reliable, and environmentally friendly sources of energy (Barnes et al. 2011; González-Eguino 2015). In other words, energy poverty entails not only the lack of physical access to energy resources but also the inability to afford the energy needed (IEA 2020). This phenomenon is a major contributor to carbon emissions in developing countries, particularly in Africa: according to the IEA (2014), roughly 600 million people in sub-Saharan Africa lack access to electricity, while more than 700 million rely on traditional cooking methods. Many households facing energy poverty turn to easily accessible but highly inefficient and polluting fuels, such as coal, animal dung, and wood. The continuous burning of these fuels produces significant quantities of greenhouse gases, including carbon dioxide and black carbon, a powerful climate-forcing agent (Sovacool 2012). Over time, the reliance on these options becomes self-reinforcing: given limited disposable income and few modern alternatives, poorer urban dwellers consistently resort to whichever fuel is cheapest or most readily available, even if it emits a high level of pollutants. This dynamic both reflects and perpetuates inequities, as wealthier segments of society are more likely to adopt cleaner, lower-carbon energy sources. Moreover, the widespread use of biomass exacerbates environmental degradation by spurring deforestation, a process that diminishes forests’ capacity to absorb carbon dioxide and sustain critical ecosystem services (Flammini et al. 2023). The steady depletion of tree cover in peri-urban regions can thereby compound overall emissions, as fewer forests remain to sequester carbon. Meanwhile, the production of charcoal, a ubiquitous household fuel in many African cities, creates additional emissions during the conversion process from wood to charcoal itself, further increasing the overall carbon footprint. Energy poverty also extends beyond household cooking or heating. Small-scale enterprises, operating on the margins of the formal economy, often power machinery or lighting with diesel generators because they cannot afford or access reliable electricity (IEA 2020). While such generators provide a temporary solution, they contribute substantial carbon dioxide and particulate matter, adding to the cumulative emissions profile of informal industrial and commercial activities. In this way, energy poverty not only affects domestic life but also shapes local economies in ways that lock entire communities into carbon-intensive patterns of energy use.

This issue is particularly evident in the building sector, where recent findings show that sub-Saharan Africa's buildings alone account for over a quarter of the region's total energy usage (Bongwirnso et al. 2023). Much of this demand is met through fossil-fuel-based power generation, which heightens carbon intensity, especially where clean energy alternatives remain inaccessible or unaffordable to many urban residents. This dynamic deepens the burden of energy poverty and entrenches reliance on high-emission fuels. In line with existing literature (Belussi et al. 2019; Cao et al. 2016), these trends highlight the pressing need for innovative building designs and more energy-efficient operations, particularly in regions already grappling with limited energy access and growing urban populations.

Furthermore, Nwokolo et al. (2023) suggest that a reliance on fossil fuels can often crowd out investments in local renewable capacity (Mutezo and Mulopo 2021). When governments and urban developers continue to focus on cheaper diesel or coal-based solutions, they perpetuate the high cost of cleaner alternatives and reduce incentives to expand solar or wind infrastructure. Overcoming this barrier often involves targeted financing, such as green funds or concessional loans, and supportive policies that encourage domestic manufacturing of low-carbon technologies, which in turn can mitigate energy poverty while reducing emissions.

Addressing these challenges by increasing access to modern and affordable energy sources, without going into specific policy measures, remains critical for cutting the emissions tied to inefficient fuels. By reducing dependence on polluting energy options, urban residents can help slow the pace of deforestation, safeguard important carbon sinks, and create an opening for more systematic approaches to decarbonization, such as the widespread adoption of renewables or improved building efficiency. With energy poverty alleviated, African cities stand a greater chance of making genuine progress towards lowering their overall carbon footprint while laying the groundwork for a more sustainable and inclusive form of urban development.

Another critical factor in the carbonization process of African cities is linked to poor urban planning. Indeed, many cities are poorly planned and unprepared to cope with events such as the rapid urbanization observed in Africa in recent decades. In most cases, they have barely moved away from the colonial planning era. Poor urban planning often results in the decline of natural environments and destruction of biodiversity (Cobbinah et al. 2015; Elmquist et al. 2013). One reason is that urban planners generally prioritize development over environmental sustainability. This emphasis frequently results in the fragmentation or complete removal of green areas, including parks, wetlands, and forested zones, that would otherwise capture carbon, moderate local climates, and uphold biodiversity (Elmqvist et al. 2013). When urban development proceeds without thorough environmental evaluations, it disrupts native plant and animal life, leading to increased habitat fragmentation and the risk of species decline (Seto et al. 2012). In many African cities, wetlands and riverbanks, previously crucial for flood control, are repurposed for housing or informal businesses, diminishing natural buffers and heightening susceptibility to climatic extremes. Moreover, fast-paced urban growth often goes hand in hand with insufficient waste and water management infrastructure, leading to contaminated water resources and in turn the degradation of nearby habitats (UN-Habitat 2020). This problem typically arises from underinvestment in drainage and sanitation, coupled with rapid population increases that exceed the current system's capacity (Cohen 2006). Over the long term, this imbalance between demand and service provision not only compromises water quality but also weakens local biodiversity, soil health, and the overall ecological resilience of urban environments. Beyond the direct impact on habitats, poorly designed transport networks can also increase carbon footprints. When residential zones are situated far from employment centres or commercial hubs, the absence of effective public-transport systems often forces residents to depend heavily on private vehicles and informal paratransit options. This pronounced reliance on private transport amplifies carbon emissions and elevates local air-pollution levels, a problem exacerbated by the prevalence of older and poorly maintained vehicles on the roads. Evidence shows a direct link between limited public-transport access and increased car dependency, which in turn drives higher traffic congestion and environmental pollution (Genç et al. 2023; Ibad 2020; Jawed et al. 2019). At the same time, sprawling, low-density urban development inhibits the creation of walkable neighbourhoods, further discouraging the use of environmentally friendly travel modes such as cycling or walking. Along these lines, informal settlements, which often emerge along ecologically sensitive areas around urban peripheries, pose another concern. Due to land use conflicts and the absence of strong regulatory frameworks, these areas frequently overlap with critical habitats, forests, wetlands, and riparian zones, and they degrade local biodiversity through unregulated construction, waste-dumping, and extraction of natural resources. The cumulative effect of these settlements contributes substantially to environmental stresses, from soil erosion to water pollution, ultimately undermining efforts to reduce emissions and sustain urban ecosystems.

Also, poor urban planning is often associated with poor infrastructure and weak public transport networks, resulting for instance in private car ownership rises, and outdated vehicles with minimal emissions controls often dominate the roads, contributing further to localized air pollution and the broader carbon footprint of urban areas. Additionally, the absence of safe and connected pedestrian or cycling infrastructure encourages short-distance trips to be taken by motor vehicles rather than more environmentally friendly methods of travel. All of these factors taken together create a feedback loop in which low-quality infrastructure perpetuates car-dependent lifestyles, reinforcing patterns of high energy use and substantial emissions. Indeed, Pucher and Dijkstra (2003) have shown that well-designed pedestrian and cycling paths can significantly reduce reliance on private cars, whereas Kenworthy (2003) notes that cities lacking robust non-motorized transport options often experience higher greenhouse gas output and heightened congestion.

A further source of carbonization is poor waste management. With rapid urbanization and population growth, waste management in African cities is becoming a critical challenge with significant implications for the environment. A common characteristic among many African countries is the widespread struggle to effectively collect, process, and dispose of waste. In fact, outside South Asia, sub-Saharan Africa is one of the poorest performers in waste collection, with only 44% of waste collected, compared with 71% in East Asia and the Pacific, and 84% in Latin America and the Caribbean (Kaza et al. 2018). In cities such as Abidjan, Accra, and Lagos, a lack of financial resources paired with weak infrastructure has led to severe waste management issues, including uncollected waste, poorly managed landfill sites, open burning, and unregulated dumping.

Poor waste management is a significant contributor to environmental degradation. Open dumping, a common practice in many African cities, generates carbon dioxide emissions alongside other harmful pollutants such as nitrogen oxides and various organic compounds. Moreover, disposing of organic waste in poorly maintained landfills produces methane (via anaerobic decomposition), a gas capable of trapping heat in the atmosphere over a 100-year period (Hoornweg and Bhada-Tata 2012). The absence of effective sorting and recycling measures further exacerbates the problem: materials ranging from plastics and metals to compostable organic matter are often discarded in landfills or burn piles instead of being reclaimed for further use. This not only increases the life-cycle carbon footprint of goods by driving up the demand for primary resources, requiring more energy-intensive extraction and manufacturing processes (Zhang et al. 2010), but also raises emissions from heavy-duty vehicles transporting waste over long distances to disposal or treatment facilities (Troschinetz and Mihelcic 2009).

Decarbonizing African cities can be significantly advanced by improving waste management practices, which remain inadequate in many urban areas. Inefficient collection, segregation, and disposal systems leave waste to accumulate in open dumps or be burned in unregulated conditions—practices that generate substantial greenhouse gases and other climate pollutants (Couth and Trois 2012; Kaza et al. 2018; Squire and Nkurunziza 2022). In contrast, adopting modern waste systems such as waste-to-energy technology, recycling, and composting can help establish a circular economy, supporting low-carbon urban development. Alongside these factors, the construction sector in rapidly urbanizing African cities plays a pivotal role in driving carbon emissions. As demand for housing, infrastructure, and public facilities grows, the embodied-energy and material requirements of concrete, steel, and other construction inputs rise sharply, while on-site activities add further energy use (Churkina et al. 2020; Hörnschemeyer et al. 2022; Pauliuk et al. 2021). In Africa, the buildings and construction sector is responsible for 36% of final energy demand and accounts for 39% of energy- and process-related emissions (IEA 2022b). Cement manufacturing, for instance, is notably carbon-intensive, requiring high-temperature kilns that rely predominantly on fossil fuels (IEA 2019). Likewise, steel production depends heavily on coal-based processes, further contributing to greenhouse gas emissions (World Bank 2020). The expansion of the construction sector thus intersects significantly with broader energy and environmental challenges, amplifying the carbon footprint of growing urban centres.

Recent work has also shown that inefficient or outdated building practices can exacerbate Africa's high carbon intensity in the construction sector. According to Bongwirnso et al. (2023), buildings worldwide can consume up to 45% of primary energy supply, and much of sub-Saharan Africa's building demand is met through fossil-fuel-heavy grids and energy-intensive materials. As urban populations grow, this dependence further entrenches carbonization patterns, given insufficient enforcement of building codes and the lack of accessible, low-carbon construction alternatives. Moreover, net-zero energy building solutions, which have proven effective in other parts of the world (Nematchoua and Reiter 2020), could substantially reduce emissions if tailored to local materials and climate conditions.

Similarly, Nwokolo et al. (2023) stress that large-scale building retrofits or greener construction practices often languish without reliable financing and policy coordination. Limited local production of energy-efficient materials and a shortage of enforcement capacity for low-carbon building codes repeatedly lock urban development into carbon-intensive pathways. Addressing these constraints through training, financial incentives, and improved governance could help shift African construction towards more sustainable designs that will lower emissions over the full building life cycle.

Rapid urbanization across sub-Saharan Africa is intensifying demand for building materials, driving expansion in housing, transport, and infrastructure projects (African Development Bank 2022b; UN-Habitat 2020). Every phase of construction, from raw-material extraction to final product delivery, contributes to carbon dioxide emissions (IPCC 2018). On-site operations, including the use of diesel generators and heavy machinery, further escalate emissions (IEA 2022b). Inefficient technologies and weak enforcement of environmental standards often result in excessive fuel use and poor materials management (World Bank 2020). Moreover, the conversion of forests and other carbon sinks into building sites diminishes ecosystems' capacity for carbon sequestration (IPCC 2018). Without integrated land use strategies and robust environmental oversight, large-scale urban development risks entrenching unsustainable consumption and emission patterns.

Addressing these emissions requires a strategic response. Providing modern, affordable energy sources can alleviate reliance on biomass and diesel, helping conserve forests and reduce soot emissions. Improving urban planning by integrating public transport, safeguarding green corridors, and creating walkable neighbourhoods can minimize car dependence and protect ecologically sensitive areas (Kenworthy 2003; Pucher and Dijkstra 2003). Effective waste management, including waste-to-energy schemes and recycling, lowers emissions by curbing open dumping and reducing raw material demand (Kaza et al. 2018). Finally, steering construction towards greener building materials—such as blended cements—and adopting energy-efficient practices can reduce its carbon footprint (IEA 2019). Coupled with rigorous policy enforcement and capacity-building, these strategies form a coherent framework for low-carbon urban development.

In essence, mitigating carbonization in African cities hinges on addressing multiple overlapping sources of emissions. Whether it is modernizing energy services to combat energy poverty, reforming urban planning to preserve carbon sinks, upgrading waste management to lessen methane release, or improving construction practices for more sustainable growth, these interventions are interconnected. By tackling all these elements, African cities can work towards a holistic decarbonization strategy that not only curbs emissions but also advances equitable economic development and bolsters long-term resilience.

3 Urbanization and environmental challenges: can African cities decarbonize through structural transformation?

While urbanization brings several challenges, including environmental pressures, it also creates opportunities to use resources more efficiently and safeguard biodiversity and ecosystems (Elmqvist et al. 2013; Seto et al. 2017). More importantly, urbanization can serve as a catalyst for structural transformation in Africa (African Development Bank 2016). In the context of African cities, it is argued that structural transformation would not only create new jobs but would also help in the decarbonization process and therefore in the achievement of sustainable cities. This section discusses how structural transformation can achieve these goals.

'Structural transformation' in the decarbonization discourse describes the profound, enduring changes necessary to drastically reduce carbon emissions and fundamentally reconfigure our economic and social systems. Broadly defined, it is the process of shifting labour from low-productivity to high-productivity sectors (World Bank 2019), a change that not only drives economic growth but also underpins efforts to decarbonize energy systems. This transformation involves moving away from fossil-fuel-dependent systems toward low-carbon alternatives, impacting on industries, energy sources, public policy, and societal behaviours while also promoting sustainable patterns of production and consumption.

In the context of African cities, structural transformation can play a dual role: it can serve as a vital mechanism for creating new job opportunities by reallocating resources to more productive sectors, while simultaneously facilitating the transition to a low-carbon economy. By adopting sustainable practices and investing in renewable energy and green technologies, urban centres can reduce their reliance on fossil fuels, lower carbon intensity, and mitigate environmental degradation. This shift not only contributes to global climate targets but also positions cities to achieve broader sustainability goals. Achieving this transformation requires significant investments and the development of supportive policy frameworks. It encompasses the implementation of measures such as waste-to-energy technologies, comprehensive recycling and composting schemes, and infrastructure upgrades that reduce the energy demands of industrial and urban systems. Such integrated strategies foster a circular economy where resources are continuously reused, minimizing the energy-intensive processes associated with raw material extraction and manufacturing. Furthermore, the process of structural transformation extends to altering individual and collective behaviours. In African cities, embracing these changes means that communities must adapt to new practices in energy consumption, waste management, and resource utilization. This societal shift is critical, as even the most advanced technologies require public support and behavioural change to reach their full potential in lowering emissions and promoting sustainable development.

Building on this basis, the next subsections explore how structural transformation can be operationalized to achieve low-carbon, resilient urban development. Drawing on recent research and international experiences, the discussion highlights specific strategies, from net-zero-energy buildings to green investments and circular economy practices, that can drive the transition to sustainable African cities. In particular, recent work by Bongwirnso et al. (2023) illustrates how structural transformation in sub-Saharan Africa can be closely linked with net-zero-energy building solutions, renewable energy uptake, and broader economic development. By integrating on-site solar, hydro, or biomass energy systems and strengthening green construction skills, African cities can reduce reliance on high-emission fuels while simultaneously creating productive employment opportunities (IRENA 2022; Zhou et al. 2022). International studies further emphasize the centrality of skills development in achieving energy-efficient urban transitions. For example, Aliagha et al. (2015) highlight the critical importance of bridging green skills gaps in the construction sector to enhance energy efficiency outcomes, while Cárcel Carrasco et al. (2022) demonstrate how work-based learning systems can effectively upskill construction workers in sustainable building methods. Although these studies are situated outside Africa, their findings are highly relevant given the similar capacity challenges faced by African cities seeking to decarbonize their building and infrastructure sectors.

Moreover, this alignment between urban growth and decarbonization objectives reflects a core dimension of structural transformation: reorienting economies away from extractive, carbon-intensive industries towards more sustainable modes of production and consumption. Such an approach not only lowers carbon footprints but also catalyses job creation across sectors such as renewable energy plant installation, building retrofits, and waste-to-energy systems (Nematchoua and Reiter 2020). In the context of African cities, the synergy between urban expansion and green investment can foster local manufacturing of sustainable construction materials, improved mass transit infrastructure, and the growth of circular economy practices, each vital for cutting emissions and attaining long-term resilience (Becqué et al. 2019).

Rather than viewing rapid urbanization solely as a source of environmental strain, African governments and their development partners can strategically utilize structural transformation principles to reshape fast-growing cities into low-carbon, economically dynamic urban centres.

3.1 Reduction in energy poverty and decarbonization through structural transformation

It is evident from earlier discussions that reducing energy poverty is essential to the decarbonization of African cities. The central question is how to use structural transformation to achieve these twin objectives. Put differently, can structural transformation provide a practical pathway for addressing energy poverty while also accelerating decarbonization in African urban centres?

Although multiple initiatives may be employed to reduce energy poverty and advance decarbonization, this subsection focuses on one particularly pivotal route: green investment. Green investment involves directing resources into projects, technologies, and infrastructure designed to reduce greenhouse gas emissions and promote sustainable development (IEA 2017). By facilitating the transition from traditional carbon-intensive energy sources to modern renewable alternatives, green investment is crucial for addressing the challenges posed by rapid urbanization in African cities while simultaneously mitigating environmental degradation (World Bank 2019). For example, technologies such as solar panels, rooftop photovoltaic systems, wind turbines, and geothermal energy sources not only provide more reliable power but also significantly decrease carbon emissions (UNEP 2024). Effective decarbonization of Africa's urban energy sectors requires aligning governance frameworks with economic incentives to facilitate renewable transitions. Approximately 80% of Africa's current electricity generation is thermal-based, stressing significant potential for emissions reduction (Momodu et al. 2022). Opportunities such as converting gas-flaring, a major emission source, into productive electricity generation highlight the need for coherent political-economic strategies. Strengthening governance structures to leverage these opportunities is therefore crucial for sustainable and inclusive energy transformations in African cities.

Furthermore, green investment can stimulate local economic growth and deliver high-productivity job opportunities (Scholz and Fink 2022). Improved access to dependable sources of energy enhances the productivity of households and local firms, thereby boosting wider economic development. Specifically, investment in renewable energy facilities, such as hydroelectric power plants, solar arrays, and biomass installations, generates employment during construction, installation, and subsequent maintenance. These activities require a workforce equipped with newly developed technical skills, confirming the importance of targeted training programmes and capacity-building initiatives. In addition, there is scope to expand local manufacturing sectors tasked with producing materials and components used in these renewable energy systems, further driving job creation (African Development Bank 2021). Modelling by Ram et al. (2019) shows that transitioning to a 100% renewable electricity system could generate substantial employment across Africa, particularly in labour-intensive sectors such as solar photovoltaic and energy storage. The study estimates that the number of new jobs created in the renewable sector would outweigh those lost from the phase-out of fossil fuels, resulting in a net employment gain across the energy transition. These findings suggest that aligning national energy strategies with workforce development is vital to ensure African economies fully capitalize on the employment and development opportunities linked to decarbonization.

Hence, structural transformation, underpinned by green investment, can serve as an effective means of reducing energy poverty while simultaneously advancing decarbonization in African cities. By integrating cleaner energy solutions with enhanced economic opportunities, this approach fosters sustainable growth and strengthens urban resilience against the escalating impacts of climate change (World Bank 2019).

Several country experiences demonstrate that targeted investments in renewable energy can simultaneously reduce energy poverty, create jobs, and advance decarbonization goals. Case studies from across Africa highlight how structural transformation can address these challenges. In South Africa, the Renewable Energy Independent Power Producer Procurement Programme fosters investment in solar and wind, significantly diversifying the country's energy mix away from coal.

Similarly, Morocco's Noor Ouarzazate Solar Complex demonstrates how large-scale solar ventures can stimulate job creation and support decarbonization. Senegal's Senergy 2 solar power plant enhances rural electrification and reduces reliance on diesel generators, while off-grid solar initiatives in Nigeria lower operational costs and expand electricity access in remote areas. Kenya's renewable energy efforts, including solar mini-grids and geothermal projects, broaden electricity access and cut emissions, as exemplified by the Lake Turkana Wind Power Project. Hydropower developments also play an important role: in Ethiopia, investments such as the Grand Ethiopian Renaissance Dam create new jobs in construction and engineering while helping to meet the energy demands of a growing population. Together, these examples illustrate that structural transformation through renewable energy investment not only addresses energy poverty but also drives broader decarbonization and inclusive economic growth across African cities and regions.

In addition, improving the energy performance of buildings is critical not only for reducing emissions but also for alleviating energy poverty, as lower energy demand makes access to affordable, reliable energy services more attainable. As has been argued by Cao et al. (2016), the move towards net-zero-energy buildings worldwide can dramatically reduce energy intensity, making it a key element of decarbonization strategies for African cities struggling with energy poverty. Likewise, Belussi et al. (2019) show that energy efficiency solutions, ranging from high-performance insulation to solar-based cooling, can yield significant emissions cuts and improve living conditions in urban settings. Meanwhile, Becqué et al. (2019) argue that targeted policy pathways, such as building codes and financial incentives, are critical for scaling up net-zero approaches across the region, further supporting both climate and energy access goals.

The transformation of the energy system can also play a pivotal role in helping African cities decarbonize while simultaneously acting as a major driver of job creation. As cities across the continent grapple with high levels of air pollution, mounting energy demands, and the pressing need to address climate change, shifting the energy mix towards cleaner, more sustainable sources has become increasingly urgent (IPCC 2021). This transition requires a sharp reduction in the use of fossil fuels, particularly in the power sector, and is closely linked with the electrification of end-use sectors such as transport and heating (IRENA 2019). By leveraging abundant renewable energy resources, such as solar, wind, hydro, and geothermal, African cities can significantly reduce their carbon footprint, improve local air quality, and foster inclusive economic growth.

A key dimension of this energy transition involves the integration of renewable energy technologies into national and municipal grids. Historically, fossil fuels have been the backbone of electricity generation in many African countries, contributing to greenhouse gas emissions and other pollutants (World Bank 2021). Recent advancements in renewable energy technologies have made them increasingly cost-competitive with conventional energy sources. The cost of solar photovoltaic systems, for instance, has dropped dramatically over the past decade, making large-scale solar projects financially feasible even in regions with limited capital (IRENA 2019). A comprehensive review has shown that technological improvements and economies of scale have significantly lowered the levelized cost of electricity for decentralized off-grid renewable energy systems, making them increasingly cost-competitive with conventional energy sources. Specifically, average levelized costs of electricity for 100% renewable energy systems declined by about 9% annually between 2016 and 2021, due to cost reductions in renewable energy and storage technologies (Weinand et al. 2023). Furthermore, a technical and financial assessment has revealed that the continuous decline in photovoltaic system prices, coupled with supportive energy policies, enhances their attractiveness as a sustainable alternative to high-emission fuels (Ibad 2020). Moreover, the modular nature of many renewable energy technologies, particularly solar and wind, enables decentralized energy production, which is crucial for expanding electricity access in remote and peri-urban areas. This decentralization aligns with broader development agendas that aim to foster equitable and reliable access to energy (African Development Bank 2022a).

In addition to reducing emissions, the electrification of the transport sector can further accelerate decarbonization efforts. Transport remains a major contributor to greenhouse gas emissions in urban centres, largely due to reliance on petrol- and diesel-based vehicles (IPCC 2021). By promoting electric mobility, encompassing electric buses, cars, motorcycles, and e-bikes, African cities can not only diminish their carbon footprint but also improve air quality and public health (Zhou et al. 2022). These initiatives support the broader transition towards sustainable urban planning, which prioritizes accessible, low-carbon public transport networks. Furthermore, the rapid adoption of electric vehicles can catalyse developments in battery manufacturing, charging infrastructure, and ancillary services, thereby generating additional job opportunities in manufacturing, installation, and maintenance (Ram et al. 2020).

The shift towards renewable energy could generate substantial employment opportunities throughout the value chain, ranging from manufacturing to research and development. Zhou et al. (2022) indicate that restructuring the energy sector could alter employment patterns and catalyse new jobs, including those in upstream supply chains, due to interconnections between the power sector and other economic activities. For instance, a solar photovoltaic project requires not only the design and production of solar panels but also the installation, operation, and maintenance of these systems (IRENA 2019). Each of these stages demands distinct skill sets, spanning low, medium, and high skill levels. Along the same lines, Ram et al. (2020) argue that a global energy transition to a 100% renewable power system by 2050 could generate as many as 52 million new ongoing jobs. Even if Africa captures only a portion of this market, the employment potential is enormous.

Similar patterns have been observed in some African countries, where strong solar, hydro, and biomass potentials are gradually attracting both domestic and foreign investments. In Cameroon, for example, installed hydroelectric capacity already exceeds 1,200 megawatts, and expansions in small-scale hydropower plants have boosted local employment while cutting reliance on diesel generators. Meanwhile, Senegal’s biomass resource alone could provide up to 2.9 terawatt hours of electricity per year if harnessed through greener technologies (Bongwirnso et al. 2023). Such developments illustrate how structural transformation anchored in renewable energy investments can address energy poverty while placing African cities on a pathway to sustained decarbonization.

3.2 Urban planning transformation and decarbonization

A starting point for this transformation is recognizing the complex consequences of poor urban planning. In many African cities, rapid urbanization has outpaced local authorities’ ability to provide reliable roads, robust public transport, and coherent zoning (Kenworthy 2003; World Bank 2020). This shortfall has resulted in an over-reliance on older high-emission vehicles, while inadequate pedestrian and cycling infrastructure reinforces car dependency (Pucher and Dijkstra 2003). Consequently, carbon emissions are rising, worsening air pollution and exacerbating public health crises, including respiratory illnesses (IPCC 2018). Additionally, severe congestion reduces worker productivity and inflates business costs, hampering urban competitiveness (Saghir and Santoro 2018). Addressing these issues requires integrated planning strategies that prioritize low-carbon transport solutions, better zoning, and sustainable infrastructure to enhance air quality, mobility, and economic vitality.

A pertinent question is how structural transformation can effectively tackle these obstacles. Indeed, it could do so by emphasizing targeted investments in green sectors and modern infrastructure (African Development Bank 2019b). By shifting from reactive to proactive urban planning, policy makers can integrate public transport, walking, and cycling networks while reforming zoning policies to minimize car dependency (Turok 2016). Aligning environmental objectives with economic development can significantly reduce health and productivity costs while fostering resilient, competitive urban economies. Such measures require coordinated efforts between public and private stakeholders.

One of the most immediate and effective strategies for reducing emissions and promoting sustainable urban development is reforming transport systems. The transport sector alone accounts for roughly 26% of Africa's carbon dioxide emissions (Sai et al. 2025), stressing the urgency of transformation. Inadequate or fragmented transport networks contribute to higher pollution levels and economic inefficiencies, as many cities rely on unreliable bus services, deteriorating roads, and a notable lack of rail-based transit (UN-Habitat 2020). Public transport, where available, is often informal, with minimal regulatory oversight and insufficient integration across modes. These weaknesses encourage car dependency, increasing congestion and emissions while reducing productivity.

By contrast, a well-regulated and thoroughly planned public transport framework can serve large populations while significantly reducing greenhouse gas emissions (Jing et al. 2022; World Bank 2020). Simulation studies further demonstrate that improvements in public transport systems can substantially decrease local air pollutant emissions, contributing to broader environmental gains (Aristizabal et al. 2020). Bus rapid transit (BRT) systems, commuter rail, and light rail represent more efficient alternatives that, when executed effectively, can improve mobility while reducing travel times. Nairobi's proposed BRT system, Johannesburg's Rea Vaya, and Lagos's expanding BRT corridors (World Bank 2020) illustrate how structured transport solutions can mitigate these challenges. Similarly, Dakar's regional express train project provides a low-emission alternative to informal minibuses while supporting compact urban development and professional roles in rail engineering and urban design (Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation 2021; Ministère des Infrastructures, des Transports Terrestres et du Désenclavement Senegal 2021). Furthermore, electrifying these networks using renewable energy sources such as solar, wind, or hydropower can considerably lower urban carbon footprints, improving both environmental and public health outcomes (IPCC 2018).

Beyond its environmental benefits, investment in sustainable transport serves as a catalyst for job creation. A modernized transport network generates skilled employment opportunities in infrastructure engineering, operational management, data analytics, and vehicle maintenance. BRT systems in particular not only improve mobility but also stimulate industrial growth in vehicle-manufacturing, service provision, and urban planning. For example, the implementation of a BRT network in Dakar facilitated access to over 120,000 jobs, many of which were in higher-productivity sectors such as transport operations and maintenance (World Bank 2020). Likewise, Casablanca's tramway network, along with Morocco's expansion in solar and wind energy, has spurred demand for architects, project managers, and energy auditors, highlighting how transport electrification can create local skill development opportunities (Moroccan Ministry of Energy, Mines, and Environment 2020).

In addition to large-scale transport infrastructure, the development of local transport modes, such as bicycle and motorcycle taxis, has proven to be a crucial employment sector, especially within informal economies. These modes provide affordable and flexible mobility solutions, particularly in areas where formal public transport systems remain underdeveloped. The rise of digital ride-hailing platforms has further integrated these transport options into formal urban mobility networks, improving job access while enhancing connectivity for marginalized communities (UN-Habitat 2020). In Rwanda, for example, Safi Universal Link, founded in 2017 by a team of engineers and experienced businessmen, has been instrumental in developing the e-mobility sector. By providing in-house training, the company offers employment opportunities to young people while promoting sustainable transport solutions. Additionally, Kigali's urban planning reforms focus on mixed-use zoning and renewable energy micro-grids, creating specialized roles in solar engineering and maintenance (Ministry of Infrastructure Rwanda 2019). Similarly, Ghana has embraced an integrated approach to urban development by upgrading informal settlements and improving access to essential services such as electricity and water (Accra Metropolitan Assembly 2020). These improvements reduce urban sprawl and congestion by making it easier for residents to access jobs and services without relying on private vehicles. Furthermore, the city has promoted public-private partnerships to develop solar mini-grids in newly upgraded neighbourhoods, fostering job opportunities for engineers, project managers, and technicians. This approach not only strengthens urban resilience but also generates employment while supporting Accra's broader transition to a green economy.

Investing in non-motorized transport can complement motorized public transport while promoting economic inclusion and sustainability. Studies by Pucher and Dijkstra (2003) stress how a well-designed pedestrian and cycling infrastructure can significantly reduce car dependency while improving public health. Expanding pavements, creating dedicated cycle lanes, and ensuring safe pedestrian crossings not only enhances road safety but also encourages more people to walk or cycle for short trips. This shift in transport behaviour can lower emissions and foster social interactions within communities. Successfully implementing non-motorized transport strategies requires integrated planning, regulatory enforcement, and collaboration among various stakeholders. City authorities must engage with urban planners, private investors, and community organizations to ensure that infrastructure developments align with real-world needs. Once operational, non-motorized transport projects often stimulate local economies by driving demand for bicycles, repair services, and related innovations (Turok 2016). These developments encourage new business opportunities in sectors such as software development for digital mobility tools, sustainable design, and logistics, fostering broader economic growth.

A comprehensive transformation of transport infrastructure, including modern BRT systems, improved pedestrian and cycling networks, and electrified transit options, can achieve multiple objectives simultaneously. It reduces reliance on private vehicles, cuts carbon emissions, and alleviates pollution while improving economic productivity through shorter commutes and increased job opportunities. As African cities face rapid urban expansion and intensifying climate challenges, transport modernization emerges as a critical pillar for sustainable urban development. Through strategic planning, skill development, and an integrated mix of motorized and non-motorized transport solutions, policy makers can address both immediate mobility demands and long-term environmental resilience.

Meanwhile, Bongwirnso et al. (2023) point out that integrating net-zero energy principles into urban planning, such as prioritizing energy-efficient building layouts, green corridors, and optimized land use, can further reduce carbon footprints at the city scale. Attia et al. (2017) similarly note that effective zoning and district-level energy planning, combined with the electrification of transport, can cut overall carbon dioxide emissions by aligning housing, amenities, and transport routes. Such integrated strategies underscore the vital link between urban forms and low-carbon futures.

3.3 Structural transformation, urban waste management, and decarbonization

Structural transformation presents a pivotal opportunity to enhance urban waste management, achieve decarbonization, and stimulate job creation in African cities. As urban populations burgeon, inefficient waste management systems contribute significantly to environmental degradation, including greenhouse gas emissions, air and water pollution, and land deterioration (Hoornweg and Bhada-Tata 2012). Practices such as open dumping and uncontrolled incineration remain prevalent, releasing CO_2, methane, and other harmful pollutants that exacerbate climate change (Kaza et al. 2018). The lack of robust recycling and composting initiatives further intensifies the demand for virgin materials, leading to increased emissions from resource extraction and production (Zhang and Wen 2014).

Structural transformation supports decarbonization through the modernization of waste collection, sorting, and disposal systems. In many African cities, informal waste collection dominates, with waste pickers operating under precarious conditions without access to protective equipment or formal employment benefits. While the informal sector plays a crucial role in recycling, its inefficiency and lack of regulation mean that a significant proportion of recyclable material still ends up in landfill or is burned in open-air conditions, contributing to emissions and environmental pollution (Kaza et al. 2018; Mlotshwa et al. 2022). Governance failures, inadequate infrastructure, and limited investment further exacerbate these challenges, although they also present significant development opportunities if properly addressed (Godfrey et al. 2020). Transitioning towards integrated waste management systems that incorporate material recovery facilities, waste-to-energy plants, and composting facilities can significantly reduce urban carbon footprints while creating a new wave of skilled jobs.

Waste-to-energy technology, for instance, captures methane from organic waste decomposition and converts it into electricity or heat, providing a renewable energy source that offsets fossil-fuel consumption. Ethiopia has invested in waste-to-energy plants such as the Reppie waste-to-energy facility in Addis Ababa, which processes 1,400 tonnes of waste per day while supplying electricity to 30% of the city’s households (Gray 2018). Such facilities generate demand for high-productivity roles in engineering, environmental science, operations management, and data analytics. Engineers and technicians are required to design, build, and maintain the plants, while environmental specialists ensure compliance with emission control standards. Furthermore, the integration of digital monitoring systems in these facilities creates high-skilled opportunities for information technology specialists in smart waste-tracking and emissions control.

In addition to energy recovery, promoting large-scale recycling and composting can reduce the demand for raw materials and prevent environmental damage caused by landfill expansion. Recycling plastics, metals, and glass reduces emissions associated with extraction and production, while composting organic waste prevents methane release and enhances soil health. In North Africa, for instance, municipal solid waste offers untapped potential as a renewable energy source in Morocco, Tunisia, and Algeria. Both Morocco and Tunisia generate substantial volumes—around 6.85 million tonnes in Morocco (2019) and 2.6 million tonnes in Tunisia—with waste largely made up of organic matter, making it well suited to anaerobic digestion. However, evidence suggests that thermochemical methods, such as pyrolysis, may offer greater efficiency and environmental benefits by producing high-energy outputs such as bio-oil and syngas. Projections show that Tunisia could generate over 32,000 terajoules of energy via incineration by 2025, far surpassing biogas yields, while Morocco’s potential exceeds 147,000 terajoules. Algeria presents a similar picture: according to Hachemi et al. (2024), the country’s municipal solid waste system remains predominantly reliant on landfilling, with limited infrastructure for energy recovery. Yet, the biodegradable portion of Algeria's waste stream alone could produce an estimated 65,000 megawatt hours of electricity annually, enough to power thousands of households, highlighting a missed opportunity to integrate waste-to-energy into national sustainability strategies. These insights emphasize the importance of investing in waste valorization initiatives to advance low-carbon development across North African cities. In Morocco, recycling programmes have been integrated into urban development strategies, creating high-skill jobs in material recovery, process engineering, and sustainable product design (Moroccan Ministry of Energy, Mines, and Environment 2020). Similarly, Tunisia has adopted a digital approach to waste collection, implementing real-time tracking systems that improve operational efficiency. This initiative has generated high-productivity roles in data management, logistics optimization, and software development (GIZ 2024). However, the roll-out of such innovations is shaped by the broader policy and institutional context. Tunisia's waste governance has historically been characterized by fragmented responsibilities, inconsistent financing, and uneven implementation of public-private partnerships, which continue to affect the scalability and coordination of modernization efforts (Mahjoub et al. 2020). Countries that invest in modern waste systems have the opportunity not only to improve environmental outcomes but also to formalize employment opportunities, transitioning workers from low-productivity, informal waste-picking roles to secure, highly skilled jobs in regulated industries.

One effective strategy for job creation is supporting start-up businesses and outsourcing waste management services. In Algeria, the government has actively promoted the creation of start-ups specializing in waste recovery, with assistance from the Algerian Commission for Renewable Energies and Energy Efficiency (Nature News Africa 2023). These companies harness artificial intelligence (AI)-driven waste sorting, advanced composting methods, and industrial-scale biogas production, generating demand for biochemical engineers, logistics managers, and sustainability consultants. By fostering innovation in waste management, Algeria is creating a new class of high-productivity jobs that contribute to both environmental sustainability and economic growth.

Complementing these entrepreneurial efforts, several African cities are investing in the transformation of waste infrastructure. In Dakar, Senegal, the World Bank-supported Promoged (2023) project is rehabilitating the Mbeubeuss landfill, aiming to transform it into a modern, environmentally controlled waste management facility. The project not only targets reductions in methane emissions but also supports the formalization of waste pickers and the creation of new jobs in waste collection, sorting, and recycling, contributing to both climate mitigation and social inclusion (World Bank 2023). Meanwhile, in Sfax, Tunisia, a project to convert household waste into methane via anaerobic digestion is estimated to produce 1.9 million cubic metres of methane annually, opening up employment opportunities in renewable energy, plant operations, and logistics (Expadd 2022).

Overall, structural transformation presents a vital opportunity for African cities, and indeed cities worldwide, to improve waste management while creating high-skill, high-productivity jobs. By shifting from informal, inefficient waste collection to technology-driven waste management systems, municipalities can reduce emissions while developing a skilled workforce in environmental engineering, data science, smart logistics, and materials innovation. Investments in waste-to-energy plants, digital waste-tracking, and advanced recycling technologies provide long-term employment in engineering, AI-driven analytics, and industrial waste recovery. As these examples show, embracing structural transformation in waste management allows nations to transition towards sustainable urban economies that are both environmentally resilient and globally competitive.

Furthermore, several studies have pointed out that sub-Saharan Africa’s organic waste streams, often made up of agricultural residues and municipal refuse, could be repurposed into valuable feedstock for biogas generation, thereby reducing reliance on diesel power (Kaza et al. 2018; Troschinetz and Mihelcic 2009). This approach not only addresses disposal challenges but also aligns with circular economy principles by transforming waste into a low-carbon energy source (Zhang et al. 2010). Such integrated strategies can cut greenhouse gas emissions significantly while creating new market opportunities for local entrepreneurs in waste-to-resource services (Hoornweg and Bhada-Tata 2012; Zhang et al. 2010).

3.4 Achieving sustainable building and construction through structural transformation

Africa’s urban population is projected to double by mid-century, adding more than half a billion people to urban centres (IEA 2019). This rapid growth has led to soaring demand for housing, transport infrastructure, and public facilities, which in turn heightens resource consumption and carbon emissions (UN-Habitat 2020). In the buildings and construction sector, energy use and process-related emissions already account for 36% of final energy demand and 39% of energy- and process-related carbon dioxide emissions across the continent (GlobalABC et al. 2020; IEA 2022b). Without careful intervention, these figures are likely to escalate as cities expand. Effective governance is central to advancing decarbonization in African cities. Robust regulatory and institutional frameworks are needed to overcome fragmented mandates and weak enforcement, which often impede coordinated climate action. Scholars highlight the importance of harmonized national and municipal legislation, supported by institutional capacity and consistent monitoring, as key to enabling effective implementation (Akrofi et al. 2022). Multilevel coordination is equally crucial. Aligning international climate goals with local urban action requires stronger integration between national policies and municipal strategies. Initiatives such as the Africa Adaptation Acceleration Programme and city networks have shown how collaborative platforms can promote policy learning and shared leadership. Inclusive governance, through decentralized approaches and participation of communities, civil society, and the private sector, has proven effective in delivering more resilient and equitable outcomes, particularly in areas such as waste and energy planning. Africa’s high solar irradiance, ranging from 1,750 to 2,500 kilowatt hours per square metre a year in many cities, makes rooftop photovoltaic systems highly viable, yet uptake remains low due to affordability constraints and regulatory gaps (Akrofi et al. 2022). Despite formalized planning frameworks in countries such as Ghana, Kenya, and Ethiopia, weak enforcement, limited technical capacity, and poor data hinder solar integration. Embedding solar energy into urban design requires governance reform, local-level planning innovation, and regulatory clarity. These interventions are essential to translate solar potential into real urban decarbonization outcomes and to support the broader structural transformation agenda. Ultimately, strengthening governance structures and improving cross-level coordination will help establish the enabling environment required for African cities to pursue both decarbonization and structural transformation (Azubuike et al. 2022).

Yet, this challenge can also be viewed as an opportunity. By embracing green building materials such as bricks, clay, wood, bamboo, and straw, along with local supply chains, construction activities can reduce their carbon footprint while stimulating local economies. Hu (2023) demonstrates that the use of locally sourced, renewable materials in construction can significantly reduce embodied carbon and promote sustainability. In the African context, traditional construction methods frequently employ materials such as mud, clay, and straw, resources that are both abundant and low in embodied carbon, offering an environmentally sustainable pathway for future development. Along these lines, Marut et al. (2020) highlight the availability, low environmental impact, and economic opportunities provided by these alternative building materials, making them an attractive option for sustainable construction in Africa. Incorporating modern design, durability, and safety measures into these practices can bring significant benefits, from lowered emissions to community empowerment (Hermanus and Cirolia 2024; Walwyn 2020; World Bank 2020). Locally sourced materials also reduce transport-related emissions (IPCC 2018; Yeo et al. 2020) and create demand for workers skilled in extraction, processing, and installation (GlobalABC et al. 2020; Kibe et al. 2023). Moreover, using such materials aligns with cultural building styles and can be cost-effective, particularly for low-income populations.

Structural transformation in the construction sector can help a shift from informal, low-productivity practices to a more formal, technology-driven industry that employs architects, engineers, data analysts, and sustainability experts (GlobalABC et al. 2020; Urrutia-Azcona et al. 2021; Zhou and Azar 2019). Green building methods such as passive design and advanced insulation require professionals capable of integrating environmental principles into architectural plans, while digital tools such as building information modelling demand software developers and data scientists (IEA 2022a; Kibe et al. 2023). The adoption of rooftop solar systems and solar water heaters for low-carbon construction creates further roles for technicians, engineers, and project managers (IEA 2019; Walwyn 2020; Yeo et al. 2020). These high-skill positions can generate upward mobility and foster a culture of innovation in African cities.

As urban populations grow and incomes rise, an expanding middle class drives demand for energy-efficient homes and offices (UN-Habitat 2020). Government institutions can capitalize on this trend through green procurement policies, stipulating low-carbon materials and construction methods for public buildings. Private developers, keen to appeal to environmentally conscious buyers, may follow suit (IEA 2019). The resulting market for green building products not only improves local manufacturing but also encourages micro-industries focused on bamboo scaffolding, compressed-earth blocks, or eco-friendly cement (World Bank 2020). This development can be amplified by regional cooperation that sets harmonized standards, helping local manufacturers access broader markets and further scaling up production.

Building on these strategies, Terblanche (2019) emphasizes that integrated design featuring passive cooling, solar-based heating, and modern insulation can help African commercial buildings move towards net-zero emissions without compromising occupant comfort. Likewise, Devraj et al. (2018) argue that zero-energy retrofits are feasible for both residential and commercial sectors, provided there is adequate local expertise and supportive policy (e.g., tax credits or green building mandates). By combining modern engineering, traditional building knowledge, and emerging renewable technologies, African cities could meet rising housing demand while maintaining a more sustainable carbon footprint.

Policy instruments are essential for sustaining this momentum. Effective building codes that set energy performance and emissions thresholds can swiftly raise construction standards, provided local authorities can enforce them (GlobalABC et al. 2020). Public-awareness campaigns can highlight the cost savings, health benefits and environmental advantages of green buildings, encouraging home buyers and small-scale developers to invest in energy-efficient features. Governments might also adopt carbon-pricing mechanisms or tax incentives to encourage businesses and consumers to choose low-carbon options (IEA 2022b). However, none of these measures will succeed without substantial investment in capacity-building, especially among local builders and contractors, who often operate informally. Training programmes at technical colleges and workshops can rapidly upskill a workforce in sustainable site-planning, life-cycle assessment, or advanced materials science (Rwanda Housing Authority et al. 2019; World Bank 2020).

Cities across Africa and beyond demonstrate the feasibility of these measures. Dakar, Senegal has shifted towards local clay bricks and rooftop solar systems, creating new jobs for masons and solar technicians. Abidjan, Côte D'Ivoire has pioneered green social-housing projects that use bamboo scaffolding and compressed-earth blocks, boosting demand for energy modellers and quality-control specialists (IEA 2019). Cape Town, South Africa enforces energy efficiency standards that drive the adoption of high-performance insulation and solar water heaters, stimulating markets for building automation services (IEA 2022b). Dar es Salaam, United Republic of Tanzania promotes straw-bale construction and compressed-earth blocks through a 'green construction lab', helping young people learn new skills in design (UN-Habitat 2020). In Cabo Verde, the capital city of Praia has introduced pilot schemes to encourage low-carbon building materials, modular design, and solar-energy integration, a strategy that tackles both the island's limited land resources and its reliance on imported fuels. Meanwhile, in Latin America, Santiago, Chile and Lima, Peru have introduced incentives for passive cooling and minimum energy performance standards, highlighting similar opportunities for eco-friendly cement and solar installations (World Bank 2020).

Such strategies show how decarbonizing buildings can also spur inclusive economic growth. Locally produced building materials and circular economy principles can stimulate rural economies, reduce rural-to-urban migration, and strengthen supply chains for green products (Kaza et al. 2018). In turn, a more skilled workforce, encompassing engineers, data analysts, carpenters, and energy auditors, broadens a city's innovation ecosystem. Health outcomes also improve when homes are built to minimize indoor air pollution, while households that save money on energy bills can reinvest in local markets (IEA 2019). Realizing these gains hinges on robust enforcement of environmental regulations and the availability of training programmes. Even the most advanced building codes prove ineffective if municipalities lack the capacity or political backing to implement them (UN-Habitat 2020). The informal sector, a substantial part of African construction, must be integrated through incentives, professionalization, and consistent land use policies.

Africa's building and construction sector therefore stands at a crossroads. Rapid urban expansion and rising consumer aspirations pose environmental risks but also present a chance to transition towards a low-carbon model that delivers substantial economic and social benefits. Investing in local renewable materials, adopting digital tools for efficiency, and fostering new markets for green construction can significantly reduce emissions while expanding opportunities for high-skill jobs. Government-led measures, from mandatory building codes to capacity-building initiatives, can steer private-sector investment towards climate-smart approaches, ensuring that low-carbon growth becomes a cornerstone of urban development. Although the emphasis here is on Africa, experiences from Latin America, such as in Santiago, Chile, and Lima, Peru, show that forward-thinking urban policies can both cut carbon footprints and strengthen local economies (IEA 2022b; World Bank 2020). As Dakar, Abidjan, Cape Town, Dar es Salaam, and Praia have begun to show, similar policies not only reduce emissions but also improve living standards. By embracing structural transformation in the construction sector, African nations can chart a path towards net-zero emissions, greater resilience, and a more equitable future.

4 Decarbonization and structural transformation in African cities: what are the key challenges?

The discussion above has clearly shown that African cities, while striving for economic development and improved living standards, are increasingly compelled to decarbonize their economies in order to mitigate the severe impacts of climate change. Although structural transformation offers a framework for shifting from low-productivity, carbon-intensive sectors to higher-value, sustainable industries (African Development Bank 2021; Scholz and Fink 2022), local realities can complicate this process. Many urban centres across the continent face rapid population growth, heightened energy demands, and expanding infrastructure requirements (World Bank 2020). These pressures create difficult trade-offs between the urgent need to enhance living standards and the imperative to reduce greenhouse gas emissions (IEA 2019; IPCC 2021). Historically, African development has relied on fossil fuels and natural resource extraction, establishing entrenched pathways that are not easily altered without significant changes in technology, governance, and societal norms (African Development Bank 2019a).

In practice, confronted by these population, energy and infrastructure stresses, cities often prioritize immediate solutions, such as diesel-based power generation or low-cost construction materials, to meet urgent developmental goals. Yet these choices can lock them into high-carbon trajectories, making future transitions more challenging and costly. Conversely, efforts to adopt greener, more expensive technologies risk placing additional strain on municipal budgets and can exacerbate inequalities unless carefully managed. Despite these hurdles, the previous sections of this paper have demonstrated that by drawing on abundant renewable energy resources, designing compact urban settlements, and investing in cleaner industries, African cities can both stimulate economic dynamism and limit their carbon footprints. This holistic perspective on structural transformation provides a pathway to reconcile developmental ambitions with environmental imperatives.

In light of these factors, there are several specific challenges that emerge when African cities attempt to decarbonize through structural transformation. One of the foremost dilemmas is balancing climate impacts, sustaining growth, and reducing carbon dioxide. Most urban centres experience rapidly rising demand for energy and infrastructure, yet remain constrained by limited access to reliable electricity, modern sanitation, and adequate housing (World Bank 2020). This dynamic leads to difficult choices, as reliance on fossil-fuel-based power or cheap materials can lock cities into carbon-intensive pathways (IPCC 2018), while enforcing strict environmental standards may strain budgets and widen inequalities if not paired with inclusive measures (African Development Bank 2021). Nonetheless, tapping into abundant renewable energy resources—solar, wind, and hydropower—can help cities minimize emissions while still pursuing economic growth (IEA 2022a). Integrating sustainable design into urban expansion can reduce future retrofit costs, and adopting compact city models and green infrastructure can limit carbon footprints while opening up new markets for green goods and services.

Another challenge concerns the cost of structural transformation. Transitioning to cleaner energy systems, resource-efficient industries, and climate-resilient infrastructure often requires significant capital outlays (African Development Bank 2019b). Renewable energy installations, modern public transport, and green building materials may incur higher initial costs than conventional options, and cities with narrow tax bases may struggle to secure the necessary funds (IEA 2019). The costs are not purely financial: local workforces require retraining to adapt to new roles in renewable energy, sustainable construction, or waste management (IEA 2022a). Without adequate planning, decarbonization can disrupt livelihoods in high-carbon sectors, leading to social resistance if people perceive that jobs are sacrificed for abstract environmental objectives (IPCC 2021). Policy makers must also account for the risk of stranded assets, where infrastructure reliant on polluting technologies becomes obsolete before its intended lifespan ends.

A third issue is the limited complexity and dynamism of African economies, which can be a barrier to green transformation. As pointed out earlier, many countries rely heavily on primary commodities or extractive industries. Producing advanced, low-carbon technologies, such as solar panels or electric vehicles, demands specialized skills, capital, and supply chains that are often underdeveloped (IEA 2022c). These limitations can deter foreign investors who might otherwise partner with local firms to manufacture green products (Turok 2016). However, this scenario also presents an opportunity to skip over intermediate, carbon-intensive stages and move straight to advanced low-carbon solutions. Cities can bypass outdated carbon-intensive technologies and adopt cutting-edge solutions directly, similarly to how some African regions skipped fixed-line telephony in favour of mobile networks (Scholz and Fink 2022). Fostering clusters of green innovation around universities or industrial parks, combined with South-South cooperation, can expedite technology transfer and create a new industrial base oriented towards sustainability. On this front, local manufacturing potential for renewable equipment remains largely untapped in many African nations (Grobbelaar et al. 2014). Weak regulatory support for domestic producers, high import taxes on specialized components, and insufficient skills training often hamper efforts to build advanced solar panels, turbines, or battery packs locally. Encouraging local supply chains for these technologies could lower costs, yield skilled jobs, and reduce reliance on expensive imports, if accompanied by strong governance incentives and stable market signals.

Weak local institutional capacity can also significantly undermine climate initiatives. Many municipal governments struggle with limited autonomy, specialized expertise, and financial resources, all of which hamper policy enforcement. In some regions, decentralization remains incomplete, preventing local authorities from wielding effective fiscal or regulatory powers. Even where legal frameworks such as building efficiency codes are formally in place, their enforcement may be undermined by corruption, understaffing, or administrative inefficiency. These combined challenges demonstrate how governance shortfalls can stall ambitious climate policies (GlobalABC et al. 2020; UN-Habitat 2020; World Bank 2020).

In light of overlapping governance challenges, institutional fragmentation and weak local planning systems still hamper urban decarbonization: many cities lack the capacity and mechanisms required to translate national climate goals into action (Akrofi et al. 2022). Kigali, Rwanda illustrates the problem: progressive spatial plans exist, yet limited climate data, unclear institutional mandates, and poor vertical coordination stall mainstreaming efforts. Weak planning also allows informal settlements to proliferate without basic infrastructure, fuelling sprawl, congestion, and higher emissions (IPCC 2021). Closing these gaps through civil-service training, data-driven policy-making, and anti-corruption measures is no less critical than deploying new technologies (Mwenje and Kumar 2024; Scholz and Fink 2022).

Finance and fiscal risk form the next binding constraint. National pledges often outstrip local budgets; private investors hesitate when payback periods are long or regulatory frameworks uncertain; high political or currency risk further deters foreign capital. The African Development Bank (2022b) estimates that the continent will require about US$200 billion per year by 2025, rising to US$400 billion by 2030, to meet infrastructure, energy, and climate targets. Cities with weak fiscal decentralization or limited creditworthiness struggle even to fund essential services, let alone transformative projects. Instruments such as feed-in tariffs, risk-sharing facilities, and municipal green bonds can help, but they demand strong governance and clear revenue streams. Freetown's donor-backed feasibility studies, for example, have flagged urgent upgrades in waste collection and landfill management, yet the city's narrow revenue base makes implementation difficult (World Bank 2020). At the national level, falling hydrocarbon demand threatens public revenues, while politically fraught subsidy reform can spark unrest unless paired with targeted social support and affordable clean alternatives (Rentschler and Bazilian 2017; Solano-Rodríguez et al. 2021).

Trade exposure adds a global dimension. Proposed border carbon adjustments in advanced economies could erode markets for carbon-intensive exports, undermining local employment. Safeguarding competitiveness will require upgrading industrial processes, investing in cleaner technologies, and meeting stricter emissions standards through public-private collaboration on technology transfer and skills (IEA 2019; IPCC 2021).

Finally, the digital divide risks slowing structural transformation. Data-driven planning platforms, real-time emission monitoring, and smart transport coordination depend on reliable electricity and broadband—services that remain patchy in many cities. Without concerted investment in digital infrastructure and inclusive capacity-building, technology roll-outs may benefit wealthier neighbourhoods while leaving marginalized communities behind (UN-Habitat 2020; World Bank 2020).

Climate adaptation and infrastructure deficits also intersect with decarbonization efforts. Many African cities still struggle to cope with flooding, heatwaves, or sea level rise, lacking the robust infrastructure required to manage these escalating risks. Although decarbonization mainly focuses on reducing emissions, adaptation measures—such as improved drainage systems, coastal defences, or heat-resistant building materials—are crucial to protect development gains from climate-related disasters. However, budget constraints often make it difficult for local authorities to prioritize these initiatives, and without them, disasters can reverse progress and disrupt supply chains vital to emerging green industries. In Dakar, for instance, the overburdened Mbeubeuss landfill shows how inadequate waste management not only raises health and emissions concerns but also heightens flood risks during heavy rains (Banna 2019).

Social inequality and community engagement also remain critical in any decarbonization strategy. Many African cities host large informal economies and settlements, where low-income residents often rely on carbon-intensive fuels due to cost constraints (Sovacool 2012). Policies such as carbon taxes or the removal of fuel subsidies, if introduced without social safeguards, risk disproportionately affecting the poorest urban dwellers. By contrast, participatory planning that involves informal workers, youth organizations, and local communities can foster broader ownership of green initiatives and more equitable outcomes. This includes targeted efforts to reduce energy poverty, expand public transport, and provide training in emerging green sectors. Embedding social equity in decarbonization policies helps ensure that structural transformation advances inclusive growth rather than deepening existing divides (African Development Bank 2019a).

Because these challenges are diverse and deeply interlinked, a piecemeal response is unlikely to succeed (Turok 2016). Structural transformation demands a holistic perspective on urban economies, taking into account not only energy systems and transport networks but also land use planning, digital infrastructure, and cultural practices (Hermanus and Cirolia 2024; Turok 2016). Effective decarbonization must integrate with broader development agendas that tackle poverty, job creation, and social equity (Walwyn 2020). Strengthening municipal governance is a logical first step: granting cities greater fiscal autonomy and equipping them with data-driven policy tools can enable them to raise and allocate resources for green projects (Urrutia-Azcona et al. 2021). Public-private partnerships may help fill financing gaps, especially if public entities can de-risk investments in renewable energy or low-carbon infrastructure through credit guarantees (Akomolafe et al. 2024). Equally crucial is human capital development, given the shortage of specialized skills in areas such as renewable energy, sustainable construction, and waste management (GlobalABC et al. 2020). Educational institutions, vocational training, and apprenticeships must be tailored to produce a workforce capable of driving a green economy. South-South cooperation and knowledge exchange are invaluable. African cities can learn from counterparts in Asia or Latin America that have successfully implemented BRT, solar mini-grids, or waste-to-energy systems (Turok 2016). Joint ventures and city-level alliances can reduce technology costs, disseminate best practices, and speed up capacity-building. These initiatives must be inclusive, ensuring that marginalized groups and informal-sector workers are active participants in policy formulation (Hermanus and Cirolia 2024). Transparent consultations, participatory urban planning, and just transition frameworks can help avoid widening social inequalities in the push towards decarbonization (IPCC 2021).

Collectively, the decarbonization of African cities through structural transformation presents both significant challenges and promising opportunities (Adun et al. 2024; Dossa and Miassi 2024; Potts 2018). The task demands a careful balancing of climate and growth objectives while addressing challenges such as financing gaps, digital divides, and governance deficiencies. However, these challenges also highlight potential avenues for leapfrogging traditional development pathways, promoting inclusive growth, and igniting innovation. By harmonizing governance reforms with targeted investments and capacity-building efforts, municipal and national authorities can enable cities to transition from carbon-intensive practices to cleaner, more equitable urban growth strategies (Kiribou et al. 2024; Ngounou et al. 2024; Ziervogel 2019). This will require strengthening local governments through clearer mandates and fiscal decentralization, reforming municipal finance systems—particularly property taxation and budgeting—and deploying blended finance tools such as green bonds, public-private partnerships, and community-driven climate funds, supported by enabling national policies (Li et al. 2022; Manteaw 2020). Although the journey to net-zero emissions is laden with obstacles, it also offers a route to resilience, prosperity, and social advancement for Africa's rapidly expanding urban populations (Adun et al. 2024).

5 Concluding remarks

African cities stand at a pivotal crossroads, confronting rapid urbanization, persistent energy poverty, and urgent decarbonization imperatives. Yet this juncture also offers an unprecedented opportunity to integrate sustainability into the very fabric of urban development. Structural transformation emerges as a crucial framework in this process: by shifting labour and resources from carbon-intensive, low-productivity sectors to higher-value, greener industries, African nations can foster economic growth, social equity, and climate resilience simultaneously.

Achieving these outcomes requires comprehensive approaches that address energy systems, urban planning, waste management, and construction practices. Investments in renewable energies such as solar and wind not only cut carbon emissions but also create skilled employment opportunities. Meanwhile, modernizing transport networks, adopting energy-efficient building methods, and enhancing waste management systems can further reduce reliance on fossil fuels and limit greenhouse gas output. These advances also present an opportunity to bypass outdated infrastructures and integrate innovative low-carbon technologies from the outset. However, decarbonization cannot happen in isolation. Strong governance structures are essential for shaping inclusive policy, coordinating stakeholders, and mobilizing green finance. Equally important is participatory planning to ensure that marginalized communities are not left behind. By engaging these groups in decision-making, particularly regarding land use, infrastructure investments, and access to clean energy, policy makers can create more equitable urban environments. This is vital to avoid burdening vulnerable populations with the potential cost increases associated with carbon taxes or the removal of fossil-fuel subsidies.

Financing remains a significant challenge. African cities often face constraints in capital-raising and institutional capacity, underscoring the importance of strategic partnerships. Public-private ventures, green bonds, and philanthropic funding can help bridge resource gaps, while technology transfer and knowledge-sharing platforms, both within Africa and globally, can accelerate capacity-building. Together, these efforts can channel transformative investments into renewable energy, resilient infrastructure, and job-creating innovations.

In sum, structural transformation offers a path for African cities to balance rapid growth with a low-carbon trajectory. By harmonizing governance, inclusive stakeholder engagement, and targeted investments in sustainable technologies, nations across the continent can secure a more prosperous, equitable, and climate-resilient future. The decisions made today will shape urban life for generations, making this transition both urgent and indispensable.

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