Journal of Conflict Management & Sustainable Development

Volume 11 Issue 1 2023 ISBN 978-9966-046-15-4

Promoting Urban Resilience and Sustainability in Kenya's Cities and Towns

By: ***Caroline Jepchumba Kibii****

Abstract

Increased urbanisation in low and lower-middle-income nations, swelling urban populations and frequent climate risks signal a need to redesign, modify and promote cities and towns that can accommodate and withstand the changes. Urban resilience and sustainability building are necessary. Urban areas are vital as more than 80% of the global gross domestic product comes from cities, and more than 70% of global greenhouse emissions come from urban areas; it is fundamental to understand the various indicators that will help cities and towns become more inclusive, liveable and self-sufficient while reducing environmental degradation. This article discusses some key indicators that, if improved and advanced, will promote urban sustainability in Kenyan urban areas to answer the following question: 'What can be done to establish and enhance resilience and sustainability in Kenya's urban areas?' The aspects discussed include urban mobility, urban water systems, urban energy systems, informal settlements, urban planning and policy and waste management by consulting various sources. The article notes, for instance, that improving the overall status of informal settlements as they are an integral part of all urban areas, where neglecting them leads to far-reaching problems for the urban inhabitants within and away from these settlements. While this article does not exhaust the key indicators, it recognises that building urban resilience and promoting sustainability requires a combination of several solutions.

* *MA (Environmental Planning and Management), B.Sc. (Environmental Science). Caroline is an International Climate Protection Fellow of the Alexander von Humboldt and a Visiting Scientist at the United Nations University, Bonn, Germany.*

1.0 Introduction

Urban areas (cities and towns) offer an incredible dynamism for human habitation worldwide. Many people are gravitating towards urban areas, with the current statistics indicating that approximately 56% of the global population live in cities.[1] The trend is expected to continue over the years, with a projection of 68% of the world's population living in urban areas by 2050.[2] While urbanisation continues across all regions, highly noticeable urbanisation was recorded in developing economies during the 2011-2021 period.[3] Besides population growth, urbanisation significantly contributes to a country's gross domestic product (GDP). World Bank estimates that more than 80% of the world's GDP comes from cities.[4] Similarly, urbanisation is responsible for one-third of Africa's per capita GDP.[5] With the approximations mentioned above, urbanisation positively influences a country's development as it enables improved access to socio-economic opportunities, services and infrastructure to many people. On the contrary, urban development contributes immeasurably to greenhouse gas emissions. Urban areas contribute to about 70% of the global energy-associated carbon dioxide emissions.[6] With the projected rapid urbanisation, the urban

[1] World Bank. (2023). Urban Development. *The World Bank Group*.
[2] UNDESA. (2018). The World Urbanization Prospects. *Department of Economic and Social Affairs of the United Nations*.
[3] UNCTAD. (2022). Total and urban population. *Handbook of Statistics 2022*
[4] World Bank. (2023). Urban Development. *The World Bank Group*
[5] OECD/UN ECA/AfDB. (2022). *Africa's Urbanisation Dynamics 2022: The Economic Power of Africa's Cities*, West African Studies, OECD Publishing, Paris, *https://doi.org/10.1787/3834ed5b-en*
[6] Wu, D., Lin, J. C., Oda, T., & Kort, E. A. (2020). Space-based quantification of per capita CO_2 emissions from cities. *Environmental Research Letters*, *15*(3), 035004. *https://doi.org/10.1088/1748-9326/ab68eb*

emission index is likely to increase should aspects of sustainability be ignored or downplayed.[7]

It is acknowledged that future urban growth will largely take place in Africa; however, its effective growth might be limited by inadequate planning systems and ill-equipped agencies to address emerging environmental challenges.[8] Urbanisation does not occur in isolation but is entangled with existential global problems such as climate change and inequalities, mandating the need to build resilience across all sectors, including improving governance, policies and regulation and infrastructural advancement.[9] This means urban areas, including those in Kenya, need to prepare for unpredictable and complex futures.[10] Resilience building and socio-economic and environmental sustainability must be at the heart of urban development.[11] A 2022 World Cities Report predicts that most city land area expansion will occur in low-income and low-middle-

[7] Nero, B. F., Callo-Concha, D., & Denich, M. (2019). *Increasing urbanisation and the role of green spaces in urban climate resilience in Africa*. In J. Tischler & I. Haltermann (Eds.), Environmental Change and African Societies (pp. 265–295). BRILL. ISBN: 9789004410848. *https://doi.org/10.1163/9789004410848_013*
[8] Cobbinah, P. B. (2023). City in Africa II: Urban environmental health. *Journal of Urban Affairs*, *45*(3), 483–487. *https://doi.org/10.1080/07352166.2023.2171617*
[9] Nero, B. F., Callo-Concha, D., & Denich, M. (2019). *Increasing urbanisation and the role of green spaces in urban climate resilience in Africa*. In J. Tischler & I. Haltermann (Eds.), Environmental Change and African Societies (pp. 265–295). BRILL. ISBN: 9789004410848. *https://doi.org/10.1163/9789004410848_013*
[10] Revi, A., et al. (2014). *Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, pp. 535-612.
[11] Ibid

income countries.[12] The same report projects, based on new data, city expansion over the next five decades, taking 2020 as the base year, that a 141% growth in low-income countries and 41% in low-middle income countries is a possibility.[13]

Urbanisation in Kenyan cities and towns is rapid and gradual. A 4.3% urbanisation annual rate has been estimated, with a projection of more than half of the country's population residing in urban areas by 2025.[14] More resources will be needed. Already, the existing natural and infrastructural resources and services have been over-stretched forcing the continued establishment of informal settlements and, in some cases, slum communities.[15] Overcrowding, limited primary resources such as water, drainage systems, energy sources and housing structures and environmental degradation are some features characterising informal settlements that form a significant part of most urban areas in Kenya.[16] Realising that climate-related risks threaten many cities and towns in Kenya, such as Nairobi, Mombasa and Kisumu, that have recorded increasing flood incidences recently, it is crucial to enhance the resilience of existing and new establishments.[17] Urban resilience building is conceivable where sustainability and, more so, environmental sustainability are an integral part of development.[18]

---

[12] UN-Habitat (2022). World Cities Report 2022. *Envisaging the future of cities. Nairobi: UN-Habitat*.
[13] Ibid
[14] UN-Habitat (2023). Urbanization in Kenya: Building inclusive & sustainable cities. *UN-Habitat*.
[15] Ibid
[16] Ibid
[17] Whitaker, E. Et al. (2023). Climate Security Study: Kenya. *Weathering Risk*
[18] Jha, A. K., Miner, T. W., & Stanton-Geddes, Z. (Eds.). (2013). *Building urban resilience: Principles, tools, and practice*. The World Bank. **ISBN:**978-0-8213-8865-5 *https://doi.org/10.1596/978-0-8213-8865-5*

In light of the information above, this article discusses some critical indicators in building and promoting urban resilience and sustainability in urban areas, with Kenyan cities and towns being the primary focus. Essentially, the article seeks to answer the question: What can be done to establish and enhance resilience and sustainability in Kenya's urban areas?

1.1 Defining and contextualising urban sustainability

Sustainability encompasses a wide range of concepts and terminologies. Before the official definition of sustainable development in 1987 under the 'Our Common Future' report, sustainability had existed and is evidenced in the indigenous or local ecological knowledge systems. The Brundtland Report defined sustainable development as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*."[19] It is clear from this umbrella definition that sustainability is an ongoing process that considers equity, justice and accountability. This means someone must be held accountable to achieve sustainable development. Sustainable development is sometimes assumed to refer only to the 'green' aspects or, in other words, to the environmental component. In practical and realistic terms, sustainable development entails environmental, social and economic sustainability.

Environmental sustainability is realised when humans consume resources at a rate that does not exceed the natural ability of those resources to regenerate.[20] This implies human consumption that does

[19] United Nations Brundtland Commission. (1987). Report of the World Commission on Environment and Development: Our Common Future. *United Nations*

[20] Andrea, V. (2015). *Handbook of research on social, economic, and environmental sustainability in the development of smart cities*. IGI Global.

not generate waste or pollutants such as greenhouse gas emissions beyond the resource's restoration rate. Social sustainability points to society being able to protect and uphold human rights while enabling availability, affordability and access to basic amenities such as food, shelter, transportation, education and healthcare. [21] Healthy communities foster productive development. Economic sustainability points to the independence of communities worldwide to access and utilise resources to meet their personal and extended needs. Social, economic and environmental sustainability are interdependent. [22] In fostering sustainable development, all three dynamics must be disparagingly considered and incorporated from the conceptualisation stages of a product, service or ideology.

Sustainable urban development, although it is centred on the three dimensions of sustainability highlighted above, is believed to have expanded to incorporate specific concepts that advance liveability, mobility, technology, and cultural and ecological wellbeing. [23] For instance, the foundation of urban infrastructure influences its sustainability, such as improving the workability of the transportation system within a given town or city eases mobility.[24] Arguably, urban areas are the locus of an effective and practical green future. Therefore, cities and towns mandate the construction of durable infrastructures and the establishment of places and spaces that stimulate development and promote interrelationships of land

[21] Rodrigues, M.J. et al (2017). *Architectural Research Addressing Societal Challenges Volume 1*. CRC Press, Technology & Engineering
[22] Andrea, V. (2015). *Handbook of research on social, economic, and environmental sustainability in the development of smart cities*. IGI Global.
[23] Song, X., Guo, R., & Zhang, H. (2022). MaaS for sustainable urban development. In *Big Data and Mobility as a Service* (pp. 265–279). Elsevier
[24] Ibid

uses but minimise human footprint.[25] Despite the urban potential to promote meaningful green futures, it is claimed that the notion that sustainable development is urban development is not automatically apparent.[26] Nonetheless, urban areas provide an avenue for effective and efficient application of green technologies.

While urban sustainability might offer an opportunity for the universal application of ideas and technologies, it is not always the case. Urban scientists determine that urban sustainability is fundamentally a geographical notion that takes into consideration the social, economic and ecological systems, including the socio-natural relations and regulations. [27] Achieving urban sustainability will almost always be influenced by the local contexts of a given city or town, although it is enshrined in most of the Sustainable Development Goals.

1.2 What is urban resilience?

Various definitions and contexts exist on what resilience and urban resilience mean, but they have a common point of convergence. The concept of resilience was introduced and appropriated in relation to ecological systems in the 1970s. Holling (1973), in their resilience and stability of ecological systems, conceptualised that "*resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist. In this definition, resilience is the property of the system and persistence or probability of extinction is the*

[25] Callender, J. (2012). Sustainable urban development. In *International Encyclopedia of Housing and Home* (pp. 129–133). Elsevier
[26] Ibid
[27] Whitehead, M. (2009). Sustainability, urban. In *International Encyclopedia of Human Geography* (pp. 109–116). Elsevier

result." [28] Others define resilience as a function of resistivity and adaptation ability of a community or system.[29] One of the definitions of urban resilience is the ability of communities, businesses, individuals and systems within a town or city to withstand, adapt, produce and expand despite the disturbances and shocks they encounter.[30] The essence of resilience building in urban areas is to lower the impacts of risks associated with intended and unintended developments. It is crucial, therefore, to improve urban resilience, especially for communities in risky and vulnerable territories.

Urban resilience and sustainability are crucial paradigms shaping city and town planning and policy formulation in the recent past. Although the two concepts are conceived variedly in terms of the indicators, principles, targets and scopes, they are bound on similar components. In a proposed model for urban resilience, three elements are identified: physical infrastructure-based urban planning, social actors and the ability to recover after a disturbance. [31] These components are also considered when advancing urban sustainability.

[28] Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*(1), 1–23. *https://doi.org/10.1146/annurev.es.04.110173.000245*

[29] Ribeiro, P. J. G., & Pena Jardim Gonçalves, L. A. (2019). Urban resilience: A conceptual framework. *Sustainable Cities and Society*, *50*, 101625. https://doi.org/10.1016/j.scs.2019.101625

[30] Cerasoli, M., Amato, C., & Ravagnan, C. (2023). The theoretical grid. An antifragile strategy for Rome post-COVID mobility. In *Resilient and Sustainable Cities* (pp. 15–37). Elsevier. *https://doi.org/10.1016/B978-0-323-91718-6.00036-0*

[31] Swapan, A. Y., & Sharifi, A. (2023). The fundamentals of smart city assessment. In *Urban Climate Adaptation and Mitigation* (pp. 117–146). Elsevier. *https://doi.org/10.1016/B978-0-323-85552-5.00005-1*

2.0 Urbans Sustainability and Resilience Indicators in Kenya

This section discusses some of the key indicators or sectors that Kenyan cities and towns can invest in, modify or advance in order to be more resilient and sustainable.

2.1 Urban mobility and smart mobility

Mobility is vital in urban areas; it enables people to move from one point to another.[32] Cities or towns' mobility is expected to address features such as affordability, diversity, inclusivity, accessibility and reliability in order to enhance urban sustainability. [33] The infrastructural and technological integration influence the features mentioned above. Currently, most cities and towns in Kenya are still at their infancy stage when it comes to smart mobility; however, mobility in general has been advanced with modern infrastructural facilities such as road networks, like the construction of super highways and expressways as enshrined in Kenya's Vision 2030.[34]

Gaining a lot of prominence and popularity across the globe towards smart and sustainable cities is the establishment of dedicated lanes for cycling, buses, trams, pedestrians and motorists. Objectively, dedicated lanes aim to improve efficiency and mobility in urban areas with mixed traffic and varied drivers, but it can be costly to implement. [35] Kenyan cities and towns could benefit from well-

[32] Semanjski, I. C. (2023). *Introduction to smart mobility. In Smart Urban Mobility* (pp. 9–23). Elsevier. *https://doi.org/10.1016/B978-0-12-820717-8.00009-9*

[33] Georgouli, C. Et al. (2021). Urban Mobility Innovation Index – 2021. Leading transformations with innovation for inclusive, sustainable and resilient urban mobility. *UMIii*

[34] Kenya Vision 2030. (2008). *https://vision2030.go.ke/*

[35] Fakhrmoosavi, F., Kamjoo, E., Zockaie, A., Mittal, A., & Fishelson, J. (2023). Assessing the network-wide impacts of dedicated lanes for connected autonomous vehicles. *Transportation Research Record: Journal of the*

designed and intentioned commissioning of dedicated lanes. Dedicated lanes in high population density cities like Nairobi and Mombasa could reduce traffic congestion during rush hours. However, arguments exist that dedicated lanes could cause traffic in some parts of the same cities.[36]

Across the globe, urban areas encourage bicycling as a population and transportation strategy. Investing in cycling infrastructure is vital to enable the populace to adopt bicycling as an everyday mode of transport; that is, separating from but connecting bicycling lanes with the motorways.[37] The strategy meets the health, safety, and reduction of traffic congestion and greenhouse gas emissions. Bicycling in Kenya's cities can be enhanced and complemented by designing safe and separate pedestrian lanes or footpaths. Accordingly, safety, continuity and comfort are regarded as the governing principles when designing and constructing pedestrian amenities. [38] For instance, the distance between the motorway and walk path should offer safety, and the possibility for two-way traffic and pedestrian paths should be independent of cycling paths. Relaxation benches and trees along the footpaths promote comfort and encourage people to walk or spend time outdoors regardless of age or physical ability.[39]

Transportation Research Board, *2677*(3), 371–388. *https://doi.org/10.1177/03611981221115431*

[36] Ibid

[37] Winters, M., Branion-Calles, M., Therrien, S., Fuller, D., Gauvin, L., Whitehurst, D. G. T., & Nelson, T. (2018). Impacts of Bicycle Infrastructure in Mid-Sized Cities (Ibims): Protocol for a natural experiment study in three Canadian cities. *BMJ Open*, *8*(1), e019130. *https://doi.org/10.1136/bmjopen-2017-019130*

[38] Kost, C., Mwaura, N., Jani, A., & Eyken, C. V. (2017). Streets for walking & cycling Designing for safety, accessibility, and comfort in African cities. *UN-Habitat*

[39] Labdaoui, K., Et al. (2021). Utilizing thermal comfort and walking facilities to propose a comfort walkability index (CWI) at the neighbourhood level.

These proposals are viable and possible with better governance and adherence to urban planning policies.

Another element of promoting urban sustainability in Kenya is upgrading and adopting smart vehicles. [40] There are several approaches, measures and benefits to smart vehicles depending on the city's size and the existing transportation infrastructure. If the primary objective is to reduce emissions associated with obsolete vehicles and those running entirely on gasoline, then motivating individuals and companies to invest in electric cars, especially those running on renewable energies, is fundamental.[41] This could be done through subsidies or tax reductions on electric vehicles and bikes and enabling accessibility and availability as well as installation of charging stations in strategic locations throughout the cities and towns. [42] While electric vehicles look attractive, scientists and researchers contend that the zero-emission tags associated with fully electric vehicles are not entirely true.[43] The argument is that fully electric vehicles produce fewer greenhouse gases.[44] Still, emissions are produced while manufacturing the vehicular parts and

---

Sage Journals; Environment and Behavior. *https://doi.org/10.1016/j.buildenv.2021.107627*

[40] Bamwesigye, D., & Hlavackova, P. (2019). Analysis of sustainable transport for smart cities. *Sustainability*, *11*(7), 2140. *https://doi.org/10.3390/su11072140*

[41] Al-Ghaili, A. M., Et al. (2022). Can electric vehicles be an alternative for traditional fossil-fuel cars with the help of renewable energy sources towards energy sustainability achievement? *Energy Informatics*, *5*(S4), 60. *https://doi.org/10.1186/s42162-022-00234-*3

[42] IEA. (2023). Global EV Policy Explorer: Key policies and measures that support the deployment of electric and zero-emission vehicles. *International Energy Agency*.

[43] Mosemand, A. & Paltsev, S. (2022). Are electric vehicles definitely better for the climate than gas-powered cars? *MIT Climate Portal*.

[44] Ibid

batteries. [45] The type of raw materials and resources used in production and manufacturing determine the cleanliness and emission factor. For instance, one emission source in electric vehicles is the development of large lithium-ion batteries.[46] Therefore, caution has to be exercised and regulations instituted to aid in availing ecologically friendly electric vehicles carrying lower emissions badges.

Another ingredient to urban sustainability is exploiting the renewable energy potential to support and transform the transport sector. For instance, Kenya has a huge solar energy potential as it receives a daily insolation of 4-6 kWh/m^2, but it has yet to be extensively exploited.[47] The charging stations for electric vehicles and bikes can be solar-powered. The walk paths, bicycles and motorways can be lit with solar energy.[48]

Although most Kenyan towns have car-sharing options in the form of a Taxi, it is yet to be adopted in smaller towns.[49] Still, car and bike sharing with self-service operation mode could be encouraged. This is attractive, particularly to young people and reduces the over-dependency on personal vehicles, which is one of the leading causes of traffic congestion in major towns. [50] This approach has been adopted and implemented in many European cities, resulting in

[45] Ibid
[46] Ibid
[47] EPRA. (2023). Solar Energy. *Energy & Petroleum Regulatory Authority*.
[48] Coutu, R., Et al. (2020). Engineering tests to evaluate the feasibility of an emerging solar pavement technology for public roads and highways. *Technologies*, *8*(1), 9. *https://doi.org/10.3390/technologies8010009*
[49] Sovacool, B. K., Daniels, C., & AbdulRafiu, A. (2022). Transitioning to electrified, automated and shared mobility in an African context: A comparative review of Johannesburg, Kigali, Lagos and Nairobi. *Journal of Transport Geography*, *98*, 103256. *https://doi.org/10.1016/j.jtrangeo.2021.103256*
[50] Ibid

economic, health and ecological benefits.[51] To achieve this step, the overall transport system needs to be overhauled, stringent policies instituted, and some road networks redesigned to include dedicated lanes.

2.2 Waste Management

Urban areas are a hub of activities whose operations lead to an increased flow of goods and services that consequently increase the amount of waste generated with respect to the core activities in a given area.[52] Diverse origins and sources of waste in towns can complicate waste management initiatives, notably where effective systems are lacking.[53] In addition, waste generation is associated with decreasing ecological resources, increased consumption of natural resources, degradation of the said resources and corrective costs.[54] Although cities occupy only 2% of the global space, it is responsible for over 75% and 70% of resource consumption and waste generated, respectively.[55]

Zero waste urban concept is an ambitious goal that many cities and towns across the globe strive towards achieving as a channel for sustainability. Attaining a zero-waste concept requires amalgamating several aspects such as behavioural change, awareness creation,

---

[51] Martínez, S. et al. (2019). The Economic Impact of Bike Sharing in European Cities. *IESE Business School*. DOI: *https://dx.doi.org/10.15581/018.ST-505*

[52] Mesjasz-Lech, A. (2014). Municipal waste management in context of sustainable urban development. *Procedia - Social and Behavioral Sciences*, *151*, 244–256. *https://doi.org/10.1016/j.sbspro.2014.10.023*

[53] Ibid

[54] Ibid

[55] Zaman, A. U., & Lehmann, S. (2013). The zero-waste index: A performance measurement tool for waste management systems in a 'zero waste city.' *Journal of Cleaner Production*, *50*, 123–132. *https://doi.org/10.1016/j.jclepro.2012.11.041*

waste-to-business scenarios, circular economy, rules and regulations, and waste management strategies. [56] Proper design and implementation of policies and regulations governing waste management (municipal or industrial waste) could be ground-breaking for zero-waste towns.[57]

Kenya's small and big urban areas are confronted by a huge waste management crisis resulting from increased waste generated or inadequate waste management structures. [58] The ballooning urban population is one of the primary reasons for the massive amounts of waste generated per day in a given town. [59] The Kenya National Environment Management Authority (NEMA) cited that most towns and cities lack sufficient waste collection and disposal structures, highlighting that approximately 30-40% of waste in Nairobi, the capital of Kenya, remain uncollected. [60] Nairobi and Mombasa, according to NEMA, generate more than 2200 tons of waste each per day. [61] With a significant proportion of the waste remaining uncollected or unmanaged, it can lead to compounding challenges that weaken the ability of the urban areas to become sustainable and resilient to potential environmental hazards.[62]

---

[56] Ibid
[57] Mesjasz-Lech, A. (2014). Municipal waste management in context of sustainable urban development. *Procedia - Social and Behavioral Sciences*, *151*, 244–256. https://doi.org/10.1016/j.sbspro.2014.10.023
[58] African Population and Health Research Center. (2019). Solid Waste Management and Risks to Health in Urban Africa: A Study of Nairobi and Mombasa Cities in Kenya. *Urban Africa Risk Knowledge.*
[59] Ibid
[60] NEMA. (2015). The National Solid Waste Management Strategy. *Kenya National Environment Management Authority*
[61] Ibid
[62] Mustafa E. (2018). *Urban agglomeration*. IntechOpen.

Many solutions exist to solve the waste crisis in Kenyan cities and towns. However, alternative options and solutions to the traditional waste management pathways that combine the socio-technical-ecological model should be adopted to realise sustainability and promote social concerns such as health-associated challenges.[63] It is, therefore, critical to adopt integrated solutions to urban waste management that will generate direct and indirect benefits to the primary and secondary subjects within those areas.[64] For instance, a waste-to-energy strategy would be one of the sustainable solutions to fix the waste menace, generating energy, a highly sought-after commodity. This strategy has been applied globally, especially among the European nations. In Sweden, for instance, only 1% of the trash goes to landfills, about 47% gets recycled, and 52% is transformed into energy.[65] Sweden uses the energy from waste for various reasons, including heating homes. It is estimated that about one million households in Sweden benefit from waste to energy strategy.[66] As a result of this strategy and the overall recycling revolution, Sweden reduced its carbon dioxide emissions by about 2.2 million tons annually with a 34% reduction between 1990 and 2006.[67] Although waste recycling has gained a lot of support as an urban sustainability approach, it should not be the ultimate goal; instead, waste minimisation at the point of generation should be advocated for, reinforced, and facilitated. Municipalities (county governments

[63] Randhawa, P., Marshall, F., Kushwaha, P. K., & Desai, P. (2020). Pathways for sustainable urban waste management and reduced environmental health risks in India: Winners, losers, and alternatives to waste to energy in delhi. *Frontiers in Sustainable Cities*, *2*, 14. https://doi.org/10.3389/frsc.2020.00014
[64] NEMA. (2015). The National Solid Waste Management Strategy. *Kenya National Environment Management Authority*
[65] Kim, C. & Mauborgne, R. (2023). Turning Waste to Energy: Sweden's Recycling Revolution. *Blue Economy Strategy*
[66] Ibid
[67] Ibid

in Kenya) play a critical role in waste prevention by developing applicable and functioning waste infrastructure and instituting realistic policies.[68] What needs to be improved in Kenyan urban areas is reducing waste at the source and throughout the waste management cycle. Waste segregation takes place in some homes and estates, but not at the point of collection, transportation and disposal is where the problem arises.[69] This issue lies squarely in the hands of the county departments mandated with waste management. [70] Privatisation and joint venture (public and private) of waste collection and management would be another way of improving efficiency issues, although this must be approached with caution.[71] Overall, active involvement of all urban stakeholders is recommended not only for efficiency but for behavioural change, effectiveness and sustainable waste management.[72]

2.3 Urban Water Systems

Water is a primary resource and the sustenance of human civilisation.[73] The urban population needs a consistent water supply to serve their various needs: drinking, industrial use, sanitation and

[68] Koop, C., Schinkel, J & Wilts, H. (2019). Waste Prevention Strategies for Sustainable Urban Development. *Urbanet*.

[69] NEMA. (2020). Kenya Waste Management Guidelines. *National Environment Management Authority*

[70] Ibid

[71] Randhawa, P., Marshall, F., Kushwaha, P. K., & Desai, P. (2020). Pathways for sustainable urban waste management and reduced environmental health risks in india: Winners, losers, and alternatives to waste to energy in Delhi. *Frontiers in Sustainable Cities*, *2*, 14. *https://doi.org/10.3389/frsc.2020.00014*

[72] Kotei, P., Annang, T., & Yirenya-Tawiah, D. (2020). Stakeholder Participation for Sustainable Solid Waste Management in Ga West Municipality, Accra – Ghana. *American Journal of Environment Studies*, *3*(1), 44–60. *https://doi.org/10.47672/ajes.611*

[73] Vuorinen, H. S., Juuti, P. S., & Katko, T. S. (2007). History of water and health from ancient civilizations to modern times. *Water Supply*, *7*(1), 49–57. *https://doi.org/10.2166/ws.2007.006*

the general well-being of the environment. Accordingly, a sustainable urban economy depends on the quality, sustainability, cost-efficiency and reliability of water supply.[74] Thus, providing sufficient potable water and adequate water for sanitation is essential. Often, demand for water in urban areas increases with population growth and the expansion of cities and towns.[75] In return, for example, the amount of wastewater generated, which is often released into the environment (land and water bodies) untreated in most developing nations, increases.[76] In fact, it is estimated that demand for municipal waters in large cities across the world will increase by about 80 million cubic meters annually by 2025 to satisfy the needs of urban inhabitants.[77]

It is noted that sustainable urban development, particularly in developing countries, faces cumulative challenges, one being the limited water resources.[78] For a long time, particularly in the early to mid-1900s, the urban water system, that is, the whole cycle from water supply to the final discharge of wastewater into the environment, adopted a linear system that did not give much consideration to the ecological impacts.[79] To break the traditional urban water system and establish an integrated approach that restores the damaged urban liveability, new strategies and measures for water sustainability are necessary.

---

[74] Bergkamp, G., Diphoorn, B. & Trommsdorf, C. (2015). *Water and development in the urban setting*. SIWI publications. ISBN: 978-91-981860-4-8.
[75] Ibid
[76] Ibid
[77] Ibid
[78] UN Water. (2018). Synthesis Report on Water and Sanitation. *United Nations Water.*
[79] Wang, X. C., & Fu, G. (Eds.). (2021). *Water-wise cities and sustainable water systems: Concepts, technologies, and applications*. IWA Publishing. *https://doi.org/10.2166/9781789060768*

In most Kenyan urban areas where water supply is inconsistent, and availability, accessibility or quality are not assured in equal measures to all communities, modification of water supply strategies and measures is crucial.[80] A spatiotemporal research carried out on water consumption and distribution in Nairobi demonstrated varied usage and unequal distribution, where those in the middle- and high-income areas, as well as in less dense and newer neighbourhoods, received larger volumes of water, almost in the recommended amounts per capita per month compared to low-income and densely populated areas.[81] Other research confirms that water supply and sanitation in Nairobi are a major problem synonymous to other fast-growing urban areas where water distribution and provision is limited to the extent that even those populations with direct connections to tap water do not receive regular supply.[82]

The essence of efficient urban water systems in promoting sustainability goes beyond the primary uses.[83] It includes unevenly distributed water resources and exacerbating climate-related risks like drought. Assessments on drought risk as an indicator of water risks (quality, reputation and quantity) rank Kenya as a medium to

[80] Mulwa, F., Li, Z., & Fangninou, F. F. (2021). Water scarcity in kenya: Current status, challenges and future solutions. *OALib*, *08*(01), 1–15. *https://doi.org/10.4236/oalib.1107096*
[81] Mutono, N., Wright, J., Mutembei, H., & Thumbi, S. M. (2022). Spatio-temporal patterns of domestic water distribution, consumption and sufficiency: Neighbourhood inequalities in Nairobi, Kenya. *Habitat International*, *119*, 102476. *https://doi.org/10.1016/j.habitatint.2021.102476*
[82] Ledant, M. (2013). Water in Nairobi: Unveiling inequalities and its causes. *Cahiers d'Outre-Mer*, *66*(263), 335–348. **https://doi.org/10.4000/com.6951**
[83] Mulwa, F., Li, Z., & Fangninou, F. F. (2021). Water scarcity in kenya: Current status, challenges and future solutions. *OALib*, *08*(01), 1–15. *https://doi.org/10.4236/oalib.1107096*

high drought-risk country.[84] This emphasises the need to develop new plans to ensure water efficiency within all cities and towns while keeping in mind the rapid urban population growth.

One of the major challenges surrounding water availability in many urban areas in developing countries, including Kenya, is that water supply is disproportionate to the demand.[85] This fact has been linked to rapid urbanisation, population growth and shifting consumption patterns. [86] Further, it is reported that poor infrastructural development and poor management of voluminous wastewater and faecal sludge generated in urban cities hamper the quality, availability and affordability of water.[87] This is mainly instigated by poor governance, weak legal framework, inefficient urban planning, lack of updated urban data and limited finances. Another major challenge is undervaluing the vitality of urban planning and the use of outdated plans.[88]

2.4 Urban Energy Sources

Of the overall global energy consumption, urban energy systems are responsible for three-quarters and account for 70% of worldwide greenhouse gas emissions.[89] With the projected increase in the global

[84] Wang, X. C., & Fu, G. (Eds.). (2021). *Water-wise cities and sustainable water systems: Concepts, technologies, and applications*. IWA Publishing.
[85] Koros, J. K., et al. (2023). Leaving no one behind: Prospects for user-owned urban water utilities in Kenya. *Public Works Management & Policy*, 1087724X231181076. https://doi.org/10.1177/1087724X231181076
[86] Bergkamp, G., Diphoorn, B. & Trommsdorf, C. (2015). *Water and development in the urban setting*. SIWI publications. ISBN: 978-91-981860-4-8.
[87] Ibid
[88] Ibid
[89] Klemm, C., & Wiese, F. (2022). Indicators for the optimization of sustainable urban energy systems based on energy system modeling. *Energy, Sustainability and Society, 12*(1), 3. https://doi.org/10.1186/s13705-021-00323-3

urban population and more so in the global south, as discussed earlier, urban energy demands are expected to rise, which might imply an increase in the greenhouse gas emissions associated with energy production and consumption if sustainable measures are not adopted.[90] Energy is a fundamental development factor irrespective of the source; it is needed for the functioning of urban areas, from domestic activities and industrial production to service operations.[91] An uninterrupted energy supply is necessary to run these operations smoothly and effectively. However, in developing countries, there is a mismatch between energy supply and consumption in urban areas.[92] It is estimated that annual energy demand in developing countries grows by about 7% while the supply remains the same despite the economic expansion, population increase and rapid urbanisation.[93] The imbalance has prompted power rationing in some cities and towns, as in Kenya.

The energy mismatch is also heightened by extreme weather events such as heavy rainfall or drought. In the past, power rationing has been applied in Kenya due to severe drought leading to low water levels in major dams.[94] Although Kenya has diversified its energy mix, green energy consisting mainly of hydro, geothermal power is still one of the leading sources of electricity production, meaning weather events such as drought could affect power generation and

[90] Lu, W.-C. (2017). Greenhouse gas emissions, energy consumption and economic growth: A panel cointegration analysis for 16 Asian countries. *International Journal of Environmental Research and Public Health*, *14*(11), 1436. https://doi.org/10.3390/ijerph14111436
[91] OECD (2011). Green Growth Studies: Energy. *Organisation for Economic Co-operation and Development*
[92] UN-Habitat. (2023). Urban Energy. *United Nations Human Settlements Programme*
[93] Ibid
[94] AGOA. (2011). Kenya Power resorts to rationing. *African Growth and Opportunity Act.*

supply.[95] Similarly, extreme rainfall could damage infrastructure, limiting the continuous power supply to all neighbourhoods, especially the densely populated areas.[96] Data shows that Kenya's energy mix consists of more than 80% green energy, that is, hydropower, geothermal, solar and wind power, with geothermal energy continuously growing over the years.[97] The growth of geothermal energy is vital in reducing the reliance on hydroelectricity.

The challenges affecting urban energy systems in Kenya range from policy ineffectiveness, unrealistic demand growth estimations, climate change, energy monopoly, and financial and unreliable supply.[98] Fixing these challenges demands well-calculated, practical and diversified solutions integrated into the urban energy plan. For instance, in response to climate change impacts, expanding renewable energy sources such as wind and solar that currently contribute less than 15% of the overall energy supply would be significant.[99] This can be done by tapping energy potentials in places neighbouring the urban areas. The use of geothermal, wind and solar energies in cities is rising; however, not extensively untapped.[100]

Similarly, improving competitiveness in urban energy supply to eliminate the existing monopoly, increasing financial investment and

[95] Trade.gov. (2022). Kenya: Energy-Electrical Power Systems. *The International Trade Administration, U.S. Department of Commerce*
[96] Ibid
[97] Ibid
[98] World Bank. (2021). Climate Risk Profile: Kenya. *The World Bank Group*
[99] Ibid
[100] IRENA (2020), Rise of renewables in cities: *Energy solutions for the urban future*. International Renewable Energy Agency. ISBN 978-92-9260-271-0

ensuring quality and reliable power supply is vital.[101] Self-sufficiency in energy production is an important feature.[102] City-specific energy production and supply models that have been applied in many cities in developed nations such as in Europe, most of which are renewable energy can be used in Kenya's urban areas.[103] Doing so can easily decarbonise the energy mix.

2.5 Upgrading Informal Settlements

Informal settlements form a very significant part of many urban areas in low and middle-income countries and are integral in urban development and advancing sustainability.[104] On the global scale, about 1 billion people live in urban informal settlements, with the majority being in low-income nations.[105] These are areas characterised by poor drainage systems, water shortage, overcrowding, poor-quality housing and located in hazardous areas such as along river banks or sewer lines.[106] The emergence and continued growth of informal settlements is associated with rapid urbanisation and population increase in many urban areas whose standing resources and facilities cannot cater for the new population.[107] Although informal settlements have existed for

[101] OECD. (2013). Policy Guidance for Investment in Clean Energy Infrastructure: Expanding access to clean energy for green growth and development. *OECD, World Bank and UNDP.*
[102] Ibid
[103] Villamor, E., et al. (2020). European cities in the energy transition: A preliminary analysis of 27 cities. *Energies*, *13*(6), 1315. https://doi.org/10.3390/en13061315
[104] Frediani, A.A.; Cociña, C.; and Roche, J.M. 2023. Improving Housing in Informal Settlements: Assessing the Impacts in Human Development. *Habitat for Humanity International, Washington, D.C.*
[105] Satterthwaite, D., et al. (2020). Building resilience to climate change in informal settlements. *One Earth*, *2*(2), 143–156. *https://doi.org/10.1016/j.oneear.2020.02.002*
[106] Ibid
[107] Ibid

decades in many urban areas, city governments responsible for overall urban development through planning, zoning and allotment of resources often ignore these areas because they are illegal from the legal framework.[108]

Figure 1: A picture of Mathare informal settlement portraying Mathare river flowing through the settlement[109]

Major cities and towns in Kenya host several informal settlements varying in size, scale, demographically and location. Nairobi, for instance, hosts some of the largest informal settlements in Africa, such as Kibera and Mathare, harbouring huge populations and

[108] Ibid
[109] Google Earth Pro. (2023). A computer screenshot

deplorable living conditions.[110] As a result of the poor conditions in these settlements, the inhabitants are subjected to health problems and are highly vulnerable to climate risks.[111] Often neglected is the fact that some of the practices in informal settlements, such as dumping waste into flowing rivers, have far-reaching impacts on other urban populations living far away from the settlements; especially those on downstream.[112]

Improving the status of informal settlements has immense direct benefits to the people within and far from the settlements and on the face of the city.[113] The smartness and sustainability of an urban area are judged not only by the few high-tech installations but also by the overall facelift.[114] The future and sustainability of Kenya's urban areas include recognising the challenges evident in informal settlements, evaluating them and developing solutions consistent with existing urban planning and zoning policies.[115] The intention has to be to improve a city or town's overall status, including the

[110] Wamukoya, M., et al. (2020). The Nairobi Urban Health and Demographic Surveillance of slum dwellers, 2002–2019: Value, processes, and challenges. *Global Epidemiology*, *2*, 100024. https://doi.org/10.1016/j.gloepi.2020.100024
[111] Satterthwaite, D., et al. (2020). Building resilience to climate change in informal settlements. *One Earth*, *2*(2), 143–156. *https://doi.org/10.1016/j.oneear.2020.02.002*
[112] Ngatia, M., Kithiia, S. M., & Voda, M. (2023). Effects of anthropogenic activities on water quality within Ngong river sub-catchment, Nairobi, Kenya. *Water*, *15*(4), 660. *https://doi.org/10.3390/w15040660*
[113] Frediani, A.A.; Cociña, C.; and Roche, J.M. 2023. Improving Housing in Informal Settlements: Assessing the Impacts in Human Development. *Habitat for Humanity International, Washington, D.C.*
[114] D'Auria, A., Tregua, M., & Vallejo-Martos, M. (2018). Modern conceptions of cities as smart and sustainable and their commonalities. *Sustainability*, *10*(8), 2642. *https://doi.org/10.3390/su10082642*
[115] UN-Habitat. (2016). Sustainable Urban Development in Kenya: Addressing Urban Informality. Volume 4: Report on Capacity Building for Community Leaders. *United Nations Human Settlements Programme*

informal settlements.[116] It is recognised that the Kenyan government has taken significant steps to upgrade slum areas and informal settlements, primarily the infrastructural facilities such as housing.[117] While the upgrading initiatives have had a positive impact, more still needs to be done to make cities, towns and human settlements safe, resilient, sustainable and inclusive as outlined and encouraged under sustainable development goal 11.[118]

The provision of functioning drainage systems and sewers, directing all wastewater into a common collection point, and enforcing a treatment-before-discharge policy are crucial in urban areas.[119] For instance, an environmental risk assessment carried out in the Nairobi river catchment area demonstrated the extensive downstream impact of untreated wastewater directedly discharged by informal settlements.[120] This indicates that the status and conditions in urban informal settlements will directly affect the socio-economic and ecological status of a city or town. In most cases, neglecting these settlements jeopardises a mission to build resilience and foster sustainability in urban areas.[121]

---

[116] Ibid

[117] State Department of Housing and Urban Development. (2018). Kenya Slum Upgrading Programme (KENSUP). *Ministry of Lands, Public Works, Housing and Urban Development*.

[118] UN-SDGs. (2023). Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable. *United Nations*

[119] Onu, M. A., et al. (2023). Challenges of wastewater generation and management in sub-Saharan Africa: A Review. *Environmental Challenges*, *11*, 100686. *https://doi.org/10.1016/j.envc.2023.100686*

[120] Bagnis, S., et al. (2020). Characterization of the Nairobi River catchment impact zone and occurrence of pharmaceuticals: Implications for an impact zone inclusive environmental risk assessment. *Science of The Total Environment*, *703*, 134925. *https://doi.org/10.1016/j.scitotenv.2019.134925*

[121] UN-Habitat. (2016). Sustainable Urban Development in Kenya: Addressing Urban Informality. Volume 4: Report on Capacity Building for Community Leaders. *United Nations Human Settlements Programme*

Energy is an important factor in improving informal settlements that need to be addressed concretely. With over 50% of the urban population in Kenya living in informal settlements, mainly in Kisumu, Nairobi and Mombasa towns, the energy demands are high.[122] However, the sources of energy for daily use, especially for cooking purposes where a significant population heavily relies on charcoal, firewood and kerosene, deserve urgent viable solutions. On a brighter note, there have been efforts by the Government of Kenya to promote liquified petroleum gas, which is considered cleaner compared to charcoal and firewood.[123] These efforts are aimed at meeting the sustainable development goals geared towards universal access, affordable and reliable energy for all, as well as reducing health and environmental challenges associated with the use of charcoal and firewood.[124] The reliance on solid biomass as a cooking energy source in Kenya harms biodiversity, air quality, and human health; it destroys natural carbon sinks.[125] By revolutionising the energy sources used in informal settlements coupled with modifying road networks, waste management and greening the surroundings gives cities and towns a boost while making them more appealing.[126]

---

[122] Christley, E. et al. (2021). Sustainable energy for slums? Using the Sustainable Development Goals to guide energy access efforts in a Kenyan informal settlement. *Energy Research & Social Science*, *79*, 102176. *https://doi.org/10.1016/j.erss.2021.102176*

[123] Ibid

[124] Besner, R., Mehta, K., & Zörner, W. (2023). How to enhance energy services in informal settlements? Qualitative comparison of renewable energy solutions. *Energies*, *16*(12), 4687. *https://doi.org/10.3390/en16124687*

[125] Kibii, C.J. (2022). Decarbonising Africa's Agriculture and Forestry. Synergies and Trade-offs for Sub-Saharan Africa. *Journalofcmsd Volume 8*(2)

[126] Douglas, I. (2018). The challenge of urban poverty for the use of green infrastructure on floodplains and wetlands to reduce flood impacts in intertropical Africa. *Landscape and Urban Planning*, *180*, 262–272. *https://doi.org/10.1016/j.landurbplan.2016.09.025*

This, however, demands policy changes, huge finances, political willingness, technology use and practicability.

2.6 Urban Planning and Policy

Urban planning is integral to establishing and maintaining a better quality of life and sustainability in cities and towns in light of rapid urbanisation and population increase.[127] Urban planning embodies a vision, is a communication tool, an evaluation tool, creates a framework for economic growth and citizen participation, guides leaders and promotes natural resource management, better land use and aids in designing practical climate adaptation and mitigation measures.[128] Urban planning is also helpful for city administrators and managers in achieving sustainable development. In cases where effective planning and implementation are lacking, several challenges emerge, such as urban poverty, encroachment into riparian zones, social and economic inequality and the emergence of informal settlements.[129] These challenges can be solved by enforcing the relevant policies and legal frameworks. [130] In Kenya, the establishment, management and government of cities and towns are enshrined in Article 184 of the 2010 Constitution with related provisions on land use planning and regulations guided under Article 166.[131] Similarly, the National Urban Development Policy of 2016, guided by the above articles in the Constitution, recommends smart and compact urban growth, integrated urban heritage conservation strategy, urban regeneration programmes and

[127] Mwau, B & Thung, I., et al. (2018). *Urban Planning for City Leaders: A Handbook for Kenya*. United Nations Human Settlements Programme. ISBN (Volume): 978-92-1-132812-7
[128] Ibid
[129] Ibid
[130] Ibid
[131] Kenya Law. (2010). The Constitution of Kenya, 2010.

classification of urban areas.[132] The same policy recognises the challenges faced by the urban poor and the need for a balanced urban development, among other issues. Ideally, policy integration into an urban development plan is critical in establishing a functioning loop where a strong nexus between the built environment, spatial planning, people's needs and ecological aspects are viewed wholesomely.[133]

3.0 Conclusion

In light of the above, Kenyan cities and towns, both small and big, will continue to record an influx of people migrating from rural areas and other towns within and across the Kenyan border. There is a high likelihood that existing urban resources will be overstretched to meet the demands of the ballooning populations.[134] More pressure will be exerted on natural resources.[135] Increased waste generation is a potential consequence of the changing urban demographics and needs.[136] Each factor of urban sustainability discussed presents unique challenges to fostering sustainable urban development. Hence, a holistic approach is necessary where all elements are

---

[132] State Department of housing and urban development. (2016). National Urban Development Policy. *Ministry of Transport, Infrastructure, Housing and Urban Development*.

[133] Mwau, B & Thung, I., et al. (2018). *Urban Planning for City Leaders: A Handbook for Kenya*. United Nations Human Settlements Programme. ISBN (Volume): 978-92-1-132812-7

[134] Whitaker, E. Et al. (2023). Climate Security Study: Kenya. *Weathering Risk*

[135] Revi, A., et al. (2014). *Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, pp. 535-612.

[136] Zaman, A. U., & Lehmann, S. (2013). The zero-waste index: A performance measurement tool for waste management systems in a 'zero waste city.' *Journal of Cleaner Production*, *50*, 123–132. *https://doi.org/10.1016/j.jclepro.2012.11.041*

recognised and considered singularly and in unison to promote liveability and resilience.

References

African Population and Health Research Center. (2019). Solid Waste Management and Risks to Health in Urban Africa: A Study of Nairobi and Mombasa Cities in Kenya. *Urban Africa Risk Knowledge.*

Al-Ghaili, A. M., Et al. (2022). Can electric vehicles be an alternative for traditional fossil-fuel cars with the help of renewable energy sources towards energy sustainability achievement? *Energy Informatics*, *5*(S4), 60. https://doi.org/10.1186/s42162-022-00234-3

Andrea, V. (2015). *Handbook of research on social, economic, and environmental sustainability in the development of smart cities*. IGI Global.

Asian Development Bank. (2014). Urban Climate Change Resilience: A Synopsis. *Asian Development Bank*

Bamwesigye, D., & Hlavackova, P. (2019). Analysis of sustainable transport for smart cities. *Sustainability*, *11*(7), 2140. https://doi.org/10.3390/su11072140

Bergkamp, G., Diphoorn, B. & Trommsdorf, C. (2015). *Water and development in the urban setting*. SIWI publications. ISBN: 978-91-981860-4-8.

Besner, R., Mehta, K., & Zörner, W. (2023). How to enhance energy services in informal settlements? Qualitative comparison of renewable energy solutions. *Energies*, *16*(12), 4687. https://doi.org/10.3390/en16124687

Callender, J. (2012). Sustainable urban development. In *International Encyclopedia of Housing and Home* (pp. 129–133). Elsevier. https://doi.org/10.1016/B978-0-08-047163-1.00601-9

Cerasoli, M., Amato, C., & Ravagnan, C. (2023). The theoretical grid. An antifragile strategy for Rome post-COVID mobility. In *Resilient and Sustainable Cities* (pp. 15–37). Elsevier. https://doi.org/10.1016/B978-0-323-91718-6.00036-0

Cobbinah, P. B. (2023). City in Africa II: Urban environmental health. *Journal of Urban Affairs*, *45*(3), 483–487. https://doi.org/10.1080/07352166.2023.2171617

Coutu, R., Et al. (2020). Engineering tests to evaluate the feasibility of an emerging solar pavement technology for public roads and highways. *Technologies*, *8*(1), 9. https://doi.org/10.3390/technologies8010009

D'Auria, A., Tregua, M., & Vallejo-Martos, M. (2018). Modern conceptions of cities as smart and sustainable and their commonalities. *Sustainability*, *10*(8), 2642. https://doi.org/10.3390/su10082642

Douglas, I. (2018). The challenge of urban poverty for the use of green infrastructure on floodplains and wetlands to reduce flood impacts in intertropical Africa. *Landscape and Urban Planning*, *180*, 262–272. https://doi.org/10.1016/j.landurbplan.2016.09.025

EPRA. (2023). Solar Energy. *Energy & Petroleum Regulatory Authority*. https://renewableenergy.go.ke/technologies/solar-energy/

Fakhrmoosavi, F., Kamjoo, E., Zockaie, A., Mittal, A., & Fishelson, J. (2023). Assessing the network-wide impacts of dedicated lanes for connected autonomous vehicles. *Transportation Research Record: Journal of the Transportation Research Board*, *2677*(3), 371–388. https://doi.org/10.1177/03611981221115431

Frediani, A.A.; Cociña, C.; and Roche, J.M. 2023. Improving Housing in Informal Settlements: Assessing the Impacts in Human Development. *Habitat for Humanity International, Washington, D.C.*

Georgouli, C. Et al. (2021). Urban Mobility Innovation Index – 2021. Leading transformations with innovation for inclusive, sustainable and resilient urban mobility. *UMIi*

Google Earth Pro. (2023). A computer screenshot

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*(1), 1–23. https://doi.org/10.1146/annurev.es.04.110173.000245

IEA. (2023). Global EV Policy Explorer: Key policies and measures that support the deployment of electric and zero-emission vehicles. *International Energy Agency*.

Jha, A. K., Miner, T. W., & Stanton-Geddes, Z. (Eds.). (2013). *Building urban resilience: Principles, tools, and practice*. The World Bank. **ISBN:**978-0-8213-8865-5 https://doi.org/10.1596/978-0-8213-8865-5

Kenya Vision 2030. (2008). https://vision2030.go.ke/

Kibii, C.J. (2022). Decarbonising Africa's Agriculture and Forestry. Synergies and Trade-offs for Sub-Saharan Africa. *Journalofcmsd Volume 8*(2)

Kim, C. & Mauborgne, R. (2023). Turning Waste to Energy: Sweden's Recycling Revolution. *Blue Economy Strategy*

Koop, C., Schinkel, J & Wilts, H. (2019). Waste Prevention Strategies for Sustainable Urban Development. *Urbanet*.

Koros, J. K., et al. (2023). Leaving no one behind: Prospects for user-owned urban water utilities in Kenya. *Public Works Management & Policy*, 1087724X231181076. https://doi.org/10.1177/1087724X231181076

Kost, C., Mwaura, N., Jani, A., & Eyken, C. V. (2017). Streets for walking & cycling Designing for safety, accessibility, and comfort in African cities. *UN-Habitat*

Kotei, P., Annang, T., & Yirenya-Tawiah, D. (2020). Stakeholder Participation for Sustainable Solid Waste Management in Ga West Municipality, Accra – Ghana. *American Journal of Environment Studies*, *3*(1), 44–60. https://doi.org/10.47672/ajes.611

Labdaoui, K., Et al. (2021). Utilizing thermal comfort and walking facilities to propose a comfort walkability index (CWI) at the neighbourhood level. *Sage Journals; Environment and Behavior*. https://doi.org/10.1016/j.buildenv.2021.107627

Ledant, M. (2013). Water in Nairobi: Unveiling inequalities and its causes. *Cahiers d'Outre-Mer*, *66*(263), 335–348. https://doi.org/10.4000/com.6951

Lu, W.-C. (2017). Greenhouse gas emissions, energy consumption and economic growth: A panel cointegration analysis for 16 Asian countries. *International Journal of Environmental Research and Public Health*, *14*(11), 1436. https://doi.org/10.3390/ijerph14111436

Martínez, S. et al. (2019). The Economic Impact of Bike Sharing in European Cities. *IESE Business School*. DOI: https://dx.doi.org/10.15581/018.ST-505

Mesjasz-Lech, A. (2014). Municipal waste management in context of sustainable urban development. *Procedia - Social and Behavioral Sciences*, *151*, 244–256. https://doi.org/10.1016/j.sbspro.2014.10.023

Mosemand, A. & Paltsev, S. (2022). Are electric vehicles definitely better for the climate than gas-powered cars? *MIT Climate Portal*.

Mulwa, F., Li, Z., & Fangninou, F. F. (2021). Water scarcity in kenya: Current status, challenges and future solutions. *OALib*, *08*(01), 1–15. https://doi.org/10.4236/oalib.1107096

Mustafa E. (2018). *Urban agglomeration*. IntechOpen.

Mutono, N., Wright, J., Mutembei, H., & Thumbi, S. M. (2022). Spatio-temporal patterns of domestic water distribution, consumption and sufficiency: Neighbourhood inequalities in Nairobi, Kenya. *Habitat International*, *119*, 102476. https://doi.org/10.1016/j.habitatint.2021.102476

NEMA. (2015). The National Solid Waste Management Strategy. *Kenya National Environment Management Authority*

NEMA. (2020). Kenya Waste Management Guidelines. *National Environment Management Authority*

Nero, B. F., Callo-Concha, D., & Denich, M. (2019). *Increasing urbanisation and the role of green spaces in urban climate resilience in Africa*. In J. Tischler & I. Haltermann (Eds.), Environmental Change and African Societies (pp. 265–295). BRILL. ISBN: 9789004410848. https://doi.org/10.1163/9789004410848_013

OECD (2011). Green Growth Studies: Energy. *Organisation for Economic Co-operation and Development*

OECD. (2013). Policy Guidance for Investment in Clean Energy Infrastructure: Expanding access to clean energy for green growth and development. *OECD, World Bank and UNDP.*

OECD/UN ECA/AfDB. (2022). *Africa's Urbanisation Dynamics 2022: The Economic Power of Africa's Cities*, West African Studies, OECD Publishing, Paris, https://doi.org/10.1787/3834ed5b-en.

Onu, M. A., et al. (2023). Challenges of wastewater generation and management in sub-Saharan Africa: A Review. *Environmental Challenges*, *11*, 100686. https://doi.org/10.1016/j.envc.2023.100686

Randhawa, P., Marshall, F., Kushwaha, P. K., & Desai, P. (2020). Pathways for sustainable urban waste management and reduced environmental health risks in india: Winners, losers, and alternatives to waste to energy in delhi. *Frontiers in Sustainable Cities*, *2*, 14. https://doi.org/10.3389/frsc.2020.00014

Revi, A., et al. (2014). *Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, pp. 535-612.

Ribeiro, P. J. G., & Pena Jardim Gonçalves, L. A. (2019). Urban resilience: A conceptual framework. *Sustainable Cities and Society*, *50*, 101625. https://doi.org/10.1016/j.scs.2019.101625

Rodrigues, M.J. et al (2017). *Architectural Research Addressing Societal Challenges Volume 1*. CRC Press, 19 Sept 2017 - Technology & Engineering.

Semanjski, I. C. (2023). *Introduction to smart mobility. In Smart Urban Mobility* (pp. 9–23). Elsevier. https://doi.org/10.1016/B978-0-12-820717-8.00009-9

Song, X., Guo, R., & Zhang, H. (2022). MaaS for sustainable urban development. In *Big Data and Mobility as a Service* (pp. 265–279). Elsevier. https://doi.org/10.1016/B978-0-323-90169-7.00011-7

Sovacool, B. K., Daniels, C., & AbdulRafiu, A. (2022). Transitioning to electrified, automated and shared mobility in an African context: A comparative review of Johannesburg, Kigali, Lagos and Nairobi. *Journal of Transport Geography*, *98*, 103256. https://doi.org/10.1016/j.jtrangeo.2021.103256

Swapan, A. Y., & Sharifi, A. (2023). The fundamentals of smart city assessment. In *Urban Climate Adaptation and Mitigation* (pp. 117–146). Elsevier. https://doi.org/10.1016/B978-0-323-85552-5.00005-1

UN Water. (2018). Synthesis Report on Water and Sanitation. *United Nations Water.*

UNCTAD. (2022). Total and urban population. *Handbook of Statistics 2022*. https://hbs.unctad.org/total-and-urban-population/

UNDESA. (2018). The World Urbanization Prospects. *Department of Economic and Social Affairs of the United Nations*. https://www.un.org/uk/desa/68-world-population-projected-live-urban-areas-2050-says-un

UN-Habitat (2022). World Cities Report 2022. *Envisaging the future of cities. Nairobi: UN-Habitat.* https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf

UN-Habitat (2023). Urbanization in Kenya: Building inclusive & sustainable cities. *UN-Habitat*.

UN-Habitat. (2016). Sustainable Urban Development in Kenya: Addressing Urban Informality. Volume 4: Report on Capacity Building for Community Leaders. *United Nations Human Settlements Programme*

United Nations Brundtland Commission. (1987). Report of the World Commission on Environment and Development: Our Common Future. *United Nations.* http://www.un-documents.net/our-common-future.pdf

UN-SDGs. (2023). Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable. *United Nations*

Villamor, E., et al. 2020. European cities in the energy transition: A preliminary analysis of 27 cities. *Energies*, *13*(6), 1315. https://doi.org/10.3390/en13061315

Vuorinen, H. S., Juuti, P. S., & Katko, T. S. (2007). History of water and health from ancient civilizations to modern times. *Water Supply*, *7*(1), 49–57. https://doi.org/10.2166/ws.2007.006

Wang, X. C., & Fu, G. (Eds.). (2021). *Water-wise cities and sustainable water systems: Concepts, technologies, and applications*. IWA Publishing. https://doi.org/10.2166/9781789060768

Whitaker, E. Et al. (2023). Climate Security Study: Kenya. *Weathering Risk*

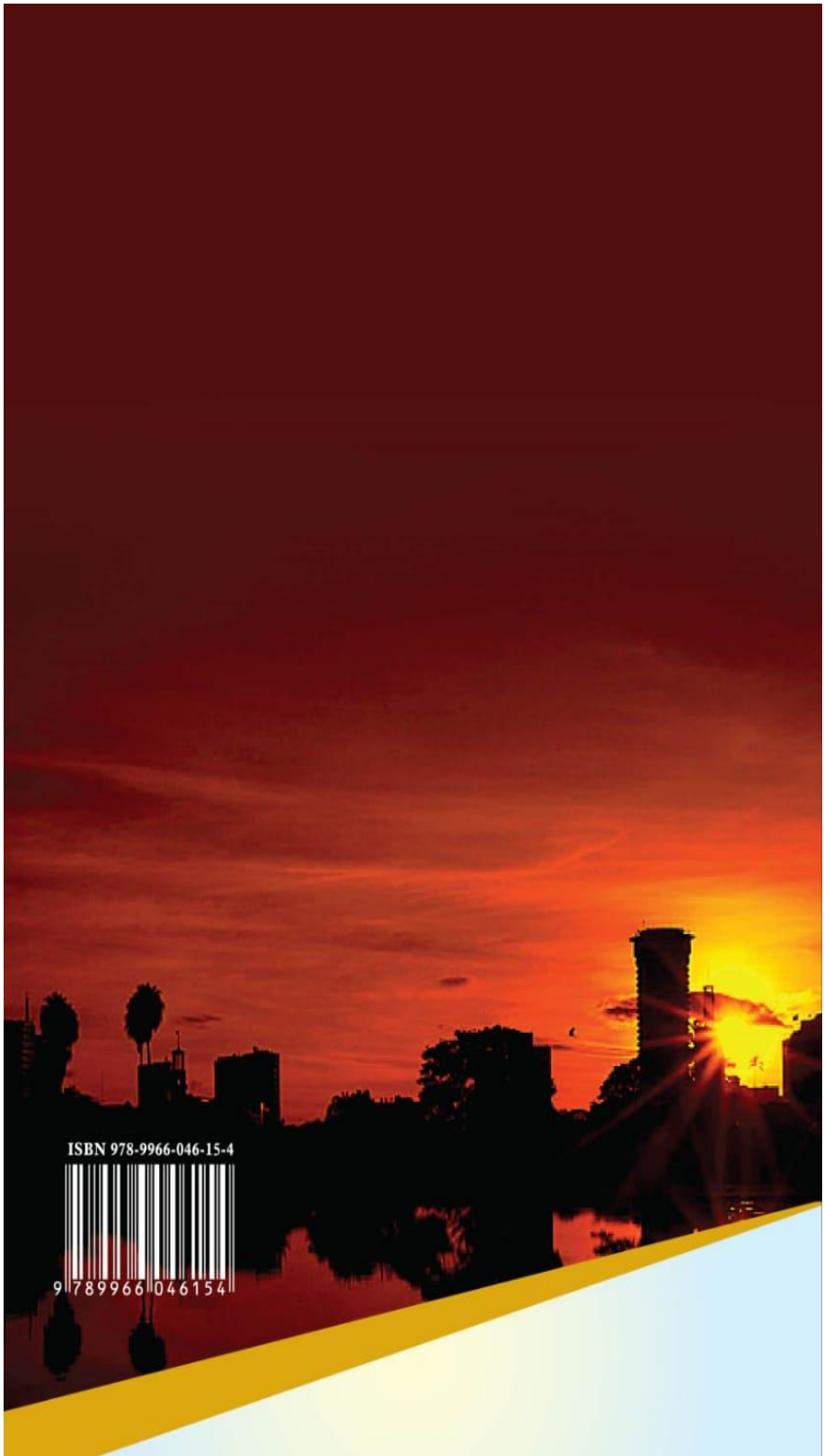
Whitehead, M. (2009). Sustainability, urban. In *International Encyclopedia of Human Geography* (pp. 109–116). Elsevier. https://doi.org/10.1016/B978-008044910-4.01103-2

Winters, M., Branion-Calles, M., Therrien, S., Fuller, D., Gauvin, L., Whitehurst, D. G. T., & Nelson, T. (2018). Impacts of Bicycle Infrastructure in Mid-Sized Cities (Ibims): Protocol for a natural experiment study in three Canadian cities. *BMJ Open*, *8*(1), e019130. https://doi.org/10.1136/bmjopen-2017-019130

World Bank. (2023). Urban Development. *The World Bank Group*.

Wu, D., Lin, J. C., Oda, T., & Kort, E. A. (2020). Space-based quantification of per capita CO_2 emissions from cities. *Environmental Research Letters*, *15*(3), 035004. https://doi.org/10.1088/1748-9326/ab68eb

Zaman, A. U., & Lehmann, S. (2013). The zero-waste index: A performance measurement tool for waste management systems in a 'zero waste city.' *Journal of Cleaner Production*, *50*, 123–132. https://doi.org/10.1016/j.jclepro.2012.11.041



ISBN 978-9966-046-15-4