Deep decarbonization pathways, strategies, governance, actors and roadblocks in cities: Climate change mitigation perspectives from selected Sub-Saharan African Cities

by

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Author's declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The complex and multidimensional effect of climate change, coupled with low socioeconomic development in sub-Saharan Africa, makes the region vulnerable to changing climate and threatens its inhabitants' survival, livelihood and health. Subnational actions have been widely acclaimed as an effective way to combat climate change due to their nearness to the epicenter of global warming – urban centers. This is because over 70% of global GHG emissions occur in urban areas. To reduce GHG emissions, local governments in sub-Saharan Africa have been developing and implementing climate action plans.

This research aims to extend the understanding of global decarbonization dynamics by studying four major African megacities' climate plans and actions. This research compares the strategies and governance structures recommended for local climate mitigation action in academic and grey literature to those described in the deep decarbonization plans of leading local governments to identify innovative implementation strategies and governance approaches for urban deep decarbonization in developing nations. This presents a new perspective in the quest for decarbonization to reduce anthropogenic global warming through the exploration of the concepts and visions of deep decarbonization pathways and examining the strategies toward reducing GHG emission in “uncharted territories” - selected African cities.

The research is based on the case study of pathways, strategies, governance mechanisms, and actors for deep decarbonization in four leading cities in sub-Sahara Africa using the qualitative research method. The four case cities are Accra (Ghana), Addis Ababa (Ethiopia), Lagos (Nigeria) and Nairobi (Kenya). The study’s methods included exploring the climate action plans of the case cities and reviewing data in the Climate Disclosure Protocol (CDP) and other city-specific deep decarbonization documents. Interviews were also conducted with the city officials involved in sustainability and climate change activities within the case cities. This was done mainly to get answers to gaps in document analysis and triangulate some of the empirical findings. The study also compared the emerged patterns from the case cities to typical

cities in the global north to gain practical intricacies into the difference in climate change mitigation practices, governance and management across the divide.

The contributions of this study to the body of literature on decarbonization frameworks are in seven major areas through the extension of literature to include the innovative approaches being deployed by cities in sub-Saharan Africa to mitigate Climate change. This study contributes new insight into the following areas: decarbonization of energy and waste management, increasing local carbon sinks, climate action coordination structure, vertical integration approaches, self-regulating governance mode, the role of traditional institutions and major barriers to decarbonization efforts at the city level.

Given that it identifies emerging best practices, the study's findings can be helpful to practitioners pursuing local deep decarbonization and international organization working on deep decarbonization at the city level.

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"Oju merin lo n m'omo w'aye, igba oju o to bo." (Yoruba proverb) – it takes a village to raise a child. To the village that raised me and everyone that has been part of my story, I thank you all.

This thesis is dedicated to the loving memory of my late mother, Juliana Onaolapo Akomolafe (1952 – 1985).

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1 Introduction

1.1 Background and History

Climate impacts caused by anthropogenic global warming are among humanity's topmost challenges (Crutzen & Stoermer, 2000). About 73% of the annual 50 gigaton CO2-equivalent (GtCO2eq) of global Greenhouse Gas (GHG) emissions is attributed to the energy sector, while 18% is from Agriculture, Forestry and Other Land Use (AFOLU) (AfDB, 2020). The most significant GHG emissions in emerging economies come from AFOLU, while in the global north, GHG emissions are from energy and industrial sectors (AfDB, 2020; Habitat, 2020; Smit, 2018). Cities are the primary sources of GHG pollution, accounting for over 70% of CO2 emissions (Currie, 2015; Fong et al., 2015; Olivier & Peters, 2020). The increase in urban population and continuous economic growth is fueling the high rate of metabolism in cities, which also correlates with a drastic increase in GHG emissions (Currie, 2015; Taminiau & Byrne, 2020). Climate change is a global challenge, and its mitigation is imperative for environmental and socio-economic sustainability. Therefore, district, municipal, and city governments must be at the forefront of deep decarbonization for global prosperity (Linton, 2020; Linton et al., 2021).

In Sub-Saharan Africa (SSA), most nations are at a crucial phase in their development. Relative peace, partnership and increasing price of commodities fuel rapid urban growth, population increase, and a young and growing workforce (Adepoju, 2000; Filmer & Fox, 2014; Fox et al., 2016; Saghir & Santoro, 2018; Yeboah & Jayne, 2018). In addition, several SSA countries are experiencing high levels of economic growth (Adepoju, 2008; Fox et al., 2016). Unfortunately, global climate change is eroding the socioeconomic gains by increasing food insecurity, land degradation, and changing weather which undermines social development and poverty reduction (AfDB, 2020; Cobbinah, 2021; Conway & Schipper, 2011; Fobissie et al., 2019; ICLEI Africa, 2021; Musah-Surugu et al., 2019; OECD, 2020). The effect of climate change in Africa is distinctive, and its vulnerability to the impacts of past and present climate change is visible. This is because of direct adverse effects, the vulnerability of agriculture, the leading

employer in Africa, food supply chain vulnerability, a limited resilience framework and a lack of capacity for adaptation (Collier et al., 2008; Conway & Schipper, 2011).

An international consensus is that unprecedented and extremely steep cuts in global greenhouse (GHG) emissions through the deployment of low-carbon economic systems are required to avert the impending global environmental catastrophe (Åhman et al., 2017; IPCC, 2018). The accomplishment of this ambitious goal involves participation from all strata of government and stakeholders to develop unique mechanisms and strategies toward deep decarbonization. Deep decarbonization will help achieve the sustainable development goals (Linton et al., 2021). Cities are developing innovative and groundbreaking solutions for deep decarbonization — promoting mitigation strategies, technological intervention, sustainable development and increasing climate resilience while reducing emissions (Altieri et al., 2015; Atkinson, 2007; CDP, 2022; Fong et al., 2015; ICLEI Africa, 2021).

The Paris Agreement stipulates that emission reduction strategies must be implemented in the context of sustainable development, considering individual national and geographical peculiarities (Bataille et al., 2020; Pye & Bataille, 2016). Deep decarbonization is a complex societal, economic, and political transformation to a net-zero carbon system in the various sectors and procedures within the study boundary while emphasizing development and climate (Altieri et al., 2015; Lefèvre et al., 2021; Linton et al., 2021). It involves overcoming carbon lock-ins to eliminate carbon-intensity in systems and reducing GHG to zero (Linton, 2020; Seto et al., 2016; Unruh, 2002, 2009; Unruh & Carrillo-Hermosilla, 2006). Many actors play diverse roles in facilitating the effective use of this approach in addressing the climate emergency. Therefore, adopting the appropriate and relevant governance strategies and structures will benefit local efforts in climate change mitigation. Transitioning to a decarbonized socio-economic system is one of the modern world's most pressing problems (Altieri et al., 2015). The global environmental system is a complex network with many levels of interaction between social, economic, technological, and institutions (Kinzig et al., 2013; Linton, 2020). Decarbonization pathways are connected to fulfilling local

development priorities, political structures, global trade, prices, financial flows, and international agreements (Barrett et al., 2016; Sovacool et al., 2019). Deep decarbonization strategies must consider governmental priorities, socio-cultural norms and economic factors for the desired environmental and social sustainability (Faiyetole, 2019; Faiyetole & Adesina, 2017). Climate change mitigation actions, including deep decarbonization, must be specific, localized and consider the local opportunities and challenges.

Climate change adaptation has been intrinsically associated with developing nations while mitigation is considered within the global north's domain (Bataille et al., 2020; Somorin, 2010). Most interventions, studies, and literature on climate action in developing nations are therefore focused on adaptation due to the vulnerability. There exists a knowledge gap in the climate change mitigation framework at the local level in developing countries (Linton, 2020; Linton et al., 2022). Climate change research on climate mitigation in African cities is insufficient (Leal Filho et al., 2018). The study of deep decarbonization in cities of developing nations is a crucial area of expansion of global climate change knowledge as this provides a more inclusive perspective to climate mitigation discourse and knowledge base. This research, therefore, aims to close these inherent gaps by studying the climate mitigation actions and plans by cities in sub-Sahara Africa. This research seeks to extend the understanding of the dynamics of global decarbonization by studying African megacities, while considering local socio-economic conditions. This research will review the theoretical basis of local climate mitigation governance, strategies and pathways using a combination of journal articles, books, grey literature, and technical documents. The literature findings are compared with deep decarbonization actions and plans of leading local governments and cities in developing nations to characterize governance strategies in implementing climate actions at the local level. This presents a new perspective in the quest for decarbonization to reduce anthropogenic global warming by exploring the concepts and visions of deep decarbonization scenarios and examining the strategies toward reducing GHG emissions in “uncharted territories” of selected African cities.

1.2 Research Questions

This study aims at determining pathways, strategies, management structures and actors for achieving deep decarbonization in cities in developing nations. Using qualitative methods, the research will examine deep decarbonization activities, plans and low-carbon transition efforts using Sub-Sahara African cities as case studies. This project aims to contribute to the knowledge of frameworks for addressing the multidimensionality of the deep decarbonization challenge in cities in the global fight against climate change.

The research will achieve its goal by answering the following questions:

1. What are the pathways being implemented and planned for GHG emission reduction for deep decarbonization in cities in developing nations with the intended co-benefits of sustainable development?

2. What institutional strategies are defined in cities in developing nations for deep decarbonization, and what progress has been made using these strategies for reaching net-zero and sustainable development?

3. What governance structures are deployed to plan and execute local deep decarbonization programs?

4. Who are the actors, and what is their role in deep decarbonization in cities of developing nations?

5. What is the uniqueness of approaches to address in cities in the global south, and how do they differ from those in the north?

6. What are the roadblocks against deep decarbonization in developing nations?

These research questions will provide insights into the enabling conditions needed for achieving low carbon transition in cities in developing nations.

1.3 Contribution to research

Understanding deep decarbonization in cities in the global south will contribute to the body of knowledge by extending the discussion of decarbonization to the most vulnerable – the global south. It aims to advance understanding of global decarbonization dynamics by studying global south locations considering local socio-economic conditions.

Deep decarbonization is about in-depth analyses of the (de)carbonization trajectory within societal systems (Lacey-Barnacle et al., 2020). Deep decarbonization is one of the most important but underdeveloped environmental concepts. Much has been written about the long-term viability of low-carbon energy systems and policies, focusing on the trilemma posed by environmental, economic, and geopolitical issues. However, the social and equity consequences of these dynamic relationships between energy and low-carbon aspirations and the complexity of injustice connected with entire energy systems have received less attention (Bickerstaff et al., 2013).

The first contribution will be bridging theoretical and practical knowledge gaps in climate governance and global south local climate mitigation activities. This project will give insights into the levels of capacity, the challenges to overcome, and the tactics that cities in developing countries employ to meet their GHG mitigation targets by studying the plans and procedures of African cities. The conceptualization of a decarbonization policymaking system to provide all citizens with a sustainable future is the basis of deep decarbonization (McCauley et al., 2019; Monyei et al., 2019). Discourse on the distributional, procedural and recognition aspects of deep decarbonization, as a call for a systems-thinking approach to governance, will be part of the contribution of this research (Sovacool et al., 2019). The theory of deep decarbonization has been applied to several frameworks for bridging sustainable development gaps, particularly in the global south (Monyei et al., 2019; Sovacool et al., 2019). Deep decarbonization is increasingly being used to conceptualize the impacts of decision-making. However, little effort has been dedicated to systematically examine the extent to which, how and pathways for achieving deep decarbonization in the

global south (Banerjee et al., 2017). This study examines and decomposes the deep decarbonization pathways of best practices in developing nation municipalities implementing deep decarbonization. The results of this study can be helpful to cities that are creating deep decarbonization plans.

Finally, this research work can provide insight into the transferability of the sustainability concept from the global north and south as part of the intergenerational and polycentric approach to global climate change mitigation. This proposed research aims to demystify the peculiar features and characteristics of deep decarbonization in sub-Saharan Africa, thereby presenting needed pathways, strategies, and governance mechanisms for achieving GHG emissions targets and solving climate change issues with consideration of the realities of diversity of urban systems, culture, and political framework in developing and emerging economies.

1.4 Thesis Outline

There are six chapters in this thesis. Chapter 1 - The Introduction - provides a high-level overview of the study, the research questions to which this work will provide answers and anticipated contribution to the body of knowledge. The literature review in chapter 2 gives a thorough overview of prior studies, information, and conclusions on deep decarbonization in cities. The literature review also formulated the study topics and highlighted the knowledge gap in the study of deep decarbonization at the city level in SSA. The research design and the data collection and analysis process are outlined in the methodology (chapter 3). The empirical findings are presented in the results chapter (chapter 4). The discussion (chapter 5) details the findings' ramifications and answers the study questions. The final chapter (conclusion) summarizes the entire thesis and discusses the research's contributions, as well as its limits and prospective future research areas.

2 Literature Review

This chapter outlines the results of a thorough literature study on deep decarbonization, climate change, and sustainable development. The literature review provides insights for framing the problem of this research project. This literature review is integrative and identifies the gaps in previous studies. It starts with an in-depth understanding of climate change (environmental sustainability) and social sustainability, followed by deep decarbonization and local action planning. An assessment of pathways, strategies, and governance for deep decarbonization is presented. The review is completed by identifying stakeholders and local actors and reviewing their roles in decarbonization at the local level. This work focuses on developing nations and sub-Sahara Africa for contextualization. For this work, Sub-Sahara Africa consists of all countries south of the Sahara, including the Republic of the Sudan (Agarana et al., 2017).

2.1 Climate change and social sustainability

Climate change is the variation of the climate system which significantly affects the earth's biogeochemical cycles (Ahmed, 2020; ICLEI Africa, 2021). Climate change is the effect of anthropogenic global warming caused by human socioeconomic activities. Its impact is seen in the form of a rise in temperature called global warming (Collier et al., 2008; Crutzen & Stoermer, 2000). There is a global consensus that mitigating climate change is the greatest challenge (Fanelli, 2014; Farber, 2006). Extremely steep cuts in global greenhouse gas (GHG) emissions coupled with an urgent transition to a low-carbon economic system is required to avert the impending global environmental catastrophe (Åhman et al., 2017; Betsill & Bulkeley, 2006; Bulkeley & Betsill, 2013; Gilley, 2017; IPCC, 2018; Linton, 2020). The issue's importance, severity, and urgency have drawn the attention of academics, practitioners, and policymakers from various disciplines, including management, psychology, sociology, political science, communication, anthropology, tourism, and economics. (Ahmed, 2020; Hornsey & Fielding, 2020).

Reducing greenhouse gases is tied to human welfare (Ahmed, 2020). The dynamic effect of climate change on socioeconomic welfare and sustainable social development is profound (Ahmed, 2020; Ahmed et al.,

2016; Faye et al., 2012). The framework for achieving global prosperity - United Nations 2030 Development Agenda for Sustainable Development involves 17 goals to end poverty and foster freedom and equality while tackling environmental sustainability (Navarro, 2000; Sen, 2000; UNDP, 2016). The inseparability of development from the environment is well documented and confirmed (Peet & Watts, 1993; Rowe, 1994; Shafer & Murphy, 1998). The ability to ensure that development fulfils current demands without jeopardizing future generations' ability to satisfy their own needs is characterized as sustainable development (Bruntland & WCED, 1987). Climate change impacts almost every element of existence, including life and livelihoods, food security, energy and water resources, national and global economies, political stability, and security, making it a societal challenge (Faiyetole & Adesina, 2017).

African countries, like other developing nations, are particularly exposed to the effect of climate change which is evident in environmental disasters - rising water levels, deforestation, desertification, land degradation and changing weather conditions (Faiyetole, 2019; Faiyetole & Adesina, 2017; Vorster et al., 2011). The resilience is further weakened, and vulnerability is compounded by poor infrastructural development and limited capacity (Sono et al., 2021). It is, therefore, inherent that climate change is not only an environmental challenge but an economic, political, and social problem that needs urgent attention (Cobbinah, 2021; Cobbinah et al., 2015; Linton, 2020; Liu et al., 2012; Robert et al., 2005; UNDP, 2016).

2.2 Reducing Greenhouse gas (GHG) emissions for global prosperity

Due to climate change, GHG emissions are presently at the center of political, environmental, technical, and cultural debates (Bernstein & Hoffmann, 2018; Betsill & Bulkeley, 2006; Iati, 2008; ICLEI Africa, 2021; Patterson et al., 2018). Greenhouse gases (GHG) are gaseous substances in the atmosphere which absorb the reflected solar energy-induced infrared radiations from the earth, preventing them from escaping from the biosphere (ICLEI Africa, 2021). The energy is transferred to non-GHGs, causing an increase in the biosphere's temperature (ICLEI Africa, 2021). Carbon dioxide, nitrous oxide, and methane are the principal

anthropogenic GHGs produced by human activity (Frank, 1999). To stay on track for a 1.5 degree Celsius warming, the Intergovernmental Panel on Climate Change (IPCC) projected in 2018 that a 45 percent decrease in global GHG emissions is required by 2030 (based on 2010 levels) and carbon neutrality by 2050 (IPCC, 2018).

The necessity for emission reductions has been established and is widely acknowledged worldwide. Transitioning to low-carbon energy sources, exploiting renewable energy resources, new technologies, making older equipment more energy-efficient, and changing management processes and consumer behaviour are all GHG mitigation measures (Day et al., 2018). The most prominent GHG mitigation plan has always been a global approach while ignoring the significance of the private and public sector activities at the local level (Bulkeley & Betsill, 2005b, 2013; Linton, 2020). It is germane to complement the global strategy with a local effort, as presented in the 1987 Brundtland Report, which argues that in pursuit of sustainable development, cities must be at the forefront as the majority of the world population now live in cities (Bruntland & WCED, 1987; Currie, 2015; Habitat, 2020).

The importance of fragmented micro-level achievements toward reducing GHG emissions has been ignored in the mainstream climate action policy and governance (Ostrom, 2010). The only policy and strategy touted for combating GHG is an international framework (Ostrom, 2010). It is essential to balance the significant attention on global solutions as the only strategy for coping with climate change with local climate action plans and strategies (Dietz et al., 2003; Ostrom, 2010). Multi-dimensional frameworks are being developed and implemented at minor scales for global climate change mitigation (Ostrom, 2010). Researchers need to understand the strength of polycentric systems where institutions at various levels may complement each other (Ostrom, 2010). While establishing a worldwide framework is important, supporting the formation of a polycentric system begins to reduce greenhouse gas emissions and encourages international governments to participate (Ostrom, 2010).

The local level is often argued as the most appropriate political jurisdiction for deep decarbonization (Linton et al., 2021). In Sub-Sahara Africa, land use and waste management authority is vested in provincial and municipal governments (Haregu et al., 2016; ICLEI Africa, 2021; Regassa et al., 2011; Wahab, 2012). They can be essential in dealing with transportation issues and energy consumption. Local actions are currently seen, by practitioners and policymakers, as of significant importance for achieving climate change mitigation targets (CDP, 2022; Currie, 2015; Wahab, 2012).

2.2.1 Climate change adaptation and mitigation

A strong relationship exists between climate change and development (Ayers & Dodman, 2010). Climate change results from unsustainable development activities resulting in high GHG emissions (Cohen et al., 1998). Sustainable development can therefore reduce social vulnerability to the effects of climate change. Adaptation and mitigation are two methods of reducing exposure to climate change (Ayers & Dodman, 2010).

Adaptation is the total transformation of social, economic and environmental systems in response to changing climate risks and effects (Ayers & Dodman, 2010). It is a process of adjustment in social structures to withstand better the risks, hazards and impact of climate change and be positioned to explore the opportunities it brings (Adger et al., 2003; Ayers & Dodman, 2010). The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.”(IPCC, 2018). Adaptation is a conservative process to support human well-being within a given social-ecological system (Smit & Wandel, 2006). Climate adaptation may be a short-term or long-term process to maintain the current system (Moser & Ekstrom, 2010; Nelson, 2011). Adaptation aims for capacity renewal and reorganization using learning in response to climate-induced disruption (Somorin, 2010).

Mitigation is defined as the process of reducing the production of GHG and enhancement of carbon sinks to combat further anthropogenic climate change (Ayers & Dodman, 2010; Gillard et al., 2016). It uses social and technological solutions to combat climate change (Gillard et al., 2016). This sociotechnical paradigm investigates the interconnected social and technological processes through which sustainability ideas develop and become established through low-carbon technology, lowering consumption and waste (Geels, 2004; Haxeltine et al., 2013; Seyfang & Haxeltine, 2012). Climate change mitigation often involves potential social and technical solutions which are expensive, with little or no consideration for the values, intentions and opinions of actors (Gillard et al., 2016). Climate mitigation actions focus on long-term impacts.

In Sub-Sahara Africa, climate action planning has majorly focused on adaptation until recently (Somorin, 2010). This is due to the relatively low contribution of the region to global GHG, inadequate technological resources and social development gaps (Nyiwul, 2019; Somorin, 2010). Mitigation is primarily attributed to the global north, which is believed to hold the most responsibility for climate change (Adger et al., 2003; Somorin, 2010). The increase in urbanization and population growth in developing nations is significantly increasing their contribution to GHG emissions, making climate mitigation action planning relevant (Currie, 2015). The energy industry is the leading area of climate mitigation actions in Sub-Sahara Africa. This is aided by the falling prices of renewable energy resources and abundant hydropower resources in the region (Boait et al., 2019). Climate actions were also built upon previous conservation efforts in the form of reservation, afforestation and land use policies (Nyiwul, 2019).

With the evident connection between sustainable development and climate change mitigation, Africa is a key stakeholder in global and local climate politics (Nyiwul, 2019). Ngum et al. (2018) concluded that Sub-Sahara Africa's climate action is focused on mitigation and adaptation. This reflects the criticality of synergizing climate mitigation and adaptation plans for optimal social and environmental gains in developing nations. This research, however, focuses on deep decarbonization for climate change

mitigation actions by exploring deep decarbonization efforts, strategies, governance mechanisms, and actors in cities in developing nations.

2.3 International climate change policy framework - Paris Agreement

Agreement on international climate policy has always been onerous due to the conflicting interests of different parties (Falkner, 2016). The United Nations Framework Convention on Climate Change (UNFCCC) is a global cross-functional establishment seeking to reduce GHG gases and climate interference (Ogle et al., 2014a; Olivier & Peters, 2020). The UNFCCC convenes the Conference of Parties (COP) to assess and reassess the progress of parties around climate change actions (Falkner, 2016; UNFCCC, 1997).

The Kyoto accord was created in 1997 under the UNFCC (Bodansky, 2016; Falkner, 2016). The 21st Conference of Parties (COP21) held in Paris in 2015 was another milestone in international climate politics and brought years of near-deadlock negotiations to a successful closure with the agreement of parties on the framework for combatting climate change (Falkner, 2016; ICLEI Africa, 2021). The Paris Agreement established a protocol to strengthen the global response to climate change, by holding the increase in the global average temperature to well below 2.0 C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 C (Bodansky, 2016; IPCC, 2018). This requires net-zero global energy and land-use GHG emissions by 2050–2070 for 1.5 - 2 C, and probably net-negative emissions after that (ICLEI Africa, 2021). Deep targets also apply to all the greenhouse gases; CH4 and black carbon must fall by half or more by 2050, and N2O by at least a third. The Paris Agreement also stipulated that net-zero GHG emissions must be achieved without jeopardizing poverty eradication efforts and sustainable development by considering the differences in territorial conditions (Ferreira et al., 2019; IPCC, 2018; Manolas, 2016). The Paris Agreement institutionalizes a new paradigm of global governance and diplomacy, which exudes more decisive international action to combat climate change because of the general acceptance and legality (Bodansky, 2016; Falkner, 2016). The Paris Agreement, where over 197 countries signed the protocol and committed to their determined national contributions, is ubiquitous,

encompassing, and globally accepted across all divides (Ferreira et al., 2019; ICLEI Africa, 2021; IPCC, 2018; Linton, 2020; Savaresi, 2016). A unique feature of the Paris Agreement is the mandate of all nations to play their part by acting as stipulated in the agreement to reduce global greenhouse emissions (Manolas, 2016). The Paris Agreement added a bottoms-up approach (Bodansky, 2016; Falkner, 2016) to existing national and transnational frameworks, which means that some emphasis was placed on local actions in combatting climate change - adaptation plans, climate mitigation actions that will culminate into national programs expected global efforts (Castillo Cifuentes, 2020).

2.3.1 Social sustainability for climate change mitigation

According to Gray and Stites (2013), sustainability is the improvements to the present and future quality of life to maintain the ecological composition on which life depends while satisfying the basic needs of all stakeholders. Combatting climate change requires diverse and inclusive social transformation. It is imperative to address the different facets of climate change to understand mitigation and adaptation methodologies essential for human well-being while encouraging broader and deeper transformational changes towards a low carbon economy and more social equity (Bickerstaff et al., 2013; Sovacool et al., 2019).

There is a need to drastically reconfigure the interaction between humans, their environment, society, and economy because most of the difficulties that humanity faces today are a mix of economic and ecological crises stemming from industrial capitalism and urban consumerism (Castillo Cifuentes, 2020; Hodson & Marvin, 2017). Social sustainability must be considered in any climate change mitigation plan (Castillo Cifuentes, 2020; Grandin et al., 2018) because of social and environmental interactions. The main pillars of sustainability are described by the Triple Bottom Line - People, planet, and profit (Elkington, 1998). The environmental bottom line refers to the efficient utilization of resources within ecological limits to avoid compromise for future generations (Castillo Cifuentes, 2020). The economic and social bottom line relates to social sustainability - the impact that the practices of various stakeholders make on

the social system, its governance, and how that system can prosper while supporting future generations (Castillo Cifuentes, 2020). All three are integrated and considered together through the lens of sustainable development.

The impact of climate change in sub-Sahara Africa is the decrease in the viability of farming in rural areas, which results in mass migration from rural communes to urban areas (Hope, 2009). Hope (2009) concludes that the ability of climate change to affect water supplies and damage agricultural productivity adversely might result in long-term and permanent rural-urban migration. This will, in turn, add more pressure to the resilience of infrastructurally fragile urban areas (Cobbinah, 2021; Cobbinah et al., 2015; Habitat, 2020). Integrating environmental and social sustainability has led to the development and localizing of critical international climate frameworks: The Sendai Framework for Disaster Risk Reduction and Sustainable Development Goals (SDGs) (ICLEI Africa, 2021). Launched in 2015 by the United Nations and constituent member countries, the SDGs aim to achieve sustainable development by 2030 (UNDP, 2016). The SDGs were built on the success of its predecessor, the Millennium Development Goals, and consist of 17 goals and 168 targets, such as poverty eradication and ecological and human development programs that ensure all people enjoy freedom, peace, and prosperity (UNDP, 2016). The SDGs are an inclusive agenda that works in the spirit of partnership and pragmatism to make the right choices to improve the quality of life in a sustainable way for the coming generation (ICLEI Africa, 2021).

Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) is the first significant agreement of the post-2015 development agenda, with seven targets and four priorities for action (ICLEI Africa, 2021). The Sendai Framework is a 15-year voluntary, non-binding agreement that acknowledges the government's central role in disaster risk reduction. However, that responsibility should be shared with other stakeholders, such as local governments, the corporate sector, and others. Its goal is to achieve the following: Significantly lowering catastrophe risk and losses in lives, livelihoods, and health, as well as the economic, physical, social, cultural, and environmental assets of individuals, enterprises,

communities, and nations (ICLEI Africa, 2021; UNDP, 2016). Developing multi-level governance systems where powerful networked civil society groups like ICLEI and C40 engage with municipal and city administrations gives a unique risk reduction potential in SSA (Pelling et al., 2018).

2.4 Deep Decarbonization

The achievement of the Paris Agreement - holding the increase in the global average temperature to well below 2.0 C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 C, is hinged on the drastic reduction of GHG gas emissions (Dienst et al., 2013; IPCC, 2018; Linton, 2020). The situation has prompted warnings from the scientific and global governance community that the biosphere may be reaching a point of no return and requests for decarbonization of economic activities. Deep decarbonization is a long-term strategy for reducing carbon emissions and phasing out carbon-emitting processes in favour of environmental-friendly alternatives for sustainable development (Bataille et al., 2020; Gilley, 2017). Deep decarbonization's core is reducing non-productive energy demand, energy efficiency improvements, greening of energy carriers, material efficiency, and direct GHG capture (Bataille, 2020; Linton, 2020). It is germane to explore how developing nations can increase their standard of living and development while lowering net CO2 emissions to zero by mid-century, with adequate reductions of other GHGs (Bataille et al., 2020; Pye & Bataille, 2016). Deep decarbonization pathways and strategies must be based on individual nations' development strategies (Ostrom, 2010). This means that climate policy economy-wide and sectoral levels must be structured to optimize synergies with other social inequities and priorities such as access to energy, food security, healthcare poverty alleviation, and other sustainable goals.

Deep decarbonization is a social and political reengineering program (Linton, 2020; Tozer, 2019). It requires “disrupting the interdependent, overarching, and reinforcing dynamics that lead to the continuing use of the carbon-emitting process across scales” (Bernstein & Hoffman, 2018 p.250). Deep decarbonization can be achieved only through specific policies that integrate national and local actions

and consider their opportunities and challenges (Linton, 2020; Ostrom, 2010). Bataille (2020) argued that a deep decarbonization strategy must take a polycentric approach that gives all social system elements autonomy to make decisions based on individual specifics. A polycentric approach fosters innovation, knowledge sharing, and adaptation for faster results (Bataille, 2020; Seto et al., 2021). Decarbonization is not only about the physical reduction of carbon emissions; it also denotes the long-term policy formulation processes for transitioning to a low-carbon social and economic systems (Biber et al., 2017). Deep decarbonization is more than just a quick, short-term fix to combat climate change. Deep decarbonization refers to the long-term, proactive approach of eliminating GHG emission sources to achieve net-zero GHG emissions. Deep decarbonization is a drastic, multi-dimensional approach to reducing emissions through a system-wide transformation supported by socio-technical changes.

Net-zero deep decarbonization does not imply that all countries must achieve 100% GHG neutrality (Linton, 2020). However, it does demand that each region's and sector's emissions trajectory be guided by the objective of carbon neutrality (Linton, 2020). Although certain areas and sectors may not reach zero, this would indicate that other regions and sectors with net negative GHG emissions will compensate. In terms of scenario design, this entails assessing the maximum possible action in each sector and finding significant country-driven reforms to accomplish these emission reductions or carbon sink upgrades rather than optimizing under a carbon constraint (Linton, 2020).

It is not only about how much carbon is cut in the near term when it comes to aligning national, regional, and sectoral emissions with net-zero deep decarbonization. It refers to how, by mid-century, deep reductions in all sectors are made possible via major changes in energy and material usage in buildings, transportation, and industry, as well as the use of agricultural, urban, and other areas.

The alignment of national, regional, and sectoral emissions with a net-zero deep decarbonization pathway is a long-term process. It is how deep emission reductions are made possible for all sectors by mid-century

through fundamental transformations to energy and material use in buildings, transport and industry, as well as the use of agricultural, urban, and other lands (Bataille et al., 2020). The rate of emission reductions will differ between nations due to the principle of 'common but differentiated responsibilities (CBDR) under the United Nations Framework Convention on Climate Change (UNFCCC) and based on the maturity of supporting technologies (Åhman et al., 2017). Linton (2020) ascertains that not all societies will be carbon neutral. Some communities must be net-carbon negative to compensate for the lagging areas (Linton, 2020).

Sub-Saharan African (SSA) countries are at a crossroads in their development, with fast urbanization, population expansion, and a youthful, dynamic, and rising workforce (Hogarth et al., 2015). The nations are experiencing unprecedented economic growth partly due to relative improvement in the standard of living (Hogarth et al., 2015). The ever-increasing concern about climate change undermines the gains in social sustainability as it triggers food insecurity and increases the intensity of drought, desertification, and land degradation (Antwi-Agyei et al., 2018; Conway & Schipper, 2011; ICLEI Africa, 2021; Ogbonna, 2014; Serdeczny et al., 2017; Shilomboleni, 2017; Sono et al., 2021; Vermeulen et al., 2012). All of these work against the global goal of poverty eradication and sustainable development (ICLEI Africa, 2021; UNDP, 2016). Anticipated urbanization and economic growth are expected to drive per capita GHG emissions. Despite having the lowest per capita greenhouse gas (GHG) emission levels globally, SSA will need to join global efforts to combat climate change through decarbonization and low-carbon development (Hogarth et al., 2015; ICLEI Africa, 2021; Ogbonna, 2014). Increased fossil fuel consumption, agricultural growth, and a predicted population rise are likely to boost GHG emissions in the region (Currie, 2015; Hogarth et al., 2015).

Deep decarbonization strategy, developing nations inclusive, must not be just about GHG emission reduction but embodiment and enmeshing of carbon neutrality in society and social institutions (Bernstein & Hoffmann, 2018; Tozer, 2019). Developing and industrializing countries account for the vast

bulk of present incremental growth in GHG emissions (Biber et al., 2017). Deep decarbonization planning is gaining traction as a sophisticated, data-driven, adaptive performance management approach (Carbon City Neutral Alliance, 2014). It is becoming more integrated with other social planning processes (Carbon City Neutral Alliance, 2014). Decarbonization will influence most sectors of economic activity globally, both in the short and long term, with a similar impact as the industrial revolution (Linton, 2020).

2.4.1 Incremental and Transformative Change

Deep decarbonization is a transformative social change that cuts across all aspects of society's life (ICLEI Africa, 2021; IPCC, 2018; Linton, 2020; Linton et al., 2021). This change must be drastic to avert global environmental disaster, must be incremental and cumulative of small actions starting from a local level and individual action up to regional, national and international scale (Amundsen et al., 2018). A multi-dimensional polycentric approach is required to bring this transformation (Linton, 2020; Ostrom, 2010). Incremental change is a slight adjustment to achieve a global large-scale GHG target cutting across several social systems and goals (Amundsen et al., 2018; Mapfumo et al., 2017). Incremental changes help save time and cost to access the effect of individual sustainability actions without high sunk costs in these programs (Mapfumo et al., 2017).

With the growing understanding that technological, institutional, and policy options on which social systems are anchored at various scales may be incapacitated due to climate change impacts, the concept of transformational change has become particularly relevant and topical in Africa. (Mapfumo et al., 2017). The study of farmers' vulnerability to climate change in Africa by Mapfumo et al. (2017) shows that most interventions were incremental changes to the way of life. The Sustainable Development Goals emphasized transformative plans for sustainable development and resilience (UNDP, 2016). The Green climate fund also specified transformative change for climate action as a paradigm shift toward climate-resilient development pathways (Fedele et al., 2019). Based on literature review in the field of socio-ecological studies, there exist six distinct and reoccurring characteristics: transformation is characterized

by restructuring, path-shifting, innovative, multiscale, systemwide, and persistent (Fedele et al., 2019). Transformative adaptation is 'restructuring' in that it entails major shifts in the essential features, functions and interconnection of the social, ecological, or social-ecological system (Fedele et al., 2019).

Transformative adaptation is path-shifting as it modifies the system's current pathway and pushes it towards an unconventional direction, usually more sustainable, e.g., from a landscape dominated by monocultures - to one with mixed plant and animal species (Fedele et al., 2019; Folke et al., 2011; Mbow et al., 2014; Smith et al., 2014). Transformation is innovative because it often adjusts systems to new statuses. For example, by learning about climate change's impact, farmers might convert cropland to agroforestry systems, or city planners replace infrastructure with new green spaces in flood-prone areas (Fedele et al., 2019; Folke et al., 2011; Mbow et al., 2014). Transformative adaptation is multiscale because it influences in multiple dimensions. Transformative adaptation is also 'systemwide occurring at large scale and leads to systemic changes across regions, ecosystems, landscapes, or communities (Douxchamps et al., 2016; Gillard et al., 2016; Ostberg et al., 2013). Finally, transformative adaptation is often a continuous change with long-term impacts but is usually reversible (Fedele et al., 2019; Mapfumo et al., 2017).

Transformative changes are often characterized by the inability to reverse the changes, which makes these changes permanent. Incremental changes allow for the continuity of the status quo but with needed scaling (Mapfumo et al., 2017). Transformative and incremental changes can be technological and behavioural; however, the single method of rating in climate change is their effectiveness in curbing GHG emissions (Fedele et al., 2019; Mapfumo et al., 2017).

2.4.2 Co-benefits of Decarbonization

Deep decarbonization can be cost-effective for carbon reduction, but environmental co-benefits and economic implications must be considered. Decarbonization study indicates that transitions to a low-carbon way of life can give 'win-win-win' solutions: lowering GHG emissions, avoiding lock-in to high

carbon development trajectories, and encouraging equitable economic growth (Hogarth et al., 2015). Full decarbonization of the power sector, based on a substantial resource endowment, rapid technological change leading to lower costs, and institutional solid capacities and experience, is technically and economically feasible and financially attractive for private investment (Hogarth et al., 2015). Climate policy, as a means of reducing carbon emissions, is a stimulant for economic growth and development (Evans, 2019; Musah-Surugu et al., 2019; Nyiwul, 2019). To guarantee that climate change policies are per a country's overall interests, an inclusive cost-benefit analysis should be included in project assessment, public investment, and decision-making processes (Pye & Bataille, 2016).

The co-benefit of the low-carbon economy transition is numerous across several environmental impacts. Air quality and model analysis reveal the health benefit of decarbonization as a renewable energy system replaces coal-fired power generation facilities (Thambiran & Diab, 2011). There is evidence that mitigation strategies have various sound side effects: human health, ecological functioning, macroeconomic, social, and equitable side effects which may exceed the value of climate change mitigation advantages in certain circumstances (Güneralp et al., 2017; Seto et al., 2016). Climate action strategies can directly impact lives by creating green jobs, healthier lifestyles, happier lives and cleaner environments (Day et al., 2018).

2.4.3 Deep decarbonization barriers

The capacity of decarbonization to limit global warming this century to well below two degrees Celsius relative to pre-industrial levels has been confirmed (IPCC, 2018). Despite global efforts to reduce GHG emissions, the rate of decarbonization is subpar to avert climate disasters. The unmatching result of international collaborations needed to solve the climate change issue leads to broad pessimism about the human ability to prevent climate disasters (Seto et al., 2021).

Deep decarbonization is a complex issue at the intersection of many environmental, economic, technical, social, and political systems and challenges. Each aforementioned contributory aspect presents a problem to decarbonization singularly and holistically. A significant impediment to decarbonization is long-term

financing and effective policies aimed at sustainable development (Papadis & Tsatsaronis, 2020). For example, there has been no incentive to justify decarbonization in the energy sector (Oberthür et al., 2021). The massive investment required to convert carbon-intensive technologies to more sustainable ones is very high, particularly for developing nations that are already impoverished and possess poor social infrastructure (Oberthür et al., 2021). "The decarbonization of energy-intensive industries is hampered by 1) lack of mature low-CO2 technology, 2) high Capex, long investment cycle; 3) high cost and low competitiveness with traditional technologies; 4) complex global value chains and 5) lack of policy frameworks" (Oberthür et al., 2021 p. 2). One factor for the lack of climate action to date is the high upfront costs of transitioning to zero-carbon power and transportation (Oberthür et al., 2021; Pye & Bataille, 2016). In a society defined by short-termism, decarbonization is more typically beneficial only over a longer time horizon. Poor institutional frameworks, weak implementation strategies, inadequate skilled workforce, and weak maintenance services were identified by Ouedraogo (2019) as a combination of factors affecting the success of decarbonization efforts.

Political calculation, lobbying efforts, populism and corruption often make required policies impossible or cause a regression in the decarbonization progress (Papadis & Tsatsaronis, 2020). Corruption and bribery affect the implementation of SDG projects, significantly undermining results and severely compromising development efforts in Africa (Hope, 2009; Senu, 2019). Senu (2019) concluded that to create a just and sustainable society in Sub-Sahara Africa, there is a need to root out the social vices and their root causes - active and benign corruption, dishonesty, nepotism, maladministration, and fraud. Prioritizing the fight against corruption is critical for attaining sustainable development, good governance, and creating effective and inclusive institutions for sustainable development (Hope, 2021). Due to low fossil fuel energy prices, the global population is not yet prepared to adjust energy consumption and lifestyle for profound decarbonization. This might be the most challenging step in the decarbonization process (Papadis & Tsatsaronis, 2020).

Societal beliefs also serve as a barrier to GHG emission plans and the lack of political commitments to following decarbonization pathways. Politically, national and sub-national government policies must align with global decarbonization strategies and sustainable economic development (Fay et al., 2015). The achievement of decarbonization target in developing nations is strongly dependent on the crucial eradication of inequality – social, economic, technological, and fiscal (Wijaya, 2014).

2.5 Local Climate Action Planning

Chapter nine of the 1987 Brundtland Report addressed the need for tackling transboundary issues like social and environmental sustainability - at a local level, claiming that because the majority of the world's future population will live in urban areas, local government should be crucial to the realization of sustainable development (Betsill & Bulkeley, 2006; Bruntland & WCED, 1987; Bulkeley & Betsill, 2005b, 2013; Hickmann & Stehle, 2019). The call for all local governments to establish a Local Agenda 21 (LA21) through inter and intra – communal engagement and cooperation put some onus on the framework to address environmental issues at a local level in the 1990s. (Bruntland & WCED, 1987; Bulkeley & Betsill, 2013; Clarke, 2013; Tozer, 2019). These local actions have recently evolved into sustainable community and climate action plans (MacDonald et al., 2019).

A climate action plan is a framework for achieving environmental sustainability goals in a transformational way, centered on the vested power of the entity (Accra Metropolitan Assembly; C40 Cities, 2021; Nairobi City County, 2020a). Local climate action planning represents a public social commitment and agreement by local governments to contribute to the global effort of reducing GHG emissions and achievement of the United Nations' Sustainable Development Goals (Clarke & Ordonez-Ponce, 2017; Nairobi City County, 2020a). The word "local" in the context of this research represents the lowest tier of government - municipal government, local government, county government, and customary government.

Due to rapid urbanization, mass migration, and improved living standards in developing nations, GHG emissions have significantly increased (Faiyetole, 2019; Ho et al., 2013; Liu et al., 2012). Local climate

action plans contribute immensely to strengthening local climate change mitigation. It is, therefore, crucial to understand how local action plans contribute to global social and environmental protocols and agreements (ICLEI Africa, 2021). Climate action planning in cities in developing nations is becoming a complicated performance management method dependent on other local government planning and budgeting procedures (Carbon Neutral Cities Alliance, 2015). The significant features of climate action planning in cities, according to an assessment of climate action plans in various African cities, include governance and political continuity, technical analysis and management, cooperation, stakeholder involvement, social development, Infrastructural management, and control (Accra Metropolitan Assembly; C40 Cities, 2021; Accra Metropolitan Assembly, 2019; Carbon City Neutral Alliance, 2014; Nairobi City County, 2020a).

2.5.1 Climate change and the city: Opportunities and potentials

Cities are the primary sources of GHG emissions, accounting for over 70% of CO2 emissions (Lombardi et al., 2017). Urbanization and continuous economic growth show that global climate change at the local level is not just an environmental problem but also a socioeconomic development issue. Therefore, cities must be active in deep decarbonization practices to meet global environmental sustainability (Betsill & Bulkeley, 2006; Linton et al., 2021). Many cities, mostly in developed nations, have detailed plans and roadmaps for achieving decarbonization, thereby tackling the problem of climate change (Currie, 2015; Ho et al., 2013; Linton et al., 2021, 2022). The advent of rapidly growing megacities in Africa, urban migration, and poor infrastructure makes it essential to explore decarbonization pathways for sustainable development in these African cities.

The similarity in economy and level of development allows for the transferability of learnings across cities in developed nations (Linton et al., 2022). This will not be so for developing countries due to massive disparity in key human and economic indicators, making a focused study on the global south local decarbonization strategy germane. Bataille et al. (2020) asserted that there are varied options for deep

decarbonization, which is evident in the diversity of regional strategies. Considering all the possible approaches in an urban settlement is very important in this case - developing nations. Pye and Bataille (2016) conclude that these include focusing on model linking, incorporating behaviour and policy impacts, the flexibility to handle unique energy systems, incorporating broader environmental constraints, and developing entry-level tools. The latter three are critical for application in developing countries which will be a strong focus of this research.

Lefevre et al. (2021) state that the key factors to be considered in decarbonization pathways include personal behaviours, lifestyles, social organization, infrastructures, and technological transformation. An in-depth understanding of the fundamentals of social dynamics of high carbon-intensity activities and processes is needed to identify demand-side and governance solutions (Creutzig et al., 2015; Pierer & Creutzig, 2019).

Boosting policy relevance and understanding deep decarbonization in cities in the global south necessitates a new conceptual framework that articulates measurements across several dimensions including social, economic, and energy (Corfee-Morlot et al., 2009; Linton, 2020; Linton et al., 2021, 2022). To achieve profound emissions reductions, decisive action across all pillars of decarbonization, including demand-side solutions, is required (Linton, 2020; Linton et al., 2021). The strategies must be tailored to carbon consumption purposes and local distinctiveness (Lefèvre et al., 2021). Reducing GHGs and environmental sustainability, in general, is a way to drive equity across the human race, especially the vulnerable in cities in developing nations (Ayers & Dodman, 2010; Mapfumo et al., 2017; Nyiwul, 2019).

2.5.2 Corporate and Community Plans

Two types of local government-led climate action plans exist - corporate and community (Clarke & Zhou, 2021). Corporate plans are local action plans that address GHG emissions reduction from the activities within municipal governments' confines and direct control (Clarke & Zhou, 2021; Linton, 2020; Linton et al., 2021). This can include local governments' control around land use, transportation planning, waste

management, and greening of public infrastructure and the amount of emissions for these sectors (Linton, 2020). Corporate climate action plans are produced via direct influence over territories, with the "corporation" being the local government and the corporate plan focusing on activities within their authority and control (Clarke & Ordonez-Ponce, 2017; Clarke & Zhou, 2021; Linton et al., 2021; Wong et al., 2020). Community-wide plans reflect actions on reducing GHG emissions within the community boundaries, including emissions from industrial and residential actors. Local governments can also influence emissions from energy and other economic activities (Clarke & Ordonez-Ponce, 2017). Community plans consider emissions from industry, residential heating, and fuel use in private automobiles (FCM & ICLEI, 2015). Local governments have limited authority over community-wide GHG emissions, and community plans must incorporate extensive multi-stakeholder partnerships to be successful (Clarke & Ordonez-Ponce, 2017).

Bond (2010) outlines three critical areas for acceleration in localizing climate actions: local adaptation, the linking of adaptation and mitigation mechanisms with local environmental issues, and the local engagement of stakeholders to develop grassroots community-based actions. These local outline programs that provide uniqueness and effectiveness and build community resilience (Bond, 2010).

2.5.3 The Planning Process

Cities in sub-Saharan Africa are already developing and disclosing GHG inventories using existing global standards through the Carbon Disclosure Programs (ICLEI Africa, 2021). Decarbonization is a long-term and continuous process that needs meticulous planning, for which several organizations have developed efficient techniques (Linton, 2020). Climate action planning is implemented through a framework of five milestones for GHG reduction and decarbonization: 1) inventory of current and forecasting of future emissions; 2) development of emission reduction objectives; 3) development of community climate action plan based on set targets and inventory; 4) execution of action plan and 5) monitoring and control of action plan execution to ensure that the program is on track (FCM & ICLEI, 2018). The process for

corporate and community climate action plans is similar however corporate plans are exclusively developed and adopted by the local government, while community plans are developed in collaboration with many stakeholders such as corporate organizations, NGOs, and civil organizations (Clarke & Crane, 2018; Clarke & Ordonez-Ponce, 2017).

Local governments may take advantage of mitigation co-benefits such as green branding, air quality, quality of life, inbound investment, first-mover advantage, and accelerated depreciation of ageing infrastructure more rapidly (Gilley, 2017). Given its smaller size, local government administration is more collaborative, and a relatively non-institutionalized sector like greenhouse gas reduction allows for successful service provision (Gilley, 2017). While rapid technology growth can help remove certain social and political barriers to climate action, technology will not be enough to get the world to net-zero emissions. (Gilley, 2017). The planning process, human behavioral changes, and societal commitment will fill the gap.

2.6 Pathways for Deep Decarbonization in Cities & Communities

Many cities increasingly recognize their potential contribution to climate change and have committed to achieving net zero (Lombardi et al., 2017). As of December 2020, more than 800 cities have committed to achieving net-zero carbon emissions (CDP, 2022). Pathways for deep decarbonization adopt social system-enabled net-zero electricity grids (Seto et al., 2021). They also build on the more typical efficiency and renewable actions, thus cities have pursued low-carbon development in transformative ways to achieve reduction goals (Creutzig et al., 2015; Seto et al., 2016). Low-emission development strategies are essential for problem-solving, long-term energy planning, and international collaboration (Sachs et al., 2016).

Decarbonization pathways define a systematic approach for creating visions of these interconnected sectoral shifts to drive implementation (Linton, 2020; Linton et al., 2022). In developing nations, in the face of infrastructural deficits, poverty and gaps in social expansion, poor people in developing countries

have established various types of resilience against natural and artificial stresses (Folke et al., 2010). This resilience may be insufficient due to its erosion by development activities. The sustainment of economic resilience requires the development of climate mitigation plans, a major output of deep decarbonization (Martin et al., 2021; Vijayavenkataraman et al., 2012). Harnessing the collective strength of diverse stakeholders through partnership is critical to addressing existing strategies, regulatory and resource gaps to help hasten decision-making (Kehbila et al., 2014).

2.6.1 Scope of Emissions

Cities have been a significant player in accelerating transformative actions for climate change mitigation and are often at the forefront of implementing adaptation and mitigation actions. Assessing organizational and societal GHG emissions at the municipal level is a vital carbon management strategy (Downie & Stubbs, 2012; Marlowe & Clarke, 2022). There exist three scopes of emissions. Scope 1 is the GHG emission from direct fuel combustion or methane release within the municipal boundary (Hoornweg et al., 2011; Wiedmann et al., 2021). The exploitation of grid-supplied electricity, if generated outside the municipal boundary, for heating and cooling within the municipal boundary is considered scope 2 (Downie & Stubbs, 2012; Hoornweg et al., 2011; Wiedmann et al., 2021). The productivity of cities leads to the production of significant emissions outside its boundary – Scope 3 (Downie & Stubbs, 2012; Hoornweg et al., 2011; Wiedmann et al., 2021). However, there is a research gap in quantifying comprehensive Scope 3 emissions in practice (Downie & Stubbs, 2012; Wiedmann et al., 2021). This research will consider the scope 1 and 2 GHG emissions to ensure this work's accuracy and compliance with current reporting practices.

2.6.2 Sustainability trajectory and gaps

Global GHG inventories are used in African climate change modelling (Liousse et al., 2014). These publications utilized available regional emission data for various parts of the world but not Africa because of the unavailability of detailed anthropogenic inventories at the continental and regional scales (Liousse

et al., 2014). Local knowledge of environmental stresses and social inequality is essential to deep decarbonization and sustainable development planning. Disaggregation of emission data is critical to quantifying sub-national states and boundaries, identifying urgent intervention areas and improving policy implementation scales (Cole et al., 2017). It would also help in climate monitoring and control which requires data disaggregation to expose inequalities, encourage local actions and avoid unreasonable incentives (Cole et al., 2017).

In Sub-Sahara Africa, there exists significant heterogeneity in the environmental status at the local level (Cole et al., 2017). This results from the variation in climate conditions, economic development, population density and urbanization rate, which all affect the environment (Cole et al., 2017). On average, African organic carbon emissions will represent a significant portion of the increase in global anthropogenic GHG emissions by 2030 (Liousse et al., 2014).

In the race against climate change and environmental sustainability, social equity is the major challenge caused by multiple socioeconomic factors (Monyei et al., 2019). The lack of substantive collaboration between sociology, environmental studies, governance, and technology continues to pose a significant threat to solving social development gaps, climate change, and making it hard to shift to pathways that guarantee sustainable trajectories (Folke, 2006; Folke et al., 2011; Westley et al., 2011).

2.6.3 Sectorial prioritization for decarbonization

Critical sectors of the socioeconomic system at the local level need to be prioritized to achieve deep decarbonization. The review of the literature identified the areas of priority for decarbonization at the local level in developing nations as electricity, cooling (and heating), building, transportation, waste, industry, manufacturing and agriculture, forestry, and other land use (AFOLU) (AfDB, 2020; Barrett et al., 2016; Biber et al., 2017; Bond, 2010; CDP, 2022; Cobbinah, 2021; Currie, 2015; Gilley, 2017; Habitat, 2020; Henderson et al., 2017; Linton, 2020; Mapfumo et al., 2017; Patterson et al., 2018; Pye & Bataille, 2016;

Urrutia-Azcona et al., 2020). The details of these areas are discussed below. The categories are not mutually exclusive. For example, energy overlaps with electricity, buildings and transportation.

2.6.3.1 Energy

Energy use accounts for 76% of anthropogenic greenhouse gas (GHG) emissions, making the energy sector a prime priority, with the potential for effective decarbonization. The energy sector, which includes the combustion of fossil fuel in transportation, fossil fuel electricity generation, heating and cooling, buildings, manufacturing and construction, fugitive emissions etc., produced 37.2 GtCO2e globally (Ge et al., 2020). Significant progress can be made in decarbonization efforts and the reduction of GHG emissions through the transformation of the energy system (Altieri et al., 2015; Atkinson, 2007; Faiyetole, 2019). These can be achieved through social reengineering, a drastic shift to low-carbon energy systems, and reducing fossil fuel energy use to ensure environmental sustainability (Liousse et al., 2014). Decarbonization efforts and reducing GHG emissions encompass energy use changes, low-carbon systems development, and broader socioeconomic systems (Blackburn et al., 2017). At the local level, deep decarbonization combines three main ideas: 1) reducing energy and material demand, 2) switching energy supply to net-zero carbon sources, and 3) enhancing carbon sequestration (Basso, 2019; Seto et al., 2021). The greatest challenge to decarbonization is the necessary changes in energy use and lifestyle (Papadis & Tsatsaronis, 2020). This change is more achievable locally due to small scale, direct communication, and impact (Papadis & Tsatsaronis, 2020). In cities in sub-Saharan Africa, access to renewable energy varies based on geospatial conditions and national environmental politics (Carbon City Neutral Alliance, 2014). When it comes to energy, many communities rely on the choices of higher levels of government and utility corporations (Accra Metropolitan Assembly; C40 Cities, 2021; Linton, 2020). In most large African cities today, the balance between striving for better energy efficiency and lowering the carbon content of the energy supply is also typical (Carbon City Neutral Alliance, 2014). The predominant energy source for most sub-Saharan Africa is biomass – burning of charcoal, fuelwood, and animal dung primarily for cooking,

cooling, and heating, which emits a significant amount of CO2, causes serious health concerns and leads to poor indoor air quality (Liousse et al., 2014; Ouedraogo, 2019).

2.6.3.2 Electricity, heating, and cooling

The electricity value chain, heating, and cooling are responsible for the most GHG emissions - 15.6 GtCO2e in 2018, or 31.9% of total greenhouse gas emissions due to reliance on most fossil fuels for generation (Ge et al., 2020). To meet the ambitious targets required to avert the impending climate crisis, the greening of electricity must be drastic and cut across generation, transmission and distribution, and energy use (Linton, 2020). Generation is electricity production at power generating stations. Transmission and distribution are the network of electric grids through which electricity is transmitted from generation facilities to end-users. The use of electricity refers to the demand and energy consumption rate (Carbon City Neutral Alliance, 2014; Linton, 2020).

To this end, there has been a significant change to low-carbon energy sources to progress decarbonization. This change has been driven by improved technology and falling prices of renewable energy systems, particularly wind power, solar photovoltaics and battery storage systems (Collett et al., 2021; Falkner, 2016; Linton et al., 2021). Most countries have gradually increased their renewable energy generation since 2005 (Falkner, 2016; IEA, 2019). However, to meet the 1.5°C pathway, governments must improve on transitional actions (Linton, 2020). The energy transition is a diverse and discrete set of processes, practices, and policies that come together and are interpreted, translated, experienced, and grounded at particular moments in specific places (Rutherford & Coutard, 2014; Stripple & Bulkeley, 2019).

In developing nations, the increase in electricity demand is driven by increased cooling due to climate change, rapid urbanization, rural-urban migration, population growth, and general social development (Karimu & Mensah, 2015; Patrizio et al., 2019). The electrification rate in sub-Sahara Africa is meager, with over 600 Million of its inhabitants lacking access to electricity (Hafner et al., 2018) which represents a little

less than 60% of the continent's total population (Chirambo, 2018; Dioha & Kumar, 2020). Electricity access problems are rampant, but choice amongst local households in SSA is constrained by material, economic, and social factors (Broto, 2017).

2.6.3.3 Buildings

Building energy use accounts for 17.5% of total GHG emissions (Ge et al., 2020), making it a good and efficient target for global decarbonization efforts (Linton et al., 2021). Decarbonization at the local level has focused on reducing greenhouse gas emissions from urban systems (Tozer, 2019). GHG emissions from building consist of industrial, residential, corporate, and public buildings (Linton, 2020). GHG emission in residential buildings is related to electricity or fuel consumption for domestic use, such as lighting, appliances, cooking, heating, and cooling at home. On the corporate front, GHG emissions are attributed to energy consumption in commercial and corporate buildings (Olubunmi et al., 2016). The carbon emissions associated with a building's energy use are called operational carbon emissions because they are caused by the building's operation (Becqué et al., 2019). The effort to reduce the extent of carbon emissions from construction activities and building operations has been advocacy and conceptualization of green building as a paradigm for developing a sustainable building sector (Olubunmi et al., 2016). Green building is a comprehensive strategy for developing structures by applying principles of sustainability through the use of low-carbon resources and resources-efficient methodologies throughout the building's life-cycle from initiating, conceptualization, construction, operation, and maintenance (Balaban, 2012; Dahiru et al., 2012; Olubunmi et al., 2016; Onyenokporo & Ochedi, 2019).

With an increasing population density in urban areas, cities largely determine and play an essential role in national and global decarbonization strategy (Currie, 2015; Habitat, 2020; Jakutyte-Walangitang & Page, 2012). The growth in energy intensity will be driven by regions and cities with growing demand for energy services for improved quality of life—for example, hot areas with an increased need for and access to space cooling (Lebling et al., 2020). The energy needed for building cooling and heating presents an

environmental and economic burden (Currie, 2015; Seto et al., 2016). However, limited studies have explored ways to improve building energy performance across Sub-Sahara Africa (Koranteng & Mahdavi, 2011). Efficiency improvement in all energy-intensive building activities and progress in building envelopes will be required. The energy use per square meter must be significantly and drastically reduced to meet the climate goal (IPCC, 2018; Lebling et al., 2020). Fossil fuel sources represent 81% of global primary energy use, and their supply has failed to meet demand in Sub-Sahara Africa due to poor energy infrastructure (Koranteng & Mahdavi, 2011; Piccardo et al., 2020). In most cases, there exist insufficient analysis and evaluation of thermodynamic features of buildings in Sub-Sahara Africa, where it exists, critical local climate conditions are not considered because design decision-making is not sufficiently informed by pertinent expertise in the area of building energy management and design method and technologies (Koranteng & Mahdavi, 2011).

Decarbonizing buildings is beyond operational energy resources and the material stocks used in the construction process. Many developing countries are experiencing rapid urbanization, and the embodied carbon emissions associated with materials such as steel and cement are substantial (Currie, 2015; Habitat, 2020). In the building sector, decarbonization involves auditing the building systems throughout their life cycle, users' energy habits, and efficiency (Currie, 2015; Mercader-Moyano & Esquivias, 2020). The energy consumed for building materials is 5-10% of total energy resources, making this carbon-intensive process a key decarbonization target (Mercader-Moyano & Esquivias, 2020).

The environmental sustainability of buildings can be improved through energy conservation and retrofits, thereby benefiting from improved well-being and comfort (Mercader-Moyano & Esquivias, 2020). Retrofitting includes upgrades to building envelopes and shifts to zero-carbon heating and cooling technologies (Mercader-Moyano & Esquivias, 2020). The efficiency of equipment for building operations has continued to increase in most parts of the world for the past quarter-century (Güneralp et al., 2017; Ürge-Vorsatz et al., 2011). Choosing the most efficient equipment (boilers, motors, fans, chillers, air-

conditioners, appliances, and office equipment) reduces energy and cooling loads. Urge-Vortsatz et al. (2011) highlighted improved lights, various types of improved cookstoves, and efficient appliances to provide cheap mitigation options for GHG emissions reduction.

Cities' governments will have to lead in fostering, governance, and accelerating ambition on the sustainability of buildings to counter the dark side of building construction and operations (Dahiru et al., 2012; Kioko, 2014). Building codes and laws exist in most developing nations, but these laws are primarily archaic and obsolete (Dahiru et al., 2012). They were developed with inadequate consideration for local externalities, making them sometimes impractical (Dahiru et al., 2012; Kioko, 2014). In Kenya, the national building code, which came to law in 1968 during the post-colonial era, is enforced by local authorities (Bucha et al., 2020; Erastus & Wuchuan, 2014; Kioko, 2014). Sustainable construction should be mainstreamed and complied with in developing nations (Babalan 2012). Guidelines on green buildings, certification systems, and incentive mechanisms can be an opportunity for cities in developing nations to promote sustainable construction practices and encourage private developers to construct green buildings (Kioko, 2014). However, to take the lead, public sector agencies and regulatory bodies must comply with the provision of these systems for most of their built investments (Bucha et al., 2020; Dahiru et al., 2012; Erastus & Wuchuan, 2014; Kioko, 2014).

The co-benefits associated with implementing GHG emission reduction measures in buildings are substantial, which help justify sustainability actions. However, a single intervention cannot make a tangible impact therefore, a portfolio of targeted and customized governance frameworks is required to reduce emissions in the building sector effectively (Becqué et al., 2019).

2.6.3.4 Waste

The growing amount of global waste is one of the world's major environmental issues (Song et al., 2015). Municipal waste generation is estimated to be 1.3 billion tons annually and will increase by 70% by 2025 and 1000% by 2050 (Kaza et al., 2018). This increased municipal solid waste generation caused by growing

urbanization is a significant problem for the global south (Wilson et al., 2016). Sub-Sahara Africa has the lowest average waste generation per capita globally but has the highest growth rate in solid waste (Haregu et al., 2016; Kaza et al., 2018).

Solid waste is considered a heterogenous non-liquid waste generated at the product's end-of-life (Njoku et al., 2018; Regassa et al., 2011). In Sub-Saharan Africa, these wastes are mainly organic, attributed to low-income levels (Haregu et al., 2016; Kaza et al., 2018). Organic waste decomposition is a significant source of methane, a potent GHG.

Landfill remains a common and one of the cheapest methods for managing municipal solid waste in most parts of the world (Wahab, 2012). The waste collection rate in developing nations is meagre at 44% (25 Million tonnes/year), with most of this organic waste ending up in landfills (Olukanni et al., 2016; Regassa et al., 2011). The management and operation of most landfills and dumpsites across developing nations are poor, leading to resultant environmental issues like uncontrolled emissions of landfill gases (LFG) such as methane (CH4) and CO2, which play a significant role in climate change (Couth & Trois, 2010; Idowu et al., 2019; Njoku et al., 2018). This has made municipal waste through landfills a leading emitter of methane (Linton, 2020; Njoku et al., 2018). Capturing and burning landfill gas, with energy recovery when possible, is the most common method for lowering carbon emissions from waste management (Couth & Trois, 2010). Africa is the most vulnerable region due to the climate effect of unregulated and uncontrolled LFG emissions (Njoku et al., 2018). In 2012, Africa produced 0.49 million tonnes of potential methane (Njoku et al., 2018). As a result, effective management of the LFG created is critical to the decarbonization strategy in developing nations.

Municipal waste management challenges in cities globally are well documented, but insufficient progress has been made in alleviating this socio-environmental issue (Wahab, 2012). Waste management involves using land and energy to construct and manage waste management infrastructure (Linton, 2020). There

is a significant infrastructural deficit in developing nations and emerging economies to manage waste. Typically, municipal governments are responsible for ensuring cleanliness and waste management; however, due to lack of funding, governance structure, and general neglect, waste management in most parts of a developing nation is abysmal, unattended to, and left for the informal sector (Stotko, 2006; Wahab, 2012). For example, in Nigeria, the municipalities are not as functional as they should be in terms of effective and efficient planning for municipal solid waste management due to several constraints: socioeconomic, political, financial, technical, and institutional constraints (Wahab, 2012). Nearly half of the municipal solid waste generated in the Nairobi municipal area of Kenya is not collected (Haregu et al., 2016). The Waste Management Authority responsible for managing solid waste in Nairobi cannot provide such services to residents of the city for numerous reasons (Haregu et al., 2016). The agency's capacity is impeded by personnel, technological, and monetary resources needed to plan efficiently for municipal solid waste management in the city (Birke, 1999; Teshome, 2021; Wahab, 2012). This obstacle makes most of the populace resort to haphazard waste dumping in the waterways, roadsides, and unapproved dumpsites (Achankeng, 2003; Haregu et al., 2016; Regassa et al., 2011).

The increasing threat of human activities on the environment has made it imperative to convert a significant portion of materials destined for municipal waste into reusable and environmentally friendly materials (Wahab, 2012). Waste reduction, recovery, and recycling are the critical strategies for managing municipal waste with abundant recyclables like plastic bottles, paper, cardboard, and cans for domestic purposes (Achankeng, 2003). In the study of Yaoundé, Cameroun, Achankeng (2003) claim that the lack of a local recyclable market hampers the waste recovery process. However, the need for recycling and composting materials before landfills are established in developing countries. The waste hierarchy prioritizes materials recycling and composting. Because landfill gas is prevented from being created, rather than roughly 50% of the gas being recovered and combusted, waste recycling and composting should result in more significant emission reductions than the collection and burning of landfill gas with

energy usage (e.g., power generation) (Couth & Trois, 2010; Wahab, 2012). Product reuse and material recycling reduce significant emissions compared to creating new materials from fresh sources (Couth & Trois, 2010). Recycling waste reduces waste going to landfills, reduces GHG emissions, and saves the municipality costs in waste management services (Couth & Trois, 2010; Wahab, 2012). In developing nations, unrestrained dumps make waste disposal cheaper and more popular than recycling (Stotko & Trois, 2006). For recycling to improve, income generated from recycling must cover scavenging and transporting the waste materials (Couth & Trois, 2010). To reduce carbon emissions from waste in developing nations, cities could ensure the segregation and sorting of waste at the collection point (Idowu et al., 2019). A social reorientation, campaign, and human behavioral change would need to occur for this to happen (Birke, 1999; Haregu et al., 2016; Njoku et al., 2018).

Cities in Sub-Saharan Africa are exploring waste-to-gas projects for power generation (Khan et al., 2022). Lagos metropolitan (Nigeria) is developing a 12 MW waste-to-gas program in its Olusosun Landfill facility which processes 2.1 million Tons of municipal waste annually (OANDO, 2021). The city of Harare (Zimbabwe) has partnered with a technology company to develop and generate 16MW from Pomona dumpsite in a waste-to-energy plant project (Africa Energy Portal, 2022). Kakamega and Dandora are similar waste–to–energy projects being developed in Kenya (Agency, 2022).

2.6.3.5 Transportation

Transportation is defined as conveying goods, materials, people, and services from one location to another (Grazia Speranza, 2018). Transportation – air, road, sea, and rail accounts for 23% of energy-related carbon emission, with road transport accounting for 80% of sectorial emissions (Agarana et al., 2017; Ge et al., 2020). The transport sector has been identified as the fastest-growing source of GHG and the hardest to decarbonize (Gross, 2020a). Drastic actions are required from all stakeholders to develop carefully conceptualized, inclusive programs coupled with grounded governance at local, national, and global levels to reduce emissions from this industry which is critical to human development (Agarana et

al., 2017; Bickerstaff & Walker, 2001; Currie, 2015; Linton et al., 2021; Thambiran & Diab, 2011). Carbon emission from the transportation sector includes a small amount of electricity (indirect emissions) and all direct emissions from the combustion of fossil fuels for mobility. However, it does not include emissions from the manufacturing of transportation equipment. GHG emissions from transportation in cities occur within its territory and therefore are classified as scope 1 emissions (Bhatia et al., 2004). Scope 3 emissions from the transportation sector include inter-cities and air travel (Bhatia et al., 2004). Transportation emissions are calculated by quantifying fossil fuel consumption by transport technology, fuel quality, and transportation infrastructure (Soylu, 2007; Thambiran & Diab, 2011).

Petrol-powered passenger vehicles dominate the Sub-Sahara African landscape, with diesel-powered transport systems accounting for only ~5% (Thambiran & Diab, 2011). This disparity between fuel types is vital to GHG emission and air quality from passenger motor fleets because of the diversity of fuel combustion characteristics and technology (Thambiran & Diab, 2011). The incomplete combustion of petroleum in internal combustion engines releases toxic emissions, and the quantitative quota in SSA adversely affects decarbonization efforts (Thambiran & Diab, 2011). Using catalytic converters on gasoline engines has efficiently reduced air pollution and GHG emissions (Thambiran & Diab, 2011). A significant source of transport vehicles in Sub-Sahara Africa is the importation of used vehicles from the global north. Due to the age and technology of these aged motor vehicles in cities, most petrol-driven vehicles are not fitted with the latest emission control technologies, making them high GHG emission sources (Thambiran & Diab, 2011). One method for reducing air pollution is to replace older passenger vehicles with newer ones that use sophisticated vehicle technology (Thambiran & Diab, 2011). Policies should also address the importation of second-hand cars, such as emissions limits or efficiency requirements.

Countries of Sub-Sahara Africa characteristically lack good transportation infrastructure – poor road conditions, inadequate road networks lead to unceasing traffic jams, aging transport equipment, and poor maintenance, contributing to increased emissions (Thambiran & Diab, 2011). Despite their importance to

the supply chain, trucking vehicles have significant burdens, such as carbon footprints and pollution emissions resulting from the internal combustion of petroleum products (Orji et al., 2019). Governance of sustainability of the transport sector is challenging because of the interdependency of several pathways (Linton et al., 2021). Interest groups often challenge decarbonization strategies that promote fossil-fuel-based automotive mobility for political and economic gains (Linton et al., 2021).

Agarana et al. (2017) and Thambiran and Diab (2011) both articulate the pathway to minimize road transport emissions in Sub-Sahara Africa as 1) development of mass transit systems, 2) proper maintenance of road transports, 3) encouragement of the use of non-fossil fuel power road transportations; 4) improving the quality of fuel; 5) use of hybrid and electric vehicles; 6) reducing the need to travel, road traffic and congestion and 7) promotion of non-motorized forms of transportation. It is equally important to mention that a significant portion of transport management is within the local government's circle of authority, which is critical to the scope of this research work (Accra Metropolitan Assembly; C40 Cities, 2021; ICLEI Africa, 2021; Nairobi City County, 2020a).

In Nigeria, local authorities undertake several measures to limit the environmental externalities of freight transport through licensing and regulation, forcing transport operators to operate sustainably through initiatives like information systems, cleaner energy sources, and routing optimization (Orji et al., 2019). Orji et al. (2019) conclude that the most critical factor for sustainable transportation in Sub-Sahara Africa is management and organizational leadership, which aligns with the conclusion of other research works (Bickerstaff & Walker, 2001). The limitation of poor electricity supply has significantly constrained the penetration of electric vehicles and other electric mobility services, which can help reduce the carbon footprint of transportation in sub-Saharan Africa (Collett et al., 2021). To have the needed impact, renewable electricity sources are required to power electric vehicles (Collett et al., 2021). Decarbonizing transportation systems requires collaboration between countries, corporate organizations, and cities to develop transport and low-carbon energy infrastructure with low-carbon vehicles (Gross, 2020b). The

socioeconomic capacity of the populace needs to be considered to ensure the affordability and ubiquitous adoption of low-carbon transportation modes.

Cities in Sub-Sahara Africa will also need to promote non-motorized forms of transportation as part of a decarbonization strategy by developing a dense cycle network, reduced traffic levels, and better streets for cycling and walking (Barrett et al., 2016; Goulding & Butler, 2018). At the local level, targeted initiatives such as efficiency improvements, operational improvements, behavioral change programs, and speed control might be investigated as a decarbonization approach (Goulding & Butler, 2018; Habitat, 2020; Kennedy et al., 2019; Somda et al., 2017; Stern, 2020). As improved logistics and efficient vehicle loading are suggested to be the most viable solutions to tackle emissions from this sector due to their efficacy and ease of deployment, the use of freight internet-based systems to match light vehicle capacity and freight demands, as well as to limit the frequency of empty running expenses by locating return loads, should be a priority. (Gross, 2020b; Thambiran & Diab, 2011).

2.6.3.6 Industry

The deep decarbonization of industries, especially energy-intensive industries (EII), significantly limits global warming (Oberthür et al., 2021). The energy-intensive industries – manufacturing and construction-contribute over 20% of GHG emissions without considering the indirect emission from purchased heat and electricity (Åhman et al., 2017). EII comprises several industries with high energy consumption, including iron and steel, basic chemicals, cement, aluminum, glass, ceramics and pulp and paper (Åhman et al., 2017; Oberthür et al., 2021; Wesseling et al., 2018). Focusing on a specific set of industries and processes can generate tremendous results because 90% of GHG emissions from industrial processes are from the top 10 industries, and approximately 55 percent of industrial GHG emissions are from chemical, steel, plastic and cement industries (Rissman et al., 2020). To meet the Paris Agreement's goals, energy-intensive industries (EIIs) must decarbonize significantly during the next few decades. (Åhman et al., 2017).

Decarbonizing the power sector, ensuring policies have sector-wide coverage and full participation, and providing new fuels (such as hydrogen) or carbon capture and sequestration for hard-to-decarbonize businesses are all critical to deep decarbonization success (Rissman et al., 2020). In developing nations, international collaboration on R&D will be necessary, and great potential for systemic cost-reduction improvements is important (Åhman et al., 2017; Löfgren & Rootzén, 2021).

Significant changes to current industrial processes, the development and use of breakthrough technologies, the introduction of low-carbon substitutes for materials and fuels, more innovative end-product design to reduce basic materials' intensity, efficient consumption, and a circular resource model with increased reuse and recycling are all required to achieve deep decarbonization (Åhman et al., 2017; Löfgren & Rootzén, 2021; Oberthür et al., 2021; Patrizio et al., 2019; Wesseling et al., 2018). Most local climate plans do not account for industrial emissions as these are better addressed by higher government and the private sector (Bulkeley & Betsill, 2005a; Clarke & Zhou, 2021).

2.6.3.7 Agriculture, Forestry and other Land use (AFOLU)

The agriculture, forestry, and other land use (AFOLU) sectors are responsible for approximately 60% of anthropogenic GHG emissions in sub-Sahara Africa (AfDB, 2020). As a result, the sector's mitigation actions are critical to attaining emission reduction objectives. Because of complex patterns and carbon storage below ground and on the forest floor, natural forests store more carbon than planted forests. (Smith et al., 2014). These characteristics take centuries to develop. Mature natural forests give considerable extra advantages and should be preserved, while secondary natural forest regeneration should be encouraged (AfDB, 2020; Lebling et al., 2020). Land use and natural ecosystem carbon fluxes are primary sources of GHG emissions (Kim et al., 2016; McNicol et al., 2018). Kim et al. (2016) and Borges et al. (2015) reported that CO2 eq. emissions from 12 river channels in SSA and wetlands of the Congo River represent 25 % of the global terrestrial and ocean carbon sink. A carbon sink, according to UNFCCC,

is any mechanism that removes atmospheric CO2, and this atmospheric CO2 can be stored as carbon in continental vegetation, soil and water bodies (Pradhan et al., 2019).

Agriculture, Forestry, and Other Land Use (AFOLU) are most important for global food security and social development (Mbow et al., 2014; Smith et al., 2014). Plants take nitrogen and carbon dioxide (CO2) from the soil and atmosphere for growth which they re-distribute below and above ground, leaving behind biomass, dead residues and soil organic matter. Plants emit greenhouse gases in the form of CO2, methane and nitrous oxide during decomposition and combustion. Within AFOLU, the principal mitigating methods include a mix of the following strategies: reducing CO2 emissions by substituting biological products for fossil fuels or energy-intensive products; sequestration - increasing carbon intake in terrestrial reservoirs and thus removing CO2 from the atmosphere; and reducing CO2 emissions by substituting biological products for fossil fuels or energy-intensive products (Smith et al., 2014; Wollenberg et al., 2016).

The continual surge in GHG emissions related to AFOLU is anticipated in developing nations because of the forecasted increase in food production and land development attributed to the growing population and rapid urbanization (Grau & Aide, 2019; Pradhan et al., 2019). The loss of biodiversity and other ecosystem services are severe implications of transforming natural ecosystems into agricultural lands (Grau & Aide, 2019).

The adaptation and mitigation of the AFOLU sector are critical to the impacts of climate change and the ecosystem (Fobissie et al., 2019). The industry is also a pillar of sustainable development as a critical source of goods and services that are important for improving the adaptive capacity of vulnerable peoples and food security in the African continent (Fobissie et al., 2019; Mbow et al., 2014; Ogle et al., 2014a; Wollenberg et al., 2016). The environmental impact of intensified agricultural practices, food production and deforestation cause adverse effects on soil and biodiversity, thereby giving rise to climate

externalities, food insecurity and general socioeconomic development among rural farmers – significant demography in developing nations (Mbow et al., 2014; Smith et al., 2014). The paradoxical and conflicting need to boost forestation and reduce tropical deforestation conflicts with the intensification of agriculture to feed the growing populace is a tricky issue that needs to be carefully analyzed for sustainable implementation (Pradhan et al., 2019). There has been a significant focus on reforestation and forest management as a climate change mitigation pathway (Mbow et al., 2014). Agroforestry, integrating forestry with agriculture (Mbow et al., 2014), could be a win-win solution to deal with the deforestation and food production paradox and meet sustainable development goals.

The changes to land use and the growing resource need for biodiversity conversation and carbon sequestration are prevalent drivers of global climate change and cause increased competition for land (Smith et al., 2014). Infrastructural changes in cities, governance and demand, can significantly influence sustainable land use transition (Seto et al., 2016; Smith et al., 2014). Climate change mitigation in the agricultural sector is through sequestration and GHG emission reduction of farm processes on the supply and demand side. The opportunity for GHG emission reduction on the supply side in agriculture includes (1) land management; (2) pastoral improvement; (3) management of organic soils; (4) restoration of degraded lands; (5) livestock management; (6) manure management; and (7) bioenergy use (Herrero et al., 2016; Ogle et al., 2014a; Smith et al., 2008, 2014). Using sustainable cooking stoves and an off-grid energy supply will reduce the pressure on biofuel such as firewood and charcoal (Dioha & Kumar, 2020; Muza & Debnath, 2021). These are critical for SSA.

There exist several options for reducing emissions from the forest sector, including 1) forest conservation through afforestation and reforestation; 2) sustainment of the stand-level carbon density; 3) maintaining or increasing the landscape-level carbon density using forest conservation, longer forest rotations, fire management and protection against insects; and 4) increasing off-site carbon stocks in wood products, enhancing product and fuel substitution using forest-derived biomass to substitute products with high

fossil fuel requirements and increasing the use of biomass-derived energy to substitute fossil fuels (Harvey et al., 2014; Herrero et al., 2016; Nabuurs et al., 2007; Ogle et al., 2014a; Smith et al., 2008; Smith, 2014; Smith et al., 2014).

Investment viability in SSA is hampered by many obstacles unique to the region. There are few with insufficient infrastructure, a small and dispersed rural population, low skill and education levels, high poverty and hunger levels, and poor governance (Fobissie et al., 2019). Demand-side options in the form of behavioral changes (e.g., lifestyle changes, changes in wood consumption) may play a role despite being a challenging endeavour (Smith et al., 2014).

2.6.4 Synergies Between Sectors

Decarbonization and reduction of GHG emissions are synergetic with sustainable development because of their interrelationship and interdependency of development goals (Agyeman, 2008; Falkner, 2016; Linton, 2020; UNDP, 2016). These interdependencies must be considered in decarbonization decision-making, allowing each sector to complement the other, therefore co-benefiting individual sectors (Linton, 2020; Vorster et al., 2011). The decarbonization of road transport in cities in developing nations has successfully proved the multiple social and environmental sustainability benefits of emission reduction and air quality improvement (Thambiran & Diab, 2011).

Local governments can unleash the political co-benefits of mitigation more rapidly, including green branding, air quality, quality of life, inbound investment, first-mover advantage, and expedited depreciation of ageing infrastructure ("building back better") (Antwi-Agyei et al., 2018; Karlsson et al., 2020; Sovacool et al., 2019). Today's public better understands co-benefits in economic opportunity, health, business, and quality of life (Echeverri, 2018). Chirambo (2018) opine that the synergetic approach might be the lifeline for meeting Sustainable Development Goals. Studies of sectorial synergy revealed that emphasizing rural electrification and linking agriculture and irrigation development could successfully diversify African countries (Chirambo, 2018). Integrating climate change policies' co-benefits, such as

improved environmental integrity, sustainable development, and food and energy security, can make it more appealing to policymakers and other stakeholders (Gilley, 2017; Lempert & Trujillo, 2018; Pradhan et al., 2019; Ürge-Vorsatz et al., 2011).

2.6.5 Carbon Offsetting and Carbon Sinks in Cities

Because of their low degree of industrialization, most tropical nations, such as Ghana, have long regarded themselves to be net carbon sinks or, at worst, carbon neutral (Moussa et al., 2019). However, considering the considerable land-use change in many tropical nations, such as deforestation and land degradation due to poor management and recurrent bushfires, their GHG emissions may rise (Musah-Surugu et al., 2019). Few studies in Sub-Saharan Africa estimate GHG emissions, particularly in the agricultural sector, and comparison research across major land-use types is also rare (Kim et al., 2016). As a result, most climate change approaches and promoted techniques are primarily based on information acquired in other regions. The mitigation and adaptation to climate change at the city level will require transforming urban infrastructure, particularly implementing green infrastructure as a carbon sink (Linton, 2020; Linton et al., 2021). Due to the ability of vegetation to capture and store carbon, urban green infrastructure in the form of parks, greenways, gardens, green roofs, woodlands, waterways, and forests can be an efficient approach even at the microscale (AfDB, 2020; Habitat, 2020; Linton et al., 2022; Mbow et al., 2014; Smith et al., 2014). Moussa et al. (2019) reveal that cities in Sahel contain a considerable amount of aboveground vegetation and significant carbon sinks. This position was held for sudano-Sahelian woodlands in Burkina-Faso, miombo forests in southern Africa and the urban forests of Ghana (Moussa et al., 2019; Musah-Surugu et al., 2019; Pelletier et al., 2018). Planting and nurturing trees in the urban area is beneficial to decarbonization for carbon bio-storage (Chen, 2015; Habitat, 2020; Mbow et al., 2014). Sinks are captured under AFOLU in this thesis. Table 2.1 shows the key variables for technical pathways to decarbonization, their contribution to GHG emissions and applicable references.

Table 2.1: Key variables for technical pathway to decarbonization

Sectorial Pathways	Contribution to GHG	Findings	References
Agriculture, Forestry and other land use (AFOLU)	61%	AFOLU is the central area of focus for deep decarbonization in developing nations. Implementing sustainable agricultural practices like farm management and agroforestry will help reduce GHG emissions from agriculture. Reducing overdependence on forests for energy sources, land restoration, and Spatial planning is also crucial for climate mitigation. There has been a significant focus on reforestation and forest management as a climate change mitigation pathway.	(Kim et al., 2016; Mbow et al., 2014; McNicol et al., 2018; Ogle et al., 2014b; Smith, 2014)
Energy - Electricity	17.5%	Energy accessibility for over 500 Million Africans with energy poverty through renewable sources like hydro, wind and solar and energy efficiency will support the decarbonization of the electricity sector. Decarbonizing electricity involves reducing energy consumption (efficiency) and switching the energy supply to net-zero carbon sources. Socioeconomic factors constrain the penetration of low-carbon electricity sources.	(Broto, 2017; Karimu & Mensah, 2015)
Building	8.8%	The sustainable building sector involves the reduction of emissions related to residential and corporate building construction, operation and maintenance. Using sustainable materials in the building sector will also aid decarbonization. The sustainability of buildings can be improved through energy conservation and retrofits.	(Dahiru et al., 2012; Mercader-Moyano & Esquivias, 2020; Olubunmi et al., 2016; Onyenokporo & Ochedi, 2019)
Industry	6.6%	Collaboration on research and development will aid decarbonization efforts. Transitioning to a low-energy source for industrial processes is crucial for reducing GHG emissions. Most local climate plans do not account for industrial emissions.	(Bulkeley & Betsill, 2005b; Clarke & Zhou, 2021; Rissman et al., 2020)
Transportation	6.1%	High GHG is recorded from the use of imported secondhand cars. Poor road infrastructure and networks in cities contribute significantly to GHG emissions.	(Goulding & Butler, 2018; Gross, 2020b;

		Electricity access and socioeconomic limitations are affecting the use of electric vehicles. The development of a non-motorized mode of transportation is critical to decarbonization.	Thambiran & Diab, 2011)
Waste	3.5%	Major challenges are the collection, sorting and segregation of waste. Social reorientation is needed for sustainable waste management—poor construction of landfills. There is a lack of market for recyclables due to low manufacturing and economy. Cities in sub-Sahara Africa are exploring waste-to-gas projects for power generation.	(Achankeng, 2003; Idowu et al., 2019; Khan et al., 2022; Njoku et al., 2018; Wahab, 2012)

2.7 Institutionalization Strategies and Tools

Decarbonization is a transformational process that thrives on social reengineering, technology, behavioral changes, and effective governance (Fazey et al., 2018; Linton, 2020; Seto et al., 2016). As a result, knowing how alternative policies or legal instruments that society enacts now could either assist or delay future attempts to decarbonize our energy systems is critical to solving climate change (Linton et al., 2021). Researches encourage not just questioning what kinds of policy instruments are best or practicable right now but also what kinds of tools society can use now to help progress, enhance decarbonization politically, and allow future efforts to be stronger and more extensive than what we can do now (Bulkeley & Betsill, 2005b; ICLEI Africa, 2021; Smit, 2018).

2.7.1 Engagement

Evidence from the literature review shows that inclusiveness through the engagement of non-traditional stakeholders and community is an effective tool for long-term social transformation (Bond, 2010; Ho et al., 2013; Linton, 2020). Engagement is not limited to inclusion in the policy development process and actions but motivation, knowledge and taking action on decarbonization efforts through communication,

educational campaigns, community events, transparency and celebration of achievements (Bond, 2010; Carbon City Neutral Alliance, 2014; Linton et al., 2021). Engagement at the local level helps resolve the complexities of deep decarbonization efforts, increase public knowledge and facilitate action on climate change (Clarke & Ordonez-Ponce, 2017; Granberg & Elander, 2007; Seyfang & Haxeltine, 2012; Whelan & Lyons, 2005). The primary function of community engagement is to coordinate efforts and design deep decarbonization strategies focusing on behavioral changes, policy development and pressurize additional social actors for change, including measuring and reporting (Bond, 2010; Clarke & Macdonald, 2019; Gillespie et al., 2016). Inclusive stakeholder engagement can lead to innovative ideas, ownership and capacity development (Linton, 2020). Social engagement in developing nations must consider the heterogeneous nature of varying societal cultures and norms (ICLEI Africa, 2021; Kennedy et al., 2019).

The use of advocacy tools for social engagement at the local level is equally essential (Clarke & Zhou, 2021). This advocacy involves working with stakeholders to encourage them to use their regulatory and investment levers to promote deep decarbonization technical pathways (MacDonald et al., 2019; Ordonez-Ponce, 2018). Participation in sub-national, national and transnational networks of cities is a keyway to helping local decarbonization efforts through awareness, sharing of best practices, technical support and learning (CDP, 2022; ICLEI Africa, 2021; Linton et al., 2021). These international networks make learning, peer-to-peer sharing, and access to tools and resources easier, allowing for more ambitious goals. Membership in the network also provides a sense of community, inspires more ambitious action, and recognizes local accomplishments. (UN Habitat, 2015).

The growing population of youth aged between 15 – 35 necessitates engaging them in local climate action like every other social program (Cobbinah et al., 2015; Zimba et al., 2021). The engagement method in municipal climate action planning ought to incorporate youth inclusiveness; as such, the engagement capacities of the youth need improvements (Akinboye et al., 2007; Zimba et al., 2021). Youth engagement can be through technical skills, co-designing of targeted activities, youth-focused spaces and tools

development (Akinboye et al., 2007; MacDonald et al., 2019; Zimba et al., 2021). Communication is a crucial aspect of engagement, as it fuses the most relevant data and information currently produced by global and local stakeholders regarding assessment indicators for development projects and creates a framework of sustainability indicators that can be used by a wide range of people in the field to assess the sustainability of existing and potential projects (MacDonald et al., 2019; Servaes et al., 2012).

2.7.2 Technical Capacity

Cities in developing nations must build technical capacity - a significant barrier to environmental sustainability, as a deep decarbonization mechanism (Wang et al., 2012). Capacity building is the ability and empowerment of individuals, organizations, or society to mold its destiny (Corfee-Morlot et al., 2009; MacDonald et al., 2019). Capacity building entails developing technical know-how and increasing the leadership required for designing, planning and executing climate actions (Bernstein & Hoffmann, 2018; Chaudhury, 2020; Schuetz et al., 2017; Wang et al., 2012). The long term sustainability is linked to leadership capacity, which includes setting sustainability goals, integrating these goals into operations, and creating a supportive framework (Carbon City Neutral Alliance, 2014; Linton, 2020; Wang et al., 2012). The capacity for long-term sustainability initiatives is increased by involving all stakeholders (Clarke & Ordonez-Ponce, 2017). Local governments that lack the means to enhance their internal capacity might benefit from enlisting the services of external experts and forming collaborations with appropriate organizations (Carbon City Neutral Alliance, 2014; Linton et al., 2021).

Capacity development may include building on the experiences and lessons of previous capacity enhancement programs in other regions (Olawuyi, 2017). Technical capacity can also be aided by offering practical and valuable advice for practitioners and decision-makers in cities in developing countries and the international civil community (Clarke & Zhou, 2021; Linton, 2020; Linton et al., 2022). Capacity to establish goals, formulate strategies, draw action plans, design and implement appropriate policies, develop regulatory and legal frameworks, build and maintain partnerships, foster a supportive framework

for civil society, mobilize and manage resources, implement action plans, and evaluate performance are the core capacities required for decarbonization at the local level (Mizrahi, 2004).

Despite many decades of knowledge transfer to Africa under the United Nations Framework Convention on Climate Change's numerous processes and initiatives (UNFCCC), Africa has the lowest degree of technology necessary to respond to climate change (UNFCCC, 1997). Many developing countries, particularly in Africa, continue calling for more climate technology exchange to close the gaps. These calls are made by developing countries without considering how they can improve domestic capacity to manage transferred capacity to boost and enhance climate action (Olawuyi, 2017). A comprehensive approach aimed at developing local capabilities to ensure imported technology, adapt or repair them as needed, and, in the long term, develop its domestic resources to manufacture required technologies are required to sustain deep decarbonization (Altieri et al., 2015; Creutzig et al., 2015; Crick et al., 2018; Olawuyi, 2017). The government may empower a new generation of climate technology entrepreneurs by developing policies and the ability to encourage clean technology entrepreneurship and startup innovation initiatives that can both sustain the maintenance of imported technologies and unearth endogenous climate solutions (Olawuyi, 2017).

2.7.3 Economic enhancement and capacity

For environmental and social sustainability to thrive, economic and social infrastructural support systems must exist for sustainment (Herslund et al., 2016). Furthermore, with over 500 million Africans still without energy access and 36 percent of the continent’s population living in extreme poverty, low levels of resilience and adaptation in many countries are likely to exacerbate the socioeconomic impacts of climate change (Dioha & Kumar, 2020; ICLEI Africa, 2021; Kates & Dasgupta, 2007). These issues and challenges make accomplishing the continent's urgent development goals more complex (Elias & Omojola, 2015; Hafner et al., 2018; Orji et al., 2019). The region remains where mass hunger and poverty prevail

due to many underlying issues like poor governance and infrastructural negligence (Hogarth et al., 2015; Iati, 2008; Senu, 2019). These underlying issues make sustainability efforts more difficult, costly and fail.

There exist tradeoffs and causality between decarbonization and poverty eradication. Most economies of developing nations are resource-based, and oil and gas exploration is the main contributor to the national Gross Domestic Product (GDP) (Nyiwul, 2019). The declining market and fossil fuel demand may jeopardize these nations' sustainable development. Shifting global demand patterns may affect the continent's oil and gas producers. Under a 1.5°C scenario, global oil consumption might fall by nearly 50% by 2040 (Petroleum, 2021). Without effective remedies, heavily oil- and gas-dependent nations could face significant budgetary stress as global demand for fossil fuels continues to plummet (Bouchene et al., 2021). Cities in developing nations will require the development of human and institutional capacity to create a viable, science-based economy (Ejeta, 2010). This transformation requires a motivated citizenry driven by an unequivocal, supportive and committed governance structure (Ejeta, 2010).

2.7.4 Financial pathways for local climate action

The local government is essential in funding socio-environmental programs for climate action plans (Amundsen et al., 2018; Gilley, 2017; Leal Filho et al., 2018; Olukanni et al., 2016; Salon et al., 2014). For these plans to be effective and successful, cities must better understand the costs and payback of implementing climate action strategies. Municipalities must also have funding plans that acknowledge and even take advantage of the often-complex ways climate action projects are paid for (USDN, 2019). Local governments can use established means of funding public programs to support climate action plans and design new funding strategies to raise the resources necessary to carry out the plans (Carbon City Neutral Alliance, 2014; Linton, 2020).

Three primary financial pathways are available for climate action: funding, financing, and revenue generation (Corfee-Morlot et al., 2009; USDN, 2019). For this research work, funding refers to repayment-free capital that is available from third parties. Financing refers to borrowed capital, including loans,

bonds, and other cost-sharing mechanisms that ultimately require the borrower to pay back the money in full (typically with interest) and revenue generation from new charges, fees, or taxes, to citizens, beneficiaries, or customers, which can be placed on specific project users or applied to every resident or business in a given area (USDN, 2019). Tax revenue/local government budgets and partner and sponsor funding are all traditional financing options. Carbon taxation and trade systems, green bonds, insurance, and finance pricing are all examples of innovative sources of funding (Linton, 2020).

The colossal development deficits and poverty create a weighty burden on cities in developing nations. They cannot meet the additional costs and conditions for financing, making climate action efforts challenging without appropriate financial support (Leal Filho et al., 2018). Insufficient knowledge about alternative investment opportunities on the part of potential investors and financiers, lack of certainty in the political climate, including weak institutional frameworks in local governments, and the low attractiveness of green investment opportunities as a result of the low political priority currently given to the decarbonization agenda are all significant barriers to the funding of decarbonization initiatives (Bouchene et al., 2021). The money and effort necessary to develop bankable projects are extensively substantial (Bhattacharya et al., 2015; Bouchene et al., 2021; Habitat, 2020). Finally, the low maturity of local financial sectors hinders their capacity to raise funds for climate-friendly initiatives (Bouchene et al., 2021; Ejeta, 2010; Leal Filho et al., 2018).

2.7.5 Green Economy

A green economy is characterized as a low-carbon, resource-efficient, and socially inclusive economic model (Lindfield & Steinberg, 2013; Linton, 2020). The green economy in cities is geared towards environmental risk reduction, curbing social vulnerability, boosting resilience and curtailing environmental scarcities while fostering sustainable development (Ali et al., 2021; Hezri & Ghazali, 2011). For an economy to be green, it must also be efficient and fair.

A green economy values the natural capital of an ecosystem as an economic function (Sathaye et al., 2007). Burkart (2011) defines a green economy where consumption and production, demand and supply are within an environmental balance. Between the global north and south, there is a divide in the concepts of a green economy (Buseth, 2017). In affluent nations, the term "green economy" generally relates to technological innovations, while in underdeveloped countries, the term "green economy" refers to environmental protection, management of natural resources, and control (Buseth, 2017). Many stakeholders see agriculture as a possible pathway to alleviate poverty and improve economic growth while ensuring environmental sustainability in emerging nations (Buseth, 2017). Green economy policies, building code compliance, and waste management have all been implemented in cities in developing countries (Buseth, 2017; Dahiru et al., 2012; Kioko, 2014). In the building sector, implementing green building technologies has been identified by Ping et al. (2018) as a city decarbonization strategy. According to Darko & Chan, 2018 and Ping et al., 2018, the major impediment to these green developments is the lack of government support and social awareness.

Green economy at the city level involves six types of investments that are required for achieving green cities and thus ensuring the long-term survival of the urban environment: 1) green transportation system; 2) low-carbon industrial and agricultural sector; 3) energy-efficient buildings; 4) greening of the city itself; 5) sustainable infrastructure; and 6) intelligent systems (Lindfield & Steinberg, 2013). The key focus area for green economy is spatial development, urban area metabolism, urban city energy systems, and waste management (CDP, 2022; Cole et al., 2017; Currie, 2015; Dahiru et al., 2012; Kennedy et al., 2019; Kioko, 2014; Linton, 2020; Sharma et al., 2013).

2.7.6 Long Term Plans

Climate change action planning is a process that takes time to complete. As a result, it needs ongoing dedication and a political outlook. There is no standard or established path for planning for decarbonization at the local level. Major transnational networks like ICLEI and C40 play significant roles in

the information used. Stakeholders, in turn, localize this information by customizing local action processes to local conditions, and they are learning by doing (Accra Metropolitan Assembly; C40 Cities, 2021; ICLEI Africa, 2021; Nairobi City County, 2020a). The role of policy professionals and networks is vital in climate action planning. The public task forces or working groups formed are crucial to public approval of the proposed planning actions (Bassett & Shandas, 2010). The establishment of the African sector of ICLEI – Local Government for Sustainability - ICLEI Africa has influenced the implementation of many Climate Action Plans in Sub-Saharan Africa (Bassett & Shandas, 2010; ICLEI Africa, 2021). The role of ICLEI Africa is to lead knowledge development, advocate for impactful policies for local climate efforts and act as an innovation hub for climate actions at the city level (ICLEI Africa, 2021).

Environmental uncertainty is pushing social systems to a more flexible and openness for innovation and adaptation to social and environmental imbalances (Herrfahrdt-Pähle & Pahl-Wostl, 2012). However, a certain degree of consistency and persistence at higher levels is essential to prevent the institutional structure from losing meaningful control and purpose throughout the transition (Folke et al., 2010). Long-term planning for climate change and deep decarbonization requires political stability and continuity. Continuity can be within an institutional system (building codes, which enable and sustain an efficient building governance system) or inter-institutional (Herrfahrdt-Pähle & Pahl-Wostl, 2012). Systems that allow too much change will encounter memory loss, while systems characterized by a high degree of continuity will almost certainly experience surprise and crisis (Berkes et al., 2008).

2.7.7 Behavioural intervention tools

Decarbonization and climate action require changing the social fabrics, which requires reengineering human behaviours and processes that are typically hard to change because of human inclinations (O'Brien, 2018). It is imperative to consider the behavioural changes among community stakeholders when planning decarbonization actions because of the uncertainty of the supportive behaviour of the community towards anticipated environmental results (Stern, 2020). Behavioural interventions are

defined as influences that are neither based on regulatory compliance nor financial inducement (Stern, 2020). Behavioral interventions are most successful when paired with financial and other interventions to influence activities that affect GHG emissions (Stern, 2020). The youth are unaware of how their daily actions, like commuting and feeding, contribute to climate change and its impact on social issues (Akrofi et al., 2019). Somda et al. (2017) identified from studying farmers in five African countries that climate activities can induce behavioral changes but must be maintained for sustainability and scaling. Local governments can also affect behaviour by investing directly in carbon-reducing technology and infrastructure, such as bike lanes and better public transportation (Carbon City Neutral Alliance, 2014; Clarke & Zhou, 2021; Linton, 2020).

2.7.8 Regulatory and Policy Tools

Policy and regulatory tools are significant ways for local governments to implement climate change strategies (Clarke & Zhou, 2021). This command-and-control system, which directly impacts GHG emissions by curbing, penalizing, and criminalizing certain social acts that lead to carbonization, is implemented through local and municipal legislations: Statute laws, bylaws and codes (Clarke & Zhou, 2021; Henstra, 2016; Linton, 2020). Local governments have the authority to undertake essential societal changes in backing decarbonization initiatives due mainly to policy and regulatory instruments (Clarke & Zhou, 2021). The authority of government is anchored on its legitimate power to permit, prohibit, or command action by target populations through these legislations (Henstra, 2016). The amendment or introduction of new policies to implement transition plans is needed to meet emission targets (Urrutia-Azcona et al., 2020). These policies, which may vary depending on local socioeconomic conditions and other critical considerations, must be accepted by the stakeholders who implement the transition (Bataille et al., 2020). Deep decarbonization at the local level relies on the authority of this tier of government using one or a combination of the tools like legislation, mandates and regulations to form zoning and standards (Henstra, 2016)

Climate policy as a decarbonization tool is complicated because it is interwoven and embedded with other areas of social life (Henstra, 2016). They can impose limitations on emissions or emission intensities, send out price signals to account for externality costs, and sway purchase choices (Linton, 2020). The policy requires developing, improving, and adopting efficient and low-carbon technologies. It can also provide incentives for investment in them or their consumer adoption (Deep Decarbonization Pathways Project, 2015). Statute law can play significant roles in climate mitigation strategies, such as delegating responsibilities among stakeholders, giving statutory rights for decision-making, and clarifying risks and consequences (Dovers & Hezri, 2010).

Municipalities need to consider the feasibility of their action when planning and implementing decarbonization actions, given the current state of existing policy and jurisdiction and enforcement mechanisms (Clarke & Zhou, 2021). The risk determines the most effective decarbonization techniques, the location in question, geographical and institutional settings, organizational priorities, institutional path interdependencies, tool efficiency, and the degree of vulnerability of society (Hayward et al., 2018; Pelling et al., 2018). In Sub-Saharan Africa, law enforcement loopholes and corruption are considered significant hindrances to implementing local policies, adversely affecting decarbonization efforts (Iati, 2008; Lacey-Barnacle et al., 2020; Senu, 2019). The key variables for tools and strategies for decarbonization found in this literature review are summarized in table 2.2.

Table 2.2: Key variables for tools and strategies for decarbonization

Institutional strategies and tool	Findings	References
Engagement	Social transformation requires the inclusive engagement of stakeholders. Engagement helps increase awareness, transparency and innovation. The heterogeneous nature of developing nations must be considered in social engagement. Youth engagement at the local level is essential to	(Akinboye et al., 2007; Bond, 2010; Granberg & Elander, 2007; Samuel & Clarke, 2022)

	implementing a climate action plan in developing nations.	
Technical capacity	Technical capacity building involves the development of technical expertise to support deep decarbonization efforts. For Africa, capacity building can also birth a new generation of climate mitigations and solutions. Capacity building entails developing technical knowhow and increasing leadership required for designing, planning and executing climate actions.	(Bernstein & Hoffmann, 2018; Chaudhury, 2020; Mizrahi, 2004; Olawuyi, 2017; Schuetz et al., 2017)
Economic enhancement and capacity	Economic sustainability is required for environmental sustainability to thrive. Combatting poverty and unemployment will help drive decarbonization efforts in developing nations' cities. Cities in developing need external capacity assistance for strategic decarbonization efforts.	)(Dahiru et al., 2012; Mercader-Moyano & Esquivias, 2020; Olubunmi et al., 2016; Onyenokporo & Ochedi, 2019)
Financial pathways	Implementation of local climate actions requires financial resources which can be sourced through various channels. Three primary financial pathways are available for climate action: funding, financing, and revenue generation. Local governments can use traditional funding mechanisms for climate action plans, as well as design new funding strategies to raise the resources	(Bouchene et al., 2021; Carbon City Neutral Alliance, 2014; Corfee-Morlot et al., 2009; Linton, 2020; Linton et al., 2021; USDN, 2019)
Green economy	A green economy at the city level involves 1) a green transportation system, 2) a low-carbon industrial and agricultural sector, 3) energy-efficient buildings; 4) greening of the city itself, 5) sustainable infrastructure, and 6) intelligent systems. The key focus area for green economy is spatial development, urban area metabolism, urban city energy systems, and waste management.	(Cole et al., 2017; Currie, 2015; Lindfield & Steinberg, 2013; Sharma et al., 2013)
Behavioural intervention tool	Deep decarbonization required social reengineering. For deep decarbonization in developing nations, the optimal way to utilize behavioural intervention tools for deep decarbonization is in combination with financial and social welfare programs. There is a need for social orientation on how human activities contribute to GHG emissions.	(Akrofi et al., 2019; Somda et al., 2017; Stern, 2020; Zhou et al., 2020, 2022)

Regulatory and policy tools	Policy and regulatory tools give local governments legislative power to implement needed social changes favouring decarbonization efforts. Law enforcement and order are critical for the efficacy of regulatory compliance. The jurisdiction, enforcement and contradiction of existing policies must be considered when planning and implementing climate actions.	(Clarke & Zhou, 2021)
Long term plan	Climate change action planning is a long-term project which demands continuous commitment and political vision. Political instability in developing nations can alter deep decarbonization plans.	(Herrfahrdt-Pähle & Pahl-Wostl, 2012; ICLEI Africa, 2021)

2.8 Governance

Governance is a set of systems for managing multiple state and non-state actions (Castán Broto, 2017; Rosenau, 2000). Governance represents the organization of the various actors whose role is to drive the community towards decarbonization, resilience or sustainability goals (Okereke et al., 2009). Governance is a complex interaction between institutions, systems, and cross-sectoral and multi-level relationships of policy stakeholders in the management of public products and services (Clarke & Fuller, 2010; Sun, Clarke, & Macdonald, 2020; Wong et al., 2020). Stoker (1998) and Guy (2019), in their work on the theory of governance, characterized governance as 1) a diverse range of institutions and stakeholders that are drawn from but not limited to government; 2) the thinning boundaries and responsibilities for solving socioeconomic challenges; 3) identification of the authoritarian dependence involved in the relationships between establishment involved in collective action; 4) the autonomous networks of self-governing stakeholders; and 5) the ability to get things do not depend on the government's ability to order or utilize its authority (Peters, 2019).

A political theory of climate change in which different kinds of governance play a vital role has been encouraged by a combination of voluntary approaches to climate change strategy and a strong interest in local action (Newell, Pattberg, & Schroeder, 2012). Under a 1.5°C scenario, urbanization will continue to

expand, putting further strain on the city government (Creutzig, 2019; Falkner, 2016; Vincent, 2004). This challenge has been more prominent in SSA, where research on urban disaster risk and climate change has indicated massive gaps in capacities in climate governance, knowledge communities, data and monitoring (Conway & Schipper, 2011; Tiepolo & Braccio, 2020). According to the transitions theory, change is linked to innovation in the relationship between governance stakeholders (Meleis et al., 2010; Wesseling et al., 2018). Weak governance institutions impede transitioning towards inclusive and evidence-based planning and the appropriate use of available technology (Conway & Schipper, 2011; Herslund et al., 2016; Ngum et al., 2019; Olawuyi, 2017; Zhao et al., 2020).

This research project focuses on community-wide governance - tackling decarbonization within the geographical boundary. Community-wide governance is a process through which societies or organizations make critical choices to define whom they include in the process and how they account for their actions (Vervoort & Gupta, 2018). Successful decarbonization actions will involve significant community investment and collective actions. Therefore the community-wide structure is also critical for decarbonization planning and implementation (Clarke & Zhou, 2021).

2.8.1 Decision Making for Local Climate Change Governance

Local climate change governance as a significant way to produce actions across all sectors has been highlighted by failures of national government climate action plans (Linton, 2020). The benefits and demerits of top-down and bottom-up climate governance approaches are well documented. As a result, multi-level governance for climate action and sustainable development will be more explicit (Heinen et al., 2022). The proponents of local governance and measures highlight the benefits of self-regulation, experimentation, leadership, and mutual adjustment as the determinants of the efficacy of climate action (Betsill & Bulkeley, 2006; Bulkeley & Betsill, 2005b). Its opponents otherwise believe that the policy of sub-national and national governments helps shape local climate action through regulatory oversight and financial support (Heinen et al., 2022). These arguments are germane because global issues like climate

change cannot be solved through a single governance unit but through multi-level government interventions (Bataille et al., 2020).

2.8.2 Multi-level Governance

Multi-level governance (MLG) has been defined as a conceptual framework, systems and processes that transverse administrative territories, aimed at coping with the complex interdependencies in social development and political decision-making among public, private and civil organizations (Betsill & Bulkeley, 2006; Corfee-Morlot et al., 2009; Newig & Fritsch, 2009). The framework is a starting point to define the interrelationship between national governments and other public and private stakeholders in the conceptualization, design, and implementation of climate policy across all levels of climate actions (Corfee-Morlot et al., 2009). Irrespective of the system of government, multi-level governance aims to bridge the gaps among various government divisions through vertical and horizontal collaboration and partnership (Betsill & Bulkeley, 2006; Bulkeley & Betsill, 2013; Corfee-Morlot et al., 2009). Multi-level governance also provides a model to understand the relationships and interdependencies between national and sub-national governments across deep decarbonization policy issues (Corfee-Morlot et al., 2009). The multi-level governance framework of environmental sustainability consists of the vertical dimension across scales or levels of governance and the horizontal dimension of governance (Betsill & Bulkeley, 2006; Corfee-Morlot et al., 2009; Okereke et al., 2009). The vertical dimension of multi-level governance recognizes that national governments must partner with sub-national governments to implement climate action strategies effectively.

On the other hand, to take action, cities cannot be influential and do not operate in isolation from different parts of government. Decentralization is crucial as it defines how cities can independently develop, fund and execute climate change policies (Hickmann & Stehle, 2019; Stehle et al., 2020). Local governmental authority to implement climate policies is often embroiled with higher government's complex legal and institutional frameworks (Corfee-Morlot et al., 2009; Dietz et al., 2003). For example, while sub-national

policies determine the specific details of land use and urban development planning, implementation is directly controlled by national policies in the form of budgets, standards and development pathways (Sathaye et al., 2007). This highlights a two-way relationship between local and national governments on climate change governance.

On the horizontal axis, local and transnational governance stakeholders partner and collaborate across organizational and geographical boundaries to influence outcomes of climate change and social developmental programs (Corfee-Morlot et al., 2009; Wong et al., 2020). Co-learning, knowledge sharing, capacity development and cooperation also occur horizontally in a multi-level governance structure with cities, regions, and national governments progressively forming connections. (Bulkeley & Moser, 2007). At the city level, these horizontal relationships have been forged through formal transnational networks acting both nationally and internationally, like ICLEI and the C-40 (Accra Metropolitan Assembly; C40 Cities, 2021; Clarke & Zhou, 2021; ICLEI Africa, 2021; Linton et al., 2021; Nairobi City County, 2020a). These organizations have provided an institutional structure for a coordinated effort and collaboration on climate change at the city level (Corfee-Morlot et al., 2009). There also exist multiple local cross-sector partnership horizontally at the city level (Ordonez-Ponce et al., 2021).

Both internal and external factor influences successful decarbonization strategies at the local level. External influences range from international systems to national agendas and sub-national programs in a collaborative framework for deep decarbonization (Kern & Alber, 2009). The scholarship of decarbonization strategies at the local level identifies spatial mismatch as a critical problem in coordinating decarbonization measures due to blurred territorial boundaries, hence necessitating horizontal collaboration amongst local governments. The successful implementation of low-carbon programs and policies often transcends beyond the city limits because of shared infrastructure (electricity grid, transportation system), shared natural resources (river, forest) and proximity (air quality). This

interdependency makes horizontal collaboration between all stakeholders relevant to local decarbonization efforts (Corfee-Morlot et al., 2009).

2.8.3 Structures and decision making within the Local Governments

There is a need to avoid viewing cities as a distinct and discrete scale of political power to understand sustainable development processes and governance (Bulkeley & Betsill, 2005b). Instead, a multi-level governance approach may look at how urban sustainability is structured and disputed at many scales of governance and across diverse political spheres. Rather than seeing the two emerging accounts of multi-level governance, towards state government and transnational network, the interaction of both with local government is required to militate against the complexity of deep decarbonization (Bulkeley & Betsill, 2005b; ICLEI Africa, 2021).

Effective climate change policy necessitates establishing a proper type of organization (Kern & Alber, 2009). A climate policy committee, a climate action office with skills for promoting climate change policy, and issue-specific task teams can all be part of this (Kern & Alber, 2009). This framework offers a blueprint for integrating sectoral policies, coordinating climate mitigation initiatives, and improving overall climate policies and concerns related to sustainable development (Kern & Alber, 2009). A suitable type of institutionalized policy management helps avoid conflicts and compromises between climate change policy and other local policies (Kern & Alber, 2009). A climate staff individual or team usually coordinates plan design and execution (Clarke & Zhou, 2021). Climate change personnel at the corporate level Chief administrator's office are prominent in smaller municipalities (Clarke & Zhou, 2021). The benefit of this organization is that climate staff activities will directly impact the entire organization (Clarke & Zhou, 2021). Because climate staff are close to the municipality's top management and council officials, the overall municipal agenda will likely be linked with the climate action plan (Clarke & Zhou, 2021).

Larger cities often have their climate team inside several departments. Decarbonization activities are distributed throughout all departments, each accepting responsibility for implementing the functional

department's climate action plan (Clarke & Zhou, 2021). This structure facilitates knowledge exchange and collaboration between policy and service divisions (Clarke & Zhou, 2021). Furthermore, the CAO team is valuable in driving and controlling the entire decarbonization process in this framework (Clarke & Zhou, 2021).

2.8.4 Communication, Monitoring and Reporting

Local government must establish a formal monitoring and reporting system to track corporate and community-wide progress versus goals. The local governments must also ensure accountability and enable adjustments in actions to ensure significant progress toward their climate goals (Linton et al., 2022). Monitoring decarbonization programs confirm that the parameter for setting the goals is still intact (Clarke & Zhou, 2021; CoM, 2014). It is dedicated to any changes to the overall strategy and identification of barriers to implementing actions. Reporting is often a public-facing system, showing progress at defined intervals. Reporting focuses on GHG inventories and decarbonization programs' progress toward short-term and long-term climate and sustainability goals (Clarke & Zhou, 2021; Sun, Clarke, & MacDonald, 2020).

In large municipalities where multiple departments are involved in decarbonization projects, monitoring should occur across the individual departments and be reported to the steering committee for consolidation. Internal decarbonization projects within municipal governments and partner organizations should also be separated and tracked. (Clarke & Zhou, 2021). Municipal performance monitoring and reporting cannot be conducted in a vacuum without consideration of other stakeholders' interests. At the heart of oversight, monitoring and reporting are planning, preparedness, costs, financial reporting, outcomes consideration, and benchmarking with best practices are the key ingredients for success and can enhance good governance (Matsiliza, 2018).

2.8.5 Collaboration and partnership

Collaborative governance establishes laws and orders for public good using set processes by collective interaction and working of public, civil society and private actors (Ansell & Gash, 2008; Clarke, 2013; ICLEI Africa, 2021). In their definition of collaborative governance, Ansell and Gash (2008) stressed the six critical criteria of this type of governance at the local level as 1) public agencies or institutions initiate the forum; 2) participants include non-state actors; 3) direct engagement in decision making; 4) the forum is formally organized and meets collectively; 5) strive for decision making consensus in practice; and 6) the focus of the collaboration is on public policy or management. Collaborative governance can also be a term used to define the relationship between public agencies and non-state actors (Ansell & Gash, 2008). Collaborative governance involves two-way communication, a shared level of influence, decision-making capacity involving the public sector, representation of interest groups, and concerned citizens coming together to solve societal issues (Connick & Innes, 2003; Reilly, 1998; S. L. Smith 1998). The capacity of collaborative governance to solve environmental problems, which is the focus of this project, has been disputed because of the lack of consensus on its performance (Gerlak et al., 2013; Lange et al., 2013; Newig et al., 2018).

Participatory governance emphasizes the involvement of actors who are generally not tasked with the decision-making process for integrating local knowledge and the perspectives of many actors and promoting acceptance and implementation of decisions (Bulkeley & Mol, 2003; Edelenbos et al., 2011). Established evidence exists that participatory governance is crucial for solving complex problems of managing ecological sustainability and economic development (Morton, 2017). Participation is believed to lead to a higher sense of ownership and sustainable and innovative results (Heinelt, 2002). This participatory mode may include public hearings or other forms of consultation (Newig et al., 2018).

The success of collaborative and participatory governance will be determined by their capacity to resolve complex socio-environmental issues like climate change (Newig et al., 2018). Since the decision-making

process can be more or less participatory and collaborative because the choice to make the decision-making activity participatory or collaboratory rests on the core partners, this choice makes collaboration and participation a choice rather than a necessity (Newig et al., 2018). This thesis takes an open-minded approach in reviewing and analyzing the governance framework for climate policy at the city level in the nations of Sub-Sahara Africa. This approach may provide a unique insight into the climate governance in this region as most studies focus on the global north.

2.8.6 Modes of Urban Climate Governance

There are four modes of local climate governance with unique features regarding their administrative capacities and range from a direct form of governance to traditional forms of state intervention (Bulkeley & Kern, 2006; Kern & Alber, 2009). First, a self-governing mode of governance refers to the capacity of local government to govern and manage its activities, for example, by improving energy efficiency in government offices and other municipality-owned assets (Kern & Alber, 2009). Self-governing relies on reorganizational management, continuous improvement, and innovation (Bulkeley & Kern, 2006). Second, the function of local government in organizing and supporting partnerships with commercial businesses and fostering community involvement is referred to as governing by enabling (Ordonez-Ponce et al., 2021). Persuasion, involvement, and (positive) incentives are critical tools in this method of governance (Kern & Alber, 2009). Third, governing by provision refers to behavioral influence by providing specific infrastructure, resources, and services (Kern & Alber, 2009). This governing style is accomplished through infrastructure and financial policy. Under this mode of governance, change can easily be made towards decarbonization as the provision of services, e.g. district heat or water, under the local government's auspice. Governing by provision affects the development and transformation of urban infrastructure, which, in turn, is decisive for consumption patterns and affects local climate change policy. Fourth, regulation is the traditional mode of governance where regulation and direction are used for

enforcement. The different modes of governance typically intersect, and governance decisions are made considering a combination of multiple modes (Kern & Alber, 2009).

2.8.7 Local climate governance uniqueness in SSA

The division of responsibilities across various strata of government shapes the possibility of planning and implementing decarbonization strategies at the local level. In the territories where power is concentrated in the center (national government), the ability of municipal government to coordinate and implement climate actions is heavily constrained. This is because the local government lacks the monetary resources and autonomy to make decisions (Harker et al., 2017; Simon & Leck, 2015). There is sparse knowledge of the role of African cities in developing their decarbonization pathways (Diep et al., 2016). It is critical to understand whether cities have the financial resource, legal rights, autonomy, and vision to implement customized climate action plans.

The decentralization of power defines the degree of autonomy of local African governments. Decentralization is the equitable sharing of political powers, administrative activities and financial resources (Paulais, 2012), which varies substantially across Africa. The barriers to the decentralization of government in Africa are attributed to national politics, which tends to consolidate power and not jeopardize national interests (Diep et al., 2016; Tait & Euston-Brown, 2017). Widespread capacity constraints in the form of corruption, mismanagement, insecurity, and governmental instability have contributed to local government dysfunction in Africa (Tait & Euston-Brown, 2017). The fiscal autonomy of local governments in developing nations remains very weak in decentralization compared to other world regions (Paulais, 2012). Allocation of responsibilities without matching financial resources to implement them worsens capacity decarbonization effort (Dauda, 2006; Ladner et al., 2016; Olowu, 2003; Ouedraogo, 2003).

The centralization of government in Uganda and Ghana significantly affects the municipal capacity to affect climate action plans in those countries (Tait & Euston-Brown, 2017). This trend is rampant among

African states where local governments effectively act as implementing agencies but with neither fiscal power nor resource autonomy (Dauda, 2006; Olowu, 2003; Ouedraogo, 2003). In a decentralized government like South Africa, local governments are empowered to make their bylaws and develop, implement, and manage their fiscal policies (Tait & Euston-Brown, 2017). For example, in South Africa, electricity distribution is a municipal function that gives them a significant role in integrating low-carbon energy resources into the grid (Tait & Euston-Brown, 2017).

The nature and strength of deep decarbonization infrastructure and policies are often a function of territorial political stability (Vincent, 2004). A complete attempt to capture societal vulnerability should ideally include some measure of government strength and stability (Vincent, 2004). The prevalence of political instability in many countries in Sub-Sahara Africa makes governance of deep decarbonization at the local level unique (Vincent, 2004). Transnational organizations like ICLEI and C40 provide the hub for maintaining climate action in territories with sociopolitical instability (Accra Metropolitan Assembly; C40 Cities, 2021; ICLEI Africa, 2021; Ministry of Environment and Water Resources, 2020; Nairobi City County, 2020a). Table 2.3 provides the compilation of variables from literature review on climate governance mechanisms at the local level.

Table 2.3: Key Variables for Climate Governance at the Local Level

Governance mechanism	Findings	References
Decision making	Climate change governance's efficacy at the local level depends on the level of autonomy, leadership, and experimentation. Effective climate change policy requires institutionalization with appropriate competencies.	(Betsill & Bulkeley, 2006; Bulkeley & Betsill, 2005b; Castán Broto, 2017; Karimu & Mensah, 2015)
Coordination	The coordination of climate action program at the local level can be through a central climate office or a function within each department. The function of local government in deep decarbonization can be coordinating or collaboratory. Coordination involves	(Corfee-Morlot et al., 2009; Kern & Alber, 2009)

	planning, executing, monitoring and reporting low-carbon programs and policies. The collaboratory function is implemented to navigate multi-level systems and authority for a successful deep decarbonization strategy. Strong leadership from local governments is required to provide direction and strategy for deep decarbonization.	
Monitoring and reporting	Monitoring is the confirmation of pathways and strategies for achieving set climate targets at the municipal level—the presentation of climate action progress. The reporting of climate actions can be done at the departmental level and transferred to the central steering group. Planning, costs, and best practices are good monitoring and reporting features. A clear, concise communication process is vital across all stakeholders and functions.	(Clarke, 2011; Clarke & Zhou, 2021; Linton, 2020; Matsiliza, 2018)
Communication	A clear, concise communication process is vital across all stakeholders and functions. The mode of communication varies across each municipality.	
Collaboration and partnership	Collaborative governance establishes climate policy through collective interaction with public and private stakeholders. A participatory form of governance highlights the inclusiveness of all stakeholders in the decision-making process. It is believed that the participatory governance method yields better results than collaborative governance. This is attributed to a higher sense of ownership and promotion of acceptance of all stakeholders.	(Ansell & Gash, 2008; Connick & Innes, 2003; Gerlak et al., 2013; Heinelt, 2002; Lange et al., 2013)
Multi-level integration	Multi-level governance represents the intersectionality of the authority of several territorial units in climate governance. It helps clarify transnational, national, provincial, and local government roles in climate governance. Climate governance mechanisms are in 2 dimensions, Vertical integration is a top-down and bottom-up interaction between tiers of government for climate action policy. Horizontal climate governance allows local government to engage stakeholders and transnational social organizations for environmental sustainability directly.	(Bulkeley & Betsill, 2013; Corfee-Morlot et al., 2009; Sathaye et al., 2007)
Modes of Urban Climate Governance	The modes of climate governance are self-governance, governance through enabling, governance by provision, and regulation. The	(Kern & Alber, 2009)

	combination of multiple modes is advantageous to climate governance.	
Local climate governance in SSA	The knowledge of climate change and deep decarbonization is limited in developing nations. Decentralizing power is critical to deep decarbonization strategy at the local level in sub-Sahara Africa. Social dysfunction, political instability and societal issues affect climate action strategies. The capacity of a deep decarbonization plan is affected by funding and technical capacity.	(Diep et al., 2016; Paulais, 2012; Simon & Leck, 2015; Tait & Euston-Brown, 2017; Vincent, 2004)

2.9 Key Actors in Local Deep Decarbonization

The successful design and implementation of decarbonization strategies at the local level depend on the collaboratory efforts of all actors and stakeholders (Henstra, 2016). The review of a wide variety of scholarship indicated that multiple actors are involved in deep decarbonization at the local level with varying impacts (Matsiliza, 2018). They are interrelated in numerous adaptation and mitigation functions (Ogle et al., 2014a). Cooperation among diverse actors drives stakeholder governance and management strategy in climate policymaking (Clarke & Ordonez-Ponce, 2017; Linton et al., 2021). This heterogeneity of actors, their varying interests, the limited scope of action and their interdependencies may constrain deep decarbonization goals.

To reduce greenhouse gas emissions at the local level, the municipal government is the lead actor around which other stakeholders are interconnected (Linton, 2020). Smit (2017) highlighted the main actors of urban climate governance in African cities: government (local, sub-nation and national), transnational organizations, traditional institutions, the private sector, international agencies, and civil organizations.

The ability of an actor to implement desirable deep decarbonization action is influenced by the contribution of the action plan to individual or institutional goals and objectives (Leach et al., 2010), availability of needed resources and social infrastructures (Grubb et al., 2014a). Mitigation involves a series of interconnected decisions made over a significant period. The transformation will not occur as a

consequence of a single choice but rather as a result of a range of activities carried out in several areas over several decades. Local government can act as an influencer, knowledge hub and source of funding for deep decarbonization in sectors where the provincial government has lower levels of climate change authority (UN Habitat, 2015).

In deep decarbonization at the local level, the various actors can play diverse and multiple roles including but not limited to providing expert advice on decarbonization strategies (consulting), facilitating the implementation of these strategies, implementing the climate action plans, organizing and coordinating various stakeholders and resources, granting permission and authority for execution, financing climate action programs, managing climate action initiatives and decision-making roles (Clarke, 2011, 2013; Clarke & Crane, 2018; Clarke & Ordonez-Ponce, 2017). Each of the actors can also play a dominant role in a specific sectorial decarbonization based on their expertise and knowledge (Linton, 2020).

2.9.1 Private sector: Businesses and corporate organizations

The private sector is an integral actor in deep decarbonization programs, developing nations inclusive. The effect of GHG emissions is global and will not spare businesses. Private-sector actors are attractive participants in partnerships with public-sector actors, traditionally seen as the principal agents in implementing local decarbonization programs and providers of relevant products and services for decarbonization efforts (Cao & Zheng, 2016).

The role of the private sector, formal and informal, in climate mitigation efforts in Sub-Sahara Africa is not pronounced in works of literature where climate action focuses mainly on communities and households (Crick et al., 2018). Private sector involvement in climate action plans is motivated by its commitment to Corporate Social Responsibility expectations of their stakeholders, capacity building and their financial bottom line (Castillo Cifuentes, 2020; Clarke & Crane, 2018; Clarke & Macdonald, 2019). The private sector's contribution to the deep decarbonization effort improves efficiency and finance and helps extend public service delivery (Castillo Cifuentes, 2020; Wong et al., 2020).

The private sector is critical for sustainable development plays in developing countries. The effect of climate change on the private sector may be direct in the form of process disruption and infrastructural gaps or indirect in the form of supply chain breakdown and regulatory requirements (Crick et al., 2018; Pauw & Pegels, 2013). In developing nations, climate change will create new opportunities for the public and private sectors through innovative products and services, a new market base, non-traditional funding sources, and finance mechanisms (Crick et al., 2018). The private sector is formidable as a research and development partner, implementing organization, management entity and organizational skills, or research and development, particularly in the energy, agriculture, and water sectors (Crick et al., 2018).

2.9.2 Civil society organizations

Civil society organizations are various autonomous, voluntary institutions outside the state and market that provide services to individuals and articulate public interests (Rahmato, 2002). They occupy an intermediary space between the state and society (Rahmato, 2002). Civil societies place demands on the government for goods and services while promoting the interests of their constituencies (Ghaus-Pasha, 2004). The participation of civil society in various multi-level governance structures, climate change policy negotiations, and implementation is evident based on a literature review (Musah-Surugu et al., 2019). Civil society is a group of non-governmental organizations powerful enough to counterbalance the state. They prevent the government from dominating and atomizing the rest of society but not stopping it from performing its duty as keeper of the peace and arbiter between major interests (Iati, 2008). Civil society can help uphold good governance through policy analysis and advocacy, performance monitoring, social capital development and mobilization of stakeholders (Ghaus-Pasha, 2004).

Deep decarbonization in developing nations must include all known stakeholders at the local level. These stakeholders include civil society organizations. individuals, labour unions, professional bodies, non-governmental organizations, religious establishments, tribes, and other voluntary alliances formed to advance particular interests or objectives (Iati, 2008; Musah-Surugu et al., 2019; Rahmato, 2002). The

characteristics of civil societies include separation from the state, shared interests and values, and development through the endogenous and autonomous process without any external influence (Ghaus-Pasha, 2004). Civil organizations, as an essential sector, can help promote climate governance factors like openness, accountability, transparency and efficacy (Ghaus-Pasha, 2004).

2.9.3 Traditional institutions

In most African communities, the society recognizes the traditional institution as a form of governance, making this quasi-government a formidable force in deep decarbonization at the local level. Baldwin (2016) defined traditional leaders as a ruler vested with authority by association with the customary inclinations of a community. This traditional government is the main form of government before the advent of a colonial and neo-colonial system of government. This niche subset of government in Sub-Sahara Africa, which historically has been critical in rural community governance, can play a supportive role in climate action (Musarandega et al., 2018). In Ghana, South Africa, Nigeria and Malawi, to mention a few, the traditional institution via the traditional leaders are vested with constitutional (customary) authority and knowledgeable on traditional methods for mitigating climate change and its negative consequences. (Baldwin, 2016; Dahiru et al., 2012; Musarandega et al., 2018). Traditional rulers are regarded as the custodian of indigenous knowledge, proven to work against climate change (Marango, 2017). There are opportunities for integrating traditional institutions, which could use their knowledge and practices to promote sustainable forests, reforestation, social engagement and enforcement (Chanza & Musakwa, 2021). Marango (2017) confirmed the significance of traditional institutions in the custodianship of natural resources through sacred ecosystems (Musarandega et al., 2018) as a strategy for deep decarbonization.

The engagement of traditional knowledge (institution) accumulated over time in a particular society or location enables an understanding of climate change and underpins broader institutional deep decarbonization viewpoints (Henstra, 2016). The knowledge acquired through lived experience offers a

valuable complement to scientific knowledge because it is locally specific and applied (Henstra, 2016). Combining traditional institutions with scientific knowledge implies a partnership between community members, researchers, and stakeholders, using participatory engagement techniques to develop appropriate courses of action (Edelenbos et al., 2011)

2.9.4 Educational and academic institutions

In successful climate policy implementation, local governments and educational institutions have created effective partnership relationships (Aylett, 2013). Cities, universities, and research organizations must work together to progress the deep decarbonization programs (Clarke & Ordonez-Ponce, 2017; Clarke & Zhou, 2021; MacDonald et al., 2019). Studies suggest that researchers collaborate meaningfully with local governments, and universities play an essential role since they provide technical knowledgebase and information support to the cities they work with (Aylett, 2014). The relationship between academia and climate programs is crucial. Academia synthesizes knowledge gained from research to develop policies, documents, and toolkits for strategic climate mitigation plans (Clarke & Zhou, 2021; Glor-Bell & Clarke, 2011). Morton (2017) attributed researchers' potential role in deep decarbonization to stirring and organizing conversations, navigating politics and technology development, conducting and assessing research, developing long-term plans, and challenging myths constraining sustainable development and environmental sustainability. The summary of literature review showing key variable and role of climate action actors are in table 2.4.

Table 2.4: Key Variables for Actors and Stakeholders

Stakeholders	Role	References
Private sector	The private sector is essential in partnership, financing, funding and developing deep decarbonization strategies. Climate change is a potential disruption of business and an avenue for creating new economic opportunities.	(Castillo Cifuentes, 2020; Crick et al., 2018)

Civil society	Civil society counterbalances the government in climate policy through advocacy, arbitration, research and development.	(Iati, 2008; Musah-Surugu et al., 2019)
Traditional institutions	The traditional institution is a niche subset of government with customary local strategies and knowledge dating century for societal development. Traditional institutional uses their closeness to the populace to effect social changes, including climate policies.	(Baldwin, 2016; Chanza & Musakwa, 2021; Musarandega et al., 2018)
Educational institutions	The advancement of deep decarbonization hinges on collaboration between academics and other stakeholders. Academic institutions, through research, synthesize knowledge for understanding GHG emissions and proffer actions for effective governance and technological abatement methodologies.	(Aylett, 2013; Clarke & Zhou, 2021)
Government	The government provides the direction for climate action. It leads the monitoring and oversight of the program. It liaises and partner with national and transnational entities for climate action planning and implementation. It is the central node for all climate-related programs.	(Clarke & Zhou, 2021; Corfee-Morlot et al., 2009; ICLEI Africa, 2021; Linton et al., 2021; Stehle et al., 2020)

2.10 Roadblocks to deep decarbonization

Local governments face many challenges in implementing climate change programs to meet the targeted timeline for carbon neutrality. Climate actions have been very slow at the city level (Caetano et al., 2020). This slow pace has been attributed to varieties of challenges being faced by these cities (Bulkeley, 2010; Chan et al., 2018; Falkner, 2016; Fedele et al., 2019; Martin et al., 2021; Oberthür et al., 2021; Olawuyi, 2017; Ouedraogo, 2019; Sovacool et al., 2022). For cities in Sub-Saharan Africa to meet their climate goals, there is a need for a steep implementation of technical pathways (Olawuyi, 2017).

Many sustainability researchers and practitioners have studied the many barriers impeding climate action. In their study of cities in California, Salon et al. (2010) identified financial and human resource availability as a significant obstacle to climate action. In Mexico, institutional barriers such as the availability of resources and the coordination within and between relevant government bodies are considered major

hurdles to cross to achieve deep decarbonization (Bulkeley, 2010). Climate change mitigation through transformative changes requires high human, financial and long-term investment which may result in less stakeholder support (Adger et al., 2003; Fedele et al., 2019). According to Bulkeley (2010) and Holgate (2007), the lack of competent, capable, and accountable government and public infrastructure and services encumbered climate mitigation programs in less developed societies. There is a need to remove institutional, political, and human capacity barriers that cause the reduced climate action in Africa, primarily due to a lack of advanced technology (Olawuyi, 2017). In the study, Chan et al. (2021) identified 28 obstacles to adopting Green Building Technology (GBT) in Ghana, which is the predominant finance- and governance-related barrier.

Ouedraogo (2020) classified the major barriers to deploying renewable energy resources in Africa into financial, political, and technical challenges. These obstacles include weak institutional infrastructure and framework, high initial capital costs, weak dissemination strategies, a shortage of skilled labour, insufficient baseline data, and ineffective maintenance services (Ouedraogo, 2019). These barriers to climate actions vary across developing and developed nations (Chan et al., 2018; Olubunmi et al., 2016). Bulkeley (2007) attributed the low implementation of climate change actions in Johannesburg partly to poor institutional and governance frameworks. A lack of digital infrastructure, poor road conditions and networks, the non-existence of reliable electricity supply, high cost and low affordability hampers the adoption of low-carbon modes of transportation. Funding and innovative financial resources remain the most crucial missing link for many developing nations to address climate change and sustainable development (Caetano et al., 2020; Kern & Alber, 2009).

Some of the primary obstacles to investment in Nigeria's off-grid electricity market that affect the availability of clean energy systems are a lack of consumer affordability and project financial viability, an unfavourable business environment, and a lack of data required to make investment decisions (Yetano Roche et al., 2019). Poor governance, incoherent policies and coordination across governance levels, a

discontinuity in political agenda across electoral cycles and changes in administration all impede GHG mitigation programs (Caetano, 2020).

Table 2.5: Key Variables for deep decarbonization roadblocks

Deep decarbonization roadblocks	Findings	References
Financial and economic barriers	Funding for lack of infrastructure, poor incentives on clean technology and building retrofit, poverty	(Chan et al., 2018; Darko & Chan, 2018; Fedele et al., 2019; Olawuyi, 2017)
Political and social barriers	Discontinuity in the government plan, lack of political will, poor governance, fossil fuel subsidies, general adoption and acceptability among the populace, political instability and uncertainty	(Bulkeley, 2010; Caetano et al., 2020; Chan et al., 2018; Fedele et al., 2019)
Technical and institutional challenges	Poor geospatial data availability, data, advanced technology, electric vehicle infrastructure availability, human resource availability, poor technical knowhow and lack of electricity.	(Olawuyi, 2017; Salon et al., 2014; Sovacool et al., 2022; Yetano Roche et al., 2019)

2.11 Summary of Literature Review

A lack of social infrastructure heightens developing nations' vulnerability to climate change's impact, weak institutional framework and other socioeconomic problems (Cobbinah, 2021; Conway & Schipper, 2011; Hope, 2009). The literature review on deep decarbonization strategies revealed that the major contributor to GHG emissions in developing nations is Agriculture, forestry and other land use (AFOLU) (AfDB, 2020). The anticipated population and economic growth in developing nations are projected to skew the proportion of GHG emission sources toward building, energy and industries. The foundation for achieving decarbonization goals in developing countries is eradicating inequality (Wijaya, 2014). Deep decarbonization in developing countries is a social reengineering program coupled with behavioral changes. It requires social and political partnership, collaboration, engagement and governance across all

levels of government, civil society and transnational stakeholders (Bond, 2010; Clarke & Macdonald, 2019).

While there is a growing body of research on deep decarbonization, it remains an understudied field with much to learn about local decarbonization pathways, strategies, governance, and stakeholders (Linton, 2020). Most contemporary literature is available only in grey literature (Linton, 2020). All these are further compounded when related to developing nations whose priority has been social development and climate adaptation (Adger et al., 2003; Musah-Surugu et al., 2019; Ogbonna, 2014; Ulibarri et al., 2021). There exists massive knowledge gaps about developing nations, especially Sub-Sahara Africa, in terms of climate mitigation action and deep decarbonization efforts at the local level (Folke, 2006; Folke et al., 2011). There are few studies on sub-national GHG emissions and decarbonization efforts in Sub-Sahara Africa (Chan et al., 2018).

Consequently, most practices and techniques for climate action planning that are now being advocated are primarily based on knowledge from other parts of the world. This project aims to address this knowledge gap by providing firsthand insight into GHG emissions and strategies for their reduction in sub-Sahara Africa, focusing on cities. Through document review, analysis and interviews of practitioners across case cities, the researcher aims to decode and contextualize the process used by municipalities in sub-Sahara Africa for deep decarbonization efforts. The disparity in socioeconomic development, climate and culture limits the direct inter- and intra-regional transfer of knowledge. Key concepts and insights from this review of bodies of literature illuminate a representative theoretical set of frameworks for deep decarbonization in cities in sub-Sahara Africa and are summarized in table 2.6.

Table 2.6: Elements of research

Decarbonization Pathways	Institutional Strategies	Governance	Actors	Roadblocks

Agriculture Forestry and land use Electricity Building and building services Industry Transportation Waste	Engagement Technical capacity building Economic capacity building (Green Economy) Financing Behavioral intervention tools Regulatory and policy tools Long term plan	Decision making Coordination Monitoring and reporting Communication Collaboration & partnership Multi-level integration Governance mode Socioeconomic influence	Private sector Civil society Traditional Institutions Educational institutions Government	Barriers Challenges Infrastructure Poverty Funding Technology Capacity

3 Research Methodology

3.1 Introduction

The following chapter covers the methodology section of this research study. The study utilizes a qualitative approach using selected cities in sub-Sahara Africa, selected based on the criteria outlined in this work, as case studies. The methodology, criteria for selecting case cities, data collection, and analysis procedure are also elaborated. The chapter commences with a methodology overview, criteria for choosing case cities, data gathering procedures, and analysis techniques. At the end of the chapter, the methodology's limitations, as well as the research's reliability and validity, were explored in depth.

3.2 Research approach

Overall, this research assessed how cities in sub-Saharan Africa could achieve low carbon transition, environmental sustainability, and sustainable development. A qualitative approach was adopted in this study using primary data collected and available secondary data. Linton (2020) adopted a similar methodology in a similar previous project focused on cities in developed nations (Linton, 2020; Linton et al., 2021, 2022). The adopted qualitative methodological approach uses a multi-case study design. The cases allow for analysis, comparison, and distinction to identify trends and divergences replicable and transferable within the same context (Tomaszewski et al., 2020).

Qualitative methodology uses the words collected from people and researchers' texts to substantiate knowledge and understand a phenomenon (Creswell & Poth, 2018; Patton, 1990). The method studies a topic in a real-life context without interference or manipulation (Golafshani, 2003). It is the type of research conducted through a non-statistical procedure or quantification process (Golafshani, 2003; Strauss & Corbin, 1998). Qualitative research aims to conduct a study for in-depth understanding and not simply look at the peripheral findings (Golafshani, 2003; Johnson, 1997). The qualitative research method is applied to evaluate the knowledge, attitudes, behaviours, or opinions of subjects of a research topic (Creswell & Creswell, 2018). Qualitative research draws from individualistic interpretivism, which builds

knowledge from research participants' unique perspectives to understand a topic deeply based on the evidence (Creswell & Poth, 2018; Tomaszewski et al., 2020).

The case studies described in the following chapter apply a descriptive and qualitative method to synthesize information from various sources, notably document analysis, verifiable database and semi-structured interviews (Creswell & Poth, 2018; Golafshani, 2003; Johnson, 1997). Rather than providing predictions and causal explanations, the qualitative method contextualizes the scenario and interprets the data gathered (Paterson & Higgs, 2005).

3.3 Description of study location

Establishing pathways, mechanisms and strategies for local climate action in developing nations utilized secondary and primary data (Creswell & Poth, 2018; Linton, 2020). Although this research studies deep decarbonization in developing nations, it utilized selected leading cities in Sub-Saharan Africa as case studies. The Sub-Saharan African cities considered for this study have leading socioeconomic indices in the sub-region in terms of population, economic development, governance, gross domestic product (GDP) and social advancements. These cities have proactive and ambitious climate programs and ambitious GHG emissions reduction goals. They have the leading indicators in their plan for climate change mitigation and sustainable development. A developing country has a poor standard of life, an undeveloped industrial system, and a moderate to low Human Development Index (HDI) (Sathaye et al., 2007). HDI is an index that measures vital areas of human development by comparing socioeconomic indicators like poverty, literacy, education, life expectancy, and other aspects for nations worldwide (Max Roser, 2014; Odeh, 2010; Sathaye et al., 2007).

The cities in sub-Saharan Africa are good representative of developing nation cities as informed by the region’s low socioeconomic and sustainability indices (Bhattacharya et al., 2015; Sen, 2000). Sub-Saharan Africa has the lowest sustainability indices globally, making it the worst-case scenario for a study like this (Hope, 2009; Mutula, 2005; OECD, 2020). Sub-Sahara Africa's high vulnerability to climate change's effects

necessitates urgent and robust mitigation actions, which is an indirect goal of this study. Evaluating the least developed and sustainable countries will offer a glimpse of the second extreme compared to Linton's (2020) study of leading cities in developed nations.

The study location and cases are therefore drawn from cities in sub-Saharan Africa. Sub-Saharan Africa refers to African countries that are not considered part of North Africa. They are African countries which lie geographically fully or partially south of the Sahara Desert. This study did not consider Somalia and Djibouti as sub-Saharan African countries. Forty-six countries out of Africa's 54 are considered "sub-Saharan."

Figure 3.1 – Map of Africa showing Sub-Saharan Africa (adapted from Akomolafe, 2022).

3.3.1 Defining the city

It is essential to define what a city is because this research focuses on cities. The different interpretations of what constitutes a city highlight its ambiguous delineation, particularly in developing countries, which can impair the validity of data collection for research studies (Williams, 2012). For this study, the definition of a city is needed to enable consistent data collection for this research work. The intricate connectivity of cities, physical parallels between rural and urban areas, and complicated growth dynamics that create various patterns and situations have made it nearly impossible to disambiguate city expanses and adopt a single broadly applicable definition (Williams, 2012). Currently, numerous meanings vary by country and location (Williams, 2012). These definitions range from those that use only one criterion (for example, a population threshold) to those that use a mixture of criteria (e.g. combination of demographic size, population density, administrative setup, and economic development).

Cities are defined as human settlements that are generally big, dense, and diversified, with a complex social framework and governance, resulting in cultural creation that extends beyond their borders (Williams, 2012). In this project, cities are an integration of the urban plus suburban areas that are part of the city boundaries under a single jurisdiction, municipality and administrative control (Williams, 2012)

3.3.2 Case study selection criteria

The selection of cases followed a specific pattern and operational characteristics, which are highlighted in this section. In a multi-case study, this pattern and functional characteristics must be present across all the cases (Linton, 2020; Tomaszewski et al., 2020; Yin, 2014).

For this study, the criteria are as follows:

1. The case must have adopted an ambitious climate action commitment with significant targets of reducing GHG emissions by 2050.
2. The case must have been reported to the Carbon Disclosure Protocol's Cities 2021/2022 database.
3. The case must have a written document(s) that outline the climate action plan. This document

ideally includes GHG emissions targets, actions to decrease GHG emissions, an activities' implementation schedule, and a measurement system.

4. The case must have completed at least one citywide GHG emission inventory.

5. The climate action plan must be in the execution phase.

6. Reports must be available in the English language.

7. All cases must be in sub-Saharan Africa and evenly spread geographically across the sub-continent – East, west, south and north.

8. Cases of significant economic development and demographics will be selected using economic size and population.

The processes of identifying the correct sample and acquiring data are intertwined, as initially, the scope of available data was unknown. The research utilized the Carbon Disclosure Project (CDP) Cities 2021 database as a starting point. The CDP is a comprehensive dataset that identifies cities and how they solve environmental issues with new and innovative strategies for reducing carbon emissions and mitigating risks from climate change (CDP, 2022).

The Carbon Disclosure Project (CDP) Cities 2021 database used for this thesis is an open-access database that includes all data points for cities reported publicly through 2021 (CDP, 2022). CDP Cities provides a globally unified reporting system based on a simple questionnaire that allows city governments to publicly disclose their greenhouse gas emissions data (CDP, 2022). CDP is a not-for-profit organization that manages a worldwide disclosure system to help stakeholders regulate their environmental impacts (CDP, 2022). Over the past 15 years, the CDP platform has engaged exceptionally in global environmental issues. More than 1000 cities worldwide have a system for measuring, managing, and disclosing their environmental data through the CDP platform. With over half of the world's population living in cities, this database offers enormous potential in addition to showcasing among municipal leaders the actions of their colleagues in addressing GHG emission and climate change risk mitigation (CDP, 2022).For this study,

the CDP platform offers a unique starting point for identification of potential case cities. The dataset of over 1000 cities worldwide, downloaded and presented in Microsoft Excel format, was filtered based on case criteria. The figure below shows the process of narrowing down the data to the final studies. The researcher sorted the global CDP data to contain only the African CDP region. The resulting data (49 cities in 23 countries) was limited to only English-speaking countries by filtering out non-English-speaking countries. This is done to fulfil the criteria of the case studies, as all documents must be in English. This filter reduces the data to 34 cities.

Due to their comparatively advanced economy and sustainability advancement, cities in countries with very high and high planetary pressures – adjusted Human Development Index (HDI) are excluded from this case study (UNDP, 2022). Planetary pressures – adjusted Human Development Index (HDI) is a compound index for determining the average achievement in the areas of basic human development which is adjusted by the level of carbon dioxide emission and material footprint per capita (UNDP, 2022). These cities were excluded thereby ensuring that the case cities of the same balanced socio-economic and demographic levels relatively. The exclusion of cities based on HDI reduces the number of potential case cities to 24 in 14 countries. The data was after that filtered to limit the number of cases to one city per country, focusing on capital cities, political centers and economic hubs. These cities are the central economic hub of their respective nation, making them major contributors to GHG emissions (Accra Metropolitan Assembly, 2019; Nairobi City County, 2020a; Nyyssölä et al., 2021; Rahmato, 2002; Uduku et al., 2021). The countries with dual national languages of French and English were also filtered out. This action reduced the possible case cities to 12 cities in 12 countries.

The case cities were reduced to seven with a presence in West, East, North and south-central Africa using socioeconomic indicators and geographical location (spreading case cities). These seven cities were reduced to four based on their socioeconomic index, availability of literature, documents, and publications on their climate action programs. The cities with relevant resources and materials were

chosen as the final case cities for this project. The list of cities selected for this case study and their visual presentation are shown in Table 3.1 and Figure 3.3 respectively.

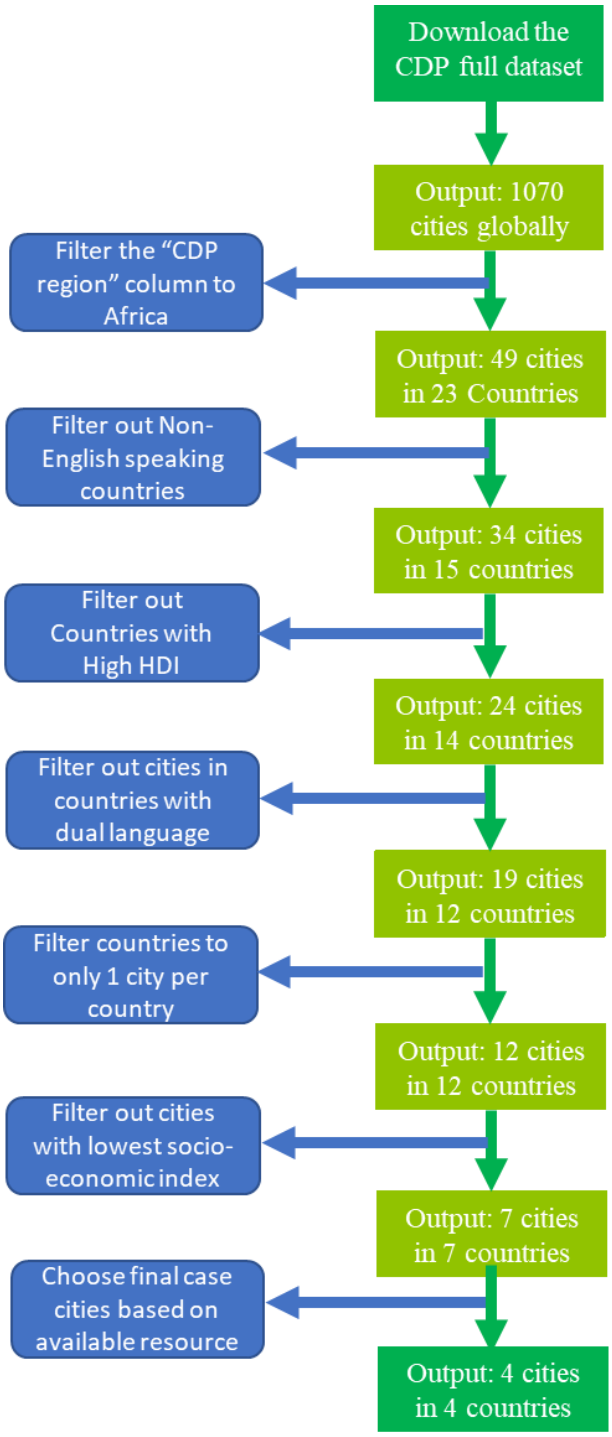

Figure 3.2 - Data filtration process, criteria and output

Table 3.1: Selected case cities for research

City	Country	Population	Sub-region	Role
Lagos	Nigeria	15,388,000	West Africa	Commercial hub
Accra	Ghana	2,650,000	West Africa	Capital city and commercial hub
Addis Ababa	Ethiopia	5,228,000	North Africa	Capital city and commercial hub
Nairobi	Kenya	5,119,000	East Africa	Capital city and commercial hub

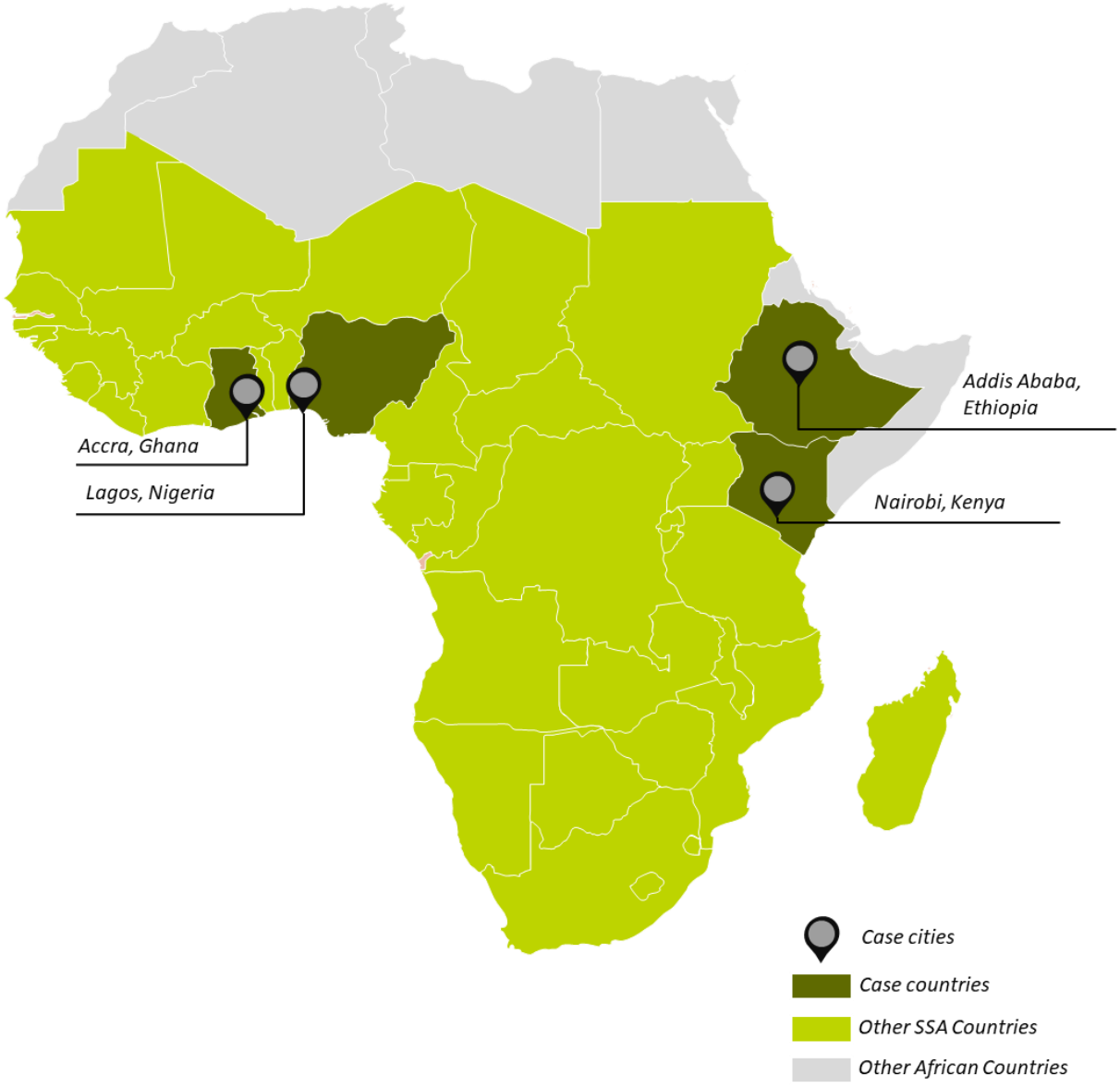

Figure 3.3 - Map of Africa showing the case cities (Adapted from Akomolafe, 2022).

3.3.3 Case cities

3.3.3.1 City of Accra

Ghana's capital city, Accra, is the largest population center and the country's economic hub (World Bank, 2015). Accra generated a total of nearly 2.4 million tonnes of carbon dioxide equivalent (tCO2e) in the year 2015. On average, a person residing in Accra would emit about 1.2 tCO2e per year (Accra Metropolitan Assembly; C40 Cities, 2021). Most emissions in Accra (44%) are from solid waste and wastewater treatment, followed by transportation (30%) and finally stationary energy (26%) (Accra Metropolitan Assembly; C40 Cities, 2021). The Accra Metropolitan Assembly (AMA) has developed a Climate Action Plan (CAP), the first to be prepared at a sub-national level in the country.

Economic development and mounting difficulties from climate change have made municipal resilience development more crucial than ever. Ghana's urban population has officially exceeded the 50% mark, meaning that more people live in cities than in rural regions (Accra Metropolitan Assembly; C40 Cities, 2021; Accra Metropolitan Assembly, 2019). As the country's capital and most significant city, Accra has both growth potential and urgent issues that must be adequately addressed (Accra Metropolitan Assembly, 2019). As a result, the Accra Metropolitan Assembly began mainstreaming climate change mitigation efforts (Accra Metropolitan Assembly; C40 Cities, 2021). The plan includes several related activities that will lead to significant reductions in greenhouse gas emissions, improved quality of life, green job creation, and setting the city on track for climate resilience and carbon neutrality by 2050. Accra's first city-level GHG inventory for the baseline year of 2015, was published in 2019 (Accra Metropolitan Assembly; C40 Cities, 2021).

3.3.3.2 City of Addis Ababa

Addis Ababa has quickly risen to become the Republic of Ethiopia's most prominent commercial, educational, and administrative centre (Weldeghebrael, 2021). Ethiopia's capital is located in the country's geographical epicentre (Weldeghebrael, 2021). Because of its historical, diplomatic, and political

importance on the African continent, Addis Ababa is often known as the "African Capital" (City of Addis Ababa & Group, 2021). According to the constitution, Addis Ababa is a self-governing city that reports to the federal government (Weldeghebrael, 2021). It is an important economic growth hub and a centre of education, business, culture, urbanization, communication, and innovation (Rahmato, 2002). As of 2016, the city has a population of 3.3 million, accounting for nearly 17% of the overall population of the nation (City of Addis Ababa & Group, 2021). Addis Ababa is expected to have a population of 9.8 million by 2037, with an annual growth rate of 3.8 percent. (City of Addis Ababa & Group, 2021). In addition to natural population growth, this is primarily due to high rates of rural-urban migration, as people come from all over the country to seek employment opportunities and services. The rapid increase is placing additional pressure on the city's infrastructure and resources (City of Addis Ababa & Group, 2021; Haji & Assefa, 2016; Weldeghebrael, 2021).

The city accounts for one-fourth of the country's urban population. It contributes more than a quarter of the national Gross Domestic Product (GDP), with the service industry dominating the GDP, followed by industry and agriculture. With the city's rapid growth and expansion as a result of urbanization, it is imperative to look into both developmental and environmental issues that impact the lives of urban residents and take bold actions in building a clean, safe, inclusive and resilient city while adapting to the impacts of climate change.

The city has set targets for achieving transformational change by 2030, 2040 and 2050 (City of Addis Ababa & Group, 2021). Addis Ababa performed the first city-wide GHG Inventory in 2012 (Haji & Assefa, 2016). The 2016 GHG inventory estimates the emissions from Addis Ababa as 14,479,133 tCO2e (Haji & Assefa, 2016). This estimation covers the energy, transport and waste sectors, with the most extensive sectoral emissions emanating from the transport sector, followed by waste and building energy (City of Addis Ababa & Group, 2021; Haji & Assefa, 2016).

3.3.3.3 City of Lagos

Lagos is one of the major economic hubs of West Africa and one of the fastest-growing cities in the world (Elias & Omojola, 2015). The city is situated on a low-lying coastal plain, and water bodies and wetlands cover over 40% of its area. Lagos is expected to become Africa's most populated metropolis over the next 50 years. Individuals fleeing war in Northern Nigeria and the West African sub-region have joined economic migrants recently and settled in Lagos (De Gramont, 2015; Uduku et al., 2021). Most migrants to Lagos are poor and live in slums. Lagos today has a population of over 15 million people, far outnumbering Nigeria's other major cities, and more than 40% of its population is under 25 (Uduku et al., 2021). Despite its comparative development, Lagos is a continually growing city with deep-seated socioeconomic inequalities (Uduku & Lawanson, 2022).

Greenhouse gas (GHG) emissions inventory for 2015, based on the GPC Protocol for Cities, showed that Lagos generated emissions of 1.3 tCO2e per capita, which is similar to other large African cities (Ministry of Environment and Water Resources, 2020). As the figure shows, the highest-emitting sectors were stationary Within those sectors (energy use in buildings and industry) and transportation and waste.

Guided by the climate change scenarios and the target of achieving net-zero carbon emissions by 2050, the CAP team identified a series of climate actions to reduce emissions, build resilience and enhance the quality of life of all inhabitants of Lagos (Ministry of Environment and Water Resources, 2020). The State Government has taken several ambitious actions to reduce GHG emissions and mitigate climate change. Some of these actions are in the planning stages, while others are underway or have been completed (Ministry of Environment and Water Resources, 2020).

3.3.3.4 City of Nairobi

Nairobi is Kenya's capital and the largest city and among the fastest-growing cities in East and Central Africa. It has complex temporal and spatial distributions of population, infrastructure, and socioeconomic activities. Rapid urbanization and unplanned settlement driven by rapid population growth and urban

poverty lead the city to an urgency to act to mitigate and adapt to climate change. Nairobi's primacy in Kenya's urban system is unrivalled, and its rapid expansion will continue. However, settlement patterns are becoming increasingly complex. Currently encompassing 704 km2 of land, Nairobi is situated in South-Central Kenya, 140 Kilometers south of the Equator (Nairobi City County, 2019). It is surrounded by 113 km² of plains, cliffs and forest that make up the city's Nairobi National Park (Sverdlik, 2021). It is adjacent to the eastern edge of the Rift Valley, and to the west of the city are the Ngong Hills.

Nairobi's developed its most recent Greenhouse Gas Inventory based on 2016 data and following global best practices (GPC compliant). Results from the inventory showed that in 2016, total GHG emissions in the city of Nairobi amounted to 4.7 MtCO2e, equivalent to 1.2 tCO2e per person (Nairobi City County, 2020a).

3.4 Data collection

Data gathering for a qualitative study is a procedure that involves establishing research boundaries as well as a strategy for information documentation (Creswell & Creswell, 2018). A case study requires substantial data collection from various sources, including interviews, historical records or papers, and audio-visual assets (Linton, 2020). To get an insight into each instance's contemporary environment and address the research questions, archival materials were researched using the internet. Qualitative interviews were also conducted with officials in local governments with deep decarbonization programs.

An ethics clearance was obtained from the university of waterloo (See Appendix one) to ensure that ethical research data collection and management procedures are utilized. The approved ethics process includes sending a letter of recruitment (Appendix two) to potential participants seeking their interest to participate in the study. Upon confirming their interest to participate, the potential interviewees are provided the project information letter (Appendix three) which provides the details and goals of the study and a consent form (Appendix four). An interview guide (Appendix five) was provided to the interview participants after receiving their signed consent form. Upon completion of interview, a letter of

appreciation (Appendix six) is sent to the participant. Using multiple data sources helps advance the validity and generalizability of research, better inform criteria and specifications and helps contextualize the concept of decarbonization (Creswell & Creswell, 2018; Lub, 2015).

3.4.1 Document review and selection

For this study, case studies were conducted to gain insight into some of the decarbonization strategies being implemented in the global south. The research elements cut across economic-technical pathways, institutional strategy, governance, and actors. Three different methods of data collection were utilized to answer the research questions: extensive review of the scholarly literature on deep decarbonization, climate change policy in the global south and systematic content analysis of official documents of the case cities under investigation, such as laws, special reports, policy documents, plans and press releases.

The downloaded Carbon Disclosure Platform data is the first key data document for this study through which potential case cities were identified. The portal includes datasets on climate-related risks and opportunities, emissions, mitigation, adaptation, energy, water, and other topics in cities, throughout the world including cities in the geographical area of interest of this study. The data serves as the first point of reference for choosing the case cities and for understand key activities and indices of these cities. The platform data were assessed for latest updates in climate mitigation actions for the case cities of this study.

The document review involved the analysis of a total of thirty-one documents across all four case cities of this study. The identification of relevant documents started with searching for the available Climate Action Plan (CAP) document for each case city which is already a criterion for their selection for the case study. Upon location of the CAP document, the official website of each case city was searched for various municipal policies in the areas of deep decarbonization pathways identified in the literature review: energy, building, transportation, waste management and AFOLU. All the documents that are directly related to the technical pathways with climate mitigation objectives were selected for content analysis.

Across the case cities, there are several similarities in the available document related to deep decarbonization. The documents used for content analysis for this study are outlined in Table 3.2 for each case city.

Table 3.2: List of documents used for content analysis across all four case cities

Accra	Addis Ababa	Lagos	Nairobi
Accra Climate action plan (2020 - 2025)	Addis Ababa Climate Action Plan (2021 - 2025)	Lagos Climate Action Plan (2020 - 2025)	Nairobi Climate Action Plan (2020 - 2050)
Accra Resilience Strategy	Addis Ababa Non-motorized Transportation Strategy	Lagos Resilience Strategy	Nairobi Air Quality Action Plan
Pedestrian Safety Action plan for the Accra Metropolitan Assembly	Addis Ababa Air Quality Management Plan	Lagos State Development Plan (20212 - 2025)	Nairobi City County Budget Review and Outlook Paper
Towards a Carbon Neutrality by 2050	Addis Ababa Scenarios for 2030 Transportation Master plan	Lagos: City Scoping Study	Nairobi City County Youth Policy
Accra: City Scoping Study	Addis Ababa: City Scoping Study	Lagos Urban Transportation Project Report	Nairobi: City Scoping Study
Accra Metropolitan Assembly Annual Action plan	Addis Ababa City Structure Plan (2017 - 2027)	CDP Data	Nairobi County Annual Development Plan (2022/2023)
CDP data	Addis Ababa Greenhouse Gas Emissions Inventory.	Lagos Non-Motorized Transport Plan	Nairobi County Annual Development Plan (2020/2021)
	CDP Data		Nairobi City County Integrated Development Plan (2018 - 2022)
			CDP Data

3.4.2 Interviews

Interviews with key players from all of the case cities were undertaken. The interviews were conducted to gather information regarding the study topics. During the document analysis phase, the researcher identified and utilizes a series of networks, including practitioners, consultants and academia, who have been engaged with these case cities to identify city officials responsible for climate mitigation who can

provide relevant insights into the research objectives. The researcher leveraged the extensive network of transnational organizations like C40 and ICLEI Africa for references to prospective interview participants.

Following the approved ethics procedure, prospective interview participants were first approached through email, which included a recruiting letter (Appendix two), to confirm their willingness to participate in the study as an interviewee. Before the interview, the participants were emailed an interview guide (Appendix five) and the interview date and time were agreed upon by both the participant and the researcher. The interviews, which were recorded, complemented with written notes and transcribed in real time, were done using Skype, Zoom, WhatsApp software or the telephone.

For this study, the researcher reached out to over 50 stakeholders for support and references out of which only eight stakeholders responded. These responses led to the identification 12 potential participants that were invited for interview representing three participants per case cities. The total of number of interviews conducted was three in two case cities.

3.5 Data analysis

To meet its objectives, this study utilized a combination of primary and secondary data analysis. The key strength of secondary data analysis is the timesaving benefit of using already-collected data, which permits triangulation. In data-rich contexts, the researcher might be picky about the data they use (Linton, 2020). When creating consistent datasets, however, this choice might be difficult. Such inconsistencies include differing years of data collection, the discrepancy in units, differing methods for data estimation or collection, and a wide range of data sources. The researcher must also find a compromise between more accurate data (often of limited quantity) and more comprehensive or consistent data, which may be of lower reliability (Currie, 2015).Upon completion of data collection, the first step before coding the data was transcribing and reading the interviews given by participants (Creswell & Creswell, 2018).

This study used qualitative content analysis, following deductive and inductive category development.

Deductive category development involves selecting a research question, defining categories, then a theoretical-based coding system, revising categories, working throughout the text, and interpreting the results (Cho & Lee, 2014). Inductive category development is conducted when the categories or codes developed are drawn from the data collected due to limited knowledge of the theme being studied (Cho & Lee, 2014). These results created tables for each case, and a cross-case comparison was made. The data analysis through coding helps the researcher identify emerging patterns and theories that can contribute to the study's research questions.

The data analysis was conducted in two parts. For the document analysis, all the relevant documents shown in table 3.2 were analyzed using the codes highlighted in Appendix seven to identify key patterns and trends in the data. The coding scheme was developed based on the research questions and the identified framework from the literature review. Due to the number of documents analyzed, a manual coding process was applied for this study.

For the interview, the auto-generated transcriptions from the interviews from Microsoft Teams application were verified by the researcher for grammatical errors after which a thematic analysis was performed using identified codes. The interview data were used for answering specific research questions which could not be answered through document analysis.

3.5.1 Coding

Once the data collation step was finalized, the researcher coded the date with the deductive categories. Coding organizes research data into chunks and develops word connotations to represent a category in the margins (Creswell & Creswell, 2018; Creswell & Poth, 2018). Coding follows the deductive category development, followed by the development of inductive categories. The inductive category is needed because some of the codes and sub-codes under the structural features were based on the responses of interview participants, given that they were not found in the literature(Creswell & Creswell, 2018).

The collated contents were deductively and inductively coded to aid in understanding each city's climate action strategy, structure, pathway and actors. The deductive codes used for this data analysis are based on review of literature and are highlighted in appendix seven of this thesis. The final coding sub-categories were based on the deep decarbonization framework as shown in Table 2.6: Pathway, strategies, governance and actors, and their respective elements.

The empirical findings from the technical pathways, institutional strategies, governance mechanisms and climate actors from this study of Sub-Saharan African cities were compared with the results of the similar study of cities in developed countries by Linton (2020) to gain insight to the uniqueness of municipal-level climate action mitigation programs in Sub-Saharan Africa. This comparison and its outcome formed the basis for answering research question five of this research.

In identifying the roadblocks to climate change mitigation in cities of Sub-Saharan Africa in order to answer research question six, the climate action programs of each case cities were coded for barriers and challenges identified in these plans. The interviews with professionals who were involved in the development of the climate action plans were also coded for barriers, challenges and roadblocks to climate action program implementation. The question of climate action roadblocks was specifically asked to the interview participants to get their opinion for triangulation.

3.6 Validity and reliability

There are concerns about validity in qualitative studies because qualitative research relies on the interviewees' perspectives and knowledge, which may be biased or insufficient (Patton, 1990; Savage & McIntosh, 2017). The validity of qualitative research confirms that the findings are accurate from the viewpoint of each stakeholder (Creswell & Miller, 2000). There is a significant threat to the validity at the three major stages of qualitative research – data collection, data analysis and interpretation (Onwuegbuzie & Leech, 2006).

Construct validity identifies a qualitative study's causes, effects, settings, and participants (Creswell & Creswell, 2018; Fink, 2010). Construct validity is demonstrated empirically when a study distinguishes between participants who have and do not have specific characteristics (Fink, 2010). This study of decarbonization strategy in developing nations utilizes a convergent validity construct, which identifies similarities in characteristics of deep decarbonization management strategies (Fink, 2010).

Internal and external validity are the two categories for a qualitative research project (Lub, 2015; Patino & Ferreira, 2008). Internal validity is the extent to which the outcomes represent the truth in the population under investigation and are hence not attributable to methodological flaws (Patino & Ferreira, 2008). After establishing internal validity, external validity, which confirms whether the study outcomes apply to cities like the case cities, must be determined (Patino & Ferreira, 2008). It defines the generalizability of findings to other cities in developing nations (Patino & Ferreira, 2008).

While interviews are an important research method in qualitative studies, they entail several potential deficiencies, such as selection bias, false information, or misinterpretation (Linton, 2020). However, acknowledging the various benefits of qualitative interviews and their shortcomings was addressed by interviewing more city climate action personnels who are familiar with the city climate action plan (Bogner et al., 2009). Multiple data sources were collected to ensure internal validity, and a crosscheck of data sources was used to establish the research's validity and protect against researcher bias (Creswell, 2014). External validity was increased by using a broad case city selection criteria and a single established research design, resulting in a study pool that resembles the majority of large Sub-Saharan African cities (Linton, 2020; Patino & Ferreira, 2008).

The researcher ensures careful study planning and adequate quality control and implementation strategies—including good recruitment strategies, data collection, data analysis, and sample size.

Qualitative reliability is an indicator of the consistency of the research approach with different researchers or projects (Creswell & Creswell, 2018). In this project, three ways of confirming qualitative reliability were used. A detailed account of the goal and perspective of each stakeholder are documented (Creswell & Creswell, 2018). All the steps taken in this research work are well documented for repeatability, which indicates reliability for the research work (Creswell & Creswell, 2018; Yin, 2014). Triangulation was utilized by collecting and analyzing data through multiple methods.

In qualitative research, the reliability and validity of the work are critical (Golafshani, 2003). This gives the research its generalizability, which Patton (2001) confirmed as a criterion for the validity of case studies. The author also used a triangulation method to increase the validity of this study by converging and combining particular research criteria and a diverse data set (Creswell & Creswell, 2018; Creswell & Miller, 2000). This data set includes a variety of interviewees, the geographic spread of case cities, and socioeconomic indicators.

3.7 Research limitations

The case study cities were determined using criteria and data from the CDP Cities 2022 database, considered secondary data as they are intended for different projects. It is critical to assess the data quality constraints when using secondary data for qualitative research (Castillo Cifuentes, 2020). The study was limited by the inability of the researcher to understand other languages except for English; hence all non-English speaking countries of SSA were not considered for this research. Limiting case cities to one per country has alienated some major cities, while small cities were excluded. Despite these constraints, the CDP Cities 2021 database was the best choice for case study selection since it is the most extensive database for municipal climate action and GHG emissions statistics (CDP, 2019). There was a significant limitation in securing interview participants partly due to technical issue but mostly willingness to participate. There is however enough document content to complete the thesis questions and triangulate results.

4 Empirical Results

The chapter presents the empirical results from archival data, documents, and interviews of the five chosen cities as case studies. The following subsection gives the overview of sustainability and climate action programs for each case study for the qualitative data analysis, which answers the first research objective related to deep decarbonization in cities. Each case sub-section presents the findings of the technical pathways, the institutional strategies, the governance structure, the actors, and the tools used by each case city. The results of each framework element from the data collection process are summarized and presented in a tabular format. The following section presents cross-case tables that collectively summarize findings across the case studies for cross-case comparison purposes. The last sub-section presents the qualitative data analysis that allows for answering the last research question by synthesizing deep decarbonization roadblocks identified during the analysis of each case study.

4.1 Case Studies

For the attainment of the objectives of this study, the following cities have been selected as case studies - The City of Accra, Ghana, the City of Addis Ababa, Ethiopia, the City of Lagos, Nigeria and the City of Nairobi, Kenya. Each case city was studied and examined under four primary criteria:

- Technical pathways: This describes the technical pillars and pathways for each sector involved in the climate action plans.
- Institutional strategies: This examines the actions, tools, and strategies that institutionalize deep decarbonization into local government planning and policymaking.
- Governance: The study of the decision making, management, monitoring, reporting, partnership, communication, and oversight structures of the climate action plan.
- Actors: Investigates the key stakeholders and their roles in the planning and implementation phases of the climate action plans.

Table 4.1: City emissions by sector in MTCO2e

	Energy	Building	Industry	Transportation mode	Waste management	AFOLU	Total emissions	Population	Emission per capita
Accra, Ghana	0	381,478.4	238,424	715,272	1,049,066	0	2,384,240	2,650,000	1.2
Addis Ababa, Ethiopia	0	1,115,659	11,434	6,641,237	1,946,389	141,372	9,856,091	3,353,000	2.9
Lagos, Nigeria	0	8,461,970	6,082,041	5,288,731	6,610,914	0	26,443,656	21,000,000	1.3
Nairobi, Kenya	0	1,052,596	0	2,097,274	1,529,828	0	4,679,698	4,900,000	1.2

4.1.1 Accra, Ghana – Sustainability and climate mitigation action plan

From a small town, the city of Accra has blossomed since 1877 into the capital city of Ghana (Accra Metropolitan Assembly, 2019; Acheampong, 2021). Accra metropolis is Ghana's administrative, educational, industrial, and commercial hub (Accra Metropolitan Assembly, 2020). This dominance of the Accra metropolis is a major driver of its population growth. Accra today covers approximately 139.7 km2 administrative area known as the Accra Metropolitan Area (AMA), with an estimated population of 2.65 Million (Accra Metropolitan Assembly, 2020). About 47 percent of the resident population are migrants born outside Accra.

The decline in agriculture in rural communities in Ghana, coupled with the late-1980s boom in the service sector, further propelled immigration to Accra. This accelerated rate of growth and associated population increase has effectively outpaced urban planning, presenting the city and administration with a range of complex urban challenges.

4.1.1.1 Sustainability and climate action

The city of Accra published its city-level greenhouse gas inventory in 2019 using GHG data for 2015 (Accra Metropolitan Assembly; C40 Cities, 2021). The inventory used an international standard tailored for urban areas, which meets Intergovernmental Panel on Climate Change (IPCC) requirements. The baseline year is used to form a projection of emissions up to 2050, with interim targets for 2030 and 2040 based on the best opportunities for mitigation. GHG emissions in Accra are currently 2.38MtCo2 with an average emission per capita of 1.2tCO2, comparable with other major cities in Sub-Saharan Africa (Accra Metropolitan Assembly; C40 Cities, 2021; Chance, 2018). These emissions are due to waste (44%), transportation (30%) and stationary energy (26%) (Accra Metropolitan Assembly; C40 Cities, 2021).

In 2020, the Accra Climate Action plan (2020 – 2025) was developed and published. The City of Accra is the second C40 city in Africa to publish a climate action plan. The plan sets out 20 priority actions to be implemented between 2020 and 2025, which will set the city toward carbon neutrality by 2050. The

priority actions focus on solid waste and wastewater, energy, buildings and industry, transportation, land-use and spatial planning, and several measures to mainstream the climate change threat into development over the next five years.

As part of the decarbonization effort, the Accra Resilience Strategy was published. It is a framework for addressing increasingly urgent urban trends in Accra — from improving the city's processes for planning and engagement to upgrading infrastructure and delivery of services such as energy, waste management, and transportation in both the formal and informal sectors (Accra Metropolitan Assembly, 2019). The resilience strategy is grounded by eight goals and twenty-seven initiatives — that are not just actionable but also have the potential to produce multiple benefits (Accra Metropolitan Assembly, 2019).

4.1.1.2 Technical Pathway: Accra, Ghana

The Accra Climate Action Plan categorizes actions into four technical programs and a mainstreaming enabling process. These technical programs and their respective actions significantly reduced GHG emissions in Accra. The climate change mainstreaming enabling process is geared toward engaging and implementing climate mitigation actions in the city of Accra through inclusivity, participation and ownership (Accra Metropolitan Assembly; C40 Cities, 2021).

Table 4.2: Technical Pathways, Accra

Variables	Findings
Energy/electricity	- No specific target, but the Accra aims to sustain the high proportion of Ghana's renewable energy source - Grid decarbonization does not fall under the jurisdiction of the city government[1] - Influencing national government policy to allow municipalities to purchase renewable energy from Independent Power Producers (IPP)[2] - Implemented solar-powered street lighting program in public places[3]
Buildings and building services	- Developing a bylaw requiring old buildings to be retrofitted with energy-efficient technologies by 2025[4]

[1] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 37
[2] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 38
[3] Accra metropolitan Assembly, Accra Resilience Strategy, pg. 36
[4] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 39

	- Development of green building rating system by 2023[5] - Formed an AMA working group to develop the Green Buildings Programme - Piloted Energy Efficient Project, where building energy audits were carried out for select municipal schools and hospitals - Develop an education toolkit that lays out the codes, the energy savings, and the business case for adhering to them
Industry	- Double energy efficiency improvement to 20% in industrial facilities by 2030[6] - Guidelines on voluntary targets and incentives for industrial energy efficiency by 2023
Transportation mode and fuel shifting	- Deployment of low-emission bus rapid transit (BRT) - New buses of higher and improved engine technology with the capacity to attain emission level equivalences on biodiesel fuels[7] - Expansion of operational infrastructure, including priority lanes and electric charging at depots post[8] - Development of walking and Cycling Infrastructure Strategy for Accra[9] - Introduction of schemes to promote ridesharing, the use of public transport, and low-emission vehicles [10] - Develop and connect public transport feeder network to BRT interchange facilities - Establishment of low-emission zones by restricting access to fossil fuel vehicles beyond 2025 - The high cost of electricity and the high upfront cost of electric buses are barriers to Electric Vehicle (EV) uptake[11]
Waste management	- Increase solid waste collection to 90% and capture 65% of landfill gas by 2030 - Waste optimization strategy developed and under implementation by 2023 to boost a circular economy - Double by 2030 the composting capacity of organic wastes and divert 50% of organic waste from landfills[12] - Reduce open burning of waste by 80% by 2040 - Gas capture at wastewater treatment facilities by 2025 - Waste characterization exercise was commissioned - Construction of new micro and large waste transfer station, including a 500T per day capacity waste transfer station - Partnered with a private engineering firm to develop an engineered landfill with gas capture and utilization - Plans to secure 200 acres of land for the construction of a sanitary landfill site and is in the first phase of remediation work at the ICGC dumpsite

[5] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 39
[6] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 39
[7] CDP, "2021 Full Cities Dataset. [Dataset]," 2022
[8] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 43
[9] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 44
[10] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 44
[11] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 45
[12] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 33

	- Retrofitting of existing dumps sites into an engineered sanitary landfill with gas capture capability - Lack of market for compost, resistance from citizens on waste sorting, lack of political will, limited enforcement capacity and space[13]
AFOLU	- The Greater Accra Regional Spatial Development Framework (RSDF) is a strategic spatial plan which includes measures to address climate change.[14] - Collaboration with the Ghana Forestry Commission to reduce deforestation and degradation rates due to city-induced demand for forest products. Supporting reforestation efforts would positively impact Accra's net emissions profile[15] - Implementation of a redevelopment scheme for Accra CBD Local Spatial Plan - Accra Climate Action Plan (CAP) does not cover emissions from agriculture - Through an "Adopt a Space" campaign, AMA is currently tapping private sector actors for funding of green spaces across the city - Planned expansion to twenty-one green spaces throughout the Metropolis.

4.1.1.3 Institutional strategy, Accra

Table 4.3: Institutional strategy, Accra

Engagement	- A stakeholder engagement plan was incorporated in Accra CAP as a formal strategy to identify and communicate with key stakeholders to encourage participation and support for CAP implementation[16] - Accra climate action plan is hinged on the principles of inclusivity, participation and ownership[17] - Town hall meetings - Public education and communication campaigns, mainly through social media - Community-level or organized group meetings targeted at members of particular interest groups - Engagements and meetings are in the form of one-on-one interviews, focus group meetings, or in sector-based workshops or mixed-group workshops[18] - AMA developed four categories of stakeholders: city officials and departments, federal government parastatals, the private sector, universities and partners and the residents of Accra - Minimum of four community engagements by the assembly in various localities per year[19].

[13] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 34
[14] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 46, 48
[15] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 26
[16] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 15
[17] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 6, 8, 15
[18] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 18
[19] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 18

	- These target groups included the traditional authorities (Chiefs), community leaders, and identifiable organized groups like informal waste collectors[20]
Technical capacity building	- Accra is building capacity to enforce the building code of 2018 [21] - A technical working group comprising the departments of environment, planning, and transportation was formed[22] - Accra CAP makes provision for investment in staff expertise and provides the platform for relevant staff to participate in professional networks devoted to climate change mitigation and adaptation[23] - Train and build the capacity of technical staff to identify and develop bankable projects[24] - Capacity Building in Energy Efficiency plan was completed in 2017[25] - Strategic appraisal of climate action and initiating the GHG emissions scenario modelling, with additional workshops from 2017 to 2018.[26] - Using scenario modelling for evidenced-based decision-making and obtaining key stakeholder input to link actions to immediate needs directly[27]
Green economy	- Accra is engaging banks on industrial energy efficiency investment opportunities[28] - There is a focus on waste management and recovery in Accra Climate Action Plan[29] - Develop digital maps of waste generation, collection, transfer, processing, and disposal points in Accra[30] - Identify priority waste management infrastructure and service gaps[31] - Accra Spatial Development Framework promotes the uptake of the best available technologies in waste recycling, recovery, and waste-to-energy programs[32]
Financing	- The investment required would be undertaken by a mix of public and private sector entities and not solely the local government. - Establish a dedicated team to explore and test new funding models[33] - Leverage the private sector to finance green projects

[20] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 18
[21] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 39
[22] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 44
[23] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 52
[24] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 53
[25] Accra metropolitan Assembly, 2020 Voluntary Local Review Report on the Implementation of the 2030 Agenda for Sustainable Development, pg. 68
[26] Accra metropolitan Assembly, 2020 Voluntary Local Review Report on the Implementation of the 2030 Agenda for Sustainable Development, pg. 70
[27] Accra metropolitan Assembly, 2020 Voluntary Local Review Report on the Implementation of the 2030 Agenda for Sustainable Development, pg. 10
[28] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 40
[29] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 57
[30] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 57
[31] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 29
[32] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 34
[33] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 51

	- The City of Accra plans to access special-purpose financing vehicles like the District Assemblies Common Fund (DACF), a Development Fund created for financing local-level development[34] - Devise special allocations for community-led climate programs and initiatives - Accra works with several international donor organizations to finance its climate action plan - Accra is funding green space through an "Adopt a Space" program
Behavioural intervention tools	- Lobby the national government to allow municipalities to secure renewable energy from IPPs[35] - Development of an innovative finance program to encourage the adoption of energy-efficient measures by consumers[36] - Provision of infrastructure to incentivize composting and processing of food waste into valuable commodities[37] - Development of non-motorized infrastructure to boost walking and cycling - Development of a model for bicycle rental programs and engagement campaigns to promote the benefits of cycling - Accra initiated an incentive program that offers a 10% reduction in the building permit fee if the application incorporated a 20kW roof-mounted solar PV system in the design[38]
Regulatory and policy tools	- The AMA Transport Unit was created in 2017 through Urban Passenger Transport byelaws, empowering the city to regulate transport operators, register routes, issue and enforce permits (retaining 50% of fines) and manage a database[39] - Implement a bylaw requiring old buildings to be retrofitted with energy-efficient technologies[40] - Embarked on a program of education, and enforcement of regulations and by-laws, to improve waste management.[41]
Long term planning	- Maintaining political engagement, - Designing effective communication campaigns, - Sourcing adequate funding - Provision of access to the required skills and expertise.
Socioeconomic influence	- Developing long-term actions for building climate resilience - Reduction of emissions and improved air quality - Capacity building on climate resilience - Job creation for formal and informal waste businesses through the collection, sale and local manufacturing of recyclable materials - Promotion of the waste economy and waste service delivery - Stimulate the local market for renewable energy IPPs

[34] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 64
[35] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 38
[36] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 39
[37] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 33
[38] Accra metropolitan Assembly, Accra Resilience Strategy, pg. 58
[39] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 42
[40] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 39
[41] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 30

4.1.1.4 Governance mechanism, Accra

Table 4.4: Governance mechanism, Accra

Variables	Findings
Decision making	- The responsibility for formulating and approving long-term strategies lies with the steering committee, which comprises representatives from all the municipal assemblies within the jurisdiction of the CAP - Utilization of Multiple Criteria Analysis for prioritization of climate actions and decision making[42] - Using scenario modelling for evidenced-based decision-making and obtaining key stakeholder input directly links actions to immediate needs[43]
Coordination	- The leading departmental unit for driving climate action in the Assembly is the Resilience and Sustainability Unit[44] - Many of the partnerships are to increase Accra's capacity/expertise for sustainability as well as for funding[45] - where climate actions are not under the responsibility of Accra Metropolitan Authority (AMA), AMA departments are identified as the lead but will play a coordination and collaboration role[46].
Monitoring and reporting	- Implement campaigns, track feedback and evaluate the impact - Quarterly review meetings involving the extended metro planning coordinating team. These meetings are used to review activities listed in the annual action plan[47] - Quarterly field visits involving the monitoring of physical projects - The preparation of quarterly and annual progress reports - AMA will continue to report annually to the CDP (Carbon Disclosure Project) on GHG emissions documented through the existing Medium-term Development Plan (MTDP) framework. This framework incorporates annual action plans, which outline the activities undertaken by different departments and agencies relating to specific development objectives. These annual action plans will be updated to align with the CAP, and the existing framework will be used to assess their performance[48].
Communication	- CAP citizen and community campaign completed by 2023[49] - Accra utilized social media platforms like WhatsApp for communication and reporting waste-related offences - Using community events, traditional gatherings, and religious events as media for communication and feedback

[42] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 27
[43] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 6
[44] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 15, 50, 54
[45] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 54, 55
[46] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 14
[47] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 64
[48] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 64, 65
[49] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 52

Collaboration and partnership	- The development of Accra CAP was with the support from C40 Cities, and Accra continues to benefit from external support[50] - Accra collaborated with WHO's Urban Health Initiative on the Air quality project [51] - Accra Government partners with local businesses, NGOs and stakeholders to engage and implement actions. - In 2011, Accra implemented a Public Private Partnership Program that contracted private operators to collect solid waste on a franchise basis - In collaboration with a private partner, Waste Landfills Limited, the AMA has commenced processes to develop an engineered landfill with a gas capture and utilization system, among other amenities[52]
Multi-level integration	- Infrastructure is yet to be facilitated through existing national and local planning systems - Safer walking environments to improve quality of life[53]
Governance mode	- Accra Municipal Assembly established the Resilience and sustainability unit as a central coordinating department for leading climate action - Self-Governing – The local government of Accra does not have a clear target for corporate emissions and initiatives - Enabling – The local government oversees stakeholder engagement and communication initiatives and provides performance information to the public - Provision – The government of Accra is investing in climate mitigation programs and infrastructures - Regulation – The city has embarked on regulatory mode for waste management improvement and transportation

Figure 4.1: Organizational chart for the City of Accra

[50] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 15
[51] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 16
[52] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 30
[53] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 44

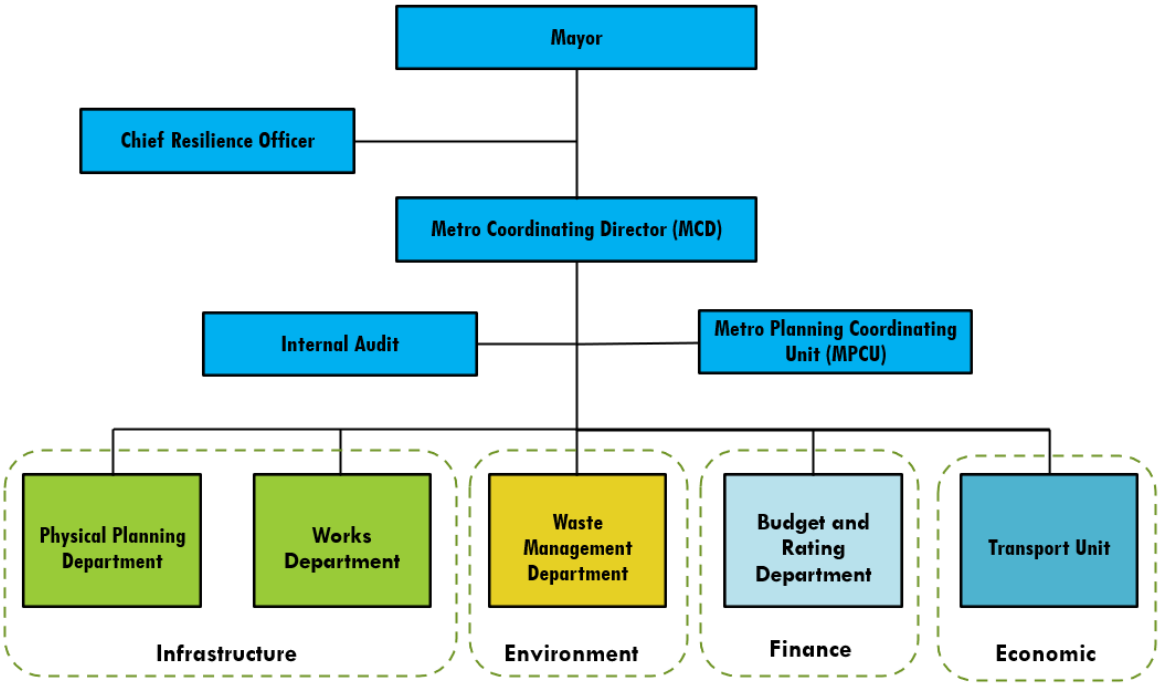

Figure 4.1 – Organizational chart for Accra (Accra Metropolitan Assembly; C40 Cities, 2021; Accra Metropolitan Assembly, 2019)

4.1.1.5 Actors: Accra, Ghana

Table 4.5: Actors: Accra, Ghana

Private sector	- Based on CAP stakeholder mapping, the waste, transport, energy and building sectors are most impacted by the private sectors[54] - Sector-specific workshops were organized in the form of focus groups for seeking professional insights[55] - The private sector is a key element for project execution with the government in the form of public-private partnership (PPP) for climate mitigation plans - The "Adopt a Space" campaign is a private sector-driven program for green space development[56] - In collaboration with a private partner, Waste Landfills Limited, the AMA has commenced processes to develop an engineered landfill with a gas capture and utilization system, among other amenities. -

[54] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 18
[55] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 18
[56] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 66

Civil Sector	- In 2018, AMA convened and presented Accra's prioritized climate challenges with key partners, including C40. IFC, EU and World Bank aimed at technical support, capacity development and funding[57] - Accra rallied local labour organizations around Climate Action Plan for Integration
Traditional Institution	- Traditional authorities are crucial for understanding the impact of the climate action plans on their respective communities - Traditional leaders act as the communication channel to their communities, especially in remote locations - They maintain close links and collaborate with formal state institutions in urban governance[58]
Educational institution	- Accra organized a collaboratory section with 100RC, Princeton University, and the University of Pennsylvania on the sustainability of city transportation[59] - The University of Ghana is a non-government representative in Accra's Climate Action Plan Steering committee
Government	- AMA Officials and departments aimed to ensure all the internal city officials and departments within the AMA whose work has a bearing or impact on the CAP process were identified, engaged and clarify roles and responsibilities[60] - "National-level institutions like the Ministry of Environment, Science, Technology and Innovation (MESTI) have the primary responsibility for climate-related issues in Ghana."[61] - The government of Accra provides funding for climate actions plan implementation - Accra works with National government agencies like Environmental Protection Agency (EPA-Ghana) to provide regulatory oversights in various actions of the CAP[62]

4.1.2 Addis Ababa, Ethiopia - Sustainability and climate mitigation action plan

Addis Ababa is the political, industrial and commercial hub of Ethiopia. Typically referred to as the African Capital, Addis Ababa is an integral centre of culture, education, religion, urbanization, and innovation. Addis Ababa is expected to have a population of 9.8 million by 2037, with an annual growth rate of 3.8 percent. (City of Addis Ababa & Group, 2021). The city's geographical boundary encompasses the whole

[57] Acheampong, R., Accra: City Scoping Study, June 2021.
[58] Acheampong, R., Accra: City Scoping Study, June 2021.
[59] Accra metropolitan Assembly, Accra Resilience Strategy, pg. 9
[60] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 9
[61] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 17
[62] Accra metropolitan Assembly, Accra Climate Action Plan, pg. 17

administrative region of Addis Ababa, an area of 540 square kilometres, including ten sub-cities (Haji & Assefa, 2016).

4.1.2.1 Sustainability and Climate Action

The city has set targets for achieving transformational change by 2030, 2040 and 2050 (City of Addis Ababa & Group, 2021). Addis Ababa performed the first city-wide GHG inventory in 2012 (Haji & Assefa, 2016). The 2016 GHG inventory estimates GHG emissions from Addis as 9,856,091 tCO2e, with the transportation sector accounting for 67 percent of all city emissions (Haji & Assefa, 2016).

Under a collaboration between the Addis Ababa Environmental Protection and Green Development Commission, the United States Environmental Protection Agency, the United States Embassy in Addis Ababa, and UN Environment, Addis Ababa developed an air quality management plan with a goal of GHG emissions (City of Addis Ababa, 2021)(City of Addis Ababa, 2021). This plan is influencing government policy in areas of vehicular emission standards as well as industrial emission regulation (City of Addis Ababa, 2021).

In 2021, the city published its climate action plan to achieve carbon neutrality by 2050. Addis Abba City Structure plan (2017 – 2027) focuses on the medium-term sustainable development of the city and satellite towns in housing, physical infrastructure, land development and transportation (Addis Ababa City Planning Project Office, 2017).

4.1.2.2 Technical Pathways: Addis Ababa

Addis Ababa Climate Action Plan outlines climate mitigation actions into the following strategies: Energy, Building, Transportation, AFOLU and waste management. The Addis Ababa CAP also highlighted the action and strategies being deployed by the Addis Ababa as a capacity developer, facilitator, and investor. The plan includes nine prioritized climate mitigation actions and five additional actions across the technical pathways to realize the set carbon neutrality goal (City of Addis Ababa & Group, 2021). The plan also

includes 20 adaptation actions, some overlapping and applicable to climate mitigation efforts (City of Addis Ababa & Group, 2021).

Table 4.6: Technical Pathways: Addis Ababa

Variables	Findings
Energy/electricity	- Smart Grid to create energy-efficient electricity distribution networks within the city. Retrofit of the electricity grid with innovative technology for more efficient distribution[63] - 100% LED streetlights by 2030[64] - Increase and diversification of Renewables in Electricity Generation. The development of a new 3000MW renewable energy project is in the advanced stage - Plan in place to Shift to efficient cooking stoves[65] - Phase out diesel generators utilized for backup power through the design and implementation of regulations for use (to almost 0% by 2030)[66]
Buildings and building services	- 75% of existing properties will use solar water heating by 2050[67] - 50% will use LED lighting by 2030 - 90% of residential and 100% of commercial properties will transition to electric stoves by 2050[68] - In both residential and commercial properties, 100% of new builds to use solar water heating by 2030[69] - 100% electric stoves in newly built residential properties by 2030 - Improvement of permitting process for new builds[70]
Industry	- Incentivizing energy audit mechanisms for energy-efficient technologies in industries - Switching toward cleaner fuels in the commercial sector and manufacturing industries - Includes 95% of industrial energy use converted to electricity by 2050[71] - Manufacturing industries' industrial efficiency will increase to 60% improvement by 2050
Transportation mode and fuel shifting	- Development of the light rail transit system (LRT)[72] - Development of the Bus Rapid Transit (BRT) – under construction[73] - Car-free days, promotion of Walking and Cycling[74]

[63] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 108
[64] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52, 81, 135
[65] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 26
[66] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 86
[67] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[68] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[69] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[70] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 64
[71] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 53
[72] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 78
[73] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 78
[74] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52

	- Motorcycles and taxis to shift away from petrol, aiming for 10% electric by 2050[75] - Reduction in diesel use by freight vehicles, in favour of increased use of biodiesels and, when technology allows, switch to electricity[76] - Improving vehicle efficiency via emissions standards - Improve public transport networks - Enhancing fuel efficiency via a switch to hybrid/electric vehicles or biofuels[77]
Waste management	- Enhancement of sewage/wastewater treatment system[78] - The city of Addis Ababa is campaigning to encourage the waste hierarchy and construct composting facilities[79] - Enhance landfill management and install gas capture facilities[80] - Addis Ababa plans to divert 70% of organic waste to compost by 2050[81] - Reduce open dumping of organic waste and the amount going to landfill to 0% by 2050[82]
AFOLU	- Increased GHG sequestration through forest management, forest protection and re-establishment[83] - Planning for green spaces that are based on an ecosystem services approach and expanding the amount of green space in the city[84] - Including green space in the city's master plan expands the area covered by green spaces, which supports various ecosystem functions[85] - Tree planting campaign and activities[86] - Greening of the city: Sheger beautification project[87] - Decentralization of urban activities and promotion of mixed land use in the city structural plan[88]

4.1.2.3 Institutional strategy: Addis Ababa, Ethiopia

Table 4.7: Institutional strategy: Addis Ababa, Ethiopia

Engagement	- Engagement and public education are areas of improvement[89]

[75] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[76] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[77] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[78] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 64
[79] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 64
[80] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 64
[81] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 64
[82] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 52
[83] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 93
[84] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 93
[85] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 19
[86] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 19
[87] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 19
[88] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 9
[89] Interview session with city official

Technical capacity building	- Improvement of permitting process for new builds - Addis Ababa University is involved in the reafforestation and biodiversity enhancement program[90] -
Green economy	- The development of a new 3000MW hydropower plant is a foundation for green economy - Climate Resilient Green Growth Strategy and Integrated Climate Change Response Investment Plan Development for Addis Ababa[91] - Climate Resilient Green Economy Strategy. Sector-wise GTP II Implementation Monitoring Checklist. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), East Africa[92] - While integrating physical infrastructure investment, land development, housing and transport with the surrounding will ensure synergistic development, the main principle of the plan is creating a competitive city and emphasizes building a solid economy in the region that is based on the international role of Addis Ababa[93]
Financing	- Sale of bonds to provide long-term funding for infrastructure investment[94] - The city government to put in place a strategy for efficient tax collection[95]
Behavioural intervention tools	- Ensuring the City's population is informed of the potential health risks and the links with climate change will increase awareness and influence behavioural change[96]
Regulatory and policy tools	- Addis Ababa Waste Management Policy[97] - Addis Ababa Structural Plan[98] - Addis Ababa Transport Strategy[99]
Long term plan	-

4.1.2.4 Governance mechanism: Addis Ababa, Ethiopia

Table 4.8: Governance mechanism – Addis Ababa, Ethiopia

Variables	**Findings**
Decision Making	- Due to Addis Ababa's political, economic and symbolic significance, its decision-making process has been significantly influenced by the national government - The city is organized into 11 sub-city administrations and 129 woredas[100]

[90] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 29
[91] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 46
[92] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 42
[93] Addis Ababa City Planning Project Office, Addis Ababa City Structure Plan (2017 – 2027), pg. 10
[94] Addis Ababa City Structure Plan, pg. 314
[95] Addis Ababa City Structure Plan, pg. 314
[96] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 101
[97] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 18
[98] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 18
[99] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 18
[100] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 117

	- The city administration is led by a mayor and 18 cabinets that is responsible for planning, implementation and budget allocation for socio-economic development and municipal services provision[101] - The Addis Ababa Environmental Protection and Green Development Commission (AA EPGDC), directly accountable to the mayor, oversees the city's environment and climate change issues[102] - The Environmental Pollution and climate change directorate under AA EPGDC has six teams[103] - The AA EPGDC has focal persons at the sub-city level to cascade climate actions at the sub-city level[104]
Coordination	- AAEPGDC is assigning two teams to work on climate mainstreaming and climate-smart technologies promotion[105] - The Addis Ababa Environmental Protection and Green Development Commission (AA EPGDC), directly accountable to the Mayor, is mandated to govern the city's environment and climate change issues[106]
Monitoring and reporting	- AAEPGDC reports its work and activities formally to the Addis Ababa City Administration and the City Planning Commission vertically[107] - Monitoring, Evaluation and Reporting (MER) of the climate action plan entails weekly, monthly and annual updates[108] - Monitoring and reporting of the Climate Action Plan occurs horizontally across city agencies and departments[109] - The AA EPGDC's focal persons at the sub-city level also perform monitoring and reporting functions to the commission[110] - Monitoring and reporting entail the review of the execution status of climate action plans against an established set of Key Performance Indicators (KPIs). - An annual evaluation report with a recommendation for changes is part of the Addis Ababa climate change mitigation plan[111] - "AAEPGDC will lead the CAP MER in collaboration with the proposed CAP Steering Committee, which will be formed at the city level. The Steering Committee will include members from selected city sectoral institutions. It will play a big role in following up on the MER on the CAP implementation"[112]
Communication	- The AA EPGDC has focal persons at the sub-city level to cascade climate actions[113]

[101] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 117
[102] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 119
[103] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 118, 130
[104] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 119
[105] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128
[106] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 119
[107] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128
[108] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128
[109] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128
[110] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 119
[111] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 131
[112] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128
[113] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 119

	- Addis Ababa is working on identifying the most effective means of communication around climate issues[114]
Collaboration and partnership	- Some projects will require collaboration between the city and other administrations, businesses, private landowners, tenants and/or other stakeholders. - The AA EPGDC receives support from national government organizations, namely the Environmental, Forest, and Climate Change Commission, via capacity building, training, and seminars, as well as funding mechanisms[115] - Partnership with champion institutions on innovative financing mechanisms - Implementation of public-private partnerships for concessional finance, funds, as well as co-financing[116] - Partnership with international organizations for technical and financial support for CAP development and data management[117]
Multi-level integration	- Vertical integration with sectoral focal points at national levels, such as Environment, Forest and Climate Change Commission, aligns well since these sectors have a shared mission of coordinating, planning and implementing climate actions - AAEPGDC reports its work and activities formally to the Addis Ababa City Administration and the City Planning Commission vertically [118] - The EPGDC has horizontal integration on the Climate Action Plan with other city agencies and departments[119] - Addis Ababa CAP is linked closely with the national climate action planning process, enabling vertical integration between the city and national government.[120]
Governance mode	- Self-regulating – There is no clear target or known action on corporate emission targets. GHG emission inventory of institutional buildings completed - Enabling - Stakeholder involvement and capacity building on energy-saving measures, including media/PR campaigns and community networks-based local training programmes for homeowners and installers - Provisioning - investments in social infrastructure and service delivery - Authority – through regulatory frameworks like criminalizing dumping and open burning
Socioeconomic influence (co-benefits)	- Environmental benefits: Restoration of natural resources, reduce deforestation, improved biodiversity - Social Benefits: Enhanced social infrastructure, health benefits, improved food security and improved air quality - Economic benefits: New local industry development, job creation, cost saving for reduced energy used, improvement in tourism

[114] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 125
[115] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 118
[116] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 122
[117] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 122
[118] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128
[119] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 119
[120] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 128

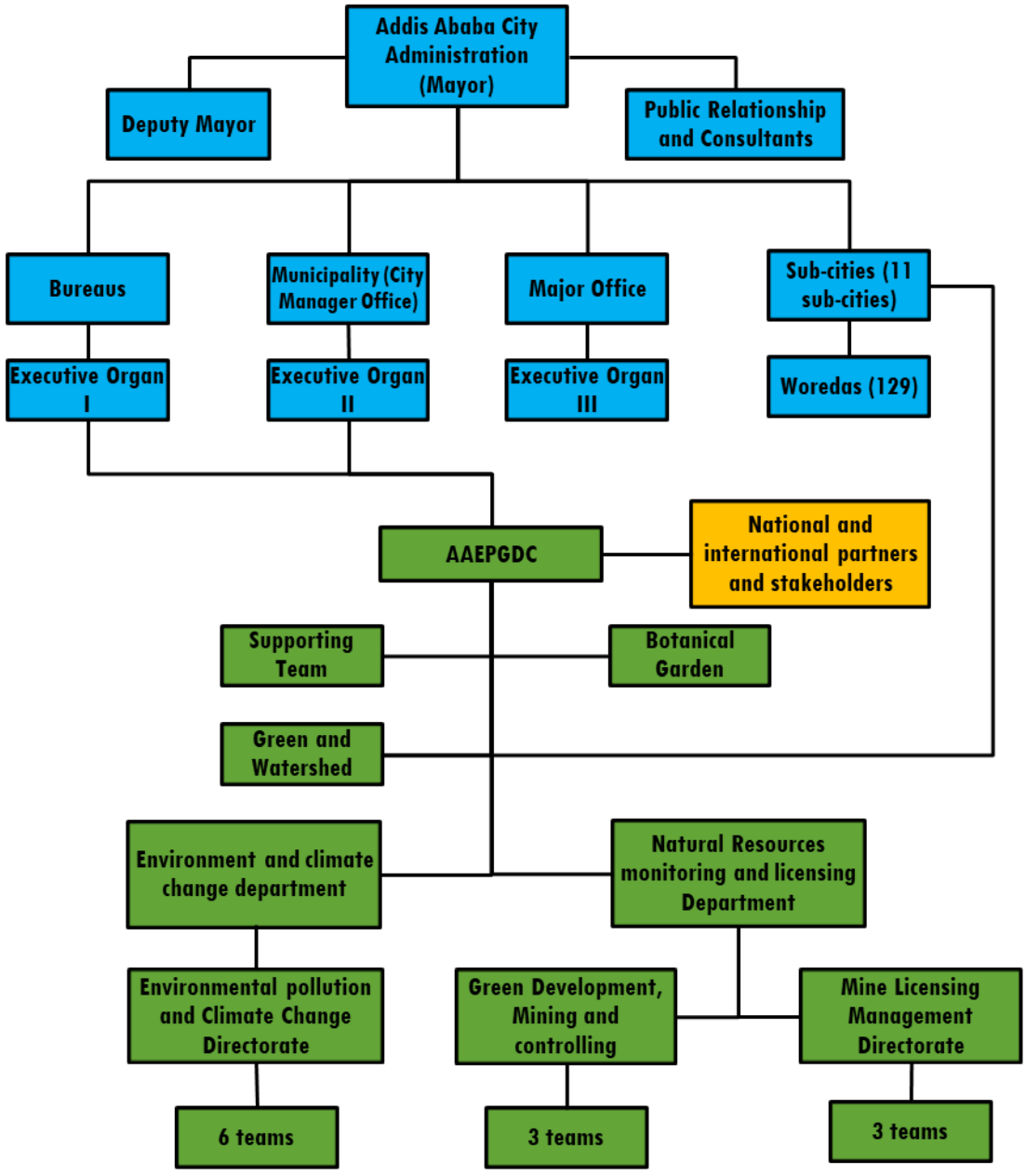

Figure 4.2 – Organizational chart for the city of Addis Ababa (city of Addis Ababa & Group, 2021 pg.118)

4.1.2.5 Actors: Addis Ababa, Ethiopia

Table 4.9: Actors: Addis Ababa, Ethiopia

Private sector	- Through private-public partnerships, the private sector provides concessional finance and fund[121]

[121] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 122

	- The private sector engagement in climate action planning is minimal - The private sector is engaged and tasked with operations and management of the city's climate action programs, like the bicycle sharing program in central Addis Ababa[122]
Civil Sector	- Bilateral and multilateral donors and civil organizations are a major source of funds for climate financing - Enhancing ISO Certified Energy Efficiency Green Building Standards[123]
Traditional Institution	- Addis Ababa, climate action is prioritized according to locally appropriate cultures and values
Educational institution	- Addis Ababa University is involved in the reafforestation and biodiversity enhancement program[124] - Addis Ababa Science and Technology University, Ethiopian Civil Service University, and Ethiopia Institute of Architecture, Building and Construction are stakeholders in the development, planning and execution of Addis Ababa's Climate Action Plan[125] - Kotebe Metropolitan University works with the Environmental Protection Agency to develop the state of the environment report for the city of Addis Ababa[126]
Government	- The government is still the largest investor (70%) in the city - Government ratifies and leads climate change mitigation strategies

4.1.3 Lagos, Nigeria - Sustainability and climate mitigation action plan

Lagos is a conurbation and a coastal city in south-western Nigeria which is the nation's economic hub. Situated on coastal lowlands of swamps and water bodies, Lagos has a population of over 20 million (Uduku et al., 2021). Lagos conurbation covers multiple administrative areas: Lagos Island, Lagos metropolis comprising 16 local administration, Lagos state and Lagos megacity, which covers the state of Lagos and its peri-urban areas (Uduku et al., 2021). The overarching administration and governance of various entities make Lagos a complicated urban system (De Gramont, 2015). Lagos's fast population expansion has resulted in urban sprawl, wetlands reclamation for buildings and infrastructure, and an increase in slum communities, with more than half of the city's citizens living in informal settlements.

[122] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 78
[123] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 83
[124] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 94
[125] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 29
[126] City of Addis Ababa, Addis Ababa Climate Action Plan, pg. 38

(Elias & Omojola, 2015; Lagos Resilience office, 2020; Ministry of Environment and Water Resources, 2020; Wale et al., 2018).

4.1.3.1 Sustainability and Climate Action

Lagos is at the forefront of climate change mitigation programs in Africa. The city has developed GHG emission reduction strategies across various pathways (Ministry of Environment and Water Resources, 2020). In 2008, Lagos established a climate change department with the Ministry for Environment and Water Resources (Ministry of Environment and Water Resources, 2020). The department leads the development and implementation of climate change mitigation programs. The Lagos resilience office was created to help build a resilient society through mitigation and adaptation actions (Lagos Resilience office, 2020). The Lagos Climate Action Plan was developed and published in 2021.

4.1.3.2 Technical Pathways: Lagos Nigeria

Lagos climate action focuses on waste management, energy and transportation. Energy in this context encompasses industrial energy use, buildings and building services. Waste sector emissions account for 25.3% of total GHG emissions in Lagos State. They are expected to rise significantly due to population growth and shifting consumption habits due to an increase in disposable income (Ministry of Environment and Water Resources, 2020). 55.1% of the total GHG emissions in Lagos are attributable to the energy sector (Ministry of Environment and Water Resources, 2020). Due to the inability of the national grid to supply enough electricity to meet the rising demand, users must rely on diesel generators as a backup during blackouts. Lagos has a daily vehicle population of 1 million, which results in significant traffic and pollution, hence decarbonization efforts also focus on the transportation sector (Ministry of Environment and Water Resources, 2020).

Table 4.10: Technical Pathways: Lagos, Nigeria

Variables	Findings

Energy/electricity	- 49% of grid electricity to be generated by renewables in 2050[127] - 80% of newly built commercial properties to use solar water heating by 2035[128] - 100% of residential properties to transition to solar water heating by 2050[129] - Installation of solar photovoltaic energy systems on government buildings and public facilities[130] - 1GW of installed PV capacity by 2030 with a proposed mix of 60 percent commercial and industrial, 20 percent residential and 20 percent government-owned buildings[131]
Buildings and building services	- The establishment of building energy efficiency rules to guarantee that structures take advantage of climatic conditions to decrease energy usage[132] - 100% of cook stoves to be electric by 2050[133] - 95% of existing buildings to use LED lighting by 2035[134] - Installation of solar photovoltaic energy systems on government buildings - The Lagos State Government retrofitted all its offices with energy-efficient lighting. The Lagos State Electricity Board is currently campaigning for energy-efficient lighting[135]
Industry	- Instituted incentives to ensure that 50% of industrial businesses effectively treat their wastewater[136] - Decarbonization of the industrial sector is based on the co-benefits of energy decarbonization
Transportation mode and fuel shifting	- Expansion of bus rapid transit (BRT), including the construction of four new bus terminals and deployment of low-emission buses[137] - Development of the light rail transit system (LRT)[138] - Launching of new ferry routes for commuters[139] - Imposition of restrictions on the use of high-polluting vehicles[140] - Lagos signed into law the non-motorized transport policy in 2018[141] - Reduce the share of private car travel from 11.5% of all trips (2015) to 2% by 2050[142] - Promote a 50% modal shift from motorcycles to bicycles by 2050[143]

[127] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 47
[128] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 47
[129] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 47
[130] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 49
[131] https://punchng.com/lagos-partners-world-bank-on-solar-power/
[132] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 47
[133] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 47
[134] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 47
[135] CDP, "2021 Full Cities Dataset. [Dataset]," 2022
[136] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[137] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiv
[138] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiv
[139] Lagos State Resilience Office, Lagos Resilience Strategy, pg.28
[140] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiv
[141] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiv
[142] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 39
[143] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 39

	- Promote an 80% modal shift from private cars to BRT by 2050[144] - 52% of buses (standard and BRT), 20% of motorcycles and 8% of taxis to be electric by 2050[145] - Increased use of biodiesel in freight vehicles[146] - Urban Rail Network into integrated e-platforms for transit riders will help improve journey planning for Lagosians[147]
Waste management	- Double waste collection rate to 90%[148] - Convert existing open dumps into sanitary landfills and capture methane to produce electricity[149] - Equip low-income communities with biodigesters to treat solid and liquid waste[150] - Install effluent treatment plants for 50% of industrial businesses for wastewater management by 2025[151] - Lagos aims to have 20 transfer loading stations by 2030 to improve waste collection and recycling capacities[152] - Development of Lagos waste initiative - Composting of 50% of organic waste by 2050[153] - Implementation of Lagos recycle Initiative[154] - Introduction of the Eko Clean Air project aimed at waste recovery and clean cooking[155] - Banning of pet bottles and single-use plastics in government agencies[156]
AFOLU	- Integrate green and nature-based ecosystem services into urban engineering solutions[157] - Planted 7 million trees since 2008[158] - Lagos is not considered an agricultural state, as most food is imported from other locations[159] - Upstream AFOLU sector GHG reductions through the utilization of compost for urban agriculture or in place of synthetic fertilizers[160]

[144] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 39
[145] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 39
[146] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 39
[147] Lagos State, Lagos Resilience Strategy, pg. 53
[148] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[149] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[150] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[151] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[152] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 26
[153] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 27
[154] https://lagosstate.gov.ng/blog/2020/12/18/lawma-launches-lagos-recycle-initiative/
[155] https://www.vanguardngr.com/2022/09/lasepa-flags-off-eko-clean-air-project-in-eti-osa-lga-community/
[156] https://www.thisdaylive.com/index.php/2022/07/21/fasawe-lagos-state-will-reduce-burning-of-fossil-fuel/
[157] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 55
[158] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 6
[159] Interview session with climate professional in Lagos state government
[160] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 31

4.1.3.3 Institutional strategy: Lagos Nigeria

Table 4.11: Institutional strategy: Lagos Nigeria

Engagement	- Develop institutional frameworks for community involvement in developing climate resilience guidelines for new city infrastructure[161] - The state climate change forum is a platform for the engagement of all stakeholders[162] - Waste separation at source and organic waste diversion programs feature community advocacy campaigns[163] - Establishment of summer schools targeting young kids - Lagos Metropolitan Area Transport Authority (LAMATA) has a dedicated YouTube channel for disseminating information - Launched a media program called EnvironTalk for engagement
Technical capacity building	- Improvement of permitting process for new builds[164] - Lagos Waste Management Agency (LAWMA) provides internships for students of tertiary institutions[165] - Lagos Waste Management Agency (LAWMA) provides specialty training in Resource Recovery and waste management, Smarter Solutions for Segregation and Logistics, Fleet Management, Waste Recycling[166]
Green economy	- The city has many circular economy actions, such as – developing a circular economy map for the city and improving construction standards and waste recovery programs - Material Recovery Facilities (MRF) will also be constructed as they play a pivotal role in improving the solid waste sector[167] - Reopening of the moribund composting facility for the production of organic manure - Deployment of the PAKAM app for effective management of recyclable waste in real-time[168] - Integrate green and nature-based ecosystem services into complex engineering solutions
Financing	- Funding for projects comes from several sources like national government, partner organizations, donor organizations and state government - State government loans and grants in collaboration with PPP - Community-saving groups - Finance raised through taxes - User fees

[161] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xv
[162] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xvii
[163] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 30
[164] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 51
[165] https://www.lawmaacademy.com/internship
[166] https://www.lawmaacademy.com
[167] https://www.vanguardngr.com/2015/05/from-stinking-waste-to-recovered-wealth-the-story-of-a-lagos-dump-site/
[168] https://lagosstate.gov.ng/blog/2020/12/18/lawma-launches-lagos-recycle-initiative/

	- Transfers and bonds within the municipality and through other spheres of government[169] - International sources such as bilateral and multilateral donors - Concessional finance and funds - Co-financing through public-private partnerships - Market-based approaches - Private sector investments - Business organization - African Development Bank in pursuing carbon credits[170]
Behavioural intervention tools	- Institute incentives to ensure 50% of industrial businesses effectively treat their wastewater[171] - Introduce incentives for non-motorized transport. - The production and distribution of colour-coded bags and sorting bins, and the establishment of a monitoring team to ensure compliance with the new systems[172] - Prioritizes the movement of people (walking and cycling), rather than the movement of cars, through an infrastructure Investment program focussed on developing a continuous network of sidewalks and cycle lanes[173] - Introduction of "trash for Cash" program to engage and motivate the populace on circular economic growth[174]
Regulatory and policy tools	- Improve regulatory oversight of the ferry services - Introduce new requirements for spatial planning to promote transit-oriented development. - Establishment of mobile courts for enforcement and prosecution of environmental crime suspects[175] - Harmonization of all environmental laws under the Lagos State Environmental Management and Protection Law 2007[176]
Long term plan	- The population of Lagos is projected to double by 2050.

4.1.3.4 Governance mechanism – Lagos, Nigeria

Table 4.12: Governance mechanism – Lagos, Nigeria

Variables	**Findings**

[169] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 70
[170] Transforming Urban Transport – The Role of Political Leadership. Case Note: Lagos 2019, Pg.4
[171] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[172] http://lagosstate.gov.ng/blog/2019/09/05/lagos-begins-rapid-waste-recycling-as-sanwo-olu-launches-blue-box-initiative/
[173] https://www.lamata-ng.com/non-motorized-transport/
[174] https://punchng.com/lasepa-begins-clean-air-initiative-backs-economic-growth/
[175] https://guardian.ng/features/law/how-enforcement-of-lagos-traffic-law-mobile-court-sittings-smack-of-well-organised-racket-for-officers/
[176] Ministry of Environment and Water Resources, Lagos Climate Action Plan

Decision Making	- There exist three climate change governance entities: the State council on climate change, state technical committee on climate change and the state climate change forum[177] - The state climate change council chaired by the state governor is responsible for overall decision-making on climate change[178] - The technical committee recommends a mitigation program for state council approval - The climate change forum is a platform for identifying, discussing, and mainstreaming climate change topics[179] - Lagos's climate change decision-making framework is parallel to the state executive (political) council[180]
Coordination	- Climate change programs coordination is done through the climate change secretariat - The secretariat is the clearinghouse for all knowledge and materials relating to climate change in the state, including documents, data, agreements and instruments[181]
Monitoring and reporting	- Lagos state is using existing Nigeria's monitoring and reporting framework[182] - Monitoring and reporting entail the review of the execution status of climate action plans against an established set of Key Performance Indicators (KPIs) - Dissemination of the Biennial City Resilience Report[183]
Communication	- Information dissemination through digital means has enormous potential - Development and improvements of the Lagos BRT mobile app can include regular updates on transit status and anticipated travel times; maps and schedules for bus, rail and ferry services[184] - Dissemination of the Biennial City Resilience Report [185]
Collaboration and partnership	- The Climate Change Department of the Lagos State Ministry of the Environment is the secretariat for climate change-related issues in the State. The Climate Change Department works closely with the Federal Ministry of the Environment to achieve the goals of the NDC and the Paris Agreement. The State has a designated Climate Change desk officer who liaises with the National Government on climate action via a series of meetings, workshops and training[186] - Lagos state collaborates with technical stakeholders in the area of Climate Action Plan consultation[187]

[177] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xvi
[178] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xvii
[179] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xiii
[180] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. xvi
[181] Ministry of Environment and Water Resources, Lagos Climate Action Plan, pg. 69
[182] Lagos State, Lagos Resilience Strategy, pg. 60
[183] Lagos State, Lagos Resilience Strategy, pg. 60
[184] https://businessday.ng/opinion/article/creating-convenient-user-experience-for-lagos-commuters-designing-the-brt-app/
[185] Lagos State, Lagos Resilience Strategy, pg. 60
[186] CDP, "2021 Full Cities Dataset. [Dataset]," 2022
[187] CDP, "2021 Full Cities Dataset. [Dataset]," 2022

	- Lagos is partnering with civil society and the general public in the "adopt-a-bin" program[188] - Lagos Metropolitan Area Transport Authority (LAMATA), in partnership with the German Agency for International Development (GIZ), Transformative Urban Mobility Initiative (TUMI) program and Walk21 Foundation, has implemented a sidewalk pilot project[189] - Public-private Partnership with OANDO PLC in the area of electric vehicle infrastructure development for public transportation[190]
Multi-level integration	- Nigeria's NDC targets generating 30% of electricity using renewable energy technology by 2030. - National Renewable Energy and Energy Efficiency Policy (NREEEP) is a vital policy for Lagos State, as it aims to reduce reliance on small-scale diesel generators for electricity production.
Governance mode	- Self-regulating – There is no clear target or known action on corporate emission targets. GHG emission inventory of institutional buildings completed - Enabling - Stakeholder involvement and capacity building on energy-saving measures, including media/PR campaigns and community networks-based local training programmes for homeowners and installers - Provisioning - investments in social infrastructure and service delivery - Authority – through regulatory frameworks like criminalizing dumping and open burning - Over-centralization of governance in Lagos state is eroding last-mile governance[191]
Socioeconomic influence (co-benefits)	- Environmental benefits: utilization of compost for urban agriculture or in place of synthetic fertilizers, improved air quality from reduced use of diesel, kerosene and other fuels - Social Benefits: Enhanced social infrastructure, mobility and accessibility, - Economic benefits: New local industry development, job creation, cost saving for reduced energy used.

[188] https://guardian.ng/tag/adopt-a-bin-programme/
[189] https://walk21.com/work/projects/lagos-sidewalk-challenge/
[190] https://www.oandoplc.com/press_release/lamata-oando-sign-mou-to-launch-electric-mass-transit-buses-june-6-2022/

[191] https://carnegieendowment.org/2022/07/18/halting-kleptocratic-capture-of-local-government-in-nigeria-pub-87513

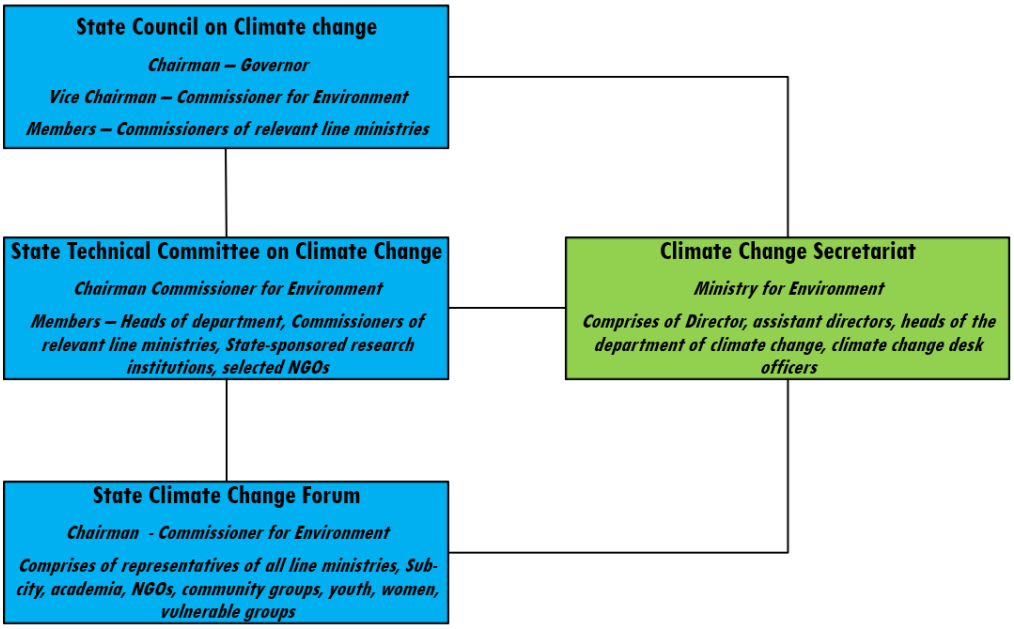

Figure 4.3 – Organizational chart for the city of Lagos (Ministry of Environment and Water Resources, 2020, pg. 69)

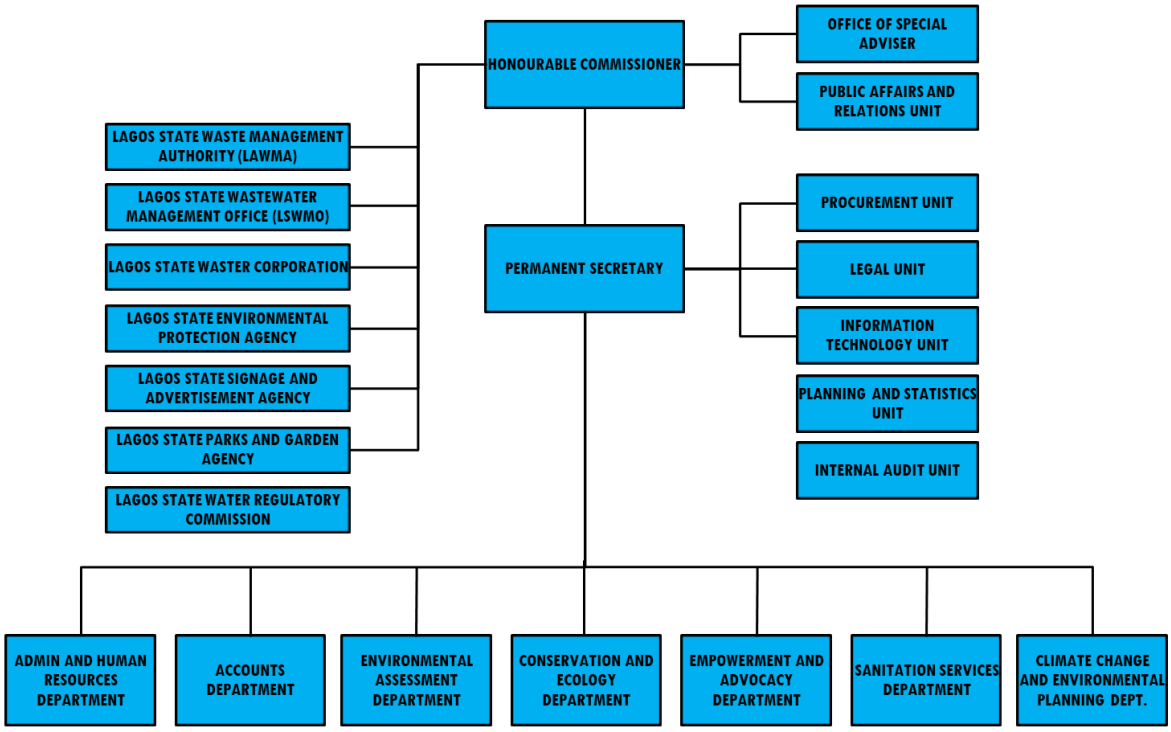

Figure 4.4 – Organizational chart for the city of Lagos Environment services (Ministry of Environment and Water Resources, 2020, pg. 73)

4.1.3.5 Actors: Lagos, Nigeria

Table 4.13: Actors: Lagos, Nigeria

Private sector	- Through private-public partnerships, the Private sector provides concessional finance and fund - The private sector engagement in climate action planning is minimal - The establishment of a Material Recovery Facility via a Public Private Partnership[192] - Bottling companies in Lagos are supporting the funding of advocacy and education programs on pollution[193]
Civil Sector	- Lagos State Waste Management Authority (LAWMA) has also received support from development agencies such as the World Bank, the Clinton Foundation, and the U.S. Agency for International Development (USAID)[194] - LAMATA benefited from World Bank protection[195] - Stakeholder workshop to develop guidelines and template for private sector participation in the water transport sector
Traditional Institution	- Lagos State Resilience Office (LSRO) conducted a series of stakeholder engagements involving individuals, communities, traditional rulers, academia, civil society, businesses and government MDAs[196] - Traditional institutions and leaders are considered part of the state climate change forum and the climate stakeholder groups in the development of Lagos CAP - The Board of Traditional Medicine is engaged in policy development[197]
Educational institution	- LASRO conducted a series of stakeholder engagements involving individuals, communities, traditional rulers, academia, civil society, businesses and government agencies - Lagos climate forum and technical committee include the academia for research and development support
Government	- LASRO conducted a series of stakeholder engagements involving individuals, communities, traditional rulers, academia, civil society, businesses and government MDAs

[192] CDP, "2021 Full Cities Dataset. [Dataset]," 2022
[193] https://www.thisdaylive.com/index.php/2022/07/21/fasawe-lagos-state-will-reduce-burning-of-fossil-fuel/
[194] https://carnegieendowment.org/2022/07/18/halting-kleptocratic-capture-of-local-government-in-nigeria-pub-87513
[195] http://documents.worldbank.org/curated/en/292191468291930528/Nigeria-Lagos-Metropolitan-Area-Transport-Authority-LAMATA-Project-procurement-plan
[196] https://www.lagosresilience.net/
[197] https://www.premiumtimesng.com/health/health-news/552134-lagos-unveils-handbook-to-regulate-traditional-medicine-practice.html

4.1.4 Nairobi, Kenya - Sustainability and climate mitigation action plan

Kenya's capital and largest city, Nairobi, is also one of the cities in East and Central Africa with the fastest population growth. Its socioeconomic activities, infrastructure, and population distributions are complex in both time and space. Rapid population growth, unplanned settlement, and urban poverty put the city under pressure to take steps to address and adapt to climate change (Nairobi City County, 2020a).

4.1.4.1 Sustainability and climate action

In 2016 Nairobi developed its GHG inventory following global best practices. Results from the inventory showed that in 2016, total GHG emissions in the city of Nairobi amounted to 4.7 MtCO2e, equivalent to 1.2 tCO2e per capita (Nairobi City County, 2020b). There have been some local efforts to improve air quality in the last decade. The Air Quality Policy and Action Plan (2019-2023) was developed by the Nairobi City County Government in collaboration with UN Environment and the Stockholm Environment Institute (Nairobi City County, 2019, 2020a). The city government is currently developing the Nairobi Air Quality Bill and Regulations, which will soon be passed into law by the county assembly of Nairobi. Plans for climate mitigation have also benefited from Nairobi's changes in governance. The Nairobi Metro 2030 Transport Plan, which promotes a modal shift and more effective mobility within the metropolis, was published by Nairobi City County in 2008 (Nairobi City County, 2020a). In 2010, the city's integrated solid waste management plan was created. The city of Nairobi committed to becoming carbon neutral by 2050 in a letter signed in 2018 (Nairobi City County, 2020a). As part of the city's integrated development plan, the city also plans to reduce vehicle emissions and solid waste. The Nairobi Climate Action Plan (CAP) was created as a result of all these plans in 2021 (Nairobi City County, 2020b).

4.1.4.2 Technical Pathways: Nairobi, Kenya

Technical pathways for decarbonization in Nairobi are categorized by the effectiveness of emissions reductions and by sector - buildings, transportation, electricity, land use planning and waste management, based on Nairobi’s 2016 Greenhouse Gas Inventory (GHG) data.

Table 4.14: Technical Pathways: Nairobi, Kenya

Variables	Findings
Energy/electricity	- The city administration has limited influence on grid decarbonization - 30% reduction in GHG emissions by 2030[198] - 80% of the energy mix coming from renewable sources by 2030 [199] - Increase adoption of renewable energy - Develop Minimum Energy Performance Standards (MEPS) for appliances[200] - Plans are underway to establish street solar lighting programs through the Green Climate Fund[201]
Buildings and building services	- Building codes for enhanced energy efficiency in buildings - Awareness campaign targeted at property owners to encourage uptake of building-integrated renewables, e.g. PV or solar hot water systems - Identify buildings or zones that are suitable for local renewable energy systems and where the Nairobi City County (NCC) has a greater ability to influence uptake and undertake detailed feasibility studies to determine appropriate technologies[202] - Review the building permitting process to ensure that it encourages the use of on-site renewable heat or power generation where appropriate[203] - To further promote clean cooking government has also discounted LPG (Liquefied Petroleum Gas) stoves to promote their use[204] - The large rollout of the Kenya Slum Upgrading Programme (KENSUP) programme to all city slums will be a crucial lever to the higher use of electricity for lighting through solar lamps[205]
Industry	- Work with local businesses to identify any efficiencies that can be achieved (such as waste heat reclamation on industrial sites) and facilitate their implementation[206] - Increased efficiency could be achieved through developing policies or regulations that encourage strict enforcement of the Act (actions to improve efficiencies of charcoal kilns and formalize the sector) and NCCAP (promotion of efficient kiln technologies) towards industrial energy efficiency[207]
Transportation mode and fuel shifting	- Nairobi's non-motorized transport policy was developed in 2015 and aimed at 600,000 tCOe reduction per year by 2050[208]

[198] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 31
[199] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 22
[200] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 45
[201] CDP, "2021 Full Cities Dataset. [Dataset]," 2022
[202] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 46
[203] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 46
[204] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 48
[205] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 74
[206] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 46
[207] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 74
[208] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 26

	- The project will reduce vehicle emissions in the project area by up to 50% thanks to the restrictions on cars and the new infrastructure for non-motorized transportation[209] - Increased Non-Motorised Transportation (NMT) space coverage, increased services along NMT facilities, safe NMT crossings (street signals, footbridges, underpasses, marked crossings) and Improved NMT user satisfaction[210] - Development of a Bus Rapid Transit (BRT) - Rehabilitation of the railway system to increase capacity from 5 million annual passengers to 60 million[211] - Enacting structural changes to accommodate the deployment of a rapid bus transit system[212] - Revised bus and rail lines shift from a radial to an orbital transportation system - Adoption of improved vehicular efficiency standards for road transport - Improvement of non-motorized transport (NMT) facilities - Decongestion and traffic are directed out of the central business district - Improved air quality through the beautification and planting of trees and improved urban mobility with more cycling lanes and pedestrian walkways - Local EV motorcycle manufacture is already planned[213]
Waste management	- Establishment of transfer points across the city for waste segregation and sorting[214] - Enforce existing by-laws for waste collection and sorting - Establish circular economy community projects to encourage reuse and communicate the benefits (e.g., revenue) - Investment plan in Solid Waste Management. This includes material recovery facility and transfer stations[215] - Construct climate-proofed sanitary landfill in the city, establish, repair and upgrade waste collection facilities - The Dandora dumpsite has undergone some changes to help manage the waste efficiently by introducing the weighbridge at the dumpsite to know disposal vis-à-vis collection and generation[216] - Establish treatment centres for recycled waste - Install landfill methane gas capture technology[217] - Monthly clean-up program development and sustainment aimed at waste source separation and segregation[218] - Ongoing development of a biogas power plant that is planned to be fed with local organic waste[219]

[209] https://www.c40.org/case-studies/nairobi-luthuli-avenue/
[210] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 37
[211] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 38
[212] Nairobi City County, County Integrated Development Plan 2018 – 2022, pg. 119
[213] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 124
[214] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 43
[215] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 51
[216] Nairobi City Council, Air Quality Action Plan 2019 – 2023 Pg. 9
[217] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 52
[218] https://www.c40.org/cities/nairobi/
[219] https://www.c40.org/cities/nairobi/

AFOLU	- Landscaping and planting of grass in open spaces to reduce erosion and beautify the city[220] - Protection of public open spaces, greenbelts, forest reserves, water bodies, wetlands, water catchment areas and other ecologically sensitive areas from physical development and urban encroachment[221] - Expansion of tree nursery at city park and promotion of tree nursery establishment and management[222] - Regulation of tree cutting, pruning and movement[223] - Promotion of agroforestry, mainly in the peri-urban sub-counties, following the farm forestry rules of 2009[224] - Promotion of climate change adaptation and mitigation technologies [225] - No data available for the AFOLU sector

4.1.4.3 Institutional strategy: Nairobi, Kenya

Table 4.15: Institutional strategy: Nairobi, Kenya

Variables	**Findings**
Engagement	- Stakeholders were engaged in the scoring and prioritization process[226] - Stakeholder participation and engagement have been deployed throughout the development process as a critical element of modern administration and decision making[227] - Engagements include surveys and meetings - Launched a campaign at the household level on the perception of waste as a resource and encouraged recycling and reuse[228] - Conduct and enhance participatory planning approaches, Enhance participatory planning and decision with communities[229] - Organize community conversations to discuss issues of development and community exchange programs[230] - Training of youths on topical issues such as climate change mitigation and Peacebuilding [231]
Technical capacity building	- Development of Nairobi Metro 2030 transport plan in 2008 - Nairobi City County strategic plan (2016-2020) – 2015 - Integrated solid waste management plan – 2010

[220] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 40
[221] Nairobi City County, Climate Action Plan 2020 – 2050, pg. 40
[222] Nairobi City County, County Annual Development Plan 2022/2023, pg. 32
[223] Nairobi City County, County Annual Development Plan 2022/2023, pg. 33
[224] Nairobi City County, County Annual Development Plan 2022/2023, pg. 95
[225] Nairobi City County, County Annual Development Plan 2022/2023 Pg. 95
[226] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 16
[227] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 16
[228] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 43
[229] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 53
[230] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 61
[231] Nairobi City County, County Annual Development Plan 2022/2023 Pg. 103

	- Country-integrated development plans[232] - Build the capacity of city planners on climate change issues - Build capacity of NCC government officials to monitor and report air quality data[233] - Prioritization process for adaptation actions, using a apid Climate Risk Assessment (CRA) as the foundation[234]
Green economy	- Rolled out a pilot project on circular economy in Ruaraka Light Industries in partnership with various government agencies[235] - Establish circular economy community projects to encourage reuse and communicate the benefits (e.g. revenue) - There is no clear green or sustainable economy plan in Nairobi city plans
Financing	- Development of a Climate Change Fund policy, and the city is already working towards developing regulations to access climate change funds at the county level, which includes opening a special-purpose account to receive climate change funds[236] - Addressing climate change in Nairobi will need financial support from the international community, such as the Global Environment Facility (GEF), banks and bilateral funds, alongside domestic funding from the county government of Nairobi, the national government budget, the private sector and other related international and regional organizations[237] - Nairobi Metropolitan Area Transport Authority (NAMATA) has some partners and donors committed to funding the BRT. Some options include development partners, World Bank, investment banks, African Development Bank (AfDB), and GCF, has different financing mechanisms - loans, grants, and equity through accredited institutions, e.g. NEMA, KCB etc.[238]
Behavioural intervention tools	- Development of a new master plan to decentralize services away from the Central Business District (CBD)[239] - Development of a pricing strategy that will suppress demand for on-street parking[240] - The government seeks to revolutionize the public transport scenario through targeted investments, road improvement, marking and signage - Develop and implement an incentive-based compliance promotion programme among the regulated community[241] - Promotion of public education on tree growing and composting[242] - A levy on kerosene has also been introduced, which has resulted in prices increasing by more than 40% since its introduction in 2018[243]

[232] Nairobi City County, County Annual Development Plan 2022/2023
[233] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 41
[234] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 73
[235] Nairobi City County, County Annual Development Plan 2020/2021 Pg. 71
[236] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 68
[237] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 68
[238] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 38
[239] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 40
[240] Nairobi City County, County Integrated Development Plan 2018 – 2022 Pg. 138
[241] Nairobi City Council, Air Quality Action Plan 2019 – 2023 Pg. 24
[242] Nairobi City County, County Annual Development Plan 2022/2023
[243] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 48

Regulatory and policy tools	- 2% of the County's budget earmarked for sustainable energy and climate change response[244] - Enforcement of traffic and public order rules - Enforce existing by-laws for waste collection and sorting. - Mainstream climate actions into development planning, decision making and implementation in all sectors of the economy - Establishment of a Nairobi Air Quality Bill
Long term plan	- The city is also committed to periodically reviewing and updating the climate action plan to explore opportunities to increase ambition in the future and strengthen the mainstreaming of climate change in the city processes, particularly the County Integrated Development Plans (CIDPs) and Annual Development Plans (ADPs)[245]

4.1.4.4 Governance mechanism – Nairobi, Kenya

Table 4.16: Governance mechanism – Nairobi, Kenya

Variables	**Findings**
Decision Making	- Counties are mandated to plan and implement their climate mitigation actions and set up the necessary infrastructure to drive their agendas on climate change through policies, laws and strategies, all developed in the city and ratified by its law-making arm[246] - The county government, which comprises the country executive and the county assembly, is also responsible for the implementation of policies set at the national level[247] - The wards are administrative units and are responsible for supporting, coordinating and managing administrative functions at the grassroots level, particularly community- and neighbourhood-based initiatives
Coordination	- Within the city of Nairobi, the Environment and Natural Resources Department has primary responsibility for climate change-related programs[248] - The County Climate Change Unit (CCU) has been established, and the CECM responsible for coordinating climate change affairs has been appointed[249] - The CCU is being morphed into a ministry with two directors in charge of climate change and energy, which minister and two directors will lead, respectively[250]
Monitoring and reporting	- Start to implement new building standards while undertaking monitoring and evaluation of compliance[251]

[244] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 22
[245] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 13
[246] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 20
[247] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 20
[248] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 19
[249] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 15
[250] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 15
[251] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 53

	- Establish an annual survey of the waste flow value chain - County Climate Change Unit (CCU) has been established, and the CECM responsible for coordinating climate change affairs has been appointed. Monitoring the institutional structures articulated includes the establishment of county Sectoral Project Planning & Monitoring Units (SSPMUs), which should include appointing M&E officers in each sector to coordinate monitoring, evaluation and reporting[252] - Sharing of key performance indicators through a public reporting platform to ensure the city's accountability and to engage with members of the public in a transparent manner[253] - Raising public awareness of the health and environmental impacts of air pollution[254]
Communication	- Design and undertake stakeholder engagement and awareness raising amongst building developers, construction companies, building owners/managers and the public[255] - Development of training manual, toolkit and handbook for implementation and enforcement of air quality legislation[256] - County Communication Platform and Strategy obligates the county government to integrate communication in all its development activities. The county government must establish an effective communication and sensitization framework using various media forms targeted at the broadest selection of stakeholders in the county - The use of community event - Social media
Collaboration and partnership	- The Air Quality Policy and Action Plan (2019-2023) which was developed by the Nairobi City County Government in collaboration with UN Environment and the Environmental Compliance Institute (ECI)[257] - Nairobi is committed to engaging and establishing formal partnerships with multiple stakeholders at different levels and with the national government[258] - NAMATA has some partners and donors committed to funding the BRT [259] - Nairobi City County has compiled the greenhouse gas inventory, C40 Cities, Sustainable Energy Africa with support from state agencies, evelopment partners, civil, business and community organizations, the media, academia and private sector stakeholders[260]
Multi-level integration	- Keep informed of ongoing work that is being undertaken to develop green building standards with UNDP and adjust the sub-actions where appropriate[261]

[252] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 69
[253] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 69
[254] Nairobi City Council, Air Quality Action Plan 2019 – 2023 Pg. 24
[255] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 49
[256] Nairobi City Council, Air Quality Action Plan 2019 – 2023 Pg. 24
[257] Nairobi City Council, Air Quality Action Plan 2019 – 2023 Pg. 3
[258] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 27
[259] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 38
[260] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 15
[261] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 49

	- Collaborative delivery and vertical integration between Nairobi's city government and the Ministry of Environment on the implementation of circular economy principles[262]
Governance mode	- Self-regulating: The City of Nairobi does not regulate corporate emission reduction because there is no sign of activity or a plan - Enabling through community engagement, education and events - Provisioning through public infrastructure investments and the provision of services such as fast transit systems and non-motorized modes of transportation infrastructure - Authority through some regulations regarding parking and city planning restrictions
Socioeconomic influence (co-benefits)	- Environmental benefits: air quality improvements through the reduction in pollutant concentrations. There is also an improvement in noise pollution. - Social Benefits: Enhanced social infrastructure, reduced fatalities and injuries among pedestrians, safer connections and employment opportunities in the construction mobility and accessibility. - Social Benefits: Reduces risk of flash flooding and associated disease outbreak. - Economic benefits: New local industry development, job creation, cost saving for reduced energy used.

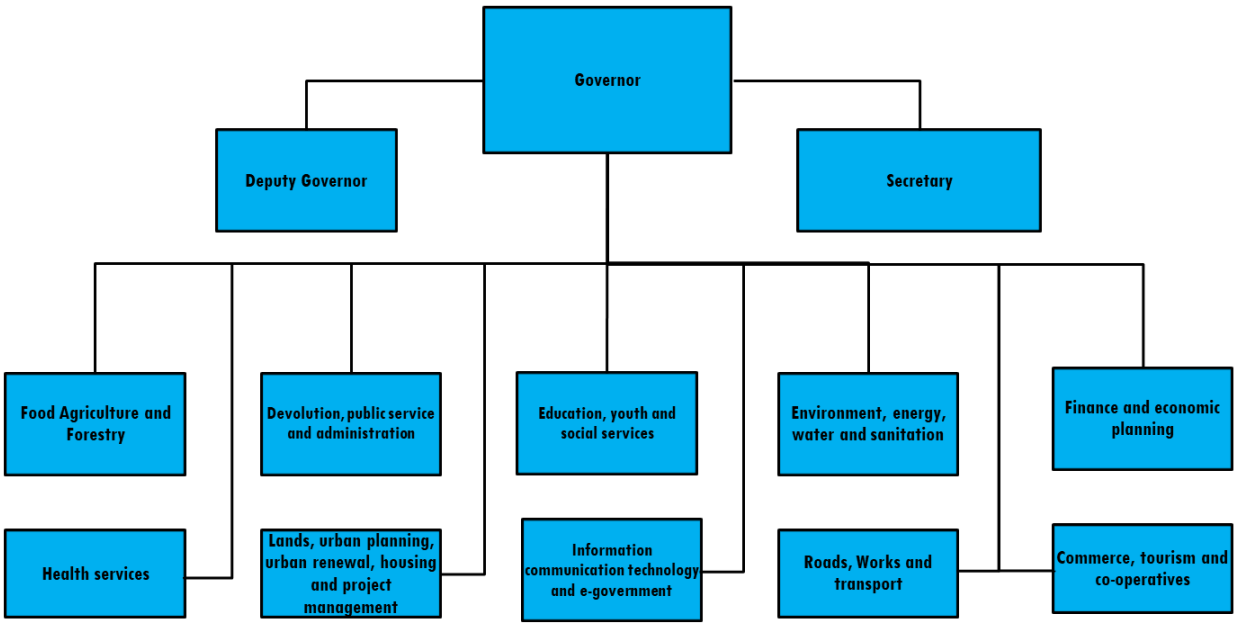

Figure 4.5 - Organizational chart for the city of Nairobi (Nairobi City County, 2020b, pg. 15)

[262] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 42

4.1.4.5 Actors: Nairobi, Kenya

Table 4.17: Actors: Nairobi, Kenya

Variables	Findings
Private sector	- Nairobi banks on PPP for renewable energy development plans[263] - Work with local businesses to identify any efficiencies that can be achieved (such as waste heat reclamation on industrial sites) and facilitate their implementation[264] - The greenhouse gas inventory has been compiled by Nairobi City County Government sectors (led by the Environment sector), Development partners, Civil, Business and Community Organizations, the media, academia and private sector stakeholders[265]
Civil Sector	- NAMATA has some partners and donors committed to funding the BRT. Some options include Development partners, World Bank, Investment banks, AfDB, and GCF, has different financing mechanisms - loans, grants, and equity through accredited institutions[266] - The greenhouse gas inventory has been compiled by Nairobi City County government sectors (led by the environment sector), development partners, civil, business and community organizations, the media, academia and private sector stakeholders.[267] - Technical assistance and transfer of knowledge will be necessary for institutions like NAMATA
Traditional Institution	- Traditional institution is non-existent in Kenya
Educational institution	- Installed ten mobile air quality real-time monitors in partnership with the University of Nairobi[268]
Government	- City governments can allocate funding to projects related to public sector buildings and coordinate with PPPs with support from national government[269] - The national government is pivotal in developing and enforcing national-level policies[270] - Kenya Forest Services (KFS) collaboration in tree planting[271]

[263] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 45
[264] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 46
[265] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 15
[266] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 28
[267] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 28
[268] Nairobi City Council, Air Quality Action Plan 2019 – 2023 Pg. 24
[269] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 45
[270] Nairobi City County, Climate Action Plan 2020 – 2050 Pg. 62
[271] Nairobi City County, County Annual Development Plan 2020/2021 Pg. 123

4.2 Cross-Case Evaluation

The variables from each section were categorized and inductively coded for keywords in a cross-case comparison. The tables highlight any patterns that may emerge across the case studies. The evaluation of each element of this research across each case city for emergent pattern, themes and trends. Table 4.18 shows the cross-case evaluation of technical pathways, table 4.19 shows cross-case evaluation of institutional strategy and the cross-examination of governance mechanisms across all case cities is presented in table 4.20 while the cross-review of climate actors is presented in table 4.21.

4.2.1 Technical Pathways

Table 4.18: Cross-case evaluation of technical pathways

Technical Pathway	Accra	Addis Ababa	Lagos	Nairobi
Energy	No Target	No Target	49% RE by 2050	30% reduction in GHG
	Solar-powered street lighting program	Development of a large hydropower project	1GW of installed PV capacity by 2030, Installing renewable energy systems, building scale RE, electricity regulation lobby	Development of energy efficiency standards, solar-powered street lighting program
Building & Building services	50% of buildings are fitted with solar photovoltaic systems	100% Solar water heaters by 2030, 90% of residential buildings to electric stoves by 2050	100% electric cook stoves by 2050	Uptake of efficient cookstoves
	Development of green building rating system, building retrofit	Fixing permitting process for new builds	Permitting process for new builds regulation, government building retrofit	Regulation, awareness, building code
Industry	45% of industrial operators to electric	95% of industrial energy to electricity by 2050, 60% industrial efficiency increase by 2050	No Target	No Target
	Industrial energy efficiency guidelines	Large hydropower development	Incentives	Policy, regulation

Transportation mode and fuel shifting	90% of buses will be powered by electricity by 2050, and 40% of trips through Non-Motorized Transportation (NMT) in 2050	10% electric transit by 2050	EV transit, 50% modal shift from motorcycle to bicycle	600,000 tCOe reduction per year by 2050, Electronic motorcycle assembly
	Infrastructure investment, low-emission policies, user-friendly platform and network, NMT infrastructure development	Low-emission transit infrastructure investment, NMT infrastructure development	Transit infrastructure investment, water transport development, regulation, NMT infrastructure development	Infrastructure development, regulation, NMT infrastructure development
Waste management	100% eradication of open dumping of organic waste, Harnessing of 65% of landfill gas by 2030	Diversion of 70% Organic waste by 2050	Composting of 50% of organic waste by 2050, 90% waste collection by 2050	No Target
	Regulation, infrastructure investment	Landfill gas capture, waste management facility investment	Policy, regulation, development of waste management infrastructure, Landfill gas capture, Waste to energy	Landfill gas capture, Awareness, engagement, infrastructure development, decentralized WTE systems
AFOLU	No Target	No Target	No Target	No Target
	Policy Development, restoration of local green spaces	Restoration of local sink, afforestation and biodiversity enhancement program	Afforestation and tree planting programs	Green space protection, regulation

4.2.2 Institutional strategy

Table 4.19: Cross-case evaluation of institutional strategy

Institutional strategy	Accra	Addis Ababa	Lagos	Nairobi
Engagement	Community-wide	No strategy	Climate change forum	Community-wide, technical experts
	Trade unions, traditional institutions		Community programs, camps	Community exchange program, surveys, meetings, prioritization

	Townhall meetings, social media		Social media	Youth training programs,
Technical capacity building	Technical scenario modelling, task forces for personnel development, technical report	Technical scenario modelling, academic partnership	Personnel development, technical scenario modelling	Internal capacity development for climate change, technical scenario modelling, strategic planning
Green Economy	Circular economy roadmap, workforce development	Green economic development policy	Circular economy plan, funding for innovation, and green tech	Green industry, local business partnership, community green economic program
Financing	Private-public partnership, private sector, special purpose financing vehicles, donor organizations, national government	Bonds, efficient tax collection, international donors	Local government funds, higher government, green bonds, private sector, PPP, donor partners	Special climate funds, international donors, national government, and local government funds
Behavioural intervention	Financial incentives, Infrastructure development	Awareness campaign	Financial incentives for industry and transportation, Infrastructure development	Decentralization, service pricing strategy, infrastructure development, public education
Regulation and policy	Building standards, policy enforcement, policy document	Transport strategy, waste management policy, social development plan, policy document	Self-regulating, voluntary stretch code, local bylaws, policy document	Enforcement, by-laws, self-regulating, policy document
Long Term Plan	Political engagement, communication funding			Short term strategy + long term pathway – sustainability embedded in other city planning, climate program periodic update

4.2.3 Governance mechanism

Table 4.20: Cross-case evaluation of governance mechanism

Governance Strategy	Accra	Addis Ababa	Lagos	Nairobi
Decision making	Climate steering committee	City administration	Council on climate change, technical	Environment and Natural Resources

			committee on climate change and the climate change forum, executive council	Department, County government
Coordination	Resilience and Sustainability Unit	Environmental Protection and Green Development Commission	Climate change secretariat	County Climate Change Unit
Monitoring and reporting	Quarterly review, field visits, annual report, impact evaluation	Weekly, monthly and annual updates, vertical and horizontal reporting	Periodic review, utilizing existing national framework	Periodic evaluation, Detail plan to be developed, plan to build on existing national framework
Communication	Community events, mass media, social media, traditional and religious events, meetings	Community focal persons	Technology, social media, mass media	Technology, social media, community events, handbook
Collaboration and partnership	Collaborative partnership for implementation	Collaborative partnership for implementation	Public-private partnerships for implementation	Collaborative partnership of stakeholders – cross-sector
Multi-level integration	Top-down – Policy is pushed down the societal strata	Top-down	Top-down	Top-down
Governance mode	Enabling, provisioning	Enabling, provisioning, and authority	Self-regulating, Enabling, provisioning, and authority	Enabling, provisioning, and authority

4.2.4 Actors

Table 4.21: Cross-case evaluation of actors

Actors	Accra	Addis Ababa	Lagos	Nairobi
Private sector	Implementation, facilitating, consulting	Implementation, enabling, coordinating, facilitating, funding	Coordinating, facilitating, funding	Implementation, coordinating, facilitating, consulting
Civil sector	Decision-making, implementation,	implementation, enabling,	Implementation, enabling,	Implementation, enabling,

	enabling, coordinating, funding	coordinating, funding	coordinating, funding	coordinating, funding
Traditional actors	Consulting, leadership, coordinating	Consulting, leadership, coordinating	Consulting, leadership, coordinating, facilitating	N/A
Educational Institution	Consulting implementation, enabling	Consulting implementation, enabling	Consulting implementation, enabling	Consulting, enabling
Government	Decision-making, implementation, leadership, enabling, coordinating, regulation, facilitating, funding.	Decision-making, implementation, leadership, enabling, coordinating, regulation, facilitating, funding	Decision-making, implementation, leadership, enabling, coordinating, regulation, facilitating, funding	Decision-making, implementation, leadership, enabling, coordinating, regulation, facilitating, funding

4.3 Deep decarbonization in cities in the global south vs. north

Understanding deep decarbonization across the global south and north divide is a key framework of this study. Table 4.22 compares the deep decarbonization elements and practices in the cities of Sub-Saharan Africa with European and North America cities. This helps in identifying the unique approaches being used to combat climate change.

To compare the deep decarbonization elements and practices between the global north and south, this study utilized the result of a similar study which studied deep decarbonization in selected European and North American local governments and cities (Linton, 2020; Linton et al., 2022). The comparison reviewed the actions, inactions and programs being implemented by the cities of sub-Saharan Africa for all deep decarbonization pillars and the elements of these pillars. These action programs and its categorization is based on the findings from content and data analysis. These actions and inactions were compared with the findings of Linton (2020). The comparison identifies where a particular action is implemented across all case cities as “present”, implementation in more than one case city as “partially

present" while "absent" represents an inaction or non-existence of this program or action in any of the case cities.

Table 4.22 – Comparison of Deep decarbonization action plan across the global south and north divide

Deep decarbonization pillar	Elements of research	Actions	Sub-Saharan African cities	Cities in developed nations (Linton, 2020; Linton et al., 2022)
Technical Pathways	Electricity /energy	Increased municipal usage of RE	Partially present	Present
		Decentralized waste-to-energy systems	Present	Absent
	Buildings and Building Services	Set KPI for municipal energy use	Absent	Present
		Energy efficiency reporting in municipal properties	Absent	Present
		Green Municipal Building Development	Absent	Present
		Municipal building retrofits	Partially present	Present
	Industry	Green procurement program at the local government level	Absent	Present
	Transportation mode and fuel shifting	The transition of local government fleet to low-emission vehicles	Partially present	Present
	Waste management	Waste collection, sorting, and diversion	Present	Present
		Circular economy development	Absent	Present
	AFOLU	Afforestation and city greening projects, Agriculture, Land use programs for low carbon emission	Partially present	Not studied
Institutional strategies	Technical capacity	Availability of technical capacity	Non-existing/ low	Readily available
	Green economy	Green procurement strategy	Absent	Present
	Financing	International donor support	Present	Absent
	Behavioral intervention tools	Use of financial incentive for intervention	Low	Present

Governance Mechanism	Decision making	Decision making mode	Centralized	Decentralized
	Coordination	Mode of coordination	Unique parallel multi-level coordination	Centralized/ decentralized
	Communication	Internal communication	Poor	Good
	Multi-level integration	Policy flow	Top-down	Integrated
	Governance mode	Least prominent	Self-regulation	Regulatory mode
	Socioeconomic influence	Source of highest GHG emissions	Transportation/ Waste	Transportation /Buildings
		Electricity accessibility	Low	High
Actors	Traditional institution	Tradition and religion institution role in climate action plan	Partially present	Absent

4.4 Deep decarbonization roadblocks in Sub-Sharan African cities

The climate action plan of all case cities identified all the barriers to successful implementation of climate action plan. Table 4.23 shows the identified roadblock in the climate action plan of respective case cities. It also shows the number of times these barriers were mentioned in the plan.

Table 4.23 - Identified roadblock in the climate action.

Accra	Addis Ababa	Lagos	Nairobi
- Lack of market for compost - Continuous engagement - Community acceptance x2[272] - Lack of political will x2 - Poor coordination	- Technical knowledge - Coordination - Funding - Jurisdictional framework - Political commitment - Political instability	- Finance - Low advocacy - Political interference - Poor planning and implementation - Poor compliance - Capacity building x 4	- Institutional challenges - Funding - Energy affordability (poverty) - Enforcement - Technological knowledge - Human capacity

[272] Number of times a challenge is mentioned in the climate action plan.

- Limited resources - Funding x3 - Local capacity x4 - Data x2 - Poor regulation - Technology - Affordability (Poverty)	- Capacity building - Poor communication		- Political constraints

The data on the cross comparison of barriers to deep decarbonization across the case cities as highlighted in their climate action plans are categorized and summarized in figure 4.6.

Categories	Sub-categories	Accra	Addis Ababa	Lagos	Nairobi
Financial and economic barriers	Poverty	✖			✖
	Incentives				
	Funding	✖	✖	✖	✖
Political and social barriers	Political stability		✖		
	Administration and governance	✖	✖		✖
	Community acceptance and engagement	✖		✖	
Technical and institutional challenges	Data and technology availability	✖			
	Technical capacity and availability	✖	✖	✖	✖
	Infrastructural gaps				✖

Figure 4.6 – Comparison chart of CAP barriers across case cities (Accra Metropolitan Assembly; C40 Cities, 2021; City of Addis Ababa & Group, 2021; Ministry of Environment and Water Resources, 2020; Nairobi City County, 2021)

5 Discussion

This study explores the frameworks for achieving deep decarbonization in cities in developing nations. This chapter synthesizes and evaluates the empirical research findings against the literature review to address the research questions posed in this study. This chapter attempts to contextualize the thesis within the larger field of study frameworks and analyses the findings considering the literature and prevailing knowledge on the subject.

5.1 Research Question #1: Technical pathways

What are the pathways being implemented and planned for GHG emission reduction for deep decarbonization in cities in developing nations with the intended co-benefits of sustainable development?

The technical pathways are aimed at identifying the sectors being implemented and planned for GHG emission reduction for deep decarbonization in cities in developing nations with the intended co-benefits of sustainable development. The pathways concentrate on GHG emission reduction initiatives in the designated priority sectors defined by the city through stakeholder engagement. The findings reveal that cities in Sub-Saharan Africa are planning and prioritizing climate actions based on GHG emission reduction capacity, mainstreaming climate action feasibility, ability to support adaptation programs, and cost efficiency.

In Sub-Saharan African cities, the pathways to decarbonization and reduction of GHG emissions are similar across the case cities. The cities had targets and key performance indications with short-term and long-term objectives. The prioritized technical pathways include mainly five areas (energy, buildings, waste, industry and AFOLU) similar to the cities in developed nations of the world (AfDB, 2020; CDP, 2022; Linton, 2020; Linton et al., 2022; Mapfumo et al., 2017; Papadis & Tsatsaronis, 2020; Pye & Bataille, 2016). Despite prioritizing pathways, some cities do not have clear targets for some sectors. For example, none of the

case cities has a set GHG emission reduction target for AFOLU. The city of Addis Ababa does not have a GHG emission reduction target for energy. Each municipality has unique circumstances and priorities, but they all prioritize their highest emitting sectors for decarbonization. The empirical findings and literature are presented in table 5.1 for technical pathway discussion.

Table 5.1: Technical pathways discussion

Pathways	Empirical	Literature	Comments
Energy/electricity	Local governments do not have control over the electricity grid. All case cities have plans to leverage renewable energy and energy efficiency for capacity improvement significantly	The transition to low-carbon energy sources, reducing energy demand and electrification of other sectors	Validate
Buildings and building services	All cases also addressed the need for low-emission building	Retrofit of the existing building, use of energy-efficient appliances, clean cooking, and improvement in building codes	Validate
Industry	Local governments are implementing climate action in industrial energy usage and waste management	Collaboration on research and development. Transitioning to low-energy sources for industrial processes	Validate
Transportation mode and fuel shifting	All case cities are developing EV infrastructure and investing in low-energy transit systems. Local governments are implementing behavioural change strategies for transportation mode shift	Poor road infrastructure and networks in cities contribute significantly to GHG emissions. Electricity access and socioeconomic limitations are affecting the use of electric vehicles. The development of a non-motorized mode of transportation is critical to decarbonization	Validate
Waste management	All cities are improving the waste diversion rate, improving waste service delivery, and developing landfill gas capture and	Waste diversion from landfills is essential for cities to reduce GHG emissions from the sector. Major challenges are the collection, sorting, and	Validate/Extend The use of decentralized waste-to-energy systems (biodigesters) in low-income communities

	waste-to-energy programs.	segregation of waste. Social reorientation is needed for sustainable waste management	for gas capture and cooking is a unique strategy
AFOLU	All cities are developing tree planting programs and green space improvement, and carbon sink protection	Local Governments focus on reforestation and forest management. Sequestration and GHG emission reduction from agricultural processes	Validate/Extend - Cities do not have any action related to the decarbonization of the agricultural process. AFOLU remains a priority sector for deep decarbonization

5.1.1 Technical Pathways Discussion

5.1.1.1 Energy

Literature review indicates that reducing GHG emissions from energy systems at the local level involves transitioning to low-carbon energy sources, reducing energy demand and electrification of other sectors (Basso, 2019; Linton et al., 2022; Papadis & Tsatsaronis, 2020; Seto et al., 2021). This transformation is more achievable locally because of the small scale, direct connection, and impact (Papadis & Tsatsaronis, 2020). However, local governments do not have direct control over their energy sources as this is managed by higher-level governments (Accra Metropolitan Assembly; C40 Cities, 2021; Linton et al., 2022). Due to the lack of control, cities focus on deploying distributed clean energy solutions for decarbonization (Carbon City Neutral Alliance, 2014; Linton et al., 2022).

The empirical results validate the literature. All case cities significantly leverage renewable energy sources and energy efficiency for capacity improvement and reduced GHG emissions. The cities of Nairobi and Lagos have set various targets for GHG emission reduction by 2050, while Accra and Addis Ababa do not have a clear target for energy decarbonization.

The four case cities of Sub-Saharan Africa are utilizing diverse strategies to accomplish the energy sector's GHG emission target, which validates the literature findings. The cities of Accra and Nairobi have

developed a solar-powered street lighting program, while Lagos is planning 1GW of installed PV capacity by 2030. Due to the socio-economic constraints of these cities, they are also implementing unique and innovative strategies to meet climate action goals through advocacy, partnership and regulatory influence. The city of Accra and Addis Ababa are leveraging their respective national government programs in renewable energy to build their renewable energy portfolio for GHG emission reduction, while the government of Lagos is lobbying the federal government to allow local governments to develop grid-connected energy infrastructures.

5.1.1.2 Building and Building services

According to the literature review, efficiency improvements in all energy-intensive activities in buildings and improvement in building envelopes in the form of energy use per square meter will be required to decarbonize buildings (Currie, 2015; Lebling et al., 2020; Mercader-Moyano & Esquivias, 2020). Efficient lighting, various forms of improved cookstoves, and energy-efficient appliances are affordable mitigation strategies for GHG emissions reduction in buildings in sub-Saharan Africa (Ürge-Vorsatz et al., 2011).

The empirical results validate the literature. All the case cities have a form of retrofit or efficiency improvement program in their climate action plan, which acknowledges retrofit and efficiency improvement as important decarbonization strategies. Accra and Lagos are at the forefront of this through retrofitting the municipal building stock. GHG emission reduction strategies in case cities are characterized by deploying varied forms of affordable, climate-friendly appliances and targets. Clean cooking using electric cookers is an integral decarbonization strategy for building, as all cities have clean cooking targets. The city of Accra adopted the use of solar power systems in buildings, while the city of Addis Ababa focuses on 100% solar water heater usage in buildings by 2030.

Cities government will have to be at the forefront of fostering, governance, and accelerating the sustainability of buildings (Dahiru et al., 2012; Kioko, 2014). There is a need to update existing building codes and laws while also building local human capacity in building sustainability (Dahiru et al., 2012;

Koranteng & Mahdavi, 2011). A wide range of targeted and customized governance frameworks is required to reduce emissions in the building sector effectively (Becqué et al., 2019). The empirical evidence shows that some cities have ambitious strategies through building policy development and bylaws. The city of Accra is developing a green building rating system for auditing, while Nairobi is reviewing building codes for enhanced energy efficiency in buildings. Addis Ababa and Lagos are fixing the permitting process for new buildings to ensure sustainability and compliance.

There is empirical evidence that none of the cities offer any form of targeted incentive or financial tool for residents and organizations to influence the retrofitting of existing building decarbonization. This is consistence with findings from the literature review. There are many possible reasons for the lack of incentives: 1) lack of fiscal capacity to implement such a program, 2) lack of adequate database for transparent implementation, and 3) existence of national subsidy programs in the form of energy prices.

5.1.1.3 Industry

Decarbonizing the power sector is critical to the successful deep decarbonization of industries (Rissman et al., 2020). Significant changes to current industrial processes, the development and use of breakthrough technologies, and efficient consumption are all required to achieve deep decarbonization. (Åhman et al., 2017; Löfgren & Rootzén, 2021; Oberthür et al., 2021; Patrizio et al., 2019; Wesseling et al., 2018). Empirical evidence corroborates these points. Electrification of the industrial process is Addis Ababa's and Accra's choice of decarbonization strategy as a co-benefit of significant improvement in renewable energy supply from the national grid. The city of Accra has taken on a much more ambitious approach through developing industrial energy audits, capacity development, engaging local banks for industrial energy efficiency investment and rolling out incentives to support GHG emissions in industries. The city also has an industrial energy efficiency toolkit. Climate action plans for decarbonization of the industrial sector are centred on co-benefit from energy decarbonization in the cities of Lagos and Addis Ababa.

Most local climate plans do not account for industrial emissions as these are better addressed by higher government and the private sector (Bulkeley & Betsill, 2005a; Clarke & Zhou, 2021). Empirical result validates this literature finding. Most cities either do not have targets or rely on the actions of the higher level of government to implement GHG emission programs in the industrial sector.

5.1.1.4 Transportation mode and fuel shifting

Agarana et al. (2017) and Thambiran and Diab (2011) both articulate the pathway to minimize emissions from the transportation sector in Sub-Sahara Africa as 1) the development of mass transit systems, 2) Proper maintenance of road transports, 3) the encouragement of the use of non-fossil fuel power road transportations; 4) Improving the quality of fuel; 5) use of hybrid and electric vehicles; 6) Reducing need to travel, road traffic and congestion, one method for reducing air pollution is to replace older passenger vehicles with newer ones that use sophisticated vehicle technology (Thambiran & Diab, 2011). Cities in Sub-Sahara Africa will also need to promote a non-motorized form of transportation as part of a decarbonization strategy by developing a dense cycle network, reduced traffic levels, and better streets for cycling and walking (Barrett et al., 2016; Goulding & Butler, 2018). At the local level, targeted initiatives such as efficiency improvements, operational improvements, behavioral change programs, and speed control might be investigated as a decarbonization approach (Goulding & Butler, 2018; Habitat, 2020; Kennedy et al., 2009; Somda et al., 2017; Stern, 2020). Poor electricity supply has significantly constrained the penetration of electric vehicles and other electric mobility services, which can help reduce the carbon footprint of transportation in Sub-Saharan Africa (Collett et al., 2021).

The empirical result validates the literature. All case cities have developed a public transit system powered by low-emission engines or electricity and dedicated roads and tracks. The cities of Lagos and Addis Ababa have developed a light rail system to aid public transit. All the case cities are promoting zero-emission non-motorized modes of transportation by developing infrastructures like streetlights, pedestrian

walkways, and shades. These improvements and infrastructural changes are geared towards incentivizing, encouraging adoption and behavioural change towards these emission-free forms of transportation.

Lagos and Nairobi are going further by regulating and disincentivizing transportation using market-based instruments through high-paid parking and tolls in commercial business districts. Addis Ababa has implemented car-free days in the city. Accra plans to establish low-emission zones by restricting access to fossil fuel vehicles beyond 2025. As a climate change mitigation plan, all case cities are improving transportation networks and tightening vehicular emission standards. Accra, Addis Ababa and Lagos are also adopting biofuels, especially in freight, as a GHG emission reduction strategy in the transportation sector.

All case cities are also developing EV infrastructure to promote the purchase and adoption of electric vehicles. Nairobi is developing a local EV motorcycle manufacturing facility. The city of Lagos is partnering with local energy company OANDO to build EV charging facilities across the metropolis. The high cost of electricity, poor electricity infrastructure and the high upfront cost of electric buses are barriers to Electric Vehicle (EV) uptake (Accra Metropolitan Assembly; C40 Cities, 2021). The detailed, high level of focus, diversified strategies, and increased investments into decarbonization of transportation is justifiable as the sector represents the highest source of GHG emission across the case cities cumulatively. None of the case cities are investing in zero-emission fleets for corporate activities.

5.1.1.5 Waste

According to literature review, product reuse, material recycling, and general reduction of the number of solid waste going to landfills provide the best pathways to reducing GHG emissions in the waste sector (Couth & Trois, 2010; Khan et al., 2022; Wahab, 2012). Capturing and burning landfill gas, with energy recovery, is also a major way to lower carbon emissions from waste management (Couth & Trois, 2010). To reduce carbon emissions from waste in developing nations, cities could ensure the segregation and sorting of waste at the collection point (Idowu et al., 2019). A social reorientation, campaign, and human

behavioral change would need to occur for this to happen (Birke, 1999; Haregu et al., 2016; Njoku et al., 2018).

Empirical finding validates the utilization of advocacy and sensitization mechanism for behavioural changes towards best practices like waste sorting, recycling and reuse by local governments. All case cities have an advocacy program for waste management in their climate action plan. Lagos is implementing camps for kids to learn about waste management. Nairobi advocates for waste source separation and segregation through its monthly clean-up program. All case cities have a solid waste plan based on waste diversion from landfills. Most case studies have a clear target for waste emission.

Service delivery and capacity-building improvements are important ways to limit waste. All the case cities are looking to improve services and build more capacity for waste management. Accra and Lagos are constructing new micro and large waste transfer stations. Lagos and Nairobi are equipping low-income communities with biodigesters to treat solid and liquid organic waste. Addis Ababa is building compost facilities, while the city of Nairobi is establishing treatment centres for recycled waste.

All the case cities have built or planning to develop landfill gas capture systems to reduce the emission of GHG from landfills. In addition, the cities of Accra and Lagos are retrofitting existing landfills into engineered landfills. All case cities use waste as energy through different W2E processes. Lagos is also developing a green circular economy through waste by repurposing waste to produce organic manure. To reduce carbon emissions from waste in developing nations, cities could ensure the segregation and sorting of waste at the collection point (Idowu et al., 2019). This point is validated by empirical findings that all cities are working on efficient waste collection, sorting and characterization methods.

5.1.1.6 AFOLU

Mitigation actions in the AFOLU sector are critical to attaining emission reduction objectives (AfDB, 2020; Smith et al., 2014). The mitigation of the AFOLU sector GHG emissions is crucial to the impacts of climate

change and the ecosystem (Fobissie et al., 2019). Climate change mitigation in the agricultural sector is through sequestration and GHG emission reduction from agricultural processes on the supply and demand side (Herrero et al., 2016; Ogle et al., 2014a; Smith et al., 2008). There has been a significant focus on reforestation and forest management as a climate change mitigation pathway (Mbow et al., 2014). Within AFOLU, the principal mitigating methods include a mix of different strategies (Smith et al., 2014; Wollenberg et al., 2016).

The empirical findings validate the literature review and affirm that GHG emission reduction in the AFOLU sector is a key pathway to deep decarbonization. All case cities have climate change actions related to AFOLU. Still, none of the studied cities have set GHG emission reduction targets. The city of Lagos did not consider GHG emissions in the AFOLU sector in designing its current climate action plan. All case cities are developing strategies to increase green spaces in their territory. The city of Accra focuses on policy development and the restoration of local green spaces. The city of Addis Ababa focuses on restoring local sinks and increasing GHG sequestration through the protection and restoration of forests. Lagos and Accra are implementing afforestation and tree-planting programs. The city of Nairobi is implementing green space protection and regulation. The city is also actively protecting public open spaces, greenbelts, forest reserves, water bodies, wetlands, water catchment areas and other ecologically sensitive areas from physical development and urban encroachment.

Lagos, Accra and Addis Ababa are incorporating green and nature-based ecosystem services into urban development. The diversified and mixed strategy in the AFOLU sector is an empirical finding in line with the literature review finding. Most cities did not include GHG emission data in the AFOLU sector in their climate action plan and GHG emission inventory. As a result of its importance in climate change mitigation and GHG emission reduction strategies, the AFOLU sector requires far more attention than it currently receives.

5.2 Research Question #2: Institutional strategies

What institutional strategies are defined in cities in developing nations for deep decarbonization, and what progress has been made using these strategies for reaching net-zero and sustainable development?

The institutional strategies being used in cities in developing nations for deep decarbonization based on empirical findings and literature review are presented in table 5.2.

Table 5.2: Institutional strategies discussion

Institutional mechanisms	Empirical	Literature	Comments
Engagement	Present in case cities	Local governments need the inclusive engagement of stakeholders. Engagement helps increase awareness, transparency and innovation. The heterogeneous nature of communities must be considered in social engagement.	Validate
Technical capacity building	Present in all case cities	Capacity building involves the development of technical expertise to support deep decarbonization efforts. Consultation, partnership and collaboration enhance capacity development	Validate
Green economy	Present in case cities	Green economy at the city level involves 1) green transportation system; 2) a low-carbon industrial and agricultural sector; 3) energy-efficient buildings; 4) greening of the city itself; 5) sustainable infrastructure, and 6) intelligent systems. The key focus area for green economy is spatial development, urban area metabolism, urban city energy systems, and waste management	Validate
Financing	Present in all case cities	The primary financial pathways for climate action are funding, financing, and revenue generation. Local governments can use traditional funding mechanisms for climate action plans, as well as design new funding strategies to raise the resources	Extend – All case cities are utilizing international donors for climate action funding
Behavioural intervention tools	Present in all case cities	Investment in low-carbon options influences behaviour among community stakeholders.	Validate

		Behavioural interventions are most successful when paired with financial incentives	
Regulatory and policy tools	Present in all case cities	Policy and regulatory tools give local governments legislative power to implement needed social changes favouring decarbonization efforts. Law enforcement and order are critical for the efficacy of regulatory compliance. The jurisdiction and enforcement of policies must be considered in the planning and implementation of climate actions.	Validate

5.2.1 Institutional strategies discussion

5.2.1.1 Engagement

Evidence from the literature review shows that inclusiveness through the engagement of non-traditional stakeholders and community is an effective tool for long-term social transformation (Bond, 2010; Ho et al., 2013; Linton, 2020). Engagement is not limited to inclusion in the policy development process and actions but motivation, knowledge and taking action on decarbonization efforts through communication, educational campaigns, community events, transparency and celebration of achievements (Bond, 2010; Carbon City Neutral Alliance, 2014; Linton et al., 2021).

The empirical results validate the literature. All case cities engage stakeholders in the planning and development phase of the climate action plan. This is evidenced in all the city climate action plans reviewed as part of this project. The studied cities implemented engagement through town hall meetings, surveys, focus group meetings, interviews, workshops, social media campaigns and community events. All the cities' climate action plans commenced with stakeholder engagement and involved technical experts and consultants in their GHG emission reductions. A stakeholder engagement plan was incorporated in all CAP as a formal strategy to identify and communicate with key stakeholders to encourage participation and support for CAP implementation.

The case cities have unique and diversified engagement methods. Accra utilizes organized group meetings targeted at members of particular interest groups. Nairobi conducted and enhanced participatory

planning approaches and decision-making with community engagement. Lagos developed a state climate change forum as a platform for the engagement of all stakeholders in framing sustainability issues.

Social engagement in developing nations must consider the heterogeneous nature of varying societal cultures and norms (ICLEI Africa, 2021; Kennedy et al., 2019). Accra and Lagos engage traditional leaders, religious leaders, and organized trade unions in climate change mitigation action planning and execution.

The use of advocacy tools for social engagement at the local level is equally essential (Clarke & Zhou, 2021). Empirical findings validate this. Nairobi is training youths on topical issues such as climate change mitigation and peacebuilding. Lagos and Accra use social media and podcasts to advocate for environmental sustainability. Lagos also uses its waste management academy for the community-level campaign on waste separation at source and organic waste diversion programs. The city also established summer schools targeting young kids on the issue of climate change. For the city of Addis Ababa, public engagement is considered an area of improvement in climate change mitigation.

5.2.1.2 Technical capacity building

Cities in developing nations must build technical capacity as a deep decarbonization mechanism (Olawuyi, 2017). Capacity building entails developing technical knowhow and increasing the leadership required for designing, planning and executing climate actions (Bernstein & Hoffmann, 2018; Chaudhury, 2020; Mizrahi, 2004; Schuetz et al., 2017; Wang et al., 2012). A comprehensive approach to developing domestic resources to manufacture required technologies is required to sustain deep decarbonization by sub-Saharan African cities (Altieri et al., 2015; Creutzig et al., 2015; Crick et al., 2018; Olawuyi, 2017). Consultation, partnership and collaboration enhance technical capacity development.

The empirical findings validate the literature review. All case cities are implementing a form of technical capacity as part of their climate strategy. This capacity program includes the strategic appraisal of climate risk assessment and climate action (Nairobi). The city of Accra uses scenario modelling for evidenced-

based decision-making and obtaining key stakeholder input to directly link activities to immediate needs. The cities are engaging both internal and external resources for capacity building.

The city of Addis Ababa is partnering with Addis Ababa University in its reafforestation and biodiversity enhancement program. In waste management, the city of Lagos provides special-track internships for students of tertiary institutions, specialty training resource recovery and waste management, more innovative solutions for segregation and Logistics, fleet management and waste recycling. In all case cities, the development of the climate action plans involves a diverse team of internal experts, external consultants, and practitioners. The city of Nairobi is building its internal capacity to monitor and report air quality data. The city is also developing city planners' capacity for climate change. Despite these efforts, capacity gaps are a significant hindrance to deep decarbonization in cities of sub-Saharan Africa.

5.2.1.3 Green economy

Local government can contribute to deep decarbonization strategy through green economic transformation and policy development (Linton et al., 2021). A green economy at the city level involves a green transportation system, low-carbon industrial and agricultural sector, energy-efficient buildings, spatial development, sustainable infrastructure, and waste management (CDP, 2022; Cole et al., 2017; Currie, 2015; Dahiru et al., 2012; Kennedy et al., 2019; Kioko, 2014; Lindfield & Steinberg, 2013; Linton, 2020; Sharma et al., 2013). Cities can incorporate clean technology development, circular economy and general climate consideration in their economic planning (Linton et al., 2021).

Empirical data indicates that the cities in sub-Saharan Africa are developing various technologies. The city of Nairobi is developing a circular economy pilot project in partnership with other government agencies. The city established circular economy community projects to encourage the reuse of materials. Lagos is leveraging technology to manage recyclable wastes through the PAKAM app effectively. The city has reopened a composting facility for the production of organic manure and currently developing material

recovery facilities for solid waste management. The development of a new 3000MW hydropower plant is a foundation for green economy for the city of Addis Ababa.

It is observed that green economy action and strategies in sub–Saharan Africa focus mainly on developing green infrastructure. This is because environmental sustainability is the social infrastructure on which other actions, strategies and frameworks are built. The massive gap in social infrastructure in Sub Sahara Africa makes the green economy's focus on infrastructural development appropriate, relevant, and important. Sub-Saharan African cities can sustainably leverage existing climate-friendly technologies to close their infrastructural gaps.

5.2.1.4 Financing

The local government is essential in funding socio-environmental programs for climate action plans (Amundsen et al., 2018; Gilley, 2017; Leal Filho et al., 2018; Olukanni et al., 2016; Salon et al., 2014). For these plans to be effective and successful, cities must understand and plan to fund climate action projects (USDN, 2019). Cities can use established public financing programs to support climate action plans and design new funding strategies to raise the resources necessary to carry out the plans (Carbon City Neutral Alliance, 2014; Corfee-Morlot et al., 2009; Linton, 2020).

The empirical result shows that all case cities utilize traditional funding methods through taxes, fiscal allocation from the higher level of government and partnerships. In most cases, cities leverage international donor organizations to fund climate action programs. Nairobi has some partners and donors committed to funding the bus rapid transit, including development partners, World Bank, Investment banks, and the African Development Bank through different mechanisms like loans, grants and equity. Lagos and Accra also partner with the public sector to fund climate action programs through concessional finance, co-financing through public-private partnerships and program adoption.

All the case cities are exploring innovative funding mechanisms like green bonds (Addis Ababa, Lagos), green funds (Accra and Nairobi), and carbon credits (Lagos) to supplement traditional funding sources. The cities of Accra and Nairobi have established special allocations for community-led climate programs and initiatives. About 2% of Nairobi's budget is earmarked for sustainable energy and climate change response funding. Innovative funding mechanisms will be necessary to implement a climate change mitigation action plan. What is not known is the share of each source of funds in funding climate change in SSA.

5.2.1.5 Behavioural intervention tools

Behavioural interventions are most successful when paired with financial and other interventions to influence activities that affect GHG emissions (Stern, 2020). Local governments can also affect behaviour by investing directly in carbon-reducing technology and infrastructure, such as bike lanes and better public transportation (Carbon City Neutral Alliance, 2014; Clarke & Zhou, 2021; Linton, 2020).

The results validate the literature. All the case studies are investing in new infrastructure to help support low-emission pathways adoption. Infrastructure investments are predominantly for renewable energy, promotion of low emission transportation means (all case cities), non-motorized transport (NMT) and NMT infrastructure development (all case cities), and infrastructure for electric vehicle charging (Lagos), building electric motorcycles (Nairobi) and promotion of ease of use and accessibility (Lagos and Accra). All case cities are implementing a form of incentive program for adopting low-carbon options. The city of Lagos is providing financial incentives through programs like the "trash for cash" program to engage and influence the behaviour of the populace towards waste sorting and management. Accra initiated an incentive program that offers a 10% reduction in the building permit fee if the application incorporated a 20kW roof-mounted solar PV system in the design.

5.2.1.6 Regulatory and policy tools

Policy and regulatory tools are significant ways for local governments to implement climate change strategies (Clarke & Zhou, 2021). The authority of government is anchored on its legitimate power to permit, prohibit, or command action by target populations through these legislations (Henstra, 2016). Local governments have the authority to undertake essential societal changes in backing decarbonization initiatives due mainly to policy and regulatory instruments (Clarke & Zhou, 2021). The amendment or introduction of new policies to implement transition plans is needed to meet emission targets (Urrutia-Azcona et al., 2020).

The literature is validated through the empirical findings. All case cities are implementing strategic policies and regulations towards deep decarbonization, which show its importance to the local GHG emission reduction strategy. Cities can regulate corporate emissions (self-regulate) in the sectors that they control directly (Carbon Neutral Cities Alliance, 2015) as a way to project the vision to the community (Linton, 2020). The results show that not all case cities use self-regulating policies for local climate action planning by developing corporate emissions targets and self-regulating policies. All cities studied utilizes some form of enforcement of law and order in advancing climate action programs: enforcement of traffic rules (Nairobi), establishment of mobile court for prosecution of environmental crime suspects (Lagos), development of waste, transport and city structural plan (Addis Ababa), waste management and transportation permits and bylaws enforcement (Accra).

5.2.1.7 Long-term planning

Climate change action planning is a long-term project which demands continuous commitment and political vision. Political instability in developing nations can alter deep decarbonization plans (Herrfahrdt-Pähle & Pahl-Wostl, 2012; ICLEI Africa, 2021). The role of policy professionals and networks is vital in climate action planning. The public task forces or working groups formed are crucial to public approval of the proposed planning actions (Bassett & Shandas, 2010).

The empirical results validate literature. All case cities have developed a climate action plan which lays out short-term and long-term climate actions toward a set GHG emission target. The cities are engaging expert practitioners and collaborating with international networks to advance the GHG reduction mechanism, as evidenced in all cities' climate action plans. The influence of national and subnational politics on climate actions is massive. A change in the political framework of cities and countries may heavily influence the continuity and follow-through on climate action plans. The involvement of transnational organizations like C40 and ICLEI – Africa who work with local government for sustainable development advocacy, planning and implementation provide continuity.

5.3 Research Question #3: Governance mechanisms

What governance structures are deployed to plan and execute local deep decarbonization programs?

In answering the third research question on the governance structures being deployed to plan and execute local deep decarbonization programs, empirical results were compared with available literature findings.

5.3.1 Governance mechanisms discussion

The review of empirical result and literature document on the governance mechanisms for deep decarbonization in Sub-Saharan Africa are summarized in table 5.3.

Table 5.3: Governance mechanisms discussion

Governance strategies	Empirical	Literature	Comment
Decision making	The decision-making power on climate action planning and implementation lies with the executive and/or legislative arm of the government	Government, the administrative and directly elected subjects of the state, has long been viewed as the centre of governance and decision-making in the society	Validate
Coordination	Cities in Sub-Sahara Africa plan and coordinate climate action programs through a	Climate action planning at the city level can be centralized or embedded	Validate/Extend – Empirical findings shows that a hybrid,

	unique matrix system which consists of a central sustainability department and a parallel departmental- and agency-level coordination of climate change activities		matrixed system of coordination is deployed in Sub-Saharan Africa
Monitoring and reporting	Present in all case cities but intended for internal audiences	The local government must establish a formal monitoring and reporting system. Reporting is often a public-facing system, showing progress at defined intervals.	Validate
Communication	Communication is still in print and physical form in most of case cities.	The communication process must be constant, open, simple, clear and concise. Communication can be internal or external and must be structured.	Validate
Collaboration and partnership	Present in all case cities	Internal and external collaboration and partnership improve the success of collaborative strategies	Validate
Multi-level integration	Local government integrate policies and programs horizontally and vertically. Vertical integration, in all cases, is top-down. There is a powerful influence of higher levels of government in climate policies at the local level.	Multi-level governance helps clarify the roles and responsibilities of transnational, national, provincial, and local governments in climate governance. Climate governance mechanisms are in 2 dimensions – Vertical integration and horizontal climate governance	Validate/Extend - Vertical integration, in all cases, is tops-down. There is a powerful influence of higher levels of government in climate policies at the local level.
Governance mode	Local governments use a mix of different modes of governance, including regulatory mode. The climate action plan focuses mainly on community actions. Corporate climate action is marginal or non-existing in most cases.	Cities use a combination of governing modes: self-governance, enabling, provision and regulatory. Local governments appear to be reluctant to use the regulatory mode of governance to implement climate protection strategies	Extend – Most Cities in SSA do not prioritize self-regulating mode as a GHG emission reduction strategy. The regulatory (by authority) mode of governance is applied in all case cities. All climate actions are focused only on community action plans.

5.3.1.1 Decision-making framework

Local governments require strong leadership for climate governance (Betsill & Bulkeley, 2006; Bulkeley & Betsill, 2013; Conway & Schipper, 2011; Herslund et al., 2016). Government, the state's administrative and directly elected subjects, has long been viewed as the centre of society's governance and decision-making (Bulkeley & Kern, 2006). The decision-making framework highlights the political decision-making power of various stakeholders in local climate action governance (Linton et al., 2021; Paterson et al., 2003). Climate governance needs to be flexible and based on a diverse range of institutional and stakeholder collaboration for optimal results (Betsill & Bulkeley, 2006; Linton, 2020; Linton et al., 2021).

In all case cities, the decision-making power on climate action planning and implementation lie with the executive and/or legislative arm of government using recommendations from the city's climate change coordinating entity. This city government's framework, power and mode vary across all case cities. In Accra, the responsibility for formulating and approving long-term strategies lies with the steering committee, which comprises representatives from all municipal assemblies and partners. In Lagos, the state climate change council chaired by the state governor is responsible for overall decision-making on climate change actions. The Nairobi City County government comprises the county executive and the county assembly and is responsible for implementing policies. This empirical finding validates literature.

5.3.1.2 Coordination

Climate change mitigation action plan at the local level is a complex interaction between institutions, systems, and cross-sectoral and multi-level relationships of policy stakeholders in the management of public products and services (Clarke & Fuller, 2010). Establishing the proper climate management organization is key to effective climate change policy institutionalization. Climate action planning at the city level can be centralized or embedded (Clarke & Zhou, 2021; Kern & Alber, 2009; Linton et al., 2021).

All case cities have adopted a matrix form of climate mitigation program coordination. All case cities established a centralized climate action planning organization within the city government to govern,

implement and coordinate climate change actions. The Addis Ababa Environmental Protection and Green Development Commission (AAEPGDC), directly accountable to the mayor, is mandated to govern the city's environment and climate change issues. In Lagos, climate change program coordination is done through the climate change secretariat, a clearinghouse for all climate change-related activities in the state. The Resilience and Sustainability Unit is the leading and central departmental unit for driving climate action in Accra. These cities also have each department spearheading climate action program implementation within their circle of authority. In Accra, each department across the four cardinal sub-organizations: infrastructure (spatial development, buildings), environment (waste), finance and economics (transportation) performs this satellite role. Lagos has a parallel coordinating system through the state Climate Change Forum, the state technical committee on Climate Change and the State Council on Climate Change which also engages non-governmental partners in the decision-making and coordination of climate action plan.

The empirical finding shows that some cities in Sub-Sahara Africa are planning and coordinating climate action programs through a hybrid framework. The framework comprises a central sustainability office and a decentralized independent department-level coordination system across the government departments. The resultant outcome of this matrix system is unclear partly due to the relative newness of climate governance and framework.

5.3.1.3 Monitoring and reporting

Local government must establish a formal monitoring and reporting system (Linton, 2020). Reporting is often a public-facing system, showing progress at defined intervals (Linton, 2020). Reporting focuses on GHG inventories and decarbonization programs' progress toward short-term and long-term climate and sustainability goals (Clarke & Zhou, 2021). The reporting of climate actions can be done at the departmental level and transferred to the leading steering group (Matsiliza, 2018).

According to the findings, all the case cities have monitoring and reporting processes to measure progress and report to stakeholders. While all instances have clearly defined monitoring and reporting systems, they are all different regarding reporting structure, frequency, and framework. AAEPGDC reports its work and activities to the Addis Ababa City Administration and the City Planning Commission in Addis Ababa. The city of Lagos is using Nigeria's existing monitoring and reporting framework. Accra will continue to report through the existing framework under the Medium-term Development Plan (MTDP). This self-developed framework incorporates annual action plans by outlining the activities undertaken by different departments and agencies relating to specific development objectives. Nairobi established county Sectoral Project Planning & Monitoring Units which include appointing monitoring officers in each sector to coordinate monitoring, evaluation and reporting. Empirical findings validate literature.

5.3.1.4 Communication

Communication is an integral part of climate action governance because it plays a prominent role in engagement, policy-making and adoption (Bond, 2010; Boussalis et al., 2018; Fløttum & Gjerstad, 2017; Servaes et al., 2012). The literature states that this communication process must be constant, open, simple, clear and concise (Linton, 2020; Moser & Ekstrom, 2010). Communication can be internal or external and must be structured for optimal results. Empirical findings corroborate the literature. The communication method includes e-mails, shared folders, and town hall meetings. The communication mode is two-way. The city of Nairobi obligates the county government to incorporate communication in all its development activities. The county government must establish an effective communication and sensitization framework using various media forms targeted at the broadest selection of stakeholders in the county. Lagos has no central hub for fast and open internal information sharing. Communication remains not digitalized in Lagos as the physical movement of documents is being practiced. Information are still being horded or shared based on built relationship which broadens bureaucracy around climate

change mitigation. Poor internal communication amongst government agencies and departments is a significant constraint to decarbonization at the city level.

5.3.1.5 Collaboration and partnership

The complexity of climate change and decarbonization necessitates the fusion of various stakeholders through collaborations and partnerships (Clarke & Ordonez-Ponce, 2017; ICLEI Africa, 2021). A collaborative mechanism, which can take several forms, offers a platform for focused discussions between state and non-state stakeholders (Ansell & Gash, 2008; ICLEI Africa, 2021). Collaboration and partnership approach to climate change actions can be participatory or collaborative (Ansell & Gash, 2008). The local government utilizes a participatory form of collaboration and partnership when decision-making power is not shared with collaborators and partners, but their input and expertise are acknowledged and revered (Ansell & Gash, 2008; Clarke & Ordonez-Ponce, 2017; ICLEI Africa, 2021; Linton et al., 2021; Sun, Clarke, & MacDonald, 2020). Internal and external collaboration improves the success of collaborative strategies (Linton, 2020; Linton et al., 2021).

Collaboration and partnership are the bedrock of climate action plans in all case studies. In all case cities, the climate action plans are developed in collaboration with C40 – a network of city leaders working to implement the immediate action required to address the climate catastrophe. All case cities are partnering with external organizations for technical development, funding and knowledge from the climate action planning stage through implementation. Usually, a formal partnership exists between cities and the national government. This partnership is, however, skewed toward the central government due to strong fiscal and political connections and dependency. Many technical reports and action plans were funded and developed mainly through international partners. While these partnerships are collaborative, they heavily influence local governments' decision-making regarding climate change. This has led to the belief that the development of climate action programs in some cities is not organic, self-motivated and self-designed. There is also an extensive collaboration with local actors for climate implementation. This

is mainly in the areas of advocacy. The governments are partnering with educational institution and private organization for funding and technical support as part of their corporate social responsibility.

In all case cities, internal collaboration exists within the local government through their central sustainability offices, which coordinate and ideate these partnerships. The mode and efficacy of this partnership are unknown as it is out of the scope of this study.

5.3.1.6 Multi-level integration

City-level climate governance is structured through a multi-level governance framework (Bulkeley, 2010). A multi-level integration framework is a starting point to define the interrelationship between national governments, transnational organizations and other public and private stakeholders in the conceptualization, design, and implementation of climate policy across all levels of climate actions (Corfee-Morlot et al., 2009). The multi-level governance framework of environmental sustainability consists of the vertical dimension across governance and the horizontal dimension of governance (Betsill & Bulkeley, 2006; Corfee-Morlot et al., 2009; Okereke et al., 2009).

The national government plays a vital role in shaping climate action plans in all the case cities. All the case cities collaborate with national agencies to implement and align climate change mitigation actions. In all the case cities, the grid is controlled by the national government therefore, GHG emissions reduction at the local level in the area of electricity requires integrating national plans and strategies into cities' climate action programs. In Addis Ababa and Lagos, the national climate policies form the basis for developing early emission reduction pathways. Accra will update its climate action plan in alignment with Ghana's Nationally Determined Contributions. The mutuality of integration is non-existent in all case studies as policy, funding, and strategy are only top-down, with local governments having a minimal contribution to the planning and development of national climate action programs. The same goes for integrating programs and policies from local government to the grassroots. All case cities collaborate horizontally

with international organizations for climate action planning, development, execution and funding. Nairobi's greenhouse gas inventory has been collated with C40 Cities and Sustainable Energy Africa.

5.3.1.7 Governance mode

The modes of climate governance are self-governance, governance through enabling, governance by provision, and regulatory mode of governance. The combination of multiple modes benefits climate governance (Kern & Alber, 2009). Local governments appear to be reluctant to use the regulatory mode of governance to implement climate protection strategies. (Kern & Alber, 2009).

Empirical results validate the literature. All case cities deploy various governance modes: Accra – Enabling and provisioning mode, and Addis Ababa, Nairobi and Lagos – Enabling, authority and provisioning mode. Empirical results indicate a shallow implementation of a self-regulating method of governance, as corporate climate change mitigation actions are lacking. All climate actions are focused mainly on community action plans. This can be attributed to the fiscal shortage, technical capacity and lack of resources. The low level of corporate activities and programs, which is solely within the control of the local government, suggests that the willingness to focus on climate change mitigation actions organically is low. This may indicate the preference and prevalence of climate adaptation and resilience programs. Low corporate actions strengthen the argument that the climate action plan in case cities is not out of genuine interest or conviction but due to the persuasion and influence of external actors like transnational climate organizations, donor organizations and other international development agencies. In all case cities, community led actions are absent. For example in other countries, cities like Guelph (Canada) are developing a community led energy governance actions (Linton, 2020). This is not so with any of the case cities of this study. Contrary to Kern and Alber (2009), all case cities utilize their regulatory power to implement and develop climate action programs. All case cities are implementing various combined forms of regulation in all technical pathways: areas of transportation (Ghana, Addis Ababa, Accra, Nairobi),

waste management (Lagos, Nairobi), AFOLU (Nairobi, Lagos), and building and building codes (Accra, Addis Ababa, Nairobi).

5.4 Research question #4: Actors

Who are the actors, and what is their role in deep decarbonization in cities of developing nations?

The roles and responsibilities of climate actors were reviewed based on literature and empirical finding. The summary of the findings is presented in table 5.4.

Table 5.4: Actors discussion

Actors	Empirical	Literature	Comment
Private sector	Present in all case cities. In most cases, the private sector is involved in implementation of CAP	The private sector plays an important role in the partnership, funding, and development of deep decarbonization strategy. Climate change is a potential disruption of business and an avenue for creating new economic opportunities.	Validate
Civil society	Present in all case cities.	Civil society counterbalances the government in climate policy through advocacy, arbitration, research and development.	Validate
Traditional institutions	Present in most case cities	The traditional institution is a niche subset of government with customary local strategies and knowledge dating century for societal development. Traditional institutions use their closeness to the populace to effect social changes, including climate policies	Validate/Extend – Traditional institutions are active in climate action consultation, leadership and coordination in their respective communes. They act as influencers for engagement and communication
Educational institutions	Present in all case cities	Academic institutions, through research, synthesize knowledge	Validate

		for understanding GHG emissions and proffer actions for effective governance, technological abatement methodologies and implementation strategies.	
Government	Local governments play leadership and sole decision-making roles in climate action planning.	The government provides the leadership for climate action. It is the central node for all climate-related programs.	Validate

5.4.1 Actors discussion

Decarbonization and its governance at the local level require a range of actions and interactions from diverse state and non-state actors (Bernstein & Hoffmann, 2018; Bulkeley & Schroeder, 2012; Newell et al., 2012). The main actors in urban climate governance are government, transnational organizations, academic institutions, the private sector, international agencies, and civil organizations (Aylett, 2013; Bulkeley & Schroeder, 2012; Clarke & Ordonez-Ponce, 2017; Smit, 2018). The successful design and implementation of decarbonization strategies at the local level depend on the collaboratory efforts of all actors and stakeholders (Henstra, 2016). These actors play various roles in climate change mitigation actions in the form of influencing, facilitation, implementation, coordination, consulting, decision-making, leadership, enabling, regulation, funding (Li, 2021; S. Matsiliza, 2017).

Empirical results validate the literature. In the cities of Sub-Saharan Africa, diverse actors are involved in the planning, execution, and governance of climate actions and decarbonization. In all case cities, the private sector, civil organizations, traditional establishments, educational Institutions and government play various roles in sustainable development. In all cities studied, local governments play leadership and main decision-making roles in climate action planning. National and state governments have a significant influence on the local government. The legislative arm of local governments creates laws and regulations, and various departments within the local government and other external actors make suggestions which

are reviewed and ratified by the governing council. In all case cities, the roles of municipal governments are similar and follow the same pattern: decision-making, implementation, leadership, enabling, coordinating, regulation, facilitating, and funding.

Civil society organizations through international nongovernmental organizations (NGOs) with transnational networks are also influential in creating and implementing climate action plans in all case cities. They provide funding while acting as enablers, coordinators and facilitators in these climate action programs. The local civil organizations are also involved in the climate action plan mainly for advocacy, policy influencing and consulting role. This attests to the growing power of civil society in climate change mitigation and decarbonization, as opined by Newell et al. (2012).

Traditional institution plays some critical roles in decarbonization at the local level. In most cities, the institution, which includes traditional leaders and indigenous religious organizations, is active in consulting, leadership and coordination in their respective communes. They act as influencers for engagement and communication of climate action programs in Accra. In Addis Ababa, the climate action plan ensures inclusivity by engaging local leaders who promote and protect appropriate cultures and values. Lagos is consulting the traditional institution as a source of indigenous knowledge.

All case cities are engaging academia for knowledge and climate mitigation solutions. Local governments collaborate with local and international educational organizations for knowledge sharing and as stakeholders in climate action planning. In all case cities, academic institutions serve as consultants, implementation partners and enablers of climate action planning.

As shown in the results, all case cities engage the private sector in the implementation, facilitation and are consulted in climate action planning at the local level. In Lagos and Addis Ababa, the private sector is a source of funding for the decarbonization program.

5.5 Research question #5: Deep decarbonization in cities in the global south vs. north?

What is the uniqueness of approaches to deep decarbonization in cities in the global south, and how do they differ from those in the north?

Deep decarbonization action plans in sub-Saharan Africa at the local level are similar to that of the global north in many ways. Both divides are implementing similar technical pathways while utilizing somewhat identical strategies. The dichotomy in the economic, technological and political landscape between this divide as shown in table 5.5 requires some unique and localized strategy and approach for successful implementation.

Table 5.5: Deep decarbonization action plan across the global south and north divide

Deep decarbonization pillar	Elements of research	Actions	Sub-Saharan African cities	Cities in developed nations (Linton, 2020; Linton et al., 2022)
Technical Pathways	Electricity /energy	Increased municipal usage of RE	Partially present	Present
		Decentralized waste-to-energy systems	Present	Absent
	Buildings and Building Services	Set KPI for municipal energy use	Absent	Present
		Energy efficiency reporting in municipal properties	Absent	Present
		Green Municipal Building Development	Absent	Present
		Municipal building retrofits	Partially present	Present
	Industry	Green procurement program at the local government level	Absent	Present
	Transportation mode and fuel shifting	The transition of local government fleet to low-emission vehicles	Partially present	Present
	Waste management	Waste collection, sorting, and diversion	Present	Present
		Circular economy development	Absent	Present

	AFOLU	Afforestation and city greening projects, Agriculture, Land use programs for low carbon emission	Partially present	Not assessed
Institutional strategies	Technical capacity	Availability of technical capacity	Non-existing/ low	Readily available
	Green economy	Green procurement strategy	Absent	Present
	Financing	International donor support	Present	Absent
	Behavioral intervention tools	Use of financial incentive for intervention	Low	Present
Governance Mechanism	Decision making	Decision making mode	Centralized	Decentralized
	Coordination	Mode of coordination	Unique parallel multi-level coordination	Centralized/ decentralized
	Communication	Internal communication	Poor	Good
	Multi-level integration	Policy flow	Top-down	Integrated
	Governance mode	Least prominent	Self-regulation	Regulatory mode
	Socioeconomic influence	Source of highest GHG emissions	Transportation/ Waste	Transportation /Buildings
		Electricity accessibility	Low	High
Actors	Traditional institution	Tradition and religion institution role in climate action plan	Partially present	Absent

5.5.1 Corporate climate action plan

In a similar study focusing on cities in developed nations, local climate action plans include community and corporate action activities. In Linton's (2020) study, all cities implement a self-regulatory governance mode as part of their corporate climate action strategy. All the case cities are also implementing a green public procurement program and electric fleet. The city of Guelph, Vancouver, Toronto (Canada), Oslo (Norway) and New York (USA) are retrofitting government-owned buildings. A sustainable city-owned building code has been developed by the cities of Park City (USA) and Lahti (Sweden) (Linton, 2020).

In all case cities of Sub-Saharan Africa, climate actions focus on community programs. Most of the cities are not implementing a corporate climate action plan. Corporate climate action incorporates and emphasizes climate protection strategies and programs as part of organizational activities, programs and processes. Good corporate climate action starts with detailed GHG inventory preparation based on Scope 1 emissions, data collection, climate action strategy development, monitoring and reporting and communication (FCM & ICLEI, 2018; Linton, 2020). The corporate climate action strategy includes municipal transition to the increased share of renewable energy usage, waste sorting and collection, transitioning the municipal fleet to a zero-emission fleet and greening municipal procurement strategy (Linton et al., 2022). As an organization, most of the local governments studied are implementing, within their operations, few of these climate actions across all pathways.

This led the author to infer, hypothesize and conclude that the climate action plans at the local level in developing nations, based on the case studies, are inorganic and not self-directed. The lack of self-awareness and democratization of corporate climate actions points to a pretentious and uninternalized climate program which can lead to failure to meet the set targets.

5.5.2 Behavioural intervention financial tool

There is empirical evidence that none of the cities offer any major form of targeted incentive or financial tool for residents and organizations to influence owners on commercial and residential building decarbonization. This is consistence with findings from the literature review (Chan et al., 2018; Darko & Chan, 2018; Olubunmi et al., 2016; Stern, 2020). There are many possible reasons for the lack of incentive: 1) lack of fiscal capacity to implement such a program, 2) social infrastructural gaps, institutional incapacity and database to operate for transparent implementation, and 3) existence of national subsidy programs in the form of energy prices.

5.5.1 Climate action financing

The cities in developed nations and in Sub-Saharan Africa are utilizing multiple sources for funding climate action program. They are utilizing traditional and non-traditional funding schemes. In the cities of Sub-Saharan Africa, the funding of climate action programs through international donor organizations is prevalent. This is something that is very rare in the global north.

5.5.2 Mode of coordination

Empirical findings show that a hybrid, matrixed coordination system is deployed in Sub-Saharan African cities. The cities plan and coordinate climate action programs through a unique matrix system consisting of a central sustainability department and a parallel departmental- and agency-level coordination of climate change activities. Further studies are required to confirm the efficacy of this system. The complexity of this hybrid system is a potential for communication problems and poor coordination.

5.5.3 Climate governance and leadership approach

Linton (2020) described the city government climate governance method in developed nations as a two-way method of governance with constant interaction across the strata of government: Higher lever government, local government and community. This method allows for an upward and downward flow of policy and feedback which can aid continuous improvement. The engagement of stakeholders is more productive under this form of governance. In the case studies from Sub-Saharan African cities, the municipal government adopts a top-down approach. Climate-related decisions are made solely by the higher government authority and handed down to the community without consultation and feedback. This method is authoritarian and gives the community no sense of involvement and, therefore lack of ownership. The same Top–down system is utilized by the higher levels of government (state and national government) to influence local government's climate action programs in Sub-Saharan African cities due to the latter's political and fiscal dependency on the former.

5.5.4 Traditional institution

In developing nations, traditional institutions, including religious organizations, are one of the actors in the climate action plan (ICLEI Africa, 2021; Kennedy et al., 2019). Traditional institutions fuse indigenous knowledge and culture while playing major roles in community development, including climate change mitigation programs. In most case cities, the institution, which includes traditional leaders and indigenous religious organizations, is active in consulting, leadership and coordinating their respective communes. They act as influencers for engagement and communication of climate action programs. This is a major difference from the global north, where traditional institutions are not considered in climate change mitigation and adaptation.

5.6 Research question #6 – Roadblocks to deep decarbonization

What are the roadblocks against deep decarbonization in developing nations?

There are several barriers to planning and implementation of climate action programs in cities of Sub-Saharan Africa based on the case studies. According to literature review, the main barriers to climate actions are financial and human resource availability and empirical findings validate this assertion. In the cities of Sub-Saharan Africa, while numerous challenges exist, the prominent barriers to deep decarbonization are capacity-related, financial, and poor governance details of which are presented in table 5.6.

Table 5.6: Climate action plan roadblocks discussion

CAP roadblocks	Empirical	Literature	Comments
Financial and economic barrier	Present in all case cities	Funding for lack of infrastructure, poor incentives on clean technology and building retrofit, poverty	Validated and extended. Funding is considered a leading barrier to CAP implementation

Political and social barriers	Present in all case cities	Discontinuity in the government plan, lack of political will, poor governance, fossil fuel subsidies, General adoption and acceptability among the populace, political instability, and uncertainty	Validated and extended. Climate governance and administration problems constitute a significant barrier to CAP implementation.
Technical and institutional challenges	Present in all case cities	Poor geospatial data availability, Data availability, advanced technology, electric vehicle, Human resource availability, Poor technical knowhow, and lack of electricity	Validated and extended. Human and technical capacity development is the most critical roadblock to CAP implementation

Funding problems are the main barriers impeding the efforts to integrate the different realms of climate change policy (Kern & Alber, 2009; Salon et al., 2014). Poor governance, lack of social infrastructure, low human capacity, the prevalence of poverty, education, data availability and lack of advanced technology are all barriers to climate change mitigation (Caetano et al., 2020; Chan et al., 2018; Olawuyi, 2017; Sovacool et al., 2022). These barriers are grouped under three major categories: financial, political, and technical challenges (Chan et al., 2018; Ouedraogo, 2019).

Empirical findings are consistent with the literature. Document analysis reveals that the issues hindering climate change mitigation action in case cities include access to funds, access to necessary skillsets, institutional challenges, political engagement, communication, jurisdictional authority, human resource deficiency and poor governance framework as the issues militating against the climate change mitigation action in case cities. Nairobi City County named climate governance, human capacity shortage, financing, energy affordability and technological barriers the main impediments to climate change mitigation. In Accra's Climate Action Plan (CAP), funding, lack of data, continuous engagement, communication, and human capacity are identified as the several barriers to climate initiatives. The main obstacles to climate action for Lagos are financing and the availability of human resources to support climate action programs. There is also the problem of coordination, centralization of power and internal communication problem

within the administrative structure of Lagos. At the same time, the barriers for the City of Addis Ababa are in the governance system and jurisdictional authority, community awareness and knowledge, and financial access to implement the action plan.

The inadequacy of human and technical capacity is witnessed firsthand in the CDP report for all case cities. The CDP report of each case city is scanty, with minimal data to explore. The report for each of the case cities provides either unclear data or no data at all. The leading challenges to climate change mitigation in the cities studied are funding, inadequate human and technical capacity and poor governance.

6 Conclusion

This section summarizes the study objectives and an overview of this thesis's contributions to theory, practice, and recommendations. Additionally, the section lists the limitations and makes recommendations for further study.

6.1 Objective of study

This study examines and decomposes the deep decarbonization pathways and best practices in four cities implementing deep decarbonization in developing nations. The results of this study can be helpful to cities that are developing deep decarbonization planning. The project compares urban climate literature findings with climate action programs of leading cities in sub-Saharan Africa to determine any pattern in technical pathways, governance strategies, institutional approaches and actors for deep decarbonization. This project provides insights into the levels of capacity, the challenges to overcome, and the unique tactics that cities in developing countries employ to meet their GHG mitigation targets by studying the plans and procedures of African cities.

This research shows seven areas where the empirical findings extended the current scholarly knowledge on the pathways, governance mechanisms, and strategies for deep decarbonization at the city level, particularly in developing nations. Firstly, cities in Sub-Saharan Africa are using innovative and affordable methodologies to mitigate GHG emissions. Rather than focusing on large-scale landfill gas waste-to-energy projects, certain cities in Sub-Saharan Africa are also adopting small household bio-digesters for waste diversion and producing biogas for cooking which all contribute to low emissions.

Secondly, this study highlights the need for more climate change mitigation activities in developing nations in Agriculture, Forestation and other Land Use (AFOLU). The empirical result indicates that leading cities in Sub-Sahara Africa focus only on city “greening” and beautification programs without clear actions on reducing GHG emissions through afforestation, agriculture and improved land use. With anticipated

population increase and spatial development, the AFOLU sector must be a focal point for climate actions in these cities. The proximity of cities to the coast also makes this very germane for carbon sequestration. Thirdly, empirical findings show that a hybrid, matrixed but parallel coordination system is deployed in Sub-Saharan African cities. The cities plan and coordinate climate action programs through a unique matrix system consisting of a parallel central sustainability department and departmental- and agency-level coordination of climate change activities. Further studies are required to confirm the efficacy of the system. Appointing a leader who will centrally manage and coordinate decarbonization programs is the best course of action for local government. This duty includes updating municipal executive management and working with relevant internal stakeholders from other departments. More personnel could be hired to assist the climate change leader and offer various levels of supervision. The issues with communication and coordination that plague all case cities will be helped by this strategy. This framework will prioritize and integrate the actions of various internal agencies. The roles and responsibilities of the general municipal departments and internal organizations, which currently plan and carry out climate-related programs in silos, will be described in this approach.

Vertical integration, in all cases, is top-down. The powerful influence of the high-level government makes climate decisions quasi-authoritative, and there are little or no bottom-up inputs. This is another area of improvement in deep decarbonization strategies in Sub-Saharan cities based on the cases studied.Most cities in SSA do not utilize a self-regulating mode of governance. In most case studies, there is no implementation of any form of corporate climate change mitigation actions, making climate action program development inorganic. This points to a uninternalized climate program with severe external influence which can lead to failure of climate action plans. All climate actions are focused predominantly on community action plans. Cities must be looking at decarbonizing their corporate fleets and municipal transit, decarbonizing public buildings through building retrofitting, developing zero-emission facilities and injecting renewable energy sources. The use of off-grid energy systems like roof solar PV and

distributed energy resources will be impactful in this regard. This may also include the development of mini grids to transmit and distribute locally renewable energy. These practices will convey institutional commitment and leadership for implementing community actions.

Traditional institutions are principal actors in climate action in sub-Saharan African cities. The traditional institutions are active in climate action consultation, leadership and coordination in their respective communes. They act as influencers for engagement and communication. The institution helps infuse helpful cultural nuances, norms and knowledge with established technical systems to advance climate actions.

The last contribution highlighted that the leading barriers to climate change mitigation actions in the cities studied are funding, inadequate human capacity and poor governance. The other issues hindering climate change mitigation action in case cities are further broken down into poverty, lack of infrastructure, advanced technologies, access to funds, necessary skillsets, institutional challenges, political engagement, communication, jurisdictional authority, human resource deficiency and poor governance framework.

In addition to validating the literature with empirical results, this study utilized the empirical findings to compare cities' deep decarbonization framework in developed nations with sub-Saharan Africa.

The massive political and fiscal influence of national government on case cities inherently limits the actions of local government in independently combatting climate change. All the climate action plans for all case cities are relatively new, so implementation is in the early stages. The plans, however, have their short- and long-term targets via established milestones.

In all, the socioeconomic impact and co-benefits of deep decarbonization in Sub-Saharan African cities is immeasurable. There are major impacts on healthcare with better air quality from clean cooking, use of non-motorized mode of transportation and availability of electricity. Deep decarbonization offers a path for job creation in every sector from waste management to renewable energy. The access to clean,

affordable, and accessible energy system is the fundamental of economic transformation which is much needed in the case cities and unlock sustainable growth.

Finally, as Linton (2020) opined, there are few academic research publications and literature sources on deep decarbonization at the city level, especially in the Sub-Saharan African context. This research contributes to the knowledge base of decarbonization at the sub-national level. It was also noted that the C40 organization – an umbrella organization of a transnational network of cities working to combat climate change - is involved in developing Climate Action Plan (CAP) for all case cities.

6.2 Theoretical Impact

As discussed in 6.1, this study made several contributions to the theory and literature of deep decarbonization pathways, urban governance, climate change and sustainable development in Sub-Sahara Africa. The contributions address the theoretical gap in knowledge for climate governance, actions and strategies in major urban centers in low-income countries of Africa. By studying the plans and strategies of four leading cities in sub-Saharan Africa, this research work was able to identify the innovative pathways, strategies, actors and existing barriers to meeting climate goals by sub-Saharan African cities. The comparison of climate action pathways and approaches between cities in developed and developing nations provides tangible factors and elements to consider for the transferability of sustainability ideas from the global north to the south as part of the intergenerational and polycentric approach to global climate change mitigation.

The contributions of this study to the body of literature on decarbonization frameworks are in seven major areas as highlighted in 6.1. The research extends the literature to include the innovative approaches by cities in Sub-Saharan Africa to mitigate climate change. These areas of contribution are the decarbonization of energy and waste management, increasing local carbon sinks, climate action coordination structure, top-down vertical integration tactics, self-regulating governance mode, the role of traditional institutions and major barriers to decarbonization efforts at the city level.

6.3 Practical Implications

The practical objective of this study is to help local governments understand and adopt more realistic and sustainable climate strategies. The study and breakdown of the practices of leading cities in Sub-Saharan Africa for deep decarbonization pathways provide a practical model to help other cities develop their climate change mitigation plans irrespective of varying socioeconomic and political situations.

With C40, a network of mayors working to combat climate crisis, playing the leadership, coordination, funding and advocacy roles in the development of the climate action plans for all the case cities, this study also shows the importance of transnational networks like C40 in climate change mitigation programs at the city level. It highlights the value these networks provide to cities through global learning, advocacy, information, technical support and funding. The gaps identified as part of the empirical findings of this study can be of practical use to cities and transnational networks for continuous improvement. This novel study which involves four case cities is essential in understanding sub-national deep decarbonization in Sub-Saharan Africa. It provides an all-encompassing view of urban climate governance in one of the world's most vulnerable regions – low-income countries.

Local governments must consider all the positive and negative findings across the pathways, governance, strategies and actors when planning for climate action at the local level for successful implementation.

6.4 Limitations and Future Research

This section focuses on the limitations of the research study in terms of the research design chosen. It also emphasizes the potential for future research in this field.

This study examined decarbonization pathways, strategies, governance structures and actors, focusing on four leading cities in Sub-Saharan Africa as case studies. The case cities shared many similarities, such as population, economic development and language, which are all part of the selection criteria. Due to the language barrier, these criteria alienated other major cities of similar socio-economic levels from the study. The case selection criteria also limited the case study to only four cities. Future studies will benefit

from more case studies from a more diverse set of cities. Diversity can include populations, language, location, size and type of government. A similar study with a larger sample size would highlight more emerging patterns, which will help validate findings and establish patterns with more nodes.

All the studied climate action plans are two years old on average, which provides limited data and information on the progress and efficacy of the program. The research into local government climate action in Sub-Saharan Africa at a later date (first milestone) will be beneficial to understand the effectiveness of the chosen pathways and strategies.

The research is designed and implemented with only a qualitative method. Future research in this area would benefit from adopting a quantitative or mixed methods methodology perspective because greenhouse gas emissions are quantitative. The next step in comprehending the strategies and pathways of best practice cities would be the implementation of quantifiable results.

6.5 Conclusion summary

In conclusion, this project, modelled around similar work on cities in developed nations, has explored and analyzed the deep decarbonization efforts in four sub-Saharan African local governments. The research shows the main focus areas for cities in Sub-Saharan Africa for effective decarbonization by highlighting the innovative strategies and the gaps in the climate action plan. It also opened a discussion on the commitment and motivation of cities to climate change mitigation. In addition to contributing to the literature on urban climate governance and sustainable development in Sub-Saharan Africa, it contributes to practical knowledge for developing and implementing deep decarbonization plans at the local level. Overall, this study continues the conversation around climate action in cities and climate change in the world's most vulnerable region - Africa.

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Appendices

Appendix 1: Ethic Clearance Letter

UNIVERSITY OF WATERLOO

Notification of Ethics Clearance to Conduct Research with Human Participants

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Principal Investigator: Amelia Clarke (School of Environment, Enterprise and Development)

Student investigator: Bayo Akomolafe (School of Environment, Enterprise and Development)

File #: 44446

Title: Deep decarbonization pathways, strategies, governance, actors and roadblocks in cities: Climate change mitigation perspectives from developing nations

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The Human Research Ethics Board is pleased to inform you this study has been reviewed and given ethics clearance.

Initial Approval Date: 07/15/22 (m/d/y)

University of Waterloo Research Ethics Boards are composed in accordance with, and carry out their functions and operate in a manner consistent with, the institution's guidelines for research with human participants, the Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans (TCPS, 2nd edition), International Conference on Harmonization: Good Clinical Practice (ICH-GCP), the Ontario Personal Health Information Protection Act (PHIPA), the applicable laws and regulations of the province of Ontario. Both Boards are registered with the U.S. Department of Health and Human Services under the Federal Wide Assurance, FWA00021410, and IRB registration number IRB00002419 (HREB) and IRB00007409 (CREB).

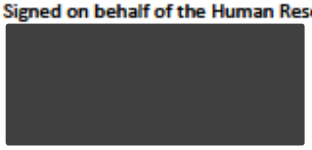
This study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

Expiry Date: 07/16/23 (m/d/y)

Multi-year research must be renewed at least once every 12 months unless a more frequent review has otherwise been specified. Studies will only be renewed if the renewal report is received and approved before the expiry date. Failure to submit renewal reports will result in the investigators being notified ethics clearance has been suspended and Research Finance being notified the ethics clearance is no longer valid.

Level of review: Delegated Review

Signed on behalf of the Human Research Ethics Board



Karen Pieters, Manager, Research Ethics, karen.pieters@uwaterloo.ca, 519-888-4567, ext. 41495

This above named study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

Documents reviewed and received ethics clearance for use in the study and/or received for information:

file: Recruitment Letter -V2-220712.pdf

file: Information Letter - V4 - 220715.pdf

Appendix 2: Recruitment Letter

Recruitment Letter

Dear (name of potential participant)

My name is Bayode Akomolafe. I am a master's degree student majoring in Sustainability management working under the supervision of Professor Dr. Amelia Clarke in the School of Environment, Enterprise and Development at the University of Waterloo, Ontario, Canada.

I am writing to you about our current research work on deep decarbonization at the city level. The research project is entitled "Pathways to Deep Decarbonization in Cities: Mechanisms, Tools and Governance Structures for Transformative Climate Action in developing nations". The purpose of this research is to collect information about the current pathways that cities in developing nations are developing towards deep decarbonization and compare case studies.

I am contacting you as the [City] is an excellent fit to be a case study for the research project, based on the data disclosed in the CDP Cities 2021 database. I would like to seek your participation as the [role] for the city. This participation entails a 30 – 60-minute interview over the phone at a time convenient for you. You will be asked only factual questions about the deep decarbonization pathways, strategies and governance structures in your city. For more information about the study please see the attached information letter.

Please reply to this email (bakomola@uwaterloo.ca) if you are interested in participating and indicate any times you are available for an interview within the next weeks.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board.

Thank you for taking the time to read this email and for your consideration.

Sincerely,

Bayode Akomolafe
Master of Environmental Studies Candidate
School of Environment, Enterprise and Development
Faculty of Environment,
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E-mail: bakomola@uwaterloo.ca
https://uwaterloo.ca/implementing-sustainable-community-plans/current-students-studies/bayode-akomolafe
https://www.linkedin.com/in/bayodeakomolafe/

Appendix 3: Information Letter

Information Letter

University of Waterloo

June 19, 2022

Dear [*participant*],

This letter is an invitation to consider participating in a study that I am conducting as part of my master's degree in the School of Environment, Enterprise and Development (Faculty of Environment) at the University of Waterloo, Ontario, Canada under the supervision of Prof. Amelia Clarke. I would like to provide you with more information about this project and what your involvement would entail if you decided to take part. Please take some time to read the following information pertaining to the research project and discuss with involved parties regarding your city's participation.

Climate change mitigation action requires a deep reduction in greenhouse gas (GHG) emissions and transformative action at the city level. The aim of this study is to identify the current pathways that leading "best practices" cities in sub-Sahara Africa and internationally are utilizing to achieve GHG reduction goals. Through examining the governance structures, key actors involved as well as the particular tools and strategies being used for the implementation of climate change mitigation and deep decarbonization plans, this study will gain an understanding of the current best practices in cities with a special focus on sub-Sahara Africa. For this, we are seeking information on the current practices occurring within your city for the creation and implementation of your climate action plan.

An analysis of your city's current climate action plan will be conducted prior to the interview. The purpose of the interview will be to clarify any gaps in the available document after the document analysis. For the interview questions, there is no preparation required. However, the list of interview questions will be shared with you prior to the discussion to provide you with an early reference. The city will be listed as a case city and highlighted within the research study.

Participation in this study is voluntary. The interview will be conducted over the phone or via Skype, Teams, Zoom or any other agreed-upon media and will be approximately 30 minutes - 1 hour in length. You may decline to answer any of the interview questions if you wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate the collection of information and later transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish.

Your name will not appear in any thesis or report resulting from this study. However, with your permission anonymous quotations may be used and attributed to your city with a generic description of your role (e.g. [insert city name], city climate change official." Depending on the size and structure of the city organization there is a possibility that a motivated individual may be able to ascertain your identity. To help mitigate this, I will send you a copy of the quotations that I would like to use and you will have the opportunity to review and let me know if you would like me to make any changes.

Appendix 4: Consent form

CONSENT FORM

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Bayode Akomolafe of the School of Environment, Enterprise and Development (Faculty of Environment) at the University of Waterloo, Ontario, Canada. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

This study has been reviewed and received ethics clearance through the University of Waterloo Research Ethics Board (REB 44446). If you have questions for the Board, please contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or reb@uwaterloo.ca.

For all other questions contact Bayode Akomolafe by email at bakomola@uwaterloo.ca.

With full knowledge of all the foregoing, I agree, of my own free will, to participate in this study.

☐YES ☐NO

I agree to have my interview audio recorded.

☐YES ☐NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research. The quotations will be attributed by city and generic role (e.g., official of the city of Nairobi). I will have an opportunity to review and verity that the quotations chosen can be used in this way.

☐YES ☐NO

Participant Name: _____ (Please print)

Participant Signature: _____

Witness Name: _____ (Please print)

Witness Signature: _____

Date: _____

Appendix 5: Interview guide

Interview Guide

I am looking to see what factors stand out across leading cities in sub-Saharan Africa on climate change mitigation programs

I have already conducted some online research of the publicly available documents and this interview is meant to fill in some of the gaps that I have not been able to find online. This study aims to collect factual information on cities' climate change mitigation plans and not personal opinions.

This interview is completely voluntary, and you may say no if you do not want this information used in the study. Kindly let me know at anytime if you would like to skip a question or stop at the interview. In addition, let me know if there is anything that you do not want to be used in this research.

With your consent, this interview will be recorded and transcribed. Direct quotes may be used, you will be sent a copy of the transcribed interview in order to redact or clarify anything said in the interview. The quotations will be attributed to you by city and a generic role (e.g. Transport specialist for the city of Nairobi).

Do you still agree to participate in this interview?

To start, for record purposes, can you state your name, your current role, and how long you have been in that role

Technical pathways

- What sectors does the climate action plan focuses on?
- What climate action projects have been implemented or are being implemented (presently +/- 5 years)?
- What actions is your city taking in each sector?
- What actions are the city taking to reduce GHG emissions in the agricultural sector, forestry, and land use?
- Does the plan consider carbon sinks and or carbon offsets? If so, how is your city going about this?
- What are the challenges faced by your city in implementing climate change mitigation plans in the aforementioned sectors?

Governance:

- Describe the governance/decision-making structure used to implement the climate action plan
- Can you tell me about the planning process of climate change mitigation programs?
- Is there any overseeing body that actors and partners report to and holds them accountable?
- Describe the means of communication used between the city, actors and partners
- How is the local government (city) collaborating with other sectors such as businesses, NGOs, higher levels of government, etc.?
- How many external partners/actors are involved in the climate action plan?
- What are their roles? (Do they determine their own contribution, do they take part in decision making, do they play a consultative role?)
- How is monitoring and reporting done on the progress of the plan and actions?

Appendix 6: Letter of appreciation

Letter of appreciation

[Date]

Dear Participants,

I would like to thank you for your participation in this study entitled "Deep decarbonization pathways, strategies, governance, actors and roadblocks in cities: Climate change mitigation perspectives from developing nations". The study of deep decarbonization in cities of developing nations is a key area of expansion of the global climate change knowledge as this would provide a more inclusive perspective to climate mitigation discourse and knowledge base.

The data collected during interviews will contribute to a better understanding of the pathways, actors, strategies, and governance structures being used by city governments in developing nations for climate change mitigation. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics board. If you have questions for the board, contact the Office of Research Ethics at 1-519-888-4567 ext. 36005 or reb@uwaterloo.ca. For all other questions, contact Bayode Akomolafe at bakomola@uwaterloo.ca.

Once all the data are collected and analyzed for this project, I plan on sharing this information with the research community through seminars, conferences, presentations, and journal articles. If you are interested in receiving more information regarding the results of this study or would like a summary of the results, please provide your email address. I will send you more information when the study is completed, anticipated by [insert date].

If you have any questions regarding the study, please contact me by email at bakomola@uwaterloo.ca. You can also contact my supervisor, Professor Amelia Clarke, at 519-888-4567 ext. 38910 or email amelia.clarke@uwaterloo.ca.

Bayode Akomolafe
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https://www.linkedin.com/in/bayodeakomolafe/

Appendix 7: Deductive and inductive thematic codes for cross-case comparison

Technical pathways

Energy	Building & Building services	Industry	Transportation mode and fuel shifting	Waste management	AFOLU
Target	Target	Target	Target	Target	Target
No target - supporting actions	No target - supporting actions	No target - supporting actions	No target - supporting actions	No target - supporting actions	No target - supporting actions
No target - No action	No target - No action	No target - No action	No target - No action	No target - No action	No target - No action
Install Renewable System	Financial tools (incentives)	Financial tools (incentives)	Infrastructure investment	Waste to Energy (biofuel)	Green space
Building Scale Energy	Regulation (building code/mandate)	Regulation (building code/ mandate)	Financial tools (incentives)	Air quality	Land management
District Energy System	Voluntary standards	Voluntary standards	Regulation (Car free zone, parking limitations, Tax laws)	Carbon Capture	
	Enabling actions	Enabling actions	EV Infrastructure	Enabling actions	
			Transit + fleet action	Gas capture	

Institutional strategy

Engagement	Technical capacity building	Green Economy	Financing	Behavioral intervention	Regulation and policy	Long Term Plan
Youth Programs	Technical Scenario Modeling	Business innovation network/accelerator Policy	Higher Government (s)		Policy Document	Long Term Pathways
Climate Change center (a physical place that residents can go to be engaged/educated	Geospatial data	Workforce development/training	Local Government (tax revenue)		Stretch code	Short term Strategies
Partner with Education Institutions	Technical Report	Green local businesses network	Private Sector		Legislation	Sustainability embedded in other city planning
Organized resident engagement program	External consultants	Procurement policy	Green Bond/ Local Climate Bank / Investment scheme		Self-regulating	
Meetings/workshops/events/surveys	Partner with educational institutions		Loan			
Online engagement/ communication application	Increasing internal technical capacity		Grants			
Community-wide Engagement process for plan development						
Engagement of technical experts in plan development						

Higher governments						
Local business network						
Transnational city network						

Governance Mechanism

Decision making	Coordination	Monitoring and reporting	Communication	Collaboration and partnership	Multi-level integration	Governance mode
City council	City / City department	Progress report Frequency	Website/Online	Collaboration	Two-way	Self-governing
Other	Community Group	Reporting method	Public report	Partnership	Top-down	Governing through enabling
Traditional/Hierarchical	Other	Key performance indicators	Formal meeting		Bottom-up	Governing through provision
Collaborative		Plan update - frequency	Email		Horizontal	Governing through Authority
Multi-Level		Information made public	Informal meeting		Vertical	Community-led governance
Sustainability department						
Internal experts						

Actors

Private sector	Civil sector	Traditional actors	Educational Institution	Government
Enabling	Enabling	Enabling	Enabling	Enabling
Coordinating	Coordinating	Coordinating	Coordinating	Coordinating
Facilitating	Facilitating	Facilitating	Facilitating	Facilitating
Regulating	Regulating	Regulating	Regulating	Regulating
Decision maker	Decision maker	Decision maker	Decision maker	Decision maker
Implementation partner	Implementation partner	Implementation partner	Implementation partner	Implementation partner
Funding	Funding	Funding	Funding	Funding