UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME UN-HABITAT
SUD-NET CITIES IN CLIMATE CHANGE INITIATIVE (CCCI)

FINAL REPORT

VULNERABILTIY ASSESSMENT OF CLIMATE CHANGE IN KAMPALA AND UGANDA

Consultant Team

Shuaib Lwasa (Team Leader)
Charles Koojo
Frank Mabiriizi
Paul Mukwaya
Deogratius Sekimpi

SUBMITTED TO: URBAN ENVIRONMENT & PLANNING BRANCH

30TH JULY 2011

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

ACRONYMS/ABBREVIATIONS

CCCI	CITIES IN CLIMATE CHANGE INITIATIVE
CIESIN	CENTER FOR INTERNATIONAL EARTH SYSTEM INFORMATION NETWORK
CDM	CLEAN DEVELOPMENT MECHANISM
GCM	GLOBAL CIRCULATION MODELS
GIS	GEOGRAPHIC INFORMATION SYSTEMS
IPCC	INTER-GOVERNMENTAL PANEL ON CLIMATE CHANGE
KCCA	KAMPALA CAPITAL CITY AUTHORITY
LSSP	LAND SECTOR STRATEGIC PLAN
MoAAIF	MINISTRY OF AGRICULTURE, ANIMAL INDUSTRIES AND FISHERIES
MoH	MINISTRY OF HEALTH
MoLG	MINISTRY OF LOCAL GOVERNMENT
MoLHUD	MINISTRY OF LANDS, HOUSING AND URBAN DEVELOPMENT
MoWE	MINISTRY OF WATER AND ENVIRONMENT
NAPA	NATIONAL ADAPTATION PLANS OF ACTION
NEMA	NATIONAL ENVIRONMENTAL MANAGEMENT AUTHORITY
OPM	OFFICE OF PRIME MINISTER
SWOT	STRENGTHS, WEAKENESSES, OPPORTUNITIES and THREATS
UBOS	UGANDA BUREAU OF STATISTICS
UNDP	UNITED NATIONS DEVELOPMENT PROGRAM
UN-HABITAT	UNITED NATIONS HUMAN SETTLEMENTS PROGRAM
WFP	WORLD FOOD PROGRAM

EXECUTIVE SUMMARY

Climate change is strongly felt as a reality and has moved high up on the global agenda while many of country and regional programs are re-aligned to climate change adaptation and mitigation. The reality of dealing with the effects of climate change has dawned but as observed by the United Nations Environment Programme (UNEP), the most vulnerable region is Africa due to its technological, managerial, administrative and financial unpreparedness to the effects of climate change. Africa and cities in particular are facing the reality of dealing with the effects of climate change. Cities have been identified as both contributors and vulnerable to climate change. This is partly because climate change has now been pegged to human-induced Green House Gasses (GHGs) through a host of anthropogenic activities many of which relate to city functions. For example, resource extraction, consumption and carbon emissions are partly due to high consumption in cities and this is expected to rise with the fast urbanization. UN-Habitat notes that the effects of climate change are exacerbating the already grim environmental, social and economic problems increasing poverty and putting the urban poor at the greatest risk. But cities are also now recognized both as centers of innovation and where large amounts of greenhouse gases can be mitigated through technological, managerial and good policies. Cities are also hubs for protecting a large mass of population that are vulnerable to climate change through improved housing, infrastructure healthcare and local economic opportunities. Under the Sustainable Urban Development Network, this assessment analyzes the urban vulnerabilities and identifies key vulnerable sectors for adaptation and mitigation. **The assessment was conducted with an overall purpose of analysing the climate change risks and vulnerabilities facing Uganda in general and Kampala. As a pilot city, Kampala Capital City Authority's (KCCA) capacity to assess and plan for adaptation and mitigation measures are identified for short term to long term intervention. Scalable adaptation and mitigation measures are identified which can be implemented at community to city level through demonstration projects and new policies.**

The vulnerability assessment was conducted at the national and the city scales. A combination of methods and materials were utilized in the assessment largely drawing from literature and secondary data available. Demographic data was analyzed spatially to elicit information on population and urban development dynamics. Geospatial analysis method of gridding was applied to spread population and relate it to designated towns at national scale. Geospatial analysis was also utilized to integrate demographic, health, environmental and socio-economic data as well as the downscaled climate models to analyze vulnerability largely. Vulnerability analysis focused mainly on exposure due to

data limitations that could not enable parameterization of internal vulnerability. Urban vulnerabilities at city region scale were discerned by integrating available spatial data on the different urban sectors. An extensive documentary review and assessment of published literature formed the major method in the assessment. Literature was analyzed in respect to vulnerabilities but also in respect to institutional weaknesses to identify existing functional mechanisms, gaps and potentials. The assessment utilizes an analytical framework that recognizes cities relating to climate change in a bi-directional manner. This means that cities contribute to climate change through emissions that come from high consumption but are affected and vulnerable to the effects of climate change including extreme events. However cities are not merely the problem but also part of the solution at mitigation and adaptation at both city, regional and global level.

Climate Change in Uganda

The global Climate Change models project an increase in average temperatures in Uganda by up to 1.5 ºC in the next 20 years and by up to 4.3ºC by the 2080's according to the fourth assessment report of the International Panel on Climate Change (IPCC) 2007. Changes in patterns and total annual rainfall amounts are also predicted in addition to expected change in temperature. Recent rainfall data recorded indicates some significant variations and changes in various parts of the country. There is evidence that rainfall variations coupled with temperature changes pose vulnerabilities to urban areas in Uganda. Based on the data analysis reveals an increase in temperatures and increase in rainfall of 10 – 20% over most of the country with a decrease expected over the semi-arid cattle corridor. This correlates with the downscaled prediction models evidence that the climate could be changing in Uganda.

Urbanization and Climate Change

Urbanization just like climate change is unequivocally occurring in Uganda with now an estimated 15% of the national population living in designated urban areas. Designated urban areas including statutory towns that follow a five tier level of; trading centers, town boards, town council, municipality and City. Urbanization is important in the climate change discourse due its bi-directional relationship with climate change. Cities contribute to climate change but are also vulnerable to the effects of climate change. Managing urban growth in Uganda seems to be oscillating within the realm of policy and at cross-

roads in respect to the guidance systems. The lack or slow process of initiating an urbanization policy, the failure of current urban planning and guidance systems and laws and continued spontaneous development of urban areas in Uganda have far reaching implications on realizing the Millennium Development Goals (MDG's), national, regional development and responding to climate change. The legislative framework at present provides no policy to address climate change nor any focus on urban areas. At present, all the national and local level interventions and actions are largely guided and supported by formal positions and international agreements on climate change under the international arrangement of the United Nations Framework Convention on Climate Change (UNFCCC) and its corresponding Kyoto Protocol. At the country level, these are coordinated and monitored by the recently created Climate Change Unit, located in the Meteorology Department of Ministry of Water and Environment (MoWE). But urban areas have not been a focus in translating laws and regulations for urban sustainable development and management which is necessary in the context of climate change.

Vulnerability of Urban Areas to Climate Change

The most critical climate changes in Uganda are increased/reduced precipitation and increasing temperature. Evidence from 60 year period shows most parts of the country in north eastern and central to have experienced reduced average precipitation period while areas around Lake Victoria and in mountainous regions, there is evidence of increased precipitation. The two scenarios have implications on urban vulnerabilities. The first scenario of increased precipitation implies that there will be more water, which requires to be tapped for urban utilization but a lot, of that water turns into runoff. The increased runoff requires more robust drainage systems for managing storm water to have less disruptive tendencies to other urban sectors such as public transportation. The runoff has an implication on flooding with associated effects. The second scenario relates to reduced rainfall and water availability in water 'stress' urban areas of Uganda where there is evidence of reduced precipitation. The vulnerability of these urban areas is in relation to urban water provision given that most rely on wetland areas from which water is drawn for treatment, storage before distribution. Besides making urban infrastructure susceptible to destruction, storms have also affected housing, social services and livelihoods of urban dwellers. For example the extended rains and floods of December 2006- February 2007 caused serious damage to housing, schools and disrupted livelihoods n addition to cutting off neighborhoods from towns in eastern Uganda. A spatialized vulnerability analysis shows moderate to high vulnerability of most urban centers in Uganda. Where precipitation has increased, excessive water causes floods and where precipitation has decreased, less water stresses urban systems.

City Regional Analysis

The city 'region' of Kampala covers an estimated land area of 1895 sq km engulfing several of the hitherto satellite towns. This is the functional city region in which economic, social and environmental processes are spatially connected. Due to urban sprawl, the natural environment is threatened by both climate change and the fast-paced expansion of the built up city. This has increased vulnerability of the population in the region. Vulnerability assessment of the city-region shows a higher risk to the population and urban infrastructure within the region. From the analysis results, most areas of the city region fall between 4 and 7 on the vulnerability index. Vulnerabilities of different urban sectors such as roads and electricity grid, health centers, education, housing and drainage infrastructure. Although a higher spatial resolution analysis would identify in more specific terms variations by sector and within sectors, this analysis brings to light the vulnerability at citywide scale. The outcome of the vulnerabilities is manifest in terms of health, livelihood destruction, destruction of properties and higher costs incurred by the population and institutions to bring systems back to functional level. Health is a key sector in which secondary impacts of climate risks can be discerned.

Although the current greenhouse gas emission levels form the city region are not adequately known, the use of motor vehicles, reliance on fossil fuels, biomass for domestic use and future trajectories of energy use provide insight into Kampala's emissions. . Public transportation and construction appear to be the most emitting sectors. The implication is the increase in emissions of carbon dioxide (CO2), the situation requiring reversal if Uganda is to achieve the IPCC emission targets. Although the contribution of Uganda to CO2 emissions is low, adapting urban transportation calls for action and getting smarter ways of urban transport and energy efficient systems is a key area for climate change mitigation. A key sector of housing is affected by climate change but also contributes to GHGs. Buildings are energy inefficient. Other sectors of solid waste collection, water and sanitation also contribute to GHGs. There are opportunities for solid waste management system to take advantage of the Clean Development Mechanism (CDM) for carbon credits emanating from landfill gas or managing garbage better.

In respect to health, the relationship between urban environmental conditions and health is well established and the health of people is an indicator of the environment in which people live. Infectious diseases especially water-related and air-borne are prevalent in many of the neighborhoods of Kampala while outbreaks of cholera have been recorded in

1997 and reoccurring in 1999, 2004, 2006 and 2008 due to the increased floods in the city. One of the most significant environmental issues related to health is flooding and it's associated problems of disease outbreaks, loss of property and life. Flooding in Kampala especially in settlements of the urban poor has become usual phenomenon even when slight down pours occur in the city and associated to Climate Change. Gender is important in understanding the vulnerability and effects of climate change in Uganda and Kampala. But it is also important when trying to develop adaptation measures to climate change effects. This is because females comprise 51.19% of the national population. Of these, 22.4% are women of child bearing age, 25.8 girls below 18 years of age and 4.1% women of over 60 years of age. Therefore climate change adaptation and mitigation also needs to be gender responsive in the sense that the effects need to be analyzed in terms of how they affect the different gender groups but the strategies should also consider the different social groups including special needs for women and children.

The ecosystem of the city region characterized by low land remnants of rainforests, wetlands, lakeshore wetlands is also under threat from climate change but also urbanization. Wetland destruction, biodiversity loss and soil erosion augmented by clearance of vegetation on hill slopes are some of the indicators of ecosystem services decline. Ecosystem conservation and management remains an important component for climate change adaptation and mitigation. One of the adaptation possibilities is the assessment of the ecological potential of KCCA and design adaptation measures that enhance ecological services while providing co-benefits for the urban poor and general population. The ecosystem of the city region is also under threat from climate change but also urbanization.

Capacity of KCCA and other institutions was assessed to handle climate change plans and implementation. Tools are proposed for this purpose to guide in detailed steps and practical means that enable different stakeholders in reaching a desired goal of improving understanding and delivery of goals. One of the key tools existing is National Adaptation Program of Action (NAPA) and the Initial Climate Communication tool. At the city region level, there is no evidence of any tools that have been developed to respond to climate change. But there are opportunities of coupling with ongoing projects and programs to develop locally adapted tools to raise awareness and respond to climate change. One of these is the yet to be approved Kampala Metropolitan Authority. But tools have been developed by UN-Habitat which are customized to build capacities of municipalities and cities like KCCA. But a key gap is the linkage between NAPAs and local adaptation programe of action known as LAPAs. The current NAPA is silent about urban areas and yet urban areas are important in climate change adaptation and

mitigation. The implications of this is also that international funding available to developing countries such as the Adaptation Fund use the NAPA as a reference for funding and if urban issues are not included it is unlikely that they will be funded. Frameworks and tools for climate change are very necessary to bring climate change on the agenda of policy actors and all other stakeholders in city development and management. At Kampala city region level, tools on climate change and or related activity are yet to be developed.

The establishment of a platform for exchange of information and practices will be crucial to mitigation and adaptation. Information sharing networks are vital to enable the flow of such information but also for climate change adaptation. UN-Habitat under the SUD-NET is to promote Local Urban Knowledge Arenas (LUKA) and it's hoped that through this network that is to occur both at city and national level flow and exchange of information will be stimulated.

Recommendations

The recommendations based on the assessment focus on both mitigation and adaptation Based on the findings it is clear that urban adaptation and mitigation are necessary for immediate action. The increasing climate risks and exposure of a sizeable population in the city region calls for specific adaptation and mitigation measures. These are distinguished as short term and long term interventions.

Adaptation; a range of measures some of which can build on existing projects or lessons of completed projects can be elaborated further by KCCA to kick start adaptation in the city.

- A key adaptation measure is the recognition of vulnerabilities associated with flooding. Adapting to floods will require a carefully designed strategy that combines community based adaptation as well as citywide adaptation strategies. Whereas increasing rainfall is likely to worsen flooding, the causes are more than excessive rainfall. Interventions including productive land cover on hilltops, building robust drainage infrastructure, enabling community based waste recovery and recycling, plot level infiltration technologies, harvesting rainwater, can reduce the risk of flooding. A well-designed system for household based activities scaled out to citywide households can have a cumulative effect on flood reduction. The role of women in adapting at community level will be very important.
- In respect to energy, adaptation options include enhanced cooking technologies that conserve energy, recovery of energy from wastes to reduce reliance on biomass from rural areas. There are clear co-benefits of livelihood based adaptation in energy sector such as health improvement, income sources for the

poor and potential for enhancement of lives. Other alternative energy sources for middle class include encouraging use of natural gas and electricity. This has implications for the poor due to issues of affordability. Thus a combination of livelihood based energy adaptation will be important for the urban poor but also for the energy use related to buildings.

- In respect to warming temperatures, adaptation options range from design of houses with materials that increase reflectivity, productive greening at plot level and ventilation. Energy efficient building codes also offer opportunities for a range of house types in the city and these can be developed, enacted and enforced. A note that enforcement traditionally has focused on prohibitive and punitive approach. Arguably adapting to climate change by KCCA may require a shift to incentive based rather than punitive enforcement.
- Institutional adaptation will also be very crucial. KCCA has the options to adjust its system of service delivery, planning and operationalization of such plans in the context of climate change. Institutional readiness to enhance resilience and inclusive cities is a key driving factor for urban adaptation to climate change. This is because local governments and city authorities are the locus of adaptation planning, funding and decision making. Urban governance relies on institutional, regulatory and legal frameworks but it is important to recognize importance of knowledge that supports the process of decision making. Knowledge on adaptation exists in communities and research institutes but is not widely shared with policy makers for response and action. The consequence is that good practices of adaptation remain at micro-level dotted around Kampala with many potential adopters unaware. Kampala Capital City Authority has the option to provide leadership in climate change adaptation with a wide range of examples for institutional adaptation (by way of changing practice as an example, energy efficient administrative buildings), to climate campaigns, climate change development plans and integrating climate change adaptation into municipal plans, which present opportunities for institutional adaptation.

- Adaptation costing and financing will be a crucial aspect in the city. Adaptation costs need to be looked at from the view point of 'hard adaptation' and 'soft adaptation. There have been several studies to evaluate adaptation cost estimates all of which are at global level. These estimates provide insights into various components of evaluation including climate-proofing, costs of National Adaptation Programmes of Action (NAPAs), Non-Governmental (NGO) projects and Poverty Reduction Strategy Papers (PRSP). There has not been specific framework for estimating costs at national as well as city levels. However the vulnerability assessment and subsequent adaptation measures provide a starting point for estimating adaptation costs. Urban infrastructure on which 'hard adaptation' is needed is relatively easier to estimate but livelihoods systems, which constitute the 'soft adaptation' present challenges of estimating adaptation costs. Despite the lack of cost estimate frameworks at city level, there is a promise of project level evaluations in the city to form the building blocks. Costs related to health burden of climate change induced impacts, livelihoods and costs

related to adoption of alternative energy sources provide a basis for estimating adaptation costs. A key recommendation here is KCCA to initiate costing for adaptation. With adaptation funding streams expanding, there has to be readiness on the part of KCCA to absorb the funding and implement the measures.

- In respect to mitigation, There is a clear need for mitigating of climate change in the city despite the comparatively low emissions. Mitigation options exist that would make the city a low or carbon neutral city. Recommendations for this are as below;
    - Spatial planning and implementation that can influence compact urban form to reduce on energy use in transportation, buildings and service provision
    - Energy efficient and socially inclusive transport system including non-motorized transportation (NMT) to provide options for different social groups. There is a design and project for NMT, which is ongoing. It is appropriate that demonstration of this project be undertaken to create buy-in for the masses in Kampala
    - Energy efficient and affordable residential neighborhoods that can generate energy at household or neighborhood level. This can be through promotion of tapping methane form pit latrines
    - Building codes for energy efficient construction and housing sector will be an important part of the long term strategy for mitigation in Kampala. This together with transportation can create opportunities through the green economy framing to use green technologies, create green jobs and drive towards a carbon neutral or low carbon city.
    - The land fill gas flare from the city landfill can be tapped and utilized to generate electricity. Although the technology of gas and water driven turbines, the CDM project underway can be framed in the context of mobilizing resources for future extraction and generation of electricity.
    - A key requirement and recommendation of this assessment is the GHG inventory. This is urgent and will be crucial in benchmarking the city's emission levels and support the formulation of mitigation strategies.

There is a dearth of literature which supports framing mitigation in the context of adaptation but this seems to be the consensus building in the developing countries. In order not to slow economic growth and disadvantage the urban poor through large scale mitigation strategies, some adaptation measures can have co-benefits of mitigation and thus form the outset mitigation can be framed by adaptation.

- With these recommendation, it is important to highlight the enabling framework for adaptation and mitigation. Enabling factors largely involve policy, regulatory and institutional mechanisms that would support adaptation and mitigation. More

specifically the following will be crucial in initiating and enhancing adaptation in the city.

- Urban Governance improvement and preparedness to respond to climate change. This involves dialogue, internal institutional reorganization and structures that will commit to climate change issues
- KCCA's response in capital investments to climate proof public infrastructure to reduce vulnerability will be crucial
- KCCA's response to spatial planning failure will require rethinking planning, how it is done and building on existential needs of the population
- KCCA's response to the reducing area under green either as parks or multi purpose nature reserves. Conservation and management of and urban natural resource for biodiversity and keeping the city vegetative through urban greening and preservation of the hill tops will be crucial
- Developing tools for awareness raising and capacity building in the city and at national level for secondary towns. The tools provide space for advocacy, dialogue and improved decision making
- Initiating and stimulating LUKA which is underway and linked into the National Urban Forum will help generate ideas from stakeholders but also empower KCCA in terms of knowledge for evidence informed decision making

1.0 INTRODUCTION

Climate change is strongly felt as a reality and has moved high up on the global agenda while many of country and regional programs are re-aligned to climate change adaptation and mitigation[1-4]. Africa and cities in particular is facing the reality of dealing with the effects of climate change[5]. But as observed by UNEP, the most vulnerable region is Africa due to its technological, managerial, administrative and financial unpreparedness to the effects of climate change[6]. UNEP further notes that the future of close to one billion Africans will be determined by the pace at which governments and institutions implement adaptation and mitigation measures to the climate change effects. Sectors reported to be affected include agriculture, energy, water resources, industry settlements and society, health sector, tourism sector, national economies; and ecosystems and wildlife sector[7]. Cities have been identified as both contributors to and vulnerable climate change but centers of solutions to mitigation as well[8]. This is partly because climate change has now been pegged to human-induced Green House Gasses (GHGs)[4] through a host of anthropogenic activities many of which relate to city functions. For example, resource extraction, consumption and carbon emissions are partly due to high consumption in cities and this is expected to rise with the fast urbanization[5]. Thus the earlier, climate policies are adapted and action taken, the better for future adaptation and mitigation pathways. Although African urbanization level is comparatively still low, its urbanization rate is faster posing challenges for cities in the context of climate change[9, 10]. Urban vulnerabilities to climate change in Africa are increasing as many coastal cities face sea-level rises, while others experience the wrath of extreme weather events including intensive precipitation, violent storms, fires, extended droughts, increasing temperatures accentuating the urban heat island effects[11].

UN-Habitat further notes that the effects of climate change are exacerbating the already grim environmental, social and economic problems increasing poverty and putting the urban poor at the greatest risk[5] Urban vulnerabilities are manifest in areas of water resources, health, housing, energy, food security, functional transport infrastructure, environmental services and economic productivity. In response to the threats of climate change and the need to formulate strategies to address climate change impacts, the SUD-Net Cities in Climate Change Initiative (CCCI) under UN-Habitat was launched to provide city-specific information, develop tools and build capacity for municipalities and intensification of adaptation and mitigation activities to climate change among other initiatives. This information and tools are targeting practitioners, academia and policy makers in cities of the developing countries in order to respond to the effects of climate change in a more concerted effort and integrated manner. This assessment report analyses urban vulnerabilities and identifies scalable adaptation and mitigation measures,

which can be implemented at community to city level through demonstration projects for sustainable urban development[1]. This report presents findings of the study in Uganda and Kampala based on an extensive review of literature, analysis of secondary data and consultations that have been undertaken with a wide range of stakeholders.

1.1. AIM AND OBJECTIVES OF THE ASSESSMENT

The overall purpose of this assessment was to analyse the climate change risks and vulnerabilities facing Uganda in general and Kampala in particular. The study provides a baseline analysis of the management, environmental, social situation on the national and city level, synthesizes and evaluates the current and potential consequences of climate variability/change. The assessment also summarizes policies strategies, action plans as they relate to climate change (national, and city-level), provides an overview of key institutional stakeholders and provides recommendations for potential city-related climate change mitigation and adaptation measures. In addition, on the city level is a detailed climate change vulnerability assessment. On the national and city level an assessment of existing tools and a gap analysis was also conducted, along with a capacity-building needs assessment for Kampala. This report provides the foundation for the Kampala Capital City Authority and their national partners to strengthen the adaptive and mitigation capacities vis-à-vis Climate Change. The assessment report identifies opportunities for policy change at the national and city level, capacities and training gaps as well as priorities for tool development and city-level responses to climate change.

1.2. METHODS AND MATERIALS

The vulnerability assessment was conducted at two levels. At the national level, urbanization is analysed in the context of climate change that expands the focus from a primate city to medium and small secondary cities, which are fast growing. The assessment also focuses on Kampala city deepening the analysis on sectoral vulnerabilities within the city but also the city-region[2]. A range of data sources has been utilized in the assessment. Demographic data has been analyzed to elicit information on

[1] Sustainable urban development is considered in this report as multi-dimensional encompassing social, economic and environment issues. These are decomposed in six areas of governance, social and cultural considerations, social infrastructure and public services, urban land use and housing, urban transport and natural resource management, and employment and the enhancement of economic growth.

[2] At both of these levels, the team conducted a comprehensive analysis of sustainable urban development in the context of climate change with the latter focusing on Kampala city region

urban development dynamics, density and agglomeration. A geospatial analysis of population using the gridding approach was applied at the country and 'city region' levels. Geospatial analysis integrated demographic, health, environmental and socio-economic data to further assess vulnerability at national and city-regional levels. Due to data limitations (due to lack of disaggregated and georeferenced data at household level), analysis of vulnerability in this report is taken as exposure to risks (of climate change effects) although combined external and internal vulnerability assessment would provide better information on risks to inform adaptation and building resilience. The bioclimate data sets at 1 km resolution [12] was utilized in the assessment and integrated with the 60 year period rainfall data for Uganda from 1950. More specifically the HADCM3 projection of 2050 and CISRO 2050 models were utilized in the assessment[12]. These were integrated with the country dataset of land use land cover, soils data, Digital Elevation Model, roads, drainage, agro-ecological zones and gridded population at 1 km resolution with adjusted population to 2010[13-15]. A vulnerability assessment geospatial model was prepared in a GIS environment to integrate these datasets and generate vulnerability surfaces that identify areas, population and sectors based on the available location based information. In respect to energy use, demand and supply analysis, data analyzed was largely secondary. The city analysis covers the same aspects and provide a detailed analysis through quantitative and qualitative assessment.

Through documentary review and field interviews, institutional issues were analyzed to identify existing functional mechanisms, gaps and potentials. Institutional mapping is one of the tools applied to elicit information on how the Ministry of Lands, Housing and Urban Development as well as KCCA are structured to respond to climate change currently or in the future. In addition existing vulnerability assessment tools for adaptation and capacity at national level are analyzed in terms of adequacy and appropriateness. In general, a combination of Participatory Analytical Techniques including interviews, quantitative analysis have been utilized to elicit data from the stakeholders. This report presents and integrated of vulnerabilities and linkages between adaptability and climate change effects.

For institutional, human capacity and tools assessment, the institutions were analysed based on SWOT analysis in respect to existing frameworks, tools and human resource capacities in the context of adaptation and mitigation of climate change effects. The institutional set up assessment encompassed policy, strategy, planning, human resource, management and monitoring and evaluation frameworks for climate change management and sustainable urban development at all levels. Because of the interconnectedness of components, the analysis was within the context of the relevant institutional and governance structure frameworks that covered the legal and regulatory instruments. Constructive engagement with stakeholders has yielded information from political

leaders, relevant technocratic managers, as well as other necessary contact persons in KCCA, MoLHUD as well as relevant institutions. This has enabled the identification and ranking of action areas for institutional adaptation to climate change. Meta-evaluation of climate change related projects within KCCA was conducted based on the project evaluation and other reports. This method provided information on demonstration projects, which can be up scaled or out scaled basing on the actual or envisaged outcomes of existing interventions. A list of potential 'candidate' demonstration projects that can be mainstreamed into on-going projects is included in this report.

To structure the report analysis and also provide a basis for coherence in the relationships between the various components of the study, the team developed an analytical framework as indicated in figure 1 below. This analytical framework recognizes that cities relate to climate change in a bi-directional manner. This means that cities contribute to climate change through emissions that come from high consumption but are affected and vulnerable to the effects of climate change including extreme events. Various sectors are responsible for the emissions and are affected in particular ways. Around these biophysical relationships are the institutional and governance systems which shape and determine the development pathways of cities as well as the consumption patterns. The urban system is exposed and vulnerable to the climate stressors while impacts are recorded to occur. Adaptation and mitigation are requisite in order to reduce the vulnerability but also the emissions which are directly linked to climate change.

ANALYTICAL FRAMEWORK

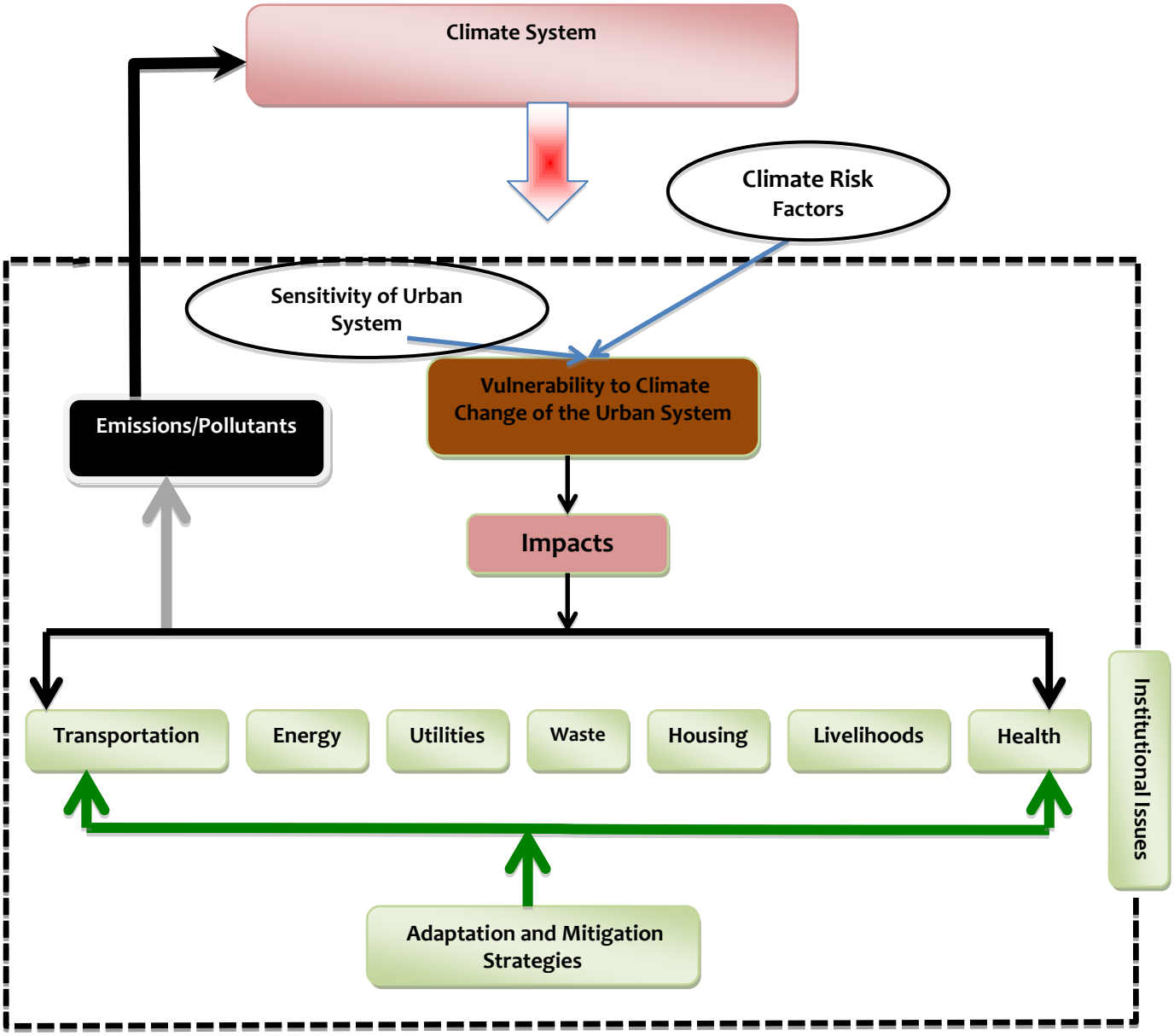


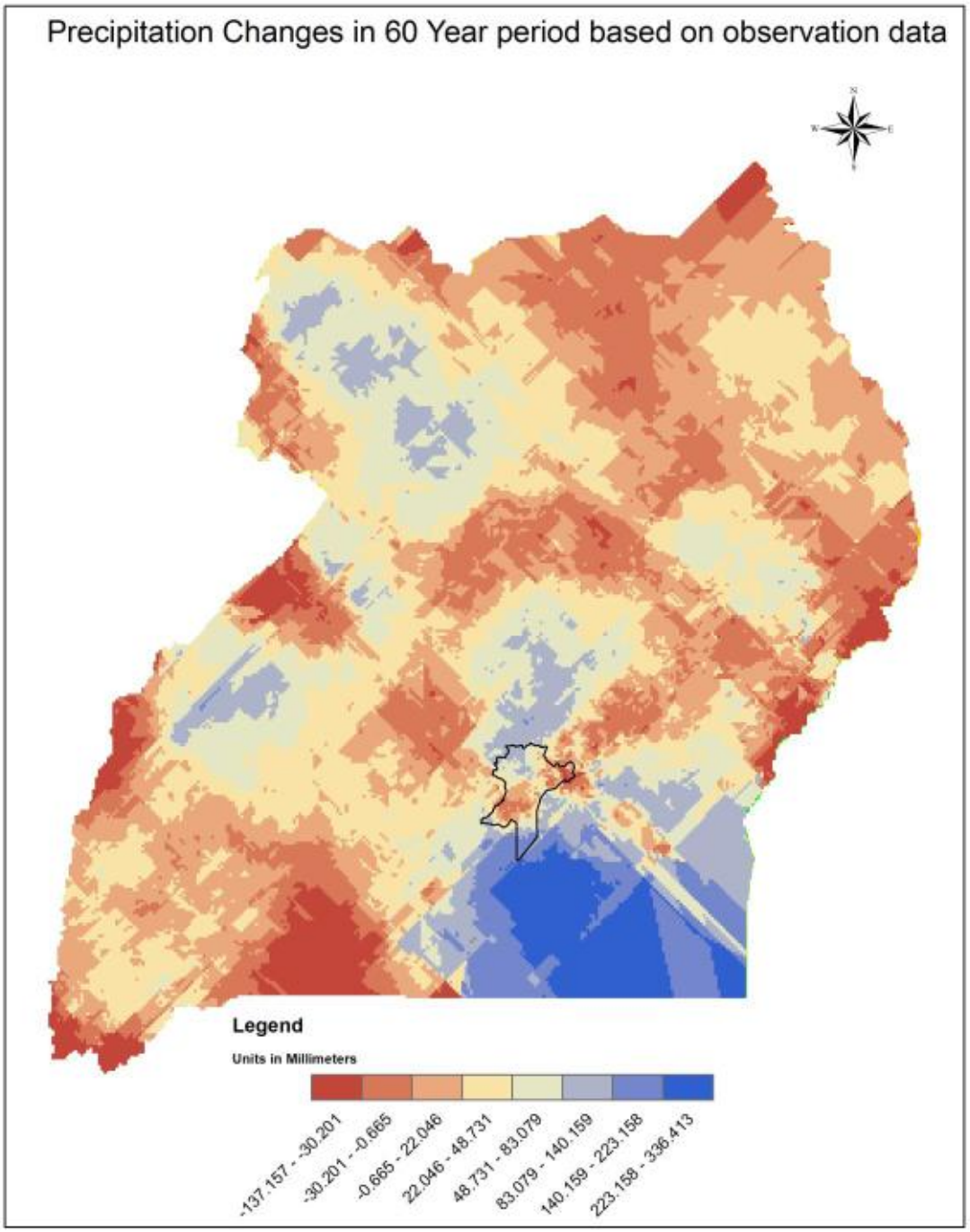
Figure 1 Vulnerability Assessment framework

2.0 COUNTRY LEVEL ANALYSIS

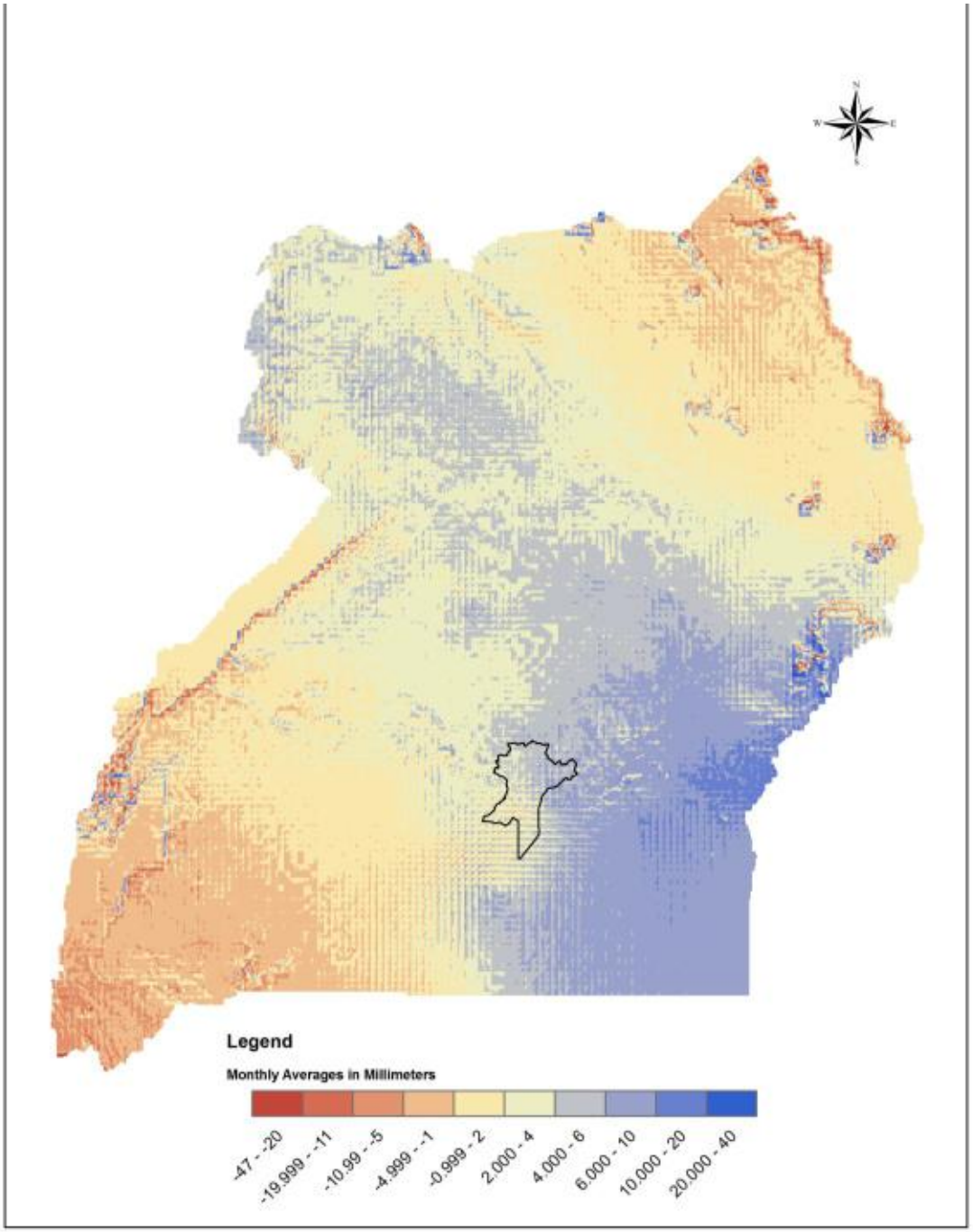
This section of the report covers the country level analysis of urban vulnerabilities. The section starts with a global perspective on climate change futures and focuses on Uganda utilizing the downscaled Global Circulation Models of HADCM3, ECHAM and CISRO[16]. This assessment utilized the delta precipitation data for ECHAM model which fairly correlated with the 60-year period data from meteorological stations. The section ends with an examination of changes in Uganda and the implications of such changes on urbanization and sustainable urban development.

2.1. CLIMATE CHANGE IN UGANDA

The global Climate Change models project an increase in average temperatures in Uganda by up to 1.5 ºC in the next 20 years and by up to 4.3ºC by the 2080's according to the forth IPCC assessment report[7, 16]. Changes in rainfall patterns and total annual rainfall amounts are also expected but these are less certain than changes in temperature. Recent rainfall data recorded indicates some significant variations and changes in various parts of the country. The climate in Uganda has become wetter on average and the increase in rainfall is unevenly distributed, occurring as extreme or more frequent intense rainfall as shown in map 1. Based on 60 year annual average rainfall data, the map 1 shows changes in most areas of below 1 standard deviation while the Lake Victoria region registered above average rainfall in the same period. It is this region where most populated urban areas exist with a rainfall ranging between 1200-2000 mm annually. An overlay of the urban areas in Uganda on the rainfall changes map shows that some urban centers are in areas experiencing wetter seasons or likely to experience more rainfall. Changes in temperature are likely to have significant implications for water resources, food security, natural resource management, human health, settlements and infrastructure. For example there are reported cases of Meningitis in north and eastern parts of the country where temperatures have changed over time. Although there is not rigorous analysis that relates the two, indications are that the health situation may be influenced by the climate variability and change. In Uganda, as for the rest of the world, there are likely to be changes in the frequency or severity of extreme climate events, such as droughts, floods and storms[17]. Such rates of increase are unprecedented and these will be felt in fast growing urban areas including Kampala. Each year there are climatic events that represent risks to most urban areas, people and sectors[18]. These risks arise from 'normal' day-to-day, seasonal, and year-to-year variability in climate as well as regional climate differences.



Map 1 Rainfall (mm) changes in the 60-year period from 1950 - 2010



Map 2 Precipitation changes based on SRES B2 ECHAM predictions for 2050

In chart 1 below, rainfall variations over a 60-year period indicate that there are variant outliers but the general pattern depicts a smooth variation over the period with exclusion of data since 2000 to 2008. In map 2, most areas with annual average rainfall ranging between 1200 – 2000 mm have recorded changes well above the average and it is these

areas where high concentration of urban population exists as shown by the map of population distribution in the country. This evidence in rainfall variations coupled with temperature changes pose vulnerabilities to urban areas in Uganda. Based on the downscaled GCM model predictions there is expected increase in temperatures and rainfall of 10 – 20% over most of the country and a range of 1.3 to 2^0 C in temperature[16]. From the precipitation predictions, it is estimated that there will be 10 to 20% increase in runoff under future climate change scenarios for most of Uganda as shown in map 2. Although it may be too early to reach any conclusions, the real precipitation averages have increased over time in most of the country whereas some areas have decreased precipitation. But in areas with decreased precipitation, there is a continuous extreme of erratic rainfall which falls in a short time causing massive destruction through flooding.

2.2. FUTURE CLIMATE CHANGE

An important study issue is climate change variability and change in Uganda and Kampala city region is the variability indicated by analysis of actual climatic data. The analysis of change reveals variation of rainfall totals received over the same period with a range of up 350 mm of rainfall across the country. This variation and or change are important in assessing urban vulnerabilities[19]. The pattern emerging from the data indicates that there is a variation between short but intensive rains and extended periods of dryness and drought.[12, 20-22] This is also supported by anecdotes from around the country as the assessment of other studies indicate[3, 23-28]. With confidence, findings from the anecdotes correlate with the analysis of the actual rainfall data that shows significant reduced rainfall varying across the country. The implication of this variation is far reaching and scales out from livelihoods, infrastructure, housing, transportation services, access to social services to life threatening risks of flooding. The vulnerability of communities and households to climate change risks can be looked at in current terms but also future and this depends largely on future discernible trends in climate change and impacts. Although there are uncertainties regarding projected trends in climate change both globally and locally, the current experiences give a glimpse of the likely trajectories of climate change impacts[29]. The global models for climate change have varying prediction in temperature and rainfall with some models being pessimistic while some being optimistic about the future anthropogenic forcing that would keep temperature rise within minimal range. Climate change scenarios of A1B and A2 of the CGCM1 model are pessimistic while B1 and B2 are optimistic about the development pathways of developing regions of the globe and increased emissions. On the other hand both the CGCM1 and ECHAM models predict an up to 1.5 degree increase in temperature by 2020 in the region while they defer on rainfall[12]. Whereas the CGCM1 predicts a reduction in rainfall by between 300 – 400 mm, the ECHAM model predicts an increase in rainfall by 200 – 300 mm in the region. It's important to note that though these models

have been downscaled, regional models are yet to become available and will most likely give a better understanding of current and future trends. An important observation in this study is that analysis of the rainfall data based on actual recordings ground stations indicates an increase in rainfall within the study area by up to 300 mm while the national vulnerability assessment reports indicates an increase by 2^0 C degrees in temperature in most parts of the country. Therefore the future climate change trends are uncertain but with population increase and pursuance of development in Uganda the impacts which are largely driven by regional and global scale changes are likely to impact severely impact on cities. Kampala city region lies in the region with predicted increase in rainfall during the October, November and December (OND) period and reduced rainfall during the long rains of MAM march, April may.

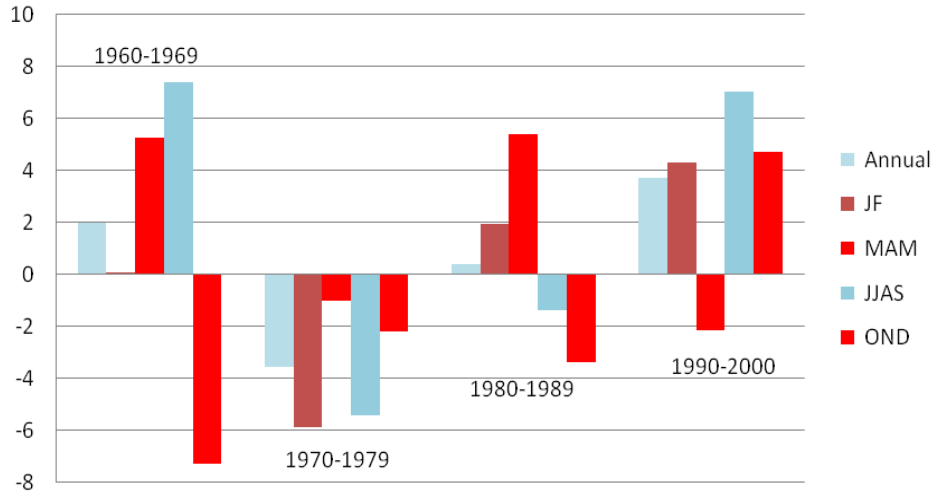


Figure 2 Precipitation Anomalies mm in Uganda 1970 - 1999 SRES A2

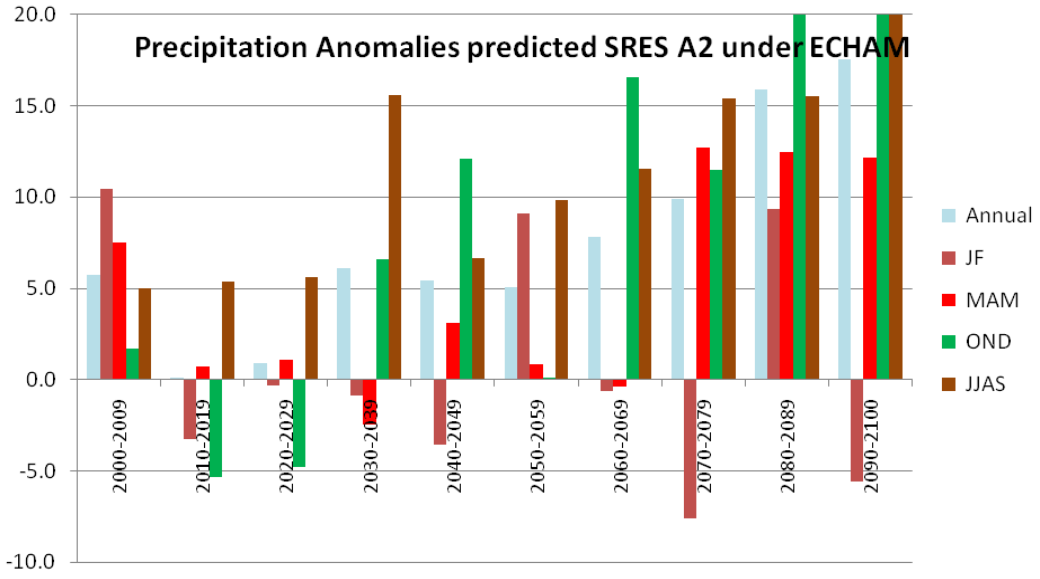


Figure 3 Precipitation Anomalies mm predicted SRES A2 ECHAM

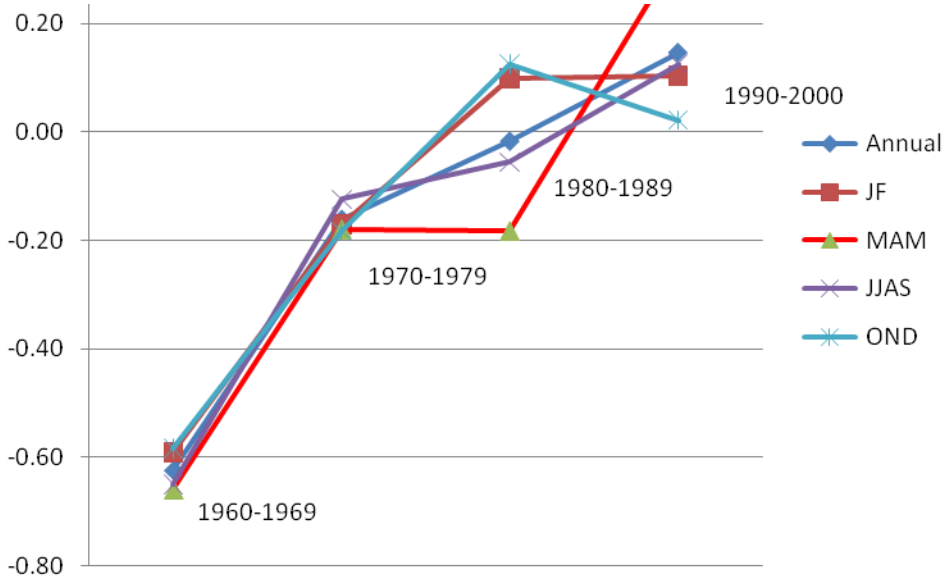


Figure 4 Temperature Anomalies ^{0}C 1960 - 1999

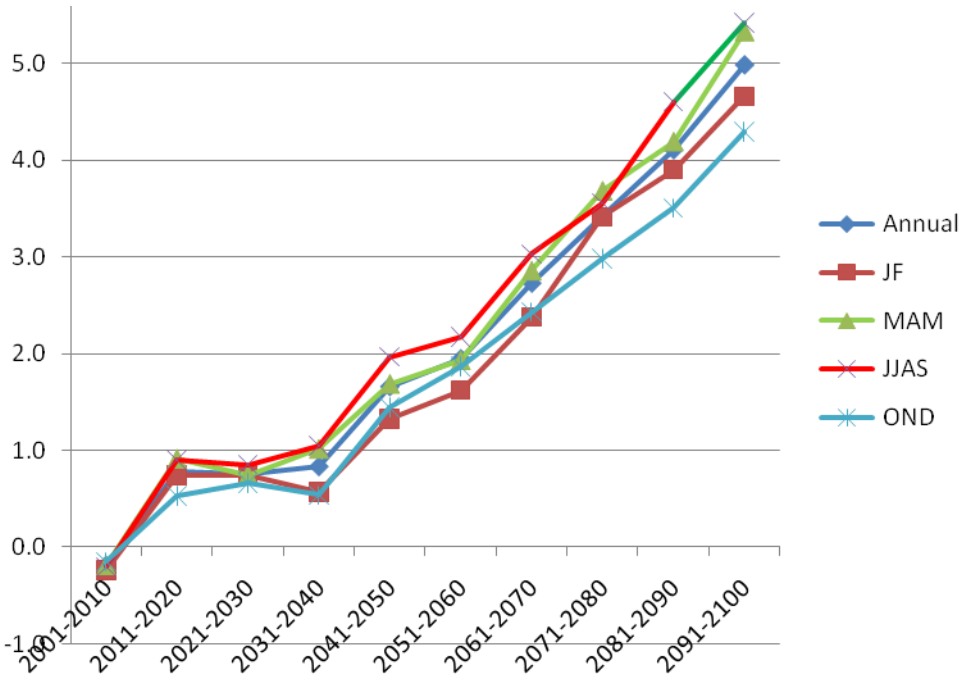


Figure 5 Temperature Anomalies ^{0}C predicted SRES A2 ECHAM

2.3. URBANIZATION AND CLIMATE CHANGE IN UGANDA

Urbanization and national development in Uganda have remained both interconnected through history but also elusive in terms of sustainable urban development [30, 31]. This is manifest in the primacy of Kampala city with about 60% of the national urban population and a spatial form that sprawls to an estimated 830 sq km. At country level, analysis covers issues of urban development sustainability, vulnerability assessment of urban areas, spatiality of demographic dynamics and institutional readiness to adapt to climate change.

Urbanization just like climate change is unequivocally occurring in Uganda with now an estimated 15% of the national population living in designated urban areas[15, 32]. Designated urban areas including statutory towns that follow a five tier level of; trading centers, town boards, town council, municipality and City. The population living in these areas has increased from 635,000 in 1969, 938,000 in 1980, 1.9 million in 1991 and 3.7 million in 2007 (UBOS, 2002 39). Urbanization level in Uganda is low but rates have been averagely high posing a challenging task to ensure environmental sustainability especially in the metropolitan area of Kampala[33]. The urban challenge in Uganda is visible in the designated urban areas but the growth in population and density of small rural hamlets and trading centers that are not designated urban areas cannot be ignored see map 5. This urbanization by implosion needs not to be negated because of its

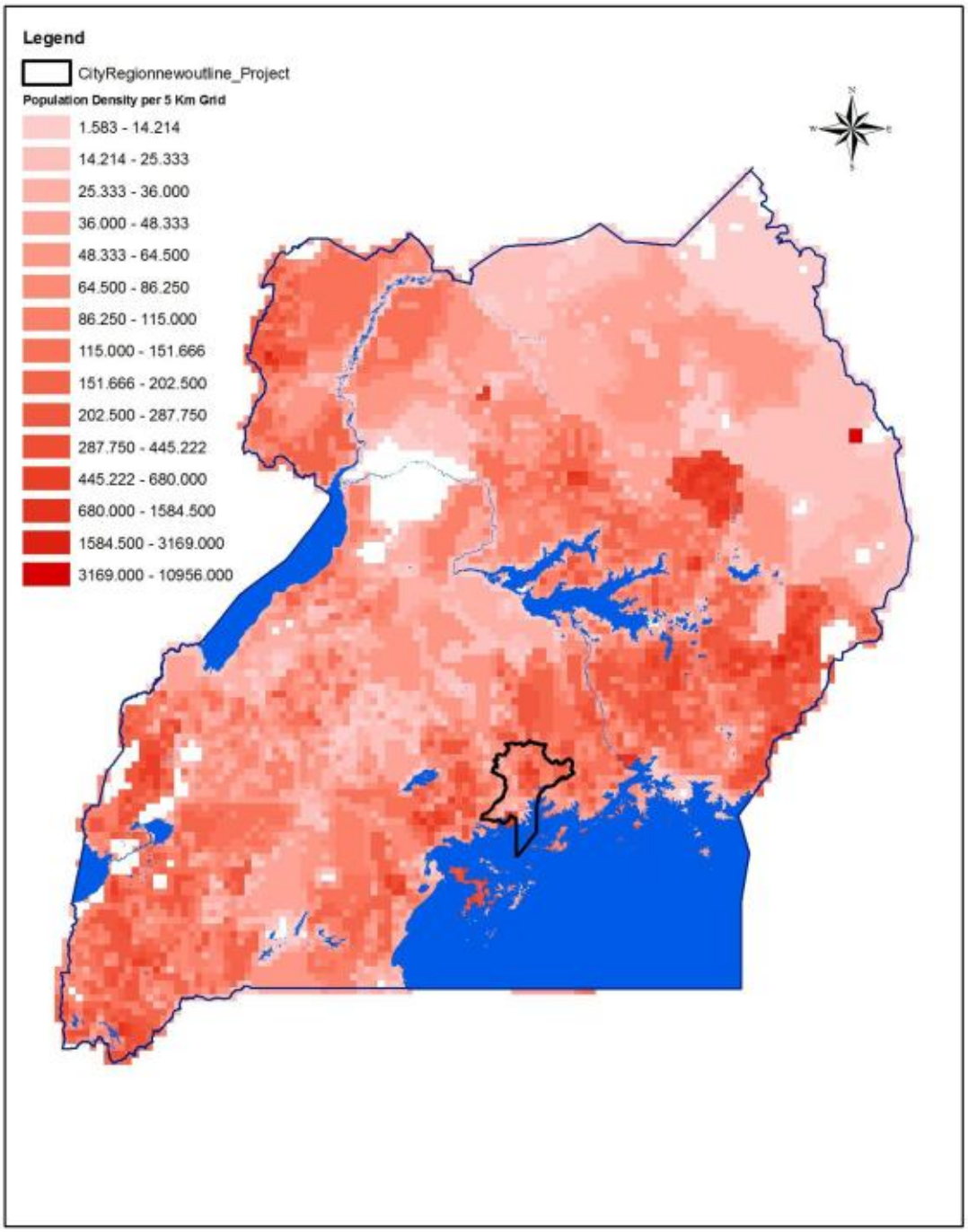
influence on sustainable urban development in the country. This is because they are not only influential in shaping the pattern and trends of urban development in Uganda but will also determine the urban functionality that is characterized by social spatial interactions. In the context of climate change, these secondary cities face serious climate related risks and challenges due to lack of institutional readiness to confront the problems[18, 34].

Urbanization in Uganda is characterized by the primacy of Kampala as the major urban center that has continued to sprawl engulfing hitherto satellite towns forming a functional city region. This expansion has directly led to population increase through growth and migration[15]. The city growth stands at annual rate of 3.7% and its growing much faster than any other urban area sin Uganda. There are a number of reasons for this urbanization trend including; population dynamics, industrialization, rural urban migration and economic growth leading to labor shifts. These factors still influence urbanization and future trajectories point to a fast paced urbanization[5]. Although urbanization needs not to be taken as a problem the challenges that come with the rate are overwhelming especially in the context of climate change[9, 11]. This is because of the urgent need to re-engineer urban governance system, infrastructure and social fabric to respond to inherent problems and the now added climate change effects.

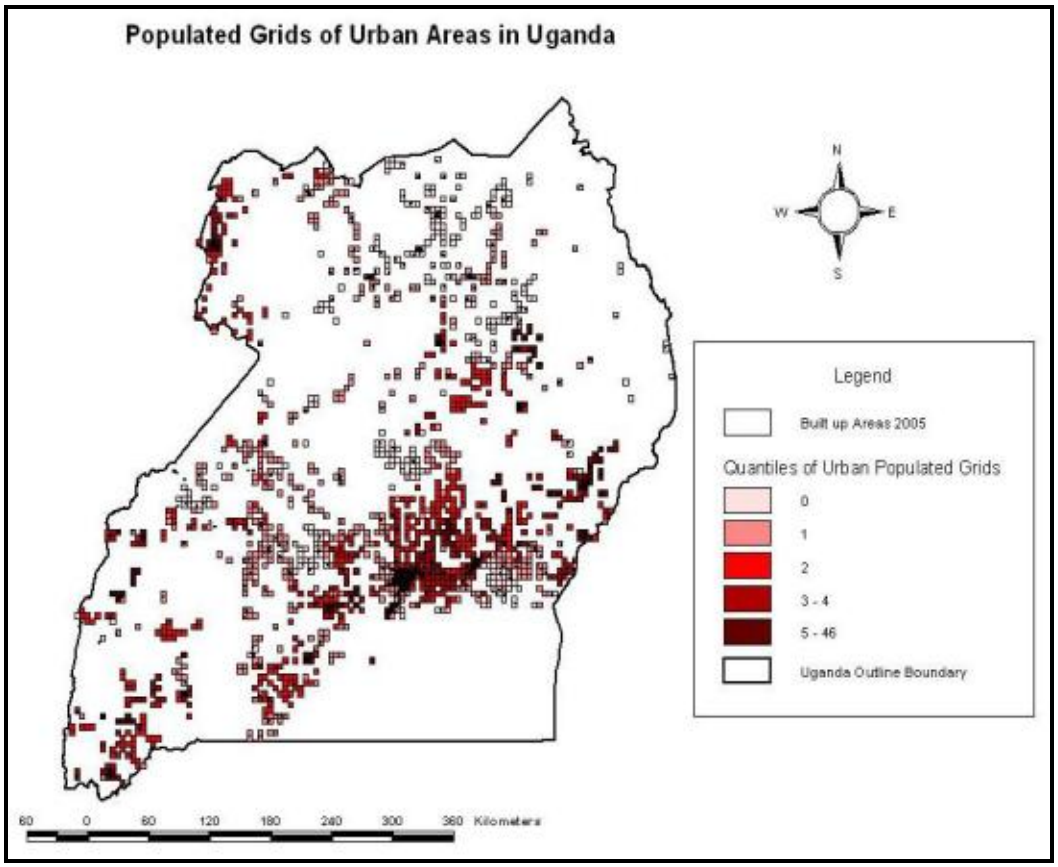
The urban population of major towns in Uganda has steadily increased despite remaining comparatively low to the national urban population. Significant to note is that the service centers, which are located between dispersed rural settlements and urban centers, are often too small to be defined as urban and yet too nucleated to be rural. A spatial analysis to explore demographic data shows that the high population density areas are not only urban centers maps 3 - 6. For example in the North eastern and north western parts of the country, high densities occur due to refugee camps some of which have urban characteristics and so are their needs in terms of services, infrastructure and therefore need climate change adaptation and mitigation. On the other hand, some areas in central and western parts of the country have rural settlements with densities comparable to those of Kampala city. Non-designated urban centers have low densities compared to some rural settlements. It is important to note that there is no urbanization policy but the notion that the degree of urbanization was a measure of industrialization level, modernization and socio-economic development greatly determined the urban development pathways in the country. Experiences in Uganda indicate a phenomenon which is occurring with less or no concurrent proportional changes in social transformation though there is limited research that correlates urbanization with modernization, industrialization and socio-economic development in Uganda. What is being experienced is rural-urban migration that has often averaged urban growth rates in the order of between 4 – 6 percent, and in some urban centers, this growth is more than the national growth rates[10, 15]. There is

also growth of secondary urban centers often adjacent to the administrative boundary of the city. This nature of growth and expansion is associated with poor services, informal (emerging) economic growth and segregated spatial distributions of housing and services creating inherent challenges in urban management. This presents challenges in the planning and management of urban areas not only in the major cities but as well in the secondary urban centers[30, 35].

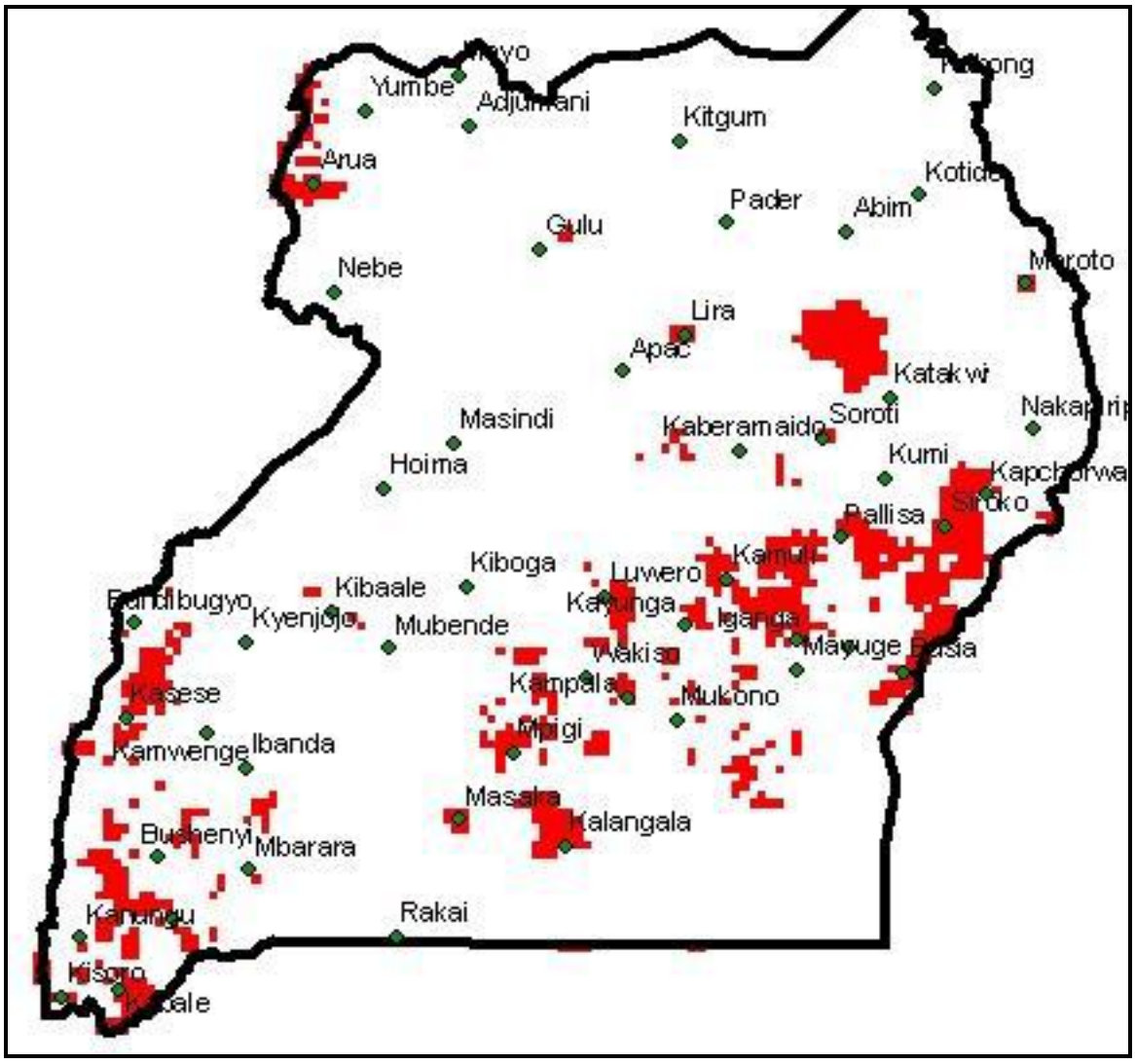
At regional scale in Uganda, about 54% of the urban population lived in the Central region (as indicated in map 4 with populated grids), while other regions have slightly differing proportions of the urban population with 17% for the Northern, 14% Western and 13% for Eastern[36]. Uganda has experiencing urbanization characterized by exploding urban centers in a steadily growing economy since 1989. More recently urban areas in Uganda have become vulnerable to climate change. The negative consequences have subsequently led to deterioration of human settlements´ conditions, depletion of natural resources while urban infrastructure costs are increasing due to effects of climate change. What has happened is the growth of an emerging' economic sector that not only contributes to the national economy but also provides employment and livelihood for many urban dwellers. But this emerging economy relies heavily on natural resources and existing infrastructure which are vulnerable to climate change[34, 37]. The 'emerging' economic sector provides livelihood strategies to majority of the urban population and form the base of the urban economies in Uganda, but these urban livelihoods are affected by the effects of climate change.



Map 3 Gridded Population and distribution in Uganda



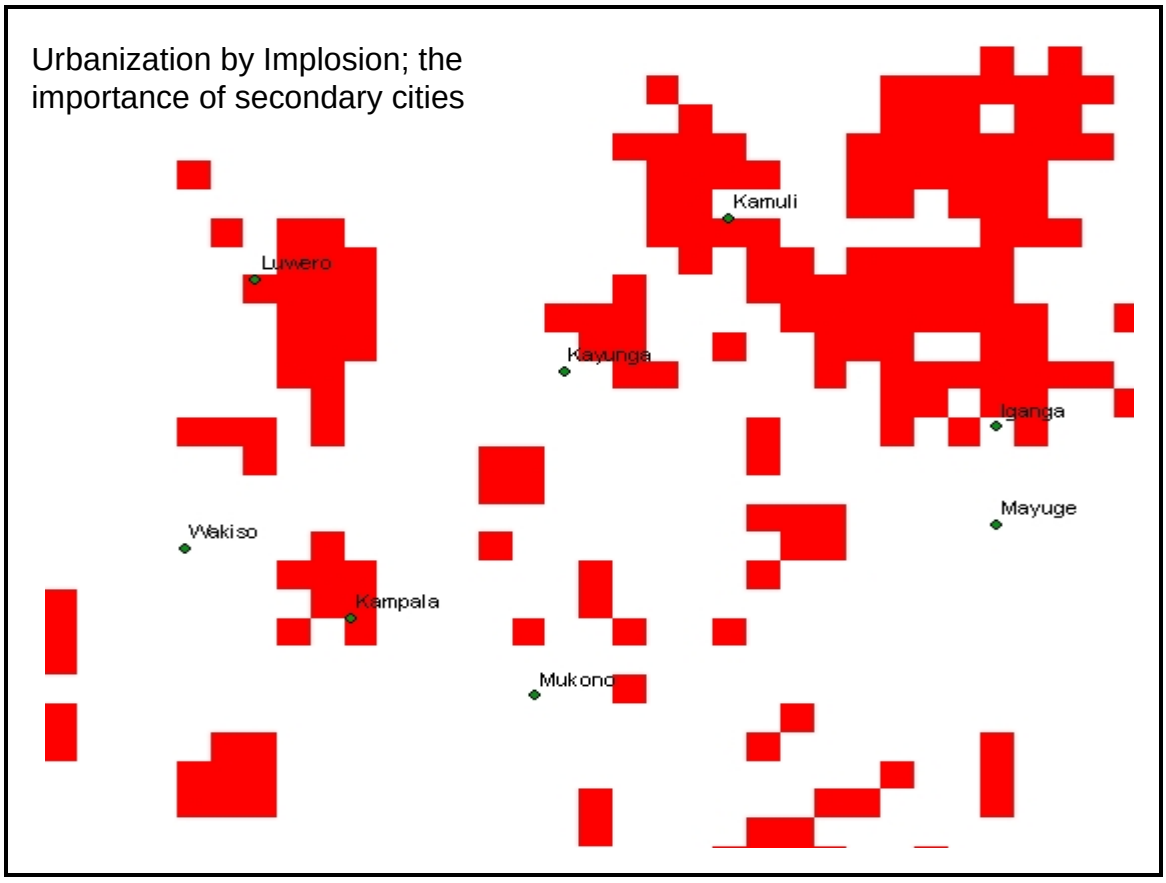
Map 4 Urban Population Grids in Uganda 2010



Map 5 Population Grids with density > 250 persons per Sq. km

The nature of urbanization in Uganda has two dimensions; first an increasing growth path that continuously presents urban management problems and sustainability challenges; second the districting which is creating more urban centers but inadequate capability of authorities to manage the urban jurisdictions from the administrative, financial, social and economic perspectives but with limited capacity to plan and manage the urban centers[30]. The rush for new urban centers through districting poses challenges of creating and nurturing functional institutions for urban governance. Given the growth trajectory, sustainable urban development and management should be of high priority on the urban agenda in Uganda as the future trends indicate a fast-paced urbanization. Urban development is crucial to national development, as engines of growth, urban centers need to be managed properly in order to enhance and promote national development but also be at the forefront of adaptation and mitigation of climate change. Managing urban growth in Uganda seems to be oscillating within the realm of policy and at cross-roads in

deciding the guidance systems for urban growth. The lack or slow process of initiating an urbanization policy, the failure of current urban planning and guidance systems and laws and continued organic development of urban areas in Uganda have far reaching implications on realizing the MDG's, national, regional development and responding to climate change. Therefore institutional changes are needed for sustainable urban development. Without expedited institutional adaptation, urban vulnerabilities in Uganda will increase putting an estimated 7.7 million or 25% (*adjusted 2009 population based on gridding*) urban population at greater risk, destruct the urban infrastructure investments and destroy livelihoods. The cost of increasing urban vulnerabilities in Uganda is likely to continue rising that urban adaptation is a necessary action now.



Map 6 Central Uganda with high-density grids and no designated towns

2.4. DRIVERS OF URBANIZATION IN UGANDA

Several drivers explain the urbanization in Uganda, which are both underlying and proximate. These include; population dynamics economic transformation policies and employment creation, the balkanization of administrative regions are responsible for a

fast-paced urbanization rate posing sustainability questions in terms of social, environmental and economic dimensions. Although the relationship between climate change and urbanization is yet to be established, studies show that rural communities are adapting by externalization of excess fertility to urban areas. Because of this externalization coupled with disproportionate absorption into the urban economy, inequality and environmental degradation have become common features of urbanization in Uganda. In discussing drivers of urbanization, proximate factors are important and one such is the role Private sector that cannot be underestimated in influencing urbanization. Industrial establishments, housing estates, higher education institutions and commercial agricultural entities are greatly contributing to the expansion of urban areas. This is markedly in the major towns which double as education services provision hubs. Jinja, Mbale, Kampala, Mbarara, Soroti and Mubende urban centers are all experiencing the growth driven partly by establishment of educational institutions. The increase in educational centers is driven by the liberalization of educational sector has allowed private providers of education. These have mostly been established at the fringes of Kampala City and other major towns such as Mbarara, Jinja, Masaka and Mbale. While real estate business is establishing ultramodern residential neighborhoods amidst impoverished peri-urban and rural settings with inadequate urban infrastructure. These planned neighborhoods exist around Kampala most especially along Kampala-Entebbe corridor. The growth of the private sector has influenced labor migrations into urban areas as rural populations search for employment accelerating the housing sector development and proliferation of the urban informal (emerging) sector but with limited access to infrastructure and social services. Employment levels show that retail, wholesale and service sectors combined provide employment to a bigger proportion of the labor force in Kampala. But transport and communication are also sectors which employ a sizeable proportion of the labor force and real estate is an emerging sector. The implication of this dominance of Kampala is the continued attraction of the urban population in the city region which increases vulnerability given the processes of settling for migrants.

2.5. SUSTAINABLE URBAN DEVELOPMENT IN UGANDA

Since the Brundtland report of 1987, the concept of sustainable development has attracted considerable debate which is reflected in the vast amount of literature on its interpretation and feasibility. According to the report, sustainable development is “to ensure that development meets the needs of the present without compromising the ability of future generations to meet their own needs”[38]. Conflict arising between the protection of the biosphere and the continuous demand for growth seems not resolvable. Debate has increasingly drawn attention to the societal conflicts of the environmental sustainability and more recently the need to mitigate and adapt to climate change. With urbanization,

the intertwining of societal and environmental conflicts is evident in cities In the developing world, the environmental considerations are continuously challenged because they have not been coupled with efficient programs of easing urban poverty. But with the unequivocal urbanization on one hand and climate change on another, there is no alternative between urban poverty reduction and adaptation to climate change or mitigation. Improvement in the urban infrastructure, sanitation, waste management, water accessibility, education and the health care service, housing, transportation and communication cannot be done without giving equal rights to the poor and the other disadvantaged social groups, and without recognizing their organizations. But such improvement also has to target the effects of climate change for adaptation. In other words no environmental policy can be efficient without a social policy with latter providing the entry point for adaptation to climate change.

Recognizing that sustainable development is multi-dimensional in nature encompassing social, economic and environment sustainability, sustainable urban development can be looked as encompassing six areas of (1) governance, (2) social and cultural considerations, (3) social services and public infrastructure, (4) urban land use and housing issues, (5) urban transport and urban natural resource management, and (6) employment and the enhancing of economic growth. These six areas form the framework for understanding the sustainability of urban development but also give pointers on how to achieve sustainable urban development. Evaluating the sustainability of urban development requires robust but flexible methodologies and formulation of indicators, which are important in understanding the nature of urban development in the context of climate change. With the current urbanization trends, urban sustainability remains a challenge due to spontaneous developments, peri-urban developments, urban environmental change, land-use change and industrialization. This is because environmental burdens (*including the effects of climate change)* intertwine with poverty in a concomitant and reinforcing manner. In Uganda, research into these challenges has intensified and scaled up to the national level. Due to the increasing complexity and interactions at all scales of urban development the need for adaptive capacity building and institutional reorientation has become more pronounced.

2.6. INSTITUTIONAL ASPECTS OF URBAN MANAGEMENT IN UGANDA

This section discusses the legal and policy frameworks existing and which could provide a basis for entry points in climate change adaptation and mitigation. Although there is no specific regulation and policy on climate change, there is reference of it scattered across existing laws. Government of Uganda ratified the UNFCCC and its corresponding Kyoto Protocol to which Uganda is a party, but no national legislation specifically addressing climate change[19, 39] was ensued. Drawing from the discussion of urbanization and

sustainable urban development, climate policy would need legislation specifically guiding and supporting interventions for adaptation and mitigation through awareness raising, understanding, dynamics and impacts, in-depth analysis, monitoring as well as prioritizing the intervention at national and local level. This would enable responding to climate change in a holistic, systemic and sustainable manner. The existing relevant legislative framework draws its strength and legitimacy from the Constitution of the Republic of Uganda (1995), which is coupled with particular international conventions and treaties. The constitution essentially guides and supports national and local level interventions and actions in other sectors other than climate change which is a new focus area. These sectors are local governance, urban development and management, infrastructure, environmental and natural resource management. The legislative framework at the national level in Uganda which guides sustainable urban development consists of the following;

1) The Physical Planning Act (2010); which, inter alia, prescribes the procedure for declaring a locality as a planning area; and the process for formulating spatial planning schemes as a framework for urban service provision[40].
2) The Public Health Act (1964) which, inter alia, details building standards and requirements[41].

   These legislations are largely focused on governing and guiding spatial development.

3) The Local Governments Act, 1997, (plus its amendment of 2001), which in part, focuses on urban-wide provision of services, including street lighting; solid waste management; environment management; infrastructure development; as well as governance[42].

The legislations are also complemented by other related laws governing the related sectors and include the following;

4) The National Environmental Act, CAP 153, under which a number of vital environment management guidelines and regulations have also been formulated and put into effect. The major ones among these include:
   - The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, 2000.
   - The National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations, 1999.
   - The National Environment (Minimum Standards for Management of Soil Quality) Regulations, 2001.
   - The National Environment (Conduct and Certification of Environmental Practitioners) Regulations, 2003.
   - The National Environment (Management of Ozone Depleting Substances and Products) Regulations, 2001.
5) Other relevant legislation related to climate change include those on water, forestry, control of agricultural chemicals, industrial licensing, atomic energy, petroleum production, the Land Act, Land Registration, Rivers and Roads Act and the National

Planning Act. These regulations will be instrumental in any future climate policy and regulation as several aspects of climate change are already addressed

The Local Governments Act, 1997, (plus its amendment of 2001) mandates municipal authorities to plan and manage towns but also gazetted local urban authorities (city councils, municipalities, town councils, etc.), are also empowered to make specific by-laws and ordinances concerning specific urban management issues. These are developed to implement laws and address emerging challenges that are unique to specific local communities. For example, Kampala Capital City Authority Council passed in 2005 five (5) Ordinances on urban agriculture. This effectively legalized an area of socio-economic activity that was hitherto widely known to be illegal. Indeed, it was only until these ordinances were passed that one of then KCC's *potential demonstration projects* for mainstreaming of adaptation, the Kyanja Edible Landscape Project (KELP) was approved.

As is the case with the legislative framework, there is at present, no policy in place specifically addressing climate change that is focusing on its key elements. At present, all the national and local level interventions and actions are largely guided and supported by formal positions and agreements reached periodically by the international community on climate change under the international arrangement of UNFCCC and its corresponding Kyoto Protocol, as well as the related institutional framework of the IPCC. At the country level, these are coordinated and monitored by the recently created Climate Change Unit, located in the Meteorology Department of MoWE. The activities of the climate change unit are based on the First National Communication and the NAPA[19, 39]. In both, urban areas are only mentioned passively or not at all. In addition, the direct and specific intervention of the initial effort by Government to conduct climate change vulnerability analysis provides the entry for a policy on climate change. In the recent National Development Plan (NDP) however, climate change has been included as c ross cutting theme based on the NAPA that identified five sectors as highly vulnerable[19].

Urban development has, however, suffered the problem of lack of a vision at national level to steer the formulation of appropriate and sustainable urban development policy. The political leadership in the country has not provided the guidance on sustainable urban development and the consequence is 'business as usual' scenario that maintained an organic development pathway for urban areas. For example, the government agency concerned with urban development and planning has been switched, split and merged with other sectors several times. The switching and seemingly lack of vision put urban guidance in the balance and this partly explains the lack of a national urban development and planning policy to guide urbanization, but also manage city growth and development. Currently, there is an overlap of responsibilities between the Ministry of Lands, Housing and Urban Development (with urban development reinstated in April 2006) and the Ministry of Local Government; the two of which are the critical institutions responsible for guiding sustainable urban development. Despite several public and professional calls for a national urbanization policy and guidance system, a couple of efforts to kick start

the policy formulation have either been slowed or abandoned[3]. This situation has also contributed to the urbanization trends, especially sprawl of urban areas, with no controls to address challenges augmented by effects of climate change. The implication of policy analysis at country level is the downside of possible inadequacy to integrate climate change adaptation and mitigation strategies focused on cities in Uganda. This is coupled with the current development model of private-sector led development that has pursued strategies of foreign direct investment FDI's, Private Public Partnerships, Liberalization all of which have a bearing on growth at the expense of environment including a possible future increase in GHG emissions. Recently, however, the Ministry of Lands, Housing and Urban Development was established with some promises of crafting policies and frameworks for sustainable urban development. In addition, the land policy is being formulated and is expected to include issues of sustainable urban development. Furthermore, the NDP has provided space for urban and regional planning, while the long-awaited Kampala City Authority (KCCA) was recently launched and is in the process of being fully established.

Translating laws and regulations for urban management has largely been pursued through two approaches; the project-based approach and the sector-wide approach. The project-based approach is the most common in Uganda while the sector-wide approach was only recently introduced at National level. One of the disadvantages of the project-based approach is projectization with no follow up to complete the cycle; which has left some communities un-serviced compared to the pilot communities. At the national level, urban development is disproportionate given the substantial infrastructure development in terms of transportation and communication, socio-physical and environmental infrastructure in a few towns and Kampala while many lag behind as shown in table 1. The inequitable investments and development significantly contributes to vulnerabilities of these towns to climate change.

Table 1 Summary of Expenditure on Urban Services 2006/2007 by Major Urban Authorities

City	Population	Expenditure 2006/2007 on services and infrastructure	Equivalent in dollars	Per capita expenditure on urban services
Mbarara	69,208	773,481,473	465,953	11,176.19

[3] Although in 2007, a National Land Use Policy was launched with a specific policy statement on sustainable urban development. This is also related to the on-going land policy formulation and the shelved Physical Planning Bill 2008

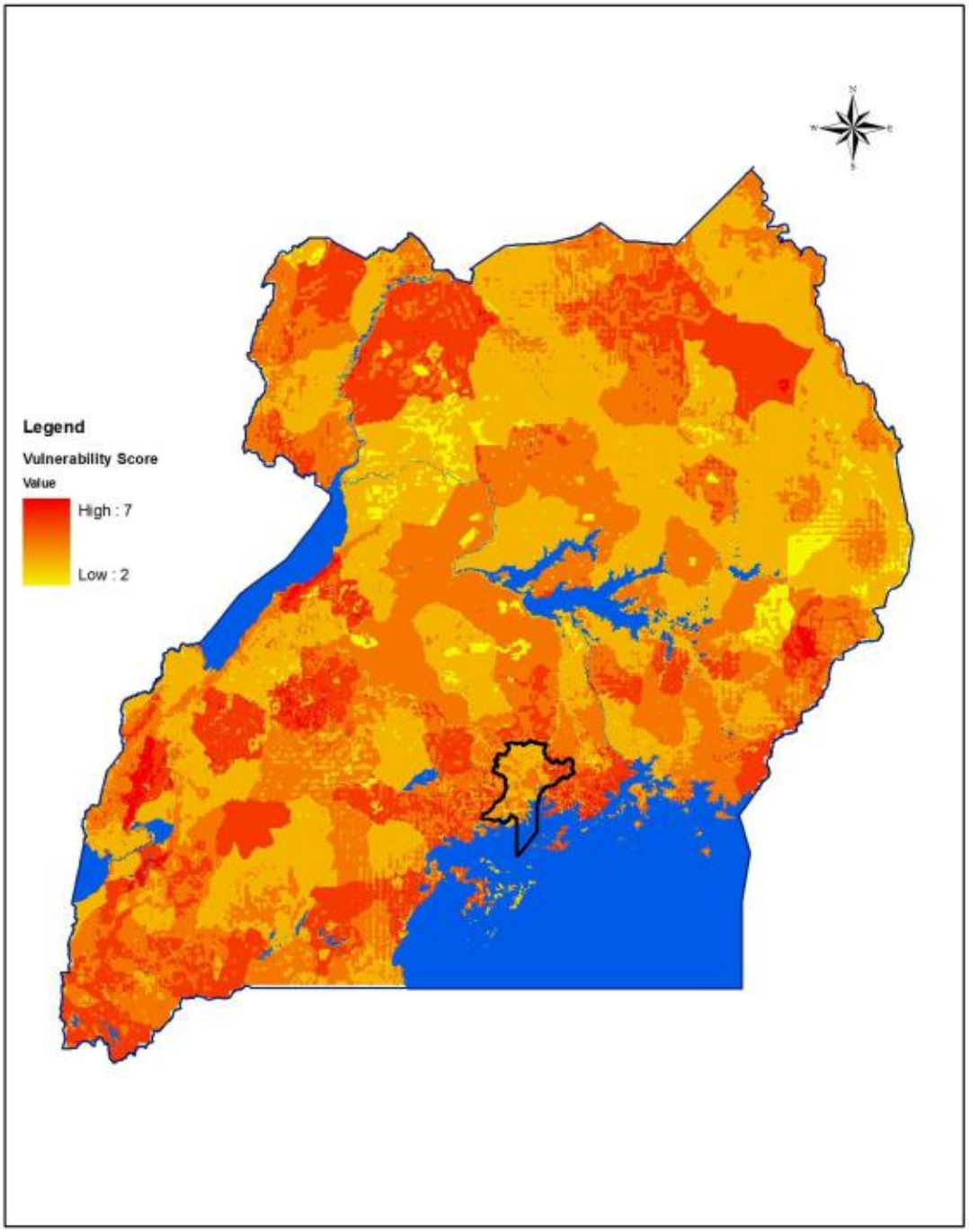
Mbale	70,437	374,413,801	225,550	5,315.58
Kampala	1,189,142	35,867,679,200	21,607,036	30,162.65
Jinja	86,520	561,549,044	338,283	6,490.40

The Sector-wide programs have all embraced the principles of sustainability to ensure a participatory identification of solutions to the social and environmental challenges. With the devolution of powers to local governments there is an opportunity for effective planning, implementation of plans and delivery of services including response to climate change threats. But the capacity as discussed later in this report may be short to meet the requirements for effective interventions.

3.0 CLIMATE CHANGE AND URBAN VULNERABILITY IN UGANDA

As indicated by the spatiality analyzed data, the most critical climate changes in Uganda are increased/reduced precipitation and increasing temperature that is geographically differentiated. A geospatial model of vulnerability was run with projected climate changes, biophysical and social economic parameters which include, slope, land cover, drainage, population density and housing area. The result of the model indicate vulnerability at a scale ranging from 2 to 7 based on a weighted model. Different locations across the country have different vulnerabilities. As shown in the map 7, most parts of the country in north eastern and central are highly vulnerable to climate risks. The major climate risk is associated with changes in rainfall patterns and totals received. Whereas some areas have increased rainfall based on the 60-year period data such as areas around Lake Victoria and in mountainous regions, there is evidence of reduced precipitation in other areas across the country. But the vulnerability to climate risks is related not only to precipitation changes. Population density, biophysical factors are important in the result of the vulnerability assessment. The vulnerability assessment map shown below illustrates the spatial differentiation of exposure. Likewise the impacts of the threats will also differ from water stress areas to excessive water in some towns, which has implications to infrastructure, housing and livelihoods. On the other hand a warming climate has implications to cooling of buildings, water resources and associated energy demand.

There are two scenarios of the climate risks in Uganda. First is the increase and reduced rainfall and second is the warming of temperatures. The two scenarios have implications on urban vulnerabilities. The first scenario of increased precipitation implies that there will be more water which requires to be tapped for urban utilization but a lot of that water turns into runoff subsequently flooding settlements. The increased runoff requires more robust drainage systems for managing storm water to have less disruptive tendencies to other urban sectors such as public transportation. Severe flash floods are already making urban infrastructure of roads, culverts, bridges and drainage system vulnerable to destruction. The other aspect of the first scenario is relates to reduced rainfall and water availability in water 'stress' urban areas of Uganda where there is evidence of reduced precipitation. The vulnerability of these urban areas is in relation to urban water provision given that most rely on wetland areas from which water is drawn for treatment, storage before distribution. A reduction in precipitation will have an impact on the water pumping systems which have to be adapted to the variations and or changes related to this scenario is the situation of erratic rainfall most of which is received in relatively short periods of time. This would require technological changes that for example would trap the rainwater. Coupled with changes in amount of precipitation in the country, the increased extremes of weather especially violent storms are also adding to urban vulnerabilities. Besides making urban infrastructure susceptible to destruction, storms have also affected housing, social services and livelihoods of urban dwellers. For example the extended rains and floods of December 2006- February 2007 caused serious damage to housing, schools and disrupted livelihoods in addition to cutting off neighborhoods from towns in eastern Uganda. The second scenario is that of increasing temperatures. This has implications to water stress areas by potential high evapotranspiration, which will exacerbate the water scarcity problem. On the other hand it has been loosely associated with disease patterns such as malaria in mountainous areas and meningitis in relatively dry land areas.



Map 7 Vulnerability to Climate Change in Uganda

A focus on urban areas, data shows variable vulnerabilities to the different urban centers. An estimated 81% of the urban population countrywide is highly exposed to climate change threats as indicated in the analysis with a mean vulnerability score of *4*. The table below shows the vulnerability scores of some towns and the estimated population by location. Kampala and the towns around the lake Victoria region with observed increase in precipitation have the highest populations exposed to climate change threats as according to the vulnerability analysis results. It is also important to note that most other towns shown in the table are areas where reduced and highly variable climatic conditions exist. These are some of the areas where

Vulnerability of urban infrastructure to climate induced exposures such as flooding is on the increase. A spatial analysis of the vulnerable areas to flooding reveals that an estimated 1600 km of urban roads segments are highly vulnerable to flooding and extreme weather events. The climate change extremes have also affected health either directly or in transient. Malaria, dysentery and cholera epidemics are increasing. Cholera cases and frequency has increased in the last 8 to 10 years due to erratic rainfall contributing to slow onset floods in many towns. All urban sectors are vulnerable to climate change but infrastructure, housing and livelihoods are the most affected. Given the current urban development experiences and climate change in Uganda, inherent poverty and structural problems will most likely be accentuated by the increasing threats of climate change. This is because climate change is likely to increase social polarization of urban communities, urban poverty, environmental degradation and increasing burdens (sanitation, flooding, wastes accumulation, public health, and disasters) to large proportions of the urban populations in Uganda, regional imbalances in urban development (industrialization in Kampala) and the challenge of urban sustainability.

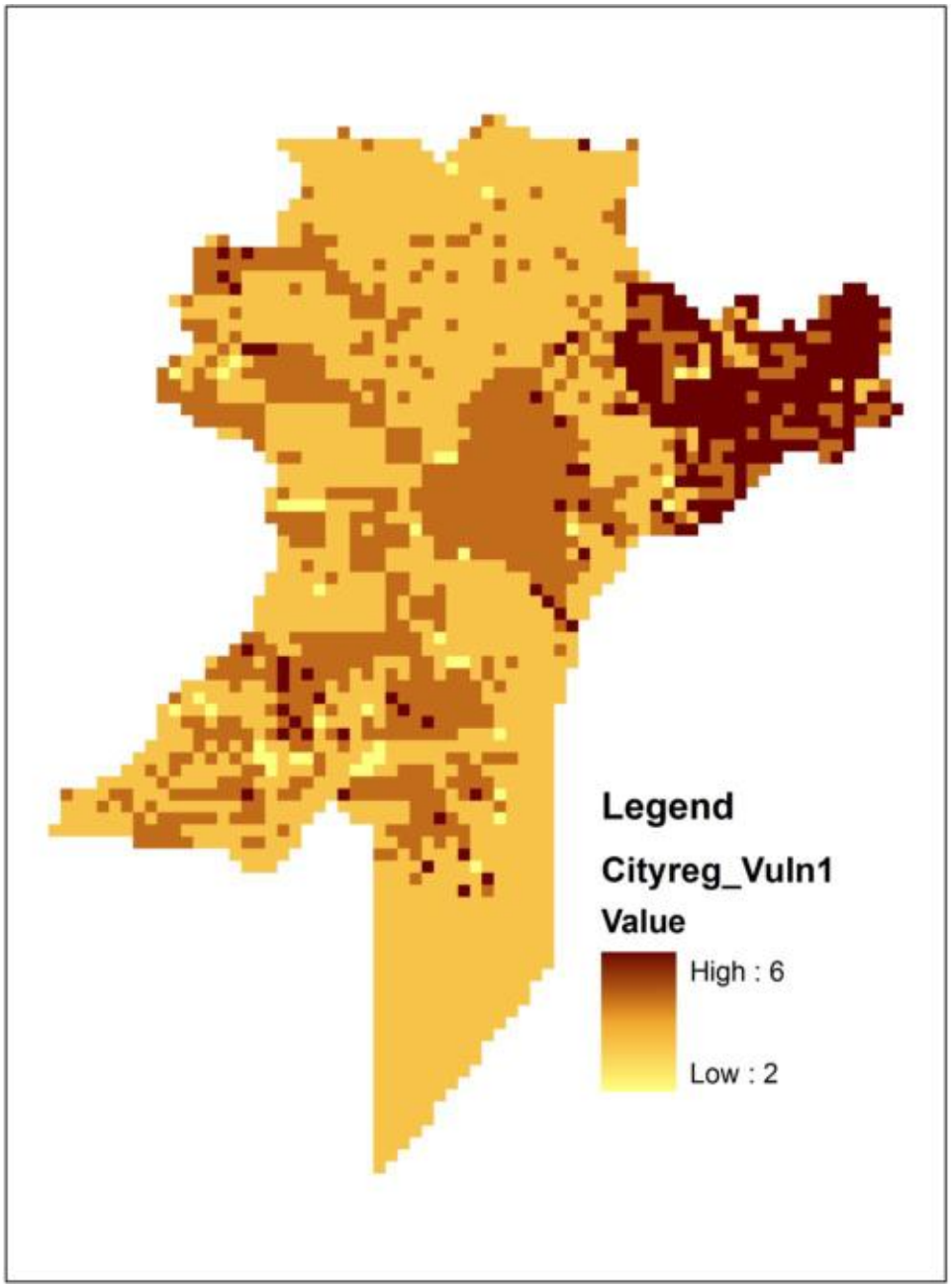
Table 2 Towns by vulnerability score and estimated population

	VULNERABILITY INDEX SCORE 1-7 LOW-HIGH				
	2	**3**	**4**	**5**	**Total Population**
TOWN					
BUDADIRI				20273	**20273**
KISORO				9774	**9774**
KIBALE				5069	**5069**
BUIKWE				128535	**128535**
MASINDI				18153	**18153**
BUGIRI			5874		**5874**
MAYUGE		2429			**2429**
MASINDI			973		**973**
ENTEBBE		3161			**3161**
KASESE				14226	**14226**

KASANDA			1296		**1296**
BUNDIBUGYO			30756		**30756**
ABIM			1200		**1200**
KABONG				203	**203**
MOROTO				3336	**3336**
JINJA MUNICIPALITY			759576		**759576**
KABALE MUNICIPALITY			170390		**170390**
KABERAMAIDO		4575			**4575**
BUWENGE			5007		**5007**
MASAKA		2281			**2281**
KAMPALA CITY COUNCIL			1236631		**1236631**
LUWERO			30225		**30225**
KIBOGA			1610		**1610**
IGANGA			29360		**29360**
KOBOKO			20772		**20772**
LYANTONDE			4394		**4394**
KUMI			5033		**5033**
MBALE MUNICIPALITY		153463			**153463**
MITYANA			5522		**5522**
OKORO			5099		**5099**
PADER			4897		**4897**
PALLISA			7833		**7833**
BUSIA			18348		**18348**
SOROTI MUNICIPALITY	105255				**105255**
TORORO MUNICIPALITY		72562			**72562**
BUKEDEA		1531			**1531**
Total Population	**105,255**	**240,002**	**2,344,796**	**199,569**	**2,889,622**

4.0 VULNERABILITY OF THE CITY-REGION

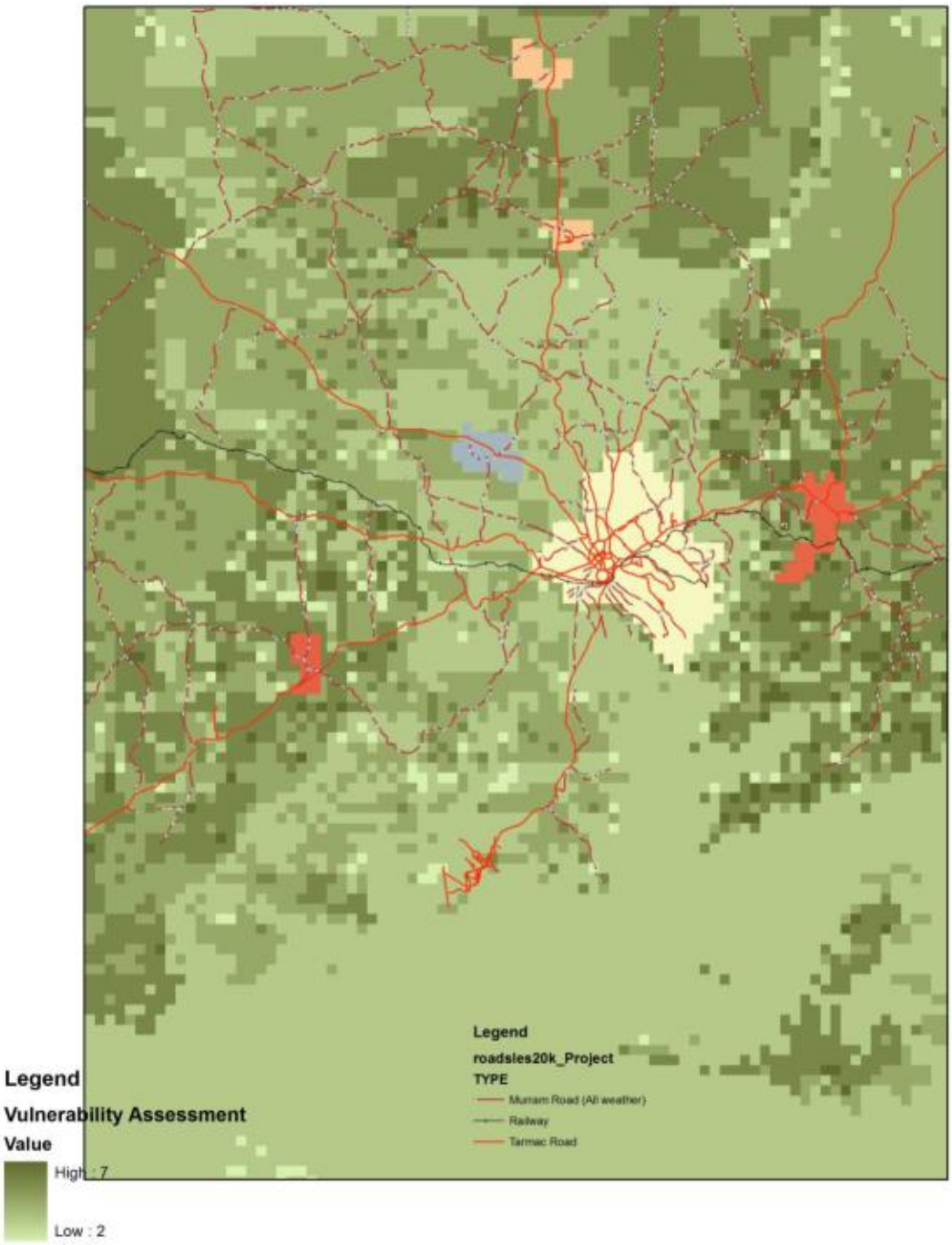
Vulnerability assessment of the city-region shows a higher risk to the population and urban infrastructure within the region. From the analysis results, most areas of the city region fall between 4 and 7 on the vulnerability index as shown in map 8. This implies moderate to high vulnerability of the city as a whole to climate change risks. At this city regional scale, infrastructure nucleated population clusters provide a depth-profile of vulnerability. Analysis of population exposed to climate threats shows less than 15% is not directly exposed to climate change threats while 74% is exposed with scores ranging from 4 to 6 on the index. Kampala, Entebbe and Mukono areas are highly vulnerable due to the underlying urban structure and population.



Map 8 Kampala City-region vulnerability

With an estimated land area of 1,895 sq km engulfing hitherto satellite towns of Entebbe, Wakiso, Mukono and Gayaza. This is the functional city region in which economic, social and environmental processes are spatially connected. The opportunities of urbanization are disproportionate in the region and so is the exposure to climate change risks. The urban structures and social economic factors influence the sensitivity and subsequently vulnerability. Livelihoods, public transportation, energy, social services and the ecological zones in the region are highly vulnerable to climate change[19, 43, 44]. Further analysis of data shows higher vulnerabilities the urban sectors. For example table

2 show the number of education, table 3 health facilities based on vulnerability score by location. Analysis was also done on vulnerabilities of roads and electricity grid by location. Although a higher spatial resolution analysis would identify in more specific terms variations b sector and within sectors, this analysis brings to light the vulnerability at citywide scale.



Map 9 Vulnerability of Road Infrastructure

	Vulnerability Scores by location					
School type	**2**	**3**	**4**	**5**	**6**	**Total of schools**
Non Formal	1	1	31			33
Other		12	13	2		27
Post Primary		2	2			4
Primary	12	663	843	96	5	1619
Secondary	5	232	284	29	3	553
Tertiary		12	33	3	1	49
Grand Total	**18**	**922**	**1207**	**130**	**9**	**2286**

Table 3 Vulnerability of Education facilities

Scores scale is 2-6 low to high

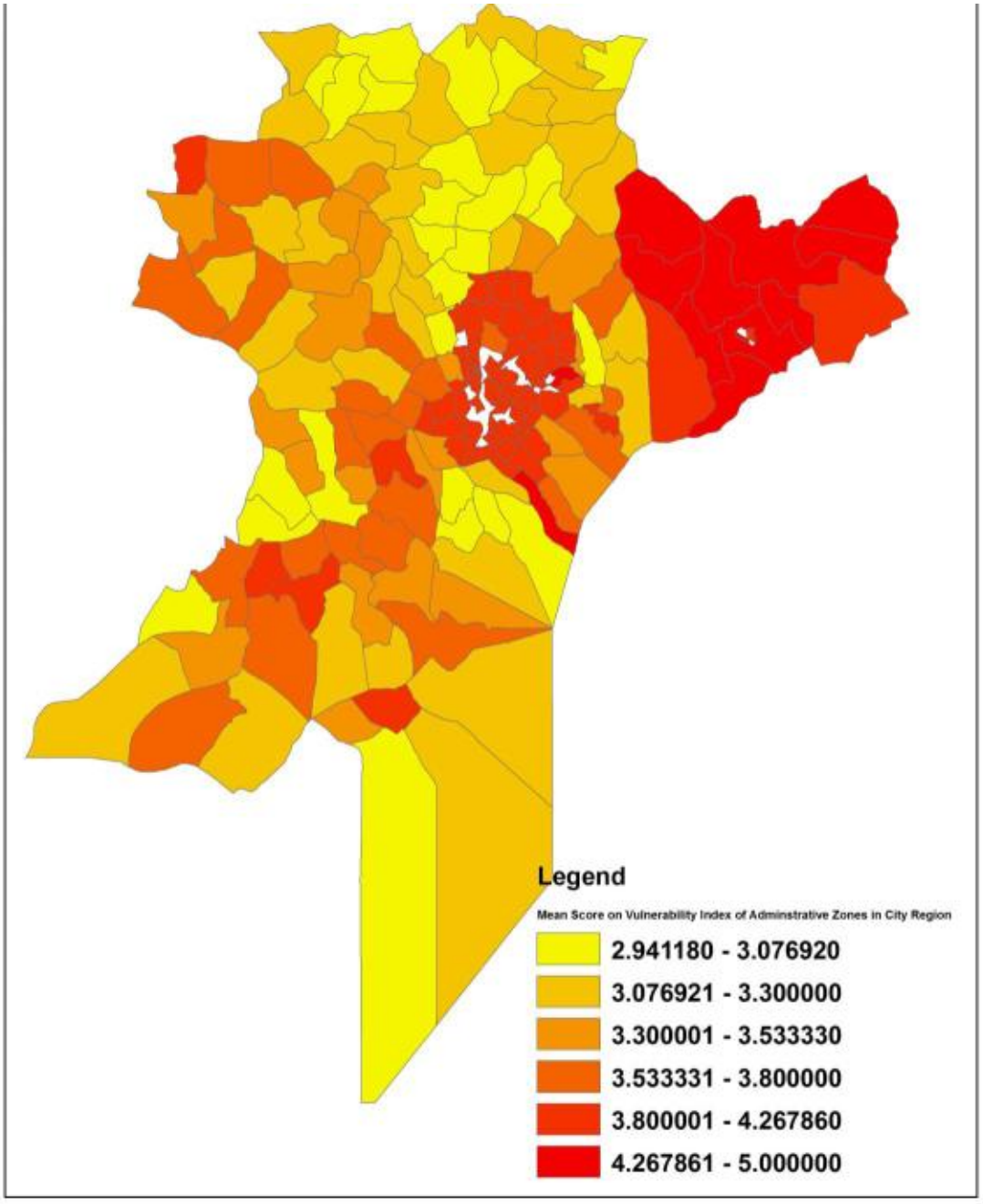
	Vulnerability Scores by location				
Health center grade	**2**	**3**	**4**	**5**	**Total number of health centers**
HC II	1	15	113		130
HC III	2	5	91	1	99
HC IV		3	4	1	8
HOSPITAL			16		17
Grand Total	**3**	**23**	**224**	**2**	**254**

Table 4 Vulnerability of Health centers

The outcome of the vulnerabilities is manifest in terms of health, livelihood destruction, destruction of properties and higher costs incurred by the population and institutions to bring systems back to functional level. Health is a key sector in which secondary impacts of climate risks can be discerned. An assessment of existing literature indicates high and increasing health costs associated with climate related risks such as flooding and quality of water[19, 25] shown in map 9. An economic valuation of health impacts associated with climate change risks shows that the poor households spend up an average 15.5% of the annual total income on defensive and direct costs of illnesses associated with floods and poor environment[25, 26]. As extreme weather events surge, these costs are likely to increase by an estimated 30% and the hardest hit are the urban poor communities who live in environmentally vulnerable zones. Associated with health is the decreasing level of urban ecological services from the natural resources. The natural environment zones are threatened by both climate change and the fast-paced expansion of the city. Threat for the environment is manifest in destruction of vital environmental components such as wetlands, forests, water resources and the natural landscape of Kampala[45]. Urban land uses have greatly accelerated soil erosion manifest in the increased levels of siltation of the drainage channels and deposition on the road infrastructure as augmented by climate change[23, 45, 46]. Wetland resources have diminished both in area coverage and in

terms of biodiversity. The degradation of wetlands has been complicated by over-lapping institutional mandates of different agencies such as National Environmental Management Authority and the Land Use Plan of Kampala. In 1993 it was noted that 13% of the wetland area was severely degraded. However, the estimate in 1999 showed that 46% of the wetland was severely degraded and by 2002 only 3.3% of the total wetland area was remaining[47, 48]. This implies that flood attenuation from extreme storms will be hampered exposing the population within the city region to even more stressful burdens. The degradation of wetlands and conversion of hilltops couple and lead to increasing flooding, housing destruction with human suffering. As show in map 10 below, the flood risk areas are also populated with dense housing in some of the neighborhoods. A key outcome of this analysis also indicates high risk slope erosion from steep slope in the city region likely to be associated with intensive rainfall. In Map 11, a flood risk assessment shows many neighborhoods in the city region with a high risk of experiencing floods

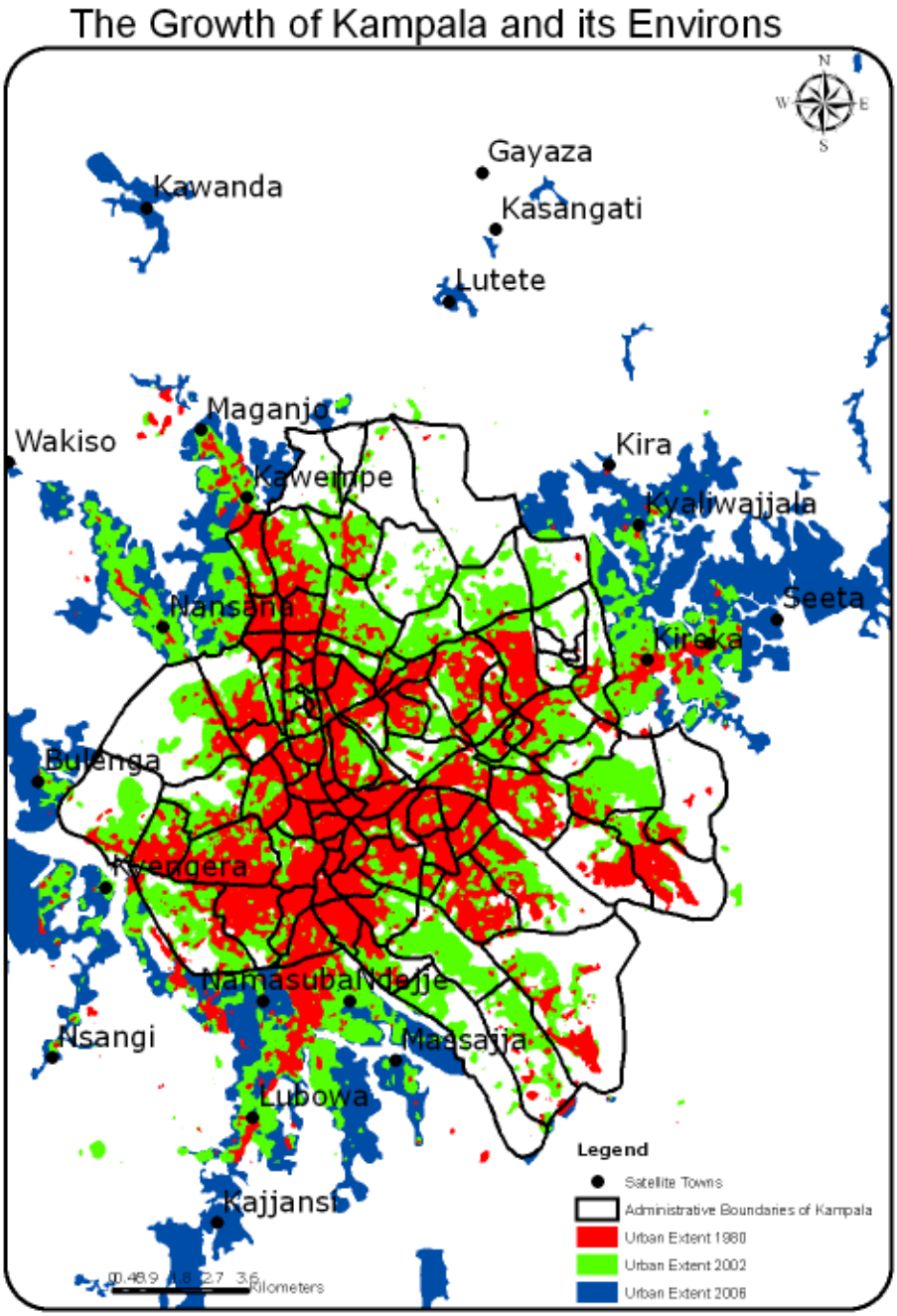
Map 10 Flood and Slope erosion hotspot Areas



Map 11 Flood risk by parishes in city region

Recent analysis of land use/cover by NFA (2006), results show extensive sprawl of Kampala. Land change data shows a continuous ribbon of urban built up from Kampala southwards to Entebbe but more recently the sprawl is characterized by in-fills leading an imprint of a metropolitan urban region. While hitherto satellite towns to the east and north of the city have also significantly expanded as show in map 12. Although the relationship between population change and urban built up cover change is statistically

weak the increasing demand for housing and proliferation of suburbia estates partly explain this 'run away' nature of the city. The land cover changes are associated with the risk of flooding.



Map 12 Urban Land Cover Changes in Kampala City-region 1980-2006

4.1. URBAN SECTOR ANALYSIS

4.1.1. ENERGY CONSUMPTION AND USE IN KAMPALA CITY

The Energy Assessment Mission of the ESMAP (expand acronym?), developed energy demand forecasts for the period 1994-2010 for Uganda[49]. These forecasts used the 1993 actual demand as the base line and considered the annual GDP (6% and 7%) and population growth rate of 3% in addition to improvements in end-use efficiency as explanatory variables. The forecasts project petroleum demand to rise at an average annual rate of 6 to 8 percent in relation to importation and use of vehicles. This implied that in 15 years the total annual demand could more than double from the current 400 million litres to more than 900 million litres with implications to emissions from energy. Although these energy demand forecasts are in relation to petroleum products, energy sources in Uganda are diverse ranging from hydropower electricity to biomass use. In addition to increasing reliance on car transportation for goods and mobility, demand for energy is largely for residential use. This implies a combination of electricity, wood fuel, charcoal and petroleum products for various domestic activities. Residential demand is followed by commercial use and industrial. In the context of climate change, high demand for residential coupled with dominance of wood fuel is a significant area for considerations of mitigation. This is due to the likely growing affluence and consumerism in Uganda as economic growth accelerates.

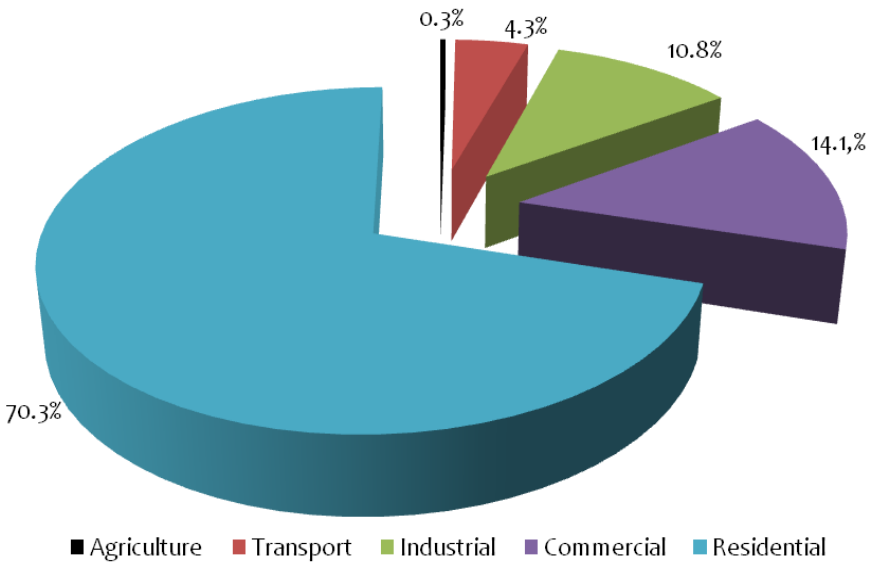


Figure 6 Sector distribution of Energy Consumption in Uganda

Specific to Kampala there is heavy reliance on biomass energy in form of wood and charcoal. This high dependence and escalated harvesting of biomass puts a lot of stress on the country's natural vegetation and has resulted in massive deforestation in many parts of the country including the vegetative areas within the metropolitan Kampala. This has implications on reduced sequestration of greenhouse gases[50]. Figure 6 below shows a steady increase in use of wood fuel in Kampala and generally in all urban areas. Wood

fuel use is dominant with 75% of households, 10% of commercial, industry 5% use it while charcoal production is 10%[51]. The trend is similar to charcoal and these have had implications for carbon production through deforestation and carbon dioxide emission through combustion. Biomass consumption in Kampala has increased significantly from 200,000 tons per year in 1995 to an estimated 300,000 tons per year 2012. The MIN minimum scenario shows an increase of about 58,000 tons per year, which is about 29% more in ten years and therefore below the estimated 3.9% population growth rate per year for Kampala. The maximum MAX scenario even shows an increase of about 100,000 tones, which is 50% more than 10 years ago. The projected consumption of Kampala in the year 2014 with estimated constant growth rates of 15, 30 and 50 percent both for the MIN and MAX scenario giving a possible consumption in 2014 ranging from 296,407 to 452,375 tons[52]. The pattern of energy use and consumption has two major implications; 1) there is a heavy reliance of traditional forms of energy such as wood, charcoal and crop residues; and 2) although biomass is renewable, strategies are needed to ensure sustainable consumption practices in the city.

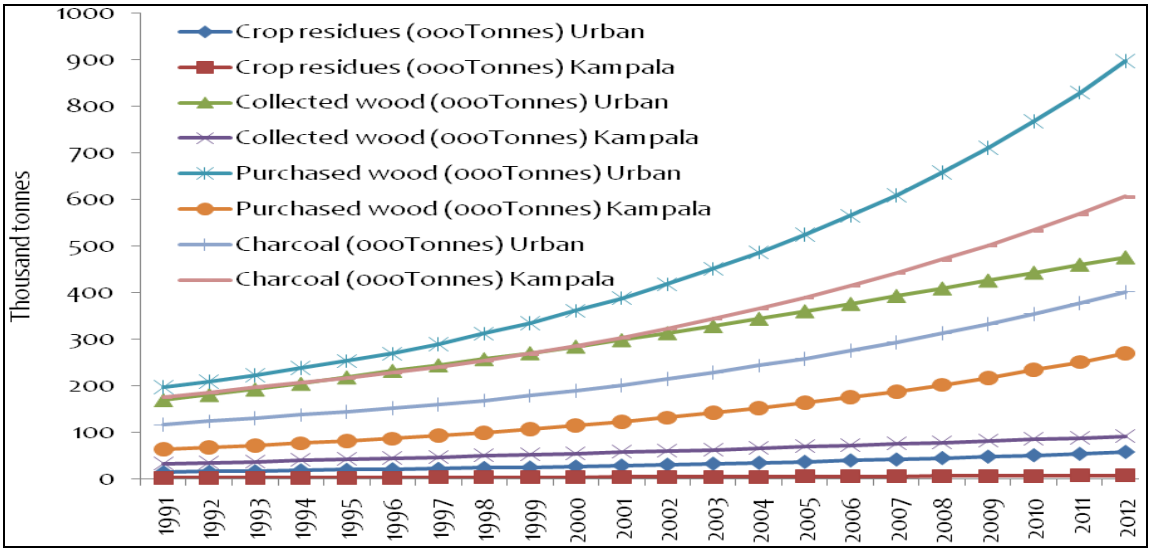
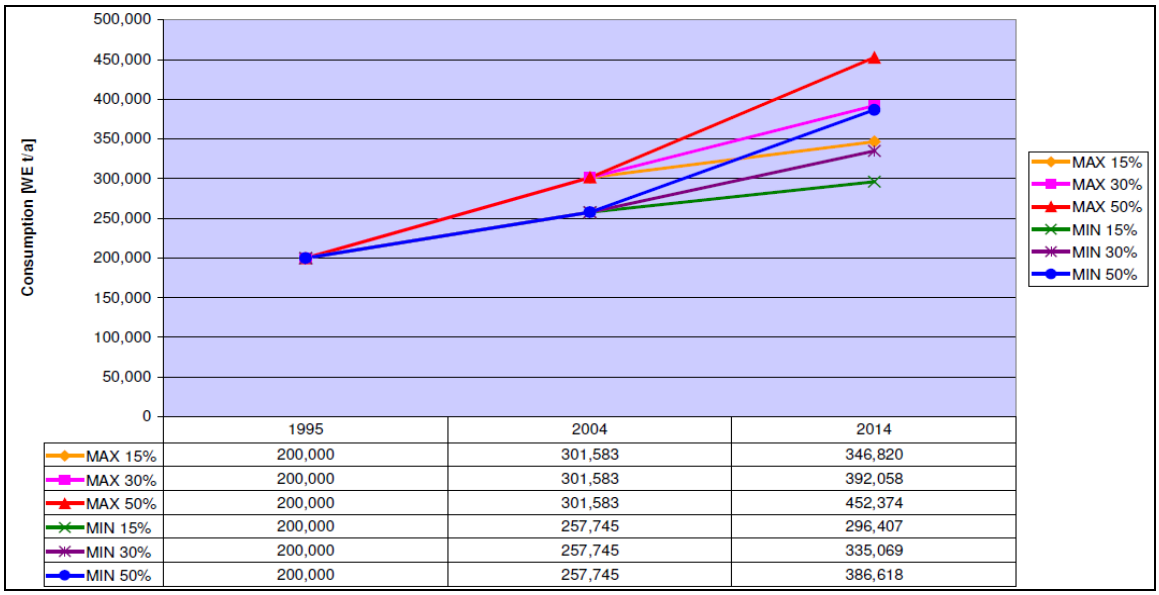


Figure 7 Biomass consumption ('000 tons) 1991 - 2012

The challenge of biomass consumption is compounded by urban poverty and duality of the urban population in Kampala. The continuous flow of materials including biomass fuel from the rural areas as well as peri-urban areas explains the increasing consumption. is the brutal interaction between poverty and climate change laid bare. With a ready market, the poor in peri-urban areas as well as rural areas extract the biomass for the urban market. This contributes to greenhouse gas emissions. A gender dimension of energy use indicates that women play a significant role the use and consumption of energy. Several studies mapping out the energy consumption patterns in different classes of society in Kampala established that in the city, there is a direct relationship between the type energy used and household income (Figure 7)[31]. Use of charcoal instead of firewood represented an improvement in the quality of life and dependence on it for cooking was high across all income groups. Use of firewood was prevalent in the lowest

income group. Statistical analyses showed that 1% of the reasons for the choice of fuel were related to income[52].



	1995	2004	2014
MAX 15%	200,000	301,583	346,820
MAX 30%	200,000	301,583	392,058
MAX 50%	200,000	301,583	452,374
MIN 15%	200,000	257,745	296,407
MIN 30%	200,000	257,745	335,069
MIN 50%	200,000	257,745	386,618

Figure 8 Projection of Charcoal consumption in Kampala to 1995 -2014

Source: Knopfle, 2004

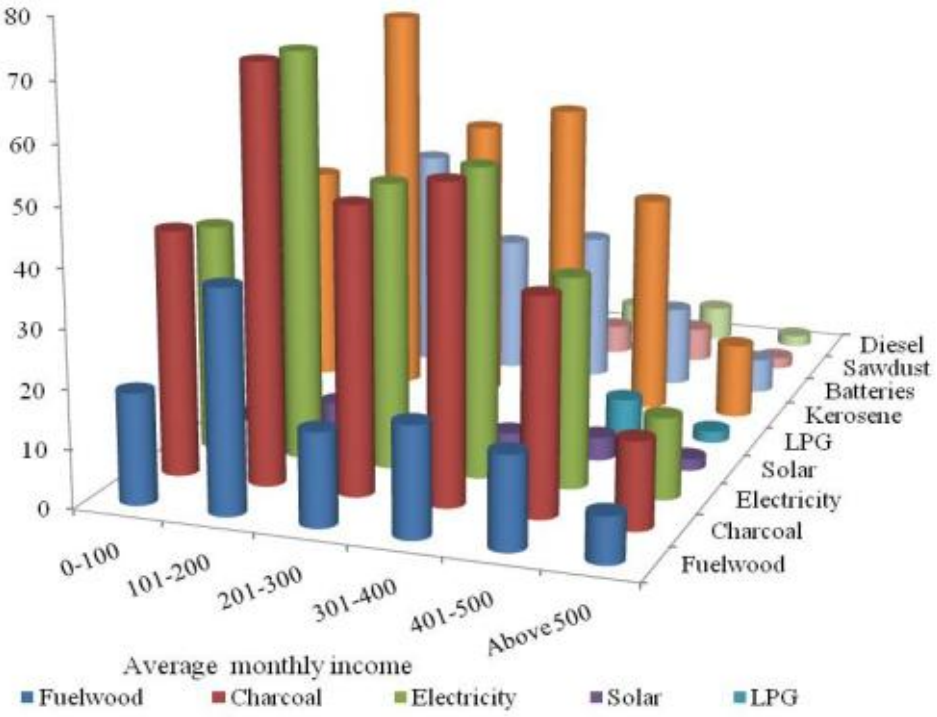


Figure 9 Energy ('000 tons) use within income groups

Source: Mukwaya, Sengendo and Lwasa (2008)

The challenges of women's involvement in use of biomass energy translates in health problems due to their exposure to in-door air pollution and the effects of the resultant carbon emissions. Not only do women suffer from health complications, but also the health of children. In view of their contribution to emissions in the energy sector and how these emissions impact on them due to their gender roles in the domestic setting, women can play a very crucial role in alternative and sustainable mitigation and adaptation scenarios. They can be encouraged and incentivized to use alternative fuels to cut down on dangerous emissions and to reduce household energy costs. By understanding their role in the production of GHGs, women can be encouraged to reduce the use of wood fuel or utilize cleaner technologies of wood fuel. Alternatively women can deploy other sources of renewable energy at the home front including low emission cookers. This will also have positive effects on their health as co-benefits.

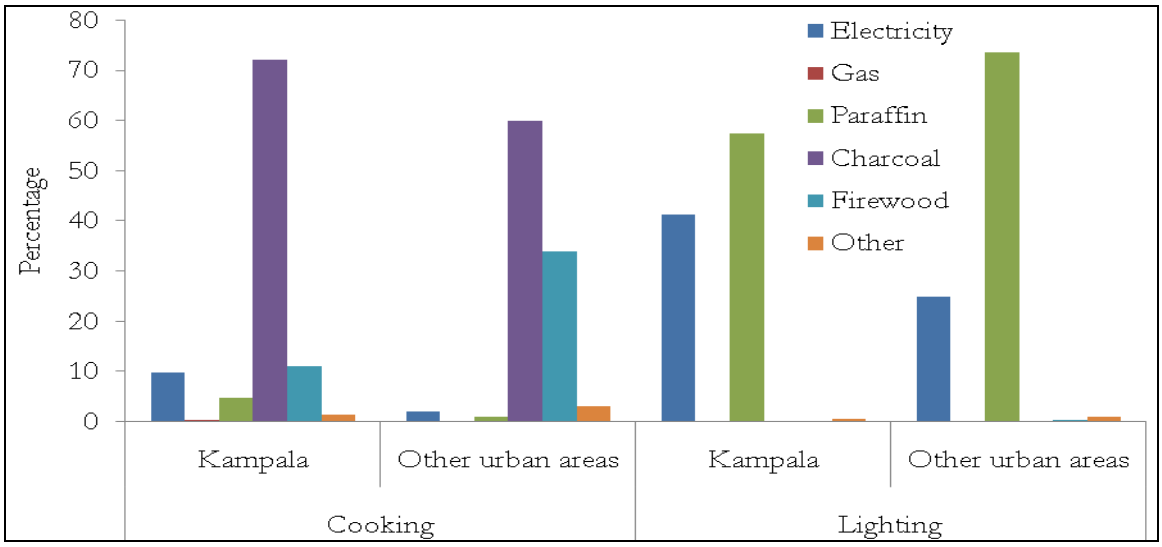


Figure 10 Energy sources for cooking and lighting in Kampala and other urban areas

Source: Olweny and Sebowa (2007)

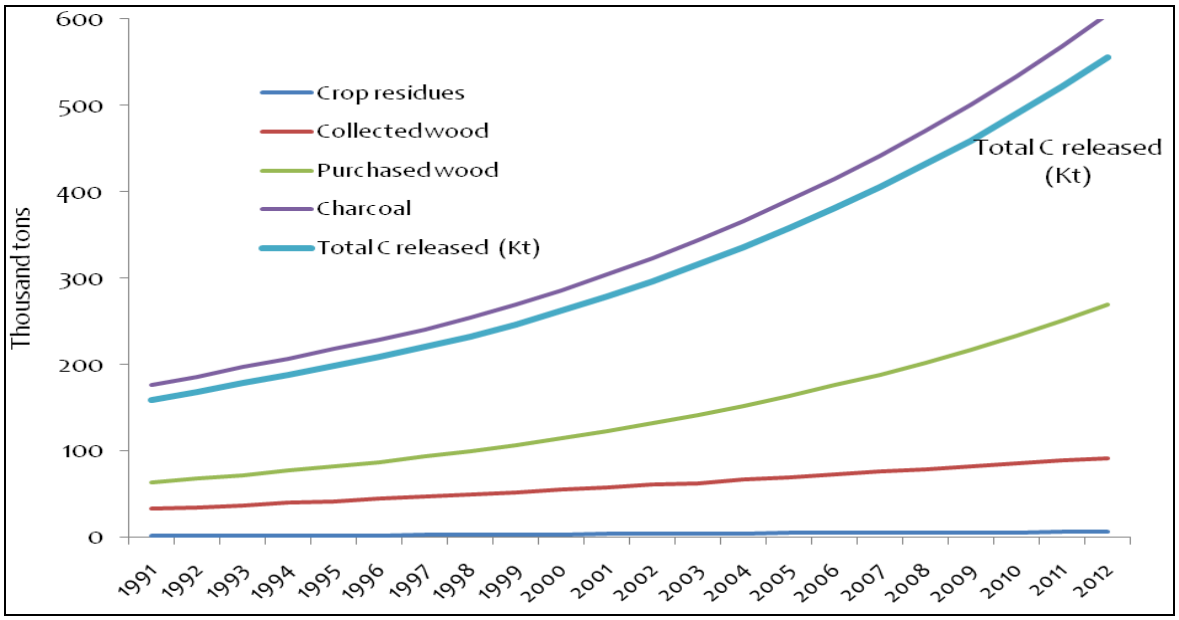


Figure 11 Carbon released in wood fuel combustion in Kampala city

Figure 10 Carbon released in wood fuel combustion in Kampala City

Source: Data from the World Bank, 1996

4.1.2. URBAN TRANSPORTATION AND ENERGY

The need for worldwide action to achieve energy efficiency in the transport sector has been recognised internationally and the need for national governments to take action to reduce the environmental impact of transport and to promote greater energy efficiency in the transport sector is discussed in various international agreements and declarations[6, 53]. The Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects refers to the need to develop motor vehicle performance standards and efficient transport infrastructures. The Kyoto Protocol to the United Nations Framework Convention on Climate Change requires each country to enhance energy efficiency by inter alia, introducing measures to limit and reduce greenhouse gas emissions in the transport sector. The most recent emphasis was made in the Johannesburg Plan of Implementation, adopted by the World Summit on Sustainable Development.

The increase in motor vehicles illustrated in Figure 11, the shift in structural composition of motor vehicles (Figure 12) and the consequent increase in the consumption of petroleum products (Figure 13) coupled with the rapid growth of urban populations and kilometers travelled (Table 3) will impact heavily on the generation of carbon emissions in the city. The demand for transportation energy is continuously growing as depicted in Figure Table 3 and Figure 11 and as a consequence greenhouse gas emissions will, therefore continue to increase.

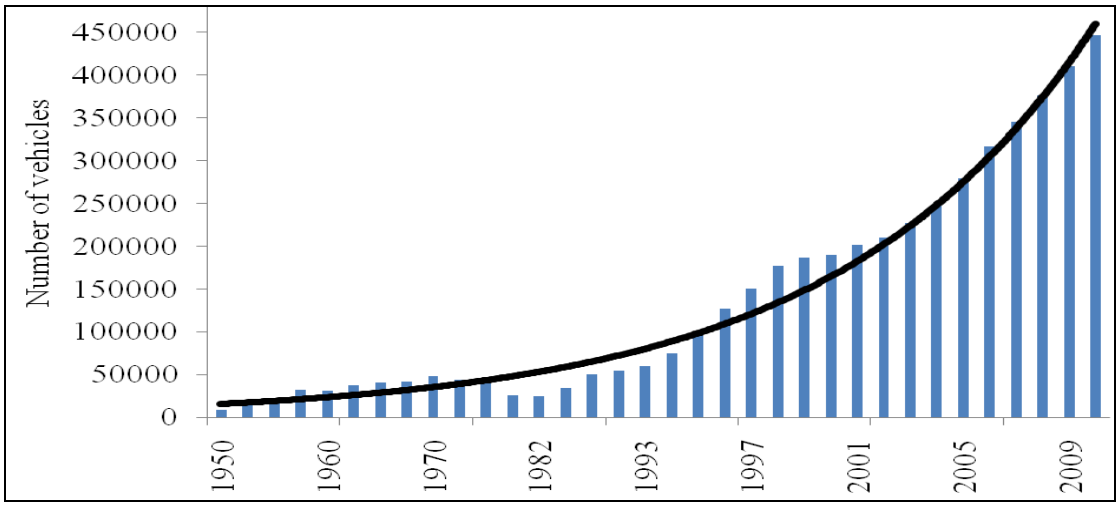


Figure 12 Vehicle Population in Uganda

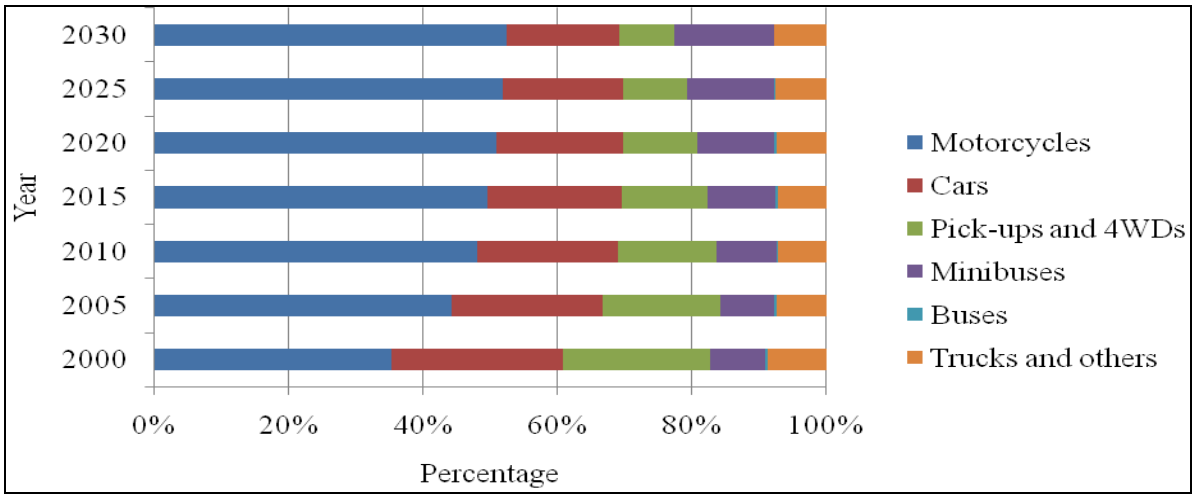


Figure 13 Projections of vehicle composition by percentage under business as usual conditions in Uganda 2000 - 2030

Source Isolo-Mukwaya (forthcoming)

According to (Magezi, 1995; and UBOS, 2002), the total energy demand for Kampala region was estimated at 3.99 million gigajoules (mgj) in 1991 and this is expected to increase to 81.8 mgj in 2010 under business as usual scenarios. Other data from (UBOS, 2002), estimated the total energy demand for Kampala region at 33.12 million gigajoules (mgj) and this would change to 76.99 mgj if and when mitigation controls are undertaken. Mukwaya (forthcoming) modelled energy consumption in Kampala City up to 2030 and found out that under business as usual conditions, energy consumption would increase by a factor of 9 to 750.9 mgj by 2030 (Figure 11) above the estimates given by Magezi

	2000	2005	2010	2015	2020	2025	2030

Motorcycles	0.7	1.1	2.9	7.3	18.2	45.1	111.8
Cars	0.8	0.9	2.1	4.9	11.3	25.8	59.1
Pick- ups and 4WDs	0.7	0.7	1.4	2.9	6.1	12.8	26.7
Minibuses	0.6	0.8	2.2	6.1	16.9	46.8	129.4
Buses	0.1	0.1	0.2	0.3	0.7	1.4	2.8
Trucks and others	0.9	1	2.4	5.9	14.6	36.3	89.9
Total	3.9	4.6	11.1	27.5	67.8	168.2	419.8

There will not only be more vehicles, but people will be driving more as well

Table 5 Vehicle usage (billion km) 2000 - 2030

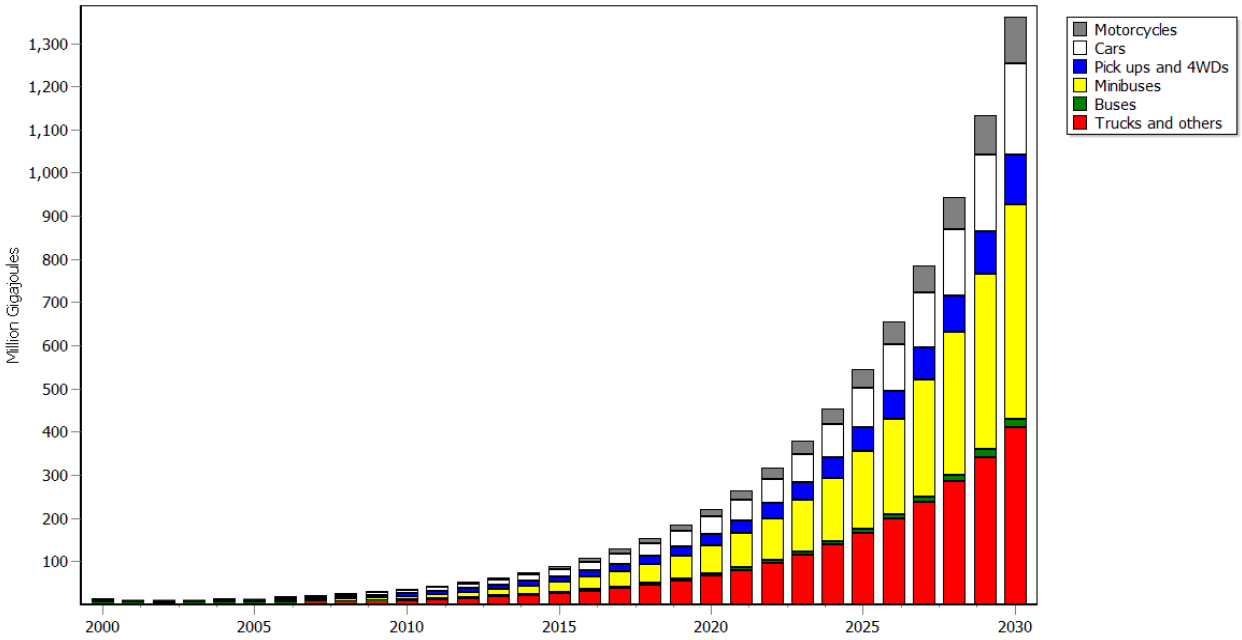


Figure 14 Energy demand (million gigajoules) 2000 - 2030

Source Mukwaya (*forthcoming*)

	1991	1995	2000	2005	2010
Air emissions – Carbon dioxide	276.11	478.02	1014.11	2327.39	5770.25 (million kg)
Air emissions – carbon monoxide	6.49	9.98	17.34	30.85	56.95 (million kg)
Hydro carbons	5.39	8.16	13.69	22.97	38.55 (000 kg)
Methane	4.5	8.97	22.88	61.76	172.5 (000kg)
Nitrous oxides	0.58	1.21	3.24	8.98	25.46 (million kg)
Sulfur oxides	200.89	303.98	510.16	856.16	1436.84 (kg)
Particulates	60.51	107.84	244.59	608	1613.91 (000kg)

Table 6 Estimated emissions from diesel and petrol in Kampala

Source; Baseline [Magezi, 1996]

Evidence is growing that higher density lead to more environmentally sustainable outcomes on energy efficiency grounds. Ideally, urban centres should have high population density with a mix of residential and commercial buildings, and connected through high speed transport systems. While this evidence is emerging about the performance of high and low density development in terms of energy consumption profiles, there has been little research in Kampala on what the contribution of density factors might play in determining the energy consumption. The city of Kampala has been allowed to spread without adequate controls and the danger is that public transport to the extended areas is inadequate, necessitating almost exclusive reliance on motor vehicles. Much has been assumed about the environmental benefits of a shift to higher density dwellings in current Kampala planning proposals such as the Van Nostrand Associates, [1994] Kampala Urban Study Phase 1 and 11. Available information showed that different scenarios of urban form generate different values of energy used and emissions generated. The values ranging from 0.11 kg CO2/litre at high population density to 3.54 kg CO2/litre from low density development shows the influence that urban form variables have over greenhouse gas emissions. This reveals the most extreme differences with high density producing 32 times less greenhouse gas emissions per litre of fuel consumed than low density developments[54].

Public transportation planning in Uganda is a responsibility of the Ministry of Works but the municipalities have the responsibility for the provision of public transport services. Like other public services, the decentralization policy passed on supervisory responsibilities to the Local Governments, which engage the private sector to directly provide services on their behalf. The idea is to reduce on costs of the local government/municipality involved in directly providing the service. Public transport provision in Kampala city is dominated by omnibuses that do not only emit highly but also contribute significantly to traffic congestion. With energy consumption rate of 0.00012 ton/vec.km, the demand for energy for public transport sector is ever increasing as urban development accelerates. Due to the type of public transport and the huge energy demand, the sector is largely inefficient and unsustainable.

4.1.3. GHG EMISSIONS

The increase in motor vehicles use leads to increase in the consumption of petroleum products responsible for 75% of greenhouse gas emissions. A large proportion of as much as 80% of diesel fuel is used in the transport sector. The petroleum products imported are largely leaded which adds to challenge of emissions due to health risks. Diesel fuel is a source of sulphur oxides (SOx) and of particulates because in Kampala automotive diesel fuel is among the highest sulphur fuels available. All three of these pollutants -- lead, sulphur, and particulate matter -- are known to create chronic health problems through respiratory diseases or other illnesses.

This raises sustainability questions and the need for revisiting the public urban transportation sector for managing of city growth and development. On average one minibus produces 18,536 Kg of carbon annually while one big bus produces 61,847 Kg of carbon a year. Five omnibuses will produce 92,680 Kg of carbon in a year, which is equivalent to 339,827 Kg of carbon dioxide. One big bus produces an equivalent carbon dioxide of 226,771 Kg. Use of bus has a potential to reduces CO2 emissions by 113,056 Kg per year per bus, which is equivalent to 30,833 Kg of carbon. Over 10,000 minibuses operate within the city, 90% of which circulate within city boundaries. If 50% of the town service minibuses are replaced with an efficient bus system then 900 buses will be required and the total carbon reduction would amount to 27,750 tons. This is one of the candidate areas for adaptation and mitigation of climate change. It is important to note that these estimates are based on data from reports, which were not comprehensive in inventorying GHG in Kampala. Since emissions reduction will be a critical area for KCCA, it is important to consider carrying out an inventory of GHG to benchmark future mitigation interventions.

Simulations conducted by Mukwaya (*forthcoming*) of carbon emissions from transportation in Kampala City up to the year 2030 and found out that under business as usual conditions, carbon emissions would increase by a factor of 9 by 2030 (Figure 10). There have been several alternative proposals suggesting the design and installation of mass transit including the provision of non motorised transport facilities and separate bus lanes within the city. Although the context was improving public transportation, these alternatives can have co-benefits of reducing emissions from transportation in the city. Mass transit systems in Kampala also have a potential for reducing the fuel intensity per vehicle kilometre. Strategic interventions by the Ministry of Works and Transport to introduce fully functional Bus Rapid Transit System by 2023 is one step in realizing an improved public transportation system but which can also promote a green economy. Other interventions suggested from Figure 15 include improvements in road infrastructure as well as looking at the relative location of jobs/services and residences in the city. Again the on-going strategic development plan is an opportunity for influencing urban form in the future as new urbanizing areas come up in the metropolitan region. When these alternatives are implemented under the mitigation scenario, it will not only reduce in carbon emissions but several other environmental co-benefits would substantially be realised (Table 5). The environmental cost of CO_2 loading has not been estimated, but a cost of $20USD per tonne of CO_2 saved was assumed in studies by Magezi (1996) and this would translate to about 21 million US dollars per annum.

	1991	**1995**	**2000**	**2005**	**2010**
Air emissions – Carbon dioxide	276.11	468.06	962.50	2201.73	5433.32 (million kg)
Air emissions – carbon monoxide	6.49	9.67	16.11	28.66	52.88 (million kg)

Hydro carbons	5.39	7.90	12.72	21.35	35.83 (000 kg)
Methane	4.50	8.68	21.19	57.17	159.62 (000kg)
Nitrous oxides	0.58	1.17	3.00	8.31	23.55 (million kg)
Sulfur oxides	200.89	294.46	474.20	795.81	1335.56 (kg)
Particulates	60.51	104.37	226.88	564.08	1495.43 (000kg)

Table 7 Estimated emissions by year physical unit from diesel and petrol for Kampala-Mitigation scenario

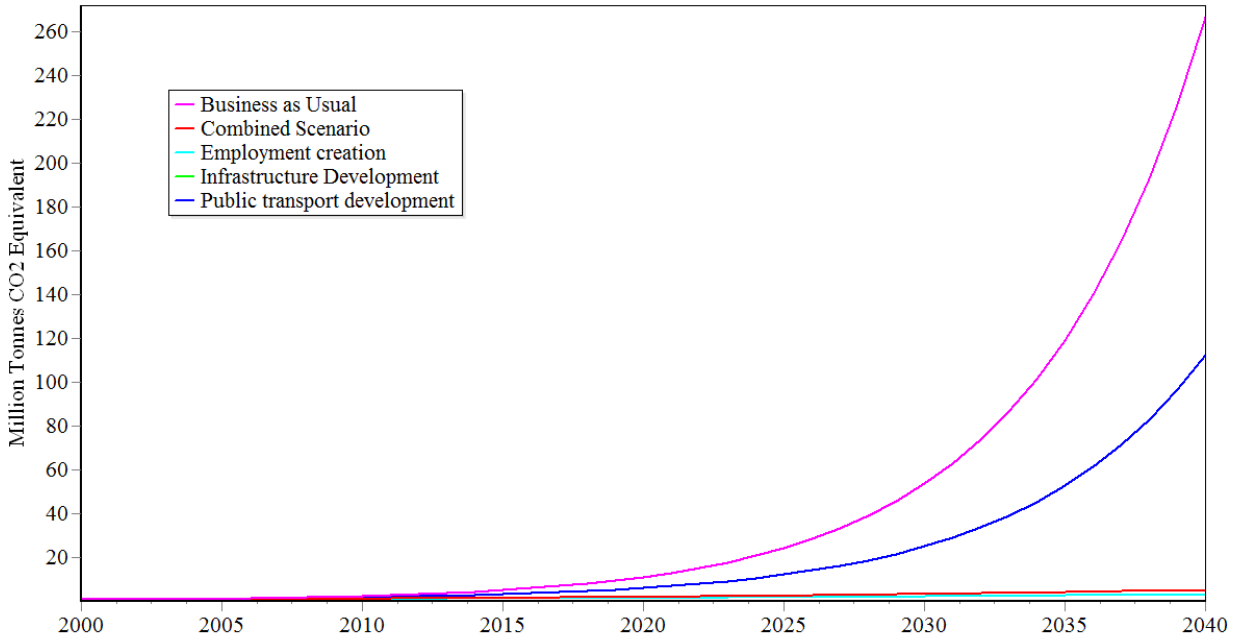


Figure 15 carbon emissions under different scenarios

Source Isolo-Mukwaya (forthcoming)

In addition to transport related energy demand, there has also been a surge in energy demand to generate power following the decreasing water levels of Lake Victoria. From domestic use, businesses, communication providers to industrial users, there was a sudden increase in demand for diesel run generators as backup system in the wake of failure for the national hydropower generation system to provide reliable energy in 2006. This led to Government's tax waiving policy on diesel products and generators and triggered off a surge in usage of diesel for power generation across the country. The implication is the increase in emissions of $CO_{2;}$ a situation that requires reversal if Uganda is to mitigate climate change agenda.

4.1.4. ENERGY AND THE BUILT ENVIRONMENT IN KAMPALA

Buildings constitute one of the central features of society providing shelter, work spaces, and places for commerce and leisure[55]. While climate change is caused and accelerated by greenhouse gas (GHG) emissions from all energy end use sectors such as transport, industry, buildings, agriculture, energy and waste management, the buildings sector

contributes about a third of all energy related CO2 emissions worldwide. Drawing on the global assessment of building-related CO2 emissions, which are estimated to increase from 8.6 billion tons in 2004 to 11.4 billion tons in 2030, under a low-growth scenario, buildings are significant contributors. At the same time, buildings are considered as "goldmines" of GHG mitigation worldwide.

The role of buildings in the context of climate change is twofold: on one hand, energy efficient buildings protect their inhabitants against the effects of climate change. On the other hand, residential buildings have embedded emissions of greenhouse gases. Research related to green buildings in developed countries has shown that green buildings can increase occupant productivity. For example, suggested that the performance of office workers is best between 21^0c -22^0C and declines as temperatures rise. This temperature is within the ASHRAE 55 temperature range and suggests that adopting the ASHRAE standard could boost productivity in Kampala City[55, 56]. (2006) concluded that at 30^0C, productivity declines by 9 per cent. Although these results were based on American office workers, the maximum temperatures of 28^0C that are experienced in Kampala City and yet predicted to increase substantially in the near future requires detailed planning studies to determine how workers' productivity will responds to increasing temperatures.

No significant quantitative assessment energy use in the built environment and its implications to climate change in Kampala city have been conducted. Consumption patterns of energy in buildings need to be considered crucial in Kampala under future climate scenarios to identify alternative cooling/warming practices. Environmental data, such as temperature, relative humidity, wind speed and direction, precipitation, topography, solar radiation and sky conditions, are important considerations in the design of built environments. The studies available are rather inconclusive over this particular matter. However, the energy used by the building sector continues to increase, primarily because new buildings are added to the national building stock faster than old buildings are retired. The construction industry and buildings contribute to emissions in three phases; during manufacture of materials such as cement, during construction and during operation when buildings are in use. An important factor in assessing buildings and emissions is the lifespan of such buildings. Existing buildings in Kampala, in particular those constructed over the last 20 years, characteristically have lower thermal efficiency and wasteful energy use as well as distribution systems. The newest buildings are likewise being built with low thermal efficiency. Unless this efficiency is improved, increased housing construction will be accompanied by higher electricity consumption, and thus higher emissions[4].

The tendency in Kampala and in all areas in Uganda is to orient buildings facing the street, irrespective of the position of the sun. Many buildings are sited with windows facing the east and west, thus subjecting the buildings to heat build-up during the day, which makes them, require mechanical air conditioning to make them habitable. At the same time, most buildings are constructed using energy intensive materials, including

[4] Senngooba-Kasule, 2003

concrete, glass and steel thereby having a net solar heat gain during most of the working time in a day. In addition the albedo is enhanced with the types of construction material and this is contribution to the Urban Heat Island in the city region. Cooling becomes an important part of energy use. Apart from the unfavourable environmental conditions that these materials create within and around buildings, their manufacture leads to environmental degradation. Many buildings have relatively dark interiors during the day, forcing inhabitants to rely on artificial lighting, when there is an abundance of free light outside. Orientation is also a factor which can only be corrected at the architecture stage.

Figure 16 Fixed lamellas or solar reflective glass on Workers House in Kampala

Consumers in Kampala show almost no preference for energy efficient buildings and choose residences and work/office locations according to other indicators. The energy conservation behaviour among building occupiers and users need to be understood seriously. Everyone forgets to turn off lights, but in some cases this habit in Kampala City is chronic especially in public buildings. This wasted lighting energy can add up quickly. In some rooms and small office lights are on unnecessarily for long hours each day, thereby pushing up energy wastage higher up in addition to emissions from the lighting.

Changes have also occurred with a wide range of domestic appliances in Kampala. As cooling systems have become commonplace there is a plethora of kitchen appliances such as the electric toaster, mixers, juicers, sandwich makers, coffee makers, electric fry-pans and a wide range of home entertainment facilities such as radios, DVD and CD players, televisions, computers and play stations all of which have dramatically been ‘taken up’ by households and substantially increased the ‘operational energy consumption’ of dwellings.

There is however no information instruments and building evaluation practices that help builders measure the energy performance of their appliances and buildings as well as considering issues such as land use, water, construction materials, and indoor air quality.
Heating and cooling demand of buildings is generally expressed in the shape of a U-curve, indicating that there is a range of outside temperature, generally set at 15.5 to 18-18.5º C, when a building does not need any type of energy input to be comfortable. Although 18.0º C may appear a low threshold, it must be kept in mind that buildings, and especially office buildings, receive residual heat from inside, for example from ICT applications. According to Swiss researchers, temperatures up to 29º C can be coped with by natural night ventilation, but only for a short-term period with an outdoor air temperature maximum of 36.7 º C[57]. The need for mechanical cooling will therefore sets in during prolonged periods of heat. Energy data from the Ministry of Energy and Mineral Development (*undated*) on selected building in Kampala City reveals that energy consumption in the building sector is mainly for air conditioning and mechanical ventilation, lighting, domestic hot water supply, catering, laundry, lifts and the health club[51]. From the energy sector's point of view, the shift air conditioning and cooling demand implies, in cases countries, a switch to greater electricity use, which has been deficient in several respects in the country. This means, that the strain on the electricity grid will increase, but little benefits can be expected for other energy networks. No record exist to indicate what magnitude of increase of annual electricity demand will be attributable solely to climate change but we can only speculate that will be substantially high.

The critical question for the future energy demand for cooling consists in the number of persons who will make increased use of air-conditioning, as temperatures climb beyond the "range of comfort". This range is not precisely understood and defined but it is obviously related to personal preferences and cultural settings. In Kampala, a survey carried out in 2006 by the Ministry of Energy and Mineral Development (Uganda) provided insights into current energy practices in a range of buildings including hotels and catering facilities. The survey revealed not only high energy consumption in the hotel sector but also much potential for saving energy While many have been constructed in the last decade or so, they all need to address energy management issues more seriously by including schemes that can lead to substantial savings in their energy consumption. Lowering the need for energy has a double cost benefit, deriving from the total amount consumed, and the unit costs that have been escalating with time. More efficient energy use will pay dividends by making services more affordable to guests and thereby attracting more business.

In large hotels, the main energy consumers are air conditioning, lighting and cooking (Figure 17). Since most electricity is used for air conditioning and lighting it would make sense to concentrate energy efficiency measures in these areas. For small hotels, on the other hand, lighting and hot water preparation are the main energy consumers (Figure 18). In large hotels, hot water is used for showering, bathing and the laundries, as well as for the dishwashers in the catering departments. Large, central water heaters are rarely used, with numerous small heaters installed instead. With the water heaters in constant operation, this is an approach which usually heats more water than is actually needed, to unnecessarily high temperatures. A great deal of energy is wasted due to a lack of

insulation and prolonged heating times. Small hotels have recently adopted a wider range of alternative heating methods, including instant water heaters and firewood boilers. The average monthly electricity consumption for an average large hotel is about 4,500kWh/month, with 62% of the electricity purchased from the grid and 38% produced by a generator. In comparison, the specific electricity per guest room for an average small hotel is about 170 kWh/month.

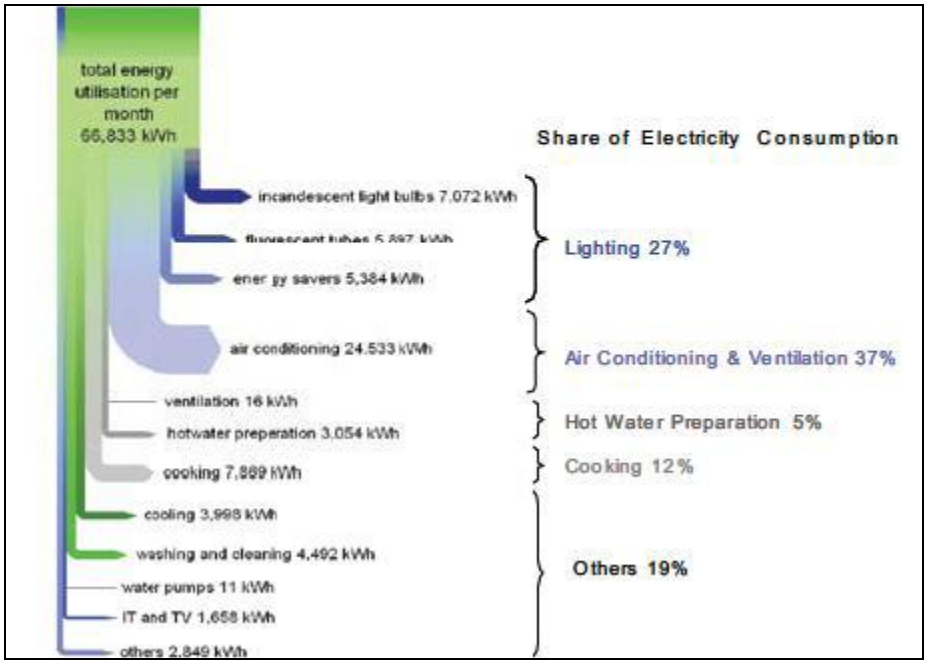


Figure 17 The share of electricity consumption for electric equipment in large hotels

Source Ministry of Energy and Mineral Development <*undated*>

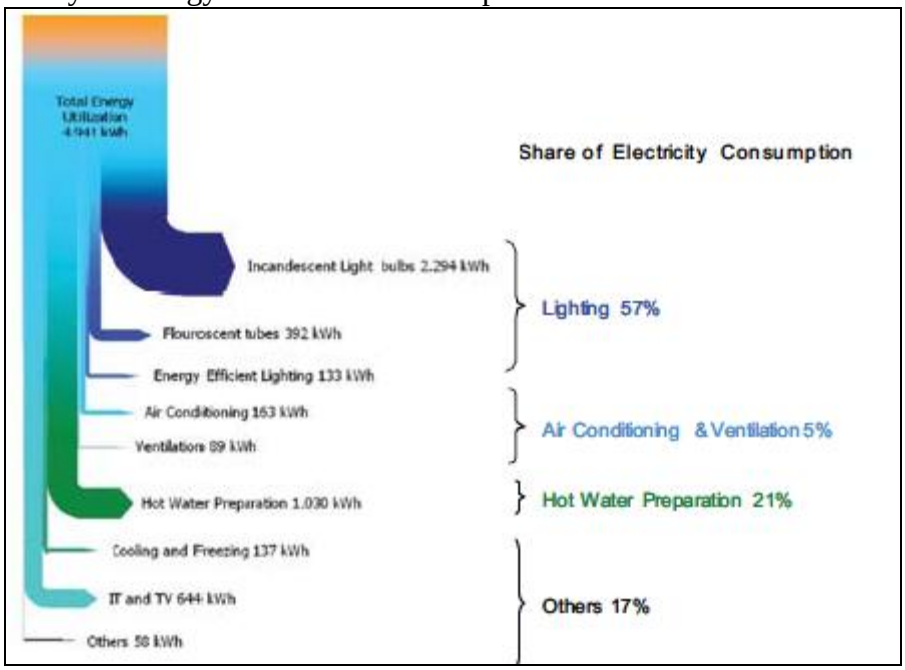


Figure 18 The share of electricity consumption for electric equipment in small hotels

Source Ministry of Energy and Mineral Development <*undated*>

Table 6 shows the amount of energy used in Sheraton Kampala Hotel. With modest housekeeping activities combined with modernization in areas such as lighting, cooking, water heating and the use of electrical equipment can lead to savings. Other opportunities include the reduction of the need for air conditioning by exploiting natural ventilation. The benefits of a recent drive to replace incandescent bulbs with energy-saving lights are a good illustration of how simple actions can lower energy demand. This is especially significant at a time when the energy supply falls far short of national demand. Frequent droughts that have been experienced in the country over the last decade have continued to disrupt energy generation and damage infrastructure. For example, Lake Victoria – at nearly 69,000 square kilometres Africa's largest, ringed by Kenya, Tanzania and Uganda – has dropped nearly a metre since 2005[5], curtailing hydroelectric generation at Nalubaale and Kiira power stations near Kampala, Uganda. Many hydraulic and other structures along the lake's shoreline, including docking facilities at Port Bell near Kampala, now need costly modification if they are not to become obsolete.

Energy Utilization Activity	Energy used per year (kWh)
Air conditioning and Mechanical Ventilation	1,894,000
Lighting	178,000
Domestic Hot water Supply	1,928,000
Catering	728,000
Laundry	614,000
Lifts	491,000
Health clubs	129,000

Table 8 Amount of energy use per year (kWh) in Sheraton Hotel

For efficiency, energy labeling programmes need to be used in Kampala and Uganda in general to inform end users about the equipment and other appliances. The need for energy standards and labeling in Kampala is pertinent because: 1) residential energy use is growing rapidly; 2) sales of household appliances and office products is growing rapidly; 3) standards and labels are among the most cost effective policy tools available; and 4) energy saving is a priority for government, private companies, households, transportation, industrial and commercial premises in a time of low national energy production due to fluctuations in water levels of Lake Victoria and now the volatile fuel prices pushing up costs of thermo-energy generation. The Energy Labels cited on the Ugandan market according to MEMD include: European Union Energy Label, The Energy Star (USA) - displayed on new electronic equipment such as computers, printers, photocopiers, fax machines, air conditioners. But this is not effective in informing end users, which points to the need for raising awareness. Of recent, the energy crisis in the

[5] See http://earthobservatory.nasa.gov/Study/Victoria/.

country and policies that followed is enabling end users to realize the importance of energy efficiency[58]. Awareness of the general public as to what all the labels mean is also critical.

As regards, the growing industrial sector more energy, mostly electricity and oil is needed. This growth in the industrial sector is contributing to sustained high gross domestic product (GDP), but it has severely affected the ability of these countries to maintain adequate fuel supply or reserves. Often, dependence on fossil fuels to power industries has cost the environment. Industries use oil furnaces for heating and there is need for viable alternatives such as solar thermal technology to reduce oil consumption and the consequent CO_2 emission as indicated in the Tables 7.

Type of gas	**Emission factor [g/MJ]**	**Emission Gg C or N**
CO_2	73.3	1.483
N_2O	0.0019	0.0000384
CO	0.51	0.010
CH_4	0.01	0.000199
NO_x	1.01	0.0204
NMVOC	0.18	0.003583
Consumption by the generators totalled approximately 20,226.57 GJ of diesel		

Table 9 Total emissions from thermal generators MEMD, 1996

As the climate change impacts intensify, the consumption of energy in climate-sensitive sectors such as building is likely to change. Possible effects would affect energy production, transmissions and distribution, and impact on energy demand. The possible impacts include (1) fluctuations in the amount of energy used in residential, commercial, and industrial buildings for domestics purposes and increases in demand for energy for refrigeration, space cooling and industrial processes cooling; 2) increases in energy used to supply other resources for climate-sensitive processes, such as pumping water for city uses; (3) changes in the balance of energy use among delivery forms and fuel types, as between electricity used for air conditioning; and (5) changes in energy consumption in key climate-sensitive sectors of the economy, such as transportation, housing and construction. A summary of climate change impacts and their effect on the energy sector in Kampala City are summarized in Table 8.

	Climate change impacts	Energy sector sensitivities
Longer warm spells and heat waves *[Virtually certain]*	▪ Increasing energy demand during the warm periods. ▪ Creation of a local air circulation that	▪ Reduced energy supply reliability ▪ Increased temperatures can also reduce transmission efficiency ▪ High energy costs and energy poverty will have knock on implications for

	produces an urban heat island with higher temperatures. ▪ Increase in the number of hot days ▪ Extended periods of drought will further lead to reduced water availability for energy generation - Power outages can result in significant economic and social costs. ▪ High energy costs and energy poverty with knock on implications for charcoal use, deforestation and land degradation ▪ Greater vulnerability to heat stress for young children	charcoal use, deforestation and land degradation ▪ Droughts can also disrupt energy generation and damage infrastructure. ▪ Greater vulnerability to heat stress for young children ▪ Installation of cooling systems – air conditioned vehicles and higher requirements for refrigeration for freight transportation ▪ Changes in cloud cover, temperature and pressure patterns are likely to directly affect potential wind and solar resources (affecting resource availability or productivity);
Heavier precipitation events and increase in their frequency over the city *[Very likely]*	▪ Overloading of drainage systems, causing backups and street flooding ▪ Destruction infrastructure – power transmission lines ▪ High transport costs for firewood and charcoal	▪ Interruptions in energy supply ▪ Increased expenditure on energy infrastructure development ▪ High prices for energy services
More intense storms, hail events and wind speeds *[Likely]*	▪ Increased intensity and frequency of severe weather events will impact on energy infrastructure, for instance power plants, transmission lines. Higher energy costs and energy poverty with knock on	▪ Interruptions in energy supply ▪ Increased expenditure on energy infrastructure development ▪ High prices for energy services ▪ Increased intensity and frequency of severe weather events impacts on energy infrastructure, for instance transmission lines in and around the city. For example, under strong winds, electric wires and other electricity distribution components can easily

		implications for charcoal use, deforestation and land degradation ▪ Increased occurrence of blackouts, power outages and brownouts may be observed as a result of higher electricity demand	collapse.

Table 10 Summary of climate change impacts and energy implications in Kampala

Although the energy sector is affected by climate change, it should be the sector that should also deliver on climate change mitigation for Kampala City. Adaptation of energy sector to climate change is a serious consideration for KCCA but this can be framed in the context of mitigation designed to optimize on co-benefits. It will require strategic measures to adapt the key sectors of energy consumption including buildings, residences, industry and urban transport system, the latter being designed under the World Bank funded project for Greater Kampala Transportation Master Plan. But it will also require mitigation measures some of which require national level intervention like the electricity sector and renewable energy sources. In each of the sector addressed above, significant energy savings can be achieved through several mitigation measures in Table 9.

Buildings	Lighting	▪ Encourage use of compact fluorescent lamps and introduction of energy saving bulbs ▪ Encourage greater use of day light through better design of buildings ▪ Encourage switching off of lights, which are not required including security lights, where possible. ▪ Encourage to always remember to switch off lights when leaving rooms empty ▪ Using control systems like motion detectors in corridors, photocells, etc.
	Office equipment	▪ Use of desktop computers with LCD screens and power management software ▪ Encourage the switching off photocopiers when not in use ▪ Encourage the replacement of low volume laser printers with Ink jet printers
	Space cooling	▪ Use of high efficiency air conditioners or replacement of old air-conditioning systems with efficient systems ▪ Encourage the use solar heating and cooling

	Facility/ Household equipment	▪ Encouraging switching off cooking, lighting, ironing, etc appliances when not in use. ▪ Encouraging that upon turning off household electronic or electrical appliances such as music system, TV, ensure that the appliances in question are off at the set or at the main. ▪ Encouraging use of pressure cookers for cooking hard foods like beans, meat etc. ▪ Encouraging boiling with instant heating appliances rather than cookers. ▪ Avoiding frequent cooking; use heat-conserving appliances like food flasks to keep food warm. ▪ Encouraging the ironing as many clothes as possible at a time because every time you switch on the flat iron you have to heat it to a certain level before ironing begins hence losing a lot of energy in the process. ▪ Encouraging shift cooking and ironing to off-peak time. ▪ Encouraging boiling the water for cooking vegetables in a kettle rather than in the pan on the cooker and carefully transfer the water into the pan when it is boiled. ▪ Ensuring that the sizes of cooking pans match the sizes of cooker plates ▪ Encouraging covering all cooking pots with a lid ▪ Encouraging staff and guests to use energy rationally.
	Refrigeration	▪ Ensuring that fridges, deep freezers are properly closed to avoid heat loss to the surroundings; if possible, use a fridge thermometer. ▪ Encouraging that people should leave food to cool down before it is put in the fridge
Transport		▪ Providing a system for mass traffic including an integrated system of foot and cycle paths ▪ Land use planning - Enforcing zoning laws that allow for mixed development ▪ Encouragement of consolidated urban growth, which makes full use of existing infrastructure as opposed to dispersed, expensive sprawl. ▪ Tightening the environmental levy to reduce the importation of very old vehicles and increasing the price of fuel on an annual national budgetary basis to discourage excessive use of fuel ▪ Ending the importation of old vehicles to phase out grossly polluting vehicles
Industry		▪ Encourage material recycling and substitution ▪ Use as much natural lighting as possible by use of translucent roofing sheets. ▪ Replace wound motors by standard motors where

	efficiency of wound motors is poor. ▪ Not using loose or excessively tight belts, check alignment and use appropriate lubricants to reduce on frictional losses.

Table 11 Mitigation and adaptation strategies in the energy sector in Kampala City

From the foregoing discussion on energy, the key sectors in GHG emissions are transportation and domestic related activities due to intensive use of biomass. Thus the city region is thus both a contributor to climate change processes but vulnerable to the effects of CO_2 accumulation in the atmosphere. Mitigation will be necessary in Kampala but this has to take care of the co-benefits and spill over effects that would reduce the impacts on the poor urban population. There has not been a serious focus on making urban areas green with more energy efficient systems. Despite the continued investment into urban infrastructure such as water, drainage, roads, communication infrastructure, waste management, sewerage systems, lighting and housing, governance systems to ensure sustainability and functionality of the infrastructure is almost non-existent. This is reflected in non-maintenance, repairs and non-replacement yet extension and expansion are limited in respect to the infrastructure.

4.2. URBAN WATER AND SANITATION IN KAMPALA

Urban water service provision in Uganda is largely a responsibility of National Water and Sewerage Corporation (NWSC). The National Water and Sewerage Corporation effectively operates in seventeen towns namely: Kampala (including Kajjansi and Nansana), Jinja/Njeru, Entebbe, Tororo, Mbale, Masaka, Mbarara, Gulu, Lira, FortPortal, Kasese, Kabale, Arua, Bushenyi/Isahaka, Soroti, Mukono and Malaba. With expansion to Iganga and Lugazi towns. NWSC will serve up to 19 towns. Despite its existence for 33 years and concentration on urban centers, 67% of the population in Kampala is served with safe water. Though this has increased over time, the remainder is largely the urban poor and residents of the peri-urban fringe. One key issue related to climate change in respect to water provision in Kampala is the receding Lake Victoria levels which dropped by 1.5 m from 2004-2006. This put pressure on the water intake of Gabba II water treatment plant serving the region. More recently Gabba III was commissioned and one of the adaptation to the falling lake levels, was to extend it into the lake to enable adequate water intake. Although the only available and functional treatment plant is operating below capacity, its outfall is only 1.5 km away from Gabba II intake. Analysts have argued that this has increased the costs of treatment of water for the region further exposing the urban population to risks due to eutrophication. Besides the risk to the population, this urban infrastructure is also at risk due to the falling lake levels that are partly related to climate change effects in the region.

Water provision is complementary to sanitation and only about 15% of the urban population in Kampala is served with sewerage network connections. Sanitation in Kampala is dominated by latrines with coverage by 74% of the population. But this method though considered fair, is not the most optimal method for human waste management. Though not yet quantified, pit latrines have a potential to contribute to methane emissions. This emphasize the need for GHG inventory in Kampala taking into consideration all potential sources of emissions from all sectors as well as income levels and quantifying for mitigation. Climate change effects are accentuating the problem of sanitation in Kampala region. This is because most settlements are in flood prone areas, which also have high water tables. With the dominance of pit-latrines, over flow of human waste will increase vulnerability of the population to health. Health problems related to flooding are already affecting many households in Kampala and costing 15% of household income for direct costs of illness and defensive expenditure. With this grim situation, increased flooding will expose even more households and urban population to health risks. In the case of urban areas in water stress areas, less water implies increase health risks such as cholera, dysentery and other diseases related to dry conditions. Coupled with poor sanitation, the problems of urban areas will be augmented by climate change. The challenge of sanitation requires a concerted effort of various actors and a multi-pronged strategy. The national water and sanitation strategy 2008 points to various aspects including managing water resources more efficiently, distributing safe water to all, designing affordable water access systems, a focus on schools to promote health and hygiene and consideration of alternative cost effective and efficient sanitation methods such as ecological sanitation. In the context of climate change adaptation, sanitation will require redesign of social and economic systems of distribution and management of water and sewerage facilities. Planning and provision of the facilities is key to climate change adaptation and existing facilities will need climate proofing as well new facilities but strategic climate proofing of urban infrastructure is necessary to reduce the health risks of poor sanitation.

4.2.1. CLIMATE CHANGE AND URBAN WASTE MANAGEMENT

Until recently in 2002, solid waste collection, transportation and disposal has been the responsibility of the municipal authorities. Under the Local Government Act 1997, its one of the services listed as the mandated role of urban authorities but it is supposed to be privately implemented. For example Kampala City Council passed revised Solid Waste Management Ordinances in 2002, in which the principle of ‘generator pays’ was established and is the basis of the current solid waste management systems. Many other municipalities are revising or considering revision of the municipal ordinances to pursue the ‘generator pays’ principle. The solid waste ordinances led to privatization of garbage collection and this was coupled with the private-sector led development policy which

supports procurement of services from private organizations by the local governments. Due to privatization as observed by refuse collection coverage in one of the municipal Division increased from 10% to 80% in the division, while the unit cost of collection reduced from Uganda shillings 11,300/m^3 to 4,500/m^3 (US$8/$m^3$ to US$3/$m^3$)[59]. Although this has improved the neighborhood environment, the challenge of waste management in context of environment is still daunting. An estimated 20 – 30% of the population is served with the solid waste management services in Kampala (UBOS, 2002 10). There are several private garbage collectors that provide a door-to-door solid waste collection service at a fee ranging from between Uganda shillings 20,000-30,000 (US$12-20) per month for a bi-weekly service. For the urban poor settlements, KCCA subsidizes due to the levels of poverty. Clustered household method which enables group contribution to the monthly fee is being tried out by the private collectors. Despite all these initiatives and approaches, existing solid waste management practices depict a deplorable but improving state with privatization and involvement of civil society organizations. Waste generation rates are high mainly due to the high population with an average household size is 5.7 the generation rate per capita is 0.89 kg for households and 0.213 kg for commercial units per day is considered. Although generation of wastes would not be a problem, it becomes so if the means for storage, transportation and disposal are insufficient and therefore overwhelmed. This presents serious environmental and health implications to the urban population.

The nature of urban expansion and extension has created a continuum of built up environment in a radial form following the major road network inlets and outlet of the city. With the space-time convergence, the hitherto distant sites have been engulfed into the greater metropolitan area with impacts on the waste management and ecological services. Consequently, urban sprawl has increased the costs of waste disposal since settlements have developed expanding towards the current landfill with health hazards and the aesthetics of the place affected. In Kampala there is one KCCA managed land fill which serves the population. Yet the city regional municipalities operate garbage dumps around and within the region that are no doubt of environmental concern. But with only about 40% of the wastes in Kampala administrative area collected and disposed of at the landfill, there is a double challenge of waste management in the context of climate change. First the current landfill is a source of GHG's especially Methane and leachates with reported inadequate management of the facility. This has exposed the neighboring population to health risks. Second the uncollected garbage in the city remains scattered around in form of heaps while much finds its way into the surface drainage system. This has two outcomes; one that the scattered garbage heaps are a source of CH4 and other gasses which contribute to micro to meso scale contribution of the city region to GHG emissions and second the garbage finding its way into surface drainage system further exposes the population to climate change effects when coupled with excess rainfall. Thus urban garbage management has bidirectional interactions with climate change. This

interaction calls for mitigation and adaption measures that would enable the city region to remain green and sustainable. Like energy, this area calls for better innovative ways of managing garbage and Kampala would participate in the Clean Development Mechanism (CDM) of carbon credits of managing garbage better. Additionally, local level innovative ways of utilizing wastes as energy would also reduce the effects of a landfill and have greater implications to terrestrial carbon stocks. Alternatively reducing the amount of waste that reaches the landfill in the first place and diverting organic waste by composting it will also reduce the overall GHG emissions at the final disposal site. The latter pointing to the potential co-benefits of mitigation and adaptation in the waste sector.

4.2.2. CLIMATE CHANGE AND URBAN HEALTH

The relationship between urban environmental conditions and health is well established and the health of people is an indicator of the environment in which people live[60, 61]. Infectious diseases especially water-related and air-borne are prevalent in many of the neighborhoods of Kampala while outbreaks of cholera have been recorded in 1997 and reoccurring in 1999, 2004, 2006 and 2008 due to the increased floods in the city. Data on floods shows that the frequency of floods increased from 1993 to 1999 as shown in the figure 19 below. The peak in flood frequency (9) was in 1997, while in 1999 least flood events were expected although recent data shows an increase between 2005 to 2008. The decrease is partly due to lack of data but also extended droughts that hit the country between 1999 to 2003. There are however floods of small magnitude and narrow extent which are not recorded as observed floods. Floods have accentuated health problems of the population in the city and the metropolitan area in general. This is coupled with the sanitation conditions, waste management practices and prevalence of pollutants in ambient air of the city due to high energy consumption and existence of a dense network of dusty roads[59, 62]. While contamination of water by prevalence of micro-organisms is evident in the water sources of the city[63].

One of the most significant environmental problem associated with climate change is flooding and its associated problems of disease outbreaks, loss of property and life. Flooding in Kampala especially in settlements of the urban poor has become a usual phenomenon even when slight down pours occur in the city. This is attributed to the nature and pattern of urban developments that have degraded hilltops, hill slopes and wetlands. The environmental destruction has changed the natural drainage system yet the drainage infrastructure is inadequate or poorly designed. But it is also coupled with climate change in the region. Flooding affects economic livelihood of the people, health, housing and accessibility to the neighborhoods. This further worsens the environmental health of the city region’s population[48, 64, 65].

In addition to health problems associated with flooding, concerns related to indoor air pollution are on the increase. As noted earlier, the most direct health impact of household energy use among the poor who depend almost entirely on burning biomass fuels in simple cooking devices in inadequately ventilated spaces. While few studies have measured human exposure in Kampala, general evidence suggests that the populations most likely to be exposed to these high levels of indoor air pollution are women, because of their greater time spent cooking and indoors. Inefficient combustion results in a complex and unstable mixture of particulate matter, carbon monoxide, hydrocarbons, nitrogen oxides, formaldehyde, and benzene that often greatly exceed the standards for indoor air pollutants in developed countries. Middle ear infection, tuberculosis, perinatal mortality (still births and death in the first week of life), low birth weight, eye irritation, cataract, asthma, and oral cancer have all been associated with biomass smoke in epidemiological studies[22].

From Public Health perspective, heavy rains can be followed by upsurge of malaria, while flooding is followed by diarrhoeal diseases such as cholera[66]. In Kampala there have been reports of people drowning when they wake up to find their houses submerged in floods. Shopkeepers with food items, such as maize flour, beans, ground nuts and sugar, also find them massively submerged in floods, leading to food insecurity. Both floods and drought lead to crop failures among urban farmers leading to food insecurity and even malnutrition[67]. While during times of drought the population is predisposed to meningitis epidemics and other diseases caused by lack of water for adequate sanitation, such as eye and skin infection. Climate change exacerbates all the above scenarios. On the other hand, warming up due to climate change has made previously non-malarious high altitude areas to become prone to epidemic malaria. The poor people are affected more because of lack of means to protect themselves. The urban health services become overstretched and cannot easily match the challenges posed both by large urban populations and high prevalence of diseases resulting from effects of Climate Change.

4.3. CLIMATE CHANGE AND GENDER

Gender is important in understanding the vulnerability and effects of climate change in Uganda and Kampala. But it is also important when trying to develop mitigation and adaptation measures to climate change effects. This is because females comprise 51.19% of the national population. Of these, 22.4% are women of child bearing age, 25.8% girls below 18 years of age and 4.1%w omen of over 60 years of age[68]. This is also against a backdrop of Uganda being comprised of a majority youth population. The numbers notwithstanding, women play an important role in the urban economy. But women also play a significant role in social and environmental issues. Expanding the triple gender roles of reproduction, economic and social roles, women's' responsibilities include

among other things; providing for the households, engagement in livelihood strategies that make them the cornerstone of household welfare. It's these roles which make it critical in analyzing gender and climate change. This is because, the most vulnerable sectors to climate change is also the turf for women when playing their provisioning role. This implies that women and children are most affected by climate change. From housing, emerging economic activities, transportation, energy, agriculture, water, sanitation and health, women are central to exposures and risks associated with climate change. Adaptation measures and mitigation to some extent will therefore rely on the mainstreaming of gender into these strategies. Household adaptation measures are likely to take root if women are included in adaptation projects with participation of other social groups in Kampala. Therefore climate change adaptation and mitigation also needs to be gender responsive in the sense that the effects need to be analyzed in terms of how they affect the different social groups with strategies considering the different social groups including special needs for women and children.

There are significant and often very diverse differences in the way women and men experience and respond to climate change events. This is due to the fact that men and women interact in different ways with the environment. It is especially important to examine cities and climate change from a gender and equity perspective as there is a broad consensus in many circles that climate change impacts are going to exacerbate existing inequities and disadvantages between men and women and thus undermine the development agenda. An understanding of gender differences in the climate change and the urban scenario context will assist in identifying the changes needed in both behaviour as well as infrastructure developments to reduce Green House Gasses but also enhance adaptation. Gender is a telling indicator of disadvantage and research reveals that women are most likely to suffer more whenever there is a catastrophe. It is therefore necessary to analyse and better understand the inequities between women and men, how they are impacted and how they are likely to respond to the climate change risks.

4.3.1. WOMEN'S RIGHTS AND GENDER EQUALITY

Women and gender rights are rooted in the discrimination and violations of human rights on the basis of gender but also due to other unequal power relations. These inequities are associated with race, ethnicity, caste, class, age, ability/disability, and other factors including if they are indigenous[69]. International and regional negotiation meetings have underlined the importance of a gender analysis in the UNFCCC processes. It is now recognized that a gender perspective in the United Nations Framework Convention on Climate Change (UNFCCC) is largely missing or obscured. Although there has been tremendous progress in various countries to mainstream gender in development policies.

4.3.2. GENDERED URBANIZATION

Until recently, the world over has been focusing only on the economic and environmental consequences of climate change. It is only after such catastrophic climate change events

that the very real ***social impacts*** of climate change have been illustrated and been brought to light, leading to greater attention being given to gender considerations[69]. Disasters have revealed that it is the poor and especially poor women who suffered the most – proving that gender is a telling indicator of disadvantage. Acknowledging the social impacts of climate change in urban areas and coming to terms with gendered differences is a first step towards responding effectively to climate change in cities. There are significant and often very diverse differences in the way women and men respond to climate events because of the different ways they interact with their environment. In this assessment gender has been mainstreamed to enable a holistic framing of mitigation and adaptation strategies. There are gendered issues from the perspective of urbanization and the urban sectors. These are briefly described below;

Energy; as noted earlier, women's role in type and use of energy sources is undoubted. It can therefore be conclusively stated that as managers of households, the use of fire wood and charcoal makes women contributors to climate change. Secondly, the use of this form of energy makes them most vulnerable to in-door population and effects of the resultant carbon emissions. Not only do women suffer from health complications, but also the health of children who are by their side during food preparations. Targeting women in mitigation strategies and adaptation will most likely augment adaptation and mitigation.

Urban transport; women and men use different modes of transport while men use cars often and women using public transport more often over short distances. This varies from city to city and country to country. Evidence suggests that women use much less emissions-intensive modes of transport than men, their level of car-ownership is lower, and their share of public transport use is higher [70]. It is important to note that an understanding of gender differences in the use of transport and energy methods, and also their emissions can assist the city of Kampala in identifying what changes are needed in both behaviour as well as infrastructure development to reduce GHG.

Urban Water and Sanitation; water is vital for the survival and health of the family, is exclusively the concern of women in the community and therefore when its supply is threatened, it is the women who are most affected. Consequently, Kampala women and girls (especially if they are poor), who owing to their gender roles are the manager of domestic water will, due to dwindling safe water resources; as a result of either increased or decreased precipitation, have an increased workload of looking for and transporting safe water for household use. This might in effect translate into them having to stand in long queues waiting for a few liters of the commodity. In severe water shortages resulting in scarcity of the commodity, there is potential for competition with male water vendors at the available water points causing conflict and exacerbating gender inequality, leaving women to get water from unsafe sources. On the other hand, sanitation services can be

out of reach or inadequate for the community during and after a climate change related extreme event. Floods for example, could render the pit latrines predominantly used in Kampala unusable, and women who are charged with taking care of homes, children and the elderly burdened with looking for alternative methods such as flying toilets which in themselves are also a hazard. Due consideration of these gender dimensions in designing mitigation and adaptation measures is necessary.

Gender and Urban Waste Management; women's role in the waste sector is undoubted. They have coped with garbage and devised ways of dealing with the problem through recycling, reuse and reducing. Technologies such as energy briquettes, plastic materials collection and recovery of nutrients for urban agriculture have until recently been dominated by women.