KIGALI

State of Environment and Outlook Report 2013

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We regret any errors or omissions that may have been unwittingly made.

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Foreword

The City of Kigali is the focus of the 2013 serial of State of the Environment Report as appropriately titled *Kigali: State of Environment and Outlook Report 2013*. Rwanda maintained a high annual GDP growth rate of over 8.2 per cent during the 5-year implementation of the Economic Development and Poverty Reduction Strategy, EDPRS I (2008-2012). The country is taking a 'green economy' approach to economic transformation as a priority in the second phase, EDPRS 2 (2013-2018) as efforts are stepped up to attain even faster GDP growth of 11.5 per cent. Bearing in mind that the City of Kigali, Rwanda's financial and economic hub, contributes 50 per cent of the country's GDP, it is critical that the status of the City's environment is given due consideration for appropriate adaptation requirements that make possible green economic growth.

The *Kigali: State of Environment and Outlook Report 2013* provides an overview of the environment around the City's jurisdictional area and a scenario analysis for the future outlook. The City of Kigali has continued to receive accolades from Rwandans and visitors alike as well as from international organizations for among others cleanliness, safety and security, discipline and friendliness of the citizens. This report does no less, revealing the City's achievements in environmental management and the now institutionalised and robust planning framework that emphasises greening plans in the growth of the key service and production sectors.

However, the report highlights a number of serious challenges faced by Kigali, including liquid and solid waste management, air quality, flooding and landslide disaster risks, access and sustainable consumption of water and energy as well as provision of green housing. In the face of a changing climate, Kigali and Rwanda as a whole is not alone in facing these challenges. Indeed, the African Ministers of Environment and Health in collaboration with the United Nations Environment Programme (UNEP) directed the third Africa Environment Outlook (AEO-3) of 2013 to focus on the negative environmental impacts that account for 60 per cent of Africa's disease of burden dominated by water borne gastrointestinal infections and malaria as well as respiratory disorders from air quality problems.

Nevertheless, the concluding scenario analysis presented in this report indicates that gaps in air quality, biodiversity, chemicals and waste, fresh water and sanitation and land impacting on health as identified in the *AEO-3 Summary for Policymakers* can be filled if the City of Kigali's development plans are successfully implemented within the EDPRS 2 framework. It is my hope that all stakeholders will use this report to identify their respective niche roles and join hands with City of Kigali authorities in contributing to the envisioned state-of-the-art aesthetically attractive, prosperous, green and climate resilient city.

Hon. Stanislas Kamanzi

Minister of Natural Resources

Preface

It is my great pleasure to present the State of Environment (SoE) Report under the title, *Kigali: State of Environment and Outlook Report 2013*. This is the third of a series of SoE reporting that fulfils the mandate of Rwanda Environment Management Authority (REMA) as required by the Organic Law 04/2005 of 08/04/2005 Determining the Modalities of Protection, Conservation and Promotion of Environment in Rwanda. The choice of Kigali as a subject for 2013 SoE reporting is a timely response to the national objective of economic transformation that takes into account rapid urbanization and green economic growth as key pillars of the second phase of Economic Development and Poverty Reduction Strategy (EDPRS) 2013-2018.

Over the past years, Kigali has consistently been recognized for its growth and development achievements from its own residents and visitors alike. These affirmations have particularly focused on management of the environment and cleanliness. The *Kigali: State of the Environment and Outlook Report 2013* discusses the City's planning framework that gives effect to national policy implementation. The report highlights aspects of environmental management, climate proof infrastructure and green economic components for the City's overall growth and expansion as a contribution to sustainable national development.

Driving forces for environmental change in Kigali include population growth and distribution, employment, education, health, poverty and economic activities. Urban land use issues and associated impacts on ecosystems and human health are highlighted by graphic representation of Hotspots. An analysis and discussion about what is being done to manage their impacts is presented. The report covers the City of Kigali's progressive achievements in implementing land use decisions since 1994. Such decisions have led to identification of new special economic zones that are prepared to promote environmental sustainability. These policy relevant interventions are increasingly freeing up ecologically sensitive areas like wetlands which will need to be rehabilitated.

Kigali as a rapidly growing City is experiencing challenges of air and water pollution, liquid and solid waste management, inadequate water

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and energy infrastructures, and unsustainable production and consumption lifestyles. This report provides recommendations geared at improving environmental sustainability, climate resilient and green growth goals in alignment with EDPRS 2 priorities.

First and foremost, I wish to express my gratitude to the Government of Rwanda, under the leadership of H.E. the President for the support to the overall vision of sustainable national development of our country. This has made the otherwise challenging job of environment management possible. I also wish to extend my sincere appreciation to our ever growing constituency of representatives from the various institutions for their invaluable inputs in the production of this report. It is necessary to mention that the sectoral stakeholders including Central and Local Government Institutions, Utility Institutions, Development Partners, Civil Society, NGOs and Academia were extensively involved in the production of this report. This made REMA's coordination role fruitful and rewarding. Their participation in the preparation and validation of this report is highly treasured.

Last but not least, I wish to share my heartfelt indebtedness to REMA colleagues for their roles in the production of this report.

It is my hope that the *Kigali: State of the Environment and Outlook Report 2013* will contribute towards the successful realisation of a green and climate resilient city, a key input to the future we want, national sustainable development.

Dr. Rose Mukankomeje

Director General of REMA

Message from the Mayor

The *Kigali: State of the Environment and Outlook Report 2013* couldn't have come at a better time as the country embarks on the second phase of the Economic Development and Poverty Reduction Strategy, EDPRS 2 2013-2018. The country intends to accelerate its economic growth from the current average GDP of over 8 per cent to 11.5 per cent annually in order to achieve middle income status by 2020. In this endeavour, the EDPRS 2 has prioritized the management of urbanization and promoting secondary cities driven by private sector economic activities. However, it is anticipated that Kigali will continue to be the heart of economic and commercial with the associated pressures on the environment.

Recognition of these pressures as well as the realization of compounding effects from the impacts of Climate Change has required a complementary priority of taking a 'green growth' approach in the pursue of rapid economic transformation. The report also affirms our development plans as responsive to the recommendations of UNEP's 3rd Africa Environment Outlook 2013 commissioned by African Ministers of Environment and Health for addressing issues linking the environment and Africa's burden of disease that include air quality, chemical hazards, water quality and land. The report is therefore timely and highly relevant and will help the City to benefit from an independent scientific opinion on the environmental baseline and available policy options that will enrich our processes as we pursue a green city.

The report makes recognition of the City's significant strides in upgrading amenities, especially public utility infrastructure, where necessary retrofitting roads against Climate Change related damage including landslides and flooding. However, environmental challenges in Kigali have been highlighted, some of which are inherited lack of urban planning in the past. The City must nevertheless retroactively address the issues while at the same time investing in green urban development with the cooperation of state and private stakeholders as well as the citizens to which the City belongs. Indeed REMA and responsible sectoral Ministries have worked tirelessly with the City of Kigali to address the historical negative environmental impacts to steer the City into appropriate and lawful land use practice by the end of the EDPRS 2 period.

I wish to thank Dr. Rose Mukankomeje, the Director General of REMA and her team for choosing the City of Kigali as a focus for the 2013 State of the Environment Report and for inviting us to exchange information and make input and comment. Our continued close collaboration as we enter the next phase of EDPRS implementation period is sure to yield greater results. Apart from the collaboration of the different state and private sectors, the citizens of Kigali are very proud and enthusiastic to apply their indigenous culture such as Umuganda, for helping themselves and each other and in nation building. I am therefore confident that together we shall realise Vision 2020 of a green state of the art and aesthetically appealing city.

Mr. Fidele Ndayisaba

Mayor of the City of Kigali

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Acronyms

AEO	Africa Environment Outlook
AEO-3 SFPM	Africa Environment Outlook 3 Summary for Policy Makers
AMCEN	African Ministerial Conference on the Environment
ARI	Acute respiratory infection
ART	Antiretroviral Treatment
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BRT	Bus Rapid Transit
BTC Rwanda	Belgian Development Agency, Rwanda
CBD	Central Business District
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CBO	Community Based Organisation
Cd	Cadmium
CFL	Compact Fluorescent Lamp
CKDP	City of Kigali Development Plan
CO_2	Carbon Dioxide
CoK	City of Kigali
COOCEN	Coopérative pour la Conservation de l'Environnement
COPED	Company for Environment Protection and Development
Cr	Chromium
CRED	Centre for Research on the Epidemiology of Disasters
CRTs	Cathode Ray Tubes
Cu	Copper
cu. m	cubic metres
cu. m/d	cubic metres per day
CWS	Conventional World Scenario
DDPs	District Development Plans
DEMP	Decentralisation and Environment Management Project
DLB	District Land Bureaus
DRC	Democratic Republic of the Congo
DRR	Disaster Risk Reduction
EDPRS	Economic Development and Poverty Reduction Strategy
EIA	Environmental Impact Assessments
EICV	Integrated Household Living Conditions Survey (Enquête Intégrale sur les Conditions de Vie des Ménages)
EPA	United States Environmental Protection Agency
EPI	Environmental Pulse Institute
ESSP	Education Sector Strategic Plan
ETZ	Environmental Treatment Zone
EU	European Union
EWSA	Energy, Water and Sanitation Authority
FAO	Food and Agriculture Organization of the United Nations
FONERWA	Fund for Environment and Natural Resources for Rwanda
GDEM	Global Digital Elevation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO-5	Global Environment Outlook 5
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GLEM	Great Lakes Electronic Management
GOFTC	Gako Organic Farming Training Centre
GoR	Government of Rwanda
GRID	Global Resource Information Database
ha	hectares
HIV	Human Immunodeficiency Virus
ICRAF	World Agroforestry Centre
ICT	Information and Communication Technology
IISD	International Institute for Sustainable Development
IRST	Institute of Scientific and Technological Research
IWRM	Integrated Water Resource Management
KCC	Kigali City Council
KCMP	Kigali Conceptual Master Plan
KIST	Kigali Institute of Science and Technology
km	kilometre
KOICA	Korean International Cooperation Agency
LDCF	Least Developed Countries Fund
LEED	Leadership in Energy and Environmental Design
L	litre
lpcd	litres per capita per day
m	metre
MDGs	Millennium Development Goals
METI	Ministry of Economy, Trade, and Industry of Japan

mg/L	milligrammes per litre
MIDIMAR	Ministry of Disaster Management and Refugee Affairs
MINAGRI	Ministry of Agriculture
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MINEDUC	Ministry of Education
MINICOM	Ministry of Trade and Industry
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MINISANTE	Ministry of Health
MW	Megawatt
MWh	Megawatt hours
NASA	United States National Aeronautics and Space Administration
NEP	National Environment Policy
NGO	Non-governmental Organisation
NISR	National Institute of Statistics Rwanda
NLUDMP	National Land Use and Development Master Plan
NSCCLCD	National Strategy for Climate Change and Low Carbon Development
NUR	National University of Rwanda
PAC	Practical Action Consulting
PAPUK	Kigali Urban and Peri-Urban Agriculture Project (Projet d'Agriculture Urbaine et Peri-urbaine de Kigali)
Pb	Lead
PCFV	Partnership for Clean Fuels and Vehicles
PES	Payment for Ecosystem Services
PET	Polyethylene terephthalate
PHHS	Post Harvest Handling and Storage
PPP	Public-Private Partnership
RBS	Rwanda Bureau of Standards
RDB	Rwanda Development Board
REC	Rwanda Environment Care
REMA	Rwanda Environment Management Authority
RFTC	Rwanda Federation of Transport Cooperatives
RHA	Rwanda Housing Authority
RITA	Rwanda Information Technology Authority
RMA	Rwanda Meteorological Agency
RNRA	Rwanda Natural Resources Authority
RRECPC	Rwanda Resource Efficient and Cleaner Production Centre
RRWA	Rwanda Rain Water Association
RTDA	Rwanda Transport Development Agency
RURA	Rwanda Utilities Regulatory Authority
Rwf	Rwandan franc
SAICM	Strategic Approach to International Chemicals Management
SEZ	Special Economic Zone
SME	Small and Medium Enterprises
SOE	State of Environment
SWH	Solar Water Heater
SWS	Sustainable World Scenario
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlement Programme
UNHCR	United Nations High Commissioner for Refugees
UNIDO	United Nations Industrial Development Organisation
USGBC	United States Green Building Council
WHO	World Health Organisation
Zn	Zinc

Executive Summary

This report provides decision makers with information about the present state of Kigali's environment. It also suggests policy options that could help it achieve Rwanda's Vision 2020 goal to make Kigali 'a state-of-the-art and aesthetically appealing city'. To achieve this goal, Kigali is implementing sustainable urban management and planning.

Chapter 1. Setting the Context: Governance and Geography

- Located in the heart of Rwanda, Kigali is built on hills, ridges and valleys. With some slopes of up to 50 per cent and two rainy seasons, the land is vulnerable to erosion and flooding. There are 25 watersheds within the city limits and the valleys are fertile. Agriculture occupies the largest proportion of the land (60.5 per cent), with built-up areas covering about 15 per cent.
- Since 2002, the City of Kigali has made a concerted effort to institute urban planning for sustainabale development, guided by seven key initiatives: The Millennium Development Goals (MDGs), Rwanda's Vision 2020, the Economic Development and Poverty Reduction Strategy (EDPRS), the National Strategy for Climate Change and Low Carbon Development (NSCCLCD), the Integrated Household Living Conditions Survery (EICV), the City of Kigali Development Plan (CKDP) and the Kigali Conceptual Master Plan (KCMP).

Chapter 2. The Driving Forces of Environmental Change

- Kigali is home to 10.8 per cent of Rwanda's total population and is one of Africa's fastest-growing cities due to a high birth rate and high levels of positive net migration. Between 1962 and 2012, its administrative boundaries grew from about 3 sq. km to 730 sq. km and its population increased from some 6,000 to more than one million people. The average male-to-female ratio is 106 to 100, and 73 per cent of its total population is under the age of 30. The city's largest employment sectors are agriculture, fishing and forestry (24 per cent); other services, such as utilities and financial services (21 per cent); and trade (20 per cent).
- The level of education is very high at the primary level, but school attendance drops off quickly in higher grades. Health care access is improving, as is access to Information Communication Technologies (ICT). By 2011, over 80 per cent of the population used mobile phones. Kigali generates 50 per cent of the country's Gross Domestic Product (GDP). It aims to become a middle-income economy by 2020 and to reduce poverty from 14.8 per cent to below 10 per cent within the next 5 years.
- Development is proceeding apace, with impressive upgrades to the Central Business District (CBD) and the consolidation of a mixed-use Special Economic Zone (SEZ).

Chapter 3. Land, Settlements and Infrastructure

- Wetlands, water bodies, forests, steep hills and other natural constraints cover 50.3 per cent of the land area. By the mid-2000s, about 19 per cent of the city was built on fragile land. In 2012, 83 per cent of the poulation lived in informal housing with limited access to facilities and poor living conditions. Since 2005, the City of Kigali has been curbing the spread of unplanned housing, relocating people into clustered settlements and improving living standards.

Executive Summary

- Buildings on steep slopes, seasonal rainfall, inadequate drainage and construction in flood prone zones have made parts of Kigali highly susceptible to flooding. The impacts of a changing climate could exacerbate the risks. Disaster management is becoming decentralised to help prevent such hazards.
- Industrial and commercial activities in wetlands have contributed to their loss and degradation, but the implementation of urban plans, including the removal of infrastructure and formally protecting wetland areas, promises to help them regenerate.
- Transportation remains a challenge. About 7 per cent of the city population owns a car and 14 per cent of roads are paved. The City's development plans are being implemented, however, bringing more modern and sustainable transport infrastructure and services.
- Fifty-six per cent of households have electricity for lighting compared to the national average of 11 per cent, while charcoal is surpassing wood as the primary source of cooking fuel, serving 51 per cent of households. Modernising energy provision will help reduce respiratory disease and deforestation.
- The water network supplies 65,000 homes and 280 public taps. Water production doubled between 2001 and 2011. Water issues include insufficient supplies, mainly during the dry season, sediments in river water and unequal access to water between unplanned and modern settlements.

Chapter 4. Pollution and Waste Management

- The City of Kigali has exceeded Vision 2020's target for 65 per cent access to improved sanitation and is striving for 100 per cent coverage by 2017-2018 as guided by the EDPRS 2 target. About 83 per cent of citizens have access to improved water sources. Some households, businesses and industries have private septic tanks to receive wastewater. Large amounts are still directly poured into rivers or wetlands, however, affecting human and ecosystem health. Industries in the Nyabugogo wetland are being relocated to reduce these impacts.
- Between 2007 and 2012, the amount of solid waste grew almost fourfold. Although the number of households served by waste collection companies has increased, the service has not fully matured to adequately provide for all of Kigali's needs, with 13 Sectors still receiving no service at all.
- Only about 25 per cent of solid waste generated in Kigali is estimated to arrive at the landfill, electronic waste is growing and is not disposed of properly and some solid waste is still dumped in public areas. There are many issues associated with the new Nduba landfill, including difficult and unequal access, higher costs, proximity to a school and roadway and its risky siting on a cliff above the Nyabugogo River. There are some promising initiatives to recycle waste, such as making briquettes for cooking fuel and sorting and selling some kinds of plastics.

Chapter 5. Key Challenges and Policy Options

Chapter 5 is a synthesis of recommendations found in the literature tailored to the specific challenges and opportunities Kigali faces as it attempts to reconcile the demand for economic and social development with the need to protect the environment and natural resources that make that development possible.

1. Mainstream climate adaptation and mitigation strategies into all aspects of city policies, planning and projects
2. All sectors should incorporate policies to help implement the city's plans for high-density urban development
3. Use policies to catalyze a green economy
4. Introduce policies that strengthen the links between the formal and informal housing sectors
5. Integrate social, cultural, economic and environmental aspects into housing policies
6. Devise city policies to support the national building code's new resource efficiency measures as soon as they are adopted
7. Implement an integrated, sustainable transport system that favours public transit, walking and cycling
8. Adopt an integrated, proactive flood management approach at the watershed level within the national Disaster Risk Reduction (DRR) framework
9. Review Kigali's Integrated Water Resource Management (IWRM) policy and strategy to strengthen demand-side management and wise use
10. Create an Integrated Solid Waste Management (ISWM) system that supports the informal waste sector and protects the environment
11. Develop and operationalise an implementation framework for expediting the city's sanitation plans
12. Establish an urban agricultural zoning policy within the wider framework of developing a green city
13. Ensure the City of Kigali's policies, plans and programmes are well integrated with those of other sectors for coherence and sustainability

Chapter 6. Environmental Outlook and Opportunities

- Rapid development and change in Kigali has boosted the public's general awareness of environmental matters, which in turn has stimulated opportunities to build on successes through green initiatives. Waste collection and recycling has greatly improved but organic waste is still an untapped resource. Likewise, small-scale rainwater harvesting projects have begun, but opportunities need to be seized to promote them further for socioeconomic development and environmental protection.
- Awards and certification schemes raise environmental awareness and stimulate sustainable practices. Examples include REMA's 'Best Environmental Performance Awards' and the Leadership in Energy and Environmental Design (LEED) certification for green buildings; they are models to follow in mainstreaming such rewards into normal practice.
- Environmental studies are integrated into formal and community education; there are opportunities to improve and expand these efforts to better equip young people to participate in the green economy.

- Renewable energy and resource efficiency can be integrated into new and upgraded housing. Programmes introducing solar water heaters and compact fluorescent lamps (CFLs) already exist.
- The results of City greening efforts are evident. There are plenty of further opportunities to use natural ecosystems for aesthetic, biodiversity, income generation, community-building and food security purposes. Examples include constructed wetlands, rain gardens, parks, plantings of native and medicinal species and kitchen gardens. The Kigali Urban and Peri-Urban agriculture project (PAPUK) and the Gako Organic Farming Training Centre (GOFTC) are examples of successful urban organic farming projects.
- There are opportunities to increase the promotion of improved cookstoves and the use of briquettes that have economic, air quality and health benefits. Likewise, the opportunity to expand improved sanitation needs to be seized. Finally, existing best practices at Lake Muhazi could provide models for future sustainable water withdrawal and shoreline development.
- Chapter 6 concludes the report with an analysis of a number of potential future scenarios for Kigali. Decision makers can use the results to help design policies oriented towards the most desired outcome. To help envision Kigali's environmental outlook, the Conventional World Scenario (CWS) and the Sustainable World Scenario (SWS) were adapted from the 2012 Global Environment Outlook 5 (GEO-5) and the information reported in the Africa Environment Outlook 3 Summary for Policy Makers (AEO-3 SFPM). In addition, to make the analysis more relevant to Kigali, the exercise also created scenarios based on recommendations stated in the EDPRS 2.
- The scenario analysis clearly shows the advantages of the SWS over the CWS and portrays the potential end results should the City of Kigali continue to succeed in putting into place its urban plans guided by the EDPRS 2. To achieve the aim of truly becoming a sustainable city that is resilient to climate change, the City of Kigali needs to ensure the plans are properly financed, implemented and maintained.

Satellite image of Kigali

ESRI and NASA Blue Marble: Next Generation

Geography and Governance 1

Kigali: Capital of the Land of a Thousand Hills

The city's name, taken from Mount Kigali, comes from the Bantu diminutive prefix 'Ki' and Rwanda 'gali', meaning broad (Rwanda Gateway n.d.). Kigali was founded in 1907 as a small German colonial outpost and trade centre. Kigali was a convenient transportation hub for commercial activities taking place between Bukoba, Kigoma (Tanzania) and Bujumbura (Burundi), and between Kisangani (Democratic Republic of the Congo) and Kampala (Uganda) (Kartas and Jütersonke 2011). At that time, the seat of the King (Umwami) in Nyanza was the traditional capital, while Butare (formerly Astrida) was the colonial seat of power. In 1916, Belgian troops defeated the Germans and Belgium occupied Rwanda until Rwandan independence in 1962 (Manirakiza 2012). At that time, Butare was the preferred option for the new nation's capital city, but Kigali's central location made it the final choice (Kigali City 2013). At independence, Kigali had a population of approximately 6,000 and covered an area of about 3 sq. km occupying the hills of Nyarugenge and Nyamirambo (ISTED 2001). After that, the city grew very quickly to become the country's political, economic and cultural centre. In 1979, a decree-law created an urban jurisdiction area of 112 sq. km, which was then expanded to about 349 sq. km with a 1990 Presidential Order (ISTED 2001). Finally, the 2005 Organic Law No. 29 changed the administrative boundaries within Rwanda and expanded the limits of Kigali from 314 sq. km to 730 sq. km, which is the current total area. (Manirakiza 2012, NISR 2012a).

Kigali continued to grow until the genocide of 1994 against the Tutsi, which was a defining moment in the city's history. The Government of Rwanda (GoR) estimates that over one million ethnic Tutsi people and moderate Hutu in opposition were killed between April and July 1994. Over 250,000 victims buried at the Kigali Memorial Centre mass grave were killed in the Kigali area alone (Kigali Memorial Centre n.d.). Population growth resumed, however, increasing threefold between 1994 and 2002 (World Bank 2009).

The populated Nyarugenge hill

With more than one million people today (representing 10.8 per cent of the country's total population), Kigali has been growing by leaps and bounds over the hilly terrain surrounding its core. It is one of Africa's fastest-growing cities. Kigali faces the challenge of catering to the needs of its growing population while ensuring the physical environment on which it is based also stays healthy. It is the natural environment that provides Kigali's citizens with ecosystem goods and services that include land for housing and growing food, sanitation, clean air, water from rivers and lakes, and forests for timber, fuel wood and wild foods. Other indirect ecosystem services include climate and disease regulation, water purification and regulation, pollination, soil formation, nutrient cycling and primary production.

Development is proceeding rapidly in Kigali to accommodate the growing population and to improve conditions for all citizens. The City of Kigali now faces the task of consciously superimposing a growing urban infrastructure upon the ecosystem's assets without destroying them. It must encourage social and economic development and at the same time ensure the air and water stay clean and natural areas remain green. Construction and roads must not erode the very ground that supports them; more water must be found to support the growing population and industries; the air needs to be breathable even with more people burning fuel and more cars and industries; and as the population grows, and as quality of life improves and people consume more, the City must not let garbage and dangerous waste pollute the soil and water, while the emissions that contribute to climate change must be stemmed. To address these challenges, the City of Kigali (CoK) aims to achieve Rwanda's Vision 2020 for its towns by implementing sustainable urban management and planning.

This report focuses closely on the question of how social and economic development in Kigali might be impinging on the environment that supports it and also how environmental change is affecting its residents and the capacity to sustain development. It also looks at the future and the options for improving urban management for sustainable development. It is the first State of the

Figure 1.1: Location map showing Kigali

Source: Various sources; visualisation by UNEP/GRID-Sioux Falls

Environment report on Kigali, providing a baseline for making informed decisions about future urban development and environmental protection. This report complements the first *Rwanda State of Environment and Outlook Report*, produced by the Rwanda Environment Management Authority (REMA) in 2009 (REMA 2009), and its 2011 report: *Atlas of Rwanda's Changing Environment* (REMA 2011a). It contributes to the provision of environmental information and policy options for decision makers and other stakeholders needed to transform Kigali into a state of the art and aesthetically appealing city and thereby help achieve Rwanda's Vision 2020 goals.

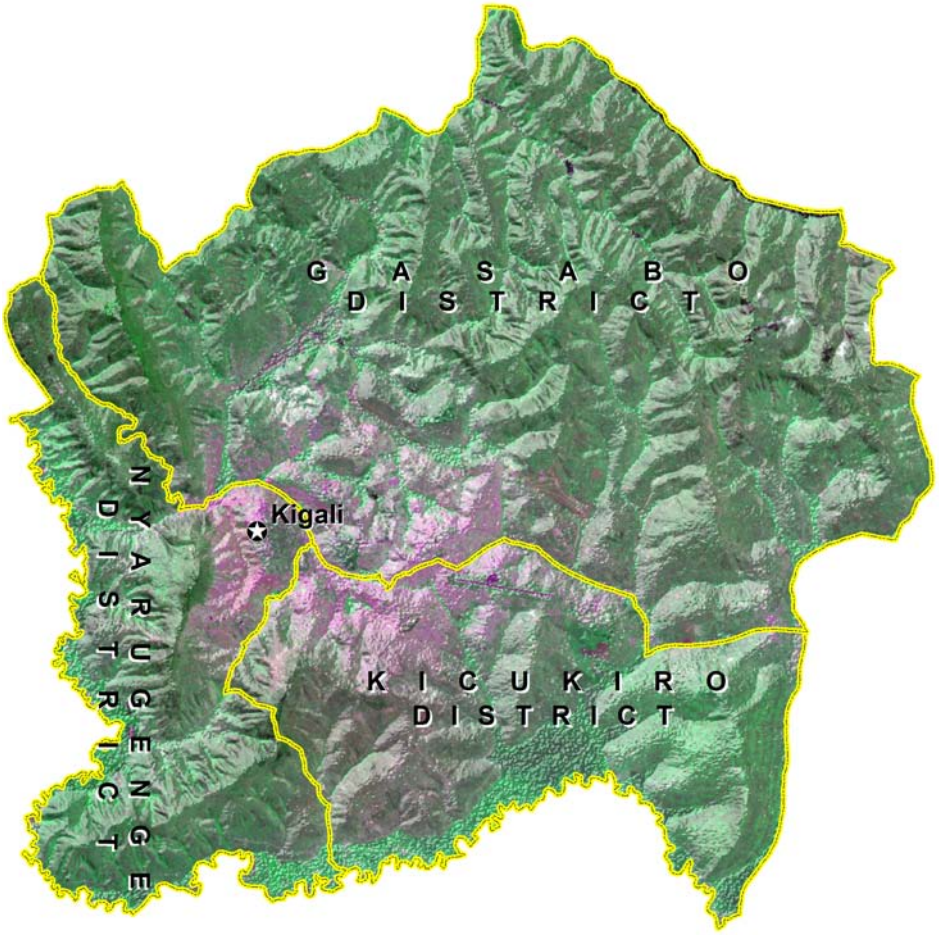
Location

Located in the heart of Rwanda, Kigali is the capital, the largest city and the most important business centre (Figure 1.1). In the continental context, Kigali is very close to the equator, at a latitude of 1° 58'S, and it lies to the east of Africa's centre, at a longitude

of 30º 07'E. In the Rwandan context, it is located in a natural region called Bwanacyambwe, close to the Nyabugogo River basin occupying land between Mount Kigali and Mount Jali. From the city centre, the urban area stretches eastwards over the hills of Kacyiru, Kimihurura, Mburabuturo, Nyarutarama, Remera and Kanombe; southward to include the slopes of Mount Nyarutarama; westward over Mount Kigali and the hills of Kabusunzu and Kimisagara; and in the north, it extends over the slopes of Mount Jali and the Gisozi, Gaculiro, Kagugu and Kibagabaga hills (ISTED 2001).

Thus, Kigali is built on many hills, sprawling across four ridges with valleys in between (Figure 1.2). The top-most ridge is 1,600 m in elevation and the valleys are 1,300 m above sea level. At 1,850 m, Mount Kigali is the highest hill. The city is bounded by the Nyabarongo River along the western and southern edge, and partly by Lake Muhazi at the north-eastern edge. The Central Business District (CBD) is located on Nyarugenge ridge while the administrative and judiciary institutions are mostly located along the Kacyiru ridge.

Figure 1.2: A satellite view of Kigali's hilly terrain



Source: ASTER GDEM, a product of METI and NASA; visualisation by UNEP/GRID-Sioux Falls

Climate

Kigali has a temperate climate. The hottest months of the year are February and March, while June and July are the coldest, and there are two rainy periods that generally occur from February to May and from November to January. March through May is the rainiest time of the year in Kigali. The monthly average rainfall and average daily temperature for Kigali are shown in Figure 1.3 and Table 1.1. The

Geography: Kigali's Environmental Context

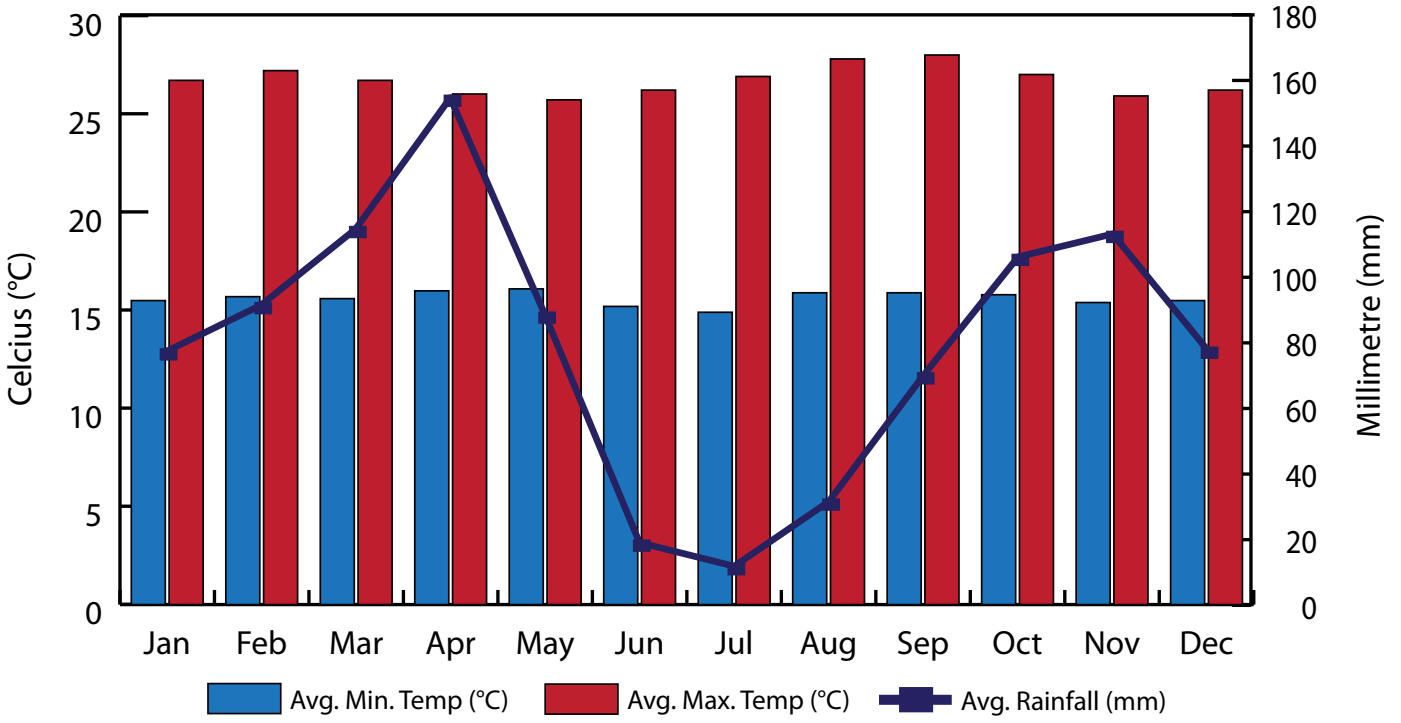
The next section of this chapter provides information about Kigali's geophysical and biological context. The city has been built, and continues to expand, within its environment. Urban development both affects, and is affected by, the land, water, climate, vegetation and wildlife that constitute its environmental context.

Table 1.1: Table of average daily temperature and rainfall

Month	Average Temperature °C		Average Total Rainfall (cm)	Average Number of Rain Days
	Daily Minimum	Daily Maximum		
Jan	15.6	26.9	7.7	11
Feb	15.8	27.4	9.1	11
Mar	15.7	26.9	11.4	15
Apr	16.1	26.2	15.4	18
May	16.2	25.9	8.8	13
Jun	15.3	26.4	1.9	2
Jul	15.0	27.1	1.1	1
Aug	16.0	28.0	3.1	4
Sep	16.0	28.2	7.0	10
Oct	15.9	27.2	10.6	17
Nov	15.5	26.1	11.3	17
Dec	15.6	26.4	7.7	14

Source: WMO 2013

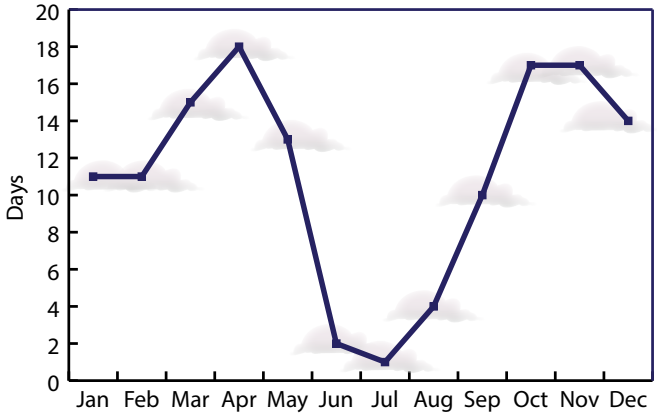
Figure 1.3: Graph of average daily temperature and monthly rainfall



Source: WMO 2013; visualisation by UNEP/GRID-Sioux Falls

variation in number of rainfall days throughout the year is shown in Figure 1.4. In times of extreme storms and rainfall, there can be a danger of flooding in the city, especially where urban developments have created impervious surfaces or changed hydrological conditions in rivers (Tsinda and Gakuba 2010).

Figure 1.4: Average number of rainfall days



Source: UNEP/GRID - Sioux Falls

Geology and Soils

Granitic and meta-sedimentary rocks underlie the City of Kigali; these include schists, sandstones and siltstones (Surbana 2012). Lateritic soils, rich in iron and aluminium, dominate the city's hillside surfaces while alluvial soils (fertile soil deposited in river valleys) and organic soils are found in the lowlands and wetlands. Inappropriate development on Kigali's hilly slopes has caused extensive soil erosion in some areas. According to the Rwanda National Land

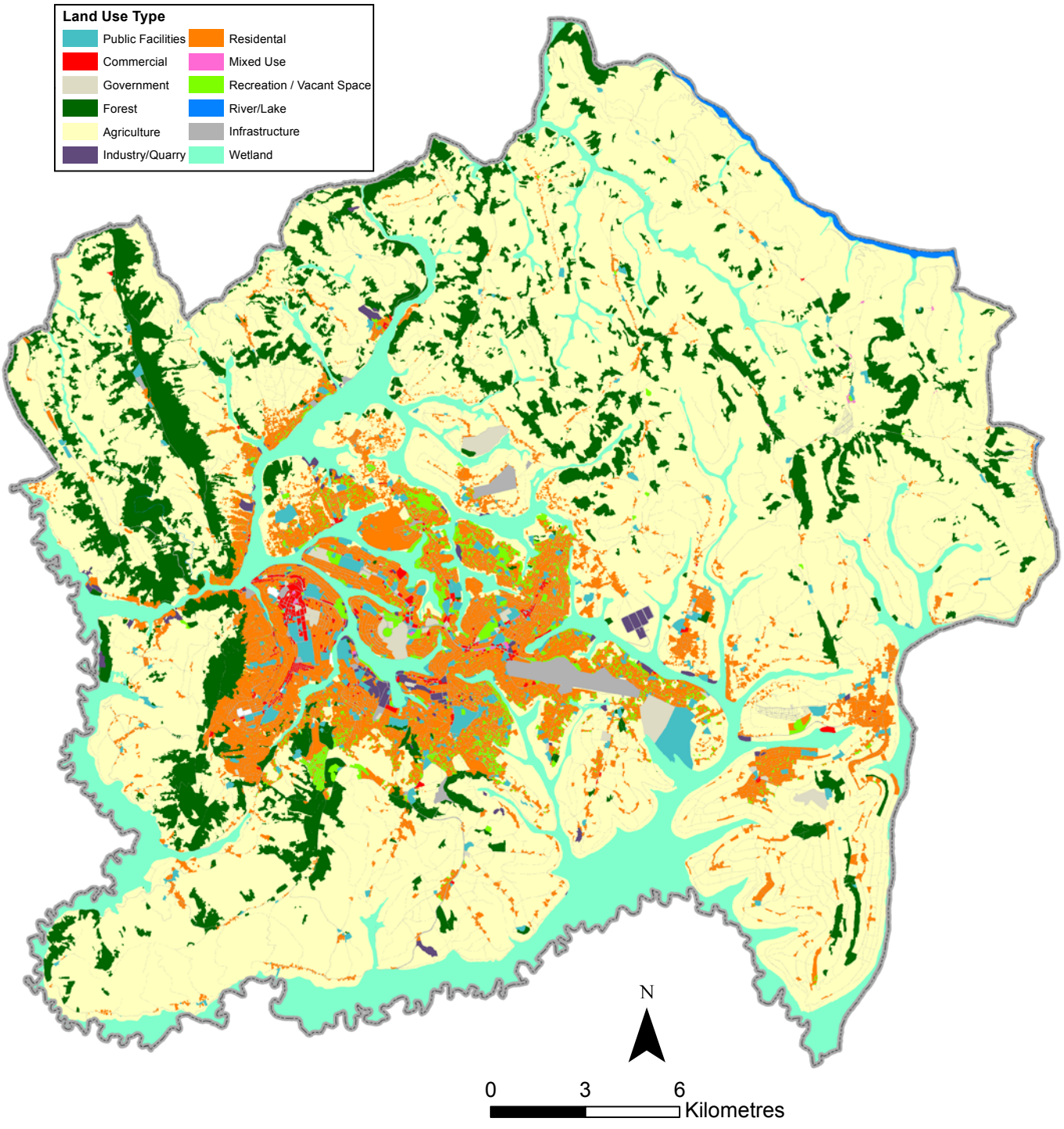
Mount Kigali is the highest point in the city

Use Development Master Plan (LUDMP), Kigali's land area is classified as being within a zone of medium-to-high risk for soil erosion and soils on slopes with more than a five per cent incline are susceptible to heavy erosion (Surbana 2012). Where soil erosion is heavy, there has been a loss of soil fertility while the accumulation of heavy silt loads in the valleys is reducing river and wetland habitats. Developments along the steep slopes of Gatsata, Gisozi, Remera and Kicukiro, among others, are threatening soil fertility and stability as shown in the next chapter.

Land Use

The land upon which Kigali is built was once heavily forested (Surbana 2012). Now, forest covers an area of only about 77 sq. km (10.6 per cent) (Table 1.2; Figure 1.5) (Surbana 2012). Urban development and farming activities, including zero-grazing and commercial dairy and subsistence farming systems, have left only small, scattered patches of forest and other areas of natural vegetation. Tree-planting schemes have reforested some areas, which are dominated by Eucalyptus plantations for

Figure 1.5: Land use map of Kigali, 2012



Source: Wetland data provided by REMA; Land use data provided by Surbana; visualisation by UNEP/GRID-Sioux Falls

Table 1.2: Land use types by proportion in Kigali

Land Use Type	Area (sq. km)	Per cent (%)
Public Facilities	12.2	1.7
Commercial	2.7	0.4
Government	4.2	0.6
Forest	77.2	10.6
Agriculture	442	60.5
Industry/Quarry	2.9	0.4
Residential	66	9.2
Mixed Use	0.2	0.03
Recreational/Vacant Space	10	1.4
River/Lake	1.6	0.2
Infrastructure	20.5	2.8
Wetland	91.6	12.5
Total	730	100

Source: Surbana 2012; visualisation by UNEP/GRID-Sioux Falls

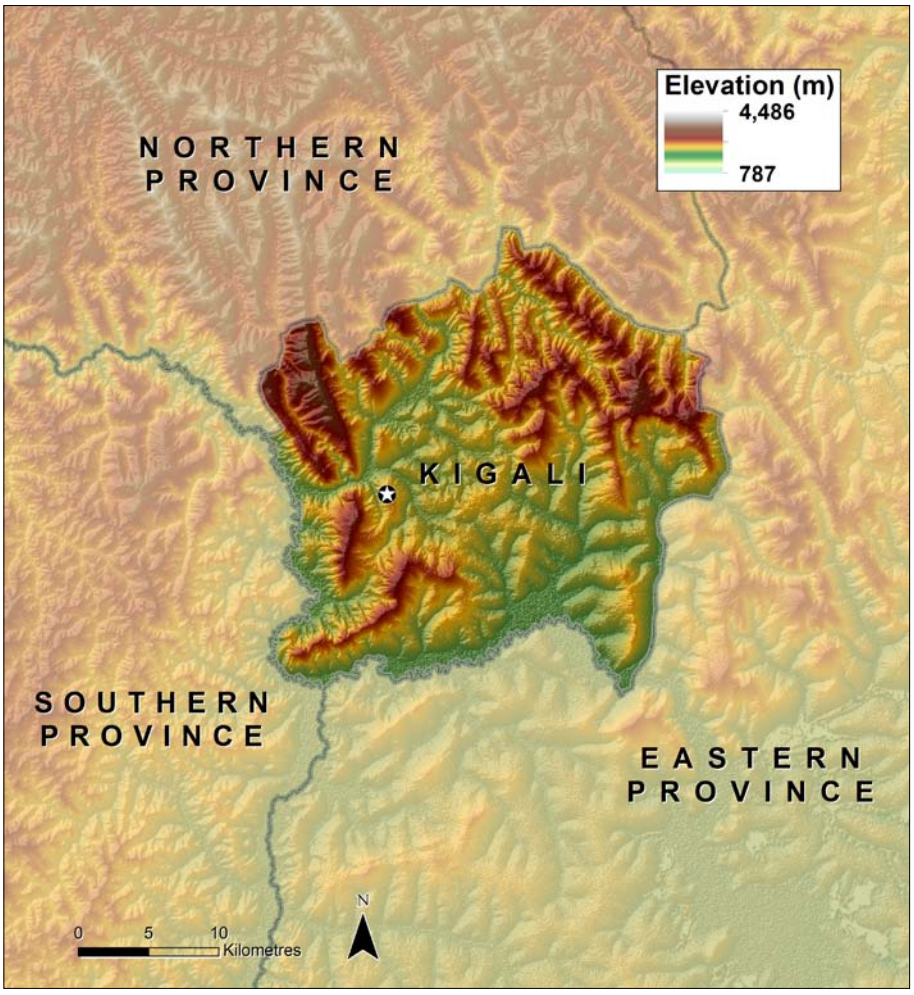
agro-forestry purposes. The loss and degradation of these natural habitats has contributed to the loss of biodiversity.

Urban land uses include residential, commercial, industrial, social and government infrastructure (Table 1.2 and Figure 1.5). Agriculture occupies the largest proportion of the city's land area (60.5 per cent) followed by wetlands (12.5 per cent). About half the wetlands are used by other land uses such as agriculture (see Chapter 3). Residential areas, including high-rise, medium-rise, low-rise and single family housing, cover just over 9 per cent, distributed as follows: Kicukiro, 14 per cent; Gasabo, 7 per cent; and Nyarugenge, 10 per cent. Commercial areas account for less than 1 per cent of land. They include finger-like commercial growth (note the red areas in Figure 1.5) from the CBD along Boulevard De L'Umuganda towards the Airport and numerous clusters of establishments, including government and non-government offices, hotels, restaurants and cafés, banks and supermarkets as well as other commercial nodes catering to local residents. Smaller market centres serve some of Kigali's rural settlements (MINECOFIN 2000).

Topography

Kigali is built on a rolling landscape of hills, ridges and valleys. It is situated between the Ibirunga volcanic mountains in the Northern Province to the northwest, famous as the only surviving natural habitat of the Mountain Gorilla, in the Northern Province to the northwest, and low-lying wetlands at the mouth of Lake Mugesera in the Eastern Province to the southeast. The surrounding region ranges in altitude from 787 m to over 4,000 m, but Kigali has a lower mid-altitudinal range of 1,300 m in the wetlands, to the peak of Mount Kigali at 1,850 m (Figure 1.6). The slopes of the city's hills vary in steepness from inclines of up to 45 or 50 per cent, to those in valley wetland areas with slopes of less than 2 per cent (Surbana 2012). The slope expresses the surface inclination relative to horizontal. According to Rwanda's Organic Law on the Environment, slopes of more than 20 per cent are not suitable for urbanisation. All three Kigali Districts, however, contain some areas with steep slopes: they

Figure 1.6: Elevation map of Kigali and surrounding region



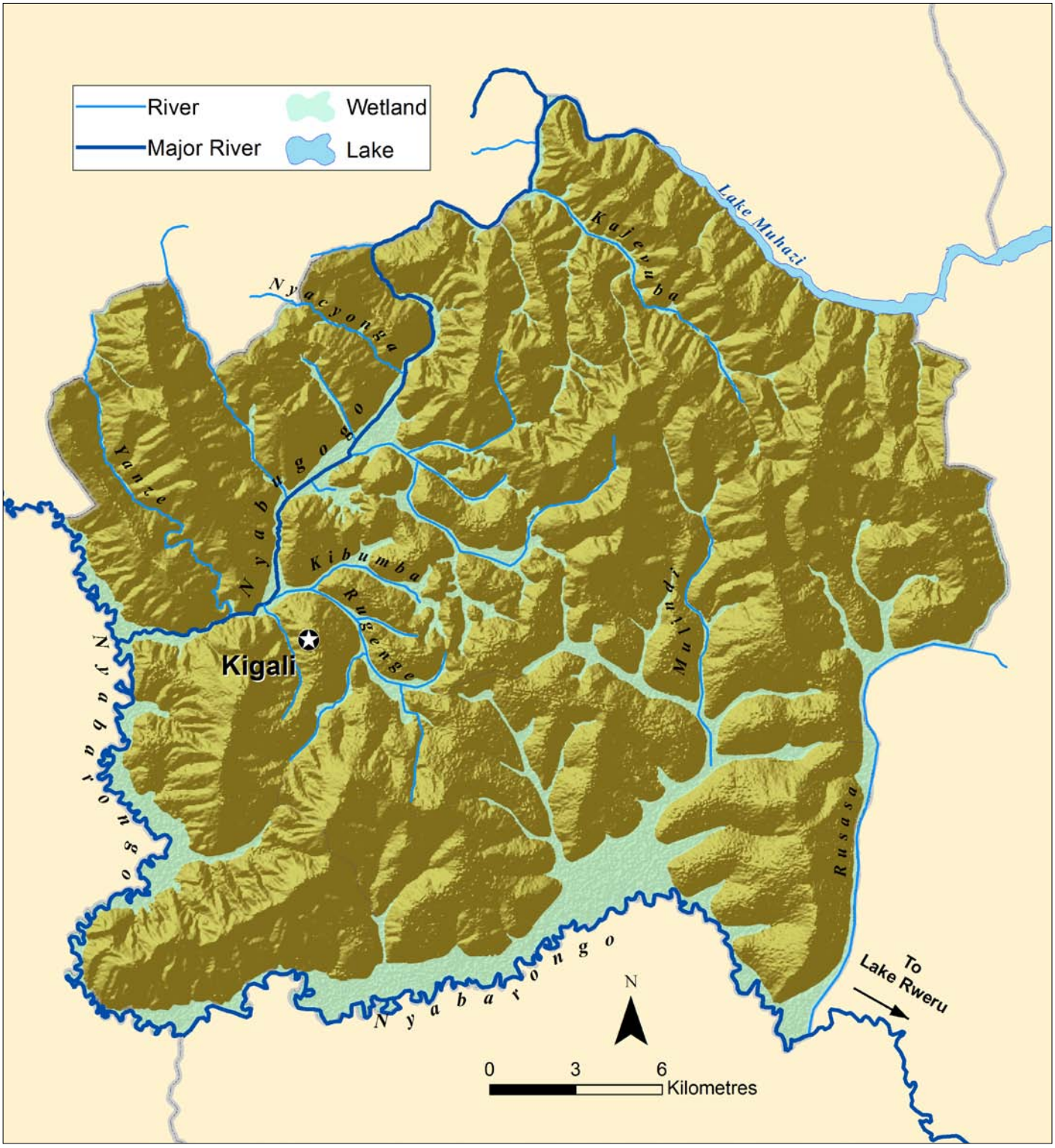
Source: ASTER GDEM, a product of METI and NASA; visualisation by UNEP/GRID-Sioux Falls

occur on some 37 per cent of Nyarugenge District, 37.5 per cent of Gasabo District and 6.8 per cent of Kicukiro District (Surbana 2012). The angles of slopes in Kicukiro District are somewhat less steep compared to those in the other two Districts. Where housing is built on steep, sandy slopes, the soil is subject to serious erosion and there is the risk of landslides during the rainy season (Kartas and Jütersonke 2011).

Hydrology

Kigali's underlying hydrology is governed by 25 watersheds within the city limits and is part of the Lake Victoria Basin (Surbana 2012). In central and northern Kigali, the topography is relatively steep and drained by the Nyabogogo River, which is the main watercourse in the northwest quadrant of Kigali flowing south to join the Nyabarongo River (Figure 1.7). Other rivers and streams within the

Figure 1.7: Kigali's network of rivers and wetlands



Source: ASTER GDEM, a product of METI and NASA; River and wetland data provided by REMA; visualisation by UNEP/GRID-Sioux Falls

The Nyabarongo River

city, such as the Yanze, Kibumba, Rwazangoro and Ruganwa also flow into the Nyabugogo. There are other streams that flow directly into the Nyabarongo River from the city's southern hills. The Nyabarongo River is the main watercourse that borders the western and southern edges of the city limits.

The Nyabarongo River itself is joined by the Akanyaru river tributary to become the Akagera River that flows into and through Lakes Rweru and Mugesera and into Lake Victoria and eventually the Nile River. Lake Muhazi is the largest natural lake in Kigali; it borders the northeastern edge of Gasabo District and is currently more-or-less undeveloped.

Wetlands are another of Kigali's key hydrological features, located mainly in the river valleys of the rivers described above; they presently cover about 12.5 per cent of the city's total area. These wetlands have important environmental functions, such as storing and releasing water and buffering the impacts of floods. They have been threatened by human activities including the conversion to agriculture, human settlements and industrial uses, and when used for livestock activities and sand quarries (see the Nyabugogo Wetland Hotspot in Chapter 4). As a result of such impacts, by 2006, only 24 per cent of Kigali's original wetland areas remained (REMA 2006).

Biodiversity

Rwanda lies in the western part of a rift valley known as the Albertine Rift, one of the most biologically diverse regions in Africa. As of 2010, there were 402 species of mammals, 1,061 species of birds, 293 species of reptiles and amphibians and 5,793 plant species in this region (UNEP 2010). Deforestation, cultivation and urbanisation in and around Kigali, however, have led to the serious destruction of wildlife biodiversity and the city no longer enjoys the same magnitude of biodiversity as the nation as a whole. It is striving to protect it more in the future (CoK 2012), however, supported by the Rwanda Biodiversity Policy implemented by REMA in 2011 and Rwanda's participation in the Convention on Biological Diversity (CBD) (REMA 2011b). Increased capacity to implement protection and regulation is needed to adequately protect the city's biodiversity.

Where some natural habitat remains, there are species of birds and reptiles, hares, jackals and a few species of snakes and fishes and CoK greening efforts have brought more trees and flowers along the roadsides. The Nyabarongo Wetland receives an exceptionally large number of migratory and congretory birds every year, but rice and sugarcane plantations, which dominate the city's wetlands and low-lying areas in river floodplains, have contributed to biodiversity loss.


John & Mel Kots / Foter.com / CC BY-NC-ND

Flora and fauna surrounding Kigali

Biodiversity is also threatened by invasive species such as water hyacinth, which has infiltrated parts of Lake Muhazi and the Nyabarongo-Akagera river-lake-wetland complex, as well as other areas in the Lake Victoria Basin, inhibiting the aquatic systems to function properly and threatening fish production (Usanzineza, et al. 2007, UNDP 2008). Kigali has the potential to regain its lost biodiversity by establishing parks and protected areas, which will also help Rwanda to achieve the Vision 2020 goal of protecting 10.3 per cent of its land area to maintain biodiversity. Loss of biodiversity — of species, genetic material and ecosystems — is an important environmental threat, since biodiversity is the foundation of all natural ecosystems.

Governance and Administration: The Institutional Context

Since 2002, the City of Kigali administration has engaged in a concerted effort to institute urban planning to guide social, economic and environmental development within this natural environment, according to national urbanisation policies. In 2002, the Kigali Economic Development Strategy focused on 'Building the Foundation to Compete in the Global Economy in the Future'. In 2004, the Rwanda Settlement Policy and the Urban Infrastructure and City Management Programme followed (Manirakiza 2012). In 2007, the Rwanda National Urbanisation Policy focused on Kigali. The City's 2007-2009 Strategic Issue Papers included a stipulation to create a Master Plan for the city. Under the Settlement, Resettlement, Infrastructure and Environment Programme, issues included protecting the environment, and managing water, energy and transportation. The City then prepared detailed City Development Plans, which recognised and began to address a number of important challenges related to environmental quality. These challenges included the lack of a centralised sewerage system; unplanned housing; informal settlements on fragile hill slopes and other high-risk areas; a lack of parks and green spaces; unmanaged storm water that eroded usable land, caused flooding and endangered human life as well as private and public infrastructure and non-rehabilitated wetland areas (Kigali City 2013).

By 2013, the City of Kigali had put in place a well-structured administrative system that was taking action to address these environment and development issues. These plans include the 2007 Kigali Conceptual Master Plan (KCMP), which projects out to 2050, and which the City is currently implementing (Manirakiza 2012). In the words of one observer 'Since the beginning of this millennium the Government of Rwanda has embarked on developing Kigali as a regional and a global leader in sustainable urbanization and improving the opportunities and potentialities of a modern and competitive city' (Manirakiza 2012 , 6).

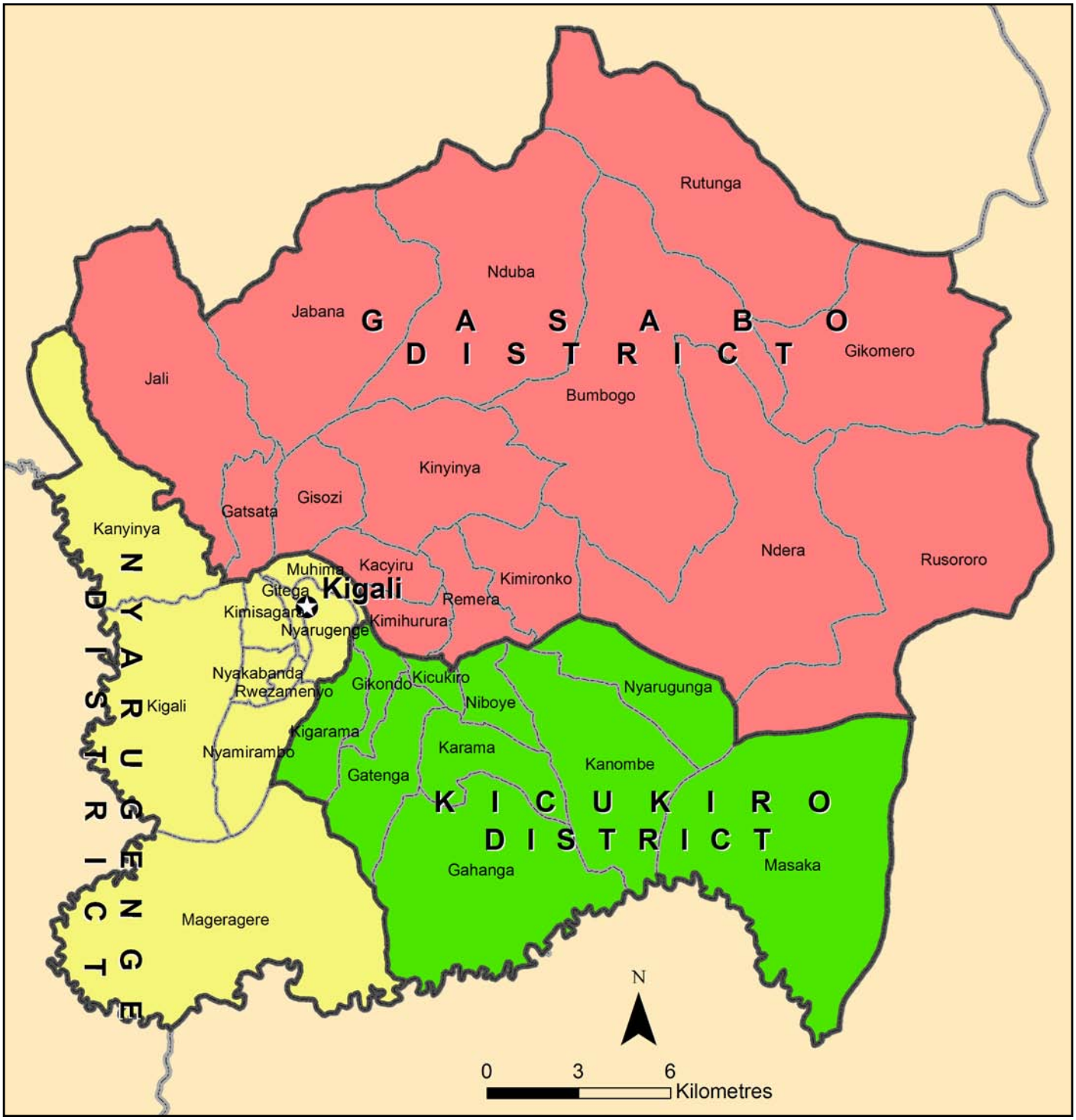
The preceding State of Environment Report, published in the form of an Atlas in 2011, reported an improvement in conditions for both people and the environment attributed to better coordination among stakeholders in environmental management.

Kigali's administrative structure divides the city into three Districts (out of the country's total 30 Districts): Gasabo (429.3 sq. km), Kicukiro (166.7 sq. km) and Nyarugenge (134 sq. km) (Kigali City 2013) (Figure 1.8). These Districts are further divided into 35 Sectors and 161 Cells, and the Cells are sub-divided into 1,061 imidugudu, or villages.

The 2006 Organic Law No. 10 established the City of Kigali as a local government with administrative, legal and financial autonomy (CoK 2012).

Kigali is a provincial-level city governed by a City Council made up of 31 Councillors who are elected for a term of five years. The Kigali City Council (KCC) establishes regulations and laws to govern the city in alignment with the Constitution. A Bureau composed of a Chairperson, a Deputy Chairperson and a Secretary runs the Council. An Executive Committee, composed of a Mayor and two deputies, runs its day-to-day operations. A Minister in charge

Figure 1.8: Administrative Districts and Sectors of Kigali



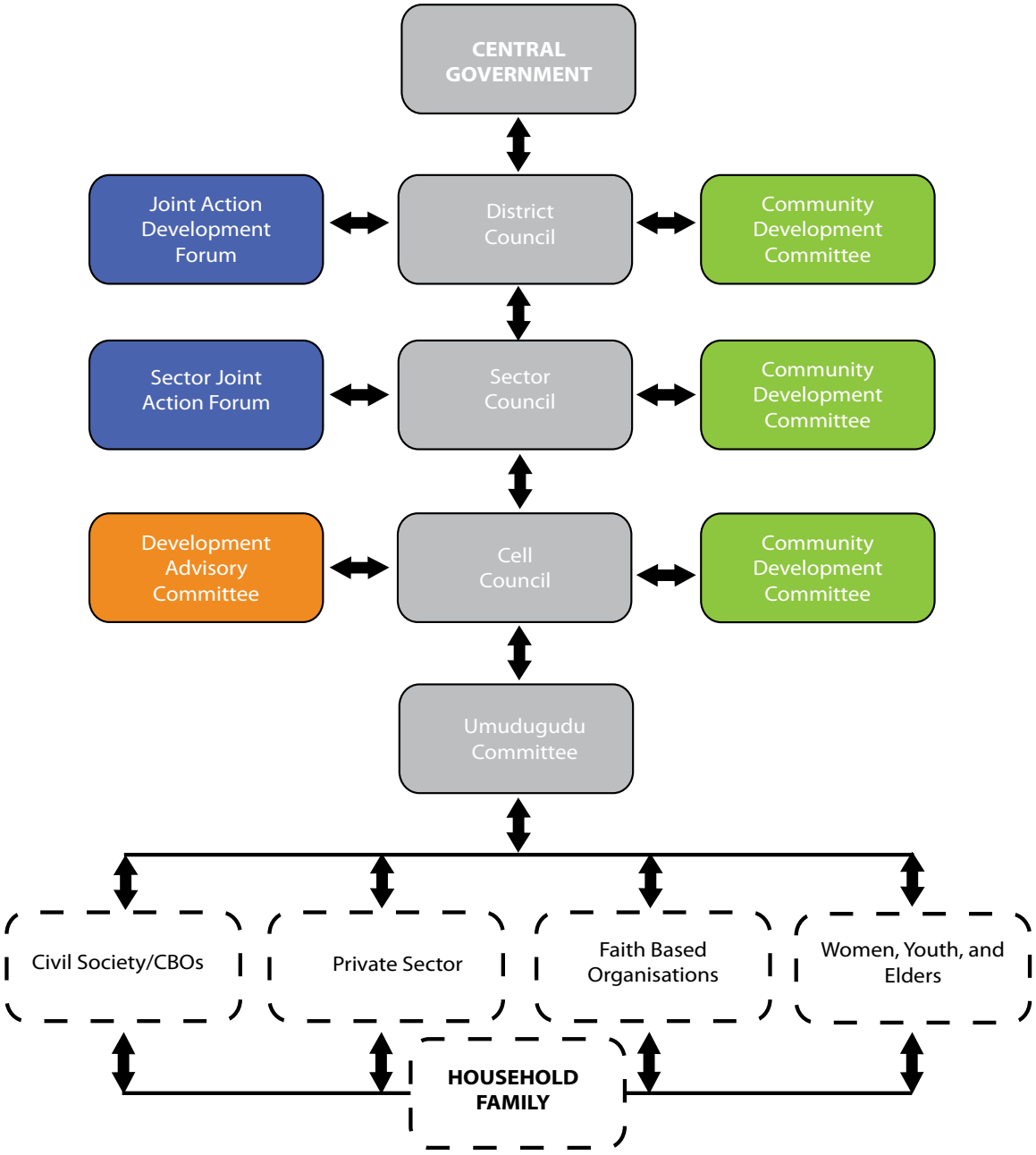
Source: Various sources; visualisation by UNEP/GRID-Sioux Falls

Figure 1.9: Kigali's administrative structure

Source: Kigali City 2013; visualisation by UNEP/GRID-Sioux Falls

of local government coordinates collaboration between the Bureau and the Executive Committee. In addition, there is an Executive Secretariat made up of the Secretary of the City of Kigali and staff members and a Security Committee (Kigali City 2013)(Figure 1.9). Figure 1.10 shows how the District Council fits into Rwanda's national administrative structure.

Figure 1.10: Rwanda's administrative structure



Source: Adapted from MINALOC 2008; visualisation by UNEP/GRID-Sioux Falls

School children planting trees

Policy Framework for Environmental Protection

Kigali's environmental laws and regulations are subject to the policy and regulatory frameworks set out in Rwanda's Constitution and the National Environmental Policy and Vision 2020, among others. Rwanda's Constitution (2003), including amendments to date, provides the legal framework for environmental protection at all levels, from national to local. It stipulates that every citizen is entitled to a healthy and satisfactory environment and that in addition to the State, everyone has a duty to protect the environment.

Organic Law on the Environment

In April 2005, the Organic Law on the Environment set out a number of principles, including the following:

- The entire population of Rwanda must contribute to protecting and managing the environment;
- Educating and sensitizing people to the need for environmental preservation at all levels, especially among women and youth, is a special priority;
- Priority should be given to prevention rather than rehabilitation;
- Impact studies must be done before any activity that might affect swamps or slopes;
- The principle of fair sharing of benefits from efficiently conserving the environment and natural resources must be upheld and those people concerned should be informed about the principle; and
- Managing the environment efficiently has advantages for local, national, regional and international interdependence; this must be explained to all the people of Rwanda.

The National Environment Policy

The Cabinet adopted the National Environment Policy (NEP) in November 2003. Its main objective is to improve human well-being by using natural resources efficiently and protecting ecosystems for sustainable development. The NEP acknowledges the links between population, poverty, health and the environment and sets out policy options for sustainable land use management in the context of population growth (MINIRENA 2003).

Table 1.3: Guiding framework for the future of Kigali

Framework	Affiliated Agency	Level	Purpose
Millennium Development Goals (MDGs)	United Nations	Global	Targets
Vision 2020	GoR	National	Targets
Economic Development and Poverty Reduction Strategy (EDPRS)	MINECOFIN	National	Strategy
National Strategy for Climate Change and Low Carbon Development (NSCCLCD)	GoR	National	Strategy
Integrated Household Living Conditions Survey (EICV)	NISR	National	Monitor/Measure
City of Kigali Development Plan (CKDP)	CoK	City	Strategy/Implementation
Kigali Conceptual Master Plan (KCMP)	CoK	City	Implementation

Regulatory Framework for Future Development

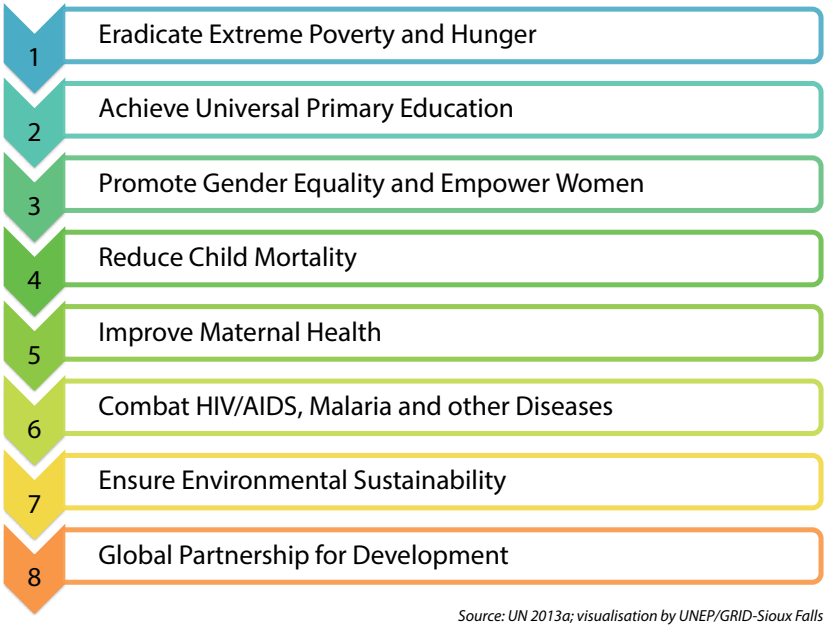
The City of Kigali, in conjunction with the Government of Rwanda, utilises several different framework systems to monitor, measure and regulate the standard of living and resource use (Table 1.3). These mechanisms of regulatory framework are valid at the global, national and local level and are interlinked. The Vision 2020 goals (explained in more detail below) were established by the Government of Rwanda (GoR) to achieve the Millennium Development Goals (MDGs); the Economic Development and Poverty Reduction Strategy (EDPRS) and the National Strategy for Climate Change and Low Carbon Development (NSCCLCD) were created at a national level to work

Street activity in downtown Kigali

REMA 2013

towards achieving Vision 2020; the City of Kigali Development Plan (CKDP) was created to help the City meet the national targets set in the EDPRS and NSCCLCD; the Integrated Household Living Conditions Survey, more commonly known as the EICV (Enquête Intégrale sur les Conditions de Vie des Ménages) is conducted for monitoring and measurement; and finally, the Kigali Conceptual Master Plan (KCMP) is in place to implement the goals and targets at both urban and rural development levels in Kigali. All seven of these initiatives are heavily referenced throughout this report; hence it is necessary to have a basic understanding of the purpose and role of each one.

Figure 1.11: Millennium Development Goals



Source: UN 2013a; visualisation by UNEP/GRID-Sioux Falls

Millennium Development Goals

The Millennium Development Goals (MDGs) were established in 2000 as a global initiative spearheaded by the United Nations to combat the circumstances surrounding extreme poverty with a target date of 2015 (UN 2013a). The MDGs consist of eight themes that encompass issues such as health, the environment, and economic and social needs (Figure 1.11). The seventh goal focuses specifically on the environment and ensuring sustainability for the future. It is composed of four targets (UN 2013b):

Target 7.A: Sustainable development to reverse environmental resource loss;

Target 7.B: Reduce amount and rate of biodiversity loss by 2010;

Target 7.C: Increase the population with access to safe drinking water and basic sanitation facilities by half, by 2015;

Target 7.D: Significantly improve the lives of at least 100 million slum residents by 2020.

These targets align with Kigali's fundamental goals of improving both the environment and the standard of living.

Vision 2020

Vision 2020 is a long-term policy statement that maps out the Rwandan Government's aims for future development; it was adopted in 2000 (MINECOFIN 2000). Environmental protection is one of the Vision's main pillars. The major economic aim of Vision 2020 is to transform Rwanda into a middle-income country. From 2002 to the year 2020, the GoR aims to control pollution and environmental degradation, and build a nation where pressures on natural resources such as land, water, biomass and biodiversity, have been reasonably reduced.

Actions to realize Vision 2020's environmental objectives include the following (MINIRENA 2009):

- Reducing pressure on natural resources by creating alternative livelihoods;
- Promoting approaches and techniques that encourage sustainable use or exploitation of natural resources through scientific and technological applications, balancing resource supply and demand and raising public awareness about the environment;
- Establishing a governance framework that ensures more equitable regulated use of natural resources in order to preserve and bequeath to future generations the basic wealth necessary for sustainable development.

The Vision 2020 targets were revised in May 2012 due to the excellent progress Rwanda had made towards reaching the goals, even surpassing

Table 1.4: Status markers and Vision 2020 targets

	Indicator	Status in 2000	Vision 2020 Target	Rwanda's Current Status	New Target
1	Average GDP growth rate (%)	6.2	8	8.3	11.5
2	Growth rate of the agricultural sector (%)	9	6	5.8	8.5
3	Growth rate of the industrial sector (%)	7	12	8.8	14
4	Growth rate of the service sector (%)	7	11	10.5	13.5
5	Domestic credit to private sector (% of GDP)	none	none	12.8	30
6	Gross national savings (% of GDP)	1	6	10.5	20
7	Gross national investment (% of GDP)	18	30	21	30
8	External balance on goods and services (% of GDP)	none	none	-14.6	-3
9	GDP per capita, in US $	220	900	540	1,240
10	Adult population accessing financial services (%)	none	none	47	90
11	Payment transaction completed electronically (%)	none	none	<10	75
12	External trade (% of GDP)	none	none	41.5	60
13	Export growth (%)	none	none	19.2	28
14	Agricultural population (%)	90	50	71.6	50
15	Agricultural production kcal/day/person	1,612	2,200	2,385	2,600
16	Food Consumption Score (CFSVA)		none		
i	Poor (%)	none	none	4	0
ii	Borderline (%)	none	none	17	5
17	Agricultural operations mechanized (%)	none	none	7	40
18	Land area protected to maintain biodiversity (%)	none	none	10.13	10.3
19	Forest cover (% of land area)	none	none	22.4	30
20	Roads in good condition (%)	none	none	59	85
21	Access to electricity (% of pop)	2	35	10.8	75
22	Housholds using wood energy as source of energy (%)	94	50	86.3	50
23	Internet users per 100 people	none	none	4.3	50
24	Mobile subscribers per 100 people	none	none	45	60
25	Population under poverty line (%)	60.4	30	44.9	20
26	Gini-coefficient	0.454	0.35	0.49	0.35
27	Number of off-farm jobs	200,000	1,400,000	1,406,000	3,200,000
28	Access to improved sanitation (% of population)	20	60	74.5	100
29	Access to clean water (% of population)	52	100	74.2	100
30	Life expectancy (years)	49	55	54.5	66
31	Population growth rate (%)	2.9	2.2	2.9	2.2
32	Women fertility rate	5.8	4.5	4.6	3
33	Urban population (%)	10	30	14.8	35
34	Infant mortality rate per 1,000 births	107	50	50	27
35	Maternal mortality rate per 1,000 births	1,071	200	476	200
36	Child malnutrition				
i	Child acute malnutrition, wasted (%)	none	none	3	0.5
ii	Child underweight (%)	none	none	11	8
iii	Child chronic malnutrition	none	none	44	15
37	Malaria related mortality (%)	51	25	13	5
38	Doctors per 100,000 inhabitants	1.5	10	6	10
39	Nurses per 100,000 inhabitants	16	20	77	100
40	Literacy rate (%)	48	100	83.7	100
41	Gross primary school enrollment (%)	none	100	127.3	100
42	Gross secondary school enrollment (%)	7	60	35.5	98
43	Pupils to qualified teacher ratio				
i	Primary school	none	none	58-1	40-1
ii	Secondary school	none	none	37-1	30-1
44	Rate of enrolment in first year of higher learning institutions and TVET colleges (%)	1	6	38	65
45	Women represented in decision making organizations (%)	none	40	30	40
46	Citizens' satisfaction with service-delivery (%)	none	none	66	80
47	Rank in world corruption	none	none	49	10
48	Index on Rule of law (%)	none	none	67.7	80

Note: *The date or range of dates for 'Current Status' vary according to category, see MINECOFIN 2012 for complete list

Source: Adapted from MINECOFIN 2012; visualisation by UNEP/GRID-Sioux Falls

some (Table 1.4). Many targets and indicators were revised and 18 new indicators were added. Revised targets and new indicators help to keep the goals relevant and maintain a sense of ambition in the Rwandan people. Two new indicators were established concerning a sustainable environmental future: 1) land protected to maintain biodiversity and 2) percentage of forest cover. As of 2012, 10.13 per cent of land was protected to maintain biodiversity and the newly established target for 2020 is 10.3 per cent. The aim to increase afforestation is reflected in Rwanda's forest cover target, which strives to increase the proportion of national land covered by forests from the current 22.4 per cent to 30 per cent by 2020.

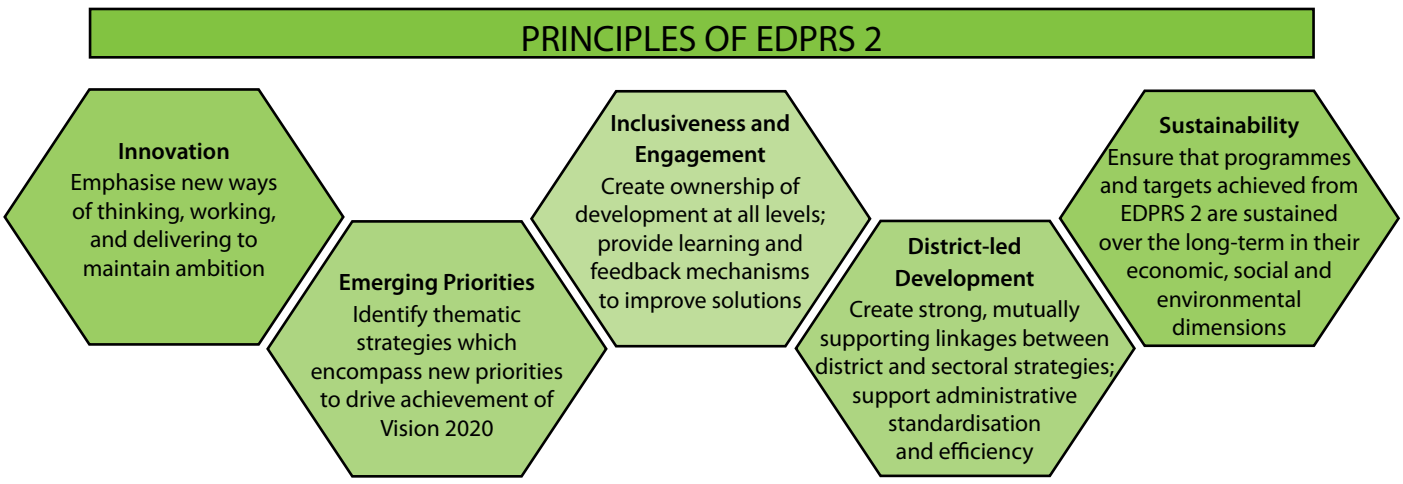
Economic Development and Poverty Reduction Strategy

The Economic Development and Poverty Reduction Strategy (EDPRS 1) serves as the platform for medium-term strategic plans for economic development, poverty reduction and better quality of life (MINECOFIN 2013). The initial strategy's framework was established in 2001 (Poverty Reduction Strategy Papers (PRSP), the second in 2008 (EDPRS 1) and the most recent in 2013 (EDPRS 2). Each strategy is implemented over a period of five years, and upon completion, the achievements and lessons learned are assessed and focus areas for the next five years determined. The revised targets of Vision 2020 guide the EDPRS 2 for 2013-2018 in Rwanda's continued effort to cope with rapid growth and attend to poverty reduction; these efforts embrace the City of Kigali. The EDPRS 2 also incorporates five principles derived from the lessons and experiences of EDPRS 1 (Figure 1.12). Although the title implies it only addresses issues related to economics and poverty, environment and climate change awareness are an integral part of the opportunities outlined in the EDPRS. Since climate change is a global issue, the EDPRS creates an opportunity for Rwanda to do its part while also making its environment attractive to investors. This is extremely important to Kigali as its population is rapidly growing and new investors are essential in developing its economy and driving sustainable development. Also, land is a scarce resource for both agriculture and urbanisation, so the EDPRS strives to accommodate both sectors.

Green Growth and Climate Resilience: National Strategy for Climate Change and Low Carbon Development

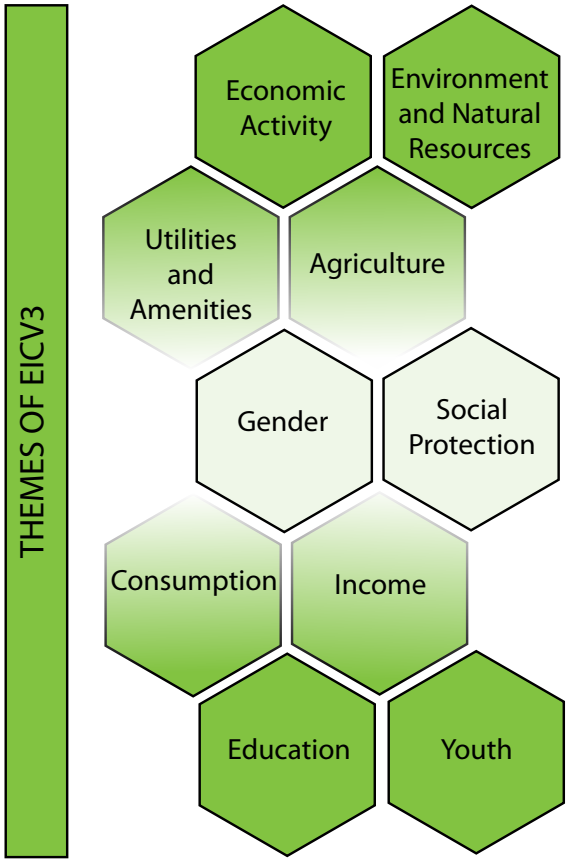
Stipulations set forth in the National Strategy for Climate Change and Low Carbon Development (NSCCLCD) aim to position Rwanda as a developed climate-resistant country with a low-carbon economy by 2050 by integrating climate considerations into policy and planning (RoR 2011). With a target date of 2050, the NSCCLCD takes the mission of Vision 2020 a step further. The Strategy is based upon a set of guiding principles, strategic objectives, programmes of action, enabling pillars and a roadmap for implementation. Through stakeholder consultation and extensive research, it created recommendations for the short-to-medium term so that actions now can resonate in the future. Adoption of the NSCCLCD demonstrates the pivotal

Figure 1.12: Five guiding principles of EDPRS 2



Source: Adapted from MINECOFIN 2013; visualisation by UNEP/GRID-Sioux Falls

Figure 1.13: Themes of EICV3



Source: Adapted from NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

role that the environment and climate change have in the GoR's policymaking (MINECOFIN 2013).

Integrated Household Living Conditions Survey (Enquête Intégrale sur les Conditions de Vie des Ménages – EICV)

The first Integrated Household Living Conditions Survey (EICV1) was conducted from 2000 to 2001, EICV2 from 2005 to 2006 and the most recent, EICV3, from 2010 to 2011 (NISR 2012b). The EICV collects information from households all over Rwanda to monitor poverty and living conditions. The survey results consist of an overview of the main indicators and poverty profile in addition to population count and it also shares ten thematic reports (Figure 1.13). The results of comprehensive studies such as this are used to monitor the progress towards achieving the goals set forth by the MDGs and Vision 2020 through the mechanism of EDPRS implementation.

City of Kigali Development Plan

The City of Kigali Development Plan (CKDP) for 2013 to 2018 was developed as a result of lessons learned from EDPRS 1, specifically to address the duplication of efforts or financial discrepancies found between the Sector Strategic Plans and the District Development Plans set by MINECOFIN (CoK 2012). The principles of EDPRS 2 served as the primary guidance tool for developing the CKDP. The CKDP highlights Kigali's achievements over the last five years and outlines the challenges and priorities for the future.

Kigali Conceptual Master Plan

Designed by OZ Architecture in cooperation with the City of Kigali, the Kigali Conceptual Master Plan (KCMP) is a roadmap for Kigali's future development. The plans urge green and sustainable structures, attempting to create harmony between people and the environment (OZ Architecture 2007). Surbana ICP, Ltd and OZ Architecture, respectively, developed additional detailed District and sub-area plans. Plans are due to be finalised in mid-2013. Implementation of the plans will come with time as finances accumulate and Sector and District administrations adopt the plans into their current agendas.

The Institutional Framework for Environmental Management

Several ministries and other bodies share the role of environmental management in Rwanda: the Ministry of Natural Resources (MINIRENA), Ministry of Agriculture (MINAGRI), Ministry of Infrastructure (MININFRA), Ministry of Local Government (MINALOC), decentralised organisations (Districts and Sectors), public institutions, local and international non-governmental organisations (NGOs) and higher educational institutions. REMA is responsible for coordinating, supervising and regulating environmental management for sustainable development in Rwanda within the structures of MINIRENA.

Conclusion

It is evident that Kigali has taken extraordinary steps to envision its future as a city that simultaneously enjoys strong economic growth, social equity and a healthy environment. It has laid out detailed urban plans to implement its goals for a sustainable city. These goals align with the Government of Rwanda's forward looking aims to create a strong economically and environmentally sound nation. The administration of Kigali also recognises itself as part of the global community with aims to achieve the MDG goals. Kigali has specific environmental targets (for example: biodiversity protection and forest area) that reveal its commitment to improving the state of its natural ecosystems. They also show its understanding of their importance to the well-being of its citizens and the stability of the environment upon which it is founded. These plans are being implemented and monitoring is ongoing to study and improve the results.

It is also evident that the administration must implement its plans within and upon a natural foundation that gives Kigali its sense of place – the capital of the Land of a Thousand Hills. Its hills, wetlands, forests, vegetation and climate are characteristics that define it and upon which it has made an indelible imprint. It needs to work within the natural limits to implement sustainable development in innovative ways that will protect and enhance ecosystem goods and services so they continue to serve both present and future generations.

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A busy street in Kigali

The Driving Forces of Environmental Change 2

Socioeconomic trends, such as a population growth, industrialisation, poverty and consumption, have impacts on the state of the urban environment. They can be looked upon as the underlying drivers of environmental change, creating direct pressures on the environment. In urban settings such as Kigali, pressures resulting from socioeconomic drivers include construction of housing, urban farming, road building, traffic and industrial pollution. Such pressures can result in changes in water quality and quantity, soil fertility and stability, air quality and the amount and condition of green spaces and biodiversity within the city.

Some of the social data highlighted here, such as poverty levels, access to health and education and levels of employment, are provided as indicators of quality of life and economic development and security. As Kigali's economy grows, there are implications for the environment. It can mean better wastewater, sewage, solid waste and air quality management that improve both human and environmental health, but it can also imply more pollution. There are also complex links between poverty and the environment; for example, poor people are more vulnerable to environmental hazards such as flooding, landslides and poor indoor air quality than are the better off.

This chapter provides data and trends about the underlying social and economic drivers of environmental conditions and trends in Kigali. In addition, the chapter shows how the City of Kigali (CoK) is already addressing the impacts of economic development on the urban environment.

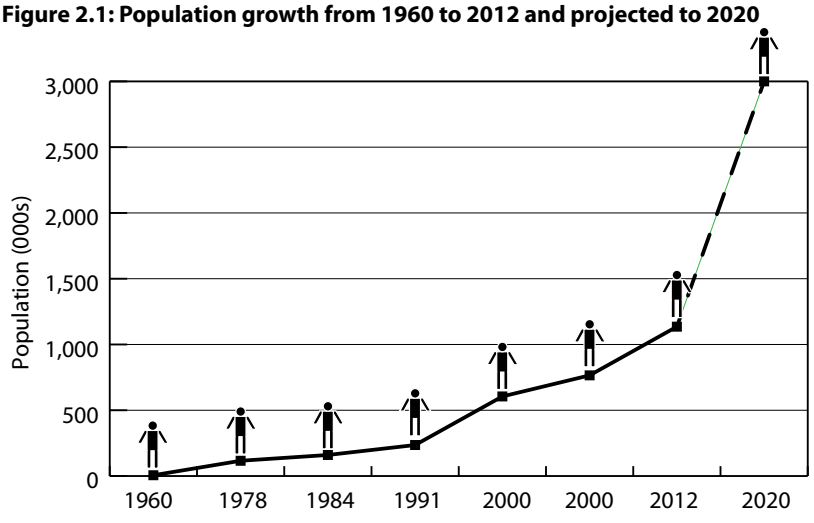
Chapters 3 and 4 describe and analyse the direct and indirect pressures resulting from these drivers.

Demographics

Population Growth

Data about Kigali's population growth are shown in Figure 2.1, revealing an initial increase from 6,000 at independence in 1962 to 600,000 by 2000 (ISTED 2001, MINECOFIN 2005). The population continued to grow quickly, swelling by almost 50 per cent between 2002 and 2012, increasing at an average rate of 4 per cent a year. This growth rate was 1.4 per cent faster than Rwanda as a whole (NISR 2012a). During that same time period, however, the administrative boundaries of the CoK changed such that data from 2012 were collected from a larger land base, although the data themselves represent figures from within the official boundaries of the CoK. By 2012, the city's population was 1.135 million and according to high projections, could reach 3 million by 2020 (NISR 2012a, OZ Architecture 2007).

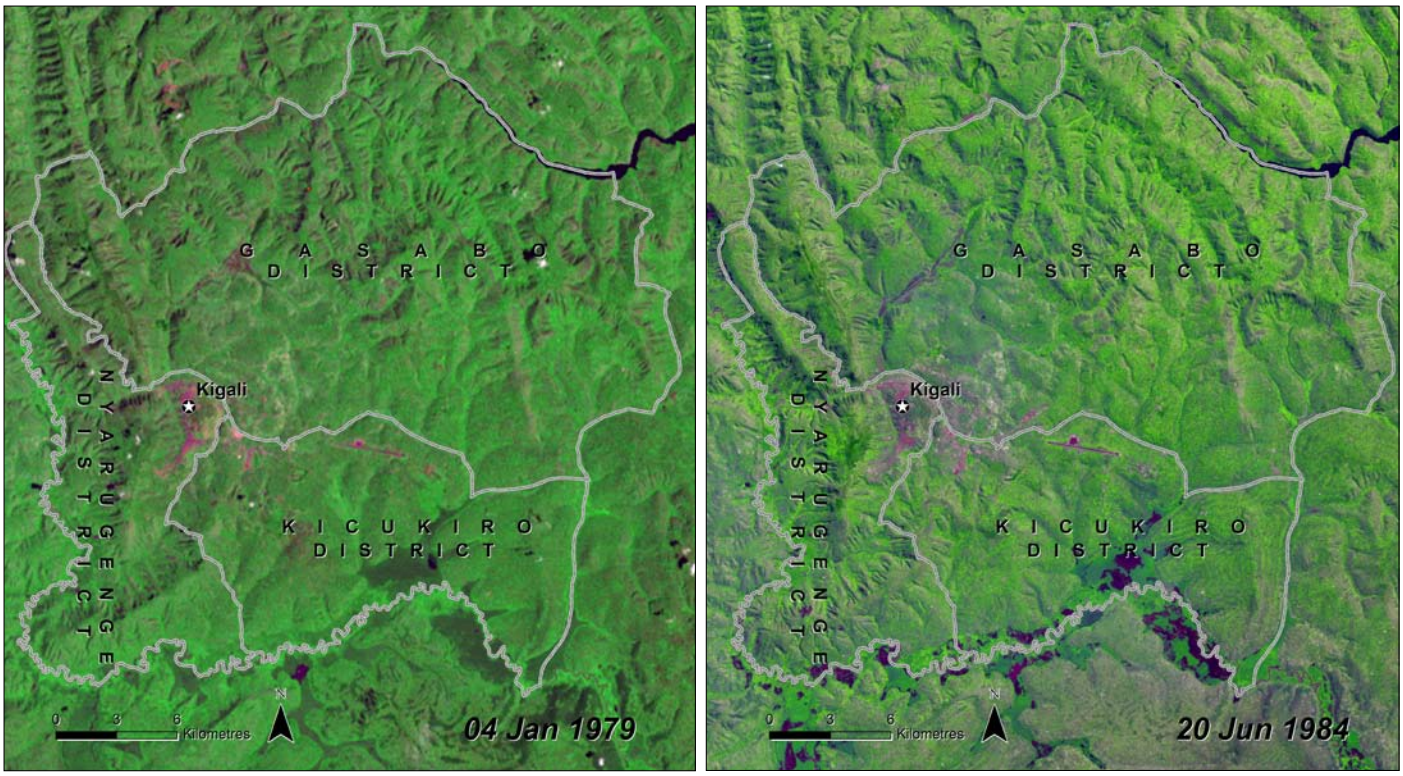
Figure 2.1: Population growth from 1960 to 2012 and projected to 2020



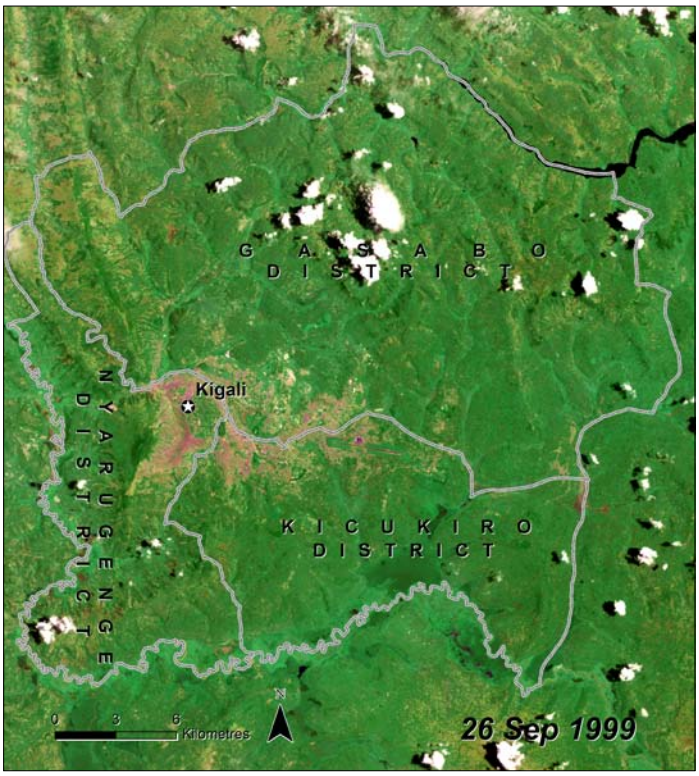
Sources: ISTED 2001, MINECOFIN 2005, NISR 2012a, OZ Architecture 2007; visualisation by UNEP/GRID-Sioux Falls.
Note: Different administrative boundaries existed for Kigali prior to 2005-2006 and therefore data preceding these years covers different territory, although it still represents City of Kigali

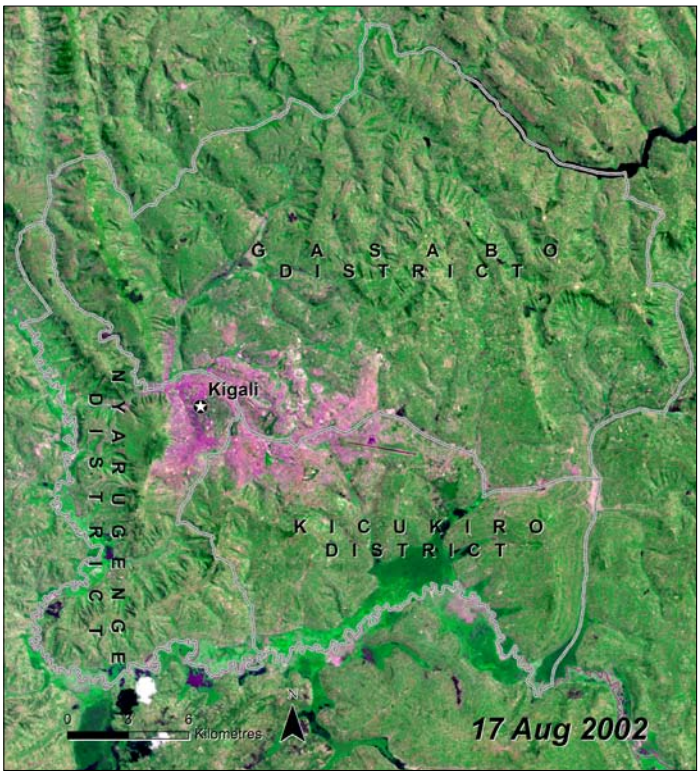
The Expansion of Kigali

Figure 2.2: Landsat satellite images from 1979, 1984, 1999, 2002 and 2011 show the increasing density and expansion of Kigali's growing population



After Rwanda won its independence in 1962 and began to recover from the genocide of 1994, population growth was accompanied by the city's expansion over the hilly terrain. Estimates from satellite imagery suggest that the city's built-up area expanded from about 4 sq. km in 1979 to about 93 sq. km in 2012. Development expanded in all directions, but mainly eastward towards the airport and south towards the Nyabarongo River.





The five Landsat satellite images in Figure 2.2, captured between 1979 and 2011, illustrate this expansion as well as the growth in population density in different parts of Kigali. Pink areas indicate developed land.

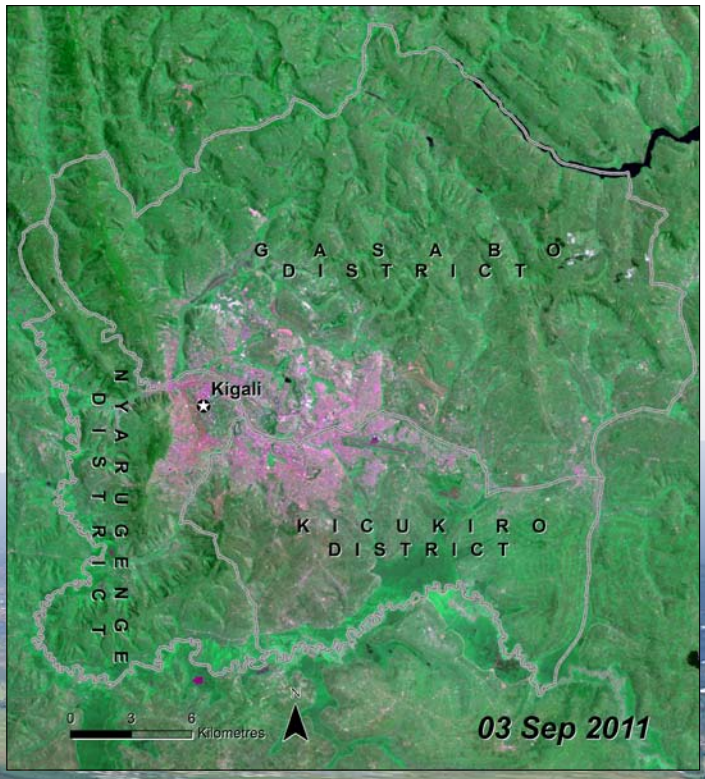
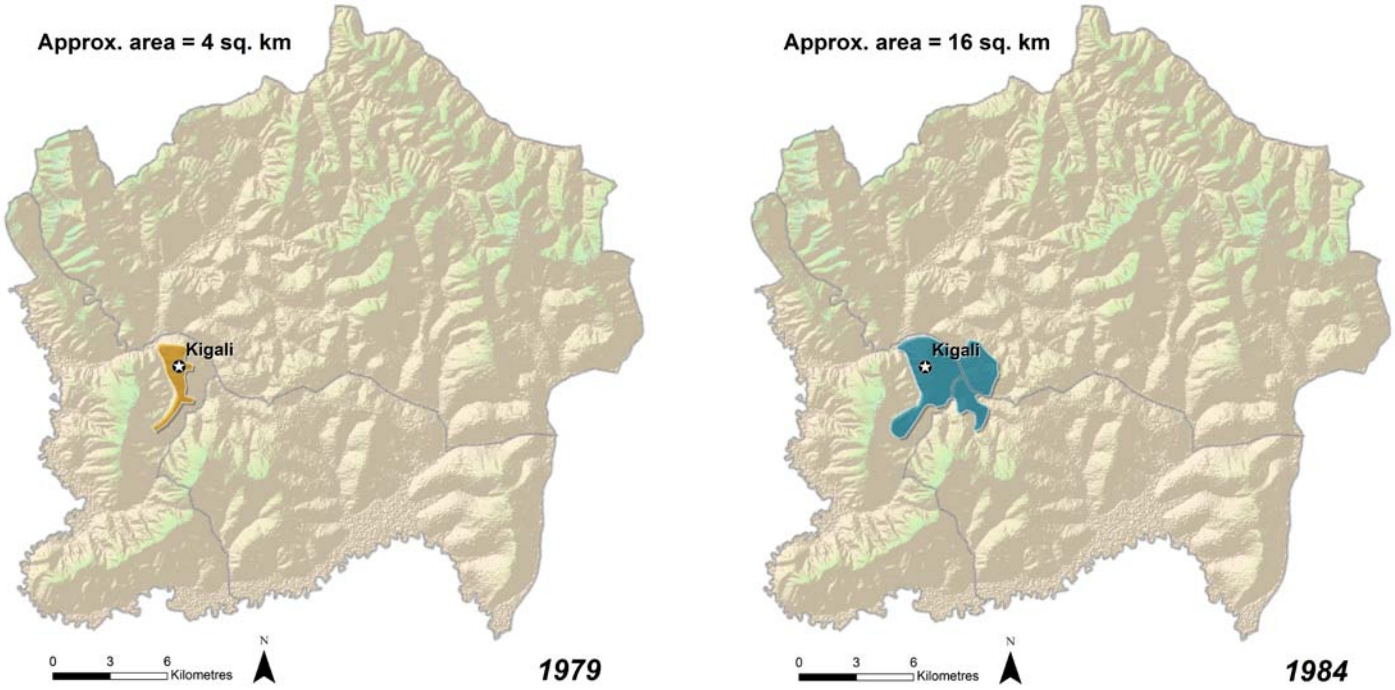


Figure 2.3: Area of Kigali's urban expansion, 1979 to 2012



Source: ASTER GDEM, a product of METI and NASA; area of urban expansion estimated from Landsat satellite imagery of the corresponding year with the exception of 2012, which was estimated from 2011 Landsat imagery and 2012 DigitalGlobe high resolution imagery; visualisation by UNEP/GRID-Sioux Falls

The coloured areas on the maps in Figure 2.3 illustrate the development's continued expansion over the challenging terrain.

Migration

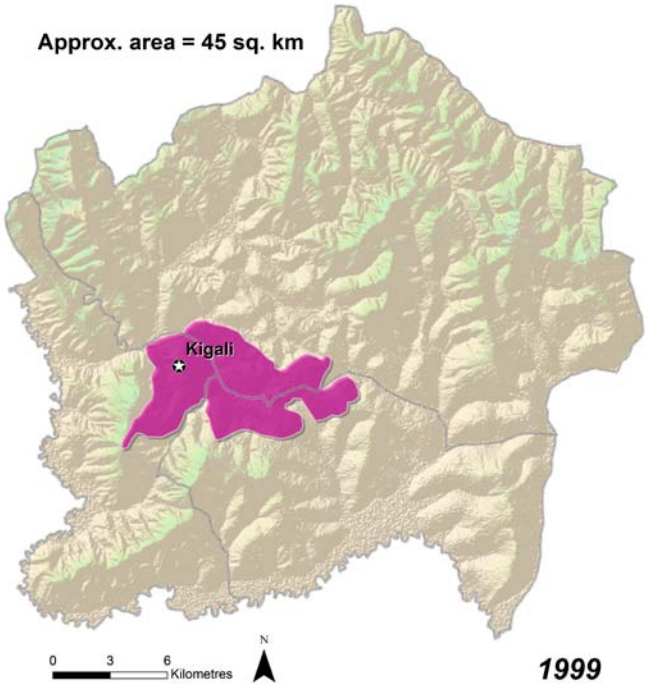
In addition to natural population growth from births exceeding deaths, migration has been a leading cause of population growth in Kigali (Manirakiza 2012). After the genocide, Rwandans living in neighbouring countries, some of whom left Rwanda in the 1950s and 1960s, began to return home (Rurangwa 2013). Since they often faced difficulties related to land rights and ownership and may have lost the social bonds needed to resettle in the countryside, returning Rwandans found themselves living in urban areas, especially Kigali. In addition, those who had fled the genocide also returned to Rwanda after 1998, leading to a significant population increase in the city. People returning to Rwanda were attracted to Kigali because it offered more security than the rural areas some of them had left (Kartas and Jütersonke 2011).

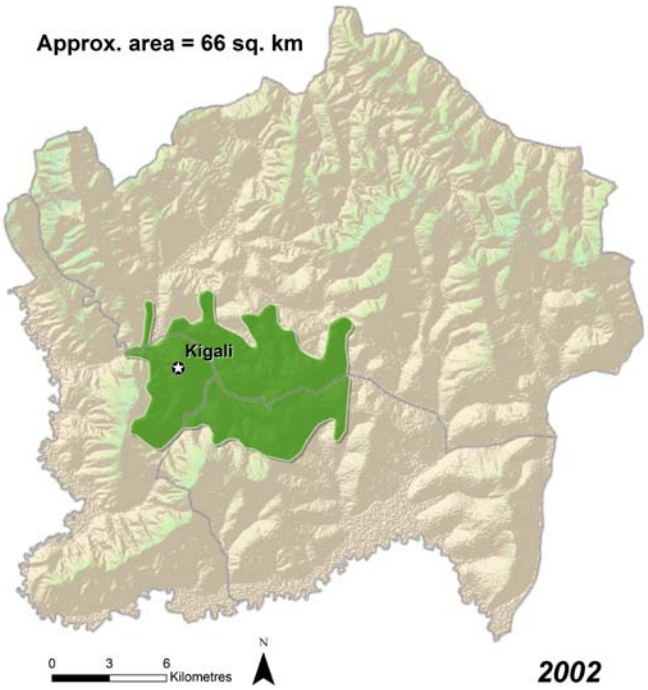
Between January and December 2012, the United Nations High Commissioner for Refugees (UNHCR) recorded the arrival of over 10,000 returnees to Rwanda. As of December 2012, UNHCR

Girls getting ready for sports at school

was supporting more than 60,000 refugees from the DRC in four refugee camps across Rwanda, some of whom were living in Kigali (UNHCR Rwanda 2012). By 2012, there were a total of 1,973 urban refugees living in Kigali, resulting from different phases of migration to the city since 1997 (UNHCR Rwanda 2013).

Rural-to-urban migration within Rwanda also accounts for some of Kigali's population growth. According to the results of the EICV3 survey, between 2006 and 2011, about 19 per cent of the adult population (over the age of 15) migrated within the country. Moreover, the survey indicates that 58 per cent of migration has been towards Kigali, a





trend virtually unchanged since the EICV2, which records that 57.6 per cent of internal migration was to Kigali.

Figure 2.4 shows how Kigali's population is distributed among the three Districts. To imagine these data geographically, recall from Chapter 1 (Figure 1.3) that Gasabo is the largest in land area, comprising 429.3 sq. km, while Kicukiro and Nyarugenge are considerably smaller, at 166.7 sq. km and 134 sq. km, respectively (Kigali City 2013). According to the provisional 2012 Population and Housing Census, Gasabo District is the fastest growing and the most populated of the three Districts, with a 5.2 per cent growth rate (NISR 2012a) and over 530,907 people; it accounts for about half

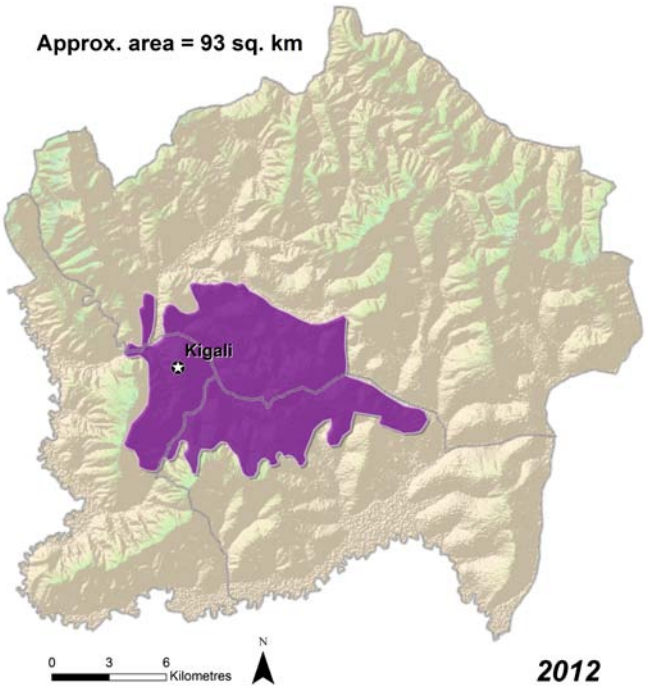
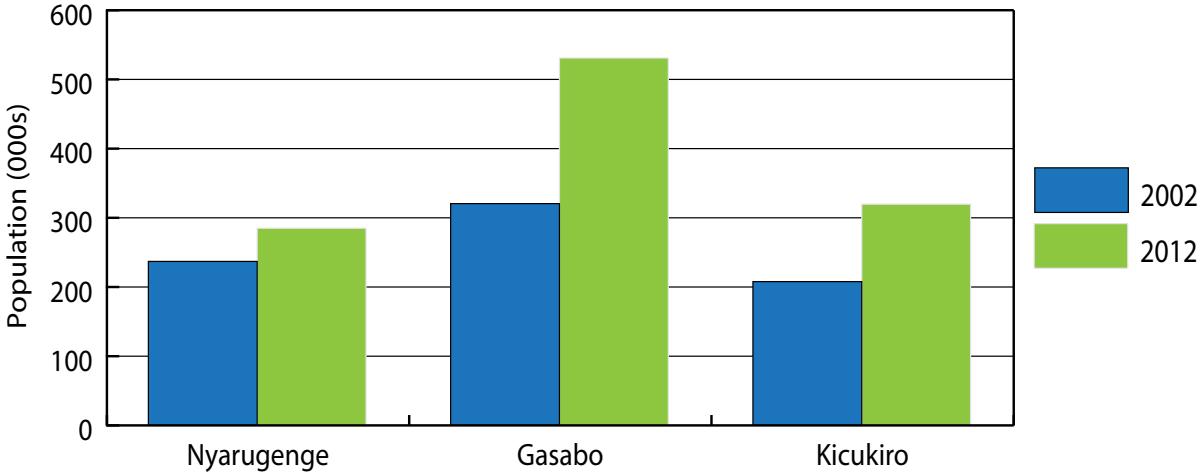


Figure 2.4: Population of Kigali by District, 2002 and 2012

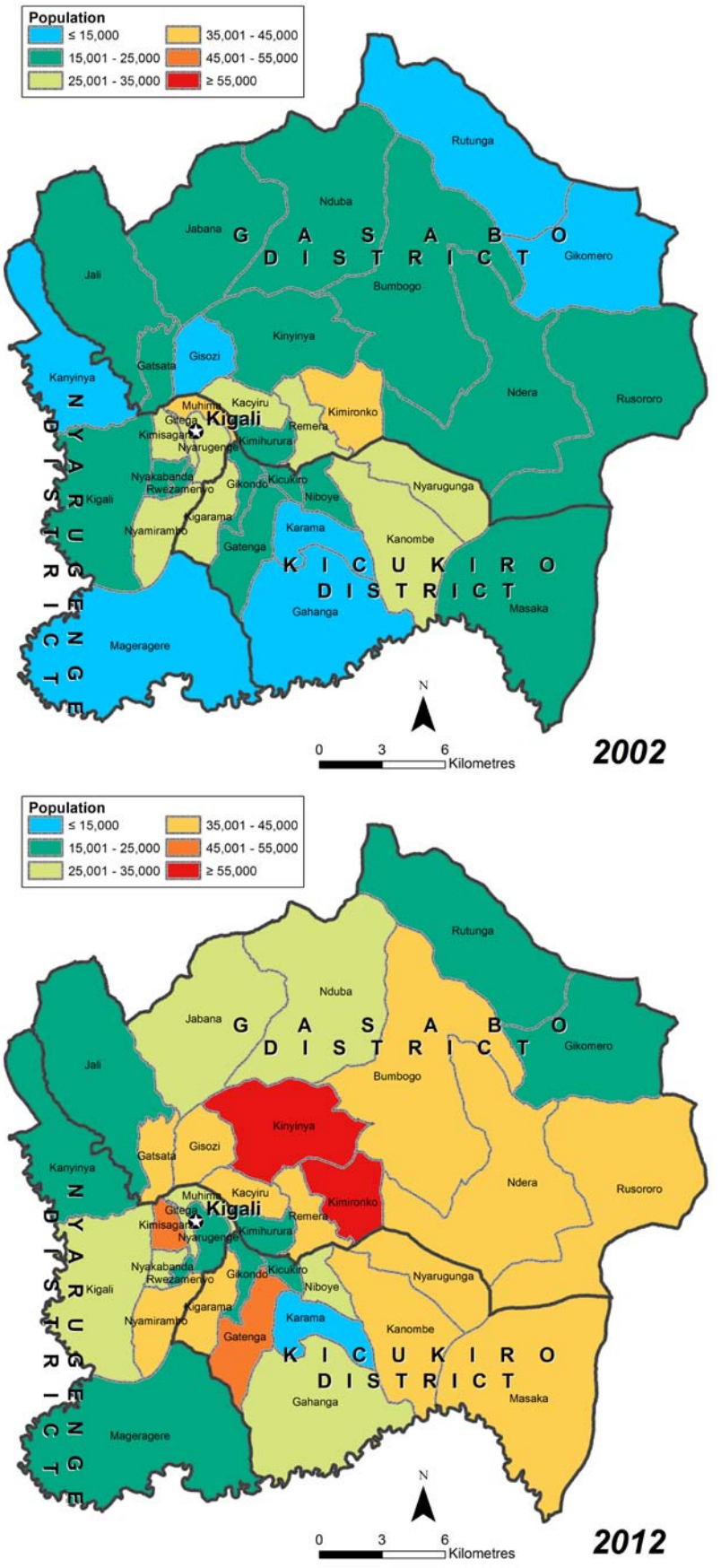


Note: The 2002 census data were collected based upon different administrative boundaries from those during the 2012 census, but for the 2012 census report, 2002 census data have been redistributed to the current administrative boundaries.

Source: NISR 2012a; visualisation by UNEP/GRID-Sioux Falls.

of Kigali's population. Gasabo District contains the city's most populated sub-area, Kimironko Sector, with 59,312 people. Nyarugenge District is the least populated District with 284,860 people, is growing at the slowest rate (1.9 per cent average annual growth rate between 2002 and 2012) and is the smallest District in area. Kicukiro has a growth rate of 4.4 per cent a year and is the least populated District with 319,661 residents. It also has the least populated Sector, Kagarama, with a population of 14,054. Figure 2.5 is a visual representation of the distribution of the city's population within the city's Districts and Sectors. It shows the difference in size of these administrative areas and the change in population numbers between 2002 and 2012.

Figure 2.5: Population growth by District and Sector, 2002 and 2012



Source: NISR 2012a; visualisation by UNEP/GRID-Sioux Falls

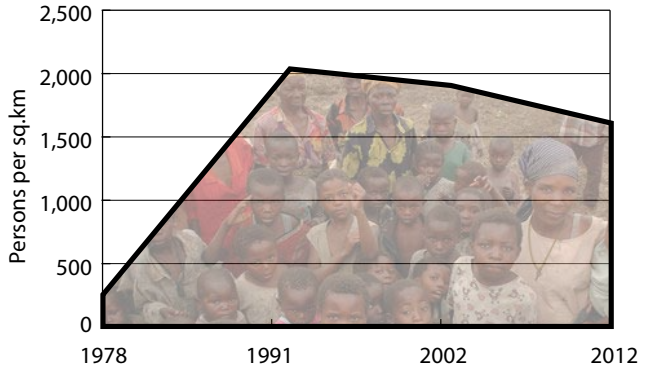
Population Density

Population density is an extremely important factor in urban sustainability and an understanding of this issue is needed to put urban population growth in the context of the land upon which people live. If unplanned, or poorly planned, high-density urban areas such as slums have negative impacts on both the environment and human health and well-being. On the other hand, when planning to create sustainable, liveable cities with the characteristics of mixed uses, adequate and efficient municipal services and lots of green space, among others, high population densities should be encouraged as a way to prevent urban developments from sprawling over precious land that should be protected for agriculture, forests and other land uses that protect ecosystem goods and services and provide the urban population with green space.

Relatively high-density settlements also promote technological innovation through the proximity of economic activities and they reduce the cost of urban infrastructure (streets, transport, water and sewerage systems) that is expensive to provide in sprawling neighbourhoods, but less expensive per unit as urban density rises (UNEP 2011).

Statistics concerning population density for Kigali vary since the administrative boundaries were changed in 2005, making it difficult to compare

Figure 2.6: Population density of Kigali, 1978 to 2012

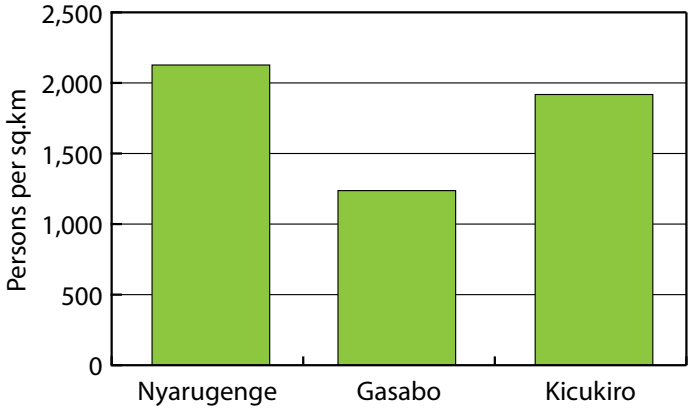


Source: Data: MINECOFIN 2005, NISR 2012a; image: Julien Harneis/Foter.com/CC-BY-SA; visualisation by UNEP/GRID-Sioux Falls

over time, but general density patterns are still evident from the data. As shown in Figure 2.6, Kigali's population density grew rapidly until 1991 and has been declining slowly since then. In 1978, population density was only 224 persons per sq. km, but it grew almost tenfold, to 2,032 persons per sq. km in the 13 years to 1991. Redistricting in 2000 and then again in 2005-2006, which increased the city's land base, most likely contributed to the decline in population density since 1991. In 2002, Kigali only covered 313 sq. km, but had a population density of 1,924 persons per sq. km (MINECOFIN 2005). By 2012, the total area of Kigali had grown to 730 sq. km and the average population density was down to 1,556 persons per sq. km (NISR 2012a). By 2012, approximately 84 per cent of the population lived in urban areas and 16 per cent lived in rural areas of Kigali (NISR 2012e).

Figure 2.7 shows the distribution of population density across the city's three Districts. Although

Figure 2.7: Population density by District, 2012



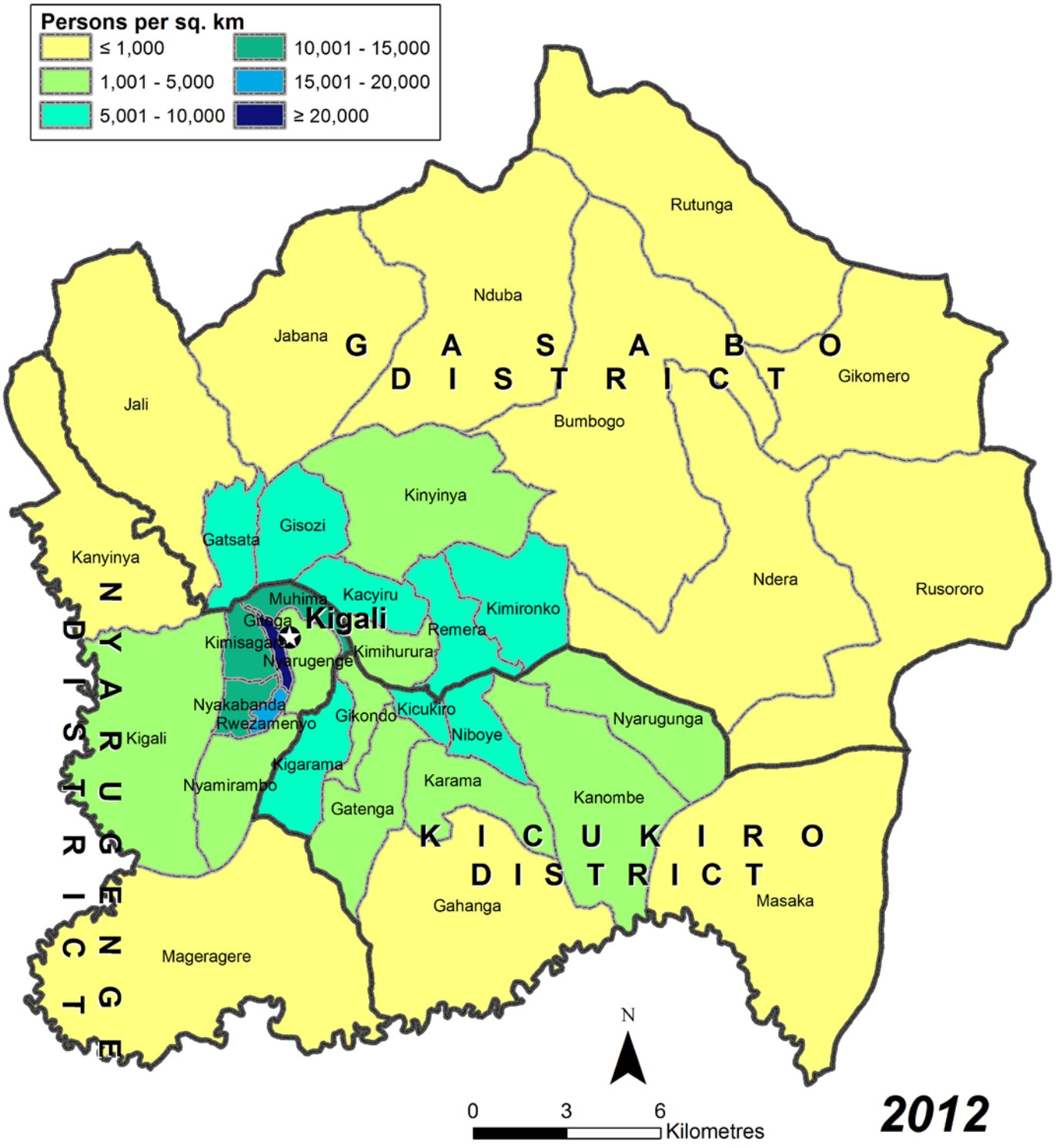
Source: NISR 2012a; visualisation by UNEP/GRID-Sioux Falls

A densely populated section of Kigali

REMA 2013

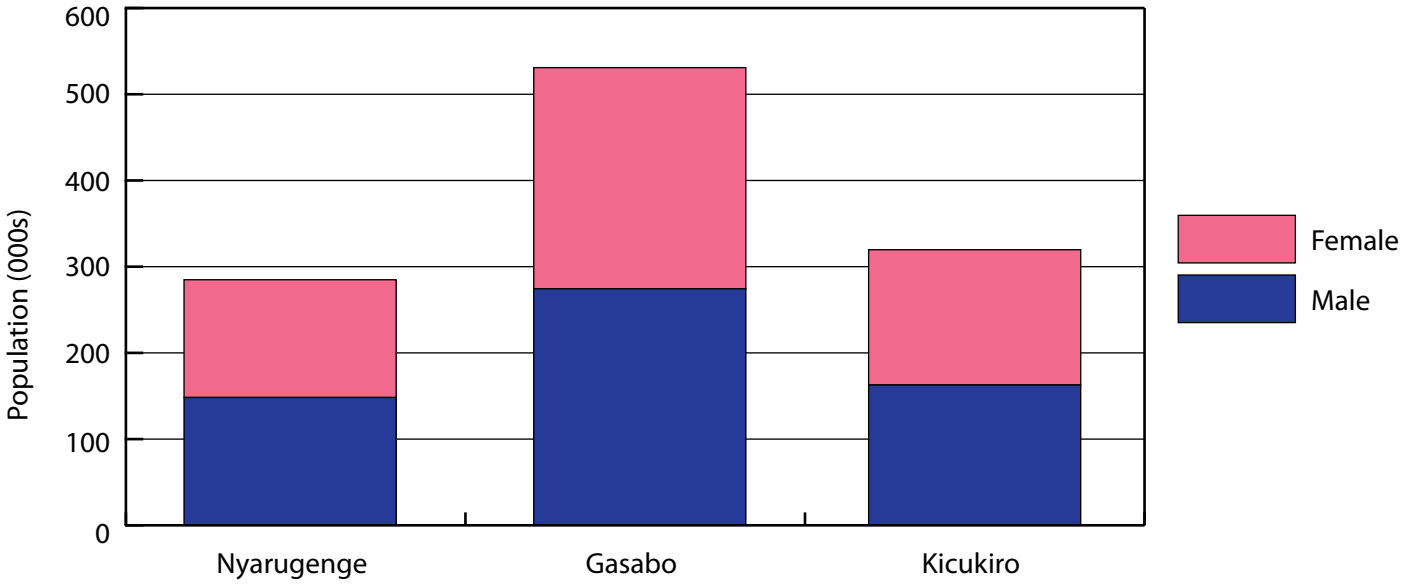
Nyarugenge District has the fewest absolute number of people, as mentioned above, it is the densest District with 2,127 persons per sq. km and also contains the densest sector, Gitega Sector, with 24,603 persons per sq. km (Figure 2.8). Gasabo, the most populated District, is the largest in area and the least dense, with 1,237 persons per sq. km; Gasabo District also contains Rutunga, the city's least densely populated Sector, with only 420 persons per sq. km (Figure 2.8). Kicukiro District has a population density of 1,918 persons per sq. km.

Figure 2.8: Population density by District and Sector, 2012



Source: NISR 2012a; visualisation by UNEP/GRID-Sioux Falls

Figure 2.9: Gender distribution by District, 2012



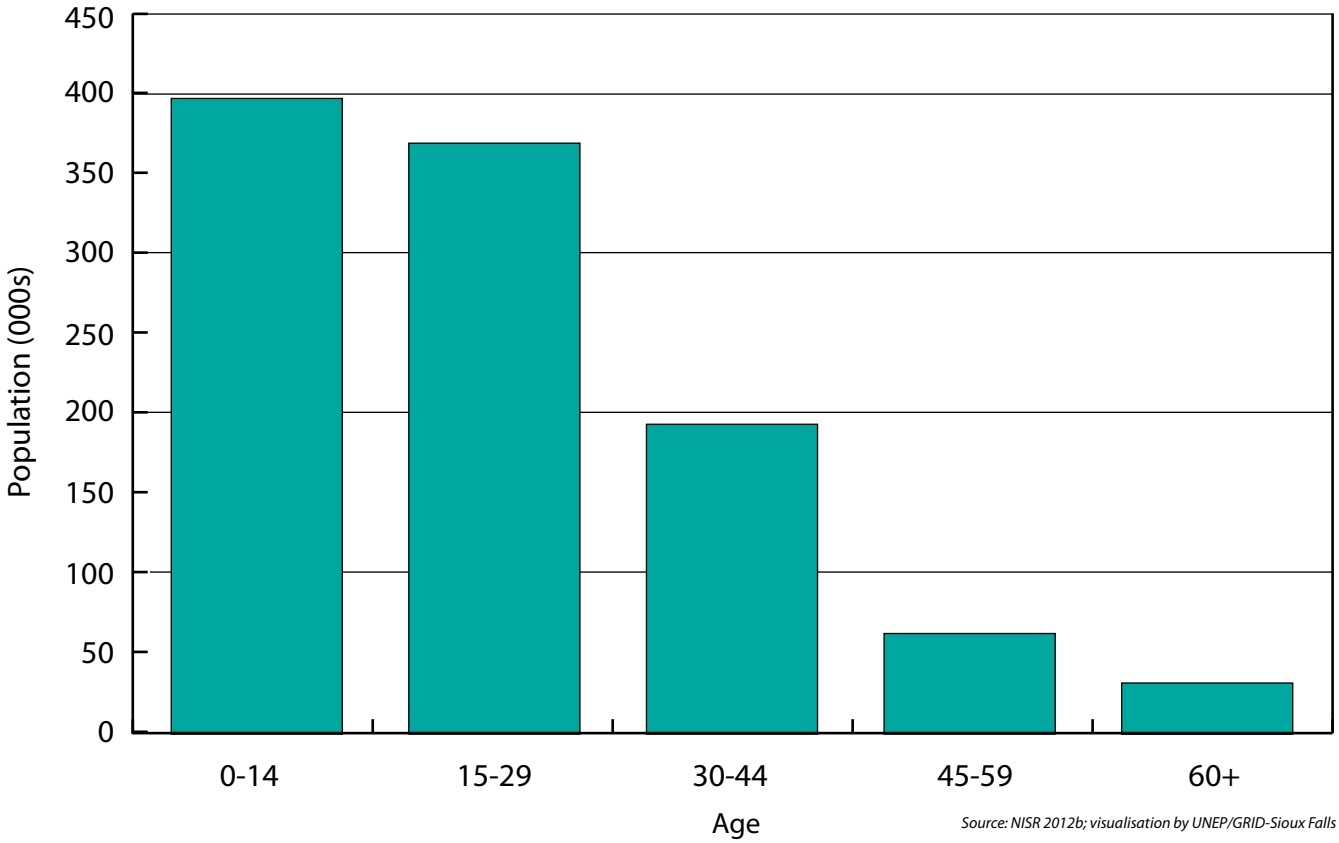
Source: NISR 2012a; visualisation by UNEP/GRID-Sioux Falls

Household Size, Gender and Age Patterns

The average household size in all three Districts is 4.7 persons. Kigali has more men than women, with an average male-to-female ratio of 106 to 100 (Figure 2.9). This fact may indicate that more men than women are migrating into the city in search of non-farm employment, leaving wives in charge of their homesteads and land holdings (REMA 2009). Kigali is also a very young city, with approximately 73 per cent of its total population under the age of 30 (Figure 2.10).

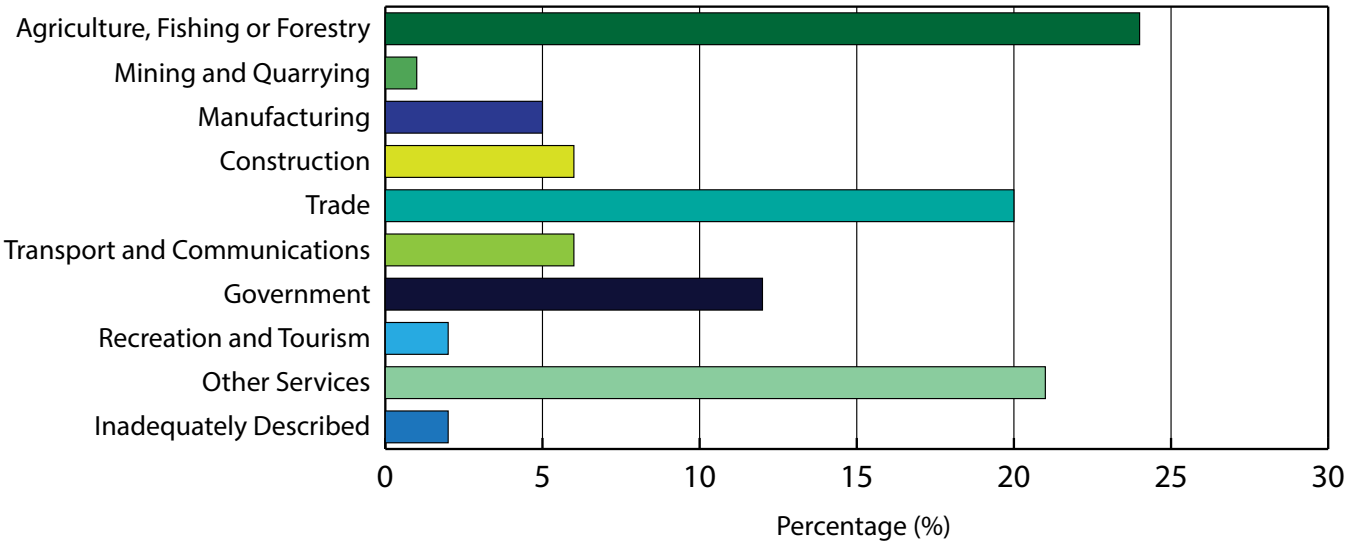
Age and gender can be important considerations in terms of the environment. Although the large number of young people can be a burden on the city's educational facilities and its ability to provide jobs, it can also represent a capacity for innovation and the potential to grow sustainable non-farm industries in Kigali. Thus, should educational and training opportunities be

Figure 2.10: Age distribution, 2010-2011



Source: NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

Figure 2.11: Main employment among persons above 16 years old, 2010-2011



Source: NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

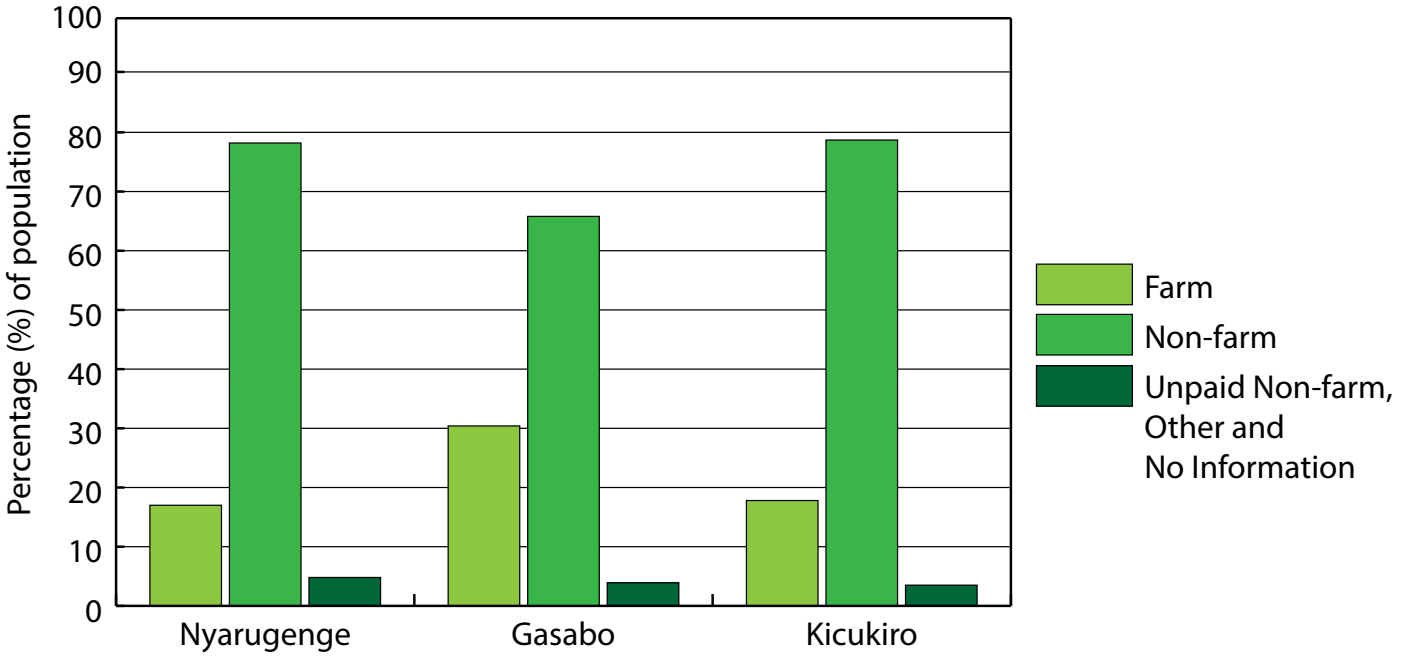
available, especially regarding green jobs, young people could contribute to the economy and environmental sustainability. Women can also contribute to environmental enhancement. For example, research shows that as women gain access to land in Rwanda, they have helped to improve soil conservation and maintenance (Ayalew Ali, Deininger and Goldstein 2011).

Employment

Some 487,000 people over Rwanda's legal employment age of 16 years old hold jobs in Kigali (NISR 2012b). The city's three largest employment sectors are agriculture, fishing and forestry (24 per cent); other services, such as utilities and financial services (21 per cent); and trade (20 per cent). Other important sectors are government (12 per cent); transportation and communication (6 per cent); construction (6 per cent); and manufacturing (5 per cent) (Figure 2.11).

Of Kigali's legally employed residents, the majority is engaged in non-farm related work, which is either independent work or wage labour. Gasabo District has the most significant proportion of residents (30 per cent) in the farm workforce as it also contains the most amount of farmland (Figure 2.12). The CoK recognises the need to increase its

Figure 2.12: Employment type engaged in by people over 16 years old, by District, 2010-2011



Source: NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

skilled-labour workforce in the effort to fulfil its goal of creating a services-led economy and growing the industrial sector (Surbana 2012). To reduce rural poverty and promote youth employment, the CKDP aims to contribute to Vision 2020's target of creating more than one million off-farm, or non-farm, jobs in Rwanda. These jobs are projected to be in the agro-processing, agri-business, manufacturing and services sectors (CoK 2012). The City also used the strategies in the EDPRS 2 for guidance, which include four priorities for productivity and youth employment: skills and attitudes, technology and ICT, entrepreneurship and business development and labour market interventions (MINECOFIN 2013).

Education

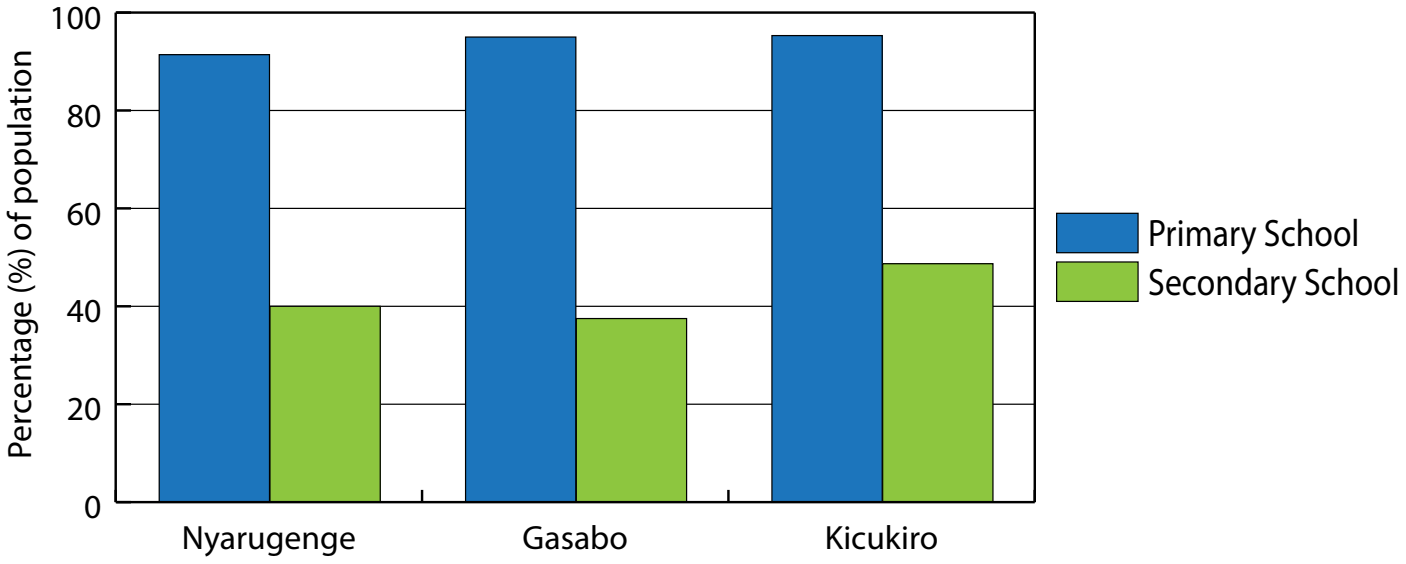
Rwanda's Education Sector Strategic Plan (ESSP) forms the basis of Kigali's goal to provide affordable and quality education to city dwellers, which is in line with the EDPRS objectives as well as the MDG goals to achieve universal basic education and promote gender equality (CoK 2012). Rwanda has a policy of providing 12 years of free basic education. It is well on its way to achieving the MDG target of 100 per cent net primary level enrolment by 2015 with a 2012 rate of 96.5 per cent, surpassing that year's target of 95 per cent (MINECOFIN 2013).

Between Kigali's Districts, there are 175 primary schools, 110 secondary schools and 31 tertiary facilities (Surbana 2012). The net attendance rate for primary school is above 90 per cent (of children ages 7 to 12) for all three Districts. Net attendance rates for secondary school, however, are much lower, with attendance by less than 50 per cent of the population ages 13 to 18 in all three Districts (Figure 2.13). Those who wish to pursue higher education may attend three years of upper-secondary study and an additional four years of upper-tertiary study. Most tertiary educational facilities are located in Kigali. As a result, many young people migrate to the city from more rural areas in search of higher education.

Children walking to school

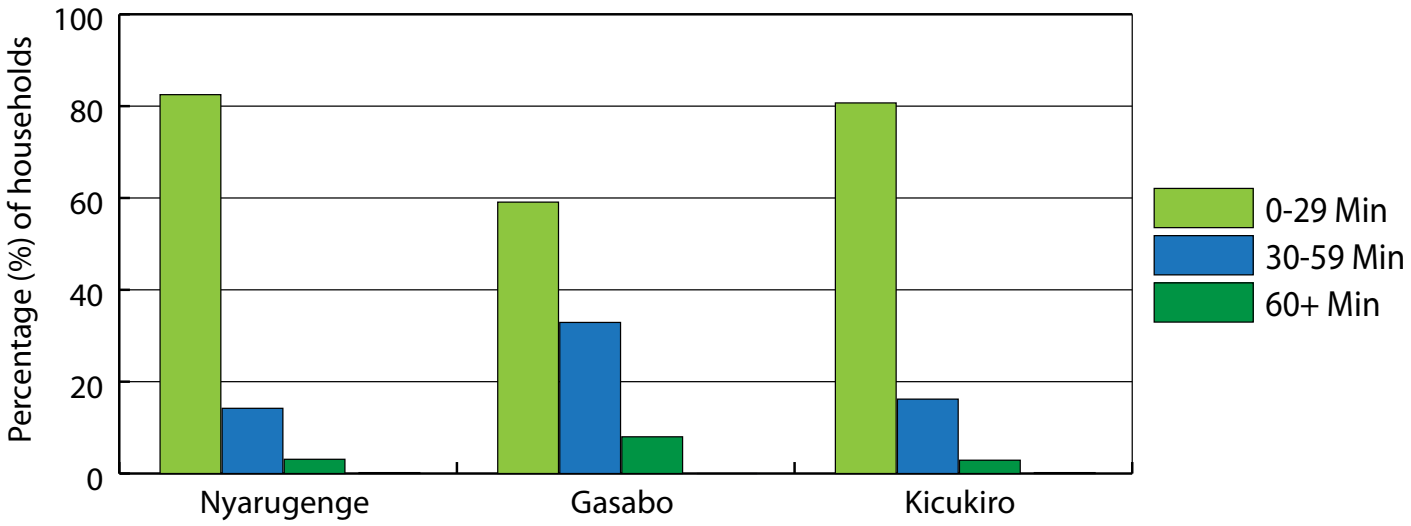
The literacy rate among those aged 15 and older is more than 80 per cent in each District. To improve literacy rates and enhance the skills of those already literate, the CoK aims to establish a public library in each District. Current plans anticipate construction to commence in 2016 or 2017 with each project completed within five years of breaking ground. The CoK will also expand its reading and

Figure 2.13: Net attendance rates for primary school and secondary school by District, 2010-2011



Source: NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

Figure 2.14: Walking time to primary school by District, 2010-2011



Source: (NISR 2012b); visualisation by UNEP/GRID-Sioux Falls

writing culture through annual academic reading and writing competitions and plans to pilot this programme from 2014 to 2015 (CoK 2012).

The walking time to school can be considered an indicator of the level of school access in a city. About 80 per cent of households in Nyarugenge and Kicukiro are within a 29 minute walk of a primary school, but only 59 per cent of Gasabo households fall into this category. The average walking time to a primary school is about 17 minutes for Nyarugenge households, 25.5 minutes for those in Gasabo and 16.5 minutes for school children in Kicukiro (Figure 2.14).

Information and Communication Technology (ICT)

Over the past few years, access to information and communication technology (ICT) has increased through the use of mobile phones, televisions, computers and other digital technologies, helping Rwanda, and Kigali, move towards becoming knowledge-based economies (MINECOFIN 2013). By March 2013, 53.7 per cent of the country's population, over six million people, had subscribed to a mobile phone plan (MYICT 2013). Rwanda's aim is that all government administrative levels and secondary schools will have Internet access by 2020 (NISR 2012d).

Children in rural areas of Kigali often must walk on dirt roads to get to school

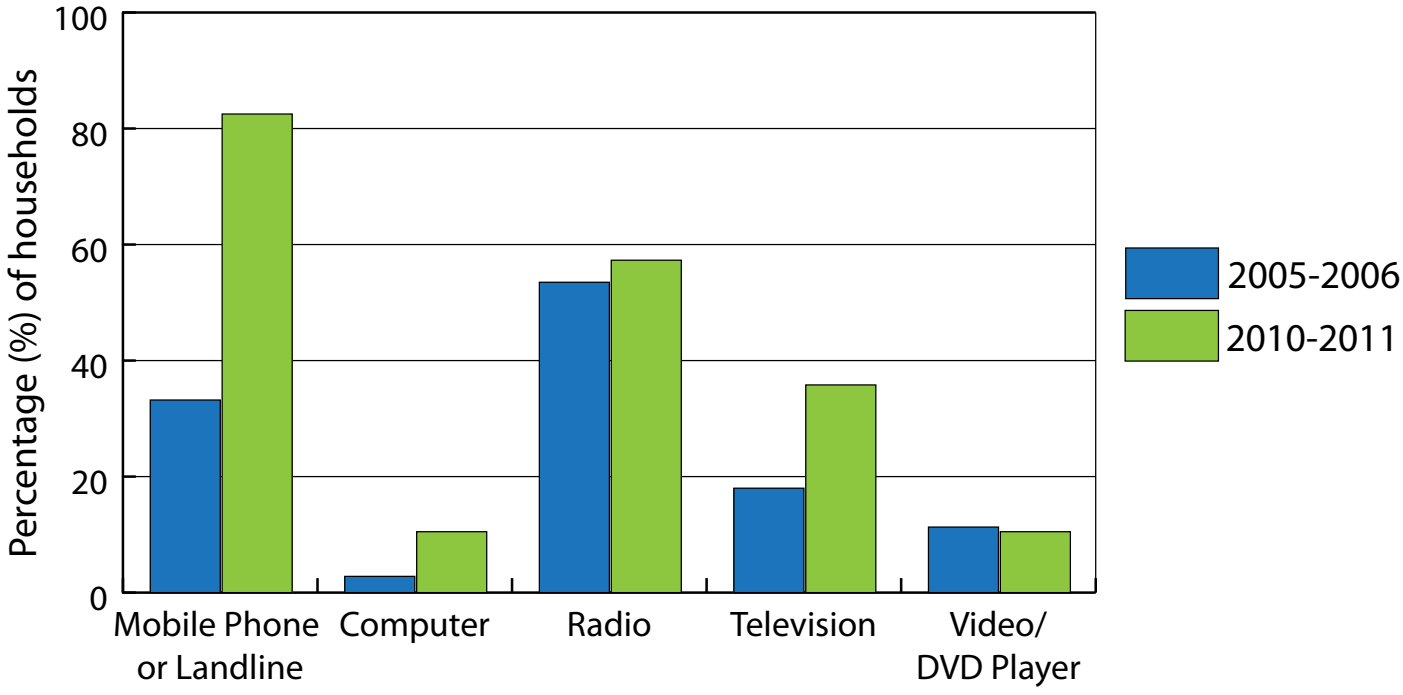
REMA 2013

The City of Kigali's administration offices now have an internal digital document tracking system, allowing employees to share documents freely and in real time. This new system has increased the efficiency of decision making. Plans are underway to upgrade and procure both hardware and software systems in numerous ways to further increase efficiency. The CoK also has a number of priorities to advance urban management through ICT and training in its use, including improving the management of city affairs and transportation navigation in the city (CoK 2012). Recently, in an effort to promote the use of ICT, create jobs and reach the EDPRS target concerning ICT, the Ministry of Youth and ICT and the Korean International Cooperation Agency (KOICA) signed an agreement worth $5.6 million USD to construct an ICT Innovation Centre at the Integrated Polytechnic Regional Centre in Kigali (RoR 2013a). The centre is expected to increase human resources education and contribute to the growth of the ICT industry.

In Kigali, the use of mobile phones appears to be the fastest growing means of ICT. Between 2005 and 2011, mobile phone users more than doubled from just over 30 per cent to 80.4 per cent of the population (Figure 2.15). Fifty-eight per cent of Kigali's urban households use public phones, with 61 per cent able to reach a public phone in less than 20 minutes. Computer usage more than tripled from almost 3 per cent to 10.5 per cent in Kigali, compared to less than 2 per cent of residents in other Rwandan provinces. About 19 per cent of households have Internet access at home and log on primarily via a mobile phone. At 75 per cent, the proportion of households that have never used a computer in the city is very high, however, with only 8.6 per cent using the Internet regularly (CoK 2012). Almost 60 per cent of the city's residents own a radio with ownership rates similar across income levels. In Kigali, 42 per cent of citizens have TV sets (NISR 2012d). Results from EICV3 show that 97.1 per cent of Kigali households report they receive information about environmental issues, of which 55.2 per cent

The use of computers and other types of ICT is increasing in Kigali

Figure 2.15: ICT ownership in Kigali, 2005-2006 to 2010-2011



Source: NISR 2012d; visualisation by UNEP/GRID-Sioux Falls

hear about them on the radio, 32.7 per cent at meetings and the remainder at school or through other media (NISR 2012c). Rwanda has taken positive advantage of the popularity of radio programmes to increase information sharing and provide informal education, especially regarding the environment. Radio programmes provide information through the production of plays, dramas and announcements.

Increasing communication technologies can play both positive and negative roles in Kigali's future development. Environmental awareness can be spread among a broader audience when there are multiple communication platforms. Public service announcements can be broadcast across radio and television and if the mobile phone network can support it, text messaging can alert residents everywhere of impending storms or disasters. MIDIMAR expects ICT to improve disaster reporting in the future. The Ministry has distributed mobile phones to the social affairs officer for each Sector, encouraging them to report disaster situations as they occur, culminating in a direct report that can be widely distributed (MIDIMAR 2012).

There is also a project to help farmers access information on market prices that affect which crops they grow and the price they can get. This first-hand information can eliminate middlemen who dictate prices, often at the expense of the farmer. The Rwanda Information Technology Authority (RITA) is implementing the e-SOKO ICT system, an ICT for Development initiative of the eRwanda Project. This Agricultural Market Pricing Information System empowers farmers to make more informed market pricing decisions by using private or village mobile phones and accessing training in using and maintaining the e-SOKO Project's equipment (MINAGRI 2010). In addition, ICT can help transportation systems become more efficient by helping to reduce traffic congestion and vehicle emissions. For example, real-time information collected using ICT instruments can be used to optimally control traffic flows and maintain the roadway system (TERI 2011). The challenging aspect of ICT is the fact that as its use continues to rise, the infrastructure to properly recycle or reuse electronics must be developed to prevent further accumulation of hazardous electronic waste (see Chapter 4).

A sign leading the way to Rwanda's largest healthcare centre

Health

Kigali's capacity to provide adequate and quality healthcare is rapidly improving. In accordance with the Twubakane Decentralisation and Health Project, Kigali is striving to move the responsibility of developing healthcare infrastructure and building service capacity to the District level from the national government to strengthen local healthcare services (OZ Architecture 2007). Public sector, government-assisted facilities, private sector and traditional healers currently deliver healthcare services. Doctors are capable of many medical specialties, including neurosurgery and oncology and the CoK aims to continue recruiting and training a variety of healthcare providers to increase the quality of services (CoK 2012).

As of 2010, there were three referral hospitals, four district hospitals, one military hospital and one police hospital in Kigali (Surbana 2012). Kigali's King Faisal Hospital in Gasabo District is Rwanda's largest hospital. By 2012, the hospital had incorporated Radiology, an Intensive Care Unit, a Neonatal Intensive Care Unit, Obstetrics and Gynaecology, Orthopaedics, Surgery, Internal Medicine and Paediatrics, greatly enhancing its level and quality of services (MINISANTE 2012). The CoK has also identified the need for additional healthcare services at the District level (Surbana 2012). Since 2007, the Muhima hospital in Nyarugenge District was promoted to a Centre of Excellence in Maternity and Neonatology and the Masaka Hospital in Kicukiro District to a National Teaching and Referral Hospital. These upgrades resulted in the elimination of two

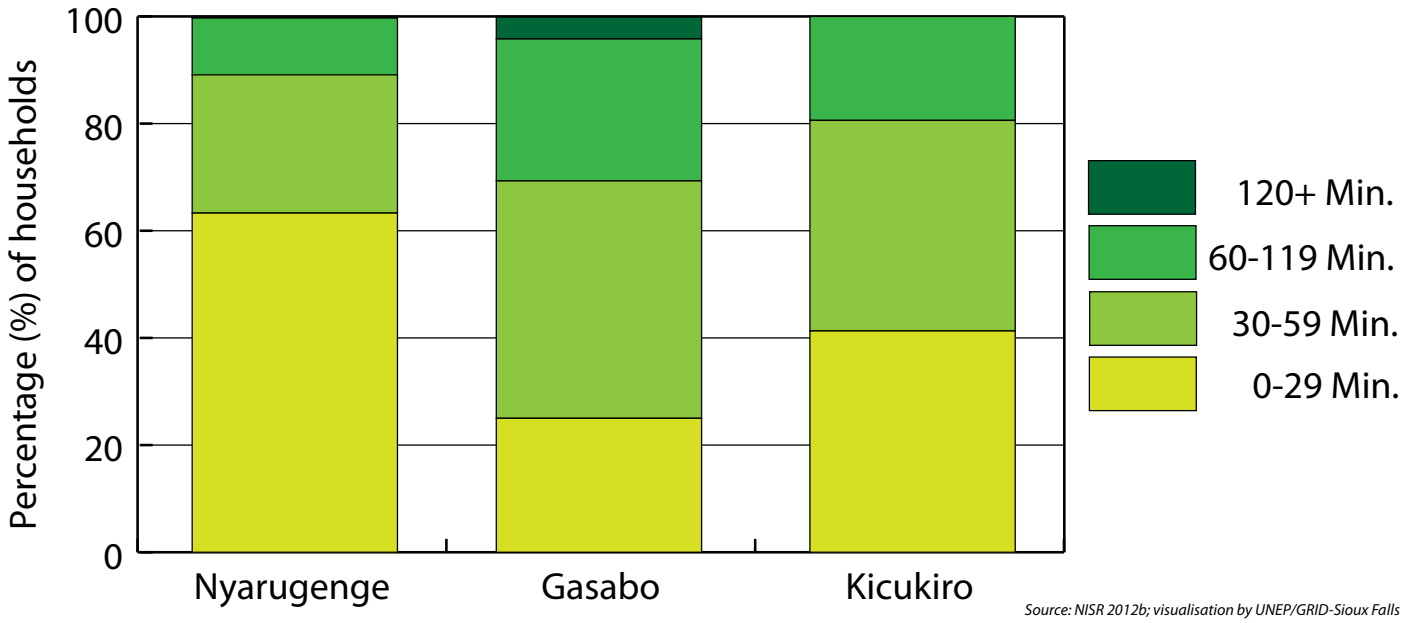
King Faisal Hospital in Kacyiru Sector, Gasabo District

District hospitals, leaving a gap in the system. The CoK hopes to begin construction on two needed replacement hospitals in the very near future (CoK 2012).

The public's access to healthcare facilities is not always easy. Although King Faisal Hospital is located in Gasabo District, the most populated District, it can be difficult to access because of the long distance some may have to travel to obtain its services. Most residents of Gasabo District must walk for 30 minutes or more to reach a health centre. In contrast, the majority of residents in Nyarugenge District have less than a 30-minute walk. For about 40 per cent of Kicukiro District residents, it takes less than 30 minutes to walk to a health centre (Figure 2.16). The difference in access to health care among Districts may be due to a disproportionate number of local health centres or a lack of resources to travel to a health centre in some areas. It may also reflect the need to improve public transportation.

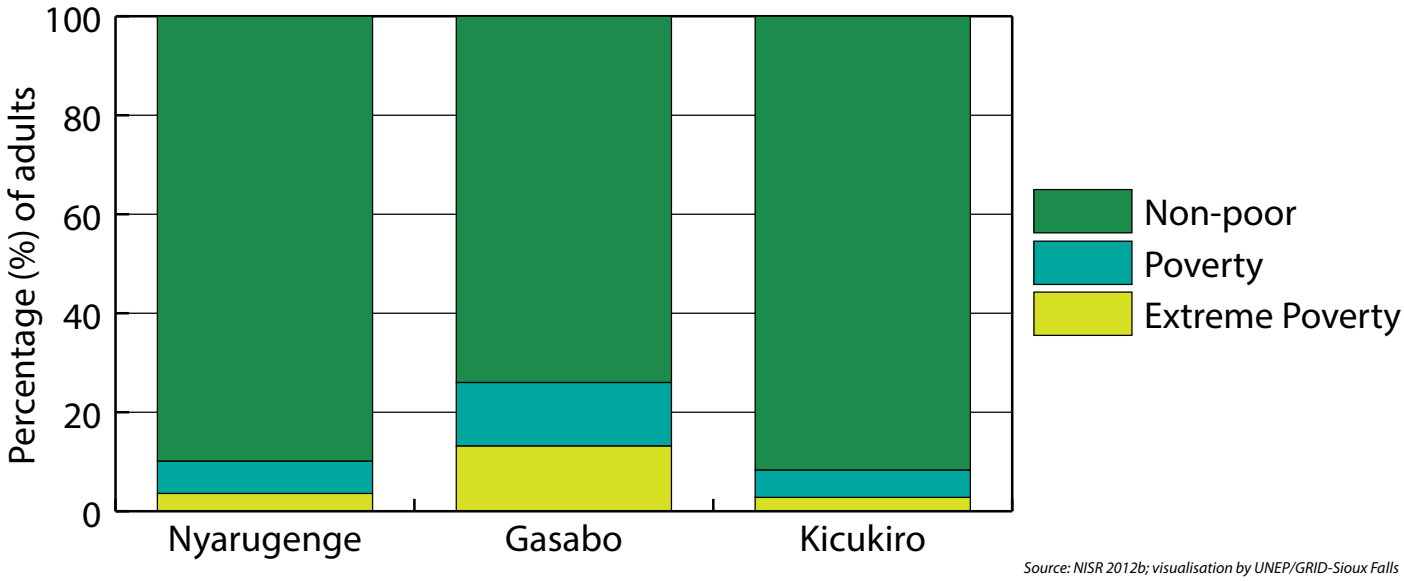
Instances of HIV in Kigali have declined significantly over the past few decades. MINISANTE recorded that less than 25,000 children and adults in Kigali were receiving Antiretroviral Treatment (ART), which is less than 3 per cent of the population (MINISANTE 2010). The CoK wants to more adequately map the infected population and use that information to build capacity in addressing the

Figure 2.16 Walking time to health centre, by District, 2010-2011



Source: NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

Figure 2.17: Proportion of people in situations of poverty by District, 2010-2011



Source: NISR 2012b; visualisation by UNEP/GRID-Sioux Falls

pandemic (CoK 2012). Malaria is a rare occurrence in Kigali. According to EICV3, only 0.2 per cent of children and 0.1 per cent of women reported cases of malaria; cases in men were not reported in this survey (NISR 2012c). Acute respiratory infections (ARI) are less rare, with 4.6 per cent of children reported as having ARI symptoms, the second-highest occurrence rate of all Rwandan Provinces. The Western Province has the highest rate (6 per cent). Diarrhoea appears to be more common among children, with the EICV3 survey reporting that 11.4 per cent of children had had diarrhoea within a two-week period when the survey was conducted (NISR 2012c).

Poverty

The poverty line is a baseline measurement of adult household consumption, based on income and the ability to purchase adequate food and non-food items. Adults who are not able to purchase non-food items because of a lack of sufficient money are thus classified as being below the extreme poverty line (NISR 2012b). The revised Vision 2020 target for poverty reduction in Rwanda is to reduce poverty to below 30 per cent by 2020, but the CoK is aiming towards reducing poverty from the present level of 14.8 per cent to below 10 per cent of the population within the next 5 years (CoK 2012).

Nyarugenge and Kicukiro Districts have reduced poverty levels to below 20 per cent of the population, but Gasabo District falls somewhat short. The breakdown in the number of residents above and below the poverty line is shown in Figure 2.17. Gasabo District has the least number of residents above the line (74 per cent) and the most number below a level of extreme poverty (13.2 per cent). In Nyarugenge District, about 90 per cent of residents are living above the poverty line. Kicukiro District has the most number of residents who have risen above the poverty line (91.7 per cent).

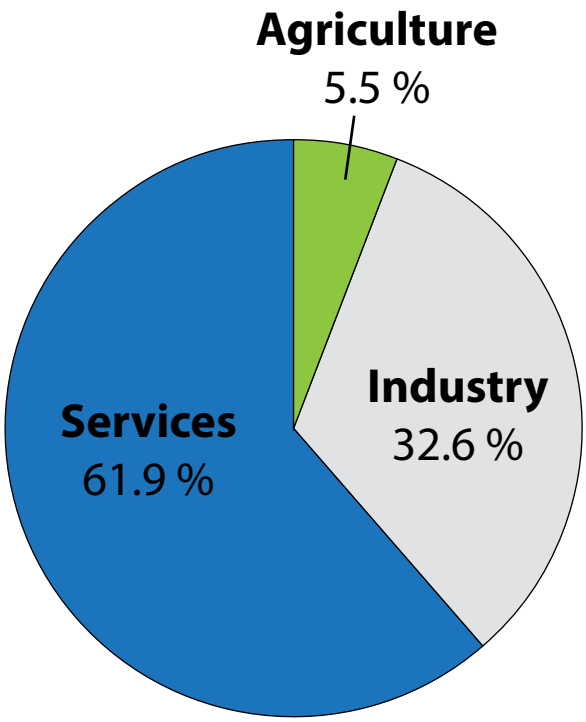
The City of Kigali's social protection sector has proposed various programmes to reduce extreme poverty, including relocating people living in informal settlements and high risk areas and targeting women and unemployed youth with programmes to provide job opportunities to boost their productivity and generate income (CoK 2012).

Economic Activity

Each District plays a key role in Kigali's economy. Generally speaking, Gasabo District is the administrative centre, where government and private administrative offices are located and new jobs are expected to flourish; Nyarugenge District is the financial hub, housing financial and insurance institutions; and Kicukiro District is the knowledge centre. By growing these Districts and continuing to create business opportunities, Kigali strives to be a middle-income economy by 2020 (CoK 2012).

Kigali generates about 50 per cent of Rwanda's Gross Domestic Product (GDP), which is comprised of revenue from three main sectors (Figure 2.18): industry (32.6 per cent), services (61.9 per cent)

Figure 2.18: Sectors of Kigali's GDP



Source: Surbana 2012; visualisation by UNEP/GRID-Sioux Falls

and agriculture (5.5 per cent) (Surbana 2012). In addition to farming, the agriculture sector includes forestry and fisheries.The industrial sector refers to construction, mining and quarrying operations; utilities; and manufacturing (Surbana 2012). Manufacturing activities in Kigali include bricks, textiles, paint, tanneries, iron and sugar (REMA 2009).

The services sector encompasses wholesale and retail trade, transportation, storage, ICT, accommodation, food storage, finance and insurance, real estate and business services, scientific and technical professionals and education and health. Business services have increased along with the expansion of the Central Business District (CBD) and construction of the Kigali City Tower.

By attracting new investors, expanding museums, establishing natural sites including eco-corridors and creating cultural sites, the CoK hopes to increase tourism revenue to expand the services sector (Surbana 2012, CoK 2012). The CoK aims to increase tourism's share of GDP to 6.5 per cent by 2020 as it moves away from agricultural income and jobs. The private sector is very active in tourism through the activities of the Tourism Chamber, which is comprised of hotels, tour operators, transport and taxis and private educational institutions (Surbana 2012). Each District Council is responsible for developing and promoting tourism opportunities within its boundaries. Increasing ecotourism, a subsector of tourism, will benefit both the economy and the environment as it is specifically designed to be environmentally conscious as well as to improve the well-being of local populations (TIES 2012).

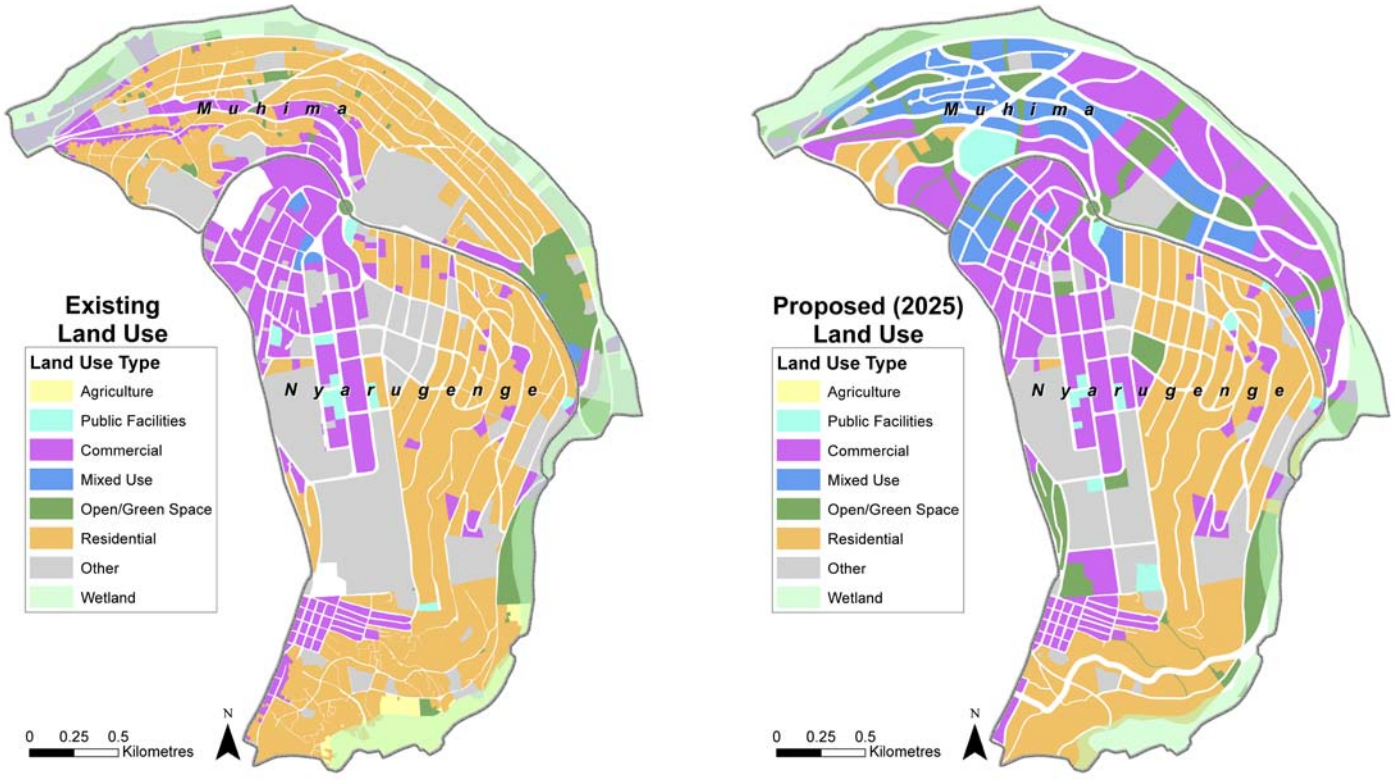
A new 237 room five star Marriott Hotel is scheduled to open in July 2013 (yellow arrow) and is expected to boost tourism in Kigali

In an effort to bring more skilled labour to Kigali and grow the services sector from just over 51 per cent to 55 per cent of the city's GDP by 2020, the City has planned two phases of expansion and development of the CBD, which encompasses Muhima and Nyarugenge Sectors in Nyarugenge District. It is seeking investors and interested parties to fill the new spaces (CoK 2012). Along with developing the CBD, the city is also looking to add more green space to diversify the area and provide recreation for its citizens (Figure 2.19). The first phase of expansion is to develop 150 ha in the Muhima Sector and in the second phase the existing CBD area will be upgraded (Kigali City n.d.). On course with the KCMP, 9.7 ha in Kiyovu in Nyarugenge Sector in Nyarugenge District has already been developed (CoK 2012).

Over the past few years, roads have been paved, low-income housing replaced (see Ubumwe Hotspot in Chapter 3) and impressive buildings constructed, such as the Kigali City Tower. As new roads are constructed and old roads paved, appropriate stormwater management measures and increased green space will be incorporated into transportation planning. Such measures are essential to offset the increase in impervious surfaces that could contribute to flooding — during severe storms, water runs off paved surfaces instead of seeping into the ground. Green spaces within dense urban areas also help to keep the city cool and prevent an urban heat-island effect from occurring (EU 2013). The proposed land use plan also shows no structures within the wetland areas. The land use plan is intended to allow degraded parts of wetlands to rehabilitate and to restore ecological functioning.

Kigali City Tower, located in Nyarugenge Sector, surrounded by the old commercial and mixed-use buildings, most of which have already been vacated for demolition to make way for new designated land uses according to the KCMP

Figure 2.19: Existing land use and proposed land use changes by 2025 for the CBD in Nyarugenge District



Note: white areas indicate roads or parking lots

Source: Land use data provided by Surbana; visualisation by UNEP/GRID-Sioux Falls

REMA's State of Environment reporting series previously identified the Gikondo Valley wetland as an area subject to severe pollution and degradation (REMA 2009, REMA 2011). Many of Kigali's heavy and light industries as well as a few commercial establishments and residences are located in the Gikondo Valley (Figure 2.20), inhibiting the wetlands from fully functioning (Gimco Ltd. 2011).

The industrial buildings typically have out-dated technologies that are environmentally inefficient and the commercial and residential buildings lack proper waste-disposal mechanisms and sewage treatment (REMA 2009). Polluted waters from these factories and buildings flow into the Nyabarongo River via the Rugenge and Nyabugogo Rivers. The proximity of industrial buildings to residences in the Gikondo Valley is also a concern since construction was unplanned and pollution unregulated (REMA 2009). In addition, new housing developments in Kigali have created impervious surfaces, such that stormwaters flow into open drains, much of which finds its way into the Gikondo Valley (Gimco Ltd. 2011).

Figure 2.20: Location of the Gikondo Industrial Park installed in a wetland zone in the 1970s

Source: Wetland data provided by REMA, image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

Since the majority of Rwanda's industries are in Kigali, the city plays a substantial role in contributing to Vision 2020's revised goal to increase the industrial growth rate to 14 per cent (CoK 2012). Finding suitable land to build infrastructure to support this goal is a challenge, as are the environmental implications that accompany industrial development. Kigali's solution to this issue is to establish well-sited, consolidated, mixed-use areas called 'Special Economic Zones' (SEZs). In 2008, a Cabinet decision declared an area in Ndera Sector, Gasabo District, suitable for heavy industry (manufacturing) and light industries (export processing and services) (MINICOM 2011). The area cited for SEZ development was previously farmland (Figure 2.21), but cattle grazers and subsistence farmers in the area reportedly welcomed the development, believing alternative lands for their activities could be found and that jobs would become available (RIPA 2004).

Two previously sited areas, the Kigali Free Trade Zone and the Kigali Industrial Park, were merged to form the Kigali SEZ (Figure 2.22). Combining these

Figure 2.21: Before the development of the Kigali Special Economic Zone, 2005

Source: Wetland data provided by REMA, 2005 image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

two efforts can help to address the key business constraints of land availability and lack of adequate industrial infrastructure (RoR 2010). The focus of the SEZ will be to target export-oriented firms, increase overall exports, create off-farm jobs and increase private sector investment.

In addition to improved land planning and development considerations, REMA has proposed an urban wetland and recreation park in Nyandungu Valley to protect the Nyandungu wetland, generate ecotourism revenue, improve the quality of life for residents in the surrounding Sectors and demonstrate the value of conserving biodiversity in Kigali's wetland ecosystems (Gakuba 2012, REMA 2012). The proposed park (white outline in Figure 2.22) covers a total area of 109 ha, has a total perimeter of 6730.8 m and is drained by the Mwanana and Kabagenda streams that flow into the Mulindi stream, a tributary of the Nyabarongo River (Gakuba 2012).

Figure 2.22: The status of development of the Kigali Special Economic Zone, 2012 and the proposed REMA Wetland Park

Source: Wetland data provided by REMA, 2012 image: DigitalGlobe, proposed wetland park outline adapted from REMA 2012; visualisation by UNEP/GRID-Sioux Falls

Conclusion

This chapter has shown the progress being made in Kigali to address socioeconomic issues to enhance the standard of living and well-being of citizens. At the same time, it is cognisant of the links between development and the environment and is taking steps to decrease the burden on the underlying ecosystems. Examples include its aim for urban population densities, its promotion of green urban growth and the removal of industrial activities from wetlands. The GoR deems it a priority to find solutions for the environmental problems associated with industrial development in Gikondo and Nyabugogo and hopes that these areas will serve as pilot projects for potentially establishing a framework for tackling similar problems affecting Kigali (RIPA 2004). The City has an extensive set of plans to cater to the growing population and to satisfy economic needs and the desire for a better standard of living for both rural and urban populations. To effectively implement these plans, environmentally sensitive land management and awareness needs to continue to accompany the efforts. These aspects of development will be explored in Chapter 3: Land, Settlements and Infrastructure.

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People relaxing in the garden of the new public library in Kacyiru Sector

Land, Settlements and Infrastructure 3

Land is a precious resource in Kigali because of the hilly topography and abundance of wetlands, which means that there is little land available for further urban expansion. Urban development already covers about 17 per cent of the land base while about 21 per cent consists of steep slopes that are barred from being developed (Surbana 2012a).

This chapter provides an overview of issues arising from urban land use, focusing in particular on housing and other infrastructure in Kigali. It looks particularly at the status of housing and settlements because so much development in the city has been unplanned, with consequences for ecosystems and the health and well-being of Kigali's citizens. The chapter also describes other human activities that put pressures on the land base, including agriculture, energy, transportation and water supply and use. It continues the assessment of human impacts on the environment by describing and analysing pollution trends that are the result of these human pressures.

The chapter also shows how the City of Kigali (CoK) is responding to these human pressures and their impacts in order to reach Vision 2020's goals for urban development, which call for the proper development and maintenance of infrastructure to improve the livelihoods of residents and Kigali's economy. To reach the vision of Kigali as a state-of-the-art and aesthetically appealing place to live and visit, urban infrastructure, such as housing, roads, drainage systems and green spaces for aesthetics and recreation, among others, will need to be developed in an environmentally, economically and socially sustainable way (MINECOFIN 2013).

Land Use Planning

Land use planning in Kigali is currently guided by the National Land Use and Development Master Plan (NLUDMP) and will become increasingly guided by the Kigali Conceptual Master Plan (KCMP) as plans are implemented. Historically there has been a general development pattern of informal and scattered housing, but the future of Kigali lies in organised land ownership records, planned housing, appropriate zoning and intermixed green space for hazard mitigation and recreation. To adequately accommodate the rapidly growing population, the CoK commissioned carefully envisioned land use planning, which is nearing completion.

Land Tenure

The 2005 Organic Land Law defines Rwanda's land administration system. All land belongs to the State, cities and Districts. Public land is reserved for public use or environmental protection and private land can be allocated to natural or legal persons, at which point it becomes 'individual land' that can be leased for up to 99 years. Land rights can be transmitted through sale, donation or inheritance, and land registration is mandatory (RDB n.d.). Land registration has increased land values as collateral to obtain credit financing and has enhanced market transactions, helping to increase agricultural production (Rurangwa 2013).

The Organic Land Law also codified key provisions eliminating bias against female land ownership (Ayalew Ali, Deininger and Goldstein 2011). Land registration thus allows women to inherit

and own land either as an individual or through marriage (Rurangwa 2013). This is an important consideration since women play a large role in agriculture and environmental conservation.

Individual land customarily owned before the 2005 law can be registered under the new law. Customary tenure, which was widespread, especially in rural areas, was governed by customary and cultural values (Kigali City 2007). Those who had no written or formal rights at that time were often unable to validate their rights to the land since there was no systematic and standardised national land registration or titling system. For example, a 2011 government survey found that most people in Kigali owned land, although only 70 per cent of those responding to the survey had documents attesting to the fact (RGAC 2011). Another study of land tenure systems in informal settlements in Kigali used a case study of the Muhima sector. It found that most plots were bought informally and land rights among 71 per cent of households were not recognised in the public land registry. Such land had no proper property boundaries and no legal value and could not fetch the proper price if expropriated for urban redevelopment (Bizimana et al. 2010).

To address this situation, Rwanda initiated an extensive land tenure regularisation process to provide an up-to-date, transparent and authoritative public record of landholdings (Lusugga Kironde 2012). One of the short-term results from a pilot study of its effects shows that legally married women improved their access to land. As well, the regularisation process resulted in significant improvements in soil conservation investments and maintenance, especially among female-headed households (Ayalew Ali, Deininger and Goldstein 2011).

The Centralised Office of the Registrar nested within the Department of Lands and Mapping in the Rwanda Natural Resources Authority (RNRA), formerly known as the National Land Centre, is in charge of developing and regularising land tenure as well as setting standards for land administration (Ayalew Ali, Deininger and Goldstein 2011, MINIRENA 2009). At District, town and municipality levels, District Land Bureaus (DLBs) are responsible for land administration and use planning, while at Sector and Cell levels, land committees serve this function, allowing implementation to be more decentralised and participatory.

Land Use Planning Framework

In 2002, Rwanda adopted a decentralisation policy, which empowered local governments to plan and implement their own development programmes (UN-Habitat 2009b). This led to the transfer of urban planning and management to the well-staffed and efficient Kigali City Council (KCC). It instituted urban construction rules and regulations that helped address some of the problems related to unplanned settlements (Twarabamenye and Mukashema 2012). With Kigali's population expected to grow at an annual rate of 7 to 8 per cent (World Bank 2012a), the KCC decided to accelerate urban planning. The City of Kigali thus commissioned the KCMP (see Chapter 1), which was adopted by Rwanda Parliament in 2008 (CoK 2012, RDB and MINISPOC 2011). It provides a roadmap for the city's development until 2030.The City of Kigali also commissioned the development of detailed master plans for Nyarugenge, Kimironko and Gahanga and sub-area plans for Kimihurura, Rebero, Kanyinya and Masaka (CoK 2012).

Vision 2020 stipulates the need for urban master plans and local town plans in an effort to develop basic infrastructure in urban areas. The EDPRS reinforces these aims, adding the more specific goals of achieving 10,000 hectares (ha) of marked out and improved plots; constructing imidugudu; reconstructing Districts where there are poor living conditions; and providing adequate infrastructure for public facilities. The EDPRS also has a number of focused sub-programmes to help achieve these goals. Habitat and Urbanism is a sub-sector ofthe Ministry of Infrastructure (MININFRA) and aims to improve urban and semi-urban settlements, public services and public buildings. Since 2005, it has been modernising housing in Rwanda, focusing in particular on curbing the spread of unplanned housing and improving living standards in informal neighbourhoods (MININFRA n.d.). Its aims are aligned with Vision 2020, the NLUDMP and the KCMP.

More effective monitoring of urban development has curbed the construction of hundreds of informal houses. Policies incorporated into the NLUDMP have helped to identify and relocate housing away from high risk areas such as steep slopes prone to washout (CoK 2012). The KCC has initiated public-private partnerships related to land and housing development and providing associated services. Rwanda also began training urban and regional planners so that Kigali and other urban areas will have professional help to continue improving urban development so they are sustainable (Twarabamenye and Mukashema 2012). The Kigali Institute of Science and Technology (KIST) will graduate its first class of locally trained architects in 2013, helping to create a workforce for current and future green building jobs (KIST 2013).

In addition to working towards more sustainable development, Kigali has adopted a 'green and clean' slogan to turn theory into practice and to promote several greening projects it is undertaking within the city. These include adding trees and flowers along 43 kilometres (km) of major roads, planting 15 ha of green gardens, constructing aesthetic retaining walls along major roads and installing street lights on 40 km of roads. In addition, it organised a cleanliness and environmental protection contest, which helped increase the number of youth cooperatives that promote the City of Kigali's greening campaign (CoK 2012).

Green, grassy retaining wall along one of Kigali's busy streets

Afforestation is also a major aspect of the greening campaign and a goal of future city planning. The CoK plans to increase forest cover on slopes greater than 60 per cent in an effort to achieve the Vision 2020 target of increasing forest cover to 30 per cent (Surbana 2012a, CoK 2012). Due to ongoing commercial and residential development, increasing forest cover will be a challenge, but the CoK is attempting to overcome it by preserving the current forest cover and increasing the amount of vegetation by planting flowers, ornamental trees and fruits; it is also rehabilitating the Gikondo and Nyabugogo wetlands (CoK 2012). The NLUDMP also states that it intends to increase forest cover by using forests for recreation and supporting landowners who convert their present land use on steep slopes to forested areas (GoR 2012).

Settlements

To help accommodate the growing population, in 1991, 2002 and 2005, the city administration expanded the city's boundaries to include rural and agricultural zones where there was no urban infrastructure and services (Twarabamenye and Mukashema 2012). Wetlands and steep slopes were not spared, and by the mid-2000s, about 19 per cent of the city's built environment occurred on land that is not ideal for development (Manirakiza 2012).

Kigali's built infrastructure in 2010 was designed to accommodate approximately 450,000 people, although population was about one million. By 2012, some 84 per cent of Kigali's population lived in the city's urban core (NISR 2012d). Today, urban development includes modern office buildings and hotels in the Central Business District (CBD) surrounded by the co-existence of luxury and low-income housing (CoK 2012). From the CBD, urbanisation expanded outwards to accommodate low- and medium-class residences, as well as

Table 3.1: Types of housing in Kigali compared to Rwanda as a whole, by percentage, 2010-2011

	Imidugudu	Unplanned Clustered Rural Housing	Isolated Rural Housing	Agglomeration	Unplanned Urban Housing	Modern Planned Area	Other
Rwanda	37.5	11.1	37.2	4.8	8.4	0.6	0.5
Kigali	7.8	2.4	21.9	2.8	62.6	2.4	0

Source: NISR 2012c; visualisation by UNEP/GRID-Sioux Falls

modern, high-class housing further away in the suburbs (Manirakiza 2012). Of the 17 per cent of land developed for urban uses, 54 per cent is residential and the rest consists of businesses and other urban infrastructure (Surbana 2012a).

Housing Types

There are four main housing types in Kigali: (1) well-planned single-family homes, usually along summits and ridges; (2) informal, densely built urban settlements typically found along slopes; (3) imidugudu that have been newly incorporated into rural sectors; and (4) dispersed rural settlements in farming areas (Surbana 2010).

According to the EICV3 survey, 62.6 per cent of settled areas in Kigali consisted of unplanned urban housing, 2.4 per cent was planned, 2.4 per cent was unplanned clustered rural housing and 7.8 per cent was in imidugudu (Table 3.1); the survey reports little change since EICV2. Over 60 per cent of the houses in Kigali are single-house dwellings and the majority of the residents, especially in Gasabo District (61 per cent), own their homes. Kicukiro and Nyarugenge Districts have high levels of tenant occupation (CoK 2012).

The quality of housing in Kigali is improving, spurred by changes to building codes, guidelines in the KCMP and the development of the NLUDMP (World Bank 2012a). According to the 2002 Census, more than 90 per cent of Kigali's houses at that time were made of temporary materials, 82.6 per cent were covered with roofs of light corrugated iron sheets and local tiles, 11.6 per cent had thatched roofs, 3.2 per cent were covered with cardboard and sheeting and 36.4 per cent had unpaved floors (Twarabamenye and Mukashema 2012). By

Planned single-family homes in Kigali

REMA 2012

A modern residential suburb in the eastern part of Kigali

2010-2011, general housing quality had improved, measured by the rise in percentage of houses with metal or corrugated iron roofs (up to 94.6), walls made of superior materials (over 50 per cent of houses compared to 31.1 per cent in 2005-2006) and a rise in houses with floors made of cement, all of which create more solid houses that are less susceptible to water damage, can sustain multiples stories (World Bank 2012a) and are associated with increased wealth (NISR 2012c). Reinforced roofing materials and better quality walls provide better protection against heavy rains. Another indication of improved housing is the high number of households that relocated since the mid-2000s, suggesting a degree of success in the housing sector's provision of improved and clustered settlements for relocation purposes (NISR 2012c).

Informal Settlements

Development of informal, or unplanned, settlements has contributed to rapid urbanisation of Kigali and has associated environmental and social impacts (Bizimana, et al. 2010). These types of settlements have restricted redevelopment and the provision of improved infrastructure (Surbana 2010). By 2012, unplanned settlements housed 83 per cent of the city's population (World Bank 2012a).

Informal housing refers to homes that have at least one of the following characteristics: built with non-durable materials; lack adequate infrastructure and services; below the minimum legal house or plot size; hold no legal land tenure; built without legal authorisation; or located on a hazardous site. There are three types of unplanned or informal settlements in Kigali: unplanned slum areas with limited access to facilities and poor living conditions; unplanned low-rise residential urban housing around the city centre lacking services; and unplanned residential areas in rural farmlands on the city's periphery (Surbana 2012a).

There are a number of slums in Kigali. These are very poor, densely populated areas such as Urukondo, where four to eight people may be living on plots as small as 10 sq. m to 15 sq. m with limited connection to electricity and where sanitation services are not as accessible. Often, as many as 20 to 40 households share one latrine (Surbana 2010). There are several slums in the Kicukiro District, in Gatenga, Nyarugunga and Gahanga (CoK 2012). Such areas are the highest priority for redevelopment or proper relocation programmes in accordance with the City of Kigali's plan to transform existing informal housing areas into planned, compact, medium-to-high density residential neighbourhoods (Surbana 2010).

Figure 3.1: Masaka Sector, in rural Kigali: informal housing outnumbers a small planned community

Source: Image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

Of all three Districts, Kicukiro has the largest amount of unplanned urban housing (76.6 per cent), but it also has the greatest number of modern planned residences in Kigali (CoK 2012). The Biryogo, Nyamirambo, Kimisagara and Gatsata neighbourhoods typically consist of unplanned low-rise residential areas. Homes in these settlements are built on plots of 200 sq. m to 250 sq. m, are usually made of wood and mud and have two or three bedrooms, one or two pit latrines, electricity and piped water supplies. They are also densely populated areas.

Almost half of Kigali consists of farmland with scattered unplanned rural housing, but some rural areas have small planned communities as well (Figure 3.1). Generally, the settlements are very low

in density. Many low and middle-income households have moved out of Kigali to peri-urban areas on the outskirts where building regulations are less strict and construction costs lower (Surbana 2012a, World Bank 2012a).

Research results suggest a number of other reasons for unplanned and uncontrolled settlements: the previous inefficiency in land provision and over-centralisation of urban planning; poor enforcement of existing laws; unaffordable formal housing; high, but unattainable urban standards; relatively easy access to land through an informal market; the large and unabated inflow of poor rural migrants; a poor financing system; the high cost of building materials; lack of small-scale contractors (Twarabamenye and Mukashema 2012); and low household incomes combined with a relatively high cost of living (Surbana 2012a).

Due to the rapid pace of urban growth, transportation, housing, education, health, sewerage and sanitation infrastructure and other municipal services were unable to keep pace with the speed of development (see Chapter 4). As a result, sewage and wastewater from informal settlements often flow in open drains and can seep into groundwater and run into wetlands (World Bank 2012a).

Most neighbourhoods are built on steep, sandy slopes; they are difficult to access and suffer from erosion, which turns into landslides in the rainy season. Connecting these neighbourhoods to power and water supplies has been a challenge (Kartas and Jütersonke 2011). As well, the high concentration of informal dwellings threatens efficient evacuation in the case of emergencies or disasters (CoK 2012).

Planned Settlements

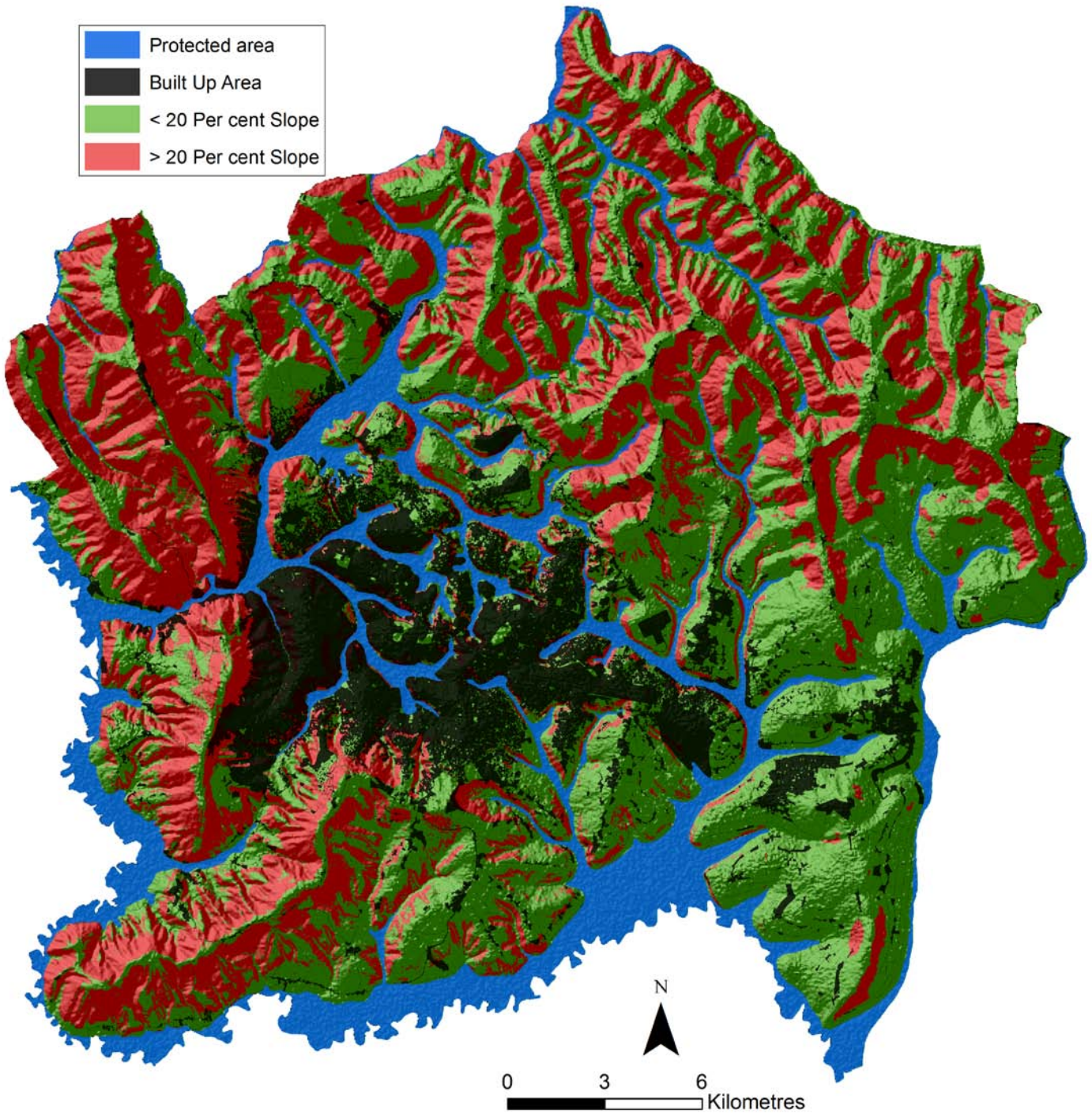
Planned housing usually refers to low density or single-family homes built in a uniform way that optimises the land. EICV3 reports that modern planned settlements occupy 2.6 per cent of Kigali's land area (NISR 2012a). After the genocide, a number of planned estates were developed, such as those in Nyarutarama, Gacuriro, Kagarama and Gisozi (Manirakiza 2012). Sites for new developments have been secured and construction has started in Akumunigo, Rugarama, Batsinda, Kinyinya, Gacuriro, Muhima and Kimisange (CoK 2012).

The City of Kigali faces numerous challenges in providing its growing population with adequate housing and associated infrastructure in the future because much of its land base is unable to support new development (CoK 2012). Wetlands, water bodies, forests, hills with slopes greater than 20 per cent and other natural constraints to development cover about 50 per cent of Kigali's land area (Surbana 2012a). In Nyarugenge District, 48 per cent of land has steep slopes and 15 per cent lies within wetlands as defined by the Rwanda Environment Management Authority (REMA), leaving only 31 per cent, or about 225 sq. km available for development. The green areas in Figure 3.2 depict places that are technically available for construction,

View of a well planned growing residential area in the eastern part of Kigali

REMA 2011

Figure 3.2: Land available for development



Source: Wetland data provided by REMA; Land use and slope data provided by Surbana; visualisation by UNEP/GRID-Sioux Falls

meaning they are not wetlands, not already built upon and the slope of the land is less than 20 per cent. Built areas that are not currently located in wetlands are displayed in black. Wetlands, which are protected against future building, are displayed in blue. Red areas indicate land that has not yet been built upon and is not a wetland, but the slope is greater than 20 per cent and therefore not suitable for development according to the NLUDMP. Although these areas are available for development, it does not mean that the land should be built upon.

Building on hillsides where soil can wash away increases the risk of landslides and erosion and makes planning and building proper roads and access for emergency vehicles difficult (OZ Architecture 2007). Steep slopes could be protected by planting trees and other conservation measures and is encouraged by the NLUDMP (Surbana 2012a, GoR 2012). These green areas also include agricultural and forest land that is important to preserve for food security and green space. The value and use of these lands should be seriously evaluated

Houses built on a hillside that has a slope of more than 30 per cent above the Nyabugogo River in Kanyinya Sector

before they are converted to different land uses such as planned residential areas.

Nevertheless, future development of some land is going to be required to support the growing population. A 2012 World Bank Housing Market Study found that there is a gap of 344,068 units needed to house Kigali's growing population in various housing categories (social, affordable, mid-range and premium housing) by 2022. Meeting this demand would require building over 30,000 units every year, a number supported by another 2012 housing study (EuropeAid 2012a). The World Bank (2012a) attributes the acute shortage in Kigali's formal housing market, even for those in the middle and upper income tiers, to a number of factors: the high cost of construction materials; limited capacity among developers; the desire for low-rise and large, single-family housing; the high cost of loans and financing; and the freezing of the housing market due to the interpretation of the Master plan's zoning and building standards, which suggest the use of materials such as brick, metal, glass and concrete rather than affordable traditional ones.

To accommodate modern urban development, many households were resettled in rural areas (CoK 2012). Planned settlements in rural areas of Kigali are usually sprawling low-density single-family housing developments that have taken advantage of lower land values and a lack of long-term growth plans. Most of these planned villas are located in Remera, Kimihurura, Kibagaga, Gikondo and Kimisange. There are some planned single-family housing areas with proper serviced roads and access to other key urban infrastructure in Nyarutarama, Gaculiro, Kiyovu and Kagarama in Kicukiro District. A few multi-family low-rise apartments can be found in Kacyiru and there is similar planned low-rise accommodation at Kagugu. There are only a few multi-family medium-rise apartments in Kigali, built for high-income households, such as the ones at Kacyiru. In addition, larger private planned estates exist in the form of cluster housing on the city's outskirts, offering multiple choices of housing units, such as those in Kabuga, Gisozi, Gaculiro and Kinyinya. Batsinda is home to 250 low-cost government-housing units, serviced with basic roads and central water points. Finally, there are some 3,000 imidugudu in Kigali's rural areas. The units are clustered in village communities and were developed to stem rural sprawl and provide post-genocide housing. They are made of cheaper materials and only have basic services such as electricity and a common water-supply point (Surbana 2012a).

In addition to the challenge of providing housing for the future, the city also faces the challenge of planning for commercial buildings and public parks and plazas, and providing new developments with basic sanitation services as well as amenities such as street lighting and beautification (Surbana 2012a).

The 2011 *Atlas of Rwanda's Changing Environment* highlighted Batsinda as an example of a planned community. Residents from the Ubumwe slum were relocated from their dwellings in Muhima to Batsinda. Residences in Ubumwe were chosen for relocation due to their dilapidated and unhygienic conditions. Ubumwe was comprised of a densely populated informal settlement located along the Rugenge River and partially in the Rwampara wetland (Figure 3.3). Its proximity to low lying land in addition to the prevalence of unpaved roads made the area susceptible to flooding and the

Figure 3.3: Site of Ubumwe in 2005 before relocation

Source: Wetland data provided by REMA; Image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

wetland vulnerable to household waste runoff. The KCC reported 33 deaths in Ubumwe (Lower Kiyovu) in 2006 as a result of landslides and poor drainage systems (Rangira 2008). Since being relocated in 2008, the area has slowly begun to be rehabilitated. A paved road has been constructed through the area alleviating traffic flow in a busy part of town and grass has grown back where the houses were removed, creating a natural buffer for the wetland and mitigating flooding effects (Figure 3.4).

Suggested plans for the future include its partial development into a commercial area to

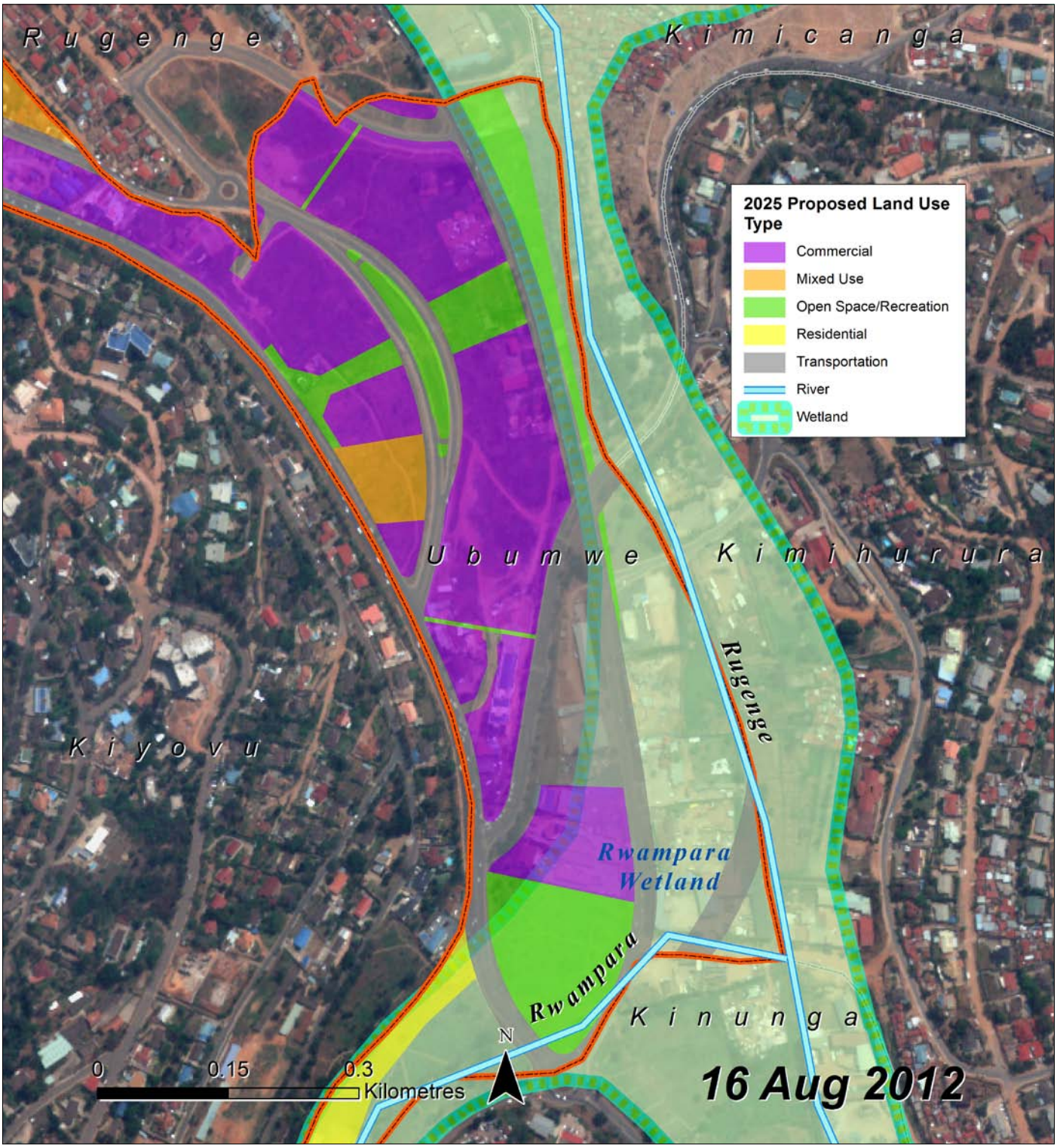
Figure 3.4: Rehabilitation of Ubumwe from crowded housing to green space

Source: Image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

support the surrounding CBD's growth, keeping only a small area as green space (Figure 3.5). As the city's population and infrastructure density continue to grow, maintaining green space will become increasingly important. Green spaces help to absorb flood waters, mitigate heat island effects created by increased asphalt and buildings and help to maintain a higher quality of life as residents enjoy parks and open spaces.

The Batsinda Housing Project consists of 250 houses intended for the low-income population. The project spans over 154 ha and houses are made of locally produced earthen bricks (EuropeAid 2012a). Families from Ubumwe moved into 112 of

Figure 3.5: Proposed land use of the previous Ubumwe slum for 2025



Source: Wetland data provided by REMA; land use data provided by Surbana; Image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

Earthen brick houses line the streets of Batsinda

the available homes (Kumaran 2011). Batsinda is an example of sustainable housing since bricks for construction were locally produced with mud from the site and without fuel or cement, thereby reducing the overall environmental impact. The community is equipped with running water, electricity, proper drainage and biogas for cooking, provided at no cost to the residents by the City of Kigali (Rangira 2008). While the community is situated on higher land that is not susceptible to flooding and although the homes are suitable for low-income households, the community is far away from basic urban resources; this forces residents to walk long distances or spend extra money on transportation (EuropeAid 2012b). Some residents, however, argue that food prices may be lower in this part of town since it caters to low-income residents (Kwibuka 2013). There are plans for a second phase of development to accommodate both low- and middle-income residents, adding 750 to 5,000 more units (Kumaran 2011, Kwibuka 2013).

Manicured gardens in Batsinda

Sand extraction for building purposes has eroded and degraded the land

Settlement Improvement

Given forecasts of future urban growth and the lack of suitable land for new developments, the City of Kigali Development Plan (CKDP) includes a strategy to increase the density of settlements, particularly in the Districts of Gasabo and Kicukiro, which still contain large rural areas. District Development Plans (DDPs) include proposals to increase urban development in these Districts through additional clustered settlements (CoK 2012). By 2011, Kigali had begun projects to upgrade informal settlements and construct new imidugudu; forty-seven imidugudu are planned around the city (Surbana 2012a). Projects also include a land consolidation programme, which optimises land for agricultural and other activities by amalgamating fragmented land areas (Surbana 2010).

There is a debate about the respective advantages of upgrading existing homes and relocating people, with evidence that low-income households in unplanned neighbourhoods prefer to remain in their crowded conditions rather than be moved away from community ties and proximity to jobs. This suggests the benefits of upgrading informal housing and gradually transforming from informal to formal housing (EuropeAid 2012b). The KCMP suggests that high density urban development zones and clustered communities with open spaces are preferable to a strategy that favours lower density, sprawling settlement patterns, avoiding expropriation as a primary option and encouraging retrofitting and upgrading (OZ Architecture 2007).

A strategy of mixing redevelopment and upgrading existing housing stock could satisfy social needs at the same time as it helps to restrain sprawl and its financial costs, including the costs of extending services and roads and the high cost of land. Such a strategy would also contribute to lowering environmental impacts because land would not have to be cleared to make way for new development, saving fragile and unsuitable land, green spaces and biodiversity. It would help also stem greenhouse gases generated by commuter traffic to and from the suburbs. Similarly, the

adoption of a building code with a mixed approach using both traditional materials and modern 'green' ones could have an impact on the amount of emissions associated with long-distance imports (World Bank 2012a, EuropeAid 2012a).

Land Use Issues

Development as a result of rapid population growth is a primary driving force of land use issues in Kigali. A number of unplanned or informal settlements have appeared across the city, especially on steep slopes, without consideration of proper management of roads, drainage, wastewater and sanitation. Industrial activities within and alongside the city's wetlands are another important land issue that has harmful environmental effects. Increased development has pushed farmers onto marginal lands in Kigali, as they have throughout Rwanda, where vegetation is cleared and steep slopes cultivated. As a result, little protection is offered to the soil and wetlands in the vicinity. The impacts affect the environment, human livelihoods and living conditions (Ayalew Ali, Deininger and Goldstein 2011).

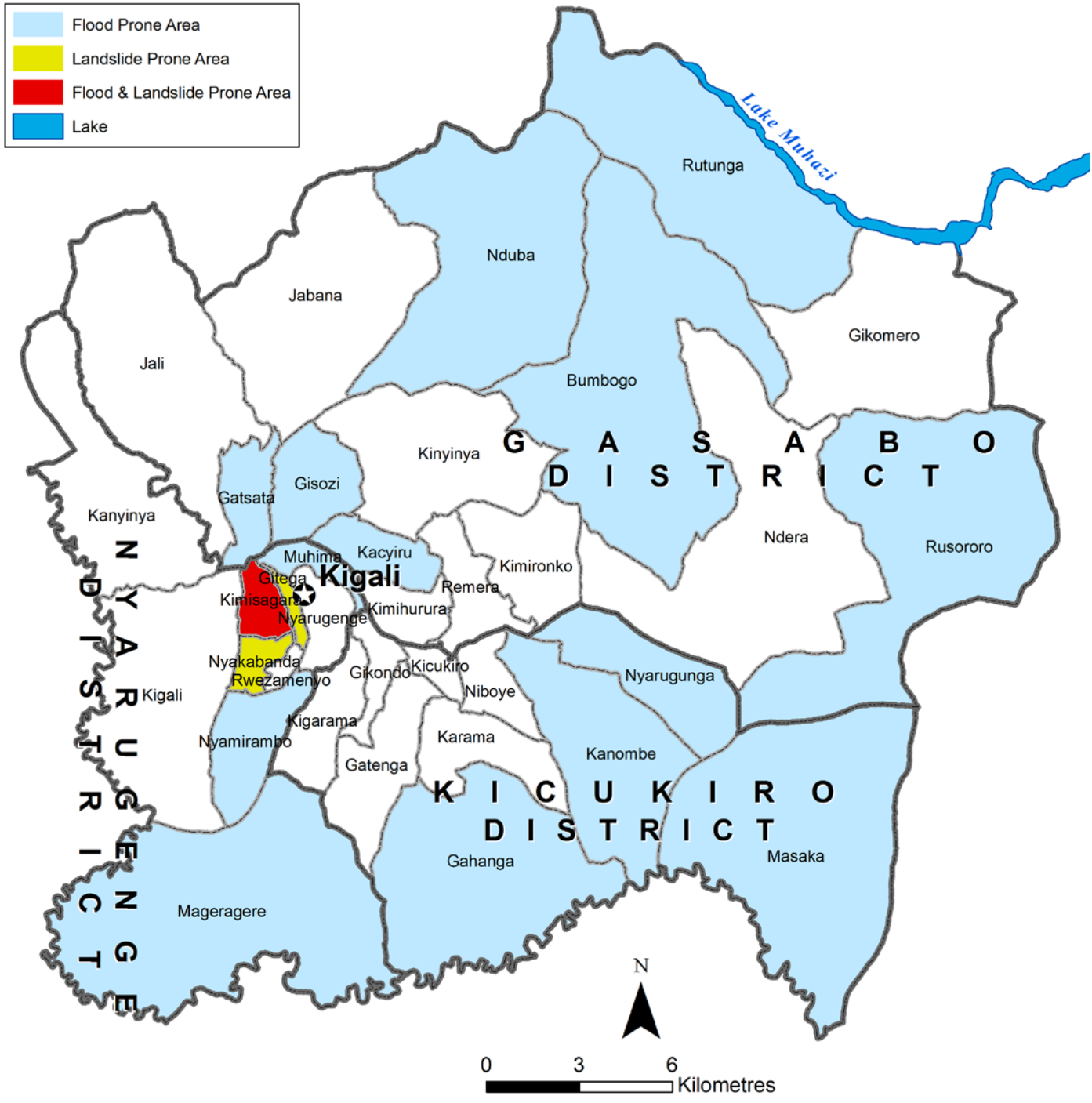
Vulnerability to Flooding and Landslides

Areas of Kigali are highly susceptible to the risk of flooding due to the burden of infrastructure on steep slopes, including informal settlements in the urban core and in rural areas; soil instability; intense seasonal rainfall; the lack of rain-water collection systems from the roofs of many houses; inadequate drainage and sewerage systems (see Chapter 4); and building in flood-prone zones such as wetlands (Bizimana and Schilling 2010). The city's swampy valleys can be hazardous locations for buildings and other infrastructure, especially along Nyabugogo River where localised flooding occurs in the Nyabugogo Taxi Park and Gikondo Industrial Park, among others (Surbana 2012a). In 2006 it was found that 27 per cent of buildings were located in flood-prone zones within the Nyabugogo River floodplain, making two infrastructure sectors, four economic activities and some 500 people vulnerable to the impacts of flooding. Since then, some establishments, such as the Kiruhura market, RWANTEXICO factory and Gatsata garages have been relocated (Bizimana and Schilling 2010).

Submerged road near Inyange factory in Masaka, Kigali

Residents of flood prone areas risk losing not only their homes, but also their lives. Severe rains in February 2013 damaged homes in all three Districts. A total of over 900 households were affected and infrastructure such as tree-lined streets, lighting and power lines were also damaged (Kigali City 2013). Three people died while driving near the Nyabugogo River during this event (Mbonyinshuti 2013). Downed trees caused traffic issues as they blocked travel through normally busy areas of the city, such as the main roundabout downtown. Heavy downpours can also loosen soil and carry sediment and rocks far from their source, clogging drains and streams and sometimes proving fatal to humans in the landslide's way (Uwiringiyimana 2013). Figure 3.6 illustrates those Sectors prone to landslides and flooding. It reveals that all three Districts and half of the Sectors are either susceptible to flooding or landslides. According to the map only one Sector, Kimisagara, is susceptible to both landslides and flooding, but it is also one of the most densely populated Sectors.

Figure 3.6: Flooding and landslide vulnerability in Kigali



Source: Adapted from RNRA 2012; visualisation by UNEP/GRID-Sioux Falls

Flooded agricultural fields

A number of other areas in Kigali suffer from flooding during heavy rainy seasons. Agricultural areas at risk for widespread flooding are the Nyabarongo-Akagera floodplain where crops and roads are submerged; dyke draining in an area on the Akagera that has unintentionally created a dam effect; and flooding in agricultural fields in Rusororo-Masaka that have also covered both crops and access to the area. Transportation infrastructure is subject to flooding at the Nyabugogo public transport hub; the southbound highway on Nyabarongo; the Kigali-Bugesera highway on Nyabarongo/Akagera; the Nyakariro-Juru access on Nyabarongo; and the Rusororo-Masaka access. Electricity transmission poles can also be at risk from floodwaters in the Kanombe-Masaka Sectors (REMA 2012).

Government officials have urged households identified as being in a 'risky zone' to relocate, but many people claim they cannot afford to move (Uwiringiyimana 2013). The Ministry of Disaster Management and Refugee Affairs (MIDIMAR) encourages city planners to incorporate disaster planning into future development plans to help make the city more resilient to disasters and climate change (MIDIMAR 2013b). Such plans could include immediate planting of trees or other vegetation to help stabilise soil after buildings are removed from an area or where land is cleared for new construction. MIDIMAR has moved towards decentralising disaster management in an effort to devolve planning, prevention and risk reduction to the District level so that weaknesses and strengths can be better accommodated (MIDIMAR 2013a).

Kigali has a system of storm drains to manage the large amounts of seasonal rainfall. It consists of open and covered masonry channels with cascades to manage steep slopes and unlined natural channels. The latter are subject to high erosion, especially on steep slopes, which results in runoff of silt into wetlands and rivers and dangerous landslides. Examples of erosion on steep slopes include the Gikondo Industrial Park and the Nyamirambo area on Mount Kigali's eastern slopes. When open drains contain liquid and solid wastes, a significant problem in Kigali, receiving waters become polluted (Surbana 2012a).

Heavy flooding (shown in this photo; taken after floods in May 2012) caused stagnant water to accumulate near the Inyange Industries and contributed to damage of infrastructure

Flooding can have significant impacts on industries over and above the obvious inconvenience. Strong winds and rains can damage infrastructure by tearing tiles off roofs, damaging power lines, flooding warehouses and affecting power and water supplies, cutting them off entirely or preventing them from fully functioning. This results in lost business, reduced productivity and costly repairs. Ruliba Clays, a brick and tile company located on the banks of the Nyabarongo River, is vulnerable to infrastructure damage as is Inyange Industries, a food processing company located in the wetland at the base of the Mulindi River. In April 2012, heavy rains shut down, or caused intermittent water supply for at least a week (Agutamba 2012). When accumulated floodwater stagnates, it can pose health hazards and floodwaters can carry toxic substances used in factories and industrial garages into the surrounding wetlands. Increased standing water also increases the amount of decaying matter, which can release toxic gases under prime conditions.

Figure 3.7 shows the Nyabarongo River at its normal level, but the river can rise up to at least the yellow line, and sometimes break its banks if rains are heavy enough. The Ruliba Clays brick factory is located right on the banks of the Nyabarongo River. While there is a narrow vegetation buffer, heavy rains can cause the river to swell and spill over into the area surrounding the factory.

Flooding at Ruliba Clays

Figure 3.7: Swell line of the Nyabarongo River, delineated in yellow (left image), near the Ruliba Clays brick factory (right image)

Photo credit: UNEP/GRID-Sioux Falls

Implications of Climate Change

Flooding is likely to become a greater problem with the impacts of a changing climate, which are expected to include higher, more intense and unpredictable rainfall and higher temperatures (REMA 2012). Already, there is evidence of changing rainfall patterns. Between 1971 and 2007, there was an average annual temperature increase of 0.9°C in Kigali. One of the predicted impacts of a changing climate is an increase in extreme rainfall events. Data analysis from continuous records in Kigali shows increasingly erratic rainfall patterns. While total annual average rainfall between 2000 and 2006 fell by 10 per cent compared to the previous 30-year average, the years 2004 and 2006 registered higher rainfall levels, by 114 per cent and 124 per cent, respectively. During these two years, rain typically fell in less than three days, or sometimes within a single day, often resulting in floods and landslides (UNEP 2011b).

To improve water management, the Government of Rwanda (GoR) established a dedicated department of Integrated Water Resources Management (IWRM) within the Ministry of Natural Resources (MINIRENA) to develop the integrated water management approach that will include addressing flooding vulnerabilities. REMA is currently developing complementary river and lakeshore rehabilitation programmes in response to urban development and soil erosion impacts (Surbana 2012a).

Development Pressures on Wetlands

Urban developments, including residential expansion and industrial and commercial activities, have contributed to the loss or degradation of Kigali's wetlands (see Chapter 2), especially in areas adjacent to Muhima Sector. The habitat's natural vegetation, dominated by *C. Papyrus* and a variety of *Pennisetum*, has been severely affected by industrial and household wastes (see Chapter 4). Industrial activities, such as brick making and sand mining, have contributed to the degradation of Kigali's wetlands. For example, only parts of the Gikondo valley still fully function as a wetland because drainage and compaction from developments have degraded large parts of the area (UN-Habitat 2009a).

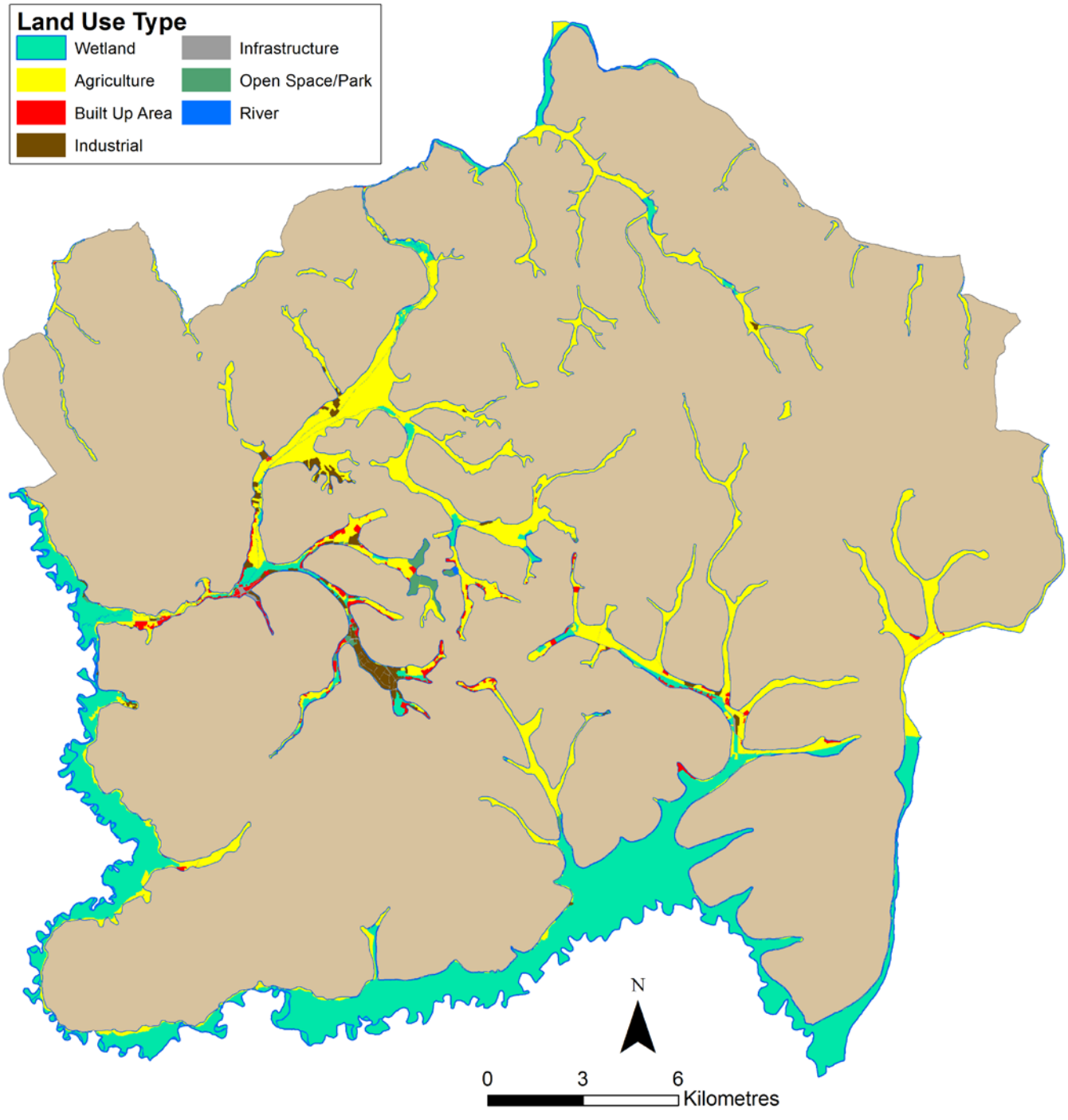
Houses built on a hillside in Kimihurura across from the Kacyiru wetland

UNEP/GRID-Sioux Falls 2013

Approximately 50 per cent of the wetlands in Kigali function as something other than a wetland (Figure 3.8). Agriculture takes place in slightly over 39 per cent of wetlands. Built-up areas consisting of commercial buildings, public facilities and residences make up 2.7 per cent of wetlands. Green spaces, such as parks and rivers, account for less than 1 per cent. Over time, as sustainable city plans become implemented and constructed installations are removed from them, wetlands will start to regenerate.

Dense housing on a hillside above the Gikondo Industrial Park, which is located in a wetland

Figure 3.8: Types of land use currently in wetlands



Source: Wetland data provided by REMA; land use data provided by Surbana; visualisation by UNEP/GRID-Sioux Falls

For years, a group of garages in Gatsata Sector, Gasabo District, known as the 'Gatsata Garages' were responsible for hazardous oils and heavy metals directly entering the Nyabugogo wetland because they lacked the proper infrastructure for waste disposal (Figure 3.9). Furthermore, most of the garage operators did not have toilets, making them dangerous to the natural environment and the health of members of the cooperatives operating in the neighbourhood (Stevenson 2012). The garages' negative impacts on the wetland were so visually striking that the government moved quickly to relocate them to higher ground.

REMA has demarcated wetland boundaries throughout the country in compliance with the law. As a result, several garages that were affecting the wetland ecology, and whose businesses suffered during flooding events, were removed. The green arrows in Figure 3.9 indicate a new area on higher ground where some of the garages have chosen as a new location. The government is currently studying the best way to rehabilitate the wetland and some recovery is already evident between the 2010 and 2012 satellite images.

Flooding is problematic in Gatsata because there are many input rivers and tributaries, but only one output — the Nyabugogo River

Figure 3.9: Relocation of the Gatsata Garage cooperative

Source: GoogleEarth; visualisation by UNEP/GRID-Sioux Falls

Impacts of Urbanisation on Agriculture

Rwanda is Africa's most densely populated country and agricultural activities provide the main source of livelihoods for about 85 per cent of its population. As shown in Chapter 2, farmland and plantations occupy 442 sq. km, or 60.5 per cent, of Kigali's land area (NISR 2012b). They are important economic sectors for the city and for citizens' livelihoods, contributing food as well as income and jobs to farming families.

Vision 2020 aims to transform agriculture in Rwanda from a subsistence activity to a modern, productive, highly valued economic sector and in the long-term, EDPRS 2 aims to diversify Rwandan agriculture. While continuing to supply food and livelihoods to smallholders, agriculture will move from a subsistence activity to a commercial one focused on high-value crops that are labour intensive and need technical and business expertise. The EDPRS 2 plans to support both public and private sector investments, recognising the need for land husbandry, including proper hillside irrigation, terracing and research to avoid erosion. Irrigation will be an important feature of this transformation (MINECOFIN 2013).

The CoK aims to transform farming communities to market-oriented activities that are both profitable and environmentally friendly and contribute to other sectors of the economy. The plan of action includes supporting more professionalism among producers, promoting product chains and facilitating the development of institutions (Surbana 2012a).

Agriculture generally takes place in the city's peri-urban areas and most of Kigali's arable land is in wetlands and lowlands. The main crops grown are traditional food crops, especially sweet potatoes, bananas and beans. Others include Irish potatoes, soybeans, maize, cassava, vegetables and small amounts of coffee. Goats, poultry and cattle dominate the livestock sector and dairy farming is a significant activity, occupying about 23.75 ha of land (Surbana 2012a). Population growth and urbanisation in Kigali has seen an increase in the demand for food and an inability to supply that demand from nearby rural producers. A related fact is that agricultural production systems (crop farming, horticulture, agro-forestry, animal husbandry) in the area have not performed optimally (FAO 2012). Urban and peri-urban agriculture in Kigali, however,

Agricultural land is progressively giving way to estate-style housing such as the Gacuriro Vision 2020 estate, pictured in the background

REMA 2012

Rice paddies in Kigali's wetlands

has the potential to increase food security. As already noted, agriculture is an important livelihood activity and its performance can be improved for the betterment of both the economy and the environment.

Currently, the expansion of urban development into Kigali's rural areas has increased both the numbers and density of people living in agricultural zones. This has led to land fragmentation and to a reduction in farm size. On average, farming households occupy 7,000 sq. m of land, out of which an average of 6,800 sq. m is cultivated. The families themselves consume an average 65 per cent of the crops they produce and sell the remaining produce in local markets (ISTED 2001, Surbana 2012a). The EICV3 survey found that 55.6 per cent of Kigali households had some portion of their land devoted to crops (NISR 2012b).

When farmers are forced to grow more crops on smaller plots of land, it can result in intensive cultivation and poor farming practices that overuse the land base without restoring soil nutrients. This increases the extent and degree of soil erosion, although it is reported that about 74.6 per cent of Kigali's farmers practice some sort of erosion control (NISR 2012b, Surbana 2012a). Eroded land is more vulnerable to drought and heavy rains and thus to the potential impacts of a changing climate. Kigali's farmers depend on rain to irrigate their crops and water livestock, so the loss of soil to erosion is a concern as is the threat of unforeseen changes in weather patterns that could affect the amount and timing of the seasonal rains they depend upon. Introducing or improving irrigation could raise crop yields, prolong the growing season and allow for several crops a year (MINECOFIN 2013). In addition, it may provide security at a time when climate change risks modifying typical rainfall patterns.

The pressure to produce a larger yield on less land may also lead to an increase in the use of fertilisers. Between 2005 and 2011, the percentage of Kigali households that purchased agricultural chemicals increased from 7.6 to 10.7, although the proportion buying insecticides dropped from 23.2 to 19.3 (NISR 2012b). Whether or not Rwanda should encourage farmers to invest in chemical fertilisers to boost harvests is a matter of debate in light of their potential impact on soil and water quality (Ishimwe 2012).

Several agricultural management and improvement projects are already in progress in Kigali. These include the Land Tenure Reform Programme (imidugudu) to facilitate the intensification and mechanisation of farmland; growing crops near the Kigali International Airport that are destined for export, such as soybeans, flowers and seeds; and an initiative of the national Post Harvest Handling and Storage (PHHS) programme that includes building silos and a post-harvest treatment plant in the SEZ in Gasabo District. In addition, the Ministry of Agriculture (MINAGRI) is encouraging farmers to produce high-value crops such as mushrooms, fruits and vegetables and to practice horticulture (Surbana 2012a).

Infrastructure

Kigali's infrastructure has sustained substantial growth over the past few decades with increased household access to electricity and clean water as well as an increase in paved roads and road connectivity. As both the economy and population grow, resources to successfully maintain industries, businesses and households will become increasingly necessary. Continued improvement in energy supply, water access and ease of transportation are important factors for achieving sustainable economic development and poverty reduction (CoK 2012).

Transportation

Presently, transportation in Kigali can be a challenge (World Bank 2012a). Due to a lack of coordinated decision-making and implementation among transport-related agencies, many aspects of transportation infrastructure have suffered (MININFRA 2012). Traffic and transport engineering has been inadequate resulting in poor road infrastructure development and maintenance. Coordinated parking facilities are scarce in Kigali and the road hierarchy is inefficient. While many paved roads are lined with paved sidewalks, there are many roads outside of the main CDB that do not have sidewalks. Also, proper drainage systems and pollution controls still need to complement most roads. Public transport is unable to provide a seamless flow of people in and out of the city during peak commuting hours and bus stations are frequently overcrowded (CoK 2012). These issues have a significant impact on the environment and human health: vehicle emissions, which will increase with growing urbanisation, affect urban air quality (see Chapter 4) and are also a source of greenhouse gases which can affect the climate. On the other hand, the City of Kigali is actively working towards remedying some of these issues by developing emissions standards, paving roads and improving signage.

Planning Framework

MININFRA is responsible for the political framework and planning projects related to transportation in Rwanda. The Rwanda Transport Development Agency (RTDA) operates under MININFRA and completes the Environmental Impact Assessments (EIA) for transport plans (MININFRA 2012). MININFRA has laid out an integrated traffic demand and supply management approach to Kigali's transportation challenges, which involves three phases in the adoption of an integrated multimodal transport

Motorcycle taxis, locally known as motos, are sometimes the fastest way to travel through town

Kigali – Bugesera highway going through the Nyabarongo/Akagera wetland

development strategy. This approach will reduce traffic congestion, energy use and pollution, helping to increase the mobility and accessibility of people and goods within urban Kigali and from rural areas into the city centre. It will help address environmental concerns, improve the economy and reduce poverty in alignment with Vision 2020 (MININFRA 2012).

Rwanda's Vision 2020 goal for Kigali to become a state-of-the-art and esthetically appealing city includes transforming its infrastructure to become more sustainable, including improving its roads and drainage systems. The aim is to improve road safety, increase funding for road maintenance and expand the paved road network. The 2010 NLUDMP includes plans and policies for land use and transport with the aim of continuing development in a very controlled way (Surbana 2012b). An environmentally sensitive strategy for transportation would include improving designated pedestrian and cycling paths linking residential areas with markets and businesses (OZ Architecture 2007).

Air Transport

Kigali International Airport is the primary airport serving the city and the nation and is the main gateway for all flight destinations. It is located at the eastern edge of Kigali and is linked to the city's road network. From 1995 to 2005, yearly air passenger traffic tripled from 85,000 to 290,000 trips. It is expected to grow at about seven per cent a year, reaching 740,000 trips per year by 2020, in line with GDP growth and trip-rate per capita (Surbana 2012b).

Since there are physical limits to expanding this airport, there are plans to build a new facility about 40 km southeast of Kigali (Surbana 2012b) on the Bugesera road, to be completed by 2025, with the first phase ready in 2016. It will have the capacity to handle 1.3 million passengers per year. The new airport plan includes the short-term requirement for a regular bus service linking the airport with the CBD (Surbana 2012a). The plan involves a number of environmental challenges, however, including building a new road that would disrupt the Nyabarongo Wetland. If the future development of supporting infrastructure, such as restaurants

and gas stations, are not built sustainably, the project could have long-term negative environmental implications.

Public Transport

Providing adequate and appropriate public transport services is an important aim for Kigali. Public transport can provide citizens with an affordable and convenient way to travel about. If Kigali citizens have access to efficient and inexpensive public transport, it can reduce the number of private cars on the roads and thus reduce both traffic congestion and air pollution while contributing to urban quality of life. Rwanda's vision for Kigali's public transport system is to create a modern infrastructure that is cost effective and offers quality services with due regard to safety and environmental concerns (MININFRA 2012).

Kigali's public transportation system is comprised of taxi minibuses and buses that connect the CBD to other parts of the city. Kigali also has a variety of other taxi services, including motorcycle ('moto') taxis that are available at a low cost. Public transport mostly uses paved roads and a route network that includes the CBD's main circular road and the radial road that connects the city's main hubs (Surbana 2012b, Niyonsenga 2013). In 2005, the government implemented the Zero Fleet Policy, which included the auctioning of 4,000 government vehicles and assistance to public servants to acquire personal vehicles or use public transportation, depending on the level of seniority (Ndoli 2012).

Almost half (48 per cent) of Kigali residents who use public transport in the city do so in 16-seater minibuses (Surbana 2012b). A number of different private companies operate them so the bus service is fragmented: there is no central coordination of routes, schedules, ticketing, revenue sharing or design and location of bus stops or shelters and other associated infrastructure. Other problems related to public transport include bus terminals that are congested and inefficient, too few bus routes, no authoritative policy on bus routing and inadequate bus services. Also, there are no dedicated bus lanes that help prioritise public transport over private vehicles. Finally, there is presently insufficient infrastructure to meet public transport demand (CoK 2012, MININFRA 2012).

Thus, access to public transport is inadequate, involving high costs and long transit times from one point to another. Only about a quarter of users take less than 20 minutes to get to a public transport

Various modes of public transport are used to get around the city, including mini-bus taxis, buses and the often dangerous, but popular, motos

REMA 2012

Government subsidised bus transport has become increasingly popular and affordable in Kigali

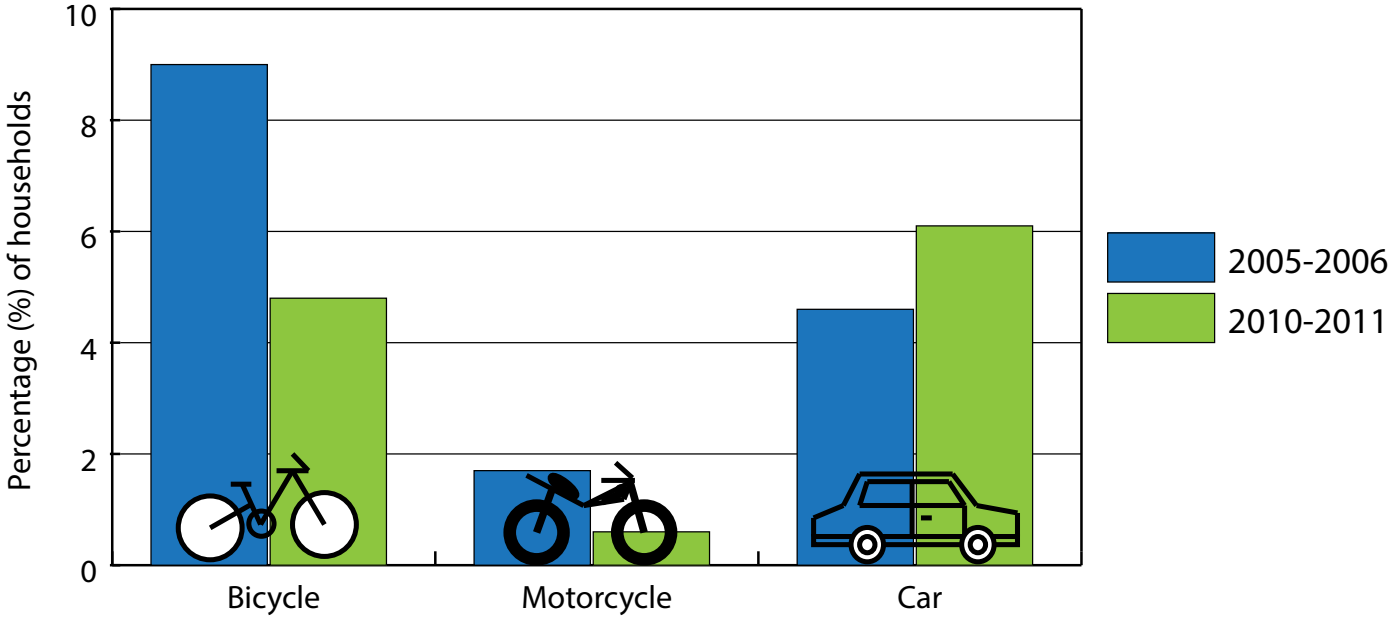
stage and over 70 per cent of city commuters either walk long distances or use motos to access public transport (CoK 2012).

The city has begun implementing the strategies outlined in the CKDP, however, and as a result, over 200 Coaster buses have been imported to add to the city's fleet. A Public-Private Partnership (PPP) has developed a business model to run the public transport system using the Net Cost Route approach, which includes the provision of comprehensive bus services run to strict schedules to ensure optimal service from 4:00 am to 11:00 pm every day including weekends (MININFRA 2012). In addition, the formation of the Rwanda Federation of Transport Cooperatives (RFTC) has boosted the investment in public transport. Regulations governing motorcycles were introduced and they were also encouraged to form cooperatives with remarkable success. More traffic lights were also installed to facilitate the freer flow of traffic (CoK 2012). Progress is also evident in a private company's recent introduction of 80-seater 'hi-tech' buses with an enhanced smart card ticketing system (The New Times 2011).

Private Transport

Generally, private vehicle ownership is low in Rwanda, but it has been increasing rapidly in the past decade. Between 2005 and 2012, car ownership in the country increased from about 40,000 cars to about 60,000 cars (NISR 2012c, de la Croix Tabaro 2013). Many of these vehicles make their way to Kigali since it is the business and industrial hub, and with them they bring increased traffic congestion, air pollution and a strain on the general transport system; these problems are likely to continue to rise along with population growth (MININFRA 2012). Based on statistics from 2011 and 2012, Kigali households own about 22 per cent of all registered cars in Rwanda, approximately a 2 per cent increase from the proportion in 2005 (NISR 2012c). Viewed within the context of population numbers, although Kigali makes up about 10 per cent of Rwanda's population, according to the EICV3 it owns 20 per cent of its cars; the proportion could be greater, however, because the survey collected information about the number of households that own a car, not the number of cars owned.

Figure 3.10: Vehicle ownership in Kigali, 2005-2011



Source: NISR 2012a; visualisation by UNEP/GRID-Sioux Falls

Data from the EICV2 and EICV3 surveys (Figure 3.10) show a rise in car ownership in Kigali from five to six per cent, but a decline in bicycle and motorcycle ownership (NISR 2012a). Most recent statistics reveal that seven per cent of urban Kigali households own cars (NISR 2012c).

An increase in cars on Kigali's roads will have implications for traffic congestion, air quality, safety and human health and will require thoughtful urban planning, which could include incentives for public transport (NISR 2012c). The Rwanda National Police regulates the road worthiness and safety of cars through annual (for personal vehicles) and bi-annual (for commercial/transportation vehicles) testing and certification (RBLP 2012). Vehicles are not only inspected for mechanical issues, such as properly working brakes and headlights, but are also tested for emissions (MININTER n.d.). The Rwanda Bureau of Standards (RBS) has established emissions standards but they remain voluntary for compliance and are being evaluated to ensure they are not too relaxed or too stringent (Kabalira 2012). Although lead gasoline was phased out in 2005 (The TEST Network 2012), new standards will need to be established to ensure pure gasoline is used in cars and to avoid the illegal mixing of kerosene, which damages engines.

In 2010, Kenya and then Tanzania adopted a new standard for sulphur content in diesel fuel, stipulating a maximum of 500 ppm. Since Rwanda imports fuel from these two countries, this has had a significant impact on the cleanliness of transportation fuels in the country. The move was facilitated by the Partnership for Clean Fuels and Vehicles (PCFV), the leading global initiative to promote cleaner and more efficient fuels and vehicles in developing countries. Vehicles that use low-sulphur fuel emit less air pollutants such as sulphur oxides, soot and smoke particles, which pose risks to respiratory and cardiovascular health. Using this fuel also enables vehicles to use emission-reducing technologies (UNEP 2011a, UNEP 2012).

Road network

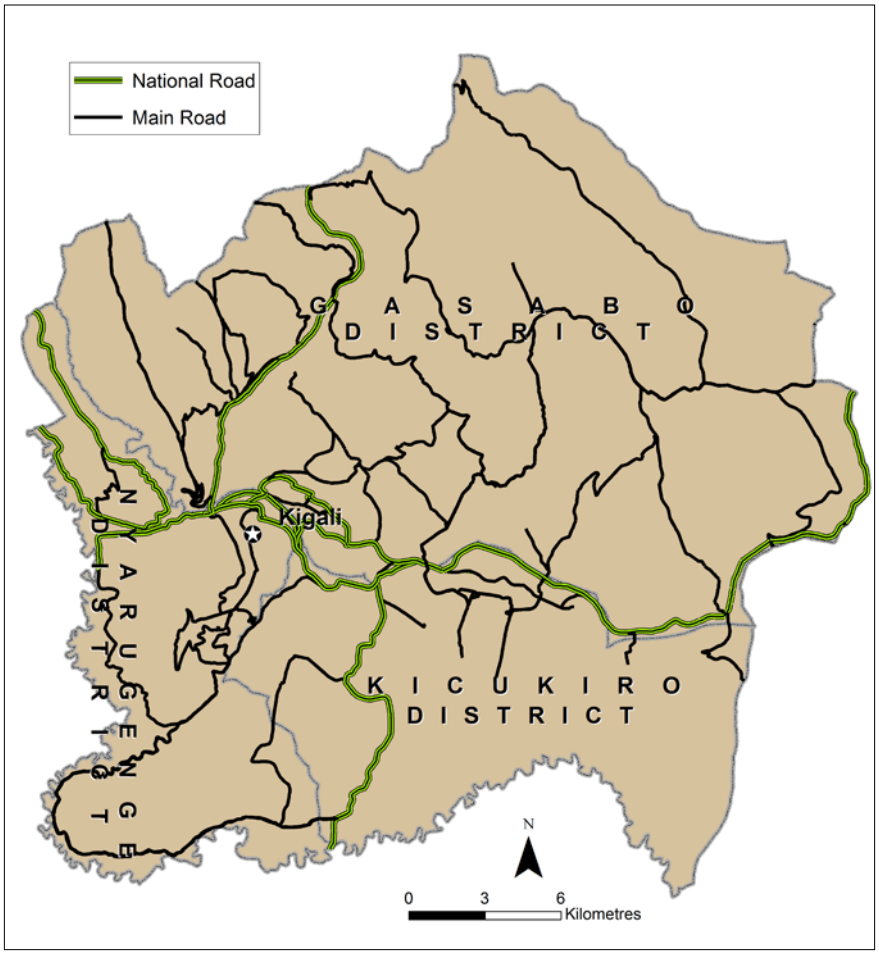
The total length of roads in Kigali is approximately 1,017 km, 14 per cent of which are paved (Surbana 2012b). Some 864 km are unpaved (CoK 2012). Major arteries are graded to even out the slopes, but many unpaved city streets are on steep hills, which are extremely dangerous for both pedestrians and motorists during heavy rainfall (World Bank 2012a) and are subject to erosion and land degradation.

The CKDP's target is to improve road infrastructure such that 85 per cent are in good condition, and as a result, new roads have been constructed and repairs and maintenance has been performed on existing ones. Since 1997, it increased the length of paved roads from 106 km to over 200 km, built 31.7 km of stone pavement roads, installed 99.2 km of sidewalks, constructed two new bus stations (Kimironko and Kicukiro), rehabilitated

the terminal at Nyabugogo and built 20 ravines of 9.8 km (CoK 2012).

The city is well connected by a national road network to other parts of Rwanda and neighbouring countries (Figure 3.11). Roads in the CBD form the centre of the network connecting Kigali to the Democratic Republic of the Congo (DRC), Burundi, Tanzania and Uganda. The network also connects the Districts to the CBD and Districts with each other. Roads to tourist sites and nationally and internationally important areas, such as the airport are also included in the network. MININFRA has recommended the building of an inner middle ring road connected to major radial roads and constructing loop roads to provide missing links, which would alleviate traffic and decrease impacts on inner city roads (MININFRA 2012).

Figure 3.11: Kigali's main road network



Source: compiled from various sources; visualisation by UNEP/GRID-Sioux Falls

Traffic management

Traffic in Kigali is generally well managed considering the available infrastructure. Traffic management strategies include traffic signals, roundabouts and pedestrian crossings. Traffic police are available around the clock to control interventions at conflicting points to keep traffic flowing (Niyonsenga 2013). Heavy trucks are prohibited in the CBD during the day, but may travel through at night. There is still a dearth of parking spots but their availability is growing steadily with each new commercial or office building, including under-cover and open-roof parking spaces.

The CKDP includes the planned construction of 24.8 km asphalt and 100 km stone paved roads, as well as the rehabilitation of 29.5 km, which will reduce congestion and increase efficiency. Other projects include developing city bypasses, building dedicated lanes for Bus Rapid Transport (BRT), a type of public transport, creating peripheral terminals for public transport, introducing intelligent transport systems and electronic ticketing for urban transport, among others (CoK 2012).

Sidewalk crossing sign in the centre of Kigali

The Conceptual Kigali Transportation Plan recommends adopting a holistic approach to the transportation strategy that includes expanding roads as well as managing their use by controlling vehicle traffic growth and restraining vehicle use (Surbana 2012b).

Energy Supply and Use

Rwanda has abundant renewable energy sources, including hydropower, solar and geothermal, but wood and charcoal are still a major source and energy demand is growing. Energy objectives in the EDPRS 2 include increasing access, introducing a sustainable tariff structure, diversifying energy resources and security and strengthening both the institutional framework and capacity (MINECOFIN 2013). Changes such as these will contribute to addressing the MDG of providing the population with modern energy services to decrease environmental pressures and health problems related to the use of fuel wood (SEA 2006).

Energy Supply

The country's power supply is derived from three main sources: hydropower (57 per cent); thermal power (38 per cent); and imported power (15 per cent) (Surbana 2012a). Small-scale solar power projects are underway, as is a micro hydropower plant on the Nyabarongo that is expected to produce 28 MW by the end of 2013 (EWSA 2012b).

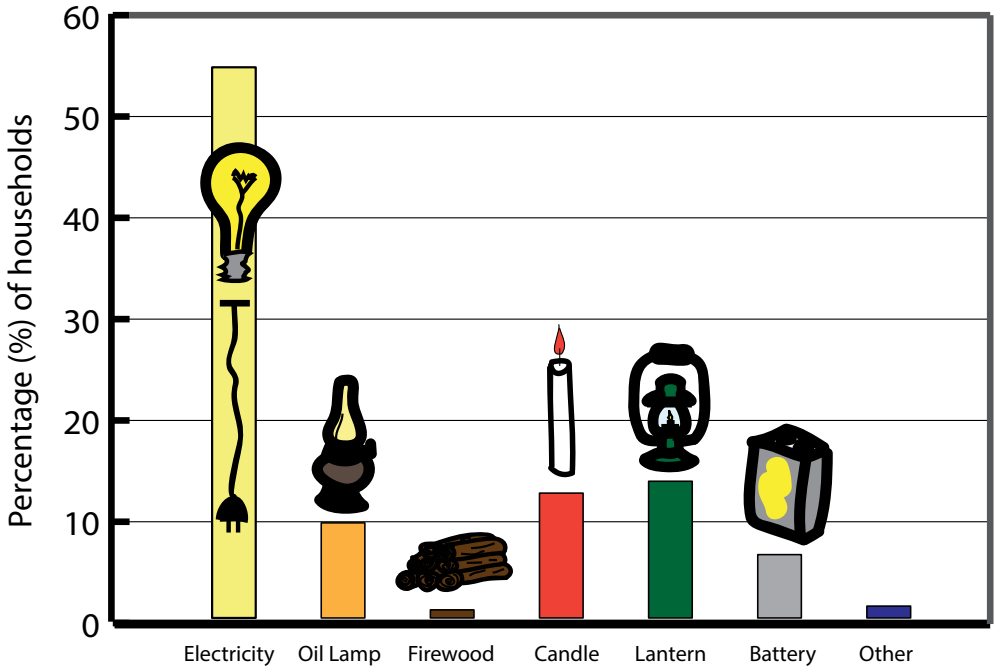
An advert for the benefits of using energy efficient water heaters

The Department of Energy within MININFRA governs energy policy in Rwanda. For Kigali, the Energy, Water and Sanitation Authority (EWSA), a state-public utility company, is responsible for electrical power generation, transmission and distribution. Four electrical substations serve Kigali:

Workers installing solar panels

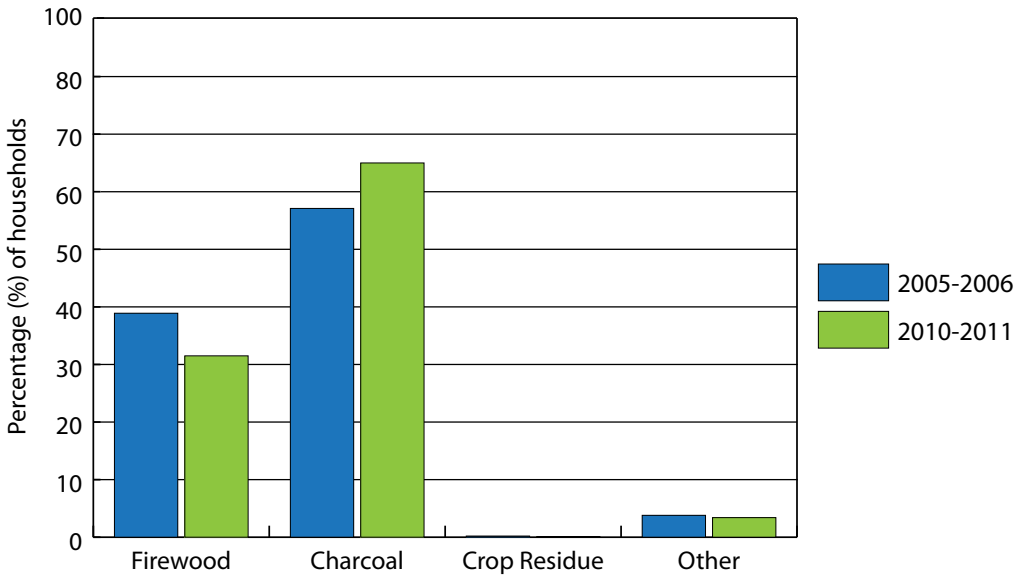
Jabana, Gikondo, Mount Kigali and Gasogi (Surbana 2012a). With the growing population, demand is still an issue both in Kigali and in Rwanda. For the country, electricity demand has increased from 46MW in 2007 to 86MW by August 2012 (EWSA 2012b). Certain electric lines are often disconnected because of an insufficient supply of electricity to serve the demand (Surbana 2012a), but new projects proposed by EWSA will supply extra poles and cable to help reduce the amount of load shedding needed (EWSA 2012a).

Figure 3.12: Fuels used for lighting in Kigali, 2010-2011



Source: NISR 2012c; visualisation by UNEP/GRID-Sioux Falls

Figure 3.13: Sources of cooking fuel in Kigali



Source: NISR 2012c; visualisation by UNEP/GRID-Sioux Falls

Energy Use

Access to electricity has increased substantially across Rwanda since 2006. In 2006, 77,181 households were connected, but by July 2012, that number rose to 321,000 households, surpassing the 2012 EDPRS target of 270,000 households (EWSA 2012a, MINECOFIN 2013). Of Kigali's households, 56 per cent use electricity (Figure 3.12) for lighting compared to only 11 per cent in the country as a whole. This represents a 26 per cent increase in electricity access since 2005-2006. However, the average household expenditure decreased from 69,447 Rwf to 60,102 Rwf over the same time period (NISR 2012c). Gasabo has lower electricity connectivity than the other Districts since a significant number of residents live away from grid connectivity (CoK 2012).

In Rwanda's rural areas, the major source of cooking fuel is still firewood, while in Kigali and other urban areas, households are moving away from wood to charcoal, which is now the primary source of fuel for cooking, used by 51 per cent of households in Kigali, followed by firewood (45 per cent). Figure 3.13 shows the primary source of cooking fuel in Kigali and the difference in results between the EICV2 and EICV3 surveys.

All over the developing world, harvesting trees for fuel wood and making charcoal contribute to pressures on forests, while cooking indoors with these fuels without proper ventilation can cause respiratory and other human health impacts (see Chapter 4). In Kigali, the demand for charcoal has led to the loss of shrubby savannahs and gallery-forests

in Bugesera and charcoal production has been implicated in the clear-cutting of forests in the buffer zone of the Nyungwe National Park. Inexpensive traditional kilns are used to make charcoal, but they burn the wood inefficiently (REMA 2009), although they have less impact on air quality than burning dung or crop waste (see Chapter 4).

Rwanda's National Biofuels Energy Strategy proposes a target of reaching just over 20 per cent of Kigali households with a fuel substitution strategy. Energy conservation, sustainable woodlot management and the introduction of improved cookstoves and more efficient charcoal-making methods will reinforce these objectives (SEI, DFID and DEW Point 2009). Already, there are efforts to use agricultural products to produce more sustainable energy; there is an experimental plant run by the Institute of Scientific and Technological Research (IRST) in Kigali, for example, that is using seed crops to produce biodiesel (UNEP 2011b).

Water Supply and Use

Vision 2020 targets concerning water supply and use are committed to improving water resources management so it is integrated, sustainable and satisfies demand and to support economic development through water collection, water conservation and improved water use (MININFRA 2010). The IWRM department within MINIRENA has taken on the role of coordinating water resources management. EWSA and each District jointly share the role of managing water services (CoK 2012).

Water Supply

The water network in Kigali is connected to about 65,000 homes and 280 public taps (Agutamba 2012). With the projected growth in the city's population, water supplies will increasingly be stretched (MININFRA 2010). MININFRA has initiated a city-wide goal of providing 80 litres per capita per day (lpcd) based on the limited supply, but as the population and standard of living grows, this goal will need to be reviewed (Surbana 2012a). To achieve the national goal for water coverage, it will need to increase to 85 per cent by 2015, which is slightly more than the EDPRS target of 80 per cent (World Bank 2012b).

Kigali's water is supplied by EWSA, which is responsible for producing, transmitting and distributing water and electricity in Rwanda. The city derives its water from the Yanze River, Nyabarongo River and Lake Mugesera. EWSA is planning on using spring water from Mutobo, Muzanse District, to increase water supplies, with the expectation that it can furnish the city and surroundings with 120,000 cubic metres (cu. m) of water per day by the time it is completed in 2017. The KCMP suggests Lake Muhazi, the Ruhengeri volcanic formation, Cyuga and Byimana as further potential sources (Surbana 2012a).

Between 2001 and 2007, water production in Kigali grew slowly from about 15 million cu. m per year to 20 million cu. m per year. Water production grew rapidly from 2008, however, to about 30 million cu. m in 2011, although the demand was still not fully satisfied (EWSA 2012a). Studies showed that in 2010, Kigali's water supply system had the capacity to provide only about 40,000 cu. m of water per day, which represented about 66.6 per cent of the total daily water requirement of 60,000 cu. m (MININFRA 2010). More recently, according to the Rwanda Utilities Regulatory Authority (RURA), 62,000 cu. m of water is currently consumed daily compared to

Water storage tanks supplying the Gacuriro neighbourhood

A public groundwater pump

55,000 cu. m in 2012; the actual demand is upwards of 82,000 cu. m of water per day (Nsanzimana 2013b).

Kigali's water is treated at the Nzove, Karenge, Kimisagara, Kinyinya and Rwampara water plants, among others, which generate a daily supply of about 68,000 cu. m (Karinganire 2012). As of the end of 2012, the Kimisagara and related water plants were treating more than capacity, Nzove was severely under capacity and Karenge was at about capacity (EWSA 2012b). Nzove has production issues when the Nyabarongo River swells after intense rains. When the river swells, the intake tanks become overloaded, reducing the efficiency of the treatment process and the resulting supply. High sediment loads in river water is a significant problem in Kigali, with annual suspended sediment levels at the Kimisagara water plant averaging 250 milligrammes per litre (mg/L) in 2006 and 134 mg/L in 2007. Treating these waters is expensive. To improve water quality, there are plans to install water sheets to filter sediments (UNEP 2011b).

Potable water is stored in various tanks throughout the city and distributed to clients through EWSA's network of pipes that covers most of the city's built-up area, with areas closest to the CBD enjoying the most extensive connections. Residents with no indoor plumbing access water from public taps that service areas of about 280 m average radius. The CoK aims to increase the number of taps so users don't have to walk any more than 250 m to get water. Residents who live too far from the network or where the population density is low obtain water from kiosks, streams or bore holes (Surbana 2012a).

Even though Rwanda generally receives abundant rainfall, water has become an increasingly scarce resource in Kigali as in other urban areas in Rwanda. The gap between demand and supply is more severe during dry periods. For example, at the end of 2011 and beginning of 2012, there was unprecedented water scarcity in Kigali and it is reported that some people used untreated water from wetlands and others resorted to rationing. Residents in Gikondo Sector, Kicukiro District had to buy expensive water from vendors (Nsanzimana 2013a). This water scarcity is due in part to increased need during the dry season and the inability of infrastructure to pump the needed water through Nyamirambo, Biryogo and Gisozi and other areas to supply Kicukiro and Gatenga with water that comes from Ntora and Kimisagara (Mbonyinshuti 2012).

To accommodate the growing need for water in all parts of Kigali, between 2011 and 2012, EWSA greatly expanded water access and water storage

in Kigali (EWSA 2012a). Access was extended to rural areas such as Masaka Sector, Kicukiro District and Bumbogo Sector, Gasabo District. Bumbogo Sector also received a new water reservoir capable of holding 400 cu. m. Kanyinya Sector in Nyarugenge District received 5 km of new pipelines and a 250 cu. m water reservoir. New elevated storage tanks were constructed in Rusororo Sector and Ndera Sector in Gasabo District and a new ground tank was constructed in Rebero Sector, Nyarugenge District.

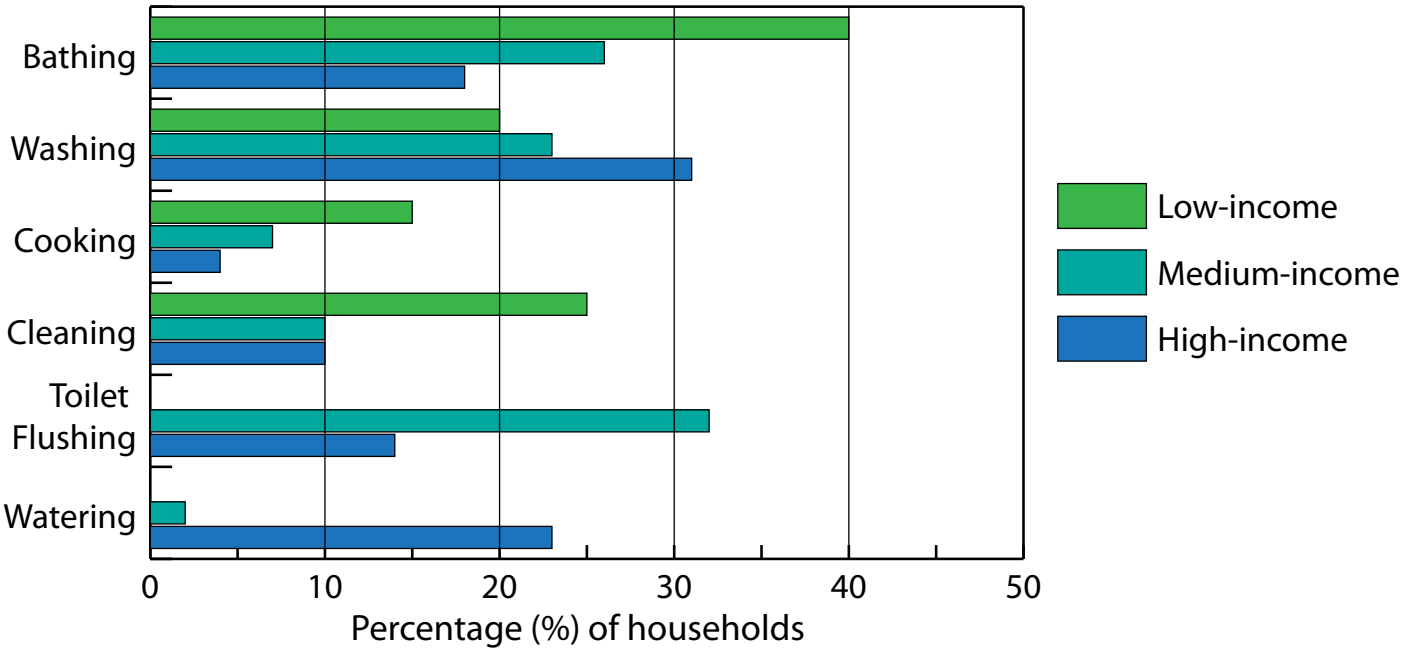
EWSA also recognises the need to complement efforts to increase supplies by implementing water-demand management. Benefits of this approach include lower water bills, a more sustainable water supply and a reduced need for wastewater treatment (EWSA 2012a). For example, rainwater could be collected from the roofs of buildings for a variety of household uses, such as cleaning, irrigation, flushing toilets, etc. It would also help prevent flooding during severe rainfall events, which can cause erosion and destroy infrastructure like roads and buildings (MININFRA 2010) and carry polluted wastewater into fragile wetland areas. EWSA has also proposed repairing and replacing old pipes and increasing water production through a project to produce another 40,000 cu. m per day, which would supply the city with adequate water until 2019. Longer-term projects include extending the water supply network by implementing the Mutobo Water Project, which could provide 100,000 cu. m of water per day for Kigali and adjacent cities of Muhanga and Nyamata (Nsanzimana 2013a). The source of water for the project is the Mutobo area, in the Northern Province's Musanze District (Karinganire 2012).

Water Use

In Kigali, water is most commonly used for drinking, cooking, bathing and toilets; irrigation for crops and livestock; sources of hydropower and for industrial uses; and support for wildlife habitat and the provision of ecosystem services (van 't Klooster, Smet and Kente 2011). In Rwanda as a whole, industry accounts for only two per cent of total water withdrawals, but considering the country's industries are mainly concentrated in Kigali, this means substantial consumption by the city (UNEP 2011b). Residential water use is higher in newer urban residential neighbourhoods where the extensive water network and the existence of public facilities make consumption easier. It is likely that water use in larger homes, office buildings and tourism facilities is as high as 200 lpcd. Conversely, unplanned settlements such as Rusororo with no access to indoor plumbing consume much less water, in the range of 15 to 25 lpcd (Surbana 2012a).

Umuhoza Mbateye, et al. (2010) reported on typical average water use among households, using a sample of 100 households of varying income levels (Figure 3.14). High- and medium-income households

Figure 3.14: Proportions of water consumed in Kigali for different domestic uses



Source: Adapted from Umuhoza Mbateye, et al. 2010; visualisation by UNEP/GRID-Sioux Falls

Rainwater harvesting from a school roof is being used to establish and maintain a playground lawn

use most water for flushing toilets and bathing, while low-income homes have no flush toilets and a significant proportion of their water is used for bathing.

Inefficient water use contributes significantly to water consumption. For example, most flushing toilets in Kigali use 12 litres (L) of good quality drinking water per flush (EWSA 2012a). Irrigating the city's green areas also consumes good quality water at a rate of about 10 cu. m per day. Using recycled water, from rainwater harvesting or grey-water reuse, for example, would substantially cut down on water consumption for activities such as toilet flushing and watering public areas. The use of more water-efficient showers and faucets for households with running water would also help reduce the level of water demand (EWSA 2012a).

Conclusion

The limited amount of suitable land for urban infrastructure within Kigali, combined with the growing population and a lag time in instituting and enforcing urban planning, has resulted in housing, industries, businesses and other infrastructure being constructed in fragile ecological areas. As a result, wetlands, steep slopes and agricultural areas have suffered. Now, the City of Kigali is acting to reverse the damage and protect the city's underlying ecology as well as the safety and health of its residents. It is moving infrastructure out of sensitive areas, setting aside protected wetlands, modernising agricultural production to improve land use practices and increasing the number of parks and open green spaces. To improve housing and the standard of living, the City of Kigali is redeveloping and upgrading housing and settlements as well as improving energy and water supplies and efficiency.

All of these plans and actions are helping Kigali to move forward in implementing its sustainable urban management plans. Acting on these plans will ensure that development is sustainable. Kigali should be able to achieve the CKDP's aim for 11 per cent growth in GDP while also sustaining ecosystem resources and social welfare (CoK 2012).

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The City is working towards having pollution-free green space for all to enjoy such as the green space around the Place de l'Unite National roundabout

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Pollution and Waste Management 4

This chapter describes and provides data and trends about the sources of pollution in Kigali and the impacts they have on environmental resources and human health. It also notes how the City of Kigali (CoK) is managing water, wastewater, sanitation, solid municipal waste, industrial effluents and air pollutants to improve living conditions in the city and protect and restore its important wetland resources and other ecosystems.

Sources of Pollution

As discussed in the 2009 and 2011 Rwanda State of Environment reports (REMA 2009, REMA 2011b), air, land and water pollution are important environmental issues in Kigali. Ecosystems and resources primarily suffer from polluted runoff and the impacts of inadequate waste disposal facilities. Kigali residents are exposed to compromised outdoor air quality mainly due to vehicle exhaust, while indoor air is often polluted due to the burning of cooking fuel.

Waste discharged from industrial, household, institutional and commercial establishments pose a threat to the city's wetlands. The Gikondo, Nyabugogo and Nyabarongo wetlands have been polluted, fragmented and degraded due to poor urban planning and the discharge of waste and toxic pollutants from establishments near and within them (Mukundwa 2011). For example, a research article in 2010 noted that the Central Prison (also known as 1930) discharged black and grey water every evening for around six hours, further contributing to wetland pollution. The water flowed close to households on its way to the Nyabugogo River (Umuhoza Mbateye, et al. 2010). Agricultural fertilisers, pesticides and herbicides also contribute to wetland pollution. The use of such chemicals in rice growing, for example, has resulted in heavy loads of phosphorous and nitrogen running off into wetland waters (Mukundwa 2011).

Solid and liquid waste management is an issue in both urban and rural areas of Kigali. While there is a central landfill system, people continue to illegally dump waste and wastewaters in rivers, wetlands, ditches, roadsides and other public spaces. Less affluent households and rural residents have limited access to the city landfill and often cannot afford the cost of waste collection services (Bazimenyera, Qiang and Karangwa 2012), which are provided by private companies. There are also problems associated with open sewers and stormwater drainage canals, since

Public garbage can

rainwater can mix directly with household and street waste. Consequently, this waste can flow directly into wetlands, such as Gikondo and Nyabugogo (NUR 2012), and people living in unplanned settlements are exposed to unhealthy water in their vicinity.

After decades of struggle to properly address pollution issues, the CoK, in conjunction with local businesses and communities, has begun to work towards improving sanitation and waste services. As a result, living conditions seem to be on an upward trend.

Health Risks of Pollution

The people of Kigali are entitled to, and actually receive, a certain number of kilolitres of water a day. Residents who take advantage of water sources that are not considered potable, however, can face health risks. For example, evidence suggests that the further away a household is from the main improved drinking water source, the higher the chance that the household actually uses another, less sanitary, water source found closer by (NISR 2012). Also, women and children are disproportionally relegated to fetching household water, potentially compromising their health and reducing the time they could devote to earning money, school studies and other pursuits (MINECOFIN 2013). People living near the Nyabugogo River use its waters for washing and cleaning (Umuhoza Mbateye, et al. 2010), and these waters suffer from pollution. Also, people living close to open drainage canals, where stagnant water accumulates that can encourage mosquito breeding, are likely to be more susceptible to vector-borne diseases.

Another potential health threat in Kigali is related to crops grown in wetland areas that might contain unhealthy levels of pollutants. A study by Etale and Drake (2013) found that metal concentrations in crops cultivated in the Nyabugogo wetland were within European Union (EU) standards for crop production, but after testing a sample population that had consumed those same crops, the amount of metal they ingested exceeded the maximum threshold of dietary intake recommended by the World Health Organisation (WHO). Lead intake was seven orders of magnitude higher than the threshold from consuming amaranthus and four orders of magnitude higher from consumption of taro (tubers). Cadmium intake was two orders of magnitude higher for amaranthus and taro and three orders of magnitude higher for sweet potatoes (Etale and Drake 2013). Exposure to heavy metals has been associated with retarded development, numerous cancers, kidney damage, and in some instances of very high concentrations, even death (WRI 1998).

Air pollution poses a threat to health when small particles from burning fuels linger in the air and are inhaled; in some places in the developing world, the toxic level of fumes from open fires can exceed by 200 times the safety levels established by the United States Environmental Protection Agency (EPA). In Rwanda, respiratory disease accounts for 34 per cent of new visits to health centres, no doubt caused mostly by indoor pollution from cooking (Ruxin 2011). Respiratory tract infections are the leading cause of child deaths in Rwanda (MINISANTE 2012), many of which may be the result of indoor air pollution (Young and Khennas 2003). A study by Henninger (2013) found elevated levels of particles in congested and busy paved areas of Kigali, but also in residential districts, most likely due to indoor cooking. Due to the dynamic of hills and valleys in Kigali, particulate matter tends to gather in the valleys, and although night-time winds tend to partially clear the air, vehicular and household emissions are still important air quality issues for those dwelling in the valleys (Henninger 2013).

Access to Improved Sanitation and Safe Drinking Water

The provision of improved sanitary facilities, access to clean drinking water and overall better urban cleanliness will help to mitigate some negative health effects of pollution. The City of Kigali has ambitious goals for improving these sectors in the future, and believes that with proper governance and community involvement, they can be achieved.

Access to Improved Sanitation

The revised Vision 2020 target for sanitation stipulates that Rwanda achieve 60 per cent coverage by 2015 and 100 per cent access by 2020 (MINIRENA 2012). The EDPRS 2 set a target of 100 per cent of

Table 4.1: Institutional framework for sanitation in the City of Kigali

	Urban	Rural	
Sector Leadership	MININFRA MINISANTE	MININFRA MINISANTE	National
Regulation	RURA REMA	REMA	
Service, Development and Provision	MINALOC CoK EWSA Districts	MINALOC Districts MINEDUC Households	Local

Source: Adapted from World Bank 2012; visualisation by UNEP/GRID-Sioux Falls

urban households with access to improved sanitation by 2017-2018 (MINECOFIN 2013). By 2012, however, Rwanda had surpassed Vision 2020's 2015 target by providing 74.5 per cent of residents with hygienic sanitation (MINECOFIN 2013). Currently, access to improved sanitation facilities for all three Districts in Kigali has also exceeded the 2015 goal. The city will continue to strive towards the 100 per cent EDPRS 2 goal for urban households, and also continues to improve access in other areas of the city. In addition, with efforts to attract investors and tourists, additional public sanitation facilities will need to be made available for visitors.

A variety of stakeholders at both national and local levels play a part in the leadership, policy development, enforcement and provision of sanitation facilities and services (Table 4.1). The national institutions of the Ministry of Infrastructure (MININFRA) and the Ministry of Health (MINISANTE) provide leadership on sanitation matters to both urban and rural populations. The Rwanda Utilities Regulatory Authority (RURA) and the Rwanda Environment Management Authority (REMA), which are national regulatory agencies, ensure that policies and best practices in urban and rural areas are being implemented. The Ministry of Local Government (MINALOC), the City of Kigali, the Energy, Water and Sanitation Authority (EWSA) and District leaders are responsible for service, development and provision for urban populations, while MINALOC, District leaders and the Ministry of Education (MINEDUC) ensure service development and provision for rural populations. Goals set forth in the EDPRS 2 strive to increase capacity building at the community level through EWSA and to improve sanitation by implementing District sanitation plans (MINECOFIN 2013).

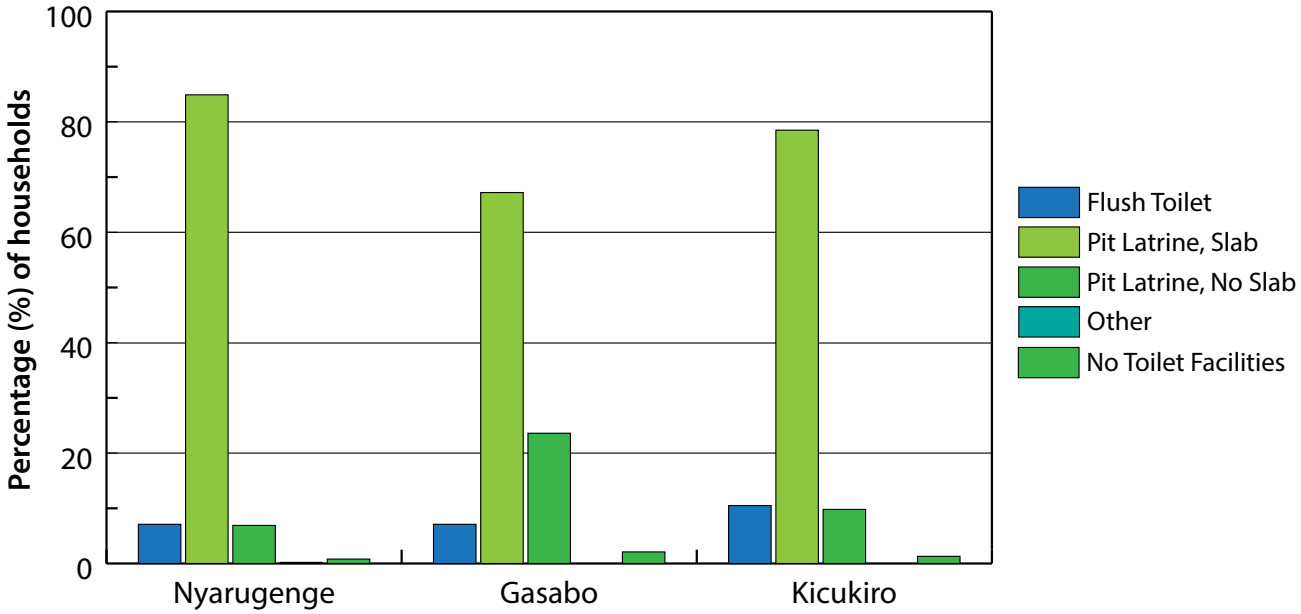
Improved sanitation facilities are defined as facilities that hygienically separate human waste from human contact (WHO and UNICEF 2010). Such facilities include composting or flush toilets that empty to a piped sewer system, septic tank or pit latrine (PL); ventilated improved pit (VIP) latrine; and pit latrines with a solid slab. A pit latrine without a solid slab is considered an unimproved sanitation facility since it can have many health and household consequences. While a pit latrine with a slab is classified as an improved sanitation facility, it can also have many problems (Table 4.2), so the city encourages the installation and use of flush toilets (CoK 2012).

Table 4.2: Issues with pit latrines and their associated effects

Issue	Effect
Pit latrines are difficult to empty safely and efficiently	Typically a latrine is used until full, then another latrine is dug, leaving the former to remain stagnant and full
Many rural areas have pit latrines with no slab	Poor sanitation and household hygiene
Deep latrines do not treat the waste before it comes in contact with surrounding soil	Untreated waste can lead to groundwater pollution
In high density areas, pit latrines are built close together	Reduces the amount of space for new latrines and increases health risks

Source: Electrogaz and MININFRA 2008, Etale and Drake 2013; visualisation by UNEP/GRID-Sioux Falls

Figure 4.1: Household sanitation facilities, by District

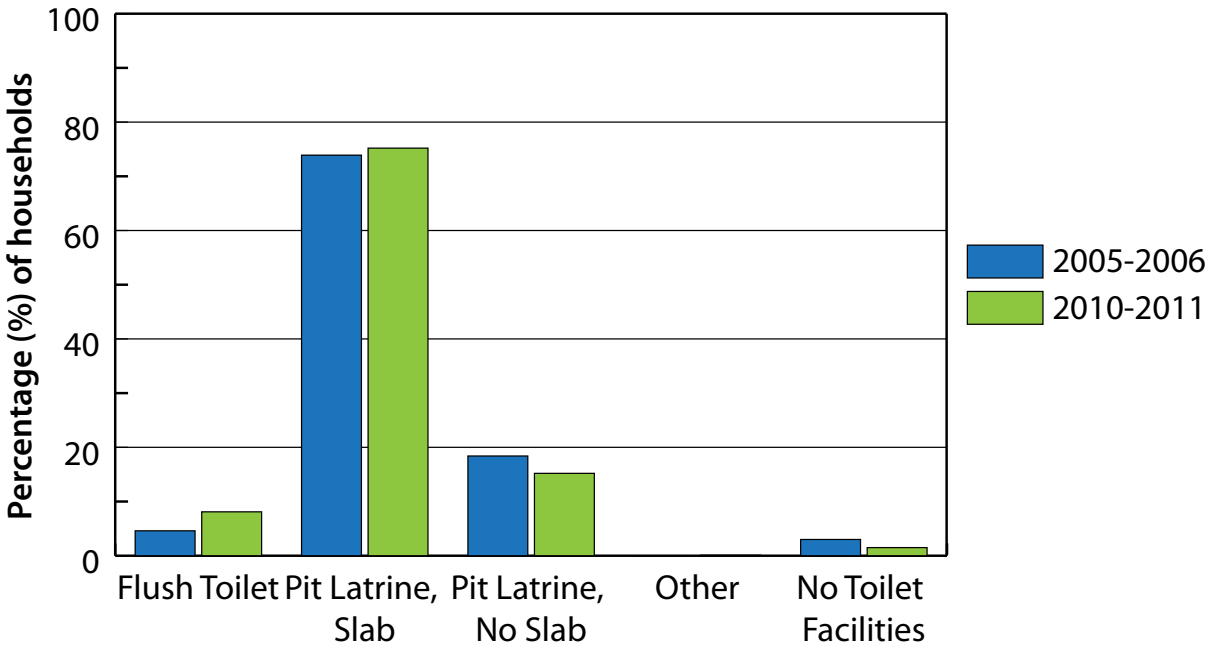


Source: NISR 2012; visualisation by UNEP/GRID-Sioux Falls

More than 70 per cent of residents in Gasabo District and more than 85 per cent of residents in Kicukiro District and Nyarugenge District have access to improved sanitation (NISR 2012). The primary type of improved facility in these Districts is a pit latrine with solid slab, but some households have access to flush toilets (Figure 4.1). Very few households — 2 per cent or less — in each District surveyed were found to have no available toilet facility. The percentage of households with flush toilets or improved pit latrines has risen since 2005, a sign that households are working towards increasing the quality of their own sanitation (Figure 4.2).

Sewerage systems in Kigali are primarily individualised, leaving it up to households to inform themselves about proper sanitation procedures and take responsibility for them. Housing developments as well as large institutional and business facilities tend to have their own sewage treatment plants. City plans are underway to develop centralised District sewerage systems in the foreseeable future. Establishments that are currently developing individualised systems must plan and design them to support current and future plans, bearing in mind how their system might eventually connect to a centralised one (RURA 2012).

Figure 4.2: Change in proportion of household sanitation facilities, 2005-2011



Source: NISR 2012; visualisation by UNEP/GRID-Sioux Falls

A public eco-toilet in the city centre

There are a number of public toilets in Kigali: an eco-toilet in the city centre near the Place de l'Unité Nationale roundabout, another near the city market in the Central Business District (CBD) and a few others in the Kimironko, Remera and Nyabugogo bus terminals (Rwirahira 2013). The CoK has encouraged businesses to install flush toilets and Rwanda Environment Care (REC), a private organisation, spearheaded the 'eco-toilet' project; these initiatives have helped to improve public access to sanitation facilities. The REC operates 12 'eco-toilets' and showers in the Nyabugogo Taxi Park that are used by an estimated 1,000 to 1,500 people every day, although only a few toilets are fully operational (MINISANTE 2011). The pressure on the City to supply public toilet facilities has led officials to reach out to petrol stations to lend their facilities for a fee. This would help to increase access to public toilets while also enabling the stations to increase revenue, although getting people to pay for use may be a challenge (Rwirahira 2013).

Improved stormwater management could contribute to more sanitary conditions in and around the city. Methods include stormwater retention strategies and harvesting excess water for non-potable uses, such as landscape irrigation and

A city stormwater drainage canal in aesthetic grassy surroundings

Table 4.3: City of Kigali sanitation priorities

Short-Term Initiatives		
Improvement	**Goal**	**Timeline**
New sanitary landfill and recycling centre	Improved solid waste management	Commence construction in 2013-14 and complete by 2015-16
Incinerator	Improved solid waste management	Commence construction in 2013-14 and complete, install and commission by 2015-16
Sewerage system in CBD1 and CBD2	Centralised sewerage system improved	Commence construction in 2013-14 and complete by 2016-17

Long-Term/Ongoing Initiatives		
Improvement	**Goal**	**Timeline**
Public toilets	Improved access to sanitary facilities	Commence construction in 2013-14 and continue construction as needed
Eco-friendly toilets available in open spaces	Improved access to sanitary facilities	Commence construction in 2013-14 and continue construction as needed
All existing (wastewater and stormwater) ravines constructed	Stormwater drainage system improved	Commence construction in 2013-14 and continue construction as needed
Disabled-friendly toilets	Enhanced social inclusion	Commence construction in 2013-14 and continue construction as needed
Train waste management operators	Proper waste handling improved	Conduct training on transportation, handling and disposal of solid and liquid waste beginning in 2013-14 and continue as needed
Promote gender in waste recycling activities	Income generation among women promoted	Impart recycling skills in 2013-14 and continue as needed

Source: Adapted from CoK 2012; visualisation by UNEP/GRID-Sioux Falls

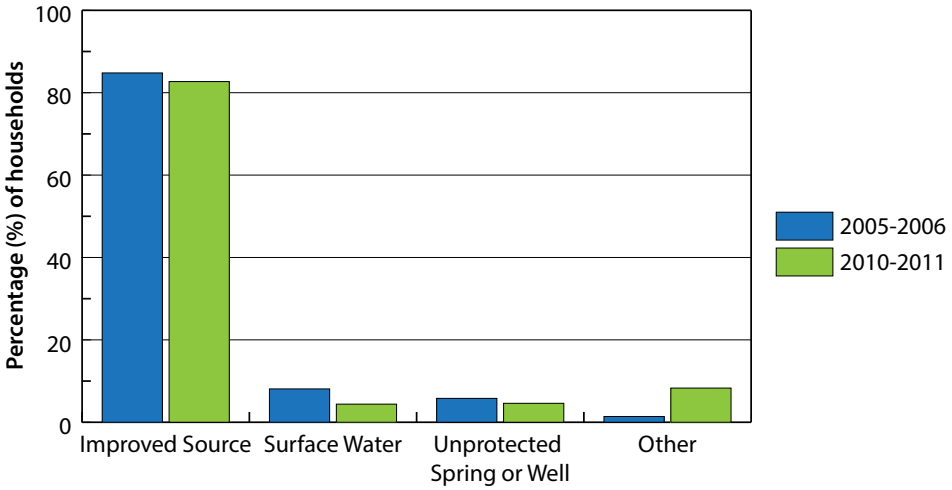
general washing purposes; this would lower water purification costs and help to reduce flood risks (Surbana 2012). The Kigali Conceptual Master Plan (KCMP) proposes instituting improved stormwater management policies and taking actions such as rehabilitating and cleaning the existing drainage network. In addition, infrastructure planning in the long-term (to 2040) includes plans for stormwater harvesting for non-potable water, household water saving devices and fittings, building artificial wetlands and constructing downstream flow paths to catch overflows from sewage treatment plants (Surbana 2013).

The City has several priorities to improve sanitation in the future (Table 4.3). As part of its 2013-2018 development plan, it anticipates opening a new landfill and recycling centre, installing a new incinerator and centralising the sewerage system in the CBD in the short-term. Long-term goals include continuing to improve public access to sanitary facilities by increasing the quantity of eco-friendly and disabled-friendly toilets. It will also construct additional ravines to improve stormwater drainage. Waste management operators will be trained to efficiently run the new landfill facility and more women will be encouraged to take jobs in recycling services to promote gender equality. The EDPRS 2 includes the aim of encouraging formal settlements that will include access to clean drinking water and improved sanitation facilities (MINECOFIN 2013).

Access to Clean Drinking Water

Improved water sources refer to water that is piped directly into a yard or dwelling; provided by a public fountain, protected spring, drilled well, or public utility; or is purchased. Access to improved water in Kigali actually declined slightly, from 84.8 per cent to 82.7 per cent between 2005-2006 and

Figure 4.3: Major sources of drinking water, 2005-2011



Source: NISR 2012; visualisation by UNEP/GRID-Sioux Falls

2010-2011 (Figure 4.3). However, other sources of drinking water, not specified by the survey, increased, which could possibly explain the decline. Access to clean drinking water is an important complement to proper sanitation for maintaining clean and safe households and optimal health. The EDPRS 2 has outlined goals for Rwanda to improve water quality and access to improved water sources. The target for 2017-2018 is for 100 per cent of urban households to be within 200 metres (m) of an improved water source (MINECOFIN 2013). The city hopes to achieve these goals by empowering Districts to plan, design and implement suitable water infrastructure projects as well as by encouraging community involvement.

Liquid and Solid Waste Management

Proper treatment and disposal of liquid and solid waste in Kigali is an issue as the amount of waste exceeds the capacity of available disposal locations. The city is working towards remedying the issue, however, by increasing the access to disposal facilities.

Liquid Waste: Wastewater Disposal and Treatment

Household wastewater is commonly generated by flushing toilets, washing clothes and dishes and bathing; water typically disposed of in the garden is not regarded as wastewater. High-income households typically generate 96 litres per capita, per day (lpcd). The estimated amount of wastewater from medium-income homes is 39 lpcd and low-income households only generate an estimated 15 lpcd (Umuhoza Mbateye, et al. 2010).

Currently, household septic tanks and the direct dumping of wastewater into rivers or wetlands are the usual practices for disposing of residential human waste and wastewater in Kigali (NUR 2012); they are extremely destructive to important wetland processes and a risk to human health. The Directives on Minimum Requirements for Liquid Wastes Disposal and Treatment consider dumping liquid waste in a way that could be harmful to the environment as a punishable offence (RURA 2009). Some higher-income communities, such as the Gacuriro and Nyarutarama Estates (REMA 2009), as well as some other estate communities, apartments, state institutions, hospitals, universities and large commercial centres are fortunate enough to have community or institutional treatment plants that collect and treat septic tank waste (Umuhoza Mbateye, et al. 2010).

As Kigali's population continues to grow and development becomes denser, the practice of sharing wastewater treatment facilities will become increasingly important. The natural wastewater pond system that services more than 400 houses in and around Nyarutarama Estates in Gasabo District is an example of such a solution. Satellite imagery and research studies, however, suggest that the ponds have not been maintained as well as they should be to treat the wastewater optimally. The following Hotspot demonstrates that when constructing future shared wastewater systems, attention should be paid to developing a maintenance plan that can be feasibly implemented.

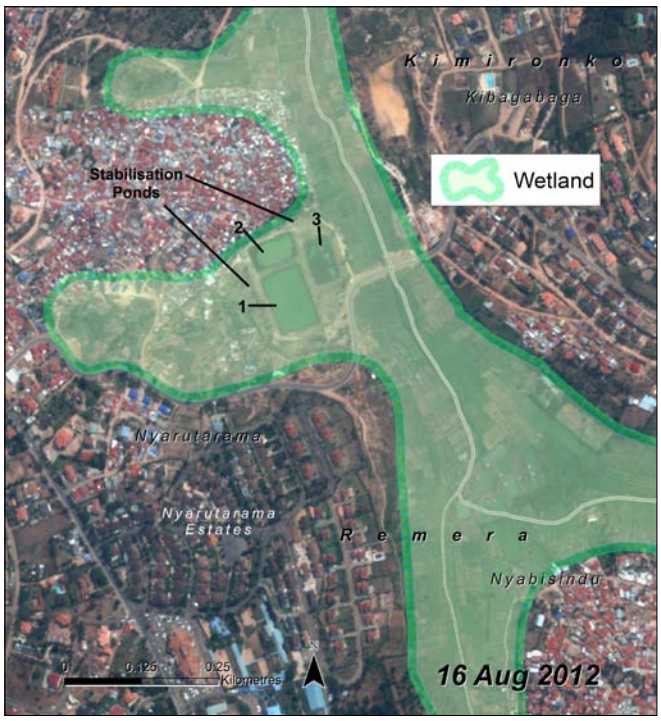
The Nyarutarama treatment system is comprised of three natural stabilisation ponds located adjacent to the Estates (Figure 4.4), but also within the wetland where sugarcane and other food crops are grown (Twagirayezu, Nhapi and Kimwaga 2007). The first pond receives pre-treated waste from household septic tanks (although some newly-built houses contribute untreated waste) and the other two ponds contain vegetation to naturally filter the waste.

The first pond in a natural wastewater system is generally anaerobic (without oxygen). It naturally separates solids from dissolved material, breaks down biodegradable matter, stores non-degradable and undigested material as bottom sludge and then finally lets the waste flow out to the next pond. In the Nyarutarama system, the first pond also has aerobic (with oxygen) sections (Twagirayezu, Nhapi and Kimwaga 2007). At this point, the effluent is partially treated. A fully functioning first pond should be covered with a layer of dense scum, which helps to maintain the pond's anaerobic state, but also helps prevent bad odours from escaping (EPA 2011).

The second and third ponds contain vegetation that furthers the natural filtration process, just as plants in natural wetlands perform the ecosystem service of water filtration. The surface of the second pond should be covered with water lettuce, while the third pond functions as a constructed wetland full of aquatic plants (Twagirayezu, Nhapi and Kimwaga 2007). The amount of carbon dioxide in the second pond is supposed to increase, thus raising the pH (a measure of acidity) and eliminating faecal coliforms (potentially harmful bacteria).

An indicator of septic waste problems in a natural treatment pond is the pH value of inflowing waste (influent). The pH of domestic influent waste should range from 6.8 - 7.5 and large fluxes could indicate that a problem is present (EPA 2011). A study by Twagirayezu, Nhapi and Kimwaga (2007) found the pH of the influent to be relatively stable, ranging from 7.4 to 7.6 over a three-month period, possibly indicating the absence of a significant septic waste problem. However, faecal coliform concentrations in the waste discharged (effluent) from the third and

Figure 4.4: Location of Nyarutarama stabilisation ponds



Source: Wetland data provided by REMA; Image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls.

final pond were found to be twice the accepted limits set by the UN Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO) for irrigation water. The pond's faecal coliform levels, its colour and lack of vegetation may indicate a deficiency in its filtration function. Twagirayezu, et al. (2007) reported that faecal coliform levels were 2,000 cfu/100 ml and the FAO and WHO limit for irrigation is 1000 cfu/100 ml (cfu refers to a colony-forming unit and is an estimate of the numbers of bacteria or fungi). These levels could be potentially hazardous to crops being grown in the neighbouring wetland. It is generally recommended that the anaerobic pond's pH remain at or near neutral (pH=7) (EPA 2011), but during the three-month study period, the water flowing out of the first pond had an average pH of 9.164 (Twagirayezu, Nhapi and Kimwaga 2007).

High-resolution satellite imagery (Figure 4.5) also provides a few clues as to how the ponds may be functioning. Pond 1 shows odd, uneven growth in October 2010 and June 2011. The bright-green colour of Ponds 1 and 2 in June 2011 and what looks like a floating mat of algae may indicate that there has been a bacterial bloom and the pond should have ceased operating (EPA 2011). In all four images,

Figure 4.5: Satellite imagery from 2008, 2010, 2011 and 2012 showing the state of the stabilisation ponds at the Nyarutarama Estates

Source: 2008, 2010, 2011 image: Google Earth; 2012 image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

Pond 2 seems to be lacking vegetative growth, which can be inhibiting to its filtering function, as water lettuce is imperative to this pond's proper functioning. The third pond seems to be covered with vegetation, although in October 2010, this pond appeared to have completely dried out; by 2012 it appears to have filled up again. Future research and consistent water monitoring is needed to maintain a safe environment around these ponds.

An environmental technician at Inyange Industries

Industrial Waste

There are many examples of innovative approaches to industrial wastewater treatment in Kigali. The plastics divisions of Sulfo Rwanda and Inyange Industries attempt to reuse water when feasible (Mugisha 2013). Sulfo treats wastewater and then reuses it in toilets. Inyange Industries has its own water and waste treatment plant, but also reuses water for irrigation in their gardens. Smaller-scale research endeavours have investigated the practice of using rice husks, a common agriculture by-product in Kigali, to remove heavy metals from water. One particular study conducted by Nhapi, et al. (2011) found that rice husks were indeed relatively successful in removing most common heavy metals from industrial water discharge.

Many industries lack on-site waste treatment, which sometimes results in illegally sending untreated discharge into rivers and wetlands. Wetlands function as an ecosystem filter and when they are clogged with waste they are unable to perform their job. Industrial waste can contain hazardous metals such as cadmium and lead, preventing the industrial establishments from reusing the water for agricultural (irrigation) or human use (toilet-water supply), based upon international standards for wastewater reuse (NUR 2012).

The ecological health of the Nyabugogo wetland and the welfare of the people living in its vicinity are issues of concern because of the waste dumping that can occur. The Hotspot on the next page illustrates the effects of industrial waste on the Nyabugogo wetland.

The Nyabugogo Taxi Park and several industrial areas are located along the three rivers that flow into the Nyabugogo River and its surrounding wetland (Figure 4.6). Increased pollution and waste inhibits the wetland from functioning properly, reducing its ability to filter water and provide a safe ecosystem for plants and animals. In addition, the Nyabugogo wetland is ultimately connected to the Nyabarongo wetland, and can contribute to issues in its environment as well.

The Nyabugogo Taxi Park is situated at the confluence of these three rivers, inflicting damage on the wetland because of oil and gasoline runoff from the paved parking surface. The Gatsata Garage zone, which has recently been evacuated (see Chapter 3), is located along the Nyabugogo River and Utexrwa, a large textile producing factory, is located along the Kibumba River, which flows into the Rwezangoro River then ultimately to the Nyabugogo. The Gikondo Industrial Park is also found upstream of the wetland along the Rugenge River. The Rugenge River flows into the Rwintare River and eventually the Nyabugogo. The forthcoming relocation of establishments in the Gikondo Industrial Park could reduce the long-term build-up of heavy metals and help alleviate environmental and social issues related to the impacts of industries in the fragile wetland.

Figure 4.6: Location of the Nyabugogo wetland area

Source: Compiled from various sources; visualisation by UNEP/GRID-Sioux Falls

The abattoir and tannery located on the Mpazi River also contribute to pollution and eutrophication of the wetland (a state of excessive nutrients) because of the discharge of animal waste and blood. A study conducted by Muhirwa, et al. (2010) from 2006 to 2007 found that the water being discharged into the Mpazi River was not suitable for such practices and contributed to high nutrient levels due to a lack of treatment before discharge. In addition, any treatment that was conducted was found to be inefficient and residual animal fat remained.

In addition to filtering water, many studies have shown the ability of wetland plants to absorb and retain heavy metals. Research in 2010 focused on *C. papyrus*, the dominant plant in the Nyabugogo wetland. It showed that the plants play an important role in retaining metals in their root systems, umbels and stems (Sekomo, et al. 2011). It also found that sediments in the industrial areas of the wetland closest to the Gatsata garages had especially high concentrations of the heavy metals cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn) and that Cd and Pb concentrations were higher than common standards for safe drinking water (WHO 2008 and EPA 2009). In only a few instances, however, Cd was found in higher concentrations than standards for irrigation water (Sekomo, et al. 2011).

Future and regular studies such as the ones mentioned here should be conducted to monitor what is being discharged into the rivers and wetlands. Water testing and the results of such studies would inform policymakers and scientists about which establishments are the heaviest polluters and help them determine exactly how each pollution source affects others downstream. Once a baseline of this information is collected, a more educated action plan can be developed to mitigate the current and future impacts of pollution.

View of the Nyabugogo Taxi Park in the wetland

REMA 2012

Table 4.4: Types of waste generated, by District

	Nyarugenge	Gasabo	Kicukiro
	Percentage (%) of waste		
Food	66.4	67.5	66.7
Paper	16.4	16.6	15.4
Grass	6.7	7.3	6.8
Plastic	1.6	1.0	1.9
Metal	0.9	0.5	1.9
Textile	1.8	2.4	1.8
Glass	1.6	0.8	1.7
Wood	3.2	3.0	2.5
Leather	0.5	0.2	0.4
Cans	0.9	0.7	0.9

Source: Adapted from Bazimenyera, Qiang and Karangwa 2012; visualisation by UNEP/GRID-Sioux Falls

Solid Waste Generation and Collection

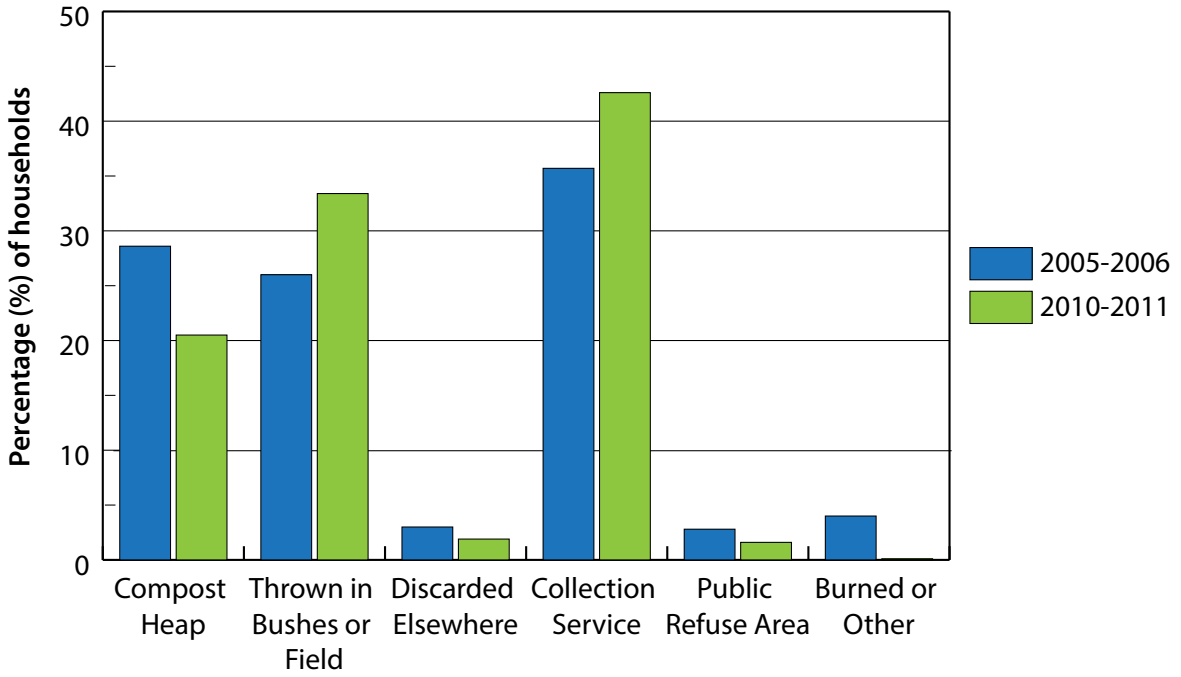
Generation

In 2007, it was reported that Kigali generated an average of 500 metric tonnes (t) of solid waste per day, but by 2012, figures quadrupled to 1,800 t to 2,000 t of waste (CoK 2007a, Bazimenyera, Qiang and Karangwa 2012). The recent estimates equate to about 1.8 kg to 2 kg of waste generated per person, per day in Kigali (Bazimenyera, Qiang and Karangwa 2012). Food waste accounts for more than 65 per cent of solid waste for all Districts and low-income populations. Middle- and high-income populations produce slightly less, with 63.1 per cent and 58.9 per cent, respectively (Bazimenyera, Qiang and Karangwa 2012). Table 4.4 explains the other types of waste generated in the city, by District. The dominant amount of waste (food and paper) is mostly biodegradable, indicating that the city would benefit from compost efforts (see the Hotspot on landfills). Most other types of waste, including plastic, metal and glass, should be recycled or reused, but proper infrastructure and awareness of the issue may still be lacking.

Collection

The World Bank (2013) estimates that municipalities in developing countries tend to spend 20 to 50 per cent of their annual budget on solid waste management, but only 40 to 70 per cent of solid waste is actually collected and less than 50 per cent of the population has access to these services. This suggests that a huge amount is disposed of illegally in vacant areas of the city, or stockpiled around homes and other buildings, potentially contributing to health and safety problems, including contaminated water and pollution runoff. In Kigali, the percentage of households using a formal collection service has increased since 2005, but the percentage of households that dispose of waste in public areas, such as bushes or fields, has also increased (Figure 4.7). The use of compost heaps has declined, possibly as a result of increased public disposal or use of collection services.

Figure 4.7: Method of waste disposal, 2005-2011



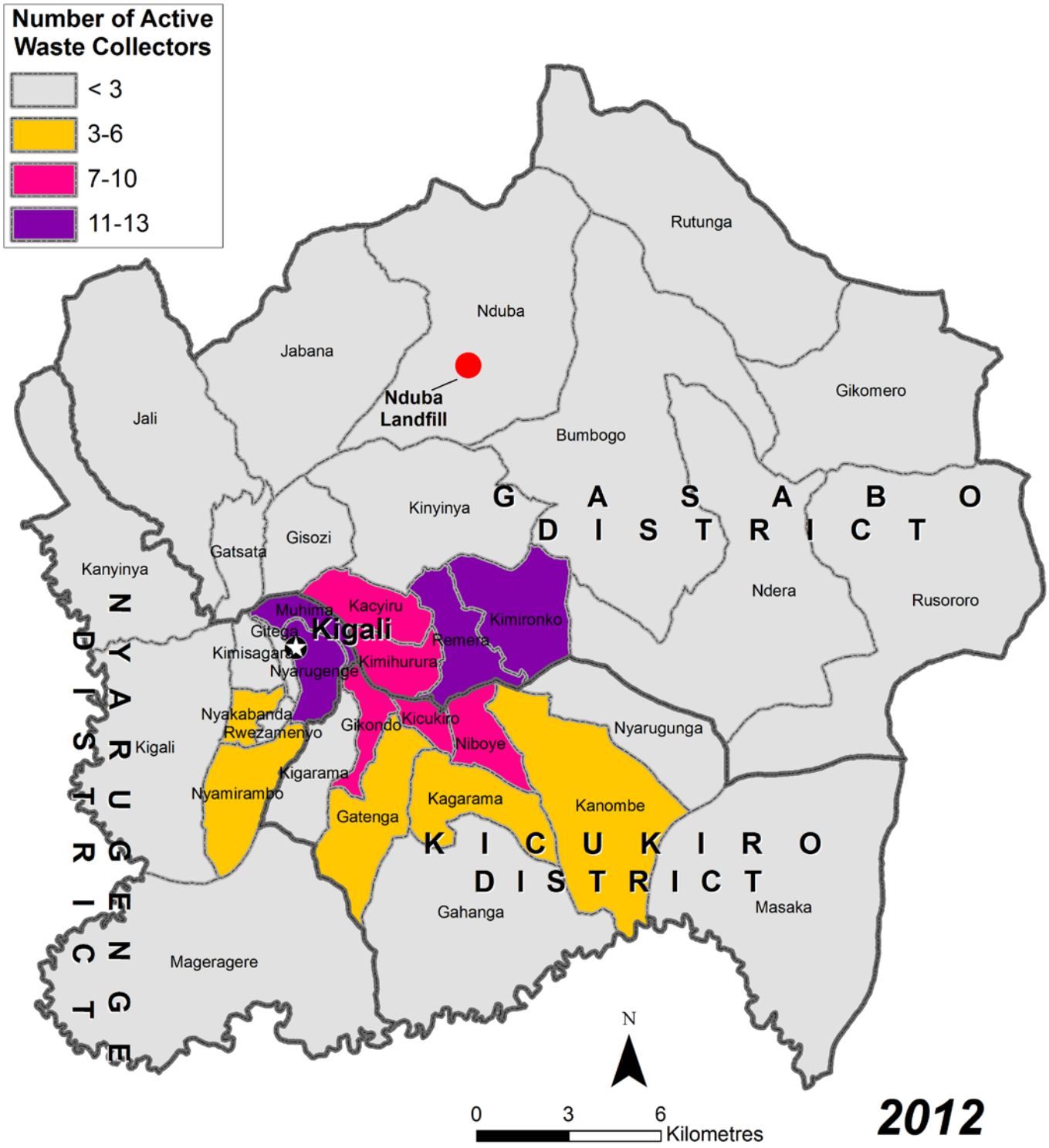
Note: The category 'Discarded Elsewhere' includes dumping in a river, lake or other place which was a category included in the EICV3, but not in the EICV2.

Source: NISR 2012; visualisation by UNEP/GRID-Sioux Falls

Private companies operate municipal waste collection in Kigali (Figure 4.8) and solid waste is required to be dumped in the city's landfill. The Nyanza landfill was logically closed in 2012 for being a health and environmental hazard, but it was located close to the population it served making it convenient for waste collection services to reach. The new landfill in Nduba is much farther away from the city's densest populations, reachable only by dirt roads on steep slopes making it challenging for both large garbage trucks and the common resident to reach. Garbage collectors had to increase their client fees to compensate for the extra mileage for their trucks and workers (Kanyesigye 2012).

The City of Kigali and the Belgian Development Agency (BTC Rwanda) conducted a study during the first few months of Nduba's opening. It found that waste brought to Nduba is primarily generated from households (65 per cent) and less often from commercial establishments (26 per cent) and industries or medical facilities (less than 10 per cent)

Figure 4.8: Number of active waste collectors for Kigali

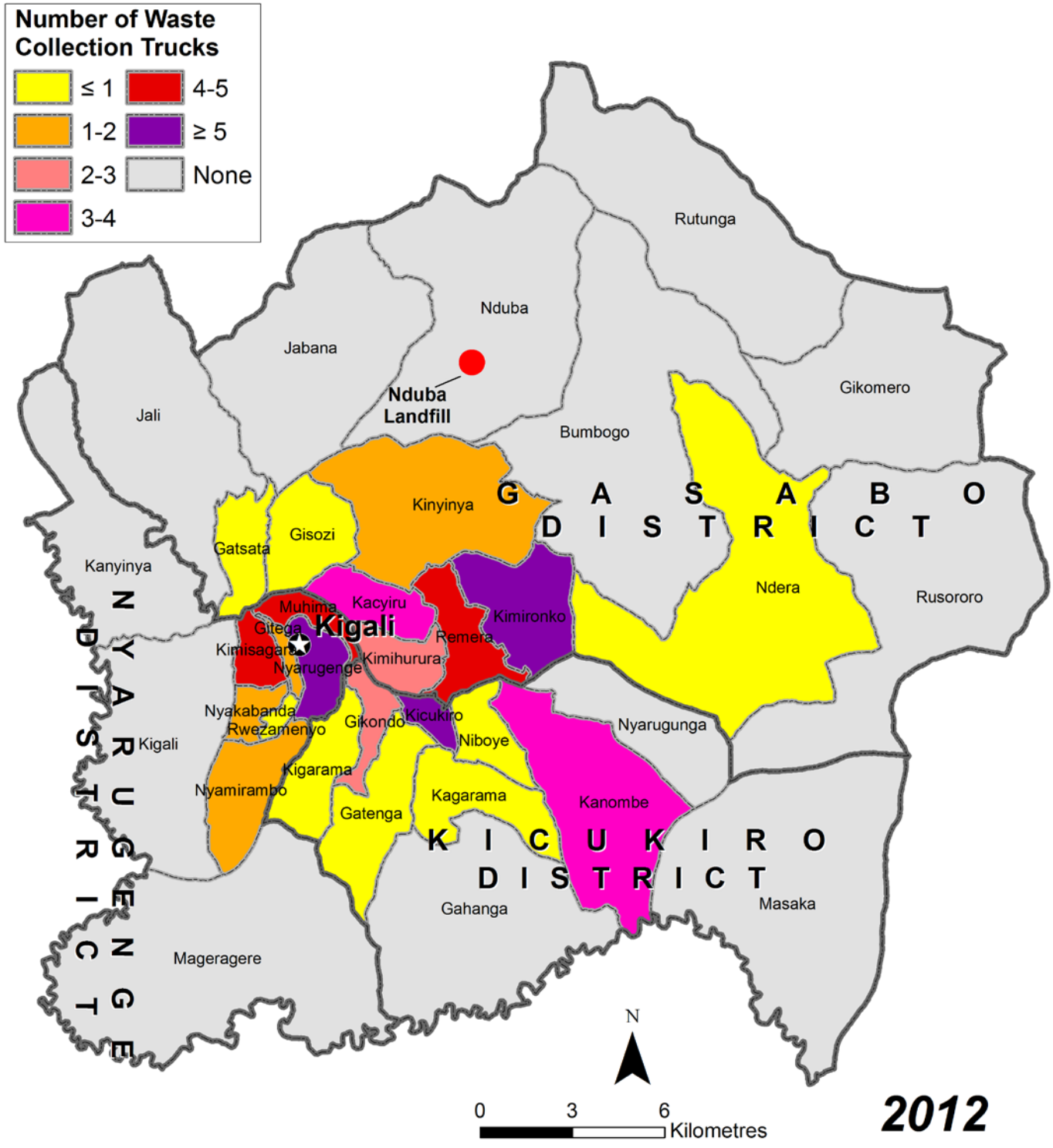


Source: Adapted from CoK and BTC Rwanda 2012; visualisation by UNEP/GRID-Sioux Falls

(CoK and BTC Rwanda 2012). Only a small percentage of medical waste is brought to the landfill because most biological waste and expired drugs are disposed of in onsite incinerators. Medical facilities throughout Rwanda are working towards increasing the number of such waste disposal incinerators (MINISANTE 2012).

Figure 4.9 shows the average number of trucks that collect waste in Kigali's different Sectors; it shows clearly that only the Sectors surrounding the main downtown area are serviced by formal waste collection operations. It is also evident that Nduba Sector, where the landfill is located, does not actually receive any waste collection services. Only three Sectors are serviced by more than five trucks per day and 13 Sectors are not serviced at all. Most Sectors that receive waste collection services are visited by at least one truck per day. Hotels and industries may dispose of their own waste relatively often and opt not to use a waste collection service (CoK and BTC Rwanda 2012).

Figure 4.9: Average number of waste collection trucks that collect in each Sector, per day for Kigali



Source: Adapted from CoK and BTC Rwanda 2012; visualisation by UNEP/GRID-Sioux Falls

Figure 4.10: Nyanza Landfill, 2009 and 2012

Source: 2009 and 2012 image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

For over 30 years, the Nyanza landfill in Karama Sector, Kicukiro District was used as a landfill for Kigali's municipal solid waste (Bazimenyera, Qiang and Ntakirutimana 2012). It was established informally so did not meet landfill standards, including using a lining to prevent leachate (CoK 2007b). Since it was full to overflowing and was a hazard, the Rwandan government closed the landfill to prevent further environmental harm. Until its closure in May 2012, Nyanza was accepting more than 100 t of waste a day (UNDP 2012); satellite imagery illustrates the amount of waste that had accumulated over a period of just a few years (Figure 4.10).

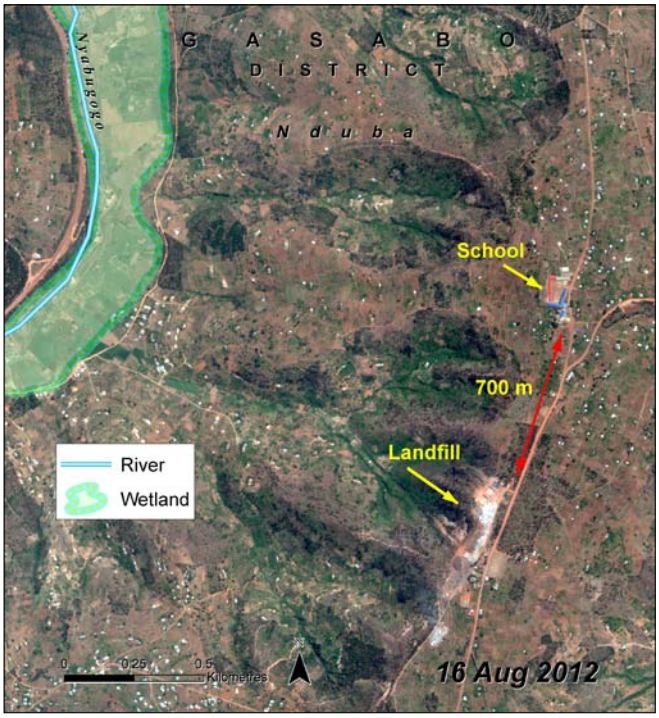
A cyclical process of compacting the waste and covering it with soil, then compacting and covering it again, was used to decommission the Nyanza landfill. Vents were inserted to safely rid the waste piles of any accumulated methane. A satellite image from 2012 shows where the decommissioning process had begun (Figure 4.10). The KCMP envisions that

A bulldozer compacting trash at Nyanza near a vent installed to release methane

once deemed safe for human use, the former landfill site will be turned into a large regional park (OZ Architecture 2007).

There are many issues associated with the location of the new landfill in Nduba. RURA regulations mandate that landfills cannot be located within 400 m of a residential development nor closer than 3,000 m to an airport or airfield, but it

Figure 4.11: Location of Nduba landfill



Source: Wetland data provided by REMA; Image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

does not stipulate minimum proximity to a school (RURA 2009). The northernmost tip of the landfill (as estimated from August 2012 imagery) is a mere 700 m from a primary school, which means that young children walk past the landfill to get to school (Figure 4.11). RURA also requires that the landfill be at least 100 m away from places that enable public access, and that a 20 m buffer be built around the landfill (Figure 4.12, next page), but in some areas

A young child playing on a garbage mound at Nduba near the road

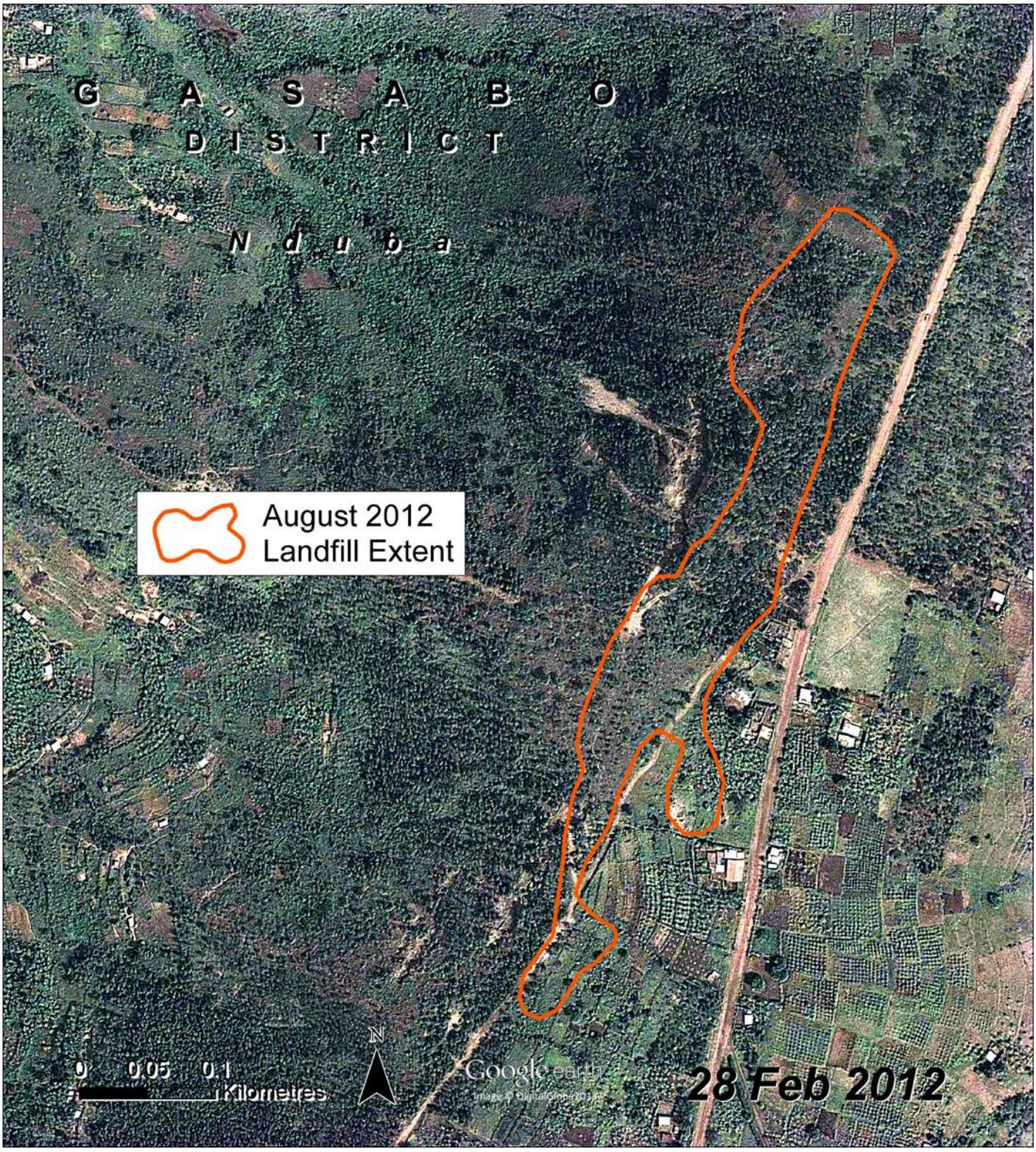
waste is found right next to a road, or less than 20 m from one. Furthermore, Nduba is located on a cliff approximately 300 m above the Nyabugogo River, the surrounding wetland and several residences (estimated from elevation data). The area containing solid and liquid waste collected from septic tanks is closest to the cliff edge and in times of excessive rainfall could be prone to spillage or runoff. Any runoff would then pour down the hillside. RURA guidelines also mandate that dead animals, animal parts, contaminated food, food scraps and edible material must be buried in a trench and should be

The Nduba landfill

covered with at least 500 millimetres (mm) of soil (RURA 2009). The majority of waste at Nduba is biodegradable, but it is not properly and adequately sorted for composting, which would be a better solution than landfilling. More importantly, waste sorting should begin at the household level and trucks should be able to effectively carry sorted waste to the dump facility.

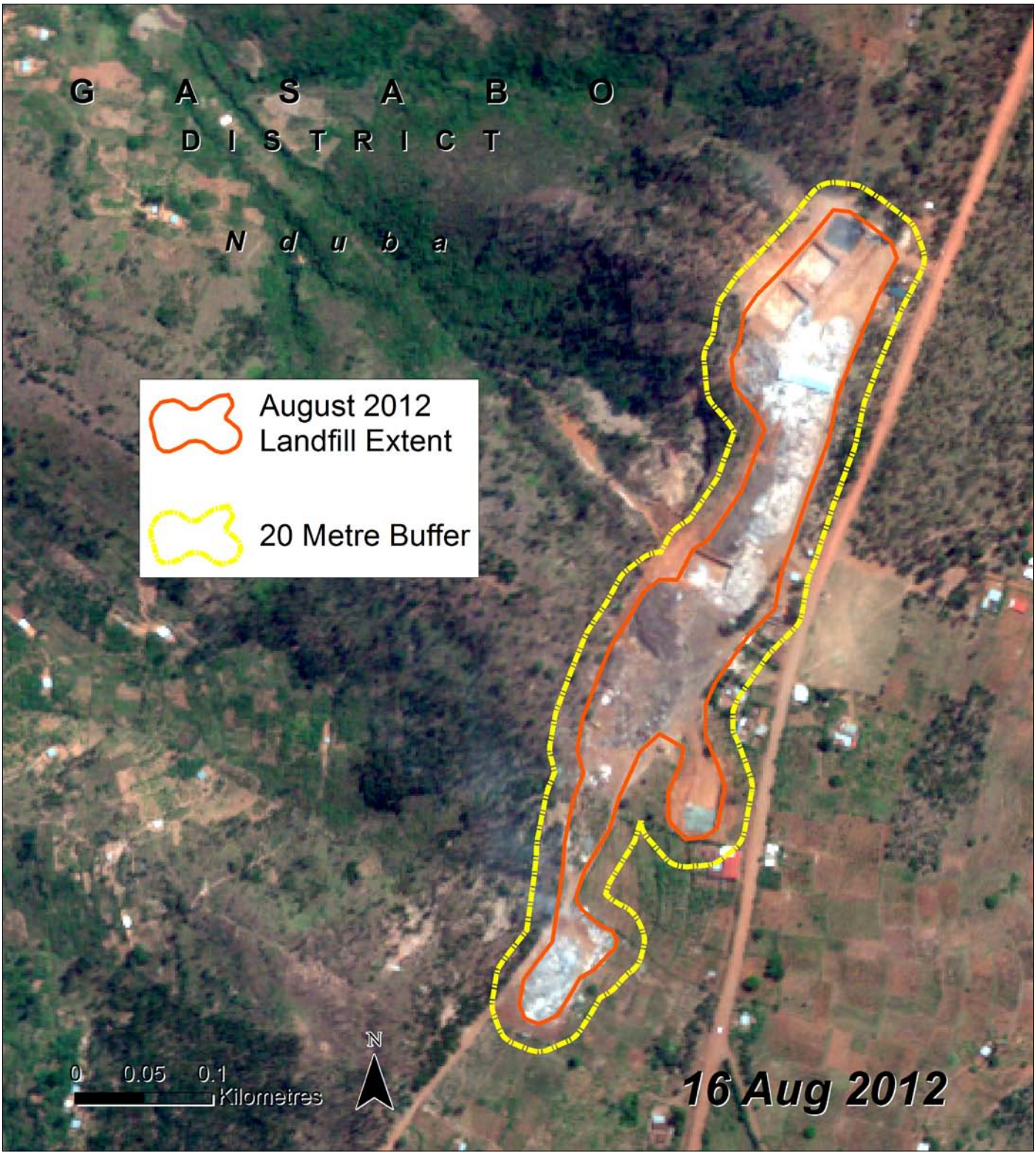
During its first two months of operation in the summer of 2012, a daily average of 55 trucks unloaded waste at Nduba, each one carrying approximately 2.1 t for a total of about 115 t a day

Figure 4.12: Rapid expansion of the Nduba landfill between February 2012 and August 2012



(CoK and BTC Rwanda 2012). By mid-August, the landfill, including waste and unloading areas, spanned about 3.75 ha (estimated from imagery; Figure 4.12).

Only an estimated 25 per cent of the solid waste generated in Kigali makes its way to the Nduba landfill, however (CoK and BTC Rwanda 2012). Officials from the City recognise the need to better manage the landfill, illustrated by its recent decision to seek a new company to run it (de la Croix Tabaro 2013a).



Source: February 2012 image: GoogleEarth; August 2012 image: DigitalGlobe; visualisation by UNEP/GRID-Sioux Falls

Electronic Waste

The term 'electronic waste' or 'e-waste' refers to electronic physical matter such as televisions, radios, mobile phones, laptops, computers and other materials that have become unusable for their intended purpose, have no recyclable purpose and are in need of disposal. E-waste is a problem not only in developing countries, but also in developed countries and those where technology is advancing rapidly. Worldwide, it represents five per cent of all municipal solid waste, almost the same proportion as plastic packaging, and continues to increase (EACO 2012). E-waste is responsible for about 1.5 per cent of waste in Kigali (CoK and BTC Rwanda 2012).

Since e-waste is not biodegrable and can contain heavy metals such as lead, barium, mercury, and cadmium as well as parts that may contain other contaminants, such as cathode ray tubes (CRTs), it must be properly managed and disposed of. Workers who recycle and dispose of e-waste can be exposed to these dangerous materials and the environment can suffer from the leaching of heavy metals from landfills and incinerator ashes (EACO 2012).

E-waste is a growing issue in Kigali as ICT capabilities expand (see Chapter 3) and aging electronic waste needs to be disposed of, but proper disposal infrastructure is lacking. According to RURA (2009), landfill operators are required to ensure that they do not dump hazardous, medical and pharmaceutical waste in the landfill. Unfortunately, electronic waste is not formally included in this characterisation scheme and as a result, it ends up in the landfill, or worse yet, is stockpiled in classrooms, houses and warehouses (REMA 2011a) where it can pose a health threat because of its toxic components.

Of the many reasons that electronic waste is a threat to Kigali's environment, there are three primary concerns: (1) it contributes to the growing amount of all types of waste; (2) electronics contain hazardous materials and substances, such as lead and mercury that can infiltrate soil and water when exposed to agents that break it down; and (3) its improper disposal wastes valuable resources (for example, if the gold and copper they contain are not extracted and sold for parts) (REMA 2011a).

RURA is responsible for fostering awareness about e-waste and promoting its management

Electronic waste such as computer monitors and parts have accumulated at Nduba landfill

and is currently developing guidelines for e-waste management in Rwanda (RURA n.d.). Presently, however, e-waste recycling facilities and mechanisms are scarce not only in Kigali, but throughout all of Rwanda. A new company based in Kigali, Great Lakes Electronic Management (GLEM), accepts e-waste for decommissioning and recycling, but most institutions have been reluctant to surrender their e-waste (Kigali Konnect 2013). Located in Kicukiro District, GLEM was able to recycle about 400 pieces (approximately 8 t) of e-waste over the first few months of 2013 during a pilot project. GLEM is working towards growing its facility to become a fully operational e-waste dismantling and recycling facility and also aims to provide education to all citizens of Rwanda about proper e-waste management (GLEM 2012).

Waste Recycling

Some recyclables such as polyethylene terephthalate (PET) are sorted and sold to outsourced recycling companies, as there are no municipal recycling facilities in Kigali for such plastics. Some other types of waste can be recycled in Kigali without much infrastructure. The COPED group collects film plastics to make into plastic materials and biomass to produce briquettes. The COPED group collects 30 t of waste per month, 10 t of which is recycled into briquettes for households to burn as fuel (Nishimwe 2013). This initiative prevents the gathering of some fuel wood, helping to alleviate deforestation in the surrounding forest.

A local women's cooperative, COOCEN, produces about 1,500 t of briquettes a year from

Sorted waste ready to be sold to recycling companies

household waste, which are sold to prisons, schools and factories to burn instead of firewood. It is estimated that the project prevents the burning of 1,200 t of firewood per year or the yearly harvesting of at least 9,000 trees, which is equal to about 9 ha of forest plantation. Another of the project's positive environmental impacts is the prevention of some 297 t of CO_2 emissions per year (GEF SGP 2008). In 2011, the UN Industrial Development Organisation helped to scale-up the project, which led to increased production efforts and awareness about briquettes as an alternative fuel (UNIDO 2011).

Air Pollution

Throughout sub-Saharan Africa, as in other developing regions, urban expansion and population growth has been accompanied by air pollution as the number of vehicles and associated emissions increases and cities struggle to put urban development, traffic and air management plans into place. Air pollution can have significant impacts on human health and matters of equity; it hampers economic development, and rising emissions of greenhouse gases, especially from transportation, is of growing concern related to climate change (The TEST Network 2012). The most significant sources of air pollution in Rwanda are vehicles, indoor fuel burning and industries. In terms of greenhouse gases that contribute to climate change, Rwanda has one of the lowest per capita emissions in the world, at only 0.65 t CO_2/person compared to the world average of 4.63 t CO_2/person (SSEE and GoR 2011). Air pollution in all areas of Kigali should be increasingly monitored and regulated, however, as the population grows, development spreads and the number of vehicles and associated emissions increase.

Rwanda is party to the international agreements related to air quality and emissions that contribute to climate change and ozone depletion: the United Nations Framework Convention on Climate Change (UNFCCC) and the Montreal Protocol on Substances depleting the Ozone Layer, and it has signed the Kyoto Protocol. Nationally, the 2005 Organic Law on the Environment does not allow activities that damage air quality, including non-authorised bush burning and illegally releasing poisonous gases, smoke, waste, soot, dust and any other chemical substances into the atmosphere (RoR 2005). REMA oversees the matter of air pollution in Rwanda and monitors emissions from industries. A Ministerial Order mandates it to suspend an

industry's activities for at least 30 days if its emissions exceed the standard set by the Rwanda Bureau of Standards (RBS) (Babijja 2012). The RBS specifies the permissible limits for sulphur dioxide, carbon monoxides, particulate matter, oxides of nitrogen, hydrocarbons and lead in both ambient air and emission sources. It also prescribes the tolerable limits for inactive dust, oxides of nitrogen and sulphur dioxide emissions from cement factories into the air (RBS 2011).

Vehicular Emissions

An increase in the number of vehicles in Kigali has led to a concern about increased air pollution. In 2005, the Rwanda Revenue Authority registered approximately 40,000 vehicles (including cars, buses, motorcycles, taxis, etc.), but by 2009, the number had risen to over 80,000 vehicles (REMA 2011b). Mid-2012 statistics placed estimates for all types of vehicles and motorcycles at over 114,000 (de la Croix Tabaro 2013b). Air pollution monitoring stations have reportedly been established, but because the system is so new, it is still difficult to obtain regular and reliable information. Regular monitoring is necessary to gauge the current status of emissions and also project impacts for the future.

Household Emissions

As noted in Chapter 3, although connectivity to the electrical grid has increased over the past decade, firewood and charcoal are still the leading fuel types for cooking in Kigali. Indoor smoke, created from burning biomass such as crop residue, or charcoal and firewood can release toxic substances such as carbon monoxide, nitrous oxides, sulphur oxides, formaldehyde and carcinogens (WHO n.d.). Of charcoal, wood and crop residue, charcoal is the cleanest burning, but still poses health threats. Sometimes, indoor air pollution can even exceed limits for accepted outdoor pollution levels. Studies in Asia, Africa and the Americas have found that levels of indoor air pollution caused by burning biomass or coal are 20 times the 24-hour average limit for outdoor air pollution (WHO n.d.).

Briquettes may be a better alternative to firewood to decrease the impacts on forests and to reduce indoor air pollution. Briquettes contain 30 to 70 per cent less moisture than wood so burn at a lower temperature with less smoke and toxic emissions (Young and Khennas 2003). The EDPRS 2 encourages initiatives to increase the use of improved cookstoves and the burning of alternative fuels as these practices have economic benefits — alternative fuels may cost less — as well as environmental benefits in terms of air pollution and clean energy. Encouraging the private sector to invest in developing and distributing improved cookstove technology will also contribute to Kigali's green economic future (MINECOFIN 2013).

Conclusion

The City of Kigali has done an excellent job in prioritising its sanitation and pollution issues. Increased scientific studies will contribute to strengthening current policies as well as to the development of more informed policies that are essential for a green future. Implementing regulations and policies to ensure compliance at household, community and city levels will help the City of Kigali to achieve its goals for better sanitation and waste management. Chapter 5 provides additional insight as to how policy can be a useful tool in this process.

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Planned communities and lush vegetation are evidence that Kigali is well on its way to becoming a green city

Key Challenges and Policy Options 5

The previous chapters of this State of the Environment Report for Kigali described data and trends on environmental conditions and analysed the driving forces and pressures that impinge on the urban environment. They also discussed the impacts of human activity on Kigali's ecological resources and the well-being of its residents. In addition, the story they told about the environment included information on how the Rwandan government, City administration and other private and public actors have responded to Kigali's environmental and related problems.

With an understanding of these findings, this chapter recommends policy options for policymakers and urban planners to consider on the path to sustainable urban development. To do so, it draws from the recommendations found in the many surveys and studies that observe environmental conditions in Kigali. It also draws from the series of plans prepared to guide its development now and into the future. In addition, it proposes policy options inferred from other authoritative sources about urban sustainability in general and in sub-Saharan Africa in particular. A summary of the recommendations is presented in Table 5.1. They are tailored to the specific challenges and opportunities the City of Kigali (CoK) faces as it attempts to reconcile the demand for economic and social development with the need to protect the environment and natural resources that make that development possible.

Table 5.1: Recommended policy options

#	Policy Option
1	Mainstream climate adaptation and mitigation strategies into all aspects of city policies, planning and projects
2	All sectors should incorporate policies to help implement the city's plans for high-density urban development
3	Use policies to catalyse a green economy
4	Introduce policies that strengthen the links between the formal and informal housing sectors
5	Integrate social, cultural, economic and environmental aspects into housing policies
6	Devise city policies to support the national building code's new resource efficiency measures as soon as they are adopted
7	Implement an integrated, sustainable transport system that favours public transit, walking and cycling
8	Adopt an integrated, proactive flood management approach at the watershed level within the national Disaster Risk Reduction (DRR) framework
9	Review Kigali's Integrated Water Resource Management (IWRM) policy and strategy to strengthen demand-side management and wise use
10	Create an Integrated Solid Waste Management (ISWM) system that supports the informal waste sector and protects the environment
11	Develop and operationalise an implementation framework for expediting the City's sanitation plans
12	Establish an urban agricultural zoning policy within the wider framework of developing a green city
13	Ensure the City of Kigali's policies, plans and programmes are well integrated with those of other sectors for coherence and sustainability

Visualisation by UNEP/GRID-Sioux Falls

Current Planning: Sustainable Urbanism

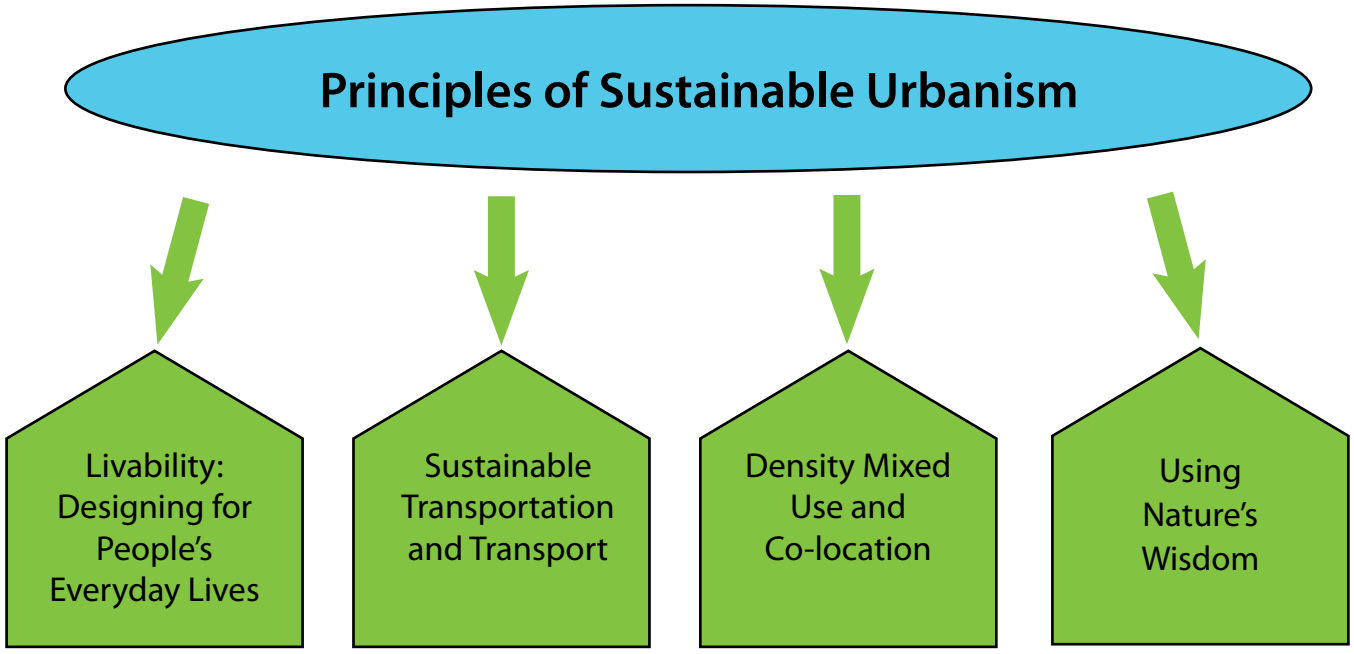
The Kigali Conceptual Master Plan (KCMP), developed in 2007, is based on the notion of sustainable urbanism, which posits that the actual design or layout of a city can contribute to environmental degradation and the emissions responsible for climate change. Similarly, wise planning can ensure a city not only avoids these problems, but contributes to the overall livability of the city in the present and the future. The KCMP proposes some key principles for designing sustainable cities: using nature's wisdom, livability, densely occupied places with mixed uses and sustainable transportation (Figure 5.1) (OZ Architecture 2010). Thus, the CoK's current urban designs aim to increase the density of urban settlements, provide alternatives to the private automobile rather than encouraging sprawl, support mixed-use neighbourhoods and include lots of green spaces. Similarly, the EDPRS 2 states that grouped settlements will be planned according to the 'green village' concept, which focuses on environmental sustainability, including local resilience to the impacts of climate change (MINECOFIN 2013).

The CoK's urban policies and plans are therefore underpinned by the requirement for sustainability. A sustainable city 'is a holistic system in which social, economic, environmental, and institutional aspects of development are mediated through urban design and are harmoniously integrated' (Robertson 2012, 3). It uses its natural resources at levels that allow them to last, does not allow its footprint on the land to degrade it and maintains long-term security from environmental hazards that can threaten its achievements (Burian 1999).

To implement these principles of sustainable urbanism, the KCMP is made up of a hierarchy of sub-plans starting with the city-wide network of wetlands, hillsides, forests and other protected areas and it links sub-area planning for open spaces and greenways to the larger network (OZ Architecture 2010).

These plans are being put into action and Kigali is already progressing towards its aim of becoming a greener, more sustainable city. In the past decade, it has made some remarkable improvements in managing its environment. It has upgraded garbage collection and the public transport and sewerage systems, beautified many city streets and altogether transformed Kigali into one of Africa's cleanest cities, earning it UN-Habitat's Scroll of Honour Award in 2008 (REMA 2011). The City of Kigali is not content to rest on its laurels and continues to implement its plans for a sustainable city. Given the KCDP's aim for an 11 per cent growth in GDP, however, vigilance will be required to ensure development is not only economically viable, but also sustains the

Figure 5.1: Principles of Sustainable Urbanism



Source: Adapted from OZ Architecture 2010; visualisation by UNEP/GRID-Sioux Falls

environment and social equity in the long-term (CoK 2012). By documenting the state of the environment, this report furnishes the City of Kigali with a baseline from which to measure change and its level of future success towards becoming a sustainable city.

Challenges and Policy Options

Findings of this Report

The primary underlying forces affecting the state and future of Kigali's environment are rapid population growth, the structural constraint of Kigali's hilly location and otherwise scarce suitable land for infrastructural development and the unpredictable impacts of climate change. Another structural handicap is the landlocked nature of Rwanda, which requires transporting needed goods from global economic resources, particularly oil-based fuels for electricity production and the transport sector, which are responsible for greenhouse gases that contribute to climate change.

The key challenges facing the city include upgrading informal settlements into serviceable housing with basic utilities, sanitation and road infrastructure, and completing the relocation of residential dwellings, businesses and industries from wetlands and steep slopes to appropriate zones. The City of Kigali has made significant progress in implementing corrective measures to this legacy of unplanned land use, some of which dates back to the early 1970s when industries began building in the Gikondo wetland. In the face of increasingly erratic and extreme weather, however, the impacts on inappropriately located structures have been devastating in recent years, including the loss of life and property.

Climate Change

Climate change has been referred to throughout this report and is one of the key environmental challenges facing Kigali. As shown in Chapter 3, climate change is expected to include higher, more intense and unpredictable rainfall and higher temperatures (REMA 2012). Kigali can expect to suffer from these and other potential impacts of a changing climate and must prepare to adapt to

A thunderstorm rolling into Kigali; climate change could bring changes to Rwanda's rainfall patterns

new conditions while it also attempts to control the growth of greenhouse gas emissions as its economy develops.

By 2050, the strategic framework for Rwanda's *National Strategy on Climate Change and Low Carbon Development* (NSCCLCD) envisions that the country will have developed low carbon domestic energy resources and practices, thus reducing its contribution to climate change and making it independent of imported oil to generate energy. It will have built the capacity to respond and adapt to climatic changes and associated impacts by supporting robust local and regional knowledge (RoR 2011). Adopting 2050 as a target date, the City of Kigali's own climate policies should work towards achieving this same vision.

To increase capacity to adapt to the impacts of a changing climate, the City of Kigali should also recall and act on this recommendation in the *Rwanda State of Environment and Outlook Report*: document the nature and impacts of climate change, especially in the sensitive sectors of agriculture, infrastructure, water and health (REMA 2009).

Policy Option #1:

Mainstream climate adaptation and mitigation strategies into all aspects of city policies, planning and projects

To strengthen its capacity to adapt to changes in temperature and rainfall patterns, the City of Kigali should mainstream climate-change risk screening and adaptation, as well as climate resilience and low-carbon development into all aspects of urban development and planning (RoR 2011). This includes Environmental Impact Assessments (EIAs), especially as they relate to improving access to drinking water and sanitation. (REMA 2010).

Urban disaster/emergency warning and management plans should be updated to address the potential for climate change to increase rainfall intensity and cause heavier floods (REMA 2010). In terms of reducing energy use and associated greenhouse gas emissions, policy options and design strategies are available. For example, cities can improve access to alternative low-carbon inputs for agriculture, transport and electricity generation through innovative technologies that consider opportunities for synergy and the potential 'lock in' effects of actions (SEI 2009, REMA 2010, UNEP 2011c).

Since almost all urban structures and functions can be vulnerable to increased temperatures and intense rainstorms, from housing types to farming, the sections of this chapter related to different urban development sectors point out various climate-adaptation and greenhouse gas mitigation policies and actions that should be considered in better managing Kigali's urban environment.

Managing climate change adaptation and mitigation within industry and urban services need not be a drain on the economy. To the contrary, if properly managed, it can generate wealth by building a skilled workforce, creating jobs and improving education and human health (RoR 2011), as described in the section below on the green economy.

Features of a Green City

One of the key features of a green or sustainable city is its relatively high population density. The literature makes plain that sprawling urban development encourages energy use, among other environmental impacts, while planned and properly serviced, compact, relatively densely populated cities, where business and residential uses are mixed, are more resource-efficient than any other urban development style with comparable levels of economic output (UNEP 2011c).

The EDPRS 2 features 'green growth' as a thematic priority for increasing green investment and environmentally sustainable urban development that exploits green economic opportunities (MINECOFIN 2013). Interventions for green growth include the establishment of a Centre of Excellence to promote and develop green urban areas and technologies, reform policies to support green urban development and pilot a green city. It discusses the available research and practices in green urban economic development, relating them to opportunities available for the City of Kigali.

Density for Sustainability

The trend towards rural-to-urban migration in Rwanda means Kigali could be overwhelmed by the influx of people seeking jobs and a better life unless it plans properly to accommodate population growth so it is an instrument of wealth creation. Urban sprawl has high costs for the environment since it increases energy demand and carbon emissions, especially through increased commuting and the need to extend municipal services, and puts pressure on natural ecosystems; furthermore, it is socially unsustainable since it is highly divisive (UNEP 2011c).

The Government of Rwanda (GoR) recognises that unless economically viable secondary cities develop in Rwanda, and unless the City of Kigali uses its land more efficiently through high-density buildings, it could become a sprawling megacity, partly due to its hilly terrain. It also warns that 'without intervention, Kigali could expand to 5,000 sq. km, nearly 20 per cent of Rwanda's land area, putting serious pressure on food production' (RoR 2011, 11).

Table 5.2: Principles of Smart Growth

#	Principle
1	Mix land uses
2	Take advantage of compact building design
3	Create a range of housing opportunities and choices
4	Create walkable communities
5	Foster distinctive, attractive communities with a strong sense of place
6	Preserve open space, farmland, natural beauty and critical environmental areas
7	Strengthen and direct development toward existing communities
8	Provide a variety of transportation choices
9	Make development decisions predictable, fair and cost-effective
10	Encourage community and stakeholder collaboration in development decisions

Source: ICMA and SGN 2003; visualisation by UNEP/GRID-Sioux Falls

Table 5.2 lists the principles that allow dense urban areas to be highly enjoyable to live in and economically viable. The North American 'smart growth' movement enunciated these principles to curb urban sprawl and make cities more sustainable and livable (ICMA and SGN 2003). By adopting them, African cities like Kigali can 'leapfrog' the problems associated with sprawling American cities before they arise and become entrenched (Arku 2009).

Policy Option #2:

All sectors should incorporate policies to help implement the city's plans for high-density urban development

The city's current density distribution ranges from 3,000 persons per sq. km in low-density single family areas to as high as 25,000 persons per sq. km in high-density unplanned areas (CoK 2012). The KCMP already has an approach to transforming the city through planning for higher residential densities. It notes the need to keep the urbanised portion of Kigali to 35 per cent or less until 2040, which limits the amount of land available for more housing. To accommodate its growing population without exanding over that limit, it proposes that gross urban density rise to 15,850 persons per sq. km by 2025 and to 19,600 persons per sq. km by 2040 (Surbana 2012). These recommendations need to be supported by firm and consistent action on the ground to implement planned mixed-use and dense settlements.

Greening the City of Kigali's Economy

As mentioned in Chapter 2, the cost of urban infrastructure is less expensive per unit as urban density rises. As well, efficient public transportation systems avoid problems related to traffic congestion and along with road charges, can offset associated economic costs of developing dense urban areas (UNEP 2011c). As a sustainable, smartly growing city, Kigali will reap these and other productive benefits that are signs of an emerging green economy.

Policy Option #3:

Use policies to catalyse a green economy

The United Nations Environment Programme (UNEP) defines a green economy as one that results in 'improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities' (UNEP 2010). A green economy is low-carbon, resource efficient and socially inclusive. It means that environmental sustainability can be achieved in a way that enhances economic growth and vice-versa. In a green economy, targeted public expenditure, policy reforms and regulation changes catalyze and support investments in reducing carbon emissions and pollution, enhancing energy and resource efficiency and preventing the loss of biodiversity and ecosystem services. In turn, these investments drive a rise in employment and incomes, thus supporting a robust economy (UNEP 2011c).

The new Special Economic Zone is being built on well-sited land using environmentally friendly infrastructure

UNEP's publication *Towards a Green Economy*, prepared as a guiding document for Rio+20, highlights the many opportunities for cities to green their economies. First, companies can benefit from the production advantages intrinsic to the proximity, density and variety of activities within cities, which also help stimulate innovation. Second, services (e.g., public transport, energy provision, installation and repair, etc.) dominate green industries and also tend to be concentrated in urban areas with large consumer markets. Third, high-tech green manufacturing industries that draw on the knowledge and skills available in university and research centres can cluster in or close to urban cores (UNEP 2011c). By implementing policies that create incentives for green service industries, educational facilities, a varied commercial sector and high-tech green manufacturing, the City can grow its economy and provide jobs while respecting its goals to protect the environment and social equity.

Ecoinnovation

New technologies and other inventions generally come out of urban areas since cities concentrate large numbers of people, as well as the knowledge, financial, social and institutional resources needed to support innovation, into small places where they can interact (UNEP 2011a).

Ecoinnovation refers to new and productive environmentally friendly technologies that create wealth and so support a green economy. Developing economies such as Kigali's may have greater opportunities for ecoinnovation than do developed ones for a number of reasons: firms may not face entrenched financial interests in certain technological paradigms that exist in developed countries; there may be greater regulatory space for new technologies to develop; there may be fewer constraints from fixed infrastructures that are difficult to change; and they may have room to flourish in

markets that are not yet mature or saturated so they can stimulate new kinds of consumer behaviour (UNEP 2011a).

The City of Kigali has already been called an 'incubator of innovation'. By increasing the orientation of its inventions towards sustainability, such as new techniques to save natural resources, harvest water, produce alternative energy and reduce environmental impacts, the City of Kigali could further boost its leadership in ecoinnovation, helping to generate jobs and wealth (EuropeAid 2012). Ecoinnovation can play a role in helping it 'leapfrog' some of the environmentally destructive impacts characteristic of industrialisation in developed countries. The ability to adopt new technologies, which includes technological capacity, knowledge and skills, is a crucial condition for leapfrogging (UNEP 2011a). Also, innovations are only green if they do not lead to a 'rebound effect', which occurs when savings to the environment are offset by increased use. This reflects the need to consider and plan ahead for how innovations change individual and societal behaviour (UNEP 2012a). As a feature of a green economy, ecoinnovation also requires the support of strong government policies and supportive institutions (UNEP 2011a).

Sustainability in All Sectors

This section looks at how urban sustainability and the green economy can be integrated into all sectors of Kigali's urban development.

Green Buildings and Sustainable Housing

There is a vast amount of literature, much of it on the internet, on the plethora of innovations to improve housing and other urban infrastructure so it becomes more energy-efficient and otherwise 'green' or sustainable. In fact, UNEP contends that urban infrastructure could become a major force for such innovation, especially regarding energy use, mobility and the sources, use and reuse of water (UNEP 2011a). A number of such solutions are offered in this chapter purely by way of example, since it is beyond its scope and mandate to focus on design details.

It is crucial to improve existing housing, since there is evidence that upgrading current construction and practices can be more successful in informal settlements than introducing new technologies or housing types (World Bank 2012). Retrofitting with sustainable technologies helps avoid an unsustainable path of fixing problems with poor and inefficient construction and breaks the 'lock-in' to infrastructure that has a high environmental footprint (UNEP 2012a). It is important to understand community lifestyles in informal settings and allow residents to use their knowledge, resources and skills (e.g., as builders, masons, brick-layers, etc.) in the process of upgrading and retrofitting (World Bank 2012). Supporting green retrofit technologies can create opportunities for local businesses and therefore increase employment levels in the city (UNEP 2012a).

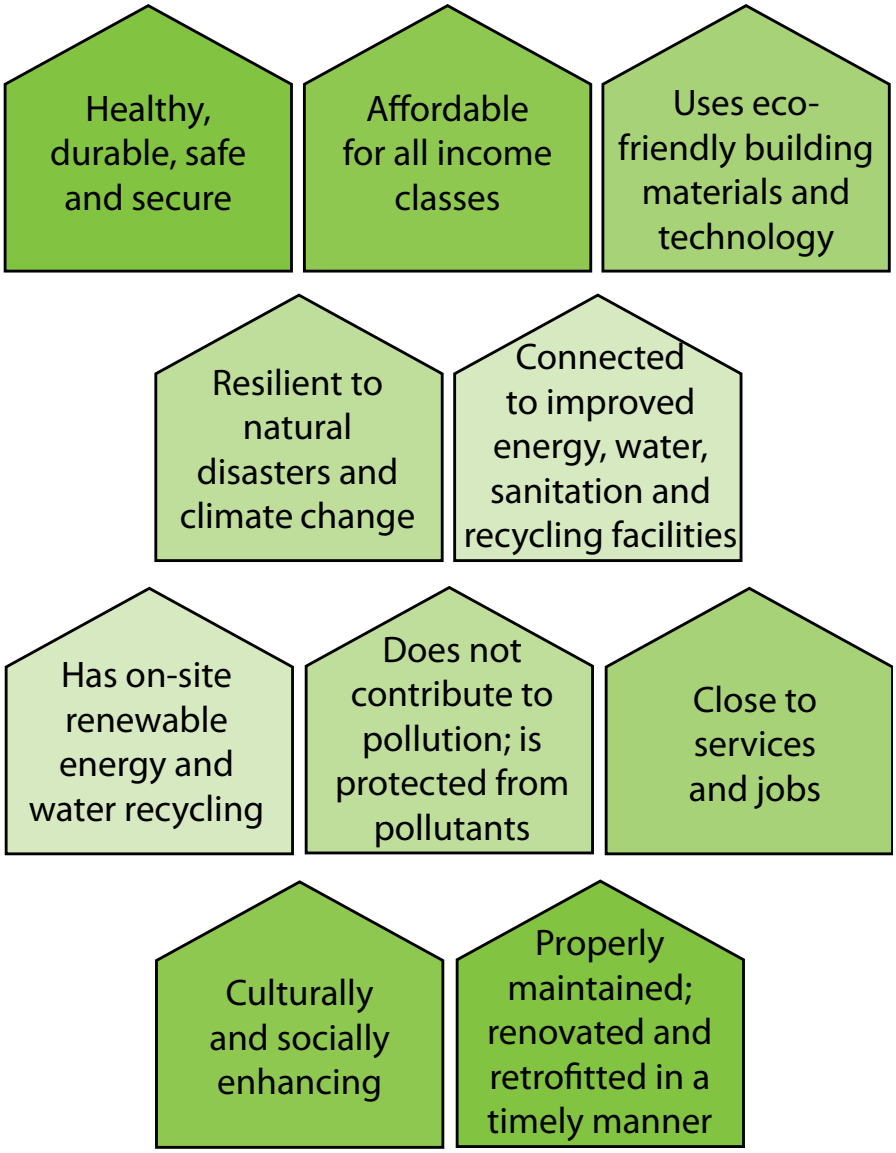
This requires strengthening the links between the formal and informal sectors. For example, upgrading schemes are more effective when the city government's housing programme engages the existing informal sector (Robertson 2012). Thus, it is wise to pursue a mixed strategy for both redeveloping and upgrading existing homes and using both traditional materials and imported ones (World Bank 2012).

Policy Option #4:

Introduce policies that strengthen the links between the formal and informal housing sectors

The sub-plans for Kigali Sectors already in place point out the need to make construction costs affordable. They suggest a number of means, such as providing micro-financing for purchasing and home improvement, easing regulations so people can upgrade incrementally without compromising on safety and using 'green' technologies and local materials (Surbana 2012). Figure 5.2 shows some of the essential features of sustainable housing that city policies should support. It is also important that a variety of financing schemes are made available, such as donations, loans, grants and tax breaks (Pouffary 2012).

Figure 5.2 Features of sustainable housing



Source: Adapted from UN-Habitat 2012; visualisation by UNEP/GRID-Sioux Falls

The notion of green building and embracing and respecting Kigali's natural environment needs to be instilled among all stakeholders and investors in the building and development process. Appreciation of the crucial value of land and natural resources is necessary to reduce the pressure on land and ensure a sustainable future. It is also a pre-requisite to integrating environmental concerns into housing policies.

Policy Option #5:

Integrate social, cultural, economic and environmental aspects into housing policies

UN-Habitat underscores the need to integrate all aspects of sustainability in a more holistic approach when greening housing and settlements. This means ensuring that the social and cultural needs of people are respected, supported and enhanced in housing developments and that they are economically as well as environmentally viable (UN-Habitat 2012). Utilising locally trained architects that understand the residents' cultural needs as well as sustainable building techniques will be essential to achieving this. As mentioned in Chapter 3, KIST is graduating its first class of architecture students in 2013 and these students are an example for the future.

Energy Efficiency and Alternative Sources

It is crucial to integrate alternative fuels and energy efficient approaches into urban infrastructure policies. One of the reasons is to help address a key challenge facing Rwanda and Kigali: In a land-

locked position, the country has large import costs for goods transported by road and air. Rwanda imports all of its oil-based products, which generate almost 40 per cent of its electricity and all of its transportation fuel. Oil price increases have an important negative impact on its economy (RoR 2011). Reducing dependency on oil imports and developing alternative renewable energy resources will help the economy by reducing energy costs and promoting economic development, providing energy security and reducing its vulnerability to external energy fluctuations. It will also help the country mitigate climate change and adapt to its potential impacts (RoR 2011, SSEE and GoR 2011). To support such efforts, the City of Kigali should offer financial and fiscal incentives to companies to comply with voluntary energy efficiency and building standards (RoR 2011).

Reducing oil imports requires increasing energy efficiency, developing renewable energy resources and consuming energy wisely. All three approaches should be taken in constructing and upgrading buildings and urban settlement designs in Kigali (Pouffary 2012). There are many ways to improve energy efficiency. Examples include increasing roof insulation to decrease heat from the sun, passive cooling and ventilation techniques, passive solar energy capture, optimising energy use in appliances, solar thermal water heaters, solar photovoltaic energy to produce electricity and geothermal surface approaches for cooling (Pouffary 2012).

Policy Option #6:

Devise city policies to support the national building code's new resource efficiency measures as soon as they are adopted

In this regard, the city administration should support the current proposal to improve national building codes to include resource efficiency measures (Nsanziman 2013). It should also quickly adopt an energy performance rating system so that construction companies building new and retrofitted buildings will have the incentives to incorporate energy efficient materials and appliances into their practices. Likewise, all building projects in Kigali should comply with the energy efficiency, renewable energy and energy conservation requirements in Environment Impact Assessment (EIA) regulations.

Sustainable Transport

Given Rwanda's reliance on imported fuel for transportation, the expected rise in transportation needs as the population grows and the impact this sector has on the local environment and human well-being, it is important that the City of Kigali adopt and implement sustainable approaches to transport. Sustainable urban transport systems reduce dependency on fossil fuels, reduce congestion, increase efficiency and lower air-pollution levels (UNEP 2012a).

Improving the cleanliness and efficiency of transport fuels by promoting low-sulphur fuels, standards for cleaner vehicles, and mandates for using air filters and fuel efficiencies can reduce local air pollution and its human health impacts (UNEP 2011c). The City of Kigali can also avoid the expansion of an inefficient transport system and associated polluting emissions by designing and implementing an integrated transport system, as recommended by MININFRA (2012). Such a system includes mass public transit (RoR 2011), which is a more sustainable solution than supporting the growth of private vehicles since it employs more people, increases mobility equality and access to public services and other amenities and reduces traffic congestion and air pollution (UNEP 2012a, UNEP 2011c).

Policy Option #7:

Implement an integrated, sustainable transport system that favours public transit, walking and cycling

Providing sidewalks, paths, lanes and other options for pedestrians and bicycles is an essential element of a sustainable transport system (UNEP 2012a). This is another way that the City of Kigali could leapfrog the detrimental aspects of the trajectory taken in industrialised countries that favours private vehicles.

Improving conditions for pedestrians and cyclists helps to reduce vehicle traffic, foster community cohesion and enhance quality of life by providing health benefits, for example (UNEP 2011c). MININFRA has already noted the need to improve access for non-motorised transport since walking and cycling are currently the most unpleasant and dangerous transportation modes in Rwanda. One of the reasons is the current focus on providing roads for the increasing numbers of vehicles to the neglect of pedestrians and cyclists. As noted in a concept paper about the value of walking and cycling facilities developed for MININFRA, among all road users, the private vehicle is the most inefficient in terms of the space it occupies, the pollution it emits and its contribution to traffic congestion (MININFRA and RTDA 2011). Regarding cycling, however, Kigali's hilly topography would make this transportation option prohibitive to most of its residents, as it is in Rwanda in general. This limitation needs to be considered in exploring cycling and walking alternatives.

Flood Management and Landslide Prevention

Managing floods, especially given the potential for climate change to increase their intensity, is an essential part of urban management in Kigali. Policies to address this issue start with proactive strategies that can help prevent flooding and landslides. There are opportunities to protect land from further erosion due to intense rainfall through sustainable land use. This approach includes agro-forestry, zero grazing and protecting green spaces. It also implies improved planning for building and repairing infrastructure, such as roads and housing on sloping land. An integrated flood management approach at the watershed level, as part of the City of Kigali's Integrated Water Resources Management (IWRM) plans would identify sensitive areas, define appropriate land uses and set management goals.

Rwanda's NLUDMP already restricts constructing homes and other urban infrastructure such as roads on steep slopes. The law and enabling regulations are also already in place for protecting

Sidewalks and trees already line many streets in Kigali, but more are planned

UNEP/GRID-Sioux Falls 2013

Some streets in Kigali are lined with open drainage canals and vented retaining walls to help channel runoff and rainwater

green spaces, wetlands and other pervious surfaces that allow rain to infiltrate the soil and replenish groundwater instead of running off in storm drains that may not be adequate to contain floodwaters or that cause erosion and landslides (Tsinda and Gakuba 2010). A simple action that could be implemented at the community level, possibly through Umuganda, Rwanda's community service day (RGB 2012), is to encourage tree planting on open, bare soil areas to prevent washout. Another action, which the City of Kigali is already taking, is to develop a modern drainage system that can accommodate larger amounts of floodwaters to prevent loss of life and property during the rainy season (Rwirahira 2013). To ensure that these drainage systems are effectively constructed, City plans have considered sustainable water management approaches that aim to improve the quality of runoff and reduce runoff velocity to diminish risks of floodwaters from flushing into downstream drainage networks and receiving water bodies (Surbana 2012).

Terraced green walls, such as the above, help to absorb rainwater and prevent soil erosion along streets

Policy Option #8:

Adopt an integrated, proactive flood management approach at the watershed level within the national Disaster Risk Reduction (DRR) framework

An integrated early warning system should complement these proactive measures. Such a system benefits from the use of Geographic Information Systems (GIS) and remote sensing techniques that provide historical and real-time data about numerous climatic, geographical, land use and other data. Dynamic flood and landslide risk maps can be created and used to inform the city administration and local communities about the level of flood risk. The City of Kigali should expedite

the establishment of community based watershed management systems through sectoral collaboration. The proposed planning strategies already include a citywide Watershed Management Plan, a 50-year flood-return period, total conservation of all water bodies and the enforcement of the legislated 20 m buffer on wetlands (Surbana 2012).

On-going DRR efforts include installing an Early Warning and Disaster Prepardness System by REMA in the framework of the Least Developed Countries Fund (LDCF) (REMA 2013). The system will support the Meteo office and provide real-time weather forecasts and warnings by 22 Automatic Weather Stations being installed across the country. Weather changes will be broadcast to the Meteo office and to stakeholders every 15 minutes, including those mandated with DRR. The database held by the Center for Research on Epidemiology of Disasters (CRED) and MIDIMAR records already maintain information on disasters, which have been used to create risk thresholds on a pilot area of four Districts in the Western Province (Palmer 2013). Furthermore, DRR is mainstreamed in all priority sectors of EDPRS 2, including urbanisation. The current City of Kigali Development Plan (CKDP) outlines DRR strategies, including constructing water ravines and improving the drainage system, continued relocation of dwellings out of risk areas, rehabilitating such areas, implementating health and safety codes in construction, planting trees and implementing all environmental laws. Rehabilitation of steep slopes following the relocation of unplanned dwellings will involve soil stablisation and reforestation (Surbana, 2012). All these strategies need to be implemented.

Water Management

The EDPRS 2 and the Five-Year Strategic Plan for the Environment and Natural Resources Sector for 2009 to 2013 advocate taking stock of available water resources and balancing them against needs, protecting watersheds, monitoring the quality and rates of water use and reconciling the multiple interests of water resource uses (MINECOFIN 2013, MINIRENA 2009).

The CoK is already implementing many aspects of Integrated Water Resource Management (IWRM) in a holistic approach to managing water at the catchment scale and improving access to water in the long-term (UNEP 2012a). It is guided by Rwanda's National Policy and Strategy for Water Supply and Sanitation Services, which focuses on managing and increasing water supplies (MININFRA 2010), emphasising the need for adequate safe water for domestic, commercial, agricultural and industrial demands. Nevertheless, adaptive strategies to conserve water also need to be implemented in light of decreasing and uncertain water resources in the face of climate change. The CoK needs to complement the focus on finding more water supplies with stonger efforts to incorporate demand-side management. Equitable efforts should be dedicated to making sure consumers understand and adopt wise-use strategies for sustainable consumption.

Policy Option #9:

Review Kigali's Integrated Water Resource Management (IWRM) policy and strategy to strengthen demand-side management and wise use

Water policies and strategies should be reformed or reviewed to mainstream water harvesting and the principle of sustainable water consumption into regulations for all new buildings, as already practiced in some countries. EWSA should also constantly be seeking how to prevent polluting water sources to improve the efficiency of water treatment. A cleaner water source, or one less impacted by flooding and siltation, needs less treatment, thereby increasing the efficiency of the process, using less energy and possibly increasing supplies.

Waste Management

The CoK should consider integrating its informal waste collection and treatment activities into a formal Integrated Solid Waste Management (ISWM) system that would benefit all citizens of Kigali. The system should mandate adequte pay for workers, provide healthy and safe working conditions, utilise energy-efficient equipment and maintain healthy water quality (UNEP 2012a).

Policy Option #10:

Create an Integrated Solid Waste Management (ISWM) system that supports the informal waste sector and protects the environment

Integrated waste management that includes a focus on reducing, reusing, recycling and recovering (the 4 Rs of waste management) has the potential to generate jobs and develop the economy (Robertson 2012, UNEP 2012a). Small businesses that make briquettes from solid waste in Kigali are shining examples of how recycling can divert waste from the landfill and thus decrease water and land pollution, create useful, high-value resources from low-value ones, provide jobs and develop the local economy.

Approximately 10 per cent of waste in the Nduba landfill is paper or cardboard (CoK and BTC Rwanda 2012), implying that paper recycling is an untapped opportunity in Kigali. The feasibility of recycling these materials should be assessed to reduce useable waste in the landfill and also decrease the demand for paper imports.

Additionally, the City should formulate and implement an incentives-based framework to promote sorting solid waste at source. It could include a subsidy formula for the currently prohibitive costs of household-waste sorting bins. Once urban households, businesses, offices, hospitals, schools, prisons and other substantial waste sources have affordable equipment to enable efficient sorting at source, awareness and best practice campaigns should be promoted to build a culture of sorting for recycling, reducing and reusing in Rwanda, and most importantly, in Kigali.

A COPED waste collection truck

The COPED group, which recycles some of Kigali's waste into briquettes and other useful products (see Chapter 4), suggests the following six-step cycle for working towards replacing waste collection and disposal with more recycle-friendly mechanisms (Kagera 2013):

1. A feasibility and profitability study
2. Staff education—equipping them with business skills, risks, health, safety and customer care issues
3. Customer education
4. Proper collection and transportation (with equipment for primary and secondary collection)
5. Proper waste recycling
6. Reporting and publication

This cycle could be incorporated into the City's current and future waste management framework to support its efforts of mainstreaming waste sorting and recycling.

Sanitation and Pollution

Increased accessibility and availability of proper waste management and sanitation facilities will help immensely with reducing the effects of pollution on the city and its ecosystems. Improving sanitation in the home and in public places will increase hygiene and lead to an overall better quality of life.

Prevention is part of the solution for pollution. The City of Kigali should implement integrated pollution management measures, which include providing or supporting the development of proper drainage for runoff from industries, businesses and households sited near or on rivers or wetlands. While the city has been proactive in removing structures that have contributed to pollution issues (Gikondo Industrial Park, Gatsata Garages), as recommended, rehabilitation schemes and mitigation measures should be expedited so the ecosystem can recover and the potential for future pollution situations be prevented.

The Nyabarongo River is an environmental asset in Kigali, but also is susceptible to pollution

Policy Option #11:

Develop and operationalise an implementation framework for expediting the City's sanitation plans

To achieve the revised Vision 2020 EDPRS 2 targets for sanitation (100 per cent coverage by 2017-2018), policies and development plans may be needed to help older homes and establishments without improved sanitation upgrade their facilities. In this regard, proposed targets in detailed District plans include requiring temporary on-site Sewage Treatment Plants (STP) for all new urban developments that are 0.4 ha or larger. Other targets include a centralised STP for each sector; separation of wastewater sewage and stormwater; 20 per cent sewerage coverage and Ecosan (ecological sanitation) or septic tank systems for rural dwellings (Surbana 2012). The City of Kigali should develop and operationalise an implementation framework for expediting these sanitation targets for the respective District master plans.

Urban Agriculture

Urban agriculture occupies a significant amount of land in Kigali that risks being developed as the population grows and urban developments expand. Developed countries are increasingly recognising the value of maintaining farms in close proximity to urban areas, often only after they have allowed sprawling settlements to replace them. The City of Kigali could avoid this stage of historical industrial development by protecting its urban farmland through zoning regulations and improving land tenure for farmers (ISTED 2001).

Some of the benefits of local urban farms include savings on importation costs and energy; employment for local farmers and food-related businesses, especially for women, which enhances community cohesion; reduced vulnerability of poor urban households; and increased resilience to price fluctuations in imported food (UNEP 2012a, Robertson 2012). Chapter 6 highlights some encouraging examples of actions in the farming sector that are enhancing environmental awareness and sustainability.

Policy Option #12:

Establish an urban agricultural zoning policy within the wider framework of developing a green city

Another way to support urban agriculture in Kigali is to heed the GoR recommendation to adopt integrated soil fertility management. This approach is defined as 'the application of soil fertility management practices, and the knowledge to adapt these to local conditions, which maximise fertiliser and organic resource use efficiency and crop productivity. These practices necessarily include appropriate fertiliser and organic input management in combination with the utilisation of improved germplasm ' (Vanlauwe 2009). These methods lower the amount of chemical fertilisers, which has a positive impact on the environment by reducing dependence on fossil fuels and reducing GHG emissions as well as agrochemical runoff. This approach also improves soil structure and the diversity of soil micro-organisms thus enhancing water retention and resilience to climate change impacts; at the same time, it reduces the cost of inputs for farmers and their vulnerability to external shocks (RoR 2011, UNEP 2011a).

Agro-forestry

The City of Kigali should increase its efforts to support agro-forestry as a proactive measure with many environmental benefits, such as flood management, water storage, biodiversity and habitat protection, nutrient recycling and carbon sequestration. In addition, agro-forestry provides fuel wood, construction materials, livestock food and non-timber forest products such as fruit and nuts. The GoR suggests that the latest best practices and research guide agroforestry development, such as those enunciated by the World Agroforestry Centre (ICRAF) (RoR 2011). The CoK's agro-forestry projects should also be guided by recommendations made in the *Rwanda State of Environment and Outlook Report*, which notes the need to provide technical and extension services by strengthening the forest sector's human resource capacity (REMA 2009).

Strengthening Environmental Governance for Sustainable Development

Improving the City of Kigali's environmental governance so as to implement the recommendations suggested above will require operationalising the integration of environmental management into urban governance, as already stipulated in the current CKDP. It addition, it will need to be accompanied by capacity building and financial mobilisation (UNEP 2011b).

The greatest challenges, however, remain integrating vertically among government hierarchies to ensure that the CoK's policies, legislation, plans and designs are coherent with those of other sectors at national, District and local levels and that they are being similarly implemented (UNEP 2011b, UNEP 2011c). It also means integrating sustainability goals, plans and projects horizontally across sectors (UNEP 2012a).

Policy Option #13:

Ensure the City of Kigali's policies, plans and programmes are well integrated with those of other sectors for coherence and sustainability

Integration involves adopting international commitments to urban sustainability. The City of Kigali is encouraged to strengthen its links to other municipalities involved in sustainability planning and implementation at national and international levels and cooperate with them to share and learn from best practices (UNCTAD 2013).

Public Participation, Strategic Intermediaries and Capacity Building

Policies, plans and programmes cannot be adopted and implemented without the bottom-up participation of the spectrum of actors and beneficiaries of urban governance. The City of Kigali needs to strengthen public participation and the involvement of what has been called 'strategic intermediaries' (UNEP 2012a). These are institutions, organisations and other institutional and sectoral bodies representing civil society, such as universities

and other institutes of higher education, research and technology centres, business and industry groups, non-governmental organisations and community associations (UNEP 2012a). When city governments work with these intermediaries, they can help instil in them the commitment to advance sustainability and green economy principles and practices at the same time as they glean information about how best to address the public's needs.

Education and capacity building is an essential aspect of environmental governance. To ensure compliance, it is essential to increase the public's understanding of the links between human activity and environmental degradation and the loss of natural resources. By extension, capacity building involves showing individuals, households and groups how they can contribute to improving conditions to benefit both ecological systems and human health and well-being. The Kigali administration already engages in outreach activities promoting urban environmental sustainability in accordance with REMA's statutory mandate. Examples include slots on radio and television promoting city policy, including compliance to land use zones, wetland protection and afforestation, among others. The City of Kigali is encouraged to continue investing in providing easily understood and packaged education to the public through popular media. It could also broaden the topics covered. For example, it could provide information about environment laws and policies to help the public participate in Environmental Impact Assessment hearings and other decisions related to urban sustainability (REMA 2009). Table 5.3 is a list of selected activities drawn from UNEP's *Towards a Green Economy* related to enhancing public awareness and engagement that the City could adopt.

Table 5.3: Selected outreach activities

Engagement	
Online Access	Increasing internet access particularly of poorer communities while making all relevant information available online
Public Conditions	Issue-based engagement with local communities and public debates with politicians presenting and defending development plans
Local Activities	Harness the potential of local activism to improve quality of life and the environment through community-based projects
Transparency	Ensure maximum levels of transparency and advance on freedom of information legislation
E-democracy	Recognise role of e-governance and participation in providing information and access to monitoring and achieving sustainability targets
Awareness	
Education	School curriculums to include "green education" and provision of professional "green training" for public and private organisations
Public Campaigns	Raising awareness of the advantages of green city strategies, particularly on compact city living and green transport
Labeling	Eco-labeling of consumer items to help consumers make more informed choices and provide additional incentives for green products
Smart Meters	New smart monitoring and metering devices can provide real time information on resource use: Without smart meters no smart consumers
Welcome Packs	Providing new residents with information packages on green living as behaviour can be best changed when building a new daily routine
Best Practice	Disseminating information on green city projects that have worked elsewhere to inform local adaptations
Demonstration Projects	Establishment of test projects within cities to allow for better assessment and public exposure to new approaches

SSource: Adapted from UNEP 2011c; visualisation by UNEP/GRID-Sioux Falls

Financial Mobilisation

The City of Kigali faces the challenge of mobilising financial resources to implement its urban plans and integrate sustainability into all sectors (UNEP 2011b). Various taxes and subsidies, as well as other type of mechanisms listed in Table 5.4, could be used as ways to generate revenue to create, implement and enforce green policies and plans (REMA 2009, UNEP 2011c).

Another financing resource the City can utilise is the Fund for Environment and Natural Resources for Rwanda (FONERWA). FONERWA was created by Organic Law no. 4/2005 as a financial mechanism to achieve environmental goals; it has the potential to contribute 20 to 30 per cent of Rwanda's current financing gap (CDKN 2012). Over time, as climate change has become a more serious issue, its name has evolved to the Environment and Climate Change Fund for Rwanda. The programme started operations in October 2012 and began accepting proposals in March 2013 (UKaid 2013). FONERWA was established as a cross sectoral financing mechanism for line ministries and Districts, private organisations and charities to access international funding to implement environmentally sustainable, climate resilient and green economic growth. Entities submit proposals summarising their anticipated project and financial needs. Financial support for the short-term or long-term is then awarded if the project objectives align with FONERWA's eligibility criteria. Approximately 20 per cent of FONERWA funds are earmarked for private organisations and 10 per cent for District allocation. Using FONERWA would be advantegous in the CoK's pursuit of sustainable development and climate change adaptation.

Goals, Targets, Measurement and Monitoring for Sustainability

The saying 'what gets measured gets managed' holds true in managing urban sustainability. Setting clear goals is an important first step, but to understand the level of progress in achieving them, they need to be matched with measurable targets and time lines. Furthermore, to be effective, mechanisms to monitor and review the targets using robust time-series data sets are also required (UNEP 2012b). For example,

Table 5.4: Select financing mechanisms

Mechanism	How to Implement
Taxes	Use local taxes and service charges as a main revenue source for public green city strategies and raise when necessary
Cost Recovery	Introduce user fees for municipal services to help green these services and support the development of greener alternatives
Land Value Capturing	Finance public transport based on integrated 'transport-property' development models
Micro-financing	Involve micro-enterprises in green city strategies, e.g. recycling
Profit-making Public Companies	City gains shares of profit-making companies, e.g. utilities to allow for long-term green investment companies
Purchasing Pools	Cities work together to purchase technology, thereby bringing down the cost
Carbon Credits	Use Clean Development Mechanisms (CDM) to pay for green city projects; CDMs already pay for a range of green city projects in Bogotá, São Paulo and Dhaka, for example.

Source: Adapted from UNEP 2011c; visualisation by UNEP/GRID-Sioux Falls

Maintaining urban green space is essential for an environmentally sustainable future

because the MDGs have time-bound targets, they can be used to measure progress.

Robust quantitative indicators that show trends over time are needed to complement clear goals and targets since they track progress towards the stated objectives. Indicators and composite indices are simplified ways to illustrate and communicate complex data and trends. They provide transparent information that can be used to help shape policy. Data are often lacking to populate such indicators, however, especially in developing countries and regions such as Rwanda (UNEP 2012b). Thus, monitoring programmes need to be set up to collect data in the field (UNEP 2012a).

Sustainability indicators attempt to reveal the interconnections among environmental, economic and social factors, unlike GDP and other traditional indicators. Box 5.1 illustrates some of the links among these three domains.

Thus, sustainability reporting and measurement needs multidimensional indicators (Sustainable Measures 2010) or at the least, indicators representing all three aspects of sustainability. In effect, when viewed from the human perspective, sustainability can be translated as 'quality of life', as long as the aim is for the long-term. Many sustainability experts advocate the adoption of

Box 5.1: Illustration of the integrated nature of sustainability indicators

'Sustainability indicators reflect the reality that the three different segments are very tightly interconnected. The natural resource base provides the materials for production on which jobs and stockholder profit depend. Jobs affect the poverty rate and the poverty rate is related to crime. Air quality, water quality and materials used for production have an effect on health. They may also have an effect on stockholder profits: if a process requires clean water as an input, cleaning up poor quality water prior to processing is an extra expense, which reduces profits. Likewise, health problems, whether due to general air quality problems or exposure to toxic materials, have an effect on worker productivity…'

Source: Sustainable Measures 2010

'Quality of Life' as a performance measurement tool that links environmental indicators such as access to water, sanitation, waste management, wastewater treatment, renewable energy, efficient transportation, suitable housing, and adequate food, health, education, jobs and security, among others, and equates certain levels of such indicators to well-being, happiness and social equity (Pouffary 2012).

Examples of sustainability indicators can be found in the literature; a comprehensive list is available from Shen, et al. 2011. In addition, the International Institute for Sustainable Development (IISD) publishes an online Compendium of Sustainable Development Indicator Initiatives that provides information on international, national, provincial/territorial/state, regional, sectoral, ecosystem and local/community indicator initiatives worldwide that could be of use to the City's administration in designing an urban indicators system (IISD 2013).

Conclusion

The City of Kigali has already developed comprehensive green urban plans, supported by national policies for sustainable development, and is making great strides to implement them. Now, the City needs to continue following through with actions on the ground, while also constantly monitoring its progress. It needs to keep the Vision 2020 targets at the top of its development agenda: to become a high density, livable city, with corridors for pedestrians and cyclists and access to neighbourhood shopping and other services as well as green public spaces (parks, squares, pathways) and mass transit. It needs to continue acting on its aim to reduce the need for energy-intensive transport, the high costs of transport for citizens, greenhouse gas emissions and oil dependency. In addition, the City must safeguard its agricultural areas so they continue to flourish within its boundaries, providing food security and economic gains. As well, it must be pro-active in preventing devastating floods and uncontrolled pollution. Taken together, these actions have the chance to provide the citizens of Kigali with improved social equality, human health and quality of life. They will be able to enjoy heightened community interaction, access to areas of natural beauty and cleaner air and water. It is indeed possible for Kigali to become a state-of-the-art and aesthetically appealing city.

A bird of paradise, one of the many types of flora used to beautify Kigali

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A boy navigating his way to school in the busy Gatsata area

Environmental Outlook and Opportunities 6

"Inside of every problem lies an opportunity"

- Robert Kiyosaki

Kigali has changed for the better over the past few decades, with more change on the horizon as it continues to implement its plans to become a sustainable and green city. These changes have instilled citizen pride as well as a heightened awareness of environmental issues. In turn, these changes are creating more opportunities for the City of Kigali to act on its Conceptual Master Plan (KCMP) and achieve its targets and goals.

This chapter looks at a select number of accomplishments, showing how these examples can inspire further progress. It extrapolates on how these successes might stimulate the creation of new opportunities to green Kigali's economy and improve overall quality of life for its citizens. In addition, this chapter explores future scenarios for Kigali by envisioning the potential results of a number of trajectories based on different points of departure that reflect a variety of assumptions or goals. For example, what will Kigali look like down the road if a conventional approach to development is taken where business-as-usual prevails, compared to a future that has benefited from plans and actions implemented on the ground to create a green and sustainable city?

Environmental Awareness

Rapid development and change in Kigali has boosted the public's general awareness of environmental matters. In addition to environmental projects being conducted by the City of Kigali (CoK), innovative citizens and entrepreneurs are increasingly engaging in 'green' initiatives. Each initiative creates additional opportunities and opens minds and doors to creating new ones in the future.

Waste Collection, Recycling and Composting

Actions

As discussed in Chapter 4, there has been an increase in organised waste collection services in Kigali and the city is cleaner than it has ever been. The closure of Nyanza alleviated pressure on the overfull landfill and on a community weary of the health threats from its fumes and polluted runoff. Officials have recently recognised that problems associated with the new Nduba landfill are now threatening its safety and they are taking action to prevent exacerbating the dangers.

In addition to the CoK administration, private and non-governmental groups have contributed to improving waste collection and recycling in the city. The COPED group, for example, makes briquettes from waste and recycles plastics. It also manufactures garbage bags from polyethylene terephthalate (PET) materials it recuperates from the waste stream. COPED views waste as a raw material, not a nuisance (Kagera 2013). One of its innovations is to provide these bags in various colours to encourage waste sorting in the home: different coloured bags help households sort waste into five categories: organic waste, plastic bottles, paper, disposable waste and hazardous waste. Wet organic waste material is turned into fertiliser, which is then sold to Kigali citizens (Kagera 2013).

Opportunities

There are enormous opportunities for further reforming waste management in Kigali. Improving all aspects, from collection to recycling, would help to clean up city streets, lots, farms and households and the resulting businesses would provide green jobs. The majority of waste in Kigali is biodegradable, pointing to the opportunity to recuperate this valuable resource before it enters the mixed waste stream. Once it is isolated at the source, it can be composted by households themselves in backyards or collected and sent to a composting site to make into organic fertiliser. Composting schemes have numerous benefits that usually outweigh the costs associated with the purchase of equipment and time to undertake the tasks. These include the production of a marketable product (organic fertiliser) that can be used to build soil structure and fertility for farming and gardening purposes, and a reduction in the mass, volume, odour and health hazards of domestic waste.

The National Strategy for Climate Change and Low Carbon Development (NSCCLCD) calls for an increase in organic fertiliser to help reduce greenhouse gas (GHG) emissions while also improving crop yield, reducing farmer costs, improving soil quality and increasing water retention capacity (RoR 2011). Integrating composting into the formal waste management system for use in local farming is a potential business opportunity that closes a resource loop through waste management (Robertson 2012). Using compost as an organic fertiliser creates an opportunity not only to reduce waste, but also to build a more resilient agricultural ecosystem. The monthly community Umuganda could be used to promote recycling and composting by providing training in composting methods. Another opportunity may be the capture of methane emissions from landfills to use as an energy resource (Peter and Swilling 2012). Recycling such waste products as new resources can help reduce energy use by lowering the amount of imported goods and materials (Peter and Swilling 2012, RoR 2011).

Building recycling infrastructure can also bring green jobs to Kigali, producing income that would contribute to a green economy. For example, COPED's inspired and successful recycling and waste collection efforts create excellent opportunities for green jobs. In response to the challenge of finding trained staff, COPED is making efforts to recruit and train personnel for its operation (Kagera 2013).

A compost chamber at a school in rural Kigali

Rainwater Harvesting

Actions

Small-scale rainwater harvesting projects are ongoing throughout Kigali including at the Kigali Institute of Science and Technology (KIST), through Trees for Cities, a school-based programme in Gasabo District (Trees for Cities 2011) and a UN-Habitat supported pilot project in what is now Gitega Sector (UN-Habitat 2007), although most may not yet be fully operational or properly maintained. Imidugudu in other Districts throughout Rwanda, such as Rubavu and Bugesera, use rainwater harvesting equipment to help stave off drought (REMA 2009, UNEP 2011). Rainwater harvesting is an excellent way to supplement water supplies for those households; it benefits people in imidugudu not connected to the main water line, for example, and also helps to protect soils from the impacts of heavy rainfall (UNEP 2011).

Opportunities

With impending uncertainty of future seasonal rains due to climate change, capturing and storing rainwater for use during dry periods may ultimately provide the only source of water for drinking or agriculture. In the future, rainwater harvesting is seen as an integral part of the National Water Security Plan and creation of new building codes (RoR 2011).

A feasibility study was conducted to determine the viability of rainwater harvesting on public buildings and the findings were positive; they revealed that public buildings in Kigali are adaptable to being used to harvest rainwater, but they are not currently utilised to their fullest extent (MININFRA 2010). The study states the following: 'the collection of rainwater for different uses such as cleaning, watering, toilets flushing, etc., becomes necessary for several reasons, in particular the prevention of possible flooding due to rainwater causing erosions in the surroundings and the destruction of the infrastructures like roads and buildings' (MININFRA 2010, 14). Out of 796 public buildings the study investigated, only 19 had an operating rainwater collection system. With the plethora of development plans on Kigali's horizons there are many opportunities to increase the design and use of rainwater collection systems.

According to the Rwanda Rain Water Harvesting Association (RRWA), rainwater harvesting could also be a mechanism for socioeconomic development (NBDFR 2007). Increased water accumulation at the household level would reduce the pressure on water treatment plants, some of which are not producing to capacity (see Chapter 3), and thereby lower water bills and ensure longevity of water supply from Kigali's rivers. Proper maintenance programmes will need to be implemented alongside harvesting projects so that the water remains clean and viable. Overall, the systems are easy to set up and operate. Training and capacity building for rainwater harvesting projects could be incorporated into the Umuganda community work days held in Kigali.

Incentives and Awards for Sustainable Best Practices

Actions

To raise awareness about environmental sustainability and encourage sustainable practices in all sectors, the Rwanda Environment Management Authority (REMA) hands out 'Best Environmental Performance Awards' to deserving entities such as Districts, Community Based Environmental Organisations (CBOs) and media reporters. Merit is based upon their demonstrated progress towards environmental protection and/or climate change adaption or mitigation. In 2013, three Districts, three CBOs and three media reporters will receive awards (Ntambara 2013).

REMA handing out a solar radio as an award to a student on World Environment Day 2012

REMA 2012

Opportunities

The awards already established by REMA, as well as its strong recognition and support of World Environment Day, are examples that other City of Kigali authorities could learn from. They could also take the opportunity to provide best practice awards, especially in the energy and water sectors. Awards such as these should become more mainstreamed in the future to encourage sustainability in all sectors.

In the construction and housing industry, international endorsement and awards such as Leadership in Energy and Environmental Design (LEED) certification could also be used as incentives to adopt green building techniques. Certification is the product of the United States Green Building Council (USGBC), but has been adopted worldwide. It has a network of Global Alternative Compliance Paths, which consists of applicable credits and standards for varying global projects (USGBC 2013). With LEED certification, individual buildings are awarded a basic certification or the higher gold, silver or platinum levels of recognition according to the building's level of energy efficiency, based on a point system (USGBC 2009). Being able to display an award attesting to the building's high achievement in energy and water efficiency and the recognition of its attainment of the top award for environmental sustainability would be an excellent incentive for greening building development in Kigali.

Integration of the Environment into the Curriculum

Actions

Education is one of the best ways to instil environmental values into all citizens and communities. In 2002, the UN declared a 'Decade of Education for Sustainable Development' that would last from 2005 to 2014 in an effort to encourage governments to use formal and non-formal education to promote sustainable development (REMA 2010). The adoption of the Rwanda Environmental Education for Sustainable Development Strategy for 2010 to 2015 was the beginning of the nation's structured environmental studies inside and outside of the classroom. A wide and diverse approach to delivering educational information allows all levels of education — primary, secondary and university — to receive the information, and it also extends it to communities.

Students on an environmental study tour

The 'Greening School Project,' a partnership between REMA and the Ministry of Education (MINEDUC), was launched to teach and instil environmental and health values through hands-on activities. Students participate in projects such as planting trees, harvesting rainwater and using improved clean water systems (Ntambara 2013).

Opportunities

Now the strategy is in place, more schools are becoming aware of its benefits and mechanisms so they can be more widely implemented throughout Kigali. When environmental education is delivered at lower grade levels, children quickly gain an understanding and appreciation of the environment. This education then creates a solid basis for environmental consciousness in secondary schools and in universities, which can help in the development and promotion of green jobs. The more training and education about environmental matters that students in Kigali and in Rwanda as a whole receive, the more they will demand eco-friendly goods and services and the better equipped they will be to participate in the green economy.

Renewable Energy Efforts

Actions

At the household level, the Energy, Water and Sanitation Authority (EWSA) has initiated the SolaRwanda Programme, which promotes solar water heaters in the home. It receives grant funding from the Global Environmental Facility Trust Fund

(World Bank/GEF) and the Nordic Development Fund. The programme is scheduled to last from 2012 to 2015 and has a goal of installing 12,000 solar water heaters (SWH) by the end of 2015. It is anticipated that 23,328 megawatt hours (MWh) of power will be saved if all 12,000 SWHs are properly installed and used. Households must apply for the installation of a SWH; subsidies and/or loans are available to offset costs (EWSA 2013).

Another household initiative to help Kigali citizens save energy is the distribution of energy saving lightbulbs (compact fluorescent lamps, or CFLs). A programme, supported by the World Bank, distributed CFLs to approximately 800,000 households by the end of 2012 (UNEP 2011). Prior to that, Electrogaz distributed 50,000 CFLs between June and August 2007.

The City of Kigali is also integrating resource efficient designs into its new Special Economic Zone (SEZ) that include energy efficient lighting, energy and water metering and wastewater and other waste recycling methods (RoR 2011). Industrial development and the associated connections to electricity and water grids can strain available resources, but the use of renewable energy can help to offset future potential resource shortages.

Opportunities

The increased construction of planned housing communities provides multitude opportunities for companies to install energy efficient appliances and fixtures. Even the simple installation of more windows can have environmental benefits, allowing for more natural light and potentially reducing the amount of electricity used for lighting. The NSCCLCD calls for other simple mechanisms, such as solar water heaters and greywater reuse (RoR 2011). There are both opportunities and challenges inherent in the solar energy market. Of course there is ample availability of sunlight, but connectivity to the grid and accumulating the funds for start-up costs may be barriers to its development. On the other hand, large solar energy projects such as solar-panel covered roofs are not the only kinds of opportunities available; small-scale projects can be equally beneficial. For example, residential solar heaters create an opportunity for more people to have access to affordable solar energy.

Increase of Green Space

Actions

The City of Kigali, Districts, Sectors and private companies have made conscious efforts over the past decade or so to increase cleanliness and beauty in Kigali. Compared to other big cities in sub-Saharan Africa, such as Nairobi and Kampala, Kigali is a much more aesthetically appealing city, due in great part to its green spaces (de la Croix Tabaro 2013). In addition to the aesthetic value of green spaces, they also serve to stablise soils and absorb floodwaters during severe rain events. Green spaces are especially important as development increases and with the potential for more intense rainfall due to climate change.

Recently, the CoK began a project to slowly start removing old avocado trees from roadsides. It hopes to replace them with new trees and increase the coverage of palm trees and flowering species that line the roads (de la Croix Tabaro 2013). City greening efforts are also taking place at the backyard level; some residents are engaging in small-scale farming, such as growing vegetables, fruits and trees, on up to 20 per cent of their residential land (Kwibuka 2013).

Opportunities

As development increases, investors and stakeholders should be aware of the city's ecologically sensitive areas. Developers should seize the opportunity to build in an increasingly environmentally progressive city and use green space to their advantage. Builders could integrate constructed wetlands and rain gardens into infrastructure plans to decrease flooding effects, provide a carbon sink and increase the aesthetic value of the city; these areas could be considered

The City is looking to increase the amount of open green space, but currently relies on wetlands for this function

Environmental Treatment Zones (ETZs). Promoting, building and maintaining recreation areas such as playing fields and parks not only encourages beneficial activity, but also helps beautify the city (OZ Architecture 2007).

Increasing green spaces in the city also has advantages for biodiversity, which is generally low in Kigali. Several flora species with therapeutic properties grow in Rwanda, but their numbers are declining as a result of soil exploitation and urbanisation (Kanamugire 2013). City and rural parks create an opportunity for the CoK to increase its biodiversity by planting native species and medicinal plants such as geranium, umuravumba and ikigorora.

Promotion of Organic and Small-scale Farming Practices

Actions

Backyard gardens are another way to add value to green spaces. The Kigali Urban and Peri-Urban Agriculture Project (PAPUK), which has been in operation since January 2004, is a successful urban agriculture initiative. It is a partnership between the cities of Kigali and Rome, in collaboration with the Food and Agriculture Organization of the United Nations (FAO). The project's main objectives are to ensure food security in Kigali and its surroundings by increasing food quantities and quality, enabling access for all, stabilising food supplies, improving production organisation and helping to sustain the plan's adoption among actors and partners. The project also aims to contribute to environmental protection. To date, it has succeeded in intensifying agricultural production, diversifying crops by promoting livestock production and strengthening agro-forestry and fruit farming while at the same time promoting betting water and soil management and integrating marshland management (FAO 2012).

Another successful organic farming initiative is the Gako Organic Farming Training Centre (GOFTC), located in Masaka Sector, Kicukiro District, which has had legal status since 2007. Since then, between its on-farm and off-farm training that spans Rwanda, Burundi and the DRC, the centre has been able to train over 200,000 farmers. In addition to organic farming, GOFTC provides training and demonstrates farming techniques to adults and children. GOFTC

A kitchen garden at the Gako Organic Farming and Training Centre

aims to provide affordable, sustainable and climate resilient best practices for farming. Activities at the centre include composting, green manure production, rainwater harvesting, agro-forestry and afforestation and it uses energy efficient cooking practices and biogas. The GOFTC provides an opportunity for local residents to become trained in the environmentally-friendly art of organic farming that can be conducted both on large-scale farms and in kitchen gardens (GOFTC 2013).

Opportunities

The NSCCLCD sees urban agriculture and kitchen gardens as a way to promote the sustainable intensification of agriculture and a grassroots way of ensuring food security (RoR 2011). Household or kitchen gardens have numerous benefits, including helping to ensure food security, lowering the costs of food purchases, improving family nutrition, reducing GHGs associated with motorised trips to the grocery store and importing food, enhancing biodiversity, building soil structure and fertility and maintaining cultural heritage through traditional foods. In addition, small-scale kitchen gardens allow households to increase efficiency; examples include harvesting rainwater for irrigation and making compost from kitchen scraps and yard waste to use as garden fertiliser. These simple actions increase the household's sustainability and decrease the impact on the surrounding environment. Also, a vegetable plot is better than a patch of exposed soil or poor grass because the vegetation helps to mitigate the impacts of flooding and stabilises the land (RoR 2011).

Improved Cooking Technology

Actions

Beginning in 2010, MININFRA and EWSA, joined later on by Practical Action Consulting (PAC), initiated an improved cookstove programme for all of Rwanda, including Kigali. It promoted the use of *canamakes*, an alternative type of stove that requires less charcoal or wood to produce heat (EWSA 2011, Rutareka 2011). While reducing the amount of fuel was the main goal, these cookstoves also produce less smoke than charcoal, improving the quality of air in the home. In addition, since less fuel is needed, their use reduces the amount of money spent on charcoal or wood. An initial result of the programme was the training of selected stove producers to make these stoves, and later in 2011, training programmes were held at the local level. Some families have reported using six times less charcoal per month when cooking with a *canamake* (Rutareka 2011).

Opportunities

The Africa Environment Outlook 3 Summary for Policy Makers (AEO-3 SFOM) recognises that indoor air pollution is a significant health issue in Africa that has not yet been properly addressed (UNEP 2013). Since wood and charcoal continue to be used for cooking in Kigali (see Chapter 3), there is a need to increase the use of clean fuels and improved cookstoves to decrease indoor air pollution in the city. The NSCCLCD calls for a mandate to license sustainable charcoal production techniques and to promote improved cookstoves to increase energy efficiency and streamline resource consumption (RoR 2011).

Increased use and awareness of the benefits of briquettes as fuel will also help decrease indoor air pollution and lessen the impact of deforestation in surrounding regions. The transition from using charcoal to briquettes is simple and does not require any changes in cooking methods or handling behaviour nor the purchase of a new stove (Mwampamba, Owen and Pigaht 2012). Opportunities should be created to continue and expand briquette production operations in Kigali, including by fostering awareness and providing training.

Improved Sanitation

Actions

City-wide improvements in sanitation have begun at a small-scale level with an increase in flush toilets and handwashing stations installed in homes and businesses and the installation of numerous eco-toilets, as discussed in Chapter 4. Nevertheless, to reach the revised Vision 2020 target and EDPRS 2 target of 100 per cent coverage, the installation and adoption of improved sanitation needs to be much more widespread.

Opportunities

The future construction of new commercial, industrial and residential areas in accordance with the KCMP provides an excellent opportunity to introduce new sanitation facilities as well as upgrade those that exist.

Opportunities need to be created to provide capacity building and a mechanism to clean and properly decommission pit latrines in both urban and rural areas so that household hygiene can be improved along with access to sanitary facilities.

Simple handwashing stations help create sanitary conditions

Shoreline of Lake Muhazi in Gasabo District, Kigali

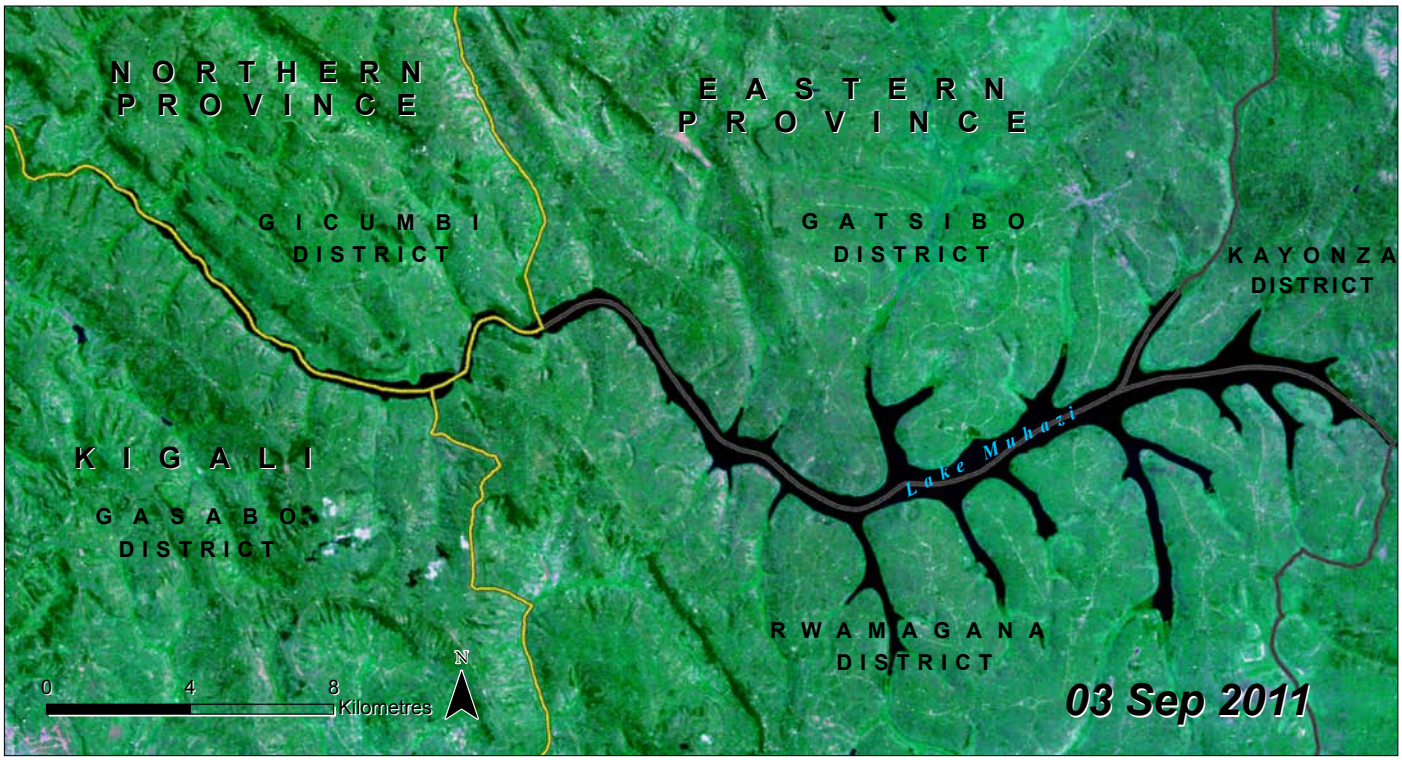
With demand for water increasing now and in the future, Kigali may have to satisfy its water needs by drawing on Lake Muhazi as a water source. Approximately 11 km of Lake Muhazi's shoreline lies along the eastern edge of Gasabo District (Figure 6.1). To date, limits on urban development and intensive agriculture have enabled a green buffer to be relatively maintained around the lake. If the lake does indeed become a source of water for Kigali, it is important to maintain its water quality (OZ Architecture 2007) as well as its surrounding habitat, which is important to the health of the Nyabugogo River. Any unwise development would affect a multitude of ecosystems.

A proposed land use plan for 2025 includes some planned development for Lake Muhazi's shoreline, including hotels and residences (Surbana 2012). In the event of such development, it is crucial to maintain the shoreline to prevent sedimentation and protect water quality so as to decrease the amount of water treatment that would be necessary.

There have already been complaints of dirty water in Lake Muhazi, north of Kigali in Rwamagana District. Approximately 6,000 Rwamagana residents who use water from Muhazi have complained of the presence of worms and dirty water (UNDP 2013). The Decentralisation and Environment Management Project (DEMP) constructed a new borehole as a water source for Muhazi residents, but it is not clear how the lake will fare in the future.

DEMP initiated a project to decrease land degradation along the Lake Muhazi shoreline in Giti

Figure 6.1: Location of Lake Muhazi



Visualisation by UNEP/GRID-Sioux Falls

Sector, Gicumbi District, north of Kigali (UNDP 2012). This project is an example of a land conservation best practice, illustrating how an organisation and community have been proactive to protect their environment for the future. The project consisted of planting bamboo trees to create a buffer zone between the lake and the land as well as training local residents to construct progressive terraces to reduce soil erosion. An added bonus of the project has been a witnessed increase in agricultural production, as the terraces have proved to be beneficial for potato cultivation. The project also incorporated gender equality and promoted women as entrepreneurs, enabling women in the community to earn a small wage through their contribution to the project.

Dewame louis/Wikimedia/CC0 1.0

Scenario Analysis to Envision the Future of Kigali

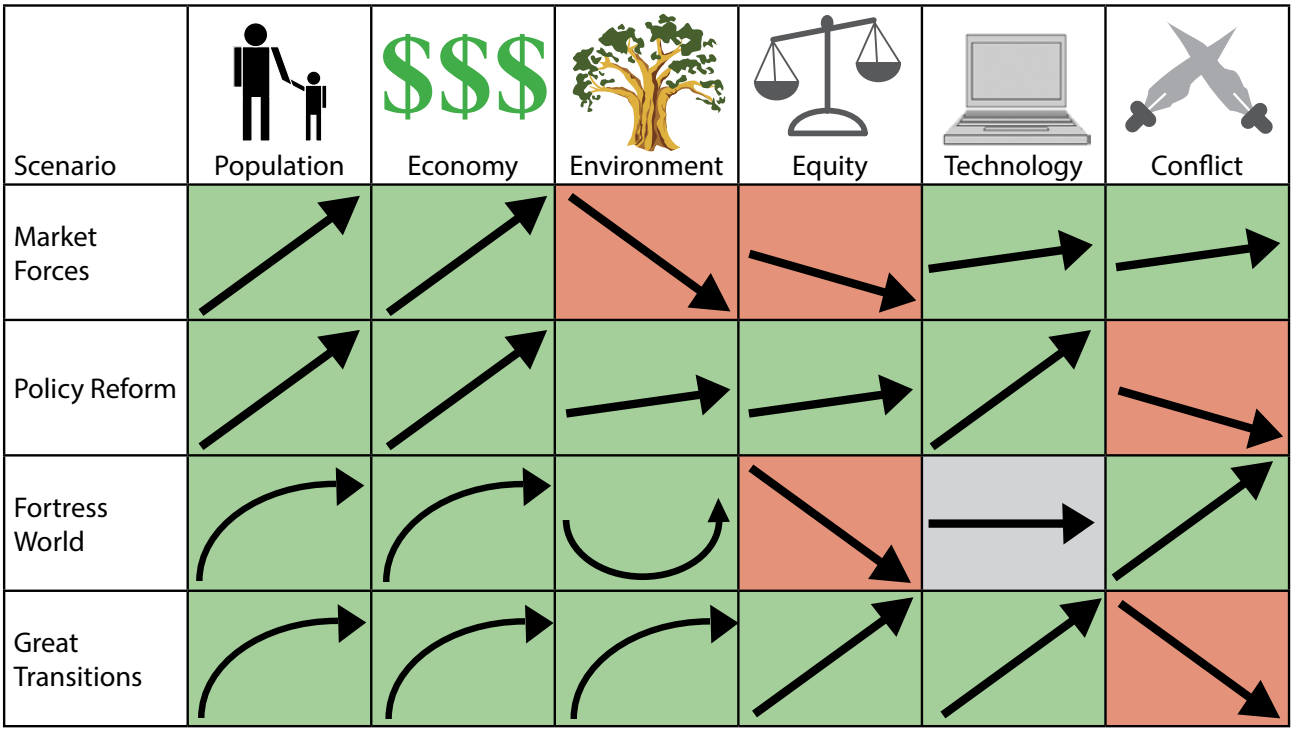
The 2009 *Rwanda State of Environment and Outlook Report* describes scenarios as 'stories of how the future might unfold — plausible stories that reflect information about trends and potential future developments' (REMA 2009, 108). Scenarios do not predict or forecast the future; rather, by assuming a number of different influencing drivers or factors as starting points (different assumptions about levels of economic growth, population increases, resource availability, political will, etc.) multiple potential outcomes of the future can be envisioned. Decision makers can use the results of scenario exercises to help design policies that will orient the society they represent in the direction towards the most desired outcome. The scenarios in the 2009 report attempted to inform the question 'how can we achieve sustainable socio-economic development in the most environment-friendly and least costly way possible?'. This State of the Environment Report (SOE) for Kigali seeks answers to the same question so it draws on the lessons from scenarios developed in relevant SOE reports.

The United Nations Environment Programme (UNEP) has used four scenarios in its publications to help envision what the future could look like depending on four different sets of assumptions and the trajectories they would set in motion. These are shown in Figure 6.2. The four scenarios are called Market Forces, Policy Reform, Fortress World and Great Transitions, which succinctly characterise the key attributes of each scenario. Each one is based on a different set of assumptions that determine future trends in the factors depicted in the top row of the table (population, economy, environment, equity, technology and conflict). The arrows in the cells show the direction of trends that can be expected by acting on these assumptions.

The characteristics of the four scenarios are summarised as follows (UNEP 2003):

- Market Forces: market-driven global development leads to a convergence toward dominant values and development patterns ('business-as-usual');
- Policy Reform: incremental policy adjustments steer conventional development towards environmental and poverty-reduction goals;
- Fortress World: as socioeconomic and environmental stresses mount, the world descends toward fragmentation, extreme inequality and widespread conflict; and
- Great Transitions: a new development paradigm emerges in response to the challenge of sustainability, distinguished by pluralism, planetary solidarity, and new values

Figure 6.2: Scenarios for the future



Source: Adapted from UNEP 2003; visualisation UNEP/GRID-Sioux Falls

and institutions.

Rwanda adopted these four scenarios in its 2009 SOE and Outlook Report, and enriched them by including the following climate change implications within each scenario (REMA 2009):

- Market Forces
  - o Rapid growth in energy use – rapid rise in CO_2 emissions
  - o Increased intensity and number of rainfall days — increased flooding
- Policy Reform
  - o GHG emissions will rise, but will have partially abated owing to lower economic growth and enforcing restrictions on the engine capacity and age of vehicles imported into Rwanda by 2015
  - o Reduced demand for wood products would lead to public interest in afforestation in anticipation of eventual recovery of demand following an economic upturn
- Fortress World
  - o Emergence of new diseases and resurgence of old diseases as their vectors advance into hitherto uncharted territory
  - o High altitude ecosystems will witness decline in productivity and declined human well-being
- Great Transitions
  - o Increased climate change implications but government adaptation will reduce effects
  - o Shift towards higher energy efficiency, fuel cells and renewable energy will reduce CO_2 emissions as Rwanda joins other developing and developed nations in implementing multi-faceted efforts to address climate change
  - o Integration of low carbon production and cost-effective adaptation mechanisms will be a cornerstone of this scenario

The 2011 *Atlas of Rwanda's Changing Environment* also used these scenarios in its Outlook chapter. It recognised that under the Policy Reform and Great Transitions scenarios, Rwanda has the potential to address and contain environmental challenges despite anticipated population growth, which would help lead to a sustainable future (REMA 2011). Adverse changes to the environment were more likely to occur under the Fortress World and Market Forces scenarios as the country's growing population would have to rely on a constrained resource base.

In adopting these scenarios for Kigali, the Great Transitions scenario would imply proper urban planning for sustainability, organised and energy-efficient transport and designs for infrastructure and settlement that can accommodate the anticipated population upsurge and climatic changes. In fact, the KCMP reflects this planning scenario, which implies that the CoK is actually on the Great Transitions trajectory. The proof, however, will only be evident as the CoK implements the planning framework it has created, especially concerning plans for better public transportation. The Policy Reform scenario also applies to the present state and future of Kigali as more and more policies are being developed with environmental protection and climate resilience in mind. Under the Policy Reform scenario, however, policies are typically adopted in reaction to environmental stresses, as opposed to the proactive policy stance taken in the Great Transitions scenario. As the CoK begins to fully identify its environmental issues, policies should begin to be adopted to prevent future deterioration. These policies are essential for a sustainable and resilient future.

Another publication that Kigali can learn from in contemplating its future is the 2013 AEO-3 SFPM, which also uses scenarios. UNEP and the secretariat of the Ministerial Conference on the Environment (AMCEN) for monitoring environmental management in Africa provide the framework for producing the AEO reports. At their 2008 joint meeting in Libreville, Gabon, the African Ministers of Environment and of Health commissioned the third AEO report. Recognising that Africa's disease burden, dominated by diarrhoea, respiratory infections and malaria, collectively account for 60 per cent of known environmental health impacts, prompted the Ministers to stipulate that the AEO-3 main report focus on linkages between health and the environment (UNEP 2013).

The AEO-3 assessment process uses two scenarios from the Global Environment Outlook 5 (GEO-5) (UNEP 2012), but focuses the scenarios specifically on the linkage between health and the

Table 6.1: The environmental outlook for Kigali

Kigali's potential future by adopting UNEP's Conventional World Scenario (CWS) and Sustainable World Scenario (SWS), and actual and potential scenario outcomes by adopting strategies from the *African Environment Outlook Summary for Policy Makers* (AEO-3 SFPM) and Rwanda's *Economic Development and Poverty Reduction Strategy 2013-2018* (EDPRS 2)

Theme	CWS for Kigali if business-as-usual maintained	SWS for Kigali if sustainable development approaches are implemented	Scenarios if relevant AEO-3 SFPM strategies are adopted	Scenarios if EDPRS 2 strategies are adopted
Air Quality	• Increased population growth, rural-to-urban migration, and lack of action on urban planning leads to the continued rise in informal settlements and the use of solid fuels • The number of private vehicles continues to rise sharply • Indoor and outdoor air pollution leads to the rise in respiratory disease incidences	• There is a dramatic reduction in use of wood and charcoal fuels among Kigali residents • Outdoor air pollution reduces sharply • Incidences of respiratory diseases associated with indoor and outdoor air pollution are falling	• There is a marked uptake of improved cooking devices and better kitchen ventilation • Sensitisation campaigns to reduce user exposure to smoke results in positive behavioural change • A combination of command and control and fiscal incentives leads to the uptake of renewable energy sources • Off-grid power generation systems are constructed, making electricity an affordable cooking energy alternative • The institution and implementation of outdoor air quality standards and regulations improves urban air quality	• Kigali benefits from government and private sector delivery of improved cookstoves and training packages to some 400,000 households in 5 years • There is rapid growth in private sector solar products • Energy education for the population is ensured • A Biogas Programme for households and institutions is expanded and delivered at the District level • Access to electricity by urban households increased from 46 per cent in 2012 to 70 per cent in 2018 • A regulatory environment provides incentives for green technologies and innovation
Biodiversity	• Biodiversity loss and extinctions accelerate in non-protected areas • Dramatic habitat loss occurs because of deforestation and wetland and aquatic ecosystem conversion in non-protected areas • Pathways for invasive alien species increase	• The extinction of species in non-protected areas is halted and declines are reversed • Terrestrial, wetland and aquatic habitats are conserved and protected • Coordinated national, and District initiatives contain the threats posed by invasive alien species	• The capacity of lead agencies to rein in deforestation and wetland conversion is scaled up • Participatory management approaches such as urban Community Based Natural Resources Management (CBNRM) are being fostered	• A biodiversity policy has been implemented, including conservation of biodiversity outside protected areas, agro-biodiversity and biodiversity knowledge management • The NSCCLCD strategies related to CBNRM are being implemented with eco-tourism and Payment for Ecosystem Services (PES) • The Lake Victoria Environment Management Programme is rehabilitating degraded wetlands and controlling alien species
Chemicals and Waste	• The number of cases of human chemical contamination is rising • The stockpiling of Persistent Organic Pollutants (POPs), inorganic fertilisers and agro-chemicals continues unabated • The accumulation of e-waste and municipal waste increases • Non-fuel sources of lead are still a challenge	• The number of cases of human chemical contamination declines • Mechanisms for safely disposing of chemical stockpiles are instituted • The amount of e-waste and municipal waste generated is reducing owing to the adoption of strategies for the 4Rs: reduction, reuse, recycling and recovery • Illegal dumping of toxic waste is contained • Command and control measures reduce the generation of non-fuel sources of lead	• The Strategic Approach to International Chemicals Management (SAICM) framework has been adapted to the African context • The domestication and implementation of the Basel, Stockholm and Bamako Conventions and cooperation among them have accelerated • The public has been sensitised to the benefits of the 4Rs: reducing, reusing, recycling and recovery • National and institutional capacities for chemicals management, including recycling and disposal technologies, have been strengthened • The implementation of the polluter pays principle has been strengthened	• Rwanda is signatory to international conventions including Basel, Stockholm and Rotterdam* • Departments of Climate Change and International Protocols within REMA continue to implement ratified agreements • Guidelines for mainstreaming Resource Efficient and Cleaner Production in Rwanda has been applied in all sectors • The Rwanda Resource Efficient and Cleaner Production Centre (RRECPC) in Kigali champions clean production in Small and Medium Enterprises (SMEs)* • Rwanda's environmental law enforces the polluter pays principle

environment. These are called the Conventional World Scenario (CWS), which assumes 'business-as-usual' and the Sustainable World Scenario (SWS), which involves both local and global changes.

CWS is based on the assumption that the business-as-usual approach will automatically lead to attaining desired goals without instituting radical policy shifts. A glance at the CWS outcomes reveals the potential health risks from continuing the prevailing approach to environmental management.

Theme	CWS for Kigali if business-as-usual maintained	SWS for Kigali if sustainable development approaches are implemented	Scenarios if relevant AEO-3 SFPM strategies are adopted	Scenarios if EDPRS 2 strategies are adopted
Fresh Water and Sanitation	• Water availability remains below the globally accepted minimum threshold of 1,000 m^3 per capita • The percentage of inhabitants experiencing water scarcity rises • Over 35 per cent of the population still does not have access to adequate sanitation by 2050 • Organic water scarcity is manifested through falling aquifer levels, persistent water shortages and exorbitant pricing • Total Sanitation proves elusive • Child mortality due to waterborne diseases such as cholera and typhoid rises sharply	• The MDGs on water and sanitation and other global targets are achieved • Behavioural change and technological innovation that promotes use efficiency leads to a considerable reduction in water withdrawal • 100 per cent access to safe drinking water and Total Sanitation is achieved by 2020 • There is a remarkable reduction in incidences of waterborne diseases	• Watersheds, including water towers, are protected • The public is educated about water saving, wastewater recycling and Total Sanitation • Conservation of water in households, industry and agriculture is being promoted through economic incentives that encourage water harvesting and recycling • Research and technological innovation that promote water use efficiency are being promoted • Integrated Water Resource Management (IWRM) is being implemented*	• Guidelines for mainstreaming Resource Efficient & Cleaner Production in Rwanda is applied in all sectors • The RRECPC in Kigali champions water-use efficiency in SMEs* • A Masters programme in IWRM is offered by the NUR and produces research and innovation for water-use efficiency* • A Department of Integrated Water Resources is established in MINIRENA, which effectively promotes IWRM*
Land	• Land degradation, coupled with climate change lowers crop and livestock yields by over 34 per cent after 2030 • Perennial hunger and famine in some agro-ecological regions coexist with abundant food in others	• There has been a coordinated holistic shift to sustainable land management • Food production is achieved without harming biodiversity • Policies to improve the productivity of marginal lands is leading to strong gains in food and nutrition security, with positive health outcomes, increased life expectancy and reduced child mortality due to malnutrition	• Land reforms that ensure food security and sustainable land management have been instituted • Irrigation coverage and efficiency have improved, which enables the proportion of land under agriculture to increase	• The national land registration roll-out is completed for clear and secure land ownership • A land husbandry approach is being promoted across Rwanda • The area under irrigation increased from 24,490 ha in 2012 to 40,000 ha in 2018, developed by public and private sectors in wetlands and on hillsides

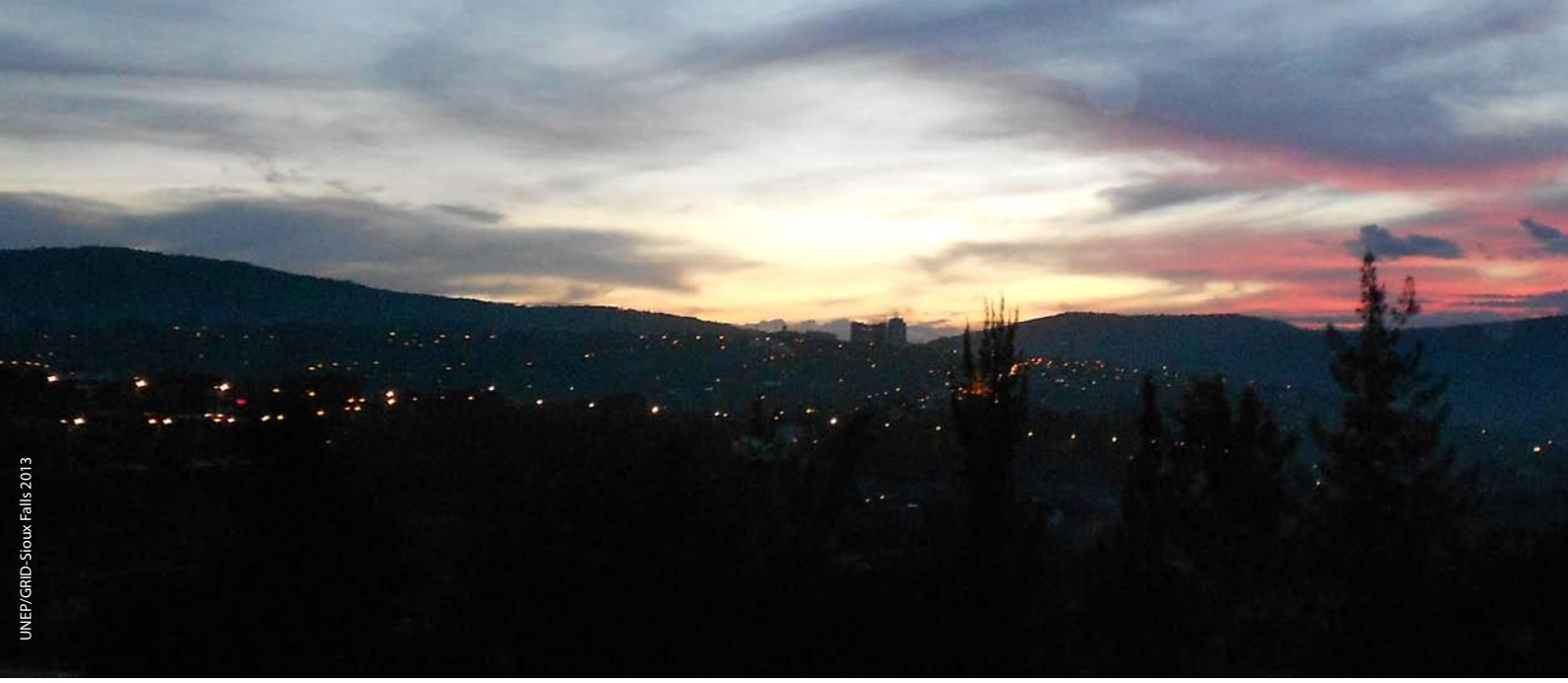
*Note: * indicates that this outcome occurred by 2013*

On the other hand, the SWS recognises both the enormous challenges and opportunities inherent in changing domestic and global environment and health situations. In effect, it accepts that transformative change needs to be an integral part of environmental management to address constraints to progress towards desired goals for sustainable development. Its main objective is to suggest policy, institutional and programme options that could radically transform current trends and set them on a path toward attaining the desired environmental and human health outcomes.

The SWS focuses mainly on the drivers of environmental change. This scenario defines the outcomes for each thematic issue and uses them to identify the needed paradigm shifts to accomplish the goals. As explained in the AEO-3 SFPM, the 'outcomes help shape the envisioned pathways and compel deliberate actions that deflect or completely halt unsustainable trends that would otherwise compromise goal attainment' (UNEP 2013, 26).

The AEO-3 SFPM analyses seven environmental themes (Air Quality; Biodiversity; Chemicals and Waste; Climate Change and Variability; Coastal and Marine Resources; Fresh Water and Sanitation; and Land) using the aforementioned CWS and the SWS. The AEO-3 SFPM proposes some important strategies to address environmental gaps responsible for perpetuating the disease burden realised from the scenario analysis.

To help envision Kigali's environmental outlook, this report has adapted the CWS and SWS scenarios from the GEO-5 and the policy recommendations offered in the AEO-3 SFPM. Table 6.1 shows the outcomes of applying the scenarios to the city with respect to addressing gaps related to the links between human health and the environment. In addition, to provide the outlook analysis with more depth specific to the City of Kigali, Table 6.1 also applies the recommended actions from the current



Sunset over the City of Kigali

City of Kigali Development Plan (CKDP) as reflected in the EDPRS 2, within the Vision 2020 timeframe. This exercise helps envision the potential outcomes of a set of plans that align well with those of SWS and allow comparison with the outcomes of a generic CWS. The goals and targets in the EDPRS 2 support those in the AEO-3 SFPM outlook since many relate to health and the environment. For example, to improve indoor and outdoor air quality for human health in Kigali, the EDPRS 2 promotes improved and diversified cooking stoves, including electricity, solar and biogas; respiratory health education; and putting in place an institutional incentives framework for technology and innovation.

To achieve the Great Transitions or SWS scenarios, the City of Kigali must be actively involved in implementing the national biodiversity policy as well as the NSCCLCD strategy, both of which place important emphasis on conserving biodiversity outside protected areas. To accomplish this, the CoK should promote Community Based Natural Resources Management (CBNRM) initiatives such as community based watershed management, Payment for Ecosystem Services (PES), ecotourism and alien species control. The operational domestication and implementation mechanisms of the international protocols and conventions Rwanda has ratified propose strategies to manage them effectively.

The Rwanda Resource Efficient and Cleaner Production Centre (RRECPC), which will soon be formally institutionalised as a state agency, has a mandate to promote clean technologies and practices with an initial focus on Small and Medium Sized Enterprises (SME), most of which are based in Kigali. The main tool for managing chemicals and waste is the available guidelines document for mainstreaming resource efficient and cleaner production into national policies and strategies.

The framework for mainstreaming resource efficient and cleaner production into Rwanda's policies and strategies provides policy options and strategic action proposals for the wise use of water, although it still lacks adequate demand-side management strategies. The RRECPC also prioritises wise water use, with an initial focus on beverage industries in Kigali. A new Department of Integrated Water Resources has been established in the MINIRENA with a mandate to develop and implement Integrated Water Resources Management (IWRM) in all sectors of the country while the National University of Rwanda (NUR) is contributing to research and innovation through its IWRM Master of Science programme.

Rwanda's national rollout of land titles for every piece of private land will be completed in the 2013-2018 EDPRS period (EDPRS 2), providing citizens with clear and secure land ownership. Secure land tenure is a prerequisite for sustainable land management necessary to optimise its productive potential. Sustainably increasing land productivity for food security will be set in motion with plans to increase the rural area under irrigation from 24,490 ha in 2012 to 40,000 ha by 2017- 2018 and improve the quality of current irrigation (MINECOFIN 2013).

Conclusion

The array of accomplishments the City of Kigali has undertaken to increase environmental awareness and improve environmental conditions for its citizens are commendable and are inspiring examples of how such efforts could be expanded in the future. The opportunities they create will help in continuing to build a sustainable future and green economy for Kigali. By keeping the environment and the welfare of its people as the central focus of future development, the City of Kigali can ensure it is on course with the Great Transitions trajectory, the scenario that provides the greatest benefit for both people and the environment. By integrating increased resource and waste management, continuing and expanding environmental education in the community and adhering to local, national and international environmental and biodiversity policies, this best-case scenario can be achieved. Officials and citizens of Kigali have the tools to continue to build a sustainable future, but proper maintenance and implementation, as well as financing mechanisms need to be ensured to achieve optimal environmental conditions, including the important matter of climate change resilience. Everyone is responsible for creating the best future possible. To do this, residents and authorities only need to ask themselves: how is this programme, policy or action going to help create a sustainable future, not just a sustainable moment?

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