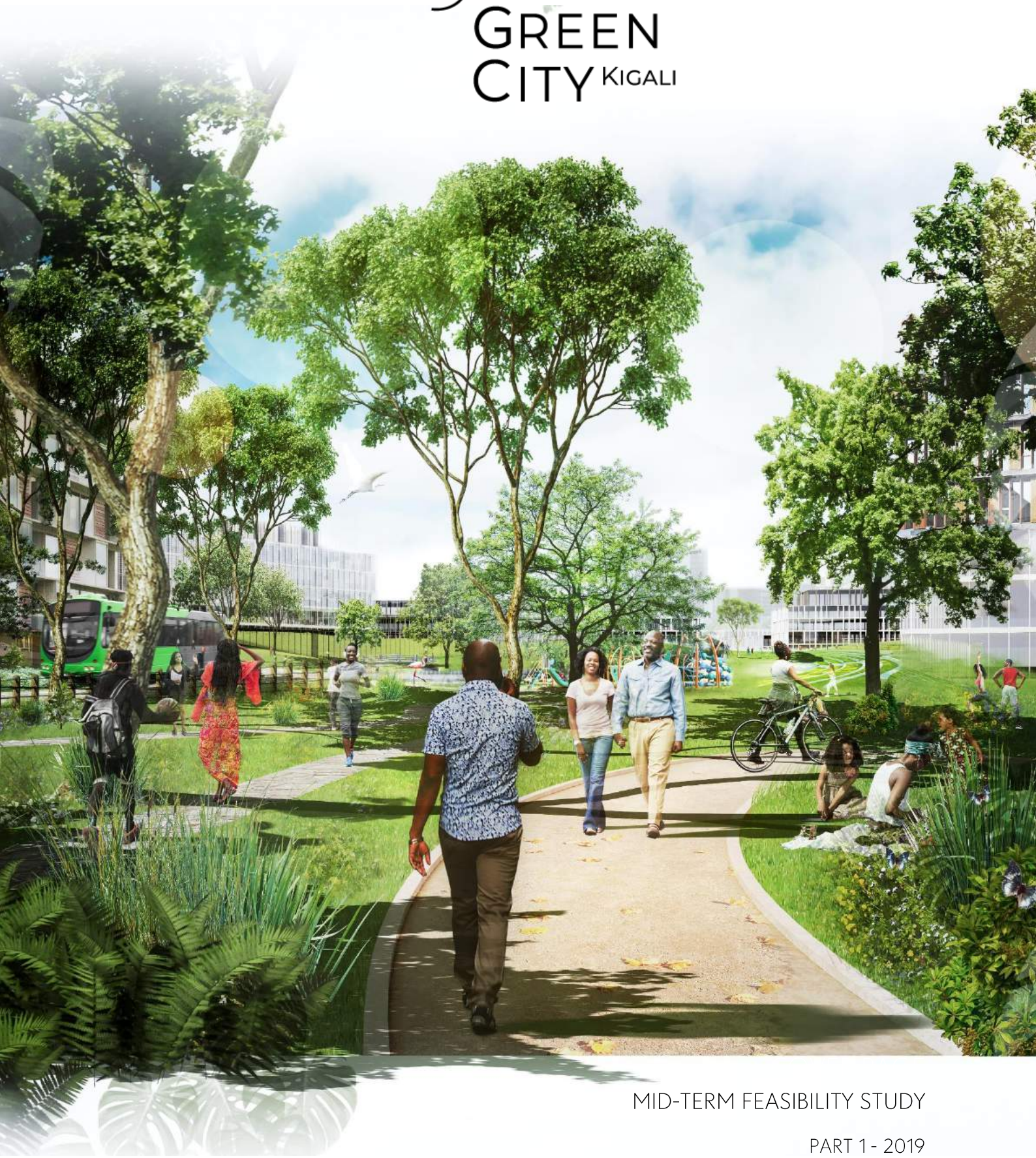
GREEN CITY KIGALI



MID-TERM FEASIBILITY STUDY

PART 1 - 2019

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ABBREVIATIONS

BMZ	German Ministry for Economic Cooperation and Development
BRD	Development Bank of Rwanda
CoK	City of Kigali
CSO	Civil Society Organization
EDPRS2	Second Economic Development and Poverty Reduction Strategy (Later replaced by NST1)
EMIP	Environmental Management and Implementation Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FONERWA	Rwanda Environment and Climate Change Fund / Rwanda Green Fund
FS	Feasibility Study
GAP	Gender Action Plan
GCF	Green Climate Fund
GCK	Green City Kigali
GGGi	Global Green Growth Institute
GoR	Government of Rwanda
HH	Household
IFC	International Finance Corporation
JV	Joint Venture
KfW	Kreditanstalt für Wiederaufbau
LGI	Local Government Institute
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MININFRA	Ministry of Infrastructure
MoE	Ministry of Environment
MoU	Memorandum of Understanding
NDC Nationally	Determined Contribution
NST 1	National Strategy for Transformation (2017-2024)
PPF	GCF's Project Preparation Facility
RAP	Resettlement Action Plan
REMA	Rwanda Environment Management Authority

RIBA	Royal Institute of British Architects
RHA	Rwanda Housing Authority
RSSB	Rwanda Social Security Board
RwaGBO	Rwanda Green Building Organization
RWH	Rainwater Harvesting
SACCOs	Savings and Credit Cooperative Organisations
SPV	Special Purpose Vehicle
SWM	Solid Waste Management
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlement Programme

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FOREWORD

Formal Project Information

The Government of Rwanda has declared the development of sustainable cities and villages to initiate a paradigm shift towards green urbanisation a thematic priority area in the Economic Development and Poverty Reduction Strategy (2013).

Rwanda's Green Fund (FONERWA) has secured funds from the German Government through KfW Development Bank through the Green Climate Fund (GCF) Readiness Programme of the German Ministry for Economic Development and Cooperation (BMZ) to undertake a Mid-Term Feasibility Study for the Green City Kigali project (GCK) in Kigali. In addition, the Ministry of Environment of Rwanda has applied for further funding for the Feasibility Study through GCF's project preparation facility (PPF) towards the project.

The foundations of Green City Kigali were formed in 2017 when the Ministry of Environment and its partners signed a Memorandum of Understanding (MoU) to work towards integrated green concepts and confirming the Kinyinya area in Gasabo District as the site for the project. This pilot project is expected to serve as a blueprint and model for sustainable urban development and initiate a paradigm shift towards green urbanisation in Rwanda.

FONERWA has commissioned a SWECO Joint Venture to undertake Phase A (Mid-term Feasibility Assessment) and Phase B (Design Competition) of the project. This document is the Mid-term Feasibility Study.

Objectives of this report

This Mid-term Feasibility Study Report aims to uncover the strengths and weaknesses of the proposed Green City Kigali project, and to suggest ways in which it can be implemented. It presents the existing socio-economic and natural context, the main features required to carry out the project, and ultimately the prospects for success. The study is conducted with an objective, unbiased approach to provide information upon which decisions can be based.

The Report compiles the findings of the feasibility phase of the project and develops an implementation framework for Green City Kigali. It describes the activities undertaken by the feasibility study consultant, summarises the findings of the study and how the conclusions have formed the basis for the proposed pilot project implementation approach, the climate-resilient and green urban master plan considerations, the financial modelling and the selection of planning and design criteria. It includes an outline of the design competition brief and a suggested approach for the facilitation of the international design competition. It outlines the next steps of the project and discusses options for the most feasible GCK project implementation approach. It will serve as the basis to compile the design competition brief.

This Mid-term Feasibility Study Report Part I should be read in conjunction with the Study Report Part II that compiles the full sector reports as well as with the Urban Design Project Handbook, that outlines the urban development context of the GCK.

EXECUTIVE SUMMARY

During the process of carrying out the Feasibility Study, a shared GCK vision was developed to align all the stakeholders toward reaching the project objectives. This vision is as follows;

"Residents of Kinyinya Hill should be able to enjoy the social and economic benefits of urbanization while minimizing ecological footprints".

It is the assessment of the feasibility of this vision that are contained in the chapters that follow. These chapters are summarized below including their key recommendations:

1 INTRODUCTION

The background and context to the project and the site, the process being undertaken and the approach to assessing delivery of the project vision expressed in terms of social, environmental and economic sustainability parameters.

2 ACTIVITIES UNDERTAKEN

A summary of the sector specialisms that carried out the technical feasibility work, the technical 'toolkit' (see right) and working processes.

3 LIVEABLE COMMUNITIES

An analysis of the urban planning context of the site along with a summary of the physical site framework and its carrying capacity to support a sustainable and liveable community on Kinyinya Hill.

Key Recommendations:

The key recommendations of the work are expressed as figures for carrying capacity and are set out in the tables below.

Overall Project Area		600 ha
Of which:		
Allowance for employment cluster	1.7 %	10 ha
Allowance for sub urban centre park(s)	1.3 %	7.5 ha
Unsuitable for development	36.6 %	220 ha
Gross Residential Development Area1		362.5 ha
Targeted population (excluding existing population)		130 154
Targeted population (including existing population)		168 892
Total number of dwellings		29 242
Of which:		
Social housing	80-210 units per ha (gross)	10%
Affordable housing	80-160 units per ha (gross)	80%
Market housing	50 units per ha (gross)	10%

Table 1: Urban development parameters[2] Figures reflect the City of Kigali's emerging 2019 masterplan.

Further details are contained in the Urban Design Handbook which accompanies this report.

[1] For detailed urban uses, please refer to the Urban Design Handbook
[2] Urban development parameters

4 HOUSING AND BUILDINGS

An analysis of the housing context in Kigali and suggested palette of housing and building typologies that can meet the needs of the community.

Key Recommendations:

The following guidelines could be considered in the design of appropriate buildings:

i. Affordability
ii. Privacy
iii. Environmental Design Considerations
iv. Konoshi[3]

The following Housing Typologies are proposed:

Proposed Housing Typologies		
Number of Floors	Housing Type	Usage
4-Story (G+3)	Multifamily Residential	Residential
4-Story (G+3)	Mixed Use	Commercial and residential
5-Story (G+4)	Mixed Use	Commercial and residential
2-Story (G+1)	Single family residential	Row House residential
2-Story (G+1)	Single family residential	Duplex residential
2-Story (G+1)	Single family residential	Villa residential
4-Story (G+3)	Mixed Use	Commercial and residential
5-Story (G+4)	Mixed Use	Commercial and residential
2-Story (G+1)	Single family residential	Row House residential

Table 2: Proposed Housing typologies:

i. Maximizing cost efficiency and space utilization.
ii. Upgradeability and adaptability of the units.
iii. Provision of good airflow and natural daylighting to reduce external energy use.
iv. Privacy and security.
v. The following Unit Typologies are proposed:

Proposed Unit Typologies		
	Type	Size
1	Apartment Units:	
1.1	1 BD unit (social housing)	45 m2
1.2	1 BD expandable microunit (affordable housing)	30 m2
1.3	2 BD expandable microunit (affordable housing)	45 m2
1.4	1 BD unit (affordable housing)	45 m2
1.5	2 BD unit (affordable housing)	60 m2
1.6	3 BD unit (affordable housing)	80 m2
2	Single Family Housing Units:	
2.1	2-Story (G+1) – Single family residential – Row House	100 m2
2.2	2-Story (G+1) – Single family residential – Duplex	120 m2
2.3	2-Story (G+1) – Single family residential – Villa	150 m2

Table 3: Proposed Unit typologies:

[3] Rich, P., Inclusion of Traditional Rwandan Cultural Characteristics into the Built Environment

5 SUSTAINABLE INFRASTRUCTURE

An explanation of the integrated infrastructure model that is proposed to deliver on the vision including essential basic networks and longer-term ideas for upgrading. The figure below shows the integrated sustainable infrastructure model which is supported by passive buildings, liveable communities and ecosystem services. Continual performance monitoring is achieved through resource modelling at its heart.

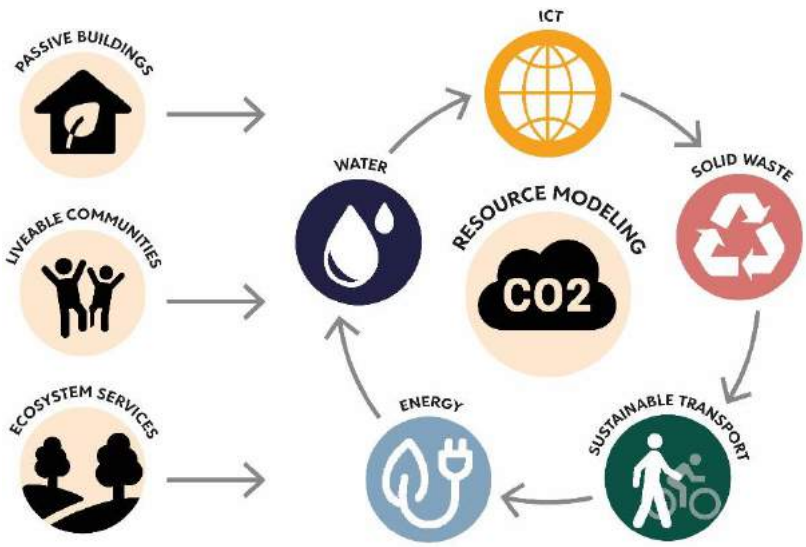

Figure 1: Sustainable Infrastructure

Key Recommendations:

ICT

- Universal fast internet access via smart phones and/or wireless broadband

Solid Waste

- Introduction of source separation points per 60 households – organic, recyclable, residual.
- Upcycling rooms to encourage reuse of waste materials

Sustainable Transport

- Prioritise provision of sustainable and more affordable transport options and innovate to keep car ownership and parking at significantly low levels.
- Locate a local or neighbourhood centre within 500m walking distance of every home.
- Create a permeable walking & cycling network throughout.
- Create Transit Oriented Development densities around local centres.
- Smart public transport systems.
- On-street EV charging for moto taxis and e-bikes etc, possibly e-cars.

Energy

- Passive building design and low energy fittings minimises energy demand.
- Lighting and water heating powered by on site renewables (PV)
- LPG for cooking (possibly transitioning to induction electricity powered by on site renewables).

Water

- Point-of-use demand reductions by low-flow high-performance fittings.

- Design, materials and technical systems to meet 100% non-potable water demand from on-site rainwater harvesting:
- Potable water sourced from local on-site boreholes and delivered to homes via reusable plastic bottles.
- Maximise permeable ground surface area to allow for groundwater recharge.
- Onsite sewerage treatment. Liquid discharge from sceptic tanks into engineered wetland to avoid site contamination of ground water. Investigate possibility of onsite biogas plant.

6 HOUSING AND COMMERCIAL MARKET REVIEW

An analysis of the existing markets in Kigali and the current constraints on delivery of affordable housing in sustainable communities, along with a recommended financial model.

Key Recommendations:

The key elements of the model are summarised below:

1. In general, construction costs are reduced from the current norm through a combination of higher density development, tax and duty relief and control over size & specification of homes.
2. Help to Own and potentially Rwanda Housing Finance Project funding is available to assist in increasing access to mortgages.
3. The following housing mix forms the basis of the model:

HOUSING TYPE	DESCRIPTION	TENURE	TYPE	SQM	AVERAGE MONTHLY HOUSEHOLD INCOME (USD)	CONSTRUCTION COST BASE RATE (USD/M2)	HOUSING COST (USD)	ROLE IN FINANCIAL MODEL	% OF DU
Social housing	Housing for the poorest and most vulnerable in society	Rent	Apartments/ rowhouses	45	0 - 215	329	Nil rent	Fully subsidised by open market homes	10%
Affordable homes	Housing for low income households	Own*	Extendable micro-apartments*	30*	215 – 380*	329*	Purchase cost at 10-12k*	Sold at cost + 10% using HtO mortgages*	20%*
	Housing for middle income households	Own	Apartments (poss. rowhouses)	45 60 80	380 - 800	329	Purchase cost at 17-31k	Sold at cost + 10% using HtO mortgages	60%
Open market homes	Housing for higher income households	Own	Villas	100 120 150	Above 800	450	Purchase cost circa 100,000	Sold at market value. Profits subsidise social housing	10%

Table 4: Proposed housing mix:

*(*note - this typology is theoretical at this point and has not yet been verified, so is not used as a basis for costing)*

4. Government of Rwanda will pay for sustainable infrastructure and management costs (poss. through Affordable Housing Fund) and subsidized by local community fees, future land value capture and/or commercial receipts (e.g. markets, kiosks, sports & recreation).

5. Potential use of UN's Green Climate Fund to cover the cost of additional green enhancements.
6. Community facilities will be provided and operated either on a commercial basis or by relevant government agencies.
7. Design decisions should support and enhance both capacity building and sustainability performance in the local construction market in terms of local materials, skills and labour where possible.

7 LOCAL JOB CREATION

A summary of the employment market and opportunities to integrate employment within the community.

Key Recommendations:

- Install training centres and skill enhancement programs
- Help existing local businesses improve and expand
- Encourage the formation of new businesses from within the community.
- Improve the community's ability to retain income within the local economy.
- Attract basic Employers from other Locations
- Job Creating Activities to be implemented on the Hill

8 CROSS CUTTING ISSUES

A narrative on the issues that are relevant to all aspects of the development and implementation process, such as gender equality, climate resilience, the environment and youth.

Key Recommendations:

- The chapter sets out a series of positive and negative impact regards the socio-economic situation.
- An EIA should be conducted in the next stage.
- Ensure facilities supporting daily activities, especially for women, youth, children and the elderly are integrated and accessible to homes and jobs.
- Promote employment options in locations accessible to residential areas.
- Define public transportation infrastructure and routes that will consider trip-chaining and commuting patterns for women and men who combine employment, household, and caring duties.
- Analyse sex and gender in relations to ergonomics and safety in the design of vehicles, routes, stations, and pedestrian paths leading to them.
- Monitor, plan, and implement specific measures for the different safety needs of women and men in public space design and maintenance, using gender aware methods.
- Explore housing designs that address the needs of working mothers and fathers, youth and of older people, and integrate common facilities as well as provide flexible spaces.
- Consider women's and men's needs and desires with respect to family care as well as the specific needs of the elderly and people with different degrees of functional ability in the design of community facilities.

9 SUSTAINABLE SYNERGIES

10 sustainable strategies which build on synergies identified by the sector specialisms, concluding with a table of sustainability standards and parameters to inform the next stages of the project process.

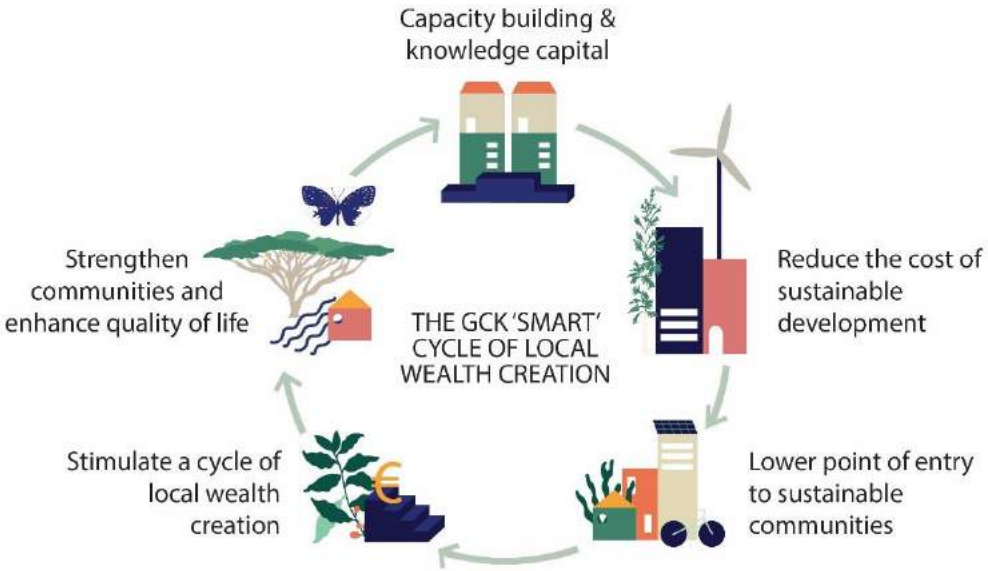

Figure 2: Sustainable Synergies

Key Recommendations:

List of sustainable strategies;

1. The Smart Cycle of Local Wealth Creation
2. The Green-Blue network and Land Efficiency
3. TOD and Sustainable Communities
4. A Roadmap to Zero Carbon
5. Water Autonomy
6. Sustainable Wastewater Treatment
7. Waste Management and the Circular Economy
8. Information and Communications Technology
9. Urban Heat Island Mitigation
10. Spatial Synergies and Placemaking

10 COST ESTIMATES

Financial calculations combining the findings of the Liveable Communities (carrying capacity) and Commercial Market Review (financial model) chapters.

Key Recommendations:

600 ha	USD
Total Project Cost	1 774 123 811
Total Contributions and Credits	1 735 923 923
Estimated Project Surplus / (Deficit)	(38 199 888)
% of Total Project Cost	2.15%
18 ha	
Total Project Cost	104 641 765
Total Contributions and Credits	106 087 748
Estimated Project Surplus / (Deficit)	1 445 982
% of Total Project Cost	1.38%

Table 5: Summary of Cost Estimates:

11 NEXT STEPS AND IMPLEMENTATION

Sets out the process to follow the completion of the feasibility study.

Key Recommendations:

The process through to Phase C is summarised in the figure below. The chapter also sets out recommendations with four possible options for the structure and funding of a Special Purpose Vehicle (SPV) to oversee and facilitate the implementation and management of GCK.

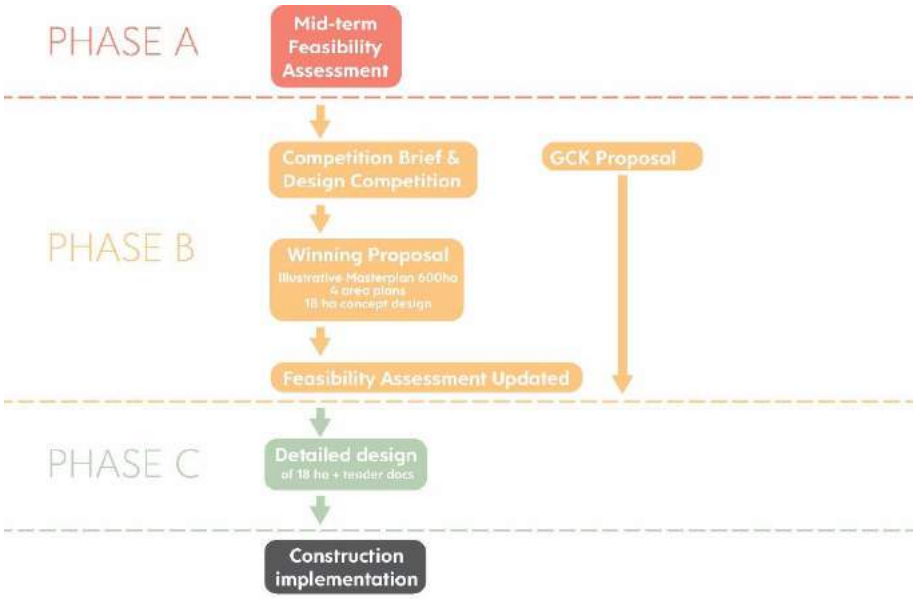

Figure 3: Implementation

12 ANNEXURES

Relevant references and sources of accompanying data.

Green City Kigali

1.0 INTRODUCTION

1.1. Background

Rwanda has seen significant economic development in recent years. Agricultural production has doubled since 2007 and industry and services are expanding. Development is supported by increasing access to electricity and fibre optics across the country. Ten years after joining the East Africa Community, Rwanda is now contributing positively to development in the region.

Rwanda's future socio-economic development is uncertain as its population grows and the climate changes, causing pressure on land, water, food and energy resources. Rwanda has the highest population density in Africa, and the population is growing at 2.8% per year. Urbanisation is increasing at 4.4% per year, with over 1 million people living in the capital city, Kigali. If this rapid urbanisation is properly managed and coupled with steady industry and services, Rwanda's cities can be instruments for wealth creation. Alternatively, there is a risk of urban slums developing and creating associated health and social problems. Job creation, education, health care and social protection are all needed to address population growth, while urban areas must be high density and resource efficient to support a growing skilled workforce.

According to the National Strategy on Climate Change and Low Carbon Development (Green Growth and Climate Resilience 2011) there are a few 'big wins' that if implemented, will make a significant impact on adaptation, mitigation and economic development. High density walkable cities have been identified as one of the three big wins. If this is not achieved Rwanda will face unprecedented levels of urban sprawl, partly due to hilly terrain. This forces people to travel greater distances than necessary, with motorised transport resulting in greater transport costs for the population and GHG emissions and air pollution – thereby combining to dramatically limit quality of life. Reduced urban sprawl limits the development of housing on steep slopes which are vulnerable to flooding and landslides. Environmentally sustainable, climate resilient and green economic growth is therefore an established development priority of the Government of Rwanda.

1.2. The Project

The overall aim of the Green City Kigali (GCK) project is to provide an urban development model for increased resilience against the consequences of climate change and ensured sustainable socio-economic development of Rwanda.

The Green City Pilot Project should create a model community in Kinyinya Hill to showcase sustainable urban development; linking affordable housing with climate change adaptation and mitigation measures and to set standards for sustainable and liveable urban communities in Rwanda and in the wider region. The expected project outputs are:

1. A master plan for the overall 600ha Kinyinya Hill site.
2. Four area plans.
3. Designs for a 18ha mixed housing development ready to be tendered.
4. A funding proposal submitted to the Green Climate Fund (GCF).

In addition, a number of communication and outreach projects have been initiated, including a collaboration with the University of Rwanda in Kigali which will support and uphold the long-term legacy of the project.

The project result chain is elaborated in the figure below:

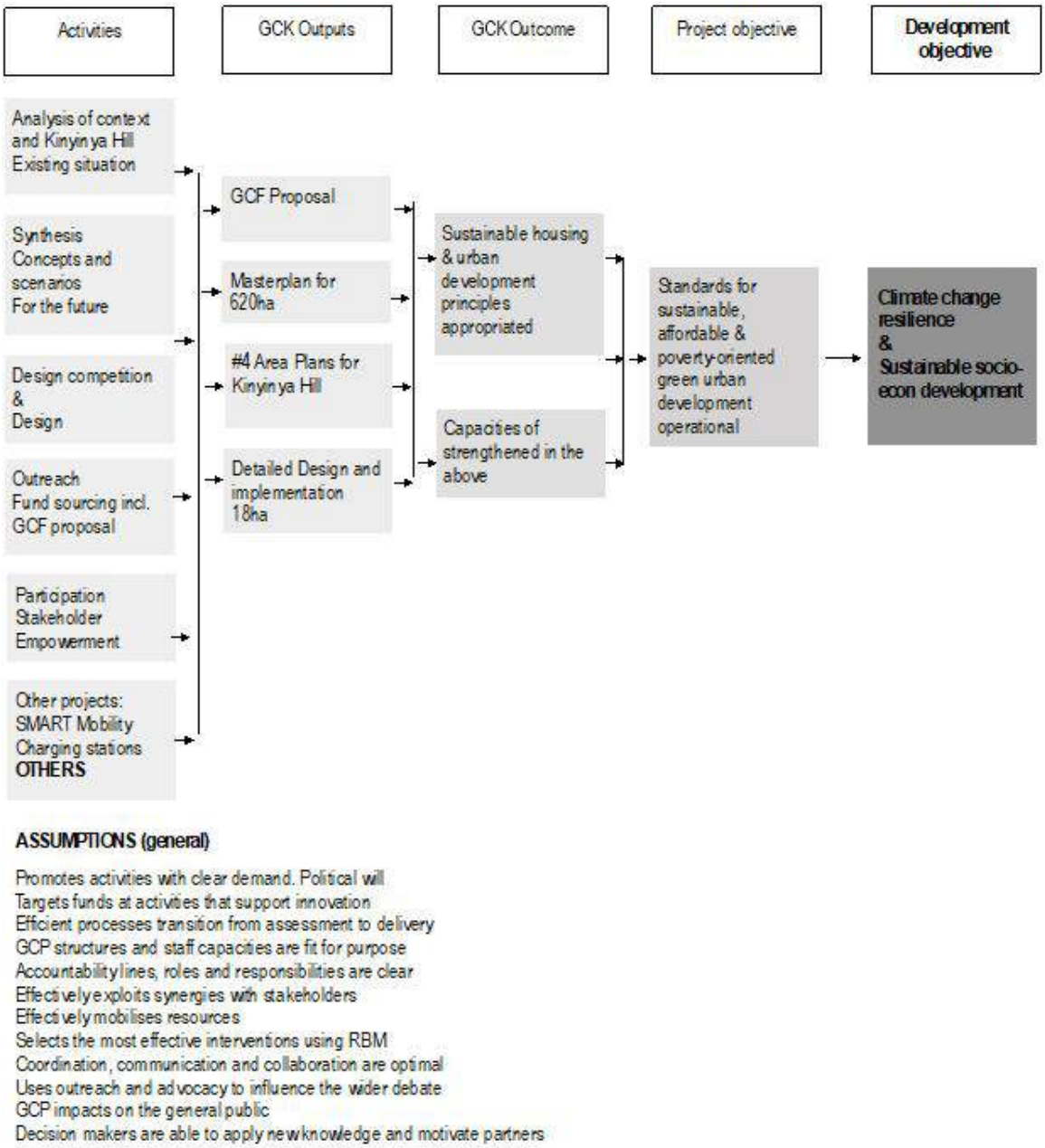

Figure 4: GCK project result chain

The activities undertaken under the Project are divided into three main phases.

Phase A - Feasibility Study; delivers an implementation framework for the Green City Kigali project.

Phase B - Design Competition; delivers an urban planning and architectural design competition and prepares a Green Climate Fund (GCF) funding proposal for submission by FONERWA.

Phase C - Detailed Design; develops detailed designs and tender document for a first phase parcel.

The approval of this Mid-term Feasibility Study Report will mark the end of Phase A. It will form a basis for the technical part of the design brief that will guide the design competition under Phase B.

1.3. The Project Vision

A project vision has been developed to align all stakeholders toward achieving the objectives of the Green City Kigali Project. It is the key point of reference for setting the targets and outcomes for the spatial and socio-economic development of Kinyinya Hill.

"Residents of Kinyinya Hill should be able to enjoy the social and economic benefits of urbanization while minimizing ecological footprints"

Sustainable urban development is grounded in the three integrated and inseparable pillars of sustainable development that are (i) social, (ii) economic and (iii) environmental. Residents of Kinyinya Hill should be able to enjoy the social and economic benefits of a liveable urban environment while minimizing ecological footprints. The Green City Kigali Project aims at incorporating the three dimensions of sustainable development in integrated proposals.

The persistence of multiple forms of poverty, growing inequalities and environmental degradation remain among the major obstacles to sustainable development worldwide. These challenges place great responsibility on strategic spatial and urban planning as a vehicle to effect socio-economic change, transform people's lives and to improve the environment. In this way, strategic spatial planning has the capacity to find integrated solutions and synergies among sectors, scales and between different stakeholders to achieve sustainable urban development.

1.3.1 Social Dimension

The social dimension aims at eradicating poverty in all its forms and dimensions, including extreme poverty and the rising number of slum and informal-settlement dwellers. The spatial organization, accessibility and design of urban space, as well as the infrastructure and basic services provision, together with development policies, can enhance social cohesion, equality and inclusion[4].

The income target groups for GCK include (i) lower-middle- and (ii) middle-income population of Kigali but also (iii) lower income households and (iv) households and individuals at the lower rungs of the socio-economic ladder that cannot afford a decent home at any price.

Woman and youth in Rwanda, according to the 2012 National Census are the majority in terms of numbers but they are among the most marginalised groups in terms of employment and economic development. There is a gender-based imbalance in urban governance roles, accessibility to secure tenure and land, affordable housing, overall safety and access to urban services[5].

The Project will be based on a thorough understanding of the Rwanda, Kigali and Kinyinya Hill cultural dynamics and social perceptions vis-à-vis the urbanisation process and of concepts such as densification and compactness of the

[4] United Nations (2016), New Urban Agenda.
[5] UN-Habitat and Government of Rwanda (April 2015).

city. If needed the Project will propose appropriate awareness raising activities to enhance understanding on the principles and social benefits of sustainable urban development.

1.3.2 Economic Dimension

The economic dimension aims toward sustained and inclusive economic growth, with full and productive employment and decent work for all. Cities and human settlements should be places of equal opportunities, allowing people to live healthy, productive, prosperous and fulfilling lives[6].

In the City of Kigali there is a significant amount of urban sprawl. Land allocated for agriculture is taken up by housing settlements, creating peri-urban areas that have longer commuting distances to the city. Investments are often not well planned as they are dispersed over scattered areas around the urban core that are physically distant from each other. The zoning of Kigali into different specific land uses creates several issues, for example longer travel distances and congestion.[7]

In response, GCK promotes phased, integrated and mixed land-use. The coordination between different stakeholders and investors will be improved, and area-specific studies will be created to ensure coordination of infrastructure, service delivery routes and communication at design phase. Transport demands will be managed through offering viable sustainable alternatives mixed combined with land use planning, which in turn will allow flexibility and adaption over time.

1.3.3 Environmental Dimension and Climate Change

Environmentally sustainable and resilient urban development recognizes that cities and human settlements face unprecedented threats from unsustainable consumption and production patterns, loss of biodiversity, pressure on ecosystems, pollution, natural and human-made disasters, and climate change and its related risks; thereby undermining the efforts to end poverty and to achieve sustainable development.[8]

The environmental analysis of the Project site not only aims at mapping the physical conditions of the environment, but further gives an insight into the impact of human settlement on the environment, now and in the future. They include the impact of travel distances on social development, elements causing environmental disturbance (emissions, noise pollution, etc), the availability of natural resources in the surrounding areas and their possible impact.

The combination of a difficult topography, high population density, high poverty levels, climate change-related erratic climate events and land degradation such as soil erosion contribute to the high vulnerability of the population of Kigali to natural disasters. These facts are considered in the Project's urban planning process. Risk areas are identified and labelled as areas not suitable for urbanisation and, hence, building. Areas suitable for agriculture, areas with a high environmental value, areas suitable as catchment basins should be put to suitable use in order to protect them from development / exploitation. Kinyinya Hill is the typical 'hillcrest to wetland' landscape with prominent spatial features that can uplift the quality of the design proposal including wetlands.

1.4. Implementation conditions of the GCK Vision

Housing and Climate Change

A key project focus is on affordable sustainable housing and on how to integrate this with climate change adaptation and mitigating measures. The Project is of assistance to the Government in implementing the 'Human Right to Adequate Housing' which is a comprehensive concept to enable and facilitate housing development through regulatory measures, public sector incentives and a wide range of actors, rather than by Government alone.[9]

[6] United Nations (2016), New Urban Agenda.
[7] UN-Habitat and Government of Rwanda (April 2015).

[8] United Nations (2016), New Urban Agenda.
[9] UN-Habitat (2013), Global Housing Strategy Framework Document.

Two-Track Approach to Urban Growth

In contrast to the current fragmented model of urban sprawl, the Green City Kigali proposes an urbanization process that is well-planned for the long-term dynamic changes that will occur in the city. It aims at allocating land for development in organized patterns of expansion as a basis for future economic and social growth and to preserve the environment. To this effect, the Project follows a two-track process to growth on Kinyinya Hill by (i) planning 'new city extensions' and (ii) 'neighbourhood upgrading' through improving the conditions of the existing neighbourhoods.

Innovation

The Project serves as a 'pilot' to inform a future development model for Secondary Cities in Rwanda. The model will include (i) access to sustainable infrastructure and services, (ii) a road map to affordable and quality living standards (iii) control and reduction of GHG emissions, (iii) promotion of good governance and (iv) multi-stakeholder engagement including catalysing the intervention of private sector investors as well as public sector. To that extent, the Project envisages drawing up proposals for the revision of existing planning instruments and /or rules and regulations supported by additional technical surveys and studies as required.

Orientation towards Implementation

GCK must be buildable and affordable. To achieve his, the Project will create conditions for creative and implementable designs supported by a viable financial model. A high-quality design brief will attract the best consultants to provide creative, sustainable technical and spatial solutions which coupled with publicity and outreach programmes will attract investors and donors to participate in implementation of the first phase site. The presence of interested investors and donors will hopefully in turn increase the attractiveness and profile of the development still further.

Spatial Approach.

The Project adopts a 'spatial' approach to identifying synergies between sectors, stakeholders and scale levels, and toward reaching sustainable urban development solutions. High visibility of the project achieved through a 3-dimentional vision focusing on character, identity and placemaking will create confidence, understanding and engage stakeholders and investors alike to participate in the project.

1.5. The Project Context

The Project Site

The project site is known as 'Kinyinya Hill' in Kigali which is situated approx. 6.5 km or a 15-minute drive to the north-east of the central business district of Kigali, in the district of Gasabo. The hill is occupied by readily developable land including a sizable government owned parcel, along with existing agricultural and village community areas with social housing. In addition to this are several planned and committed developments. The site is naturally defined by the topography of the hill and its surrounding wetlands and measures approx. 600 ha. Main access from the city to the site is from the south through the districts of Nyarutarama and Remera.

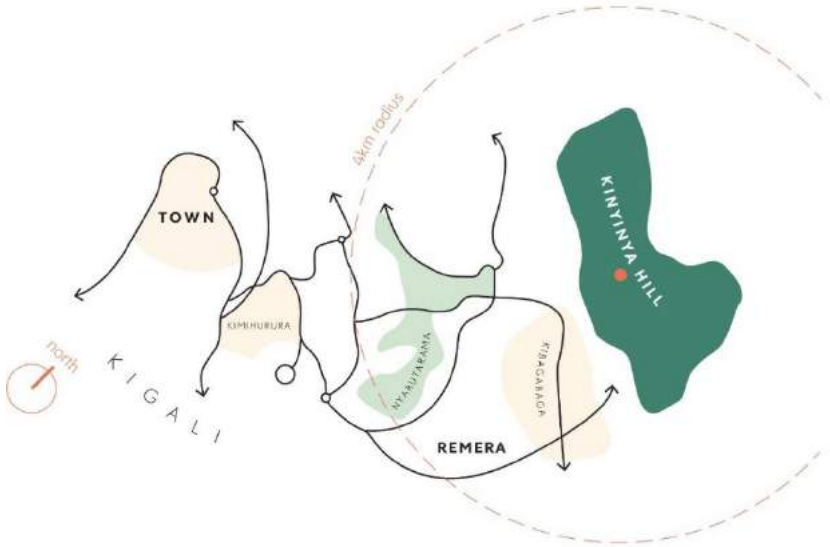

Figure 5: Project Site

Housing context

Kigali is a rapidly urbanizing city in the most rapidly urbanizing part of the world. Current expansion trends have been toward low density and outward expansion threatening Rwanda's food security and environment. In order to keep up with demand from a fast-growing city Kigali will need to produce over 35,000 dwelling units per year. Unfortunately, due to a number of constraints on supply, the actual rate of production has fallen far short of this. The result of this is that the vast majority of Kigali's residents inhabit informal housing, with the small amount of formal housing that does exist being far too expensive for the average resident.

Climate change context

The main considerations for climate change adaptation for Kinyinya Hill are related to the sloped topography and storm water drainage, along with climatic comfort. The steep slopes mean that storm water often does not have enough time to infiltrate and replenish the groundwater resource, but instead creates high runoff speeds. This in turn leads to erosion and downstream flooding and siltation. Groundwater tables are also insufficiently supplemented compared to a location with flat terrain which in turn results in plant degradation, reduced baseflow in downstream rivers and reduced ability to use groundwater as a potable water resource. Increasing global temperatures also place greater emphasis on finding solutions to tackle the urban heat island effect through zero-carbon means.

2.0 ACTIVITIES UNDERTAKEN BY THE FEASABILITY STUDY CONSULTANT

2.1 Sector Specialisms

The feasibility study has followed an iterative process of analytical and synthesis work starting with assessing the strengths and weaknesses of the project site and location, aligning with the goals and objectives of the overall project to create a long-term vision for Kinyinya Hill.

The feasibility study work has been carried out by an integrated team of sector specialists from the following technical fields. By working in close collaboration with each other and thereby finding synergies and efficiencies, they form the GCK 'Toolkit' which is illustrated in the figure below:

i. Urban planning
ii. Housing and building technology
iii. Ecology and landscape
iv. Water
v. Energy
vi. Waste
vii. Transport and mobility
viii. Financial modelling and costs
ix. Strategic sustainability
x. Cross cutting issues
xi. GIS and spatial data management

Figure 6: Project Toolkit

The following activities have been undertaken through the course of the feasibility study:

2.2 Visioning

The vision for the future development of Kinyinya Hill was created through collaborative efforts of the project team and key stakeholders. It then served to guide the specific sector work to make sure the implementation framework would be aligned with and contribute to the common goals of the GCK.

2.3 Analysis

<u>Data collection</u>

The sector specialists collected baseline data on the situation in Rwanda, on the specific situation of the site and identified important gaps in the data. At the analytic stage, mostly secondary data were used. A variety of methods were applied to collect information as listed below. These are detailed in the sector reports in Part II of the feasibility study.

i. Literature review of applicable rules and regulations, government policies and strategies, national and international guidelines. The list of documents that were consulted is compiled in the annex.

ii. Review of existing plans including the Kigali City Master Plan 2013, projects in the pipeline, reports and surveys.

iii. Semi-structured interviews were conducted with key stakeholders to complete missing information and check the validity and quality and to cross-validate the findings.

iv. Site visits and direct observation including visits to the project site as well to initiatives related to the GCK such as the Swiss Resource Centre and Consultancies for Development (SKAT).

v. Surveys including household surveys and topographic surveys.

vi. Focus group meetings with various user groups.

Analysis of the existing situation

The sector specialists then went on to outline the existing situation regarding the present built, natural and socio-economic environment on Kinyinya Hill together with the wider Rwandan regulatory framework of urban development. This included identifying existing capacities, liaise with the GIS specialist to enter data as base mapping and liaise with the urban planning team to enter sector information on the existing situation on Kinyinya Hill.

Scenarios for the future

Based on the current situation and existing capacities, the sector specialists went on to develop possible solutions and concepts for discussion with stakeholders which in turn provoked discussion, deepened knowledge of the site and its development challenges and opportunities. The solutions went on to form the basis of iterative cost estimates.

Synthesis

An 'Urban Lab' took place in Kigali from 3-10 May 2019. The Urban Lab process has been developed by UN-Habitat to respond to requests of national and local governments to support sustainable urban development. The GCK Urban Lab provided an opportunity to use tools for integrated and participatory urban planning with stakeholders and to raise awareness of the project.

During the Lab a synthesis of the sector work was undertaken and an integrated proposal for future development was developed. The synthesis was also an opportunity to deal with conflicting solutions and make sure that the development framework was harmonized. The Urban Lab also identified information gaps after which further primary data was collected. The comments of the stakeholders are summarized in Annex 1 of this report.

Public Participation

The Urban Lab also served as tool for public participation. During dedicated days with local communities and their representatives, valuable information was gathered, and future scenarios were developed in co-production with the public stakeholders and end users of the GCK.

Design competition

This mid-term Feasibility Study concludes by addressing proposed next steps and outlines the design competition brief and approach for Phase B.

2.4 Supporting activities

Several key activities supported the Feasibility Study work as follows:

Development of base-map and suitability map

The local branch of the GIS specialist ESRI developed a base-map for the 600-hectare project site. The base-map includes the site of the 600ha and a distance of 500m from the boundaries and wetlands at the bottom of the site. This was done by refining the SRTM30 Digital Terrain Model through a topographic survey.

To the base map additional map layers and site-specific thematic information has been added as follows:

i. Demarcation line of the 600 ha project site.

ii. Demarcation of the 130ha Rwanda Social Security Board (RSSB) site.

iii. Significant vegetation.

iv. Waterbodies and Wetlands.

v. Cadastral Information from the LAIS System of RLMUA (Parcel boundaries and unique Parcel identifiers only).

vi. The Kigali Master Plan (2013 version currently available, to be replaced with the 2019 version when available).

vii. The official administrative boundaries (as published by NISR for District, Sector and Cells).

viii. Soil Map (available at MINAGRI).

ix. Streets in the respective available classifications.

x. Other Infrastructure to the extent available and obtainable (Water, Power, ICT).

xi. The base map allows for 3D modelling by the design consultants.

A Project Web-Portal has been created where mapping has been placed for reference by the project team. It includes survey plans, reference plans, survey notes and associated documents linked to a geo-referenced address point.

The base-map has been used as a foundation for the spatial assessments carried out by the sector specialist, as well as to draft a suitability map developed in collaboration with the sector specialists to determine developable land on the project site.

The proposed demarcation of the 600ha serves as a proposed boundary line to be submitted for approval by the authorities.

Stakeholder participation and focus groups during sector work

In addition to the Urban Lab, the sector studies have been developed using both secondary and primary data. The primary data has been obtained via stakeholder participation events, focal groups, study visits to existing affordable housing projects and individual interviews with professionals.

For the housing sector report several community groups were consulted including Kimisagara, Batsinda and Kinyinya. Focus groups were also held with architectural students at University of Rwanda, as well as several individual interviews with professionals in the architectural, housing and building technology sphere. Several local quantity surveyors and providers were also consulted.

For the financial and economic sector report there have also been wide engagement with local stakeholders. This includes engagement with developers and agents to research housing and commercial market and testing of key emerging concepts with stakeholders. Legal and financial professionals to research current conditions and test the appetite for proposed solutions. Focus groups with possible target beneficiary groups, session with the Capital Market authority to consider ways in which bonds could be issued to fund the project as well as meeting with Ministry of Finance to review attempts made to fund infrastructure projects via issue of Municipal bonds.

University Cooperation and other outreach initiatives

In order to advance common interests of improved sustainable city development and ensure an enduring legacy for GCK, the project is partnering with higher education institutions in Kigali and elsewhere in the region to foster international inter-university cooperation and to enhance institutional capacities through knowledge sharing and collaborative work. The University of Rwanda has a longstanding cooperation with the Ministry of the Environment and the collaboration with the Green City Kigali project builds on this existing partnership.

The specific objectives of the cooperation are (i) capacity building at local level to enhance the sustainability of the GCK project, particularly with regard to the replication of the pilot in secondary cities and (ii) enriching the content of the GCK and help secure its legacy as a blueprint for the future.

The university cooperation will consist of:

- A student design project, to be run in parallel with the professional international design competition

- A 2-week summer school or short course on the theme of Green City Kigali
- Long term scoping and development of a Masters course in Sustainable Urban Planning at the University of Rwanda

The GCK urban planning sector specialist gave a lecture to the University of Kigali Architecture students introducing the project and the work undertaken to date.

In addition, the outreach initiatives include a social media programme, website, short film and Children's book about the environment and how to live sustainably and happily in cities.

What follows in Chapters 3 onwards is a summary of the findings of the sector specialisms.

Green City Kigali

3.0 LIVEABLE COMMUNTIES

3.1 Urban Planning Context

This section outlines the urban planning policy context on three different scales; Rwanda, Kigali and Kinyinya Hill.

Urban Planning Context in Rwanda (Macro scale)

Over the last 25 years there have been several framework and national policies developed to streamline the urban planning, development and implementation process with the goal of promoting socioeconomic and environmental sustainability. Below is a brief review of a selection of key policies and planning frameworks at the regional and national level:

Agenda 2063

A strategic framework for the socio-economic transformation of the African continent envisioned for the next 50 years. Among the objectives are the sustainability of economies and to develop strategies to grow African blue and green economies.

EAC Vision 2050

The East African Community vision to promote growth of the Green/Blue Economy, with the goal of contributing to low carbon development, reducing poverty as well as achieving sustained economic growth, thereby enhancing social inclusion and improving human welfare.

National Strategy for Transportation (NST) 1 (2017 – 2024)

'Accelerate Sustainable Urbanization' is a priority area of the strategy by developing flagship projects in secondary cities and other key urban areas to support thriving and sustainable urban economies. The Strategy also supports the updating of master plans of secondary cities and other key towns, promoting and developing local construction materials in collaboration with the private sector in line with the 'Made in Rwanda' policy, improving rural and urban transportation services and developing basic infrastructure through servicing 250 km of new residential zones. It was the predecessor of the NST, the EDPRS2 2013-18 that introduced efforts to create a Green City Kigali project to build a case for green urbanisation in Rwanda and identified MININFRA as the lead ministry to develop a conducive regulatory environment to support green urban development.

Vision 2020

Vision 2020 promotes the positive side of urbanisation and its contribution to economic growth through well planned and serviced rural settlement. Its 4th pillar is related to infrastructure management and focuses broadly on the interaction between urbanisation, the environment and sustainable natural resource management. It aims to increase the proportion of those living in towns from 10% in 2000 to 35% by 2020.

Urban Planning Context in Kigali (Meso scale)

The most important aspect of the Kigali Master Plan is to provide a road map for Kigali's future growth by guiding development and giving physical form to the strategic vision and values. It addresses the city's physical environment such as existing conditions, proposed developments, open space and circulation etc. whilst helping city leaders and stake holders make informed decisions regarding future growth.

Kigali City Conceptual Master Plan 2007

The key objective of the Kigali Conceptual Master Plan 2007 was to move forward from the National Strategic Plan proposed in Vision 2020, and to develop a long-range plan for the Capital City that would guide the future growth of Kigali. The key proposals were i) City Development Direction ii) Development Density and Environmental Considerations iii) Transect Model. However, in the years following the 2007 master plan the city's population grew much quicker than anticipated with a population of 1.3 million people by 2013. As a result, following master plans had to address the consequences of the rapid increase in growth.

Kigali City Master Plan 2013

The Vision of the Masterplan is to make Kigali "The Centre of Urban Excellence in Africa", with the 5 goals to be:

1. City of character, vibrant economy and diversity;
2. City of green transport;
3. City of affordable homes;
4. City of enchanting nature and biodiversity; and
5. City of sustainable resource management.

The Master Plan adopts a structure of a "radial city", with decentralised growth nodes and development meant to intensify along transit corridors mainly directed east and south, and with the Central Business District (CBD) being the centre point of the metropolitan area. The Kigali City Master Plan 2013 can be accessed online at: http://www.masterplan2013.kigalicity.gov.rw

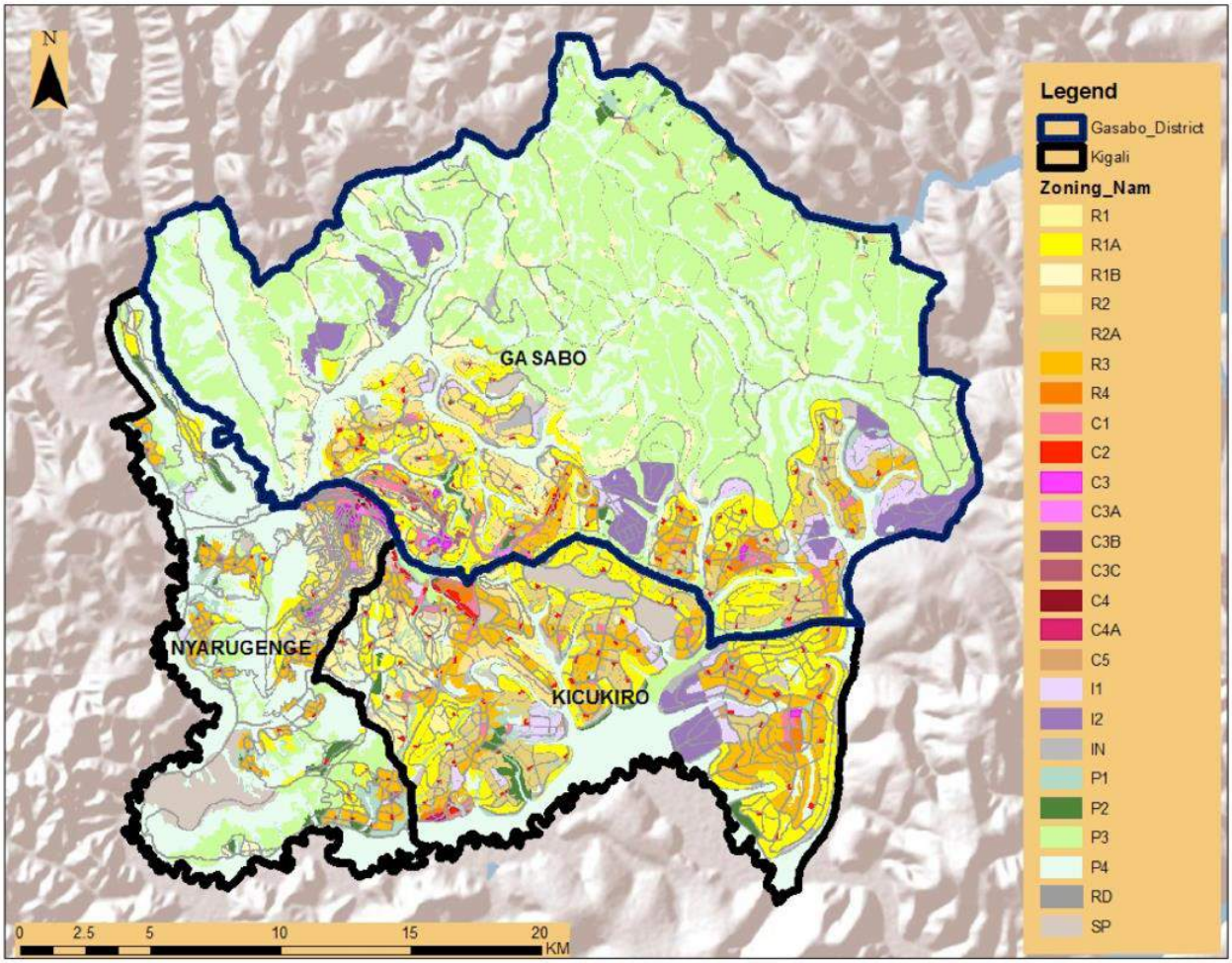

Figure 7: Kigali City Zoning Plan 2013. Source: Kigali City Zoning Plan GIS Data

Revision of the 2013 Master Plan and its Status

The Kigali City Master Plan is currently under revision with the Draft Version publicly displayed on the 21st of May 2019 for the public to provide comments. Key improvements include a focus on mixed use in residential zones to improve local commerce, increasing of densities through medium rise developments and a focus on affordability and informal settlement upgrading.

Urban Planning Context in Kinyinya Hill (Micro scale)

Since the development and preparation of the KCMP 2007, many new sub area plans and projects have been approved in Kigali. The key objective of the Kigali City Sub-areas Planning Project was to translate the vision and recommendations set in the KCMP. In Kinyinya sector there are two sub areas. The GCK project is located in the Sub Area Plan known as the "Residential Township in Kinyinya Sector, Murama Cell. According to the CoK Master Plan 2013, Kinyinya is among the 'Catalyst projects' chosen for the Masterplan implementation and project prioritisation strategy in Phase 1. Kinyinya is dedicated by the plan as a nodal development location.

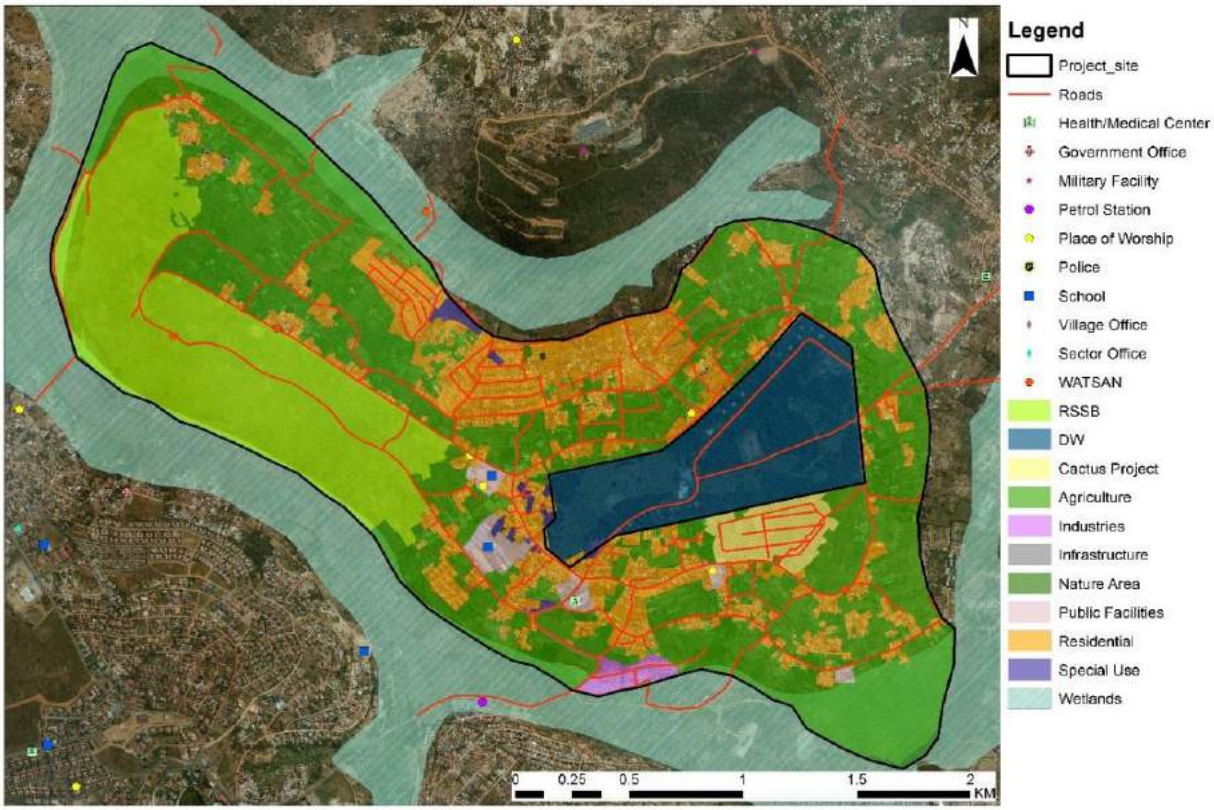

Figure 8: Existing Land Use On Site. Source: City of Kigali

General Land Use Allocations (Ha)

Residential (81ha) / Agriculture (225ha) / Industries (5ha) / Public Facilities (9ha) / RSSB (130ha) / Infrastructure (69ha) / Deutsche Welle (70ha) / Cactus Project (14ha). Approximate total: 600ha.

Existing Settlements and Projects Under Development

There are several existing settlements on the site with several more under development or consideration. Additionally, there are a significant amount of informal settlements, the majority of which come under the 'Peri-Urban' classification as determined by UN-Habitat. It is an intention to upgrade these existing informal settlements via densification, greater land use efficiency and connection to infrastructure, and avoid relocation. In the event of a future development scenario that may affect existing communities in terms of relocation however, this would be completed in line with a formalized plan conforming to Rwandan, World Bank and UN guidelines.

In addition, the Cactus Project of 14ha and the RSSB site Project of 22ha are under development in the South East and South West of the site, please refer to the Urban Design Handbook for the GCK project for more information on these projects.

Synthesis Map of Existing Situation on the Site

The map below provides an overview of the existing situation on the site highlighting existing roads, community focal points and blue/green structure. (*note that the GCK project area boundary line is still under review and will require further consideration*).

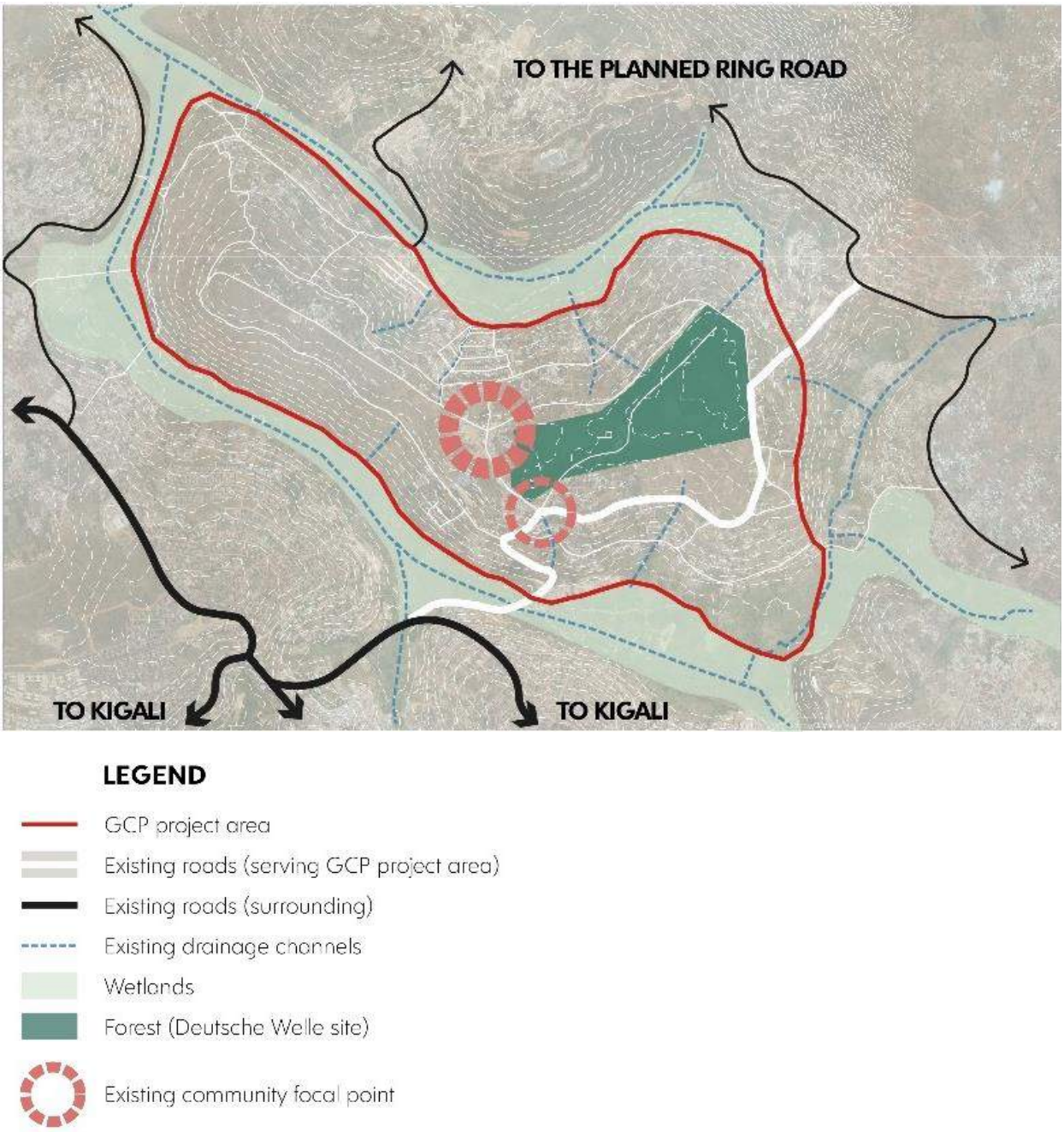

Figure 9: Existing Situation on the Site. Source: Sweco

3.2 International Standards and Lessons Learnt

The 2030 Agenda For Sustainable Development published by the United Nations forms a global development framework and plan of action for a sustainable future for the planet. The 2030 Agenda is anchored around 17 Sustainable Development Goals (SDGs) with SDG 11 focusing on cities and human settlements.[10] In addition, The

[10] UN-Habitat (2018), SDG 11 Synthesis Report

New Urban Agenda is the framework of the United Nations that lays out how cities should be planned and managed to best promote sustainable urbanization.

The New Urban Agenda

Draws upon previous lessons learnt and promotes various actions including redressing the way we plan and finance cities and human settlements. This includes utilising the input of multiple levels of government, local communities and relevant stakeholders in a transparent and accountable manner. Additionally, a sustainable, people-centric and integrated approach to urban development places a central role in the agenda.[11] The GCK's project vision is in line with SDG11 and it follows the general approach of interlinking the economic, social and environmental dimensions of sustainable development.

3.3 GCK Community Structure

The following figures have been generated through a spatial planning exercise which aims to identify the carrying capacity of the site as a basis for the Feasibility Study. What follows constitutes a brief summary and is further detailed in the Urban Design Handbook which accompanies this report.

Developable Areas

The Gross Residential Development Area (GRDA) is defined as those parts of the overall GCK study area that remain after discounting: i) the areas that are unsuitable for development ii) the areas that are allocated for non-residential clusters.

The table below summarises all the areas that are discounted from the overall GCK study area to arrive at a Gross Residential Development Area (GRDA).

Overall GCK study area	600 ha
Areas unsuitable for development	220 ha
Proposed employment cluster	10 ha
Urban centre park(s)	7.5 ha
Gross Resi. Development Area (GRDA)	362.5 ha

Table 6: Gross Residential Development Area calculation

Net Residential Developable Areas

The Net Residential Development Area (NRDA) is defined by reductions from and additions to the Gross Residential Development Area (GRDA) to allow for public rights of way and other special conditions on the site. The table below summarises the NRDA including customized calculations to account for densification of the informal settlements and key commercial areas.

Gross Residential Development Area	362.5 ha
Less inefficiency factor for informal settlements	84 ha
Plus densification factor for Sub Urban Centre	30 ha
Sub total GRDA	308.5 ha
Of which…	
Highways & footpaths	16%
Sustainable transport routes	1%
Green & blue network	13%
Net Residential Development Area	70%
Final Net Residential Development (NRDA)	216 ha

Table 7: Final Net Residential Development

[11] United Nations (2016), GA Resolution 71/256. New Urban Agenda

Populations, Densities and Housing Types

The table below shows the breakdown of housing types distributed across the 216 ha Net Residential Development Area (NRDA), followed by the projected population.

Typology		Parameters					Population	
Unit type	Building type	Typ. area (sqm)	Typ. FAR	Density category	Pers / Household*	Units/ha (gross)	% mix	Population
Basic standard	Apts	45	1.75	High	4.15	210	5	8 066
Basic standard	Houses	45	0.5	Low	4.15	78	5	5 969
Affordable 1BR	Apts	45	1.75	High	4.15	160	23.3	42 868
Affordable 2BR	Apts	60	1.4	Med	4.15	115	23.3	34 503
Affordable 3BR	Apts / rowhouses	80	1.2	Med	4.15	80	23.3	26 139
Market Villas	Villas	123	1	Low	4.15	50	10	12 609
							Total Population (NDA)	130 154

Table 8: Populations, Densities and Housing Types
**A national pers/household average rate has been applied*

If expandable micro-unit housing is considered to meet the affordability levels of lower income households who do have the potential to enter the housing market (explained in more detail in the following chapter), the following may apply:

Typology		Parameters				
Unit type	Building type	Typ. area (sqm)	Typ. FAR	Density category	Pers / Household*	Units/ha (gross)
Affordable 1BR	Apts	30	1.75	High	4.15	210
Affordable 2BR	Apts	45	1.75	High	4.15	160

Table 9: Populations, Densities and Housing Types: Affordability

In addition, it is assumed there is an estimated existing and near future development population that must be included in the calculations to provide an accurate overview of the expected final population. The table below summarises these factors:

Existing / planned housing area	No. Units	Household size [(2)]	Population
Cactus project	349	4.3	1 500
Dubai site west	110 (estimated)*	4.3	473
Central site	150 (estimated)*	4.3	645
Informal settlements	8400 (estimated)#	4.3	36 120
Total population within the NDA (see above)			130 154
Total population within the overall GCK study area			168 892

Table 10: Planned future development population

* Formal development data is unavailable. Consequently, counts have been made using satellite imagery.
# Calculation based on total area of informal settlements by 50 dwellings per ha.

3.4 Community Facilities

The 2019 Interim Kigali Masterplan provides guidelines for the provision of community facilities in residential areas. The Masterplan proposes a hierarchy of social infrastructure with population catchments as trigger points for the provision of certain services. They are:

National	3.8m people
District	1.2m people
Precinct	120 000 people
Neighbourhood	20 000 people

The projected population therefore constitutes one Precinct and around 6-7 neighbourhoods. The standards set for provision of community facilities are show below.

TYPE	PUBLIC FACILITIES	PORPOSED FOR KIGALI
COMMERCIAL	Neighborhood Centre	1 per neighborhood; 1.2 ha site.
	Town Centre	1 per precinct; 12.0 ha site.
	Regional Centre	1 per 0.5 million, 50 ha site.
EDUCATIONAL FACILITIES	Primary School	1 per neighborhood (15,000-20000 population). 1.5 ha site.
	Secondary School	1 per 20,000 - 25,000 population. 2.4 ha site.
	Primary + Secondary School (Combined)	2.8 ha site. (Based on existing school sites)
	Vocational / ICT Institute	1 per precinct. 5.0 ha site.
	Higher Education Institute	1 per 500,000 population. 6.0 ha site
SOCIO-CULTURAL FACILITIES	Community Hall*	1 per 5,000 population. 0.5 ha site.
	Regional Library	1 per 500,000 population. 0.5 ha site.
	Religious Facility	1 per neighborhood (15,000- 20000 population). 0.5 ha site.
	Cemeteries	1 per precinct 20 ha over 20 years
	Museums/ Cultural Centre etc.	1 per precinct. 1.5 ha site.
HEALTH FACILITES	Health Clinic *	1 per neighborhood (15,000-20000 population). 0.5 ha site.
	Polyclinic	1 per precinct. 5.0 ha site. Max travel time of 30 mins.
	Regional Hospital	1 per 500,000 population. 5.0 ha site
PARKS & OPEN SPACES	Neighborhood Park	1 per neighborhood (15,000-20000 population). 1.0 ha site
	Town Park	1 per precinct. 6.0 ha site
	Sports Field	1 per precinct. 1.5 ha site. (Near to schools or community centres or combine with parks.)
SPORTS & RECREATION	Sports Centre (with swimming pool and stadium)	1 for every 500,000 population. 6.0 ha site.
CIVIC FACILITIES	Fire Station	5 minutes response time. 0.5 ha site.
	Government/ Municipal Offices	1 Sector office per Sector. 1 District office per District.
*(as part of neighborhood centre)		

Figure 10: Source: City of Kigali Masterplan 2019

Further details of the carrying capacity and approach to creating a liveable community in GCK are contained in the Urban Design Handbook which accompanies this report.

4.0 HOUSING & BUILDINGS

Work undertaken regarding the housing and building technology sector comprises two primary sections; a study of the existing housing situation in Kigali and proposals for new housing for Kinyinya Hill. The existing housing situation is broken down into two areas; (i) an analysis of existing policy and regulation as it regards affordable housing at the project site, and (ii) a study of the predominant housing typology found within Kigali. The proposal for new housing is prefaced by an examination of the parameters influencing the proposal of new housing forms. This is then followed by the proposal of relevant new housing typologies at the block, building and unit level.

4.1 Existing situation for housing

As noted in previous sections of this report, Kigali faces a number of challenges regarding housing provision:

- A rapidly urbanizing city, with around 80% living in informal settlements.
- Problems with housing supply and affordability means a failure to deliver housing for the majority.
- Government drive toward sustainable development and urban excellence.
- Development must make use of the nation's existing natural resources for building over those imported from overseas.
- Current urban sprawl threatens the environment, food security and urban liveability.
- Measures are being introduced to promote densification of the city based around key growth poles - of which GCK is one.

The preference amongst the residents of Kigali however is for single-family homes which retain high levels of privacy and the opportunity for future expansion for the tenant. This trend cuts across economic lines from rich to poor.

4.2 Proposed housing typologies

Factors driving the need for a change from existing housing types include: climate change, density, affordability, accessibility, safety and security, sustainability and community. Prior to the development of any new typology, future housing grades (*level of quality*) for Kinyinya Hill have been identified. These are as follows: economic grade, intermediate grade, upper intermediate grade and premium grade.

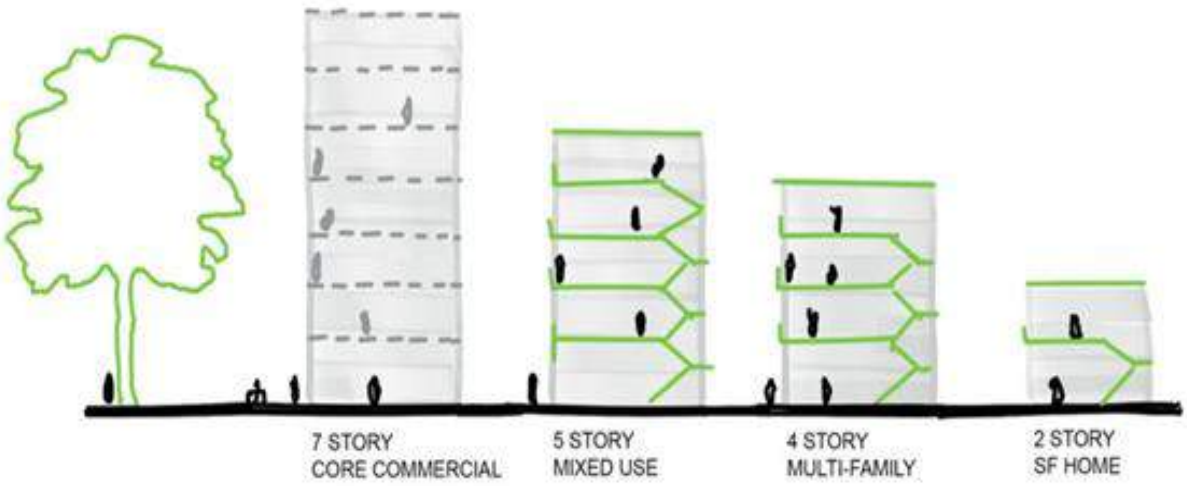

Figure 11: Human to building height scale and experience

Housing and site parameters that require examination prior to the determination of future housing typologies for Kinyinya Hill are; site planning criteria, area densities, building heights, building materials, cost, social and cultural factors (including a priority for privacy and defensibility aspects), and environmental design requirements. A detailed examination of these factors produces the necessary outputs required for the creation of a proposed future typology for Kinyinya Hill at the block, building and unit level.

4.3 Proposal housing typologies at the block level[12]

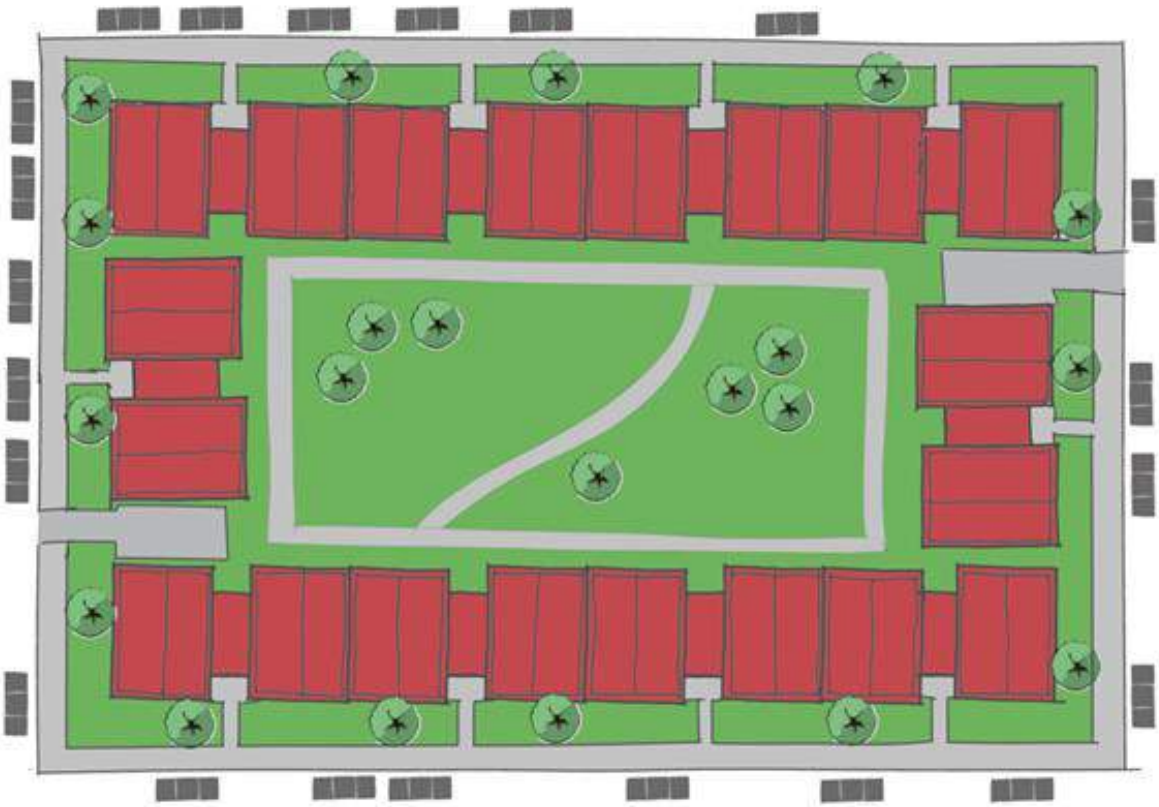

Figure 12: The Community Block

The following guidelines are considered

Community Courtyard (Igikari)

The proposed block design focuses on the need for shared private space in multi-family residential development. It is recommended that each block be based around a common community courtyard or semi-public space, allowing for shared services and promoting a sense of privacy for residents. Privacy has been repeatedly identified in research, community engagement and stakeholder interviews as a fundamental requirement in any successful future housing in Kigali. The idea of the shared courtyard is based on the Rwandan Ikigari, or central shared space found in a typical Rwandan residence. At major street fronts, a unified edge may be considered with ground floor commercial activity activating the streetscape.

Street Front

At major street fronts, a unified street edge could be considered with commercial activity activating the streetscape. At quiet residential streets, setbacks should be considered to provide for privacy for units facing the street edge.

12 A block plan shows the siting of buildings as blocks laid out on maps of the surrounding area.

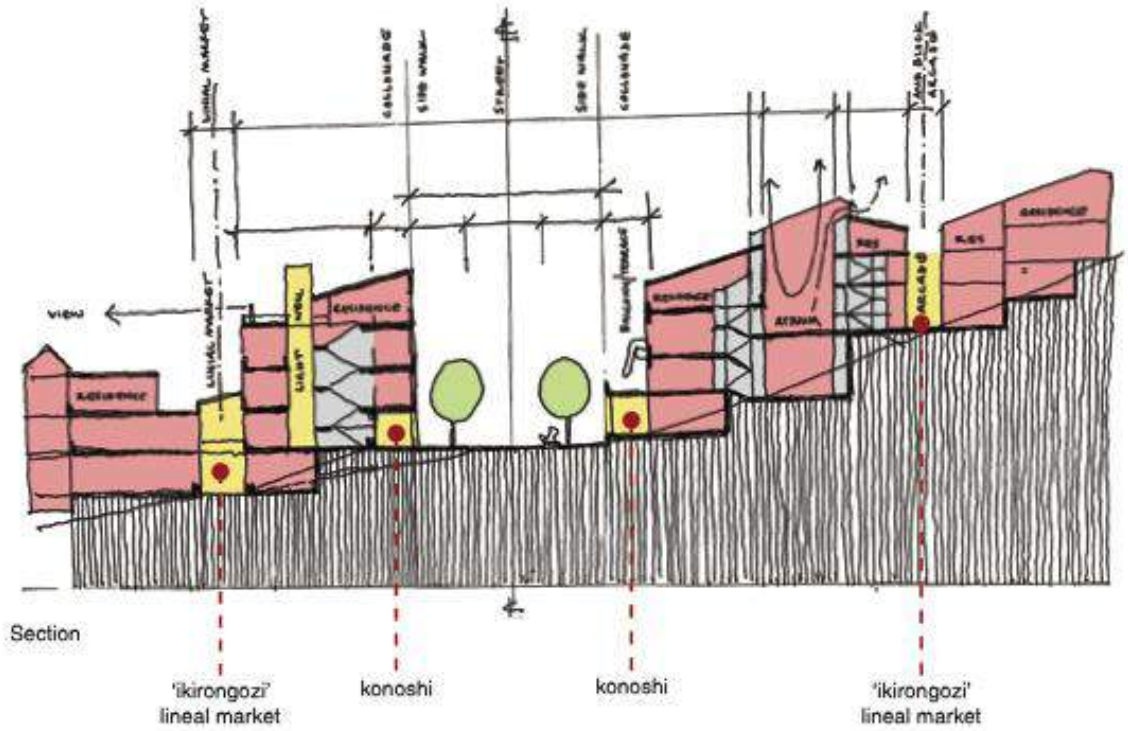

Figure 13: The use of covered collonades or kronishi in Kigali streetscapes (src: Peter Rich)

The following Block Typologies are proposed

Proposed Block Typologies		
Family type	Typology	Slope
Multi-family	Orthogonal	Decreased grade
	Slope aligned	Increased grade
	Linear aligned	High slope
Single-family	Orthogonal row housing	Decreased grade
	Slope aligned row housing	Increased grade
	Linear aligned row housing	
	Orthogonal semi and fully detached housing	
	Slope aligned semi and fully detached housing	
	One sided street	

<u>Proposal housing typologies at building level</u>

Rwanda is a culture used to living in single family homes, whether these are formal or informal. Multi-story multi-family residential living is a new concept in the country and would require an adjustment in attitude towards it and away from traditional ways of living. Kigali is a city where housing is expensive and financially out of reach of most residents. As compared to GNI per capita, Rwanda has the most expensive housing in Sub-Saharan Africa. The following guidelines could be considered in the design of appropriate buildings:

v. Affordability
vi. Privacy
vii. Environmental Design Considerations
viii. Konoshi[13]

[13] Rich, P., Inclusion of Traditional Rwandan Cultural Characteristics into the Built Environment

The following Housing Typologies are proposed:

Proposed Housing Typologies		
Number of Floors	Housing Type	Usage
4-Story (G+3)	Multifamily Residential	Residential
4-Story (G+3)	Mixed Use	Commercial and residential
5-Story (G+4)	Mixed Use	Commercial and residential
2-Story (G+1)	Single family residential	Row House residential
2-Story (G+1)	Single family residential	Duplex residential
2-Story (G+1)	Single family residential	Villa residential
4-Story (G+3)	Mixed Use	Commercial and residential
5-Story (G+4)	Mixed Use	Commercial and residential
2-Story (G+1)	Single family residential	Row House residential

Table 11: Proposed Housing Typologies

Proposal housing typologies at unit level

Unit designs are influenced by several factors which include:

vi. Maximizing cost efficiency and space utilization.

vii. Upgradeability and adaptability of the units.

viii. Provision of good airflow and natural daylighting to reduce external energy use.

ix. Privacy and security.

The transition from single family home living to higher density multi-family habitation.

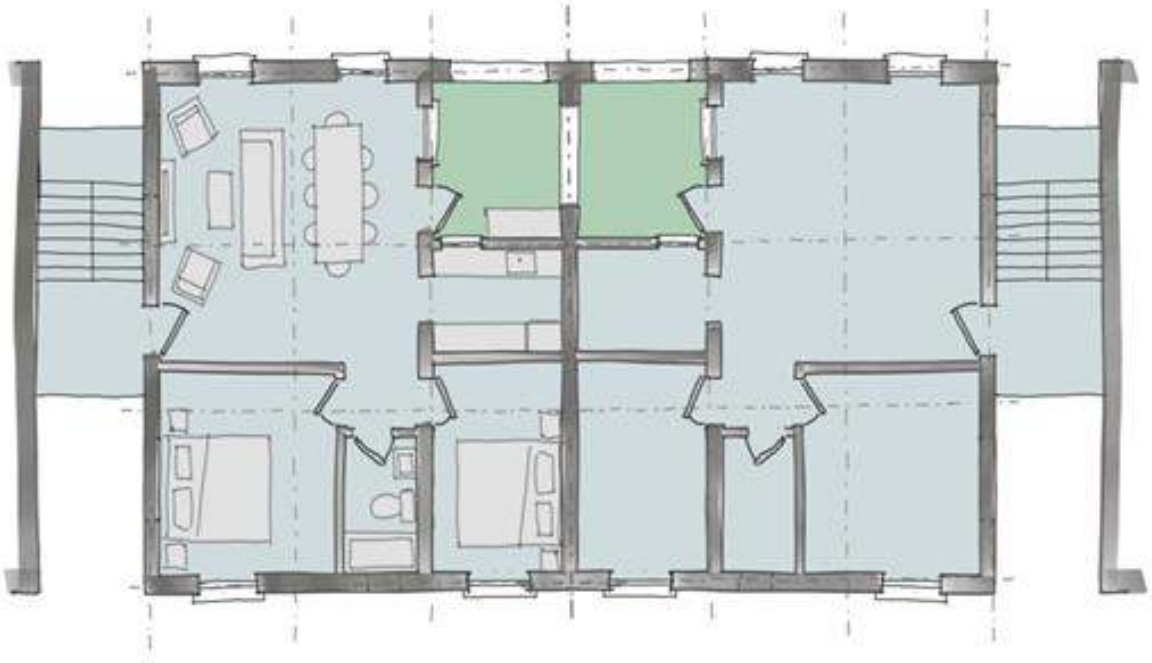

Figure 14: Efficient unit layouts for affordability

Efficient unit typologies based around a common structural grid and employing strong environmental design fundamentals, thereby reducing life cycle costs, can provide the basis for affordable and sustainable housing units at Kinynya Hill.

The following Unit Typologies are proposed:

Proposed Unit Typologies		
	Type	Size
1	Apartment Units:	
1.1	1 BD unit (social housing)	45 m2
1.2	1 BD expandable microunit (affordable housing)*	30 m2
1.3	2 BD expandable microunit (affordable housing)*	45 m2
1.4	1 BD unit (affordable housing)	45 m2
1.5	2 BD unit (affordable housing)	60 m2
1.6	3 BD unit (affordable housing)	80 m2
2	Single Family Housing Units:	
2.1	2-Story (G+1) – Single family residential – Row House	100 m2
2.2	2-Story (G+1) – Single family residential – Duplex	120 m2
2.3	2-Story (G+1) – Single family residential – Villa	150 m2

Table 12: Proposed Unit Typologies
*(*note - this typology is theoretical at this point and has not yet been verified, so is not used as a basis for costing)*

4.4 Mechanical engineering integration in buildings

The proposed housing design strategy follows passive design principles informed by the climatic opportunities in Kigali and local procurement principles. Servicing strategies are informed by climatic resources and use of appropriate technology combined with highly-progressive thinking around district-level infrastructural opportunities created by optimising density. The sketch below indicates how some of the visible elements are integrated into the housing design.

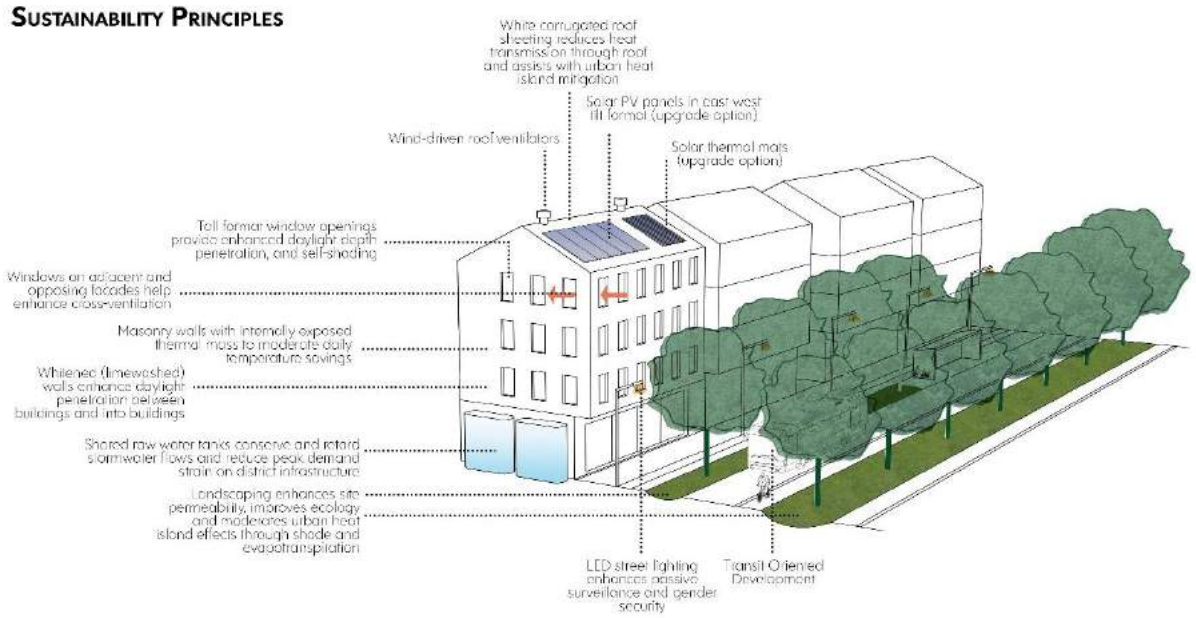

Figure 15: Sustainable solutions integrated on buildings

One of the biggest costs in district utility infrastructure (both water, gas and electricity) is providing the infrastructure capacity to meet relatively brief and/or infrequent periods of peak demand, which are often an order of magnitude higher than average demand rates. Slashing utility infrastructure costs provides a largely untapped opportunity to significantly reduce development costs that translate into high purchase price of serviced land. Realizing these savings requires behavioural change. This is achieved through imposition of peak-demand limiting at the dwelling and/or multi-dwelling level. The simplest technical solution is to limit each dwelling to a peak current linked to the size of the dwelling (e.g. 10A) via a circuit breaker at the distribution board. When simultaneous household energy

consumption rises to a level that this becomes a frustration the householders become motivated to adapt their patterns or scale of simultaneous use to suit the prevailing cap.

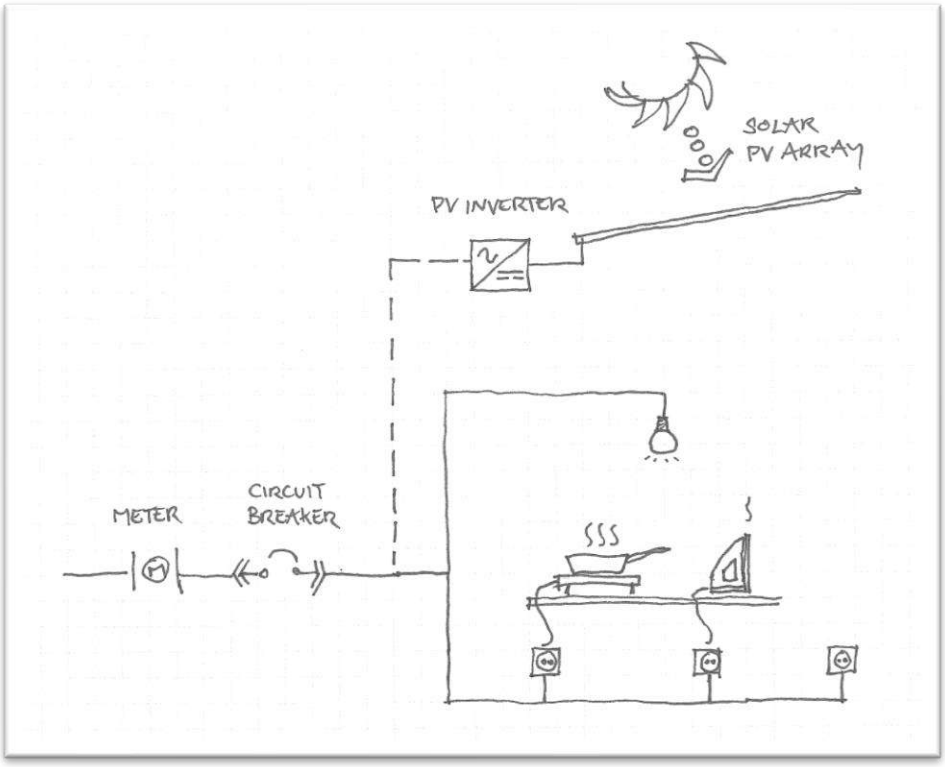

Figure 16: Illustration of peak demand limitation to reduce infrastructure cost

This may mean households are motivated to stagger high-demand activities such as using a hob, kettle or an iron or hob together. After some years as their affluence increases, they may be able to own more household appliances, or even install a small air-conditioning unit. To operate these successfully they may need to install rooftop PV modules to supplement power to the home-side of the 10A breaker. A storage battery may also be a viable option, particularly as costs fall exponentially. Energy storage is analogous to potable water tank provision in the context of reducing stress on district supply infrastructure.

Through such design and governance interventions the infrastructure provider may safely engineer-out expensive overprovision. This provides significant savings not only in copper cable capacity, but also in substation capacities and even in centralised district PV generation and storage, which may be community owned and located on large rooftops of commercial, retail and light-industrial hubs.

These solutions do not represent business as usual in the local housing sector e.g. high floor to ceiling heights would be considered much more generous that conventional. On the other hand, constrained peak water and electrical flow would be otherwise considered prohibitive if not well-balanced by the package of measures that allow high-levels of comfort amenity without incurring high hidden cost burdens such as conventionally-designed power and hydraulic infrastructure, and car-centric roadway and parking provision etc.

The base design offer suggested here promotes a relatively high standard of health and well-being with minimised upkeep costs. Upgrade options are facilitated once household prosperity allows. These include overcoming peak-power demand limitations through incorporation of rooftop solar PV systems, enhanced hot water generation, trellising for greening of facades etc.

Design thinking also anticipates rapid transformation of the solar PV sector in Rwanda over the coming decade in line with cost and scale transformations already being witnessed beyond Africa, and the global trend away from fossil-

fuel dependency in buildings and transport. At a practical level this informs design considerations around cooking fuels and alternative electrical technologies.

Several of the strategies proposed may be considered bold in isolation. It is however vital that the collective appetite to create a paradigm shift is maintained. If vision and courage become diluted over time by selectively removing key differentiating initiatives this may risk failing to meet funding criteria but more significantly condemn this project opportunity to mere incremental change. The unique cross-disciplinary benefits that can only flow from transformational step-change would then remain as unrealised potential.

4.5 Building technology and material

Work undertaken comprise four primary sections: (i) An assessment of Rwanda's construction industry. (ii)The construction materials and technologies currently used in country. (iii) Potential future materials and technologies that could be used in country. (iv) A future expansion plan of the green materials industry in country (specifically wood and brick). The full report on building technology and material is an annex to this report, while the below section is focused on the key take-aways from the study.

Assessment of Rwanda's construction industry and materials currently used.

Kigali is a city that has doubled in size in little more than ten years. This very high rate of growth is projected to continue and will require the construction of over 700,000 formal homes over the next 15 years. A major part of the green agenda for sustainable urbanization is the promotion of the use of local and green materials in the construction of new housing. The idea is that not only would this promote environmental sustainability, but also help reduce costs in a city with extremely high housing costs.

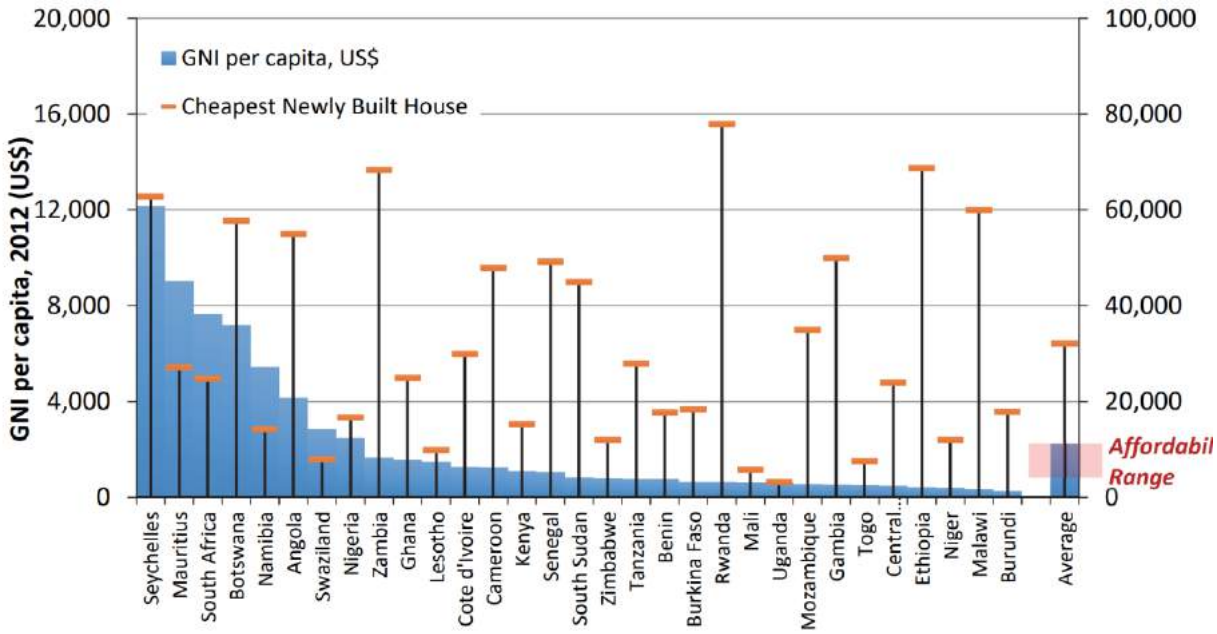

Figure 17: Income to house prices in SSA (SRC: cafh 2013)

Rwanda's construction industry has played a major part in the country's rapid economic development over the past 15 years. The sector currently contributes over 7% to the nation's GDP and is the fastest growing sector in the economy. However, Rwanda is quite remote and located far from any major seaport. The result is that imported materials must be carried via truck, increasing the embodied energy in the materials and adding to costs which is passed on to buyers. This helps to explain why Rwanda's housing costs are the highest in Africa in comparison to GNI per capita. For Kigali to be able to provide affordable and sustainable housing to its residents going forward it is essential that a domestic, low carbon, and low-cost alternative be found for the construction of housing.

Materials use in the production of housing generally depends upon the economic situation of the dwelling's inhabitants. Building materials used are one of the factors most affecting the cost of home construction. Those in the lower economic strata generally use earth-based materials such as sun-baked adobe block with earthen floors and low-cost metal roofing materials. The use of fired brick with screed flooring and higher quality roofing products is common for middle income earners, while high end and newer formal housing often adopts the use of concrete and higher quality finish products.

While there has been progress in recent years, the domestic sustainable construction materials industry in Rwanda is relatively nascent. The government has introduced various policies and incentives to promote the development of a home-grown materials industry, but there is a long way to go before the country can provide substantial quantities of materials for itself.

Potential future materials and technologies that could be used in country

However, there are substantial quantities of natural resource reserves that could potentially be exploited to satisfy the demand for building materials in country. Clay is a resource of which Rwanda has abundant reserves. It is estimated that Nyarungenge district alone has over 700,000 m3 of clay deposits. There has been some promising work done in the past several years in the development of building materials systems that can take advantage of these reserves, resulting in a prototype brickmaking method that utilizes Rwanda's clay to make brick and blocks using sustainable and low energy inputs.

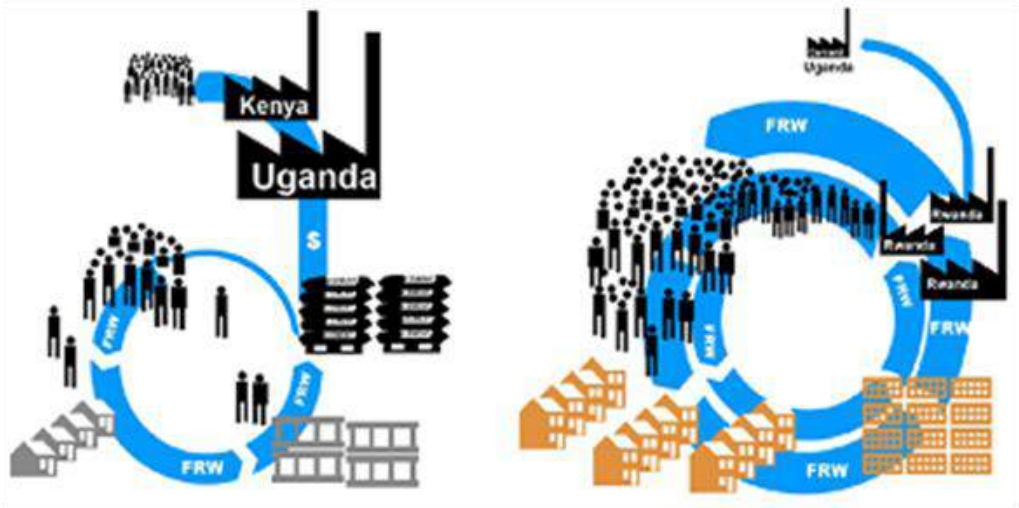

Figure 18: Potential for the use of brick in Rwanda

In addition, Rwanda's wood reserves have grown substantially in recent years and with the right effort and investment could one day provide building resources for construction. While sustainably produced brick has the most potential it is currently not available on the market in the quantities needed to feed the current demand of the housing industry. A new Autoclave Aerated Concrete production plant is due to come online later in 2019 producing large quantities of the material that could be used in lieu of brick. In addition, fast growing timber and bamboo are potential future candidates for a home-grown building materials industry providing self-sufficiency in the housing construction market. It is only through dedicated investment into domestic green materials production that an industry capable of satisfying the high domestic demand for building materials in Kigali and Rwanda overall can emerge. The following interventions to promote the production and supply to market could be made in order to kick start the development of a low cost and sustainable domestic building materials industry

Figure 19: Bamboo in building construction

Recommendation

The establishment of six low-carbon clay-based materials production facilities be supported to pilot the mass production of semi-industrial brick, planfill and maxpan unit. The creation of three small scale glue laminated (glulam) timber factories producing roof and floor beams from domestically available small timber. R&D for the expansion of domestically available low carbon and environmentally friendly fuel sources.

5.0 SUSTAINABLE INFRASTRUCTURE

5.1 GCK approach to infrastructure development

Sustainability with its social, economic and environmental aspects has been the leading design parameter for this study. Unlike so often where sustainability is separated out to be considered and assessed on its own, this project integrates it into each aspect of the development. This provides far more benefits over and above a tick box of 'sustainability features'. It offers the potential to deliver sustainable solutions that cost no more than business-as-usual benchmarks. Hence the aim, for example, is to capture the benefit of less electrical infrastructure capacity and its reduced capital cost if it is serving extra-low energy demand efficient buildings.

The figure below summarises the constructed sustainable infrastructure model. Synergies between the constructed infrastructure elements themselves with support from ecosystem services, urban liveability and passive buildings ensures the maximum efficiency of the model to achieve these added benefits. Resource modelling at the heart of the model enables continual monitoring of performance.

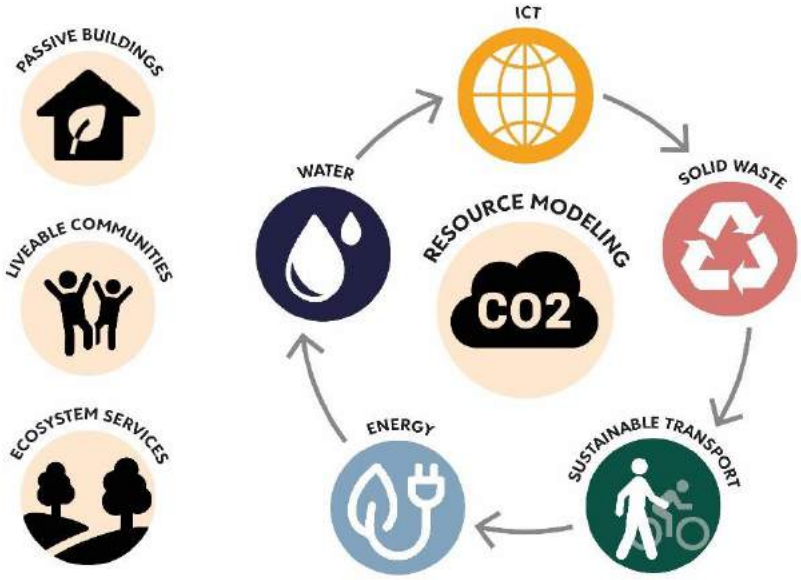

Figure 20: Resource modelling is a critical factor in ensuring the added value of the constructed integrated sustainable infrastructure model

The development at Kinyinya Hill is of course strongly connected to the Rwandan and wider global context to reduce environmental impact and constrain GHG emissions. To limit the average global 'temperature increase' to 1.5º C, as the target stands in the Paris Agreement (UNFCCC), that Rwanda ratified in 2016, bold action is needed. The Rwanda Nationally Determined Contribution (NDC) as part of the Paris Agreement including aspects on water and other resource impact aspects. This Feasibility Study has taken this as the point of departure when developing the suggested infrastructure solutions. While also addressing the strong need to plan for future impacts of climate change, the rapidly increasing urban population and the need to improve quality of life, health and wellbeing standards.

The approach includes harnessing nature (ecosystem services) to provide an affordable and low footprint ecological infrastructure that provides ecosystem services. In this regard the green & blue network is seen as a crucial part of the infrastructure provision. These are often enhanced through interventions which target specific synergies and thus offer more in return - such as using constructed wetlands which enhance biodiversity and landscape amenity whilst also being a practical and low impact, low cost solution to water filtration and management.

In contrast the resource intensive model developed by the Western economies has proved to be unsound given it would need some three planets of resources to deliver this universally worldwide. Increasing competition for finite resources and the increasing buying power of emerging nations means the West is having to fundamentally rethink. Hence for example, targets for zero-carbon developments and trajectories to zero-carbon for whole nations. Rwanda

has the opportunity to avoid following the Western model and instead aim to leapfrog the resource excesses of the West while delivering on its lifestyle aspirations and coping with anticipated the climate change impacts.

The GCK now offers the unique opportunity to become an exemplar of sustainability for Rwanda and the wider region, showing a pragmatic, cost effective and deliverable starting point and future trajectory for addressing the following issues.

i. Each technical, economic and social project strand has been considered alongside each other to identify common themes, overlaps and synergies

ii. Harnessing the extensive experience of team members, optimum solutions are proposed that specifically satisfy multiple strand objectives, instead of being simply optimised within the individual strands

As an example, the recommendation of walkability and a human scale to the new urban development is coupled with needing less car use and hence less road area, freeing up more development land for providing more homes and increased capital revenue potential. Added synergies include improved air quality, reduced energy use, reduced urban heat island and climate change effects.

iii. It is then important to quantify these cross-strand benefits, otherwise during construction implementation these multiple benefits can be very easily lost

Hence, the extra area of developable land made available by having less road area and the number of extra homes it delivers need quantifying to help ensure that any subsequent construction stage reversion to conventional road areas has strong quantified counter arguments for the retention of the original design intent.

Below will follow a deeper explanation of the infrastructure considerations and suggested solutions that have been the basis of this assessment.

5.2 Water and Sanitation

Regulatory Framework

The National Policy and Strategy for Water Supply and Sanitation Services (February 2010) has set as objectives for the year 2020 the following infrastructure goals:

i. Water supply coverage of 100 %

ii. Sanitation coverage of 100 %

iii. Stormwater management in order to reduce damage risks and to make use of the rainfall as water supply resources

iv. To provide off-site services (sewerage, sludge collection, treatment, etc.) for density populated areas

v. To establish Public Private Partnerships (PPP), especially in rural areas

Where it is necessary, collective services should substitute individual services to achieve an efficient infrastructure. Innovative management, as for example decentralized measures, are encouraged. To meet the demand for water supply and wastewater treatment, the service costs are to be covered by user fees. Sanitation masterplans are to be created for every region in Rwanda.

A need to integrate water sanitation with other disciplines

To achieve a sustainable water infrastructure, some aspects must be coordinated with other disciplines. The components of the proposed water concept, that has been the basis for this assessment, and its interconnections can be seen in the following figure.

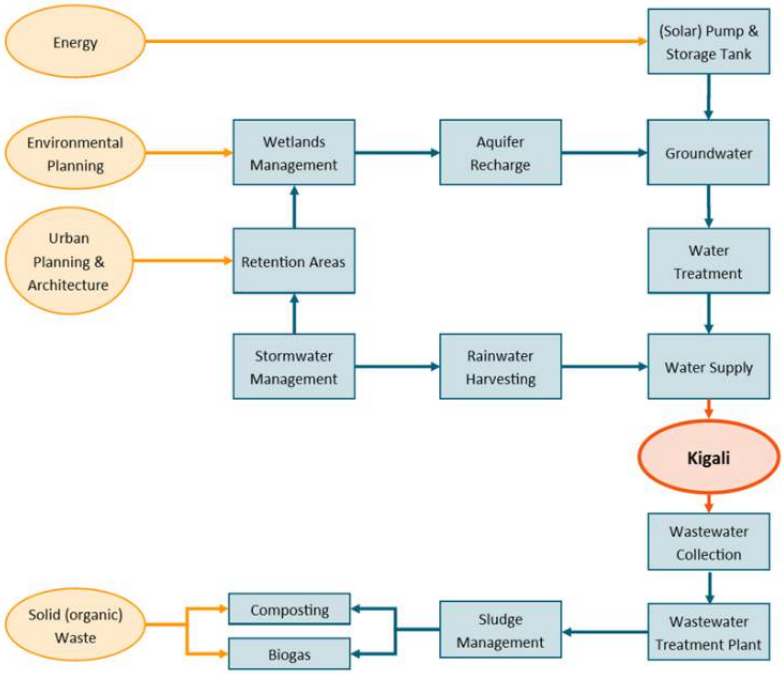

Figure 21: Overview of proposed water and sanitation system

Water supply

Buildings have access to tap water supply. Drinking water must be bought from semi-central potable water stations. The water sources are groundwater and rainwater harvesting.

Groundwater

Groundwater is extracted with semi-central pumps, which are located at strategic points for efficient distribution considering the total dynamic head. It is necessary to consider the groundwater table fluctuation and to install the pump at an adequate depth. The depth to groundwater on the site is 0 – 25 m It is necessary to analyse and measure the aquifer systems to determinate where to install the boreholes and where to build the recharge areas. Greater reservoirs can be built at certain height on strategic areas of the Hill to supply the tap water by gravity. The tank can be filled up during the day using solar energy.

COSTS: at least 3 USD/person + pipes and cisterns

i. Borehole drilling (depending on depth and soil conditions): 1.5 – 2.7 USD/person

ii. Pump (needed capacity of >0.7 kW for a total dynamic head of 50 m): 1430 USD/kW (price per kW capacity may decrease for bigger pumps)

iii. Solar modules: 1200 USD/kW

iv. 250 mm UPVC Pipes (supply and fix): 113 EUR/m

v. Cisterns: depend on size and materials

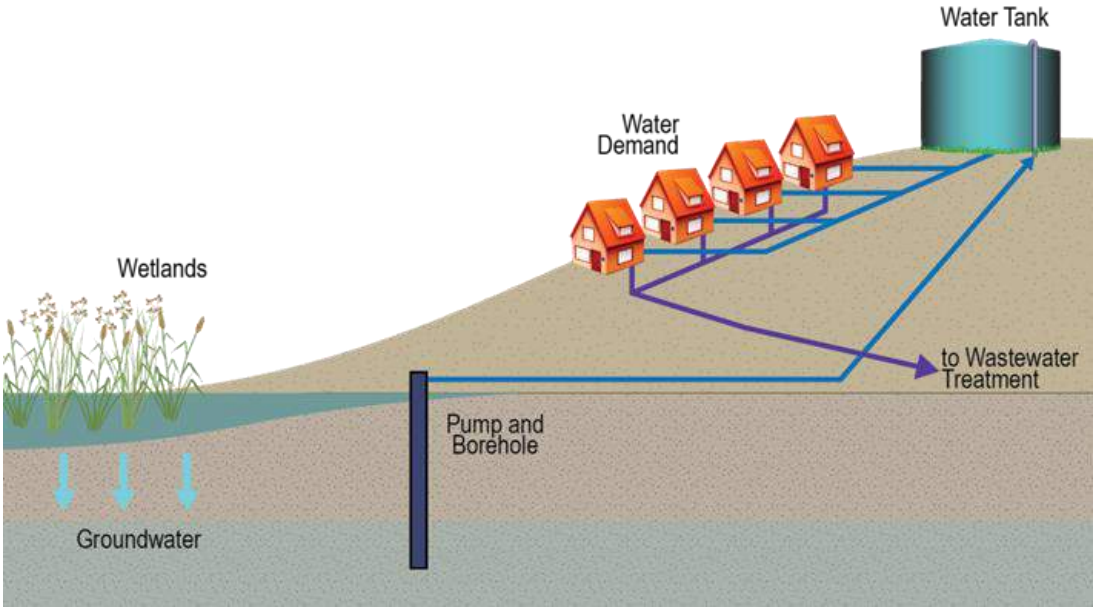

Figure 22: Groundwater system

Rainwater harvesting (RWH)

COST: RWH systems are installed in buildings, every building complex can share a cistern and redistribution system to save costs: 100 – 200 USD/building (semi-central system for 4 - 10 homes)

A rainwater harvesting system consist of

i. The building's roof or similar surfaces to catch the rainfall

ii. Gutters all around the catching area

iii. A water tank, which can be installed underground

iv. Pipelines to conduct the collected rainwater from the catchment area to the storage unit and to the consumption points

v. First flush devices to divert the first flush

Rainwater in Rwanda is generally of good quality, even in urban areas. Nevertheless, if no filters are installed, the water should not be drunk, as is may have been in contact with pollutants. The harvested rainwater can be used for toilet flushing, for washing clothes, for cleaning and for other demands that do not impact in the people's health.

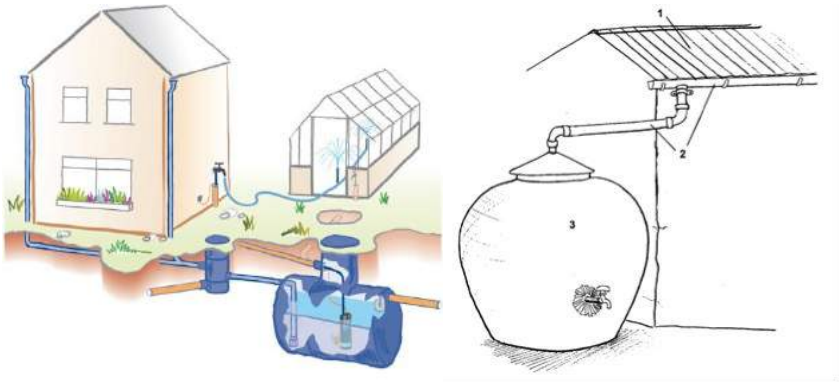

Figure 23: Rain water harvesting

Drinking water

Drinking water supply could be provided by semi-central potable water stations in reusable plastic bottles. The stations can harvest rainwater or extract groundwater and treat it properly. Treatment of drinking water can be done with: UV disinfection, or at least Solar water disinfection (SODIS). If borehole soakaways and septic tanks are used, the construction of a Water Treatment Plant may become necessary, depending on the intensity of contamination

COST: Water Treatment Plant 50-60 USD/person.

Figure 24: Potable water station

Green enhancement for water supply

Water supply enhancement to potable quality

i. Semi-central treatment stations before distribution: 1,600 USD for a capacity of 15m^3/day covering the demand of about 7,500 inhabitants

ii. Green roofs before collecting rainwater to avoid pesticides from construction materials to get in touch with the rainwater. Max. costs of 5- 10 USD/m^2

iii. To avoid contamination from particles on the roofs, it is necessary to install a system that dismisses the first rain flushed after long dry periods. These fist millimetres of rainfall (3 to 5 mm) contain the concentrated roof pollution

iv. Green enhancement features for reducing demand could include WC complex: using the grey water from sink direct for the toilet flushing[14]. Low cost option: about 20 USD/unit

v. New buildings should be designed with a dual distribution system, where grey and black water is separated. Grey water can then be reused in the building, in industry nearby or to water green areas. About 20 USD/dwelling. Awareness is also key, Educating the population to conserve water, even if they are not paying (a lot) for it

[14] Efficient plumbing fixtures to reduce the use of potable water are mandatory for commercial buildings under the green building minimum compliance system (indicators 2.2 and 2.3)

Figure 25: System to avoid contamination of particles

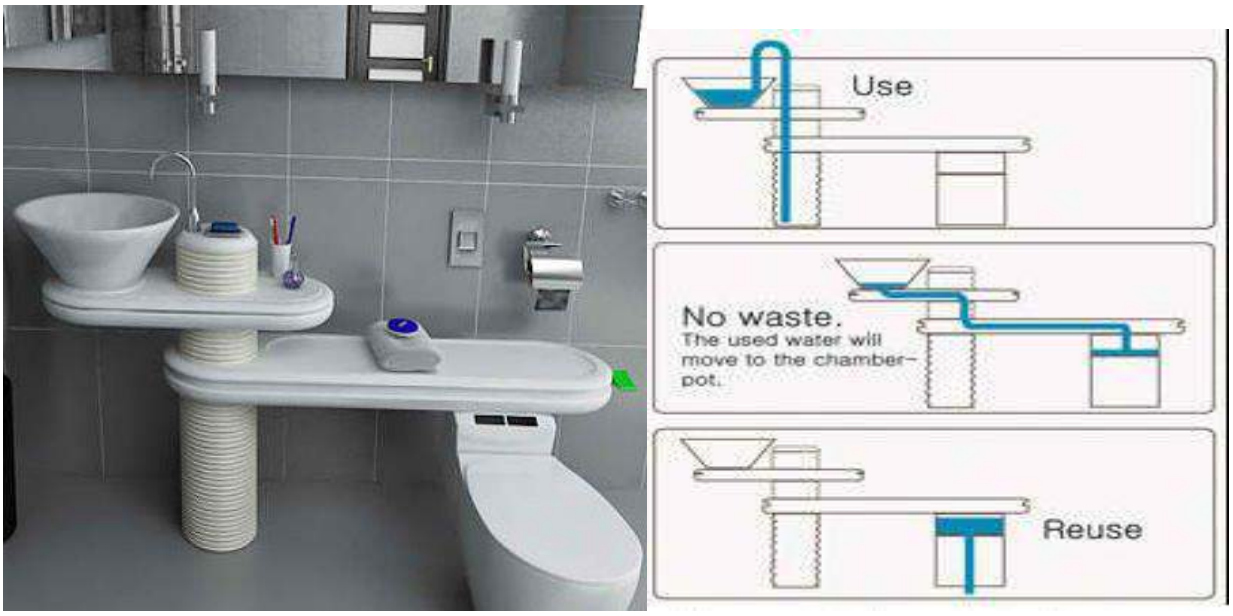

Figure 26: Example of separated grey and black water system

Green enhancement feature for improving water supply delivery efficiency

Establish drinking water distribution system per individuals and/or trucks (in reusable plastic bottles), two to four times a week, this would also create jobs. The other option would be to connect to the Kigali Water Supply Network.

Figure 27: Water bottle delivery truck, Kigali

Waste water and Sewage

The business as usual solution would be shallow borehole soakaways following septic tanks. Due to the potential negative effects on the groundwater quality, this solution is not recommended for implementation. However, the costs for this baseline scenarios are estimated for comparison.

COST of business-as-usual scenario:

i. Investment costs for borehole soakaway and septic tank: USD 90–375 (including labour and materials), depending on the size of the facility.

ii. O&M costs will be incurred for e.g. water, emptying septic tank, etc.

Proposed are, centralized or semi-centralized wastewater treatment plants with constructed wetland for tertiary treatment; distribution achieved mainly using gravity. Constructed wetland as a tertiary treatment after the wastewater treatment plant and before discharging into the (protected) natural wetlands or into the infiltration areas to recharge the aquifers. Depending on the level of treatment, the treated wastewater can be used for irrigation in nearby areas. The estimated cost for installation is 127 EUR/person.

COST of green scenario:

i. Wastewater separated from rainwater systems.

ii. (Semi-)central wastewater treatment plant in the industrial area.

iii. Screens, grids and fat removal as primary treatment

iv. EUR 3.9 mio per capacity ton BOD5 removed/day; 35 g BOD5/day/capita; removal from 700 to 50 mg BOD5/l (Kisumu 2016)

v. Sewage pipe lines (Kisumu 2016).
250 mm UPVC Pipes, supply and fix (113 EUR/m)
300 mm UPVC Pipes, supply and fix (157 EUR/m)
450 mm UPVC Pipes, supply and fix (217 EUR/m)

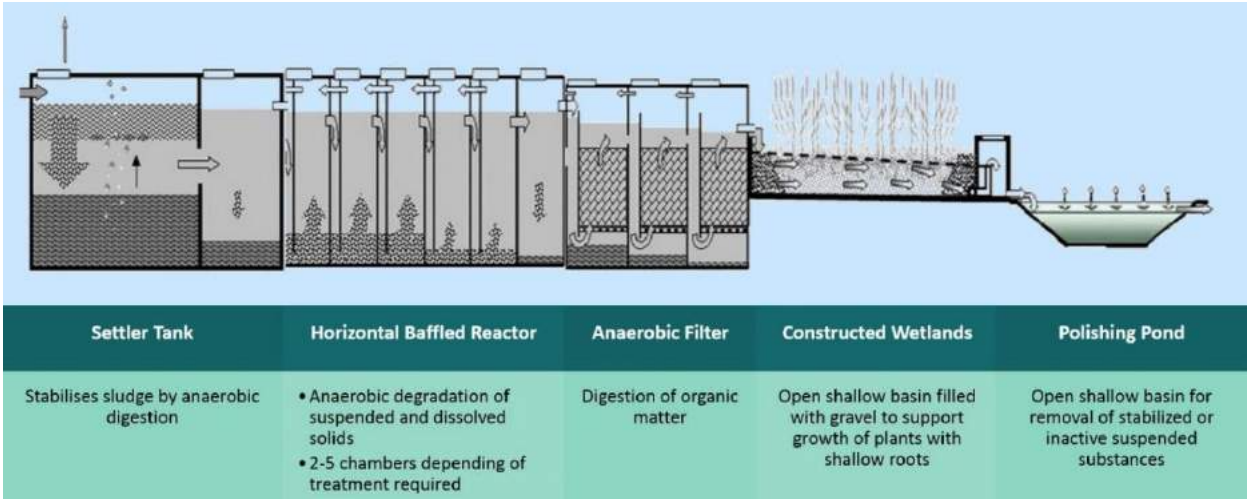

Figure 28: Example of constructed wetland with infiltration

Green enhancement for waste water and sewage

Obligatory pre-treatment for wastewater from industries with different contaminants, before entering the public WWTP[15]. This will reduce the capacity needs of the public WWTP and thus the cost for the household users; the industries will have to reduce the kind and quantity of their contaminants or to pay for their treatment. Constructed wetlands for settlements far away from the sewage pipe network, where they have enough space.

Valorisation *of Sludge*

i. Install a biogas reactor to dispose the sludge from the WWTP to be mixed and improved with other biological waste; generation of jobs and revenues though fuel sales

ii. Create composting out of the sludge form WWTP; generation of jobs and revenues though compost sales

iii. Faecal sludge treatment plant (Kigali 2016); EUR 1.6 million per capacity of ton BOD5 removed/day

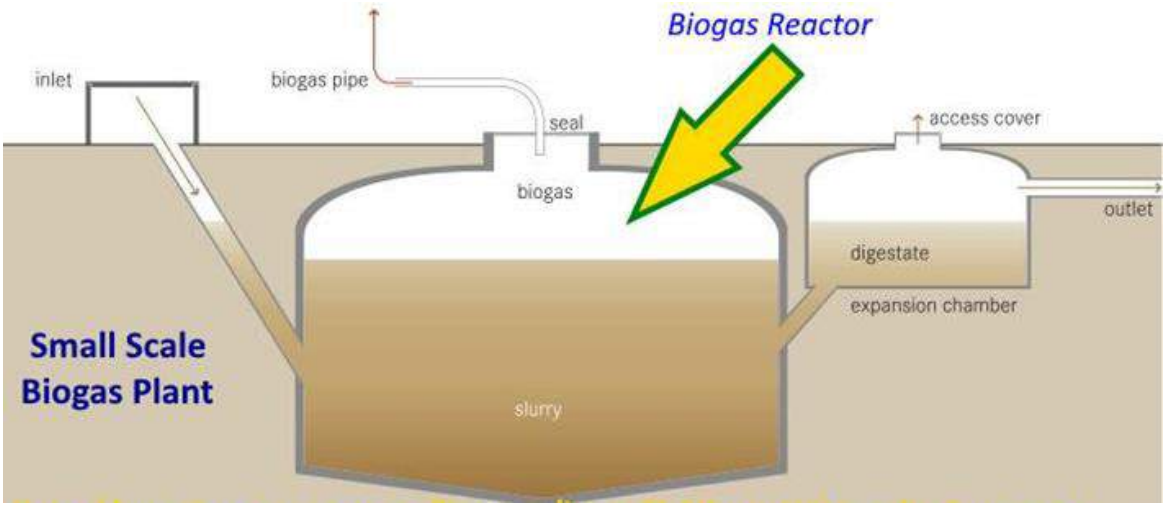

Figure 29: Example small scale biogas plant

[15] Waste water treatment is mandatory for commercial buildings under the Green Building Minimum Compliance System (indicator 2.4).

Wetlands wastewater & sewage

This aspect is not included in the baseline design but suggested as green enhancement only. Constructed wetlands (CW) should also be included as a baseline because this low-tech & low-cost technology improves the quality of rainwater and from WWTP effluent. Applying CW could reduce the capacities of the WWTP, as well as the installation and operation costs. Additionally, these could have a great retention capacity to avoid floods in extreme rainfall events (adaption to climate change). Wetlands can be managed as a touristic attraction.

Green enhancement for Wetlands

Constructed wetland as a tertiary treatment for storm water before being discharged into the (protected) natural wetlands.

i. Should have the capacity to retain HQ50 in Storm event

ii. Water-level control system

iii. Appropriate biodiversity (plants, insects, birds, amphibians) to reduce the mosquito population

iv. Monitoring system

Sizing criteria (if no wastewater treatment previously).

i. Horizontal wetlands: 5 m2 per person (total area < 20 m2)

ii. Vertical wetlands: 2.5 m2 per person (total area < 10 m2)

Pollution reduction from 135 to 35mg BOD5/l; 184 EUR/m3 wastewater discharged (Kampala 2016)

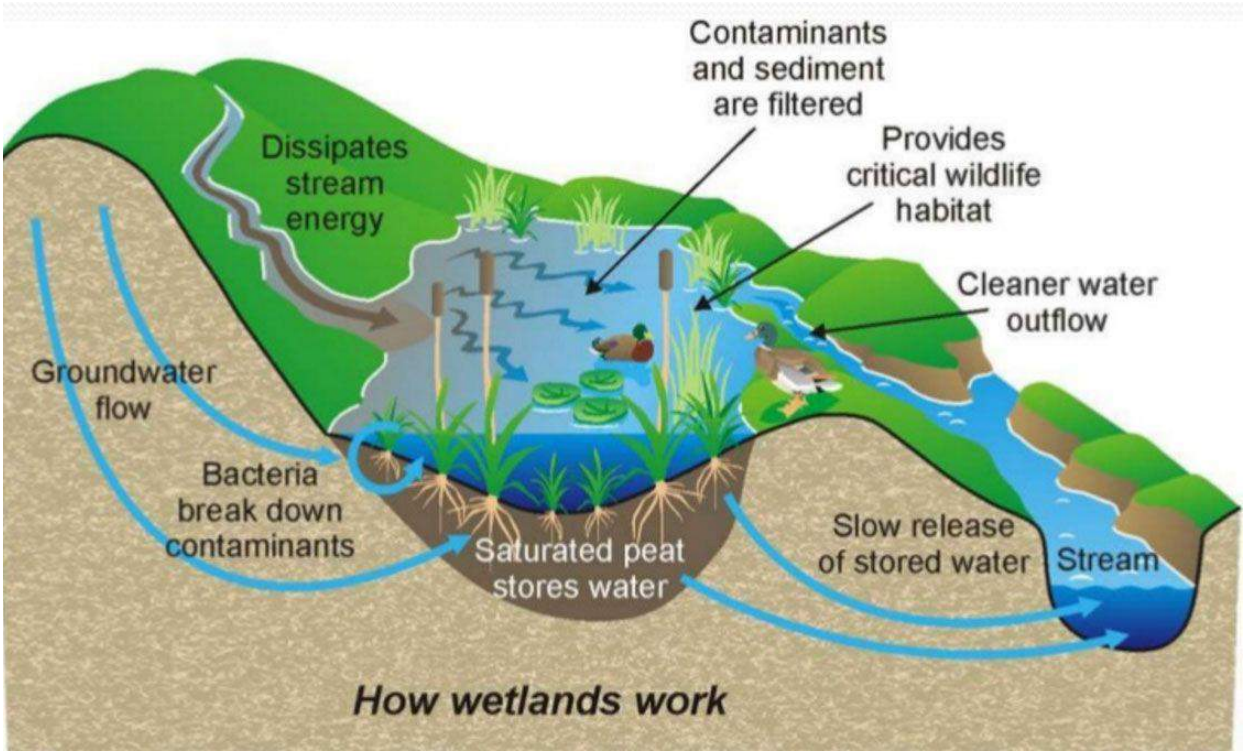

Figure 30: Diagram showing how wetlands work

Figure 31: Constructed wetlands

Further recommendations

Dwelling services → NO soakaway boreholes for wastewater! This may contaminate the shallow aquifers, which will make the tap water supply much more expensive, as it will be necessary to pump water from far areas and/or treatment process will be necessary.

Solid waste → prohibit single use plastics. Restrictions in the packing of products. Install system of reusable cups / plates / packing with deposit (this avoids extra costs in the wastewater and stormwater system) → creation of jobs for system administration, collection and distribution.

Agriculture → if allowed in the wetlands, high risk of ecosystem deterioration. Draining the land for conventional agriculture should be prohibited! Instead, adopt a water-level-resilient

"Chinampa" method, which consists of "floating" parcels made with natural local materials. Plant fruit trees on the street, this makes possible for people of lower resources to have an extra source of food or income. As well, these may also improve the biodiversity

5.3 Energy

Government

Energy demand for households and in the service sector in Rwanda would typically be divided into energy for (i) cooking/heating and for (ii) electricity demand. The energy demand situation will be very different to assess if you look at national averages and more specifically for Kigali. In the case of a new compound in Kigali province these dwellings would have electricity provided on-grid. This is in line with the policies and strategies of Rwanda (MININFRA 2016, GoR 2019).

Electricity demand and supply

In 2016 77.4% of urban households in Rwanda were connected to the grid as compared to 15.6% of rural households[16]. In Kigali city the access is above 78% (NISR 2018). The ambition is that Rwanda shall have universal access to electricity by 2023/24 where 52% of households should have access via on-grid and 48% via off-grid (GoR 2019). Access is also different between high and low income groups. Kojima, Zhou et al. (2016) provide statistics for Rwanda showing households in urban areas have a much lower electricity access (1%) than what the average households display (46%).

[16] Koo, Rysankova et al. 2018

Rwanda is presently expanding the electric power supply from around 220 MW installed capacity up to about 510 MW in 2023/24 (REG 2019). The table below provides the installed capacities and source of energy. The tariff structures for electricity takes a point of departure in differences in use of electricity in order to allow for a low tariff for low demand households. The tariffs are set by the Rwanda Utilities Regulatory Authority (RURA). The table below provides the current tariffs for residential, non-residential, hotels and health facilities. For industrial use the tariffs are organized in another way. At present there is a discussion on what tariff electric mobility charging should be found. This is not decided at present. The tariffs for industrial consumers are found in the table below.

Renewable source [MW]		Non-Renewable source [MW]	
Hydropower	103 + 3.5*	Diesel/Heavy Fuel Oil	58
Solar	12	Peat	15
		Methane (KivuWatt)	30
Total	*118*	*Total*	*103*
* Ruzizi 1 (hydropower) 3,5 MW,			

Table 13: Electricity generation capacity in Rwanda 2018 (Bimenyimana, Asemota et al. 2018, REG 2019)

Category	Consumption [kWh/month]	FRW/kWh (VAT exclusive)
Residential	0-15	89
	>15 – 50	182
	>50	210
Non-Residential	0-100	204
	>100	222
Hotels	All	126
Health Facilities	All	192

Table 14: Tariffs for electricity, user and consumption category (RURA 2018)

Category*	Energy Charge [FRW/kWh]	Maximum Demand Charge [FRW/kVA/month]			Customer Service Charge [FRW/Month]
		Peak (05:00PM-11:59PM)	Shoulder (08:00AM-04:59PM)	Off-Peak (00:00AM-07:59AM)	
Small	110	11,017	4,008	1,691	10,000
Medium	87	10,514	3,588	1,292	10,000
Large	80	7,184	2,004	886	10,000
Small	110	11,017	4,008	1,691	10,000

Table 15: Tariffs for industrial customers (RURA 2018)
**The categorization of industries depends on the amount of energy consumption per year.*

The big challenge in Rwanda is that poverty levels are high, and several households will have to try to cut costs. Also, in areas where the grid is available, households may opt not to connect. In Blimpo and Cosgrove-Davies (2019) Rwanda is displaying relatively low levels of uptake of electricity in areas also with grid as compared to other Sub Saharan African countries. In Rwanda the electricity tariff is considered relatively high (World Bank 2019). To give an example Blimpo and Cosgrove-Davies (2019) reports that operating a refrigerator for one year would represent 13% of the GDP per Capita in Rwanda, as compared to less than 0.5% for United Kingdom or United States of America of the GDP per capita. The monthly electricity bill on average represents almost 10% of an household income per month (Kojima and Trimble 2016).

The connection to the electric grid for any new installation will be done according to a set cost table. There is a connection fee, in addition to the cost for the extension. Kinyinya hill is part of the Kigali City master plan and expected grid expansion (CoK 2013, CoK 2019). The Kigali city master plan estimates that the Kinyinya Hill will

increase the power demand from present 6.56 MVA to 32.93 MVA in 2050 (CoK 2019). Plans are developed correspondingly for the infra structure. Kinyinya Hill have existing 40kV Medium Voltage (MV) line. Access points are for example at the bus station. REG will be able to provide some generic costs for installations of the power infrastructure needed for connecting the housing to the grid based on design details.

The full sector report gives electricity demands based on the Multi-Tier approach for Rwanda. In Rwanda the need for air condition and use of electric cooking has not been included which reduce the demands especially for the higher Tiers.

Cooking demand

Cooking demand in Kigali is mainly met by charcoal. NISR (2018) reports that for the last census the primary fuel17 used for cooking in Kigali was dominated by charcoal (70.8%), firewood (25.6%) and LPG (1.0%) and very few (0.1%) utilizing electricity as primary source for cooking. These results are supported by recent draft study by Innocent (2019) which report household primary cooking demand is met 15% by fuelwood, 70% by charcoal and 10% LPG. The remaining 5% are met with biogas, pellets electricity etc. Electricity for cooking is not common in Rwanda. Microwaves, water kettle etc is there, but for preparing the food other sources of energy are preferred. Also for the high income groups the use of electricity for cooking is not common, while LPG tend to be higher in this group as compared to other income groups (NISR 2018).

In Kinyinya Hill, LPG or biogas (if this is available) would be preferred and also attractive cooking fuels. Electric stoves would represent an unusual way of preparing food and might also affect the electricity demand – with increased bill as a result. If the electricity solution is opted for this would require further studies linked to user acceptance[18].

The operating cost of this would depend on option and size of household19. One 12 kg bottle of LPG is 13,600-14,200 RWF. The upfront cost of buying the first bottle can be a barrier to many households as this is about 45,000 RWF. A full kit including bottle, stove and regulator is about 80,000 RWF. It is necessary to ensure that supply points are present for the gas. According to Kojima, Bacon et al. (2011) households in Kenya used about 10 kg of LPG per month and household using LPG in 2011. Lower income quantiles used less gas. This would indicate an indicative cost of 14,200 RWF per month for cooking demand. This is similar level to what Tier 3 are paying for electricity (Annex 1). For Tier 1 and 2 this cost would be a substantial expenditure.

In schools and other institutions, it should be ensured that cooking energy is provided via efficient supply chains and ensuring that the end use technology (stove) is energy efficient. Solar water heater is an option also here.

Energy – other

Taking the point of departure in the recently published Rwanda Green Building Minimum Compliance System (RHA 2019, annex 3) several actions linked to energy can be discussed. The Rwanda Green Building Minimum Compliance System is not mandatory for residential developments but can be applied on a voluntary basis, however investors are encouraged to adopt the system to meet sustainable development targets. The table of themes are found in the full sector report.

Solar water heater is a useful technology and should be promoted. Solar water heating is a low-hanging fruit for energy efficiency for domestic and commercial end-users that have a hot water demand. The economy of a solar water heater will vary on size etc but can have payback periods of 3 years or less (see for example Da Silva, Bechtfl et al. 2010 with example from Uganda). As per the Rwanda Green Building Minimum Compliance System (RHA 2019,

[17] As in many parts in Eastern Africa cooking demand may be met with different fuels depending on preference/access the fuel is chosen. Cooking option may also be affected by access to fuel, affordability and other aspects (see for example Koo, Rysankova et al. 2018). The complexity in choice of cooking solutions is high. The energy ladder (see for example Leach 1992, van der Kroon, Brouwer et al. 2013) is often too simplistic in presenting how preferences of more clean/modern fuels will be used (see for example Makonese, Ifegbesan et al. 2017).

[18] Willingness to pay for electricity services may be low in some cases, while the aspiration to have access to electricity may be high. The constraints of economy may often be an important factor (Blimpo and Cosgrove-Davies 2019)

[19] Presently the multi-tier approach is used where households are categorized in different Tiers with associated energy demand. Depending on household tier in the houses different energy demand will be found (see for example SE4All 2013, MININFRA 2016).

annex 3) installation of solar hot water system is mandatory and applicable to all premises with hot water requirements of a capacity exceeding one hundred litres (100 L) per day.

Opportunities to install solar photovoltaic (PV) systems on the roofs is possible. Any production that is fed into the grid will have to be negotiated with Rwanda Energy Group (REG) to find price and generation requirements. The opportunity to have a net energy metering (NEM)20 arrangement is not found in Rwanda at present. Renewable energy provision is supported in the Green Building minimum compliance system (RHA 2019, annex 3) but is presented as optional. There are options to use solar PV generated electricity for off-grid purposes such as water pumping, fans, emergency lighting or back-up power. A possible option is to try to apply solar power to use in ventilation (mechanical ventilation is mandatory for green building).

Average windspeeds in Kigali are low and wind power is not considered an economical option for power generation (see for example UNEP 2017). There could be options linked to wind ventilators for ensuring ventilation demand.

There is little need for heating of the buildings in Kigali, same thing for air conditioning, if the housing is designed in a good way. Proper architectural design and application of building materials should be used to ensure a good indoor climate while avoiding need for heating or cooling.

Present supply chain and end use technologies (stoves) for solid biomass in Rwanda is associated with several challenges from environmental, health and economic aspects. A transition of the bioenergy sector in Rwanda towards more efficient and sustainable supply chains is needed and could make solid fuels interesting to certain energy demands in the future.

Light should be provided via energy efficient solutions and make use of daylight if possible. Any lamp fittings should be designed for low-energy solutions. This is mandatory in the Green Building approach (RHA 2019, annex 3).

Based on the table of point allocation for Module 1 – Energy Efficiency in Green Building module (RHA 2019) there are several points to be gained in i) Building envelope (facade design parameters), ii) ventilation, iii) daylighting and iv) enhanced artificial lighting efficiency (total of 66.5 optional points). These would also link to aspects in other actions.

5.4 Information and communications technology (ICT)

Access to the internet and services provided via mobile phones is considered basic need for all Rwandans. The ambition is that by 2023/2024 universal access to internet should be achieved (GoR 2019). By promoting broadband as utility, the signature of initiatives such as SMART housing, SMART cities (optimal space utilisation, connected cities, Broadband, Internet of things), Smart villages are some of the key initiatives to implant the ICT strategic plan. Today, Mobile increased from 640,000 to 9.7 million over the period 2010-2017 and Internet penetration rate stands at almost 40% (by May 2017).

Access to ICT services are nowadays an integrated part of many Rwandans life. Mobile phones are used to communicate with each other, but also to receive various services including banking, money transfers, and information sharing. Many times, basic phones are used (not smart phones) and services are designed to accommodate for this hardware. Access to different ICT devices in Rwanda and Kigali is presented in the table below.

Device	Mobile phone	Computer	Radio	TV
All Rwanda	67.0	3.3	73.8	10.4
Kigali	88.0	12.8	91.5	36.0

Table 16: Share of households (%) with access to one or more of ICT devices. All of Rwanda and Kigali (NISR 2018b)

[20] NEM allows consumers that have generate electricity to use the grid as a storage. The excess is fed into the grid and credits are given. These credits can then be utilized later in time.

Internet access in Kigali City households, including access via mobile phone, is reported to 39.1% in 2016/17, which can be compared to all Rwanda where access is reported to 17.2% Households in modern planned areas reported the highest access to access to internet (58.9%) (NISR 2018a).

The normal way to get access to phone services, and mobile internet is via purchasing pre-pay credits. The service easily accessible in Kigali and 4G for internet is readily available. If dedicated access is needed, there are opportunities to access this via fibre. The cost is relatively high as compared to mobile solutions. Access to internet is typically via smart phones but also laptops are found. There is a difference between income groups again. Dedicated internet via wireless broadband is presented in the table below.

Description of services	Quantity	Unit of Measure	Unit Price RWF	VAT 18%	Total Price RWF
Wireless Broadband Internet Connection - Installation Cost	1	Onetime Payment	100,000	Inclusive	118,000
Monthly Internet Connection: Dedicated	20Mbps	Monthly Fee	100,000	Inclusive	2,360,000 (one year)

Table 17: Cost of access to dedicated internet connection. Source ISPA Internet/Fibre provider

For the Kinyinya hill inhabitants most households will access ICT services via mobile solutions. Television and radio are accessible via antenna, but many stations also broadcast via social media and internet. The Kinyinya Hill development can include smart solutions and internet of things solutions based on dedicated or mobile solutions. The Rwanda Building Code for urban areas mentions that access to ICT should be considered in designing the building (RHA 2019).

5.5 Transport and mobility

The report summarises analysis and recommendations for the project and presents a transport strategy for the GCK.

The GCK transport strategy comprises

i. A transport vision

ii. Principles to support the vision and guide decision making and design

iii. A transport structure plan, and

iv. A set of complementary initiatives and policies

In developing the strategy, the most important factors have been the policy context, the project objectives, the characteristics of the existing and target population including the low

socioeconomic profile, the challenging topography, delivery financial constraints, and the existing and forecast transport context of the city of Kigali.

The GCK transport vision: "A transport system that provides the community with affordable and safe transport options for their daily activities, that allows Kinyinya Hill to develop as a lively mixed-use development with local opportunities for its residents, and that is environmentally sustainable and financially feasible".

Key transport principles:

i. Build on the existing network and travel patterns

ii. Prioritise transport options that are sustainable and affordable by residents and that facilitate the financial feasibility of the development

iii. Prioritise direct access for walking for speed and convenience particularly to neighbourhood centres

iv. Balance directness and suitable gradients for cycling connectivity

v. Public transport must have high reliability and frequency

vi. There should be no through travel for private cars

vii. The transport environment should be planned as a 'slow traffic environment' and designed for high safety and amenity.

viii. Minimise parking to maximise affordability and prioritise sustainable travel modes

ix. Stage implementation to prioritise sustainable and affordable transport options and facilitate the financial feasibility of the development

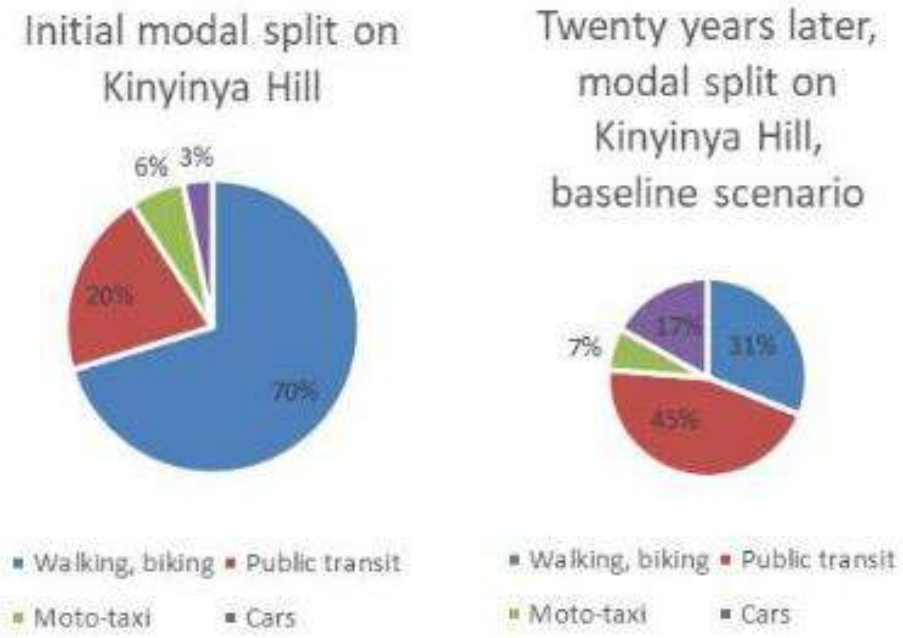

Figure 32: Projection of modal split for the coming 20 years in Kinyinya Hill (scenario without measures to support sustainable transport modes)

If the inhabitants in Kinyinya Hills (after a successful and full-scale implementation of the master) gain an economic development of 6-8 % growth of dispensable household budgets and the overall policy measures aims in other directions than supporting sustainable transport modes, most of the inhabitants have probably moved upwards on a mobility carrier, not fully depending on walking, more using public transit, motor-taxis and cars. The car-density has grown from extremely low 13 cars per 1000 inhabitants to approximately 80 (which still is very low in a global context). The non-motorized transport split decreases from 70% to 31%. Two main future transport scenarios were analysed in developing the strategy and to assess the project's financial feasibility:

A baseline scenario (BS) both drawing from the indicative road network proposed in the draft Kigali Master Plan and responding to the increasing affordability of private car use for some Kinyinya Hill residents. This scenario consists of a higher provision of road infrastructure and some walking, cycling and public transport. This scenario tries to meet the demand for increase motorization as described above.

A green enhancement scenario (GES) drawing on the draft Kigali Master Plan, heavily prioritising walking and cycling, planning for a high-quality bus service, and employing several slow traffic measures and low parking supply to complement transit-oriented development and improve affordability. This scenario caters for travel and broader needs but minimises the provision and cost of road infrastructure. This scenario needs additional support from an overall policy level to strongly promote sustainable transport modes affordable for all.

The estimated cost difference between the baseline transport scenario and the recommended green enhancement scenario – based on strategic and initial estimates – is shown in the Table below.

Total Costs	Baseline USD		Green enhancement USD		GES/BS	
	On-site	On and Off-site	On-site	On and Off-site	On-site	On and Off-site
Total cost per 365 ha	72 498 090	219 288 168	28 771 091	42 272 242	40%	19%
Average per 18 ha	3 575 248	10 814 211	1 418 848	2 084 659	40%	19%
Average per 1 ha	198 625	600 790	78 825	115 814	40%	19%

Table 18: Comparison of total investment costs for transport infrastructure on Kinyinya Hill and its surroundings. Baseline scenario vs Green enhancement scenario

The transport structure for the two scenarios is shown below in two figures that indicate the fine-grain network, and the main medium and longer distance connections over the hill. The second scenario, the green enhancement, is recommended.

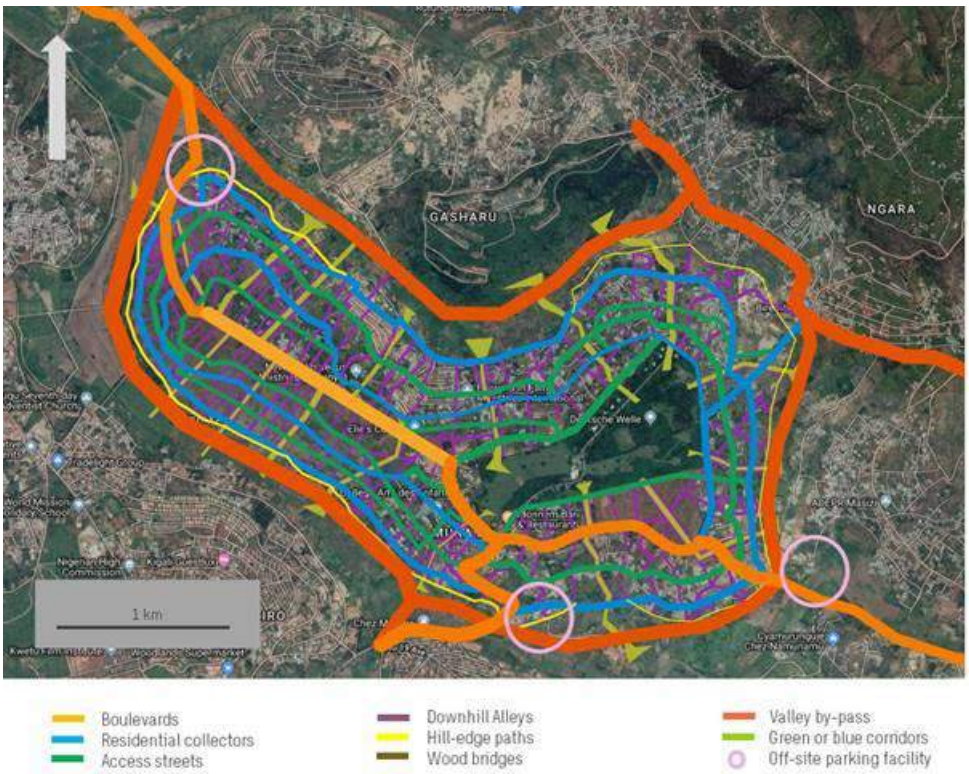

Figure 33: First of two proposed road network structures – the baseline scenario

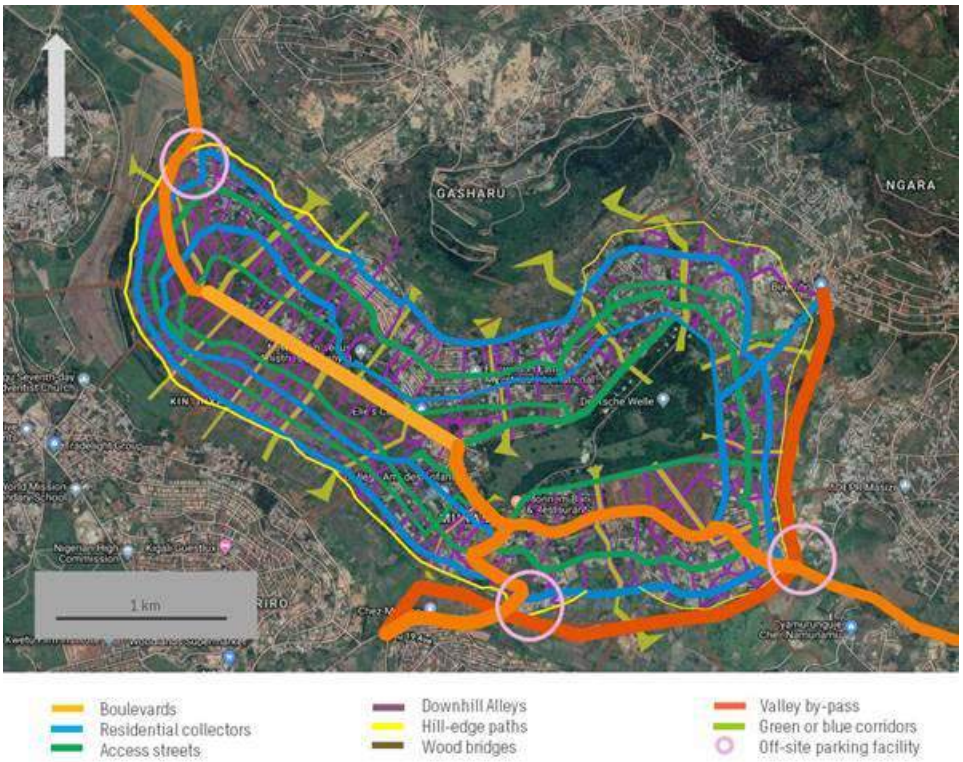

Figure 34: Second (recommended) road network structure – the green enhancement scenario

The baseline road network is based on seven road type sections, derived from the guidelines in the new Kigali Masterplan. In the green enhancement scenario, modifications have been made to suit the budget constraints and low motorization goals for Kinyinya Hill. Cross sections for all road types are shown in section below.

Scenario		Baseline	Green enhancement
Road type section		Type 3B	Type 3A
Width	m	17,5	11,8
Trees	/10 m	2	1
Sidewalk, width	m	2,0+1,3	1,3+1,3
Street parking	/10 m	1,7	0,0
Bike parking	/10 m	0	1
Lightings	/10 m	0,2	0,2

Table 19: Characteristic parameters for a baseline road type and a green enhancement road type

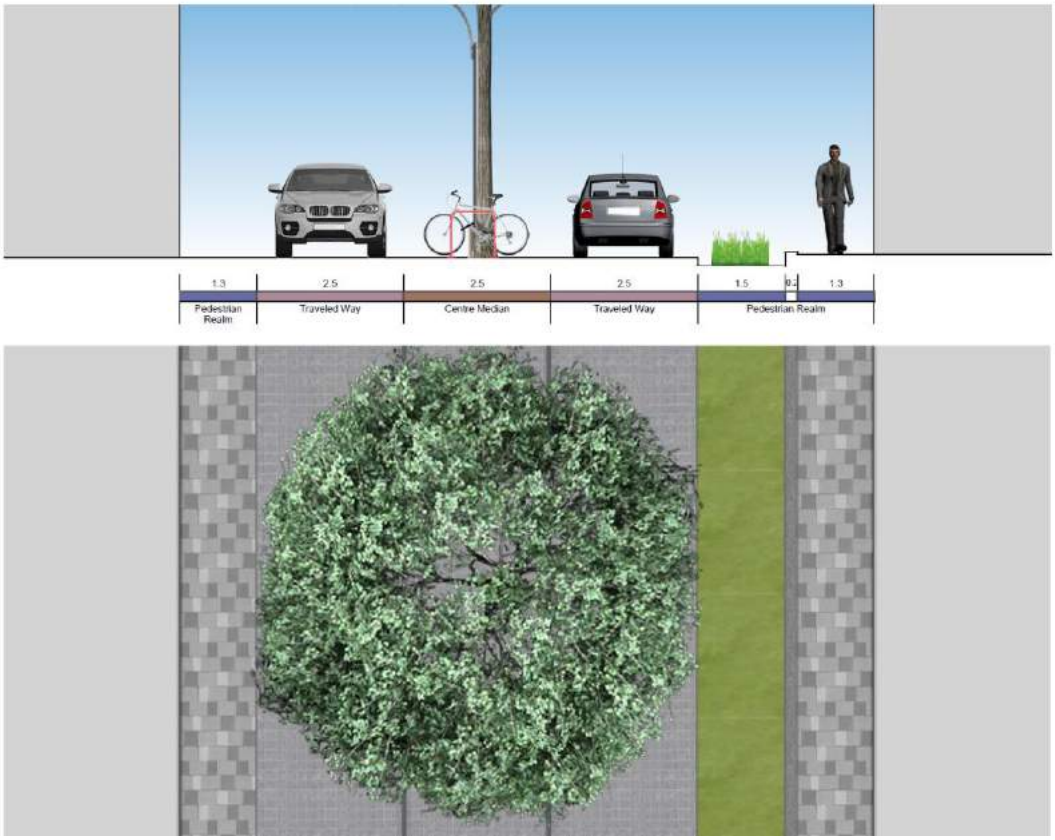

Figure 35: Road type 3A, Access road in green enhancement scenario

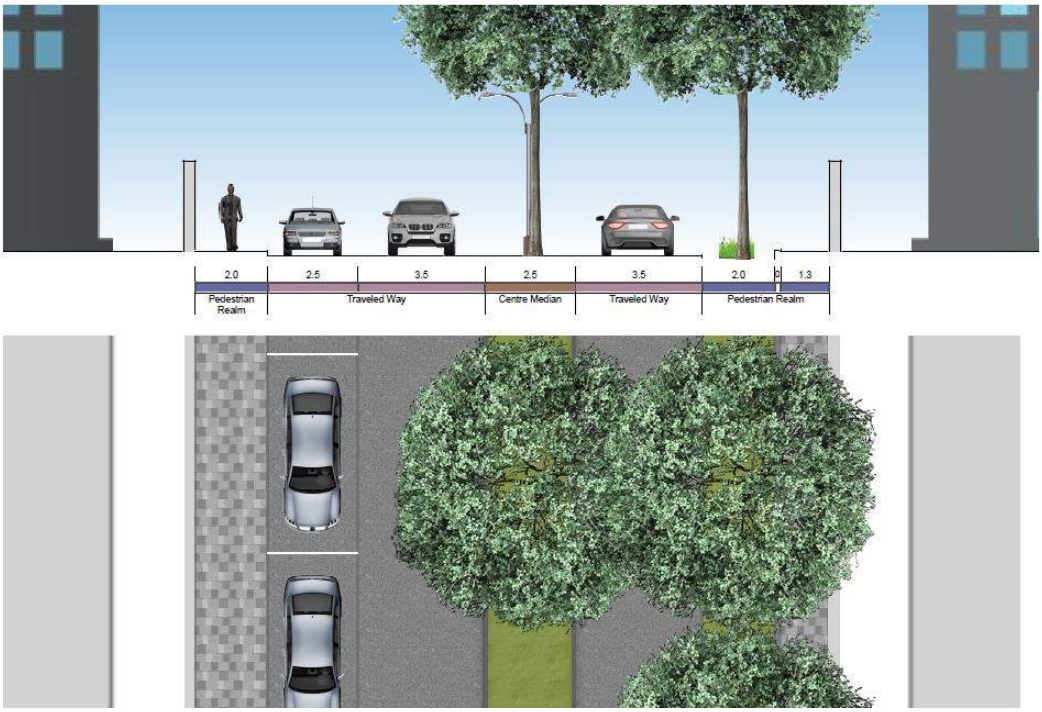

Figure 36: Road type 3B, Access road in baseline scenario

The green enhancement scenario best satisfies policy and project objectives, but also the policy objectives for the new masterplan for Kigali. The low socioeconomic profile of the existing and target population is a critical factor that necessitates planning for a very high degree of walking and cycling, paired with local jobs and services. As the wealth

of the resident population rises over time, high quality public transport services will be required to limit the demand for private car use and its space-inefficient and unaffordable road infrastructure requirements.

Important components of the spatial plan would include

i. A fine-meshed network of narrow streets on the hill to support transit-oriented development, and design for a slow traffic environment

ii. Dedicated bus lanes including on three of the hill's access roads to allow for frequent services linking to three points on Kigali's proposed bus rapid transit network

iii. A set of design measures to severely limit through travel by private car from east to west

iv. Streets designed to be a part of the slow water management and overall climate control (with less cars with heating motors and a high degree of canopy-shaded road space)

v. Comprehensive street lighting to improve safe access

vi. Low parking supply (capped at 0,15 spaces per dwelling including street and public parking

The timing of the implementation of transport actions and broader development is also critical to achieve sustainability and affordability. For example, early phases should prioritise cheaper and more efficient transport infrastructure such as walking and cycling infrastructure, and more expensive and less efficient infrastructure such as parking should be delivered later. Temporary uses can be considered if affordable and consistent with project goals, for example limited use of undeveloped land parcels for public car parking, if necessary to stimulate business activity.

A number of broader Kigali initiatives are highly recommended to support the sustainable and affordable development of Kinyinya Hill

i. Reform of Kigali bus contracting, such as the Government's preferred franchising model which would allow for service standards to be set and monitored

ii. A shared bicycle scheme to improve options for very low-cost transport allowing access to more distant locations, and in the case of a shared e-bicycle scheme, to address topographical challenges

iii. A bypass road from the south to the east / northeast, drawing from the Kigali Master Plan, allowing for economic regional traffic flows and limiting amenity impacts on Kinyinya Hill

The transport strategy at this initial feasibility stage has relied on available information about the scale, layout and mix of the proposed development and the existing and projected transport conditions in Kigali. As more information becomes available, this strategy will need to be refined. Nonetheless, the existing policy and project objectives have provided a very strong basis for the recommended approach and initiatives to achieve an affordable and sustainable project.

5.6 Solid Waste Management

There are several policies and regulations that set out requirements and targets for solid waste management in connection with urban development. Below is a short overview of the guiding documents followed by an analysis of both potential gaps and implementation problems

The Rwanda Urban Planning Code has a chapter on Planning of Solid Waste Management and Location of facilities. The document has requirements for different waste generators, for example office buildings or businesses should use waste bins for temporary storage.

The planning code stipulates that solid waste should be sorted at source in the following fractions: biodegradable, recyclables (plastics, metals and glass), other non-biodegradable, and hazardous waste. These definitions are not fully in line with international standard where the term biodegradable is not often used, as most solid waste is biodegradable with time. The term organic waste, or organic food waste is used to describe the fraction that is most suited for biological treatment (compost, anaerobic digestion etc). The planning code also says that organic materials

should be composted, briquetted, or digested, and that domestic/household organic waste should be composted on site.

The plot level services and infrastructure section of the Urban Planning Code (2015) states that source separation is a requirement for both single family homes as well as apartments. The Rwanda Green Building Minimum Compliance System (2019) also requires source separation, which is mandatory for commercial buildings. Urban Planning Code Section 4.5.2, states that waste collection points, separation and recycling commerce shall be co-located. It is not clear how this is implemented on the ground. All waste drop-off points should have possibility to sort at source.

The planning code expresses that the local authorities shall support private sorting, i.e household source separation. It is common in planning guidelines to differentiate requirements for different waste generators, households, businesses, institutions etc. However, this is not clear in the Rwandan planning code. It is common to have instructions for businesses to organize themselves the collection of at least business specific waste and recyclables while household like waste often is collected by solid waste management companies organized by or procured by the municipality.

The Plot level service and sanitation infrastructure section of the housing policy states that, non-biodegradable refuse shall be stored in proper containers for collection. Biodegradables shall be separated from non-biodegradable waste and composted. Where there is no refuse collection organized through the District, non-recyclable refuse shall be deposited in sites approved by the District. The maximum distance to solid waste disposal point is 250 meters for households, however does not indicate a maximum distance for businesses and other waste generators. The policy restricts where waste disposal sites can be located for example landfills should be built in suitable geological areas away from faults, wetlands, flood plains or other restricted areas.

Review of the current solid waste management system in Kigali

Kigali is often referred to as the "cleanest" city in Africa, pointing to that the city has less littering and informal disposal of solid waste than many of the capitals in neighbouring countries in East Africa (Kabera et. al 2019). This success has been much attributed to strong governance, Rwanda was quick to adopt single use plastic bag ban (2008) and carries out communal monthly clean-up exercises (Umuganda).

The solid waste collection is organized by the city of Kigali and operationalized by the three city districts. The services are carried out by private operators bidding for three-year contracts in 35 sectors (collection areas). Households have weekly collection and businesses have collection as needed (daily collection).

Households pay a fee for waste collection, which is collected at the cell level and paid on to the collection company directly. Households pay fees according to their Ubudehe classification, with the poorest (Category 1) receiving a free service. The fee for Category 2 is RWF 1,000 (US$ 1.2) per month and for Category 4 (the richest) RWF 5,000 (US$ 6) per month.

The estimated waste generation in the City of Kigali is about 638 tonnes per day (tpd), or 233,000 tonnes per year. This corresponds to a per capita MSW generation of 0.57 kg/day, or 205 kg/year (Kabera et al 2019).

The collection service is poorer to certain low-income areas, usually located in the outskirts of the city where road infrastructure is an obstacle for waste vehicles to travel on. The basic solid waste collection system is that householders store their waste in individual containers (or more commonly in bags as containers are expensive), which are ten collected door-to-door on a weekly basis, commercial areas have communal containers. Not all households however put waste in containers or bags, but rather in piles waiting for collection. During rains the waste can get washed away and clog up drains and channels.

The city districts themselves estimate the coverage of services they provide and on average the city of Kigali has solid waste collection for about 88% of the households. Households pay for solid waste management services according to their Ubudehe (classification), the poorest get free service. Households who do not agree to a contract a solid waste collector are fined. The waste management fee is often bundled with payment for neighbourhood security patrols. The fees from households are covering costs for waste collection but not that of treatment and other aspects of the solid waste management system.

There is a lack of reliable data on how much waste is generated and how it is managed in Kigali (Kabera et al 2019). The Nduba dumpsite (which is the main waste disposal site) does not have a weighbridge in daily use, so waste amounts are estimated based on the number of vehicles arriving. Waste composition surveys on incoming waste are also few in numbers, there is only one composition study that has been carried out in recent years, in 2012. According to research carried out by Kabera et al (2019) the MSW waste composition can be estimated at: organics 70% by weight; paper and cardboard 5%; and plastics 5%, 3% metal. According contacts with professionals in the field there are no available data are for waste density, moisture content, or calorific value.

There are two small scale compost facilities in Kigali, but they are treating a very small part of the organic waste. The only company in working on composting is called Company for Environment protection and Development (COPED) and their workers sort waste on site (separation after collection). COPED offer services to compost organic material from households, hotels and industries. COPED is actively working on incentivizing households to sort waste at source and is planning to start renewed efforts to carry out household source separation, starting with a pilot sector next year.

Recommended solutions

The lack of modern solid waste treatment in Kigali is a key issue for improving the overall performance of the SWM system. To revive confidence in source separation the inhabitants need to see that their contribution (source separation) will improve the environment and they need to have further understanding of the value that can be derived from waste.

There are likely several ways to ensure that the source separation could function better. Limited access to household waste drop-off points so that only residents can access the waste disposal, has proven to increase sorting performance in other countries. The Rwanda planning guidelines does not indicate how many households are optimal to share communal containers or give sizing requirements for how much space needs to be allocated for solid waste management.

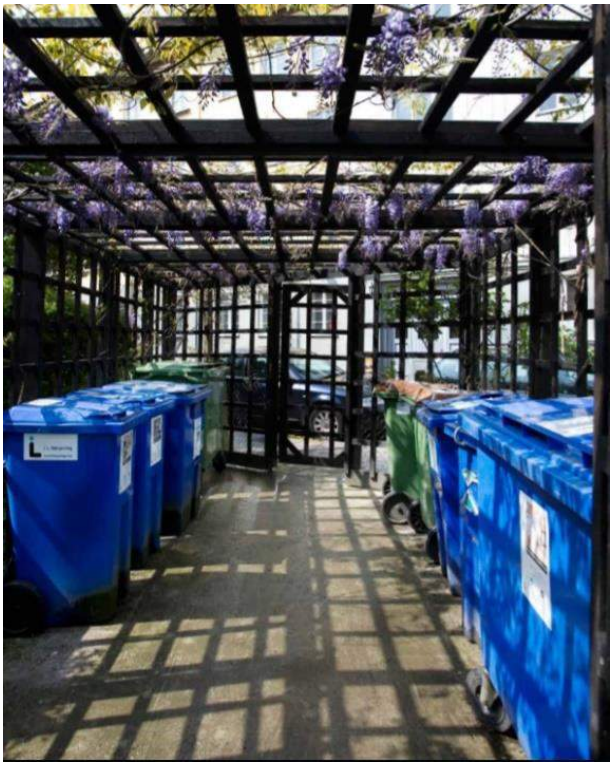

Figure 37: Simple structure to limit access to waste drop of two residents/potentially local businesses.
The drop-off point should have easy access for waste collection vehicles, waste collectors and users (image VA-Syd).

The solutions suggested aims at reducing waste, improving solid waste collection and treatment to enable reuse, recycling and recovery of nutrients and energy. at Kinyinya Hill.

Multi-family residential houses will have a waste sorting room/light structure with waste bins/containers for source separation in three fractions 1) Organic waste 2) Recyclables 3) Residual waste. Standard waste bins are available in Rwanda and they have been included in the cost assessment.

Bin size should appropriate to fraction and local collection vehicles. Recommended bin size for multifamily houses i) 120 l organic waste, ii) 240/660 l recyclables, iii) 240/660 l residual waste.

Recommendation to limit the number of households with access to a sorting room/space (60-80 households preferable). A cost calculation estimate has been done of 60 households share the same sorting room. The rooms should be located with easy access for both collection vehicles and users. The rooms should be large enough to allow for collection 1/week.

Estimated waste generation per week for waste sorting room for 60 households ((0.5kg x 4 x 60) x7= 840 kg week. An estimated 7-8 bins for organic waste, 2-5 bins for recyclables 1-4 bins for residual waste.

Note that the estimates are based on unreliable waste composition data and waste sorting rooms should allow for flexibility to add bins as needed. The rooms should be locked, to allow for access only by the households and waste collectors. The waste bins hold a value and should be clearly marked to deter theft. Restricted access is a measure to improve sorting practices from the households. Several studies have shown that waste sorting is improved when a limited number of users have access to the sorting room.

Single family houses sort waste in at least two fractions 1) Organic waste 2) residual waste. The waste should be stored in containers/bin within the property and placed on curb side on collection day. Single family houses should also have collection once a week (1/w). The recycling fraction can be organized at a neighbourhood collection point, or as a third fraction at the household level.

Features for reducing waste; a practice of reuse of items that has functional use has been established in the low- and middle-income urban areas of Kigali. There are also regulations in place to reduce waste such as the plastic bag ban. At Kinyinya hill the solid waste system will continue to support reduction of waste primarily by creating space for small scale artisan upcycling of materials that would otherwise become waste. The waste recycling rooms may also be used as centres for information on the importance of reducing waste and sorting waste to enable recycling and energy recovery.

The City of Kigali has previously introduced source separation of household waste however have not been successful. Waste bins were placed out in the community but there was lacking communication regarding how the residents should sort and the benefits of sorting. A recommendation is to, at least initially, employ waste ambassadors who give instructions to the residents about waste separation. It is also important to set a culture of keeping the waste sorting rooms clean and hygienic. Using waste ambassadors to implement new SWM systems or improving compliance with older systems have been successfully implemented in many countries.

Renewable energy generation/ recovery of energy from: If the land use plan allows, the light industry zone on Kinyinya could potentially be used to locate a waste treatment facility for organic waste. The organic fraction is estimated at about 60-80% of the total household waste, making it a priority fraction to find a treatment method for. Several reports (Gouldson et al. 2018, Biogas in developing countries, etc.) have identified that large scale anaerobic digestion of organic waste is the most cost effective low-carbon mitigation measures. However, there is no clear definition of what large scale anaerobic entails in the Kigali context. There are no larger scale biogas plants for MSW in Rwanda but there are low-tech instillations at individual properties like farms, prisons and schools. The viability of a biogas plant is tied to the demand of its outputs, biogas and biofertilizer. Biogas could be upgraded and used as cooking gas for households and restaurants.

5.7 Resource modelling

This Feasibility Study includes an approach to modelling the benefits of the suggested solutions. There is increasing need to quantify claimed benefits in a world where words are freely used to portray and often exaggerate perceived benefits. This is particularly the case for eco-cities around the world where for most there is a substantial 'performance gap' between what is delivered by the completed construction versus the originally aspirations. For the various sponsors and funders of such projects there is a growing desire to ensure their investments deliver on the claims made for their developments and secure the intended returns.

Using resource modelling as a quantified assessment tool is a key part of a continuous governance process to address this frequent gap between project aspirations and delivery. As part of this, resource modelling allows direct cost comparisons between different sustainability measures and their economic payback. This in turn allows early identification and continued focus on maximum benefit for minimum investment.

Assessment tool options

The major building environmental assessment tools available globally have been reviewed for suitability. This included LEED, BREEAM, BCA Green Mark Scheme, and others[21]. From this assessment, the IFC EDGE-buildings assessment tool[22] has been selected and adopted for modelling energy, water and materials for the following reasons:

It is an easy to use simplified assessment tool that can be implemented at each project stage, from master-planning, pre-design through to building-in-use, and for most building types and sizes. It is also underpinned by an integral financial model for identifying the most cost-effective environmental sustainability measures. It includes business-as-usual benchmarks and costs for Kigali built into the assessment tool. The assessment can be verified by third parties, to ensure a level of independence and reliability

It has the backing of the World Bank (which funded its development) and is specifically focused on developing and emerging nations where local assessment and verification experience is generally less mature.

Experience has shown that key to achieving full cost benefits it is essential to ensure certain performance levels are achieved by all buildings. For example, the capital cost benefits of a reduced electrical distribution network can only be relied upon if all buildings comply with the relevant credits. This is often at odds with most of the building environmental assessment methods because they allow considerable flexibility on which features are adopted from a wide basket of options. Instead the EDGE-buildings tool is more focuses on the specifics of energy consumption, water consumption and construction materials impact, and allows hard targets to be set, while allowing flexibility on how these targets are met.

Targets

Preliminary resource modelling has been completed for the new-build portion of GCK. This is to establish cost-realistic targets for improvements in building energy use and water.

Conventionally, the setting of these targets has been arbitrary, which in turn means there tends to be little subsequent resistance to allow target dilution during the design and construction phases.

For GCK, instead a clearly reasoned framework has been used to set these targets, based on the environmental carrying capacity and cost reasonableness specific for the location. These are:

i. 50% reduction in building energy consumption

ii. 50% reduction in water energy use

[21] The Rwanda Green Building Minimum Compliance System has many similarities with BCA Green Mark Scheme but is not aimed primary on residential buildings. The system does include several indicators that is also found in other assessment tools, such as water efficiency targets. The framework does not include the integrated cost assessment to allow the selection of the most cost-effective solutions.

[22] https://www.ifc.org/wps/wcm/connect/ef463c0047c68a0ca4e8f5299ede9589/IFC+EDGE+Brochure+-+English.pdf?MOD=AJPERES

iii. 50% reduction in building materials embodied energy

iv. Simple local cost payback of about 1 year or less

v. Site-wide water autonomy

vi. Zero-carbon emissions timeline trajectory

These targets and their proposed improvements are referenced to a baseline of business-as-usual new-build development. Thus, this baseline includes resource consumption jump expected of unconstrained new-build development. So, the baseline is not current local or national averaged consumptions.

The preliminary resource modelling has identified the major contribution needed from the buildings. Not only is this in terms of roof area for future PV power generation, but critically also in terms of reduction in building energy demand, to then permit the renewable energy generation to be enough.

To delivery zero-carbon cost effectively, certain regulatory, institutional, and capacity building changes will be needed. For example, the ability to operate buildings as power-stations using primarily roof photovoltaic (PV) extensive energy generation, will need regulatory and fiscal changes to allow renewable energy to be fed into the local electrical grid. So, for achieving zero-carbon carbon emissions, a framework has been outlined for progressing towards zero-carbon by 2050 with trajectory path critical points.

Governance

To ensure the resource reduction aspirations are delivered in the completed development, a comprehensive set of Governance Rules will be needed and enabled by embedding them into land and other contracts. This is important because sustainable resource use is a comprehensive issue involving multiple stakeholders cooperating who would not normally be motivated to safeguard these project targets and aspirations.

At each stage of the project the resource modelling should be repeated to ensure the targets are being maintained. Hence, the master planners should use the tool to demonstrate that their designs can achieve the targets. Subsequently, the master-developer should have in their contract to demonstrate that their proposals maintain these targets. Similarly, plot developers, their designers and constructors should have in each of their contracts the requirement to model and demonstrated their proposals maintain these targets. Finally, the operators of the completed buildings should be contractually obliged to submit the actual meter readings to demonstrate delivery of the targets.

Without these Governance Rules contractual requirements to deliver on the targets, the resource targets can be expected to be diluted and the benefits will be lost during the project implementation process.

This is particularly important if the cost benefits of reduced resource use are to be delivered. For example, the cost benefits of a more modest installed infrastructure capacity can only be achieved if the resource targeting Governance Rules can be relied upon because it is backed by contractual requirements through each stage of design and construction implementation.

As the first stage in this governance process, the master-planner competition is to include a scope for their modelling of their design proposals to demonstrate they comply with the overall project resource targets.

A key part of the infrastructure synthesis has been the use of resource modelling for setting realistic GCK resource use targets. This modelling has used the IFC EDGE-buildings modelling tool to allow direct cost comparisons between different building infrastructure sustainability measures with their economic payback. This has allowed early identification and then continued focus on maximum benefit for minimum investment. Preliminary resource modelling has been completed for the new-build portion of GCK. This is to establish cost-realistic targets for improvements in building energy use, for water use and materials embodied energy. The planners, and subsequently the building developers, will be expected to use this tool to demonstrate GCK will deliver on the targets set. Additional modelling analysis is expected during the master planning stage. For example, for defining the measures needed by the infrastructure and building plots to deliver on UHI mitigate and Climate Change readiness. Best practice from around

the world is expected to be applied, for example; for defining the minimum leaf area each site is expected to provide (as Singapore Green Mark).

6.0 HOUSING AND COMMERCIAL MARKET REVIEW

A part of this Feasibility Study was to undertake a review of the Rwanda housing and mortgage market to assess, the capacity of the housing market finance to support the Green city Kigali project. Assessment of current commercial and industrial market and make recommendations for the GCK project. Review ideas and suggest policy initiatives that would lead to provision of decent housing to lower income households in Kigali.

Assess and recommend development and management vehicle options to undertake the responsibilities of the master developer / special purpose vehicle as contained in the TOR of the project. Prepare financial modelling templates, conduct financial modelling and provide options on how the projects could be financed including financing through a Green bond, assessing the feasibility of such option, the required steps and the type of Green Bond and illustrative terms for potential Green Bond issuance.

The work is based on qualitative and quantitative data gathering and analysis. Wherever possible, findings from desktop and primary research has been tested with stakeholders in the project, including the project specialist and wider Rwandan government and housing sector actors and have also considered relevant best practice when applicable.

6.1 Housing Policy considerations

The Rwanda government is committed to promoting green, urbanisation centred growth and these priorities are apparent in recent GoR economic policy. For particular importance to the GCK, these existing environmental, fiscal and economic development policies support the concept and explore the possibility of innovative financial solutions to increase access to better housing solutions. The policies have also laid the groundworks for creating frameworks and institutions to promote the development of affordable housing. The most prevalent policies for the GCK and their implications for the project are outlined in the table below.

Policy / Legislation	Implications for GCK
Economic Development and Poverty Reduction Strategy, 2013 (EDPRS II), 2013, Later superseded by National Strategy for Transformation (2017-2024)	Government's commitment to test and promote a new approach to urbanisation through promotion of secondary cities Government's commitment to infrastructure and identifying supply and financing options for affordable housing GCK will act as a demonstrator scheme for sustainable city development and reflect high environmental standards and sustainable green innovation
National Housing Policy, 2015 (NHP)	Density policy Impact of GCK on low income individuals Upgrading of informal homes Green and energy efficient standards and demonstration of impact of the scheme on the build environment. City of Kigali's capacity for planning assistance Public-private financing options
Rwanda Housing Finance Project, 2018	The GCK should monitor the capacity of the fund to address mortgage demand for the project according to its various stages
Green Growth and Climate Resilience: The Rwanda National Strategy on Climate Change and Low Carbon Development 2011, updated in 2018	Access to locally-sourced materials Passive house building standards with low operational costs Walkable cities that reduce urban sprawl New training to be made available
Rwanda National Urbanisation Policy (NUP, 2015)	Key implications for densification and planning made in coordination with the district Consult with urban planners on this policy
Special Economic Zone Policy, initiated in 2010 and revised in 2018	The use of training, value-added production (i.e. through a materials supply chain) in the consideration of the GCK Recommendation:
Supporting Affordable Housing in Rwanda Plans and Options – Policy Note, 2015	The use of a central UDF hat outsources market functions to a trading SPV may be a potential model for the GCK

Table 20: Review of Policies for GCK

We understand that current government policy targets households earning between RWF 200k – 1.2k per month and that social housing for very low income and vulnerable groups is restricted. Gaps therefore exist for affordable housing beneficiaries with household earnings falling below RWF 200k.

There are also several policy instruments the GCK could employ to help support the feasibility of the GCK, including

i. Infrastructure Funding (Affordable housing Fund – AHF): The GoR Infrastructure Fund (approximately $250m) is supporting the affordable housing agenda through a project which aims to provide access to basic infrastructure and enhance urban management in selected urban centres

ii. Rwanda Housing Finance Project 2018: The World Bank has lent Rwanda $150 million (RWF 130 billion) to expand access to housing finance

iii. Tax Incentives (VAT & Corporate) and Relief from Import Duties (Note: it is understood that provision exists for affordable housing costs to be relieved from VAT and major investment projects that include affordable housing to be relieved of duties on imported materials)

iv. Construction Finance (Developers): The GoR will provide funding for basic infrastructure, assistance to purchase developable land, assistance to set up a manufacturing plant, inexpensive finance and tax incentives to builders of affordable housing

6.2 Demand Considerations: Housing Affordability

The combined results of a desktop review and qualitative research from focus group sessions of low-income household representatives from various occupations (motor bike taxi drivers, front line banking staff, graduate students and teachers) supported that:

i. At present, good quality, affordable homes are generally out of reach for low-income households in Kigali

ii. Households make careful decisions on the proportion of household incomes spent on housing or other costs. This is driven by household priorities, i.e. the desire to invest in business activity or save to purchase land or other assets

iii. Constraining factors impacting affordability of housing costs are availability of finance on affordable terms and supply of suitable housing at prices accessible to low-income households

iv. Households will willingly allocate up to 40% of their income for housing seen as desirable (e.g. in a good location or with services) and if necessary, seek additional income (e.g. by having other family members living with them)

For the purposes of this report and the financial models, we have estimated that households are willing to spend up to 35% of household income on base housing costs (excluding utilities). While this definition of affordability is higher than the IGC's proposed affordability figure of 25% of household income on base housing costs, we believe that 35% is a more realistic figure given the context of Rwanda's developing economy and the costs of volume housing. We also believe that this figure more accurately reflects what households are anecdotally willing to pay for a desirable, affordable home.

<u>Recommendation: The GCK should define affordability as 35% of the target group gross household income for the purposes of this project</u>

While primary data gathering on income levels is difficult in developing economies due to the prevalence of informal and supplementary income streams, and the nature of imprecise self-reporting methods, we wished to understand how income distribution in Kigali could support the development of housing tenure mix for the GCK.

For this reason, we analysed current and past income segmentation models and determined that using the IGC model for Kigali (2019 – Upcoming), illustrated in Figure 1 below, would act as a sufficient basis for determining income distribution of possible household demand groups.

The following income pyramid contains both the proportion of the population falling into each household income group as well as the relevant household income category. As indicated below, the vast majority of households (c. 75%) in Kigali live on an income below RWF 500,000 and a large portion of households (c. 18%) in Kigali live on an income below RWF 100,000.

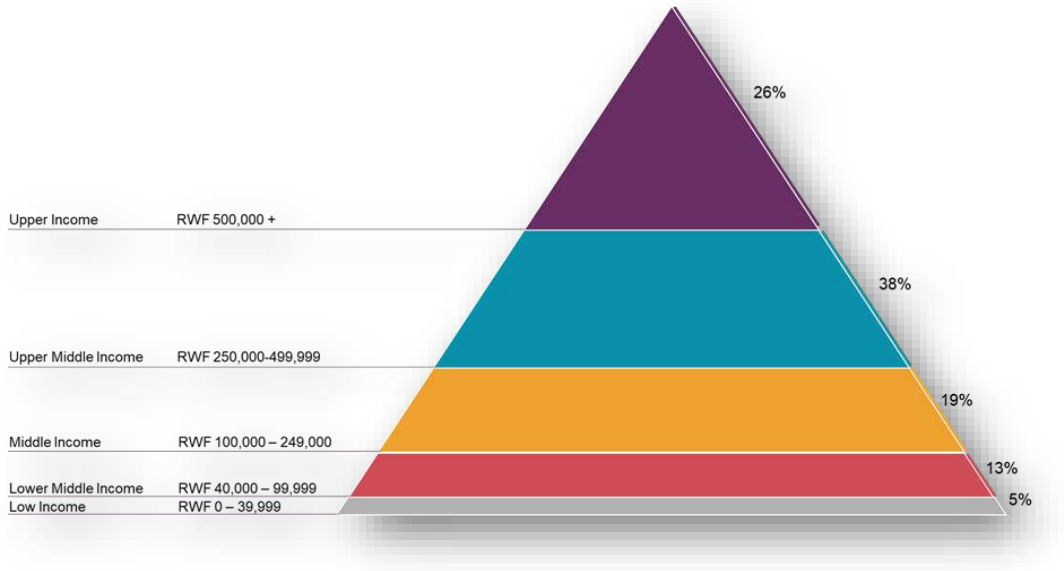

Figure 38: Income (Monthly) Distribution in Kigali 2019 (IGC -- Confidential)

By calculating affordability of current submarket formal housing products against these income distributions at a rate of the 35% of household income on base housing costs and using prevailing costs of finance, we determined that a household would need to earn RWF 1.3m monthly to afford the cheapest unit in a new development ("Vision City") in Kigali and would need to earn RWF 165,000 monthly to afford the least expensive subsidised product ("Batsinda Unit"). The conclusion of this exercise is that there are affordability gaps at almost all levels of the income pyramid, and that even the most subsidised and "basic" formal accommodation on offer is out of reach for low income households. Using submarket housing units as a basis for the calculation shows that while the government and other actors have attempted to drive down outright purchase price, the cost of finance acts as a major barrier for the affordability of housing.

As a result, we determined that housing mix will be driven by finance mechanisms for three main income categories including

i. Those falling below the poverty line would require subsidized housing (and those very poor, vulnerable households eligible for statutory social housing would require nearly 100% subsidised social housing units). This has been defined as 'free housing' or housing for the poor

ii. Those in the affordable housing category and lower end of the middle-income range will need Help to Own products to afford even a RWF 17m home. Some in the mid-range categories may be able to access mortgage finance on prevailing rates and terms but rental or rent to own products cannot be ruled out for a portion of this group as well

iii. Those in the premium housing range already can access mortgage finance

We have translated this model to an appropriate housing mix for a GCK that would see a base target population for the GCK to be

i. 10% of free housing (lowest income group at an income of less than RWF 200k monthly)

ii. 80% affordable housing (a low and middle income range from an income range of RWF 350-650k monthly)

iii. 10% higher income group (above median income RWF 650k monthly)

This model is premised on the assumption that proceeds that the market sale products will cross-subsidise the affordable housing products. This is a base case scenario, and this mix could change depending on sources of finance.

We do not believe that it is necessary to increase the higher income group product because the total floor areas of the higher income group is about 30% of the total floor areas of the housing units which may impact on the GCF application.

Also, this higher end could be saturated in the future because of planned new developments across Kigali.

Recommendation: We propose the base target population for the GCK to be 10% of free housing, 80% low- and middle-income housing and 10% higher income group housing.

6.3 Demand Considerations: The Mortgage & Capital Market

The CAHF estimated that in 2018 there was a total of 60,000 mortgages outstanding equivalent to 1% of GDP. They also determined that those mortgages had a total value of $534m or 453,860m RWF, an average of around $9,000 per loan or around RWF 8m. This is likely to be an overestimate of residential based loans as mortgages include commercial premises.

Based on the estimated number of mortgages, this is a penetration for mortgage loans of only one-third of 1% of households in Rwanda which is one of the lowest rates in Africa.

Residential mortgages range from 16%-20% per annum (CAHF) and investors' (property to rent) range from 15%-16% per annum. No meaningful reduction in market driven mortgage rates is likely to occur until the rate offered on government borrowings is reduced.

The private capital markets are inactive; there were only two corporate bonds, both short or medium dated, quoted on the Rwandan capital markets albeit the Capital Markets Authority would welcome more, and the Rwandan Development Board would assist and of these two. One has already matured.

Recommendation: Engage in follow-up work on the capital markets as a source of financing for the GCK and other affordable housing projects

This means that the alternative funding for long term retail mortgage debt through the capital markets is not currently a practical proposition. The problem is exacerbated by the issue of government treasury stock at 'premium rates' making competition for new funds unbalanced. Innovative security measures such as using entitlements in the RSSB pension fund security for deposits.

Recommendation: To address barriers posed by high housing finance costs, the GCK should implement a suite of housing finance interventions, including

i. Commercial banks using matched savings schemes, small purchase savings schemes with low administrative costs or low-start mortgages such as Help To Own (HtO). HtO has the benefit of reducing the amount of deposit, only requiring a mortgage from a retail bank of 50% which reduces the risk to the bank as well at the monthly interest and payment required. A 40% which requires no capital or interest repayment loan in the first five years. The interest rate increases incrementally from year 6 to reflect increase in household income. The overall aim is to maintain total costs at below 35% of household income for the tenor of all the loans over 20 years, at which point the loan is fully repaid. This minimises the amount of subsidy required to the difference between the interest rate at which Government borrows and the real rate on the deferred loan. This scheme was first piloted in Nigeria, modelled on schemes elsewhere in the world by Family Homes Fund a special purpose vehicle formed by the Nigerian sovereign wealth fund and Altair.

ii. To encourage savings in locally denominated bonds for government or one of the financial institutions

iii. Tax breaks which will enhance the returns on certain eligible bonds

6.4 Supply Considerations: Enabling Supply

The GoR has determined that for future property investment, particularly residential, it needs to support the capital markets and potentially look at tax breaks that would support those capital market issues which suit current government policy.

The government has been looking at how local authorities in Rwanda might issue municipal bonds. In February 2017 the Ministry of Finance and Economic Planning invited bids to shadow rate local authorities (including COK) for municipal bonds to finance infrastructure. It is understood that this has stalled with the issue of enhancing the repayment certainty where funding will depend on the infrastructure projects themselves or the central government as the government provides 90% of local authority funding.

It has also been suggested that certain sites within the pilot are identified for possible co-operatives. While the product would be similar to the most common form of personal construction in Rwanda, i.e. a self-build scheme but sped up and assisted with technical assistance and debt, this is a potential option as some SACCO[23] groups (e.g. teachers) receive subsidised mortgages from the GoR. This model could serve as a pilot at the GCK and could be extended to other cohesive groups.

Recommendation: Engage in follow-up work on the capacity of SACCOs as potential developers and rental.

Other innovative options for enabling supply identified in our research include:

i. Builders may wish to raise development finance to increase supply by accepting payment in instalments

ii. The SKAT incremental model seeks to land swap for equity in a finished home or homes.

iii. Provide financing vehicles that allow access to the capital markets for SACCO's that would enable 'cost rent' or 'rent to buy' options for their members.

6.5 Review of Commercial and Industrial Uses

To understand demand for retail and commercial space, we conducted research into the price and trends in retail and commercial space in Kigali. We found that currently there is demand for retail complexes especially those that conform to the standards of shopping malls elsewhere in Africa. However, the current trend is for developers to build mixed use retail/office developments with more office floor space.

Recommendation: A provision of a cluster of very small retail spaces of 5-40 sqm should be considered for part of the GCK

Recommendation: For the later phases when there is sufficient population numbers thought should be given to the viability of providing a shopping mall at the site.

It is unlikely with all the excess supply of office space in Kigali, and the effect that this will have on prices in the future, that Kinyinya will be able to compete with the city centre for office space. The general feeling is that Kinyinya is too far out for an office space destination and so no or very little provision of office space should be considered in Kinyinya. However, in later phases it may be possible to consider serviced or co-working office provision for small firms and NGOs. This is because these firms do not need to be located in CBD areas so if there were a great enough price differential, they may consider taking office space within the GCK.

There is huge demand for industrial space located within the correct planning zones within the Kigali area. This means that the GCK could benefit from having an area zoned for light industrial use within it. Ideally this would be an additional SEZ. There is sufficient demand to deliver this as serviced plots for developers and owner-occupiers to then develop out themselves. This will also enable the space to be future-proofed to capture future light industry uses.

23 Savings and Credit Co-operatives

Recommendation: The GCK should have an area zoned for light industrial use

Estimations of appropriate rents for the GCK based on market expectations and the likely incomes of the local population are (per month including service charge):

$4 - $8 psm for light industrial space per month including

$5 - $10 psm for office space

$15 - $17 psm for retail (shopping mall) from 80 -150 sqm

$15 - $20 psm for retail (street units) from 20 -40 sqm

$20 - $25 psm for retail (street units) from 5 -10 sqm

7.0 LOCAL JOB CREATION

7.1 Policy

Rwanda is experiencing one of the fastest GDP growths in East Africa and that such a growth in GDP is also translating to poverty reduction according to the World Bank (2015). The government prioritizes the creation of productive and decent jobs. This is reflected through its goal to create 200.000 productive non-farm jobs annually between 2011-2020. The aim has been to reduce the share of agriculture-based employment and enhance non-farm jobs. Such a measure is deemed to boost both growth in income and productivity of the workforce. The government aims to increase infrastructure development in secondary cities to make them attractive for investment and to create jobs.

7.2 Labour force

According to the national labour force survey (2018), there are significant variations in labour force participation rate and unemployment rate among the various regions in Rwanda. The survey points out that the city of Kigali experiences one of the highest unemployment rate of about 18.7% and that this is higher than the national average of 15.1% in the same year. The Northern region (11.2%) followed by the Southern (14.7%) and Eastern (14.7%) regions experience the lowest unemployment rates in that order. In the same token the labour force participation rate for the city of Kigali is one of the highest at 67.5% compared to the rest of the regions. It seems to be that the city of Kigali is feeling the heat of rapid urbanization reflected through job demands as compared to other regions.

7.3 Formal and informal

The 2018 Labour Force Survey (LFS) indicates that employment in the informal sector constitutes about 77.6% of the total employment, underlying the lack of decent work benefits. The job structure in non-farm activities in Rwanda reveals that self-employment in small enterprises dominates, followed by wage employment in the informal sector. The private formal sector absorbs four percent of Rwandans while the public sector employs only three percent of workers (WB 2015). Informal sector jobs and low wages largely reflect the skill of the workers. There is a correlation between higher level of education and the chance of joining formal employment.

7.4 Education and skills development.

The strategy needs to promote employment-intensive growth (such as labour-intensive infrastructure development projects), address structural bottlenecks in the labour market, and facilitate faster and better integration of the unemployed and jobseekers into productive work. Public employment services and technical and vocational education and trainings (TVETs) play a significant role.

7.5 Existing enterprises.

A closer look into the nature of enterprises in Rwanda reveals that an estimated 98 percent of enterprises are Small and Micro Enterprises (SMEs), of which 97.8 percent are micro and small enterprises, accounting for 41 percent and 36 percent of private sector employment respectively, thus the remaining two percent, or just over 120 enterprises, account for 59 percent. A sustainable reduction in poverty and informal employment, therefore, is dependent on growing the micro and small enterprises so that they can create more and better jobs. A holistic support for micro and small enterprises in Rwanda therefore has a multiplier effect.

7.6 Distribution of jobs across space.

Establishments are concentrated around the urban centres. Employment in tradable is concentrated around the Western Province. The service sector dominates employment in and around the city. Such activities as construction, retail trade and domestic services dominate new non-farm wages in Rwanda. While these activities are improvements over unemployment, their earing is so low that employees stay mired in income poverty while also working as these activities are not a high tech and thus non-exportable.

7.7 Policy and Legal Frameworks.

As a policy intervention, the National Employment Program (NEProg) launched in 2014 provides a framework for a coordinated approach to the implementation of active labour market policies across all sectors of the economy. Its stated objectives are: (1) to create a sufficient number of adequately paid, sustainable jobs across the economy, (2) to equip the workforce with vital skills and attitudes to deliver the increased productivity necessary for private sector

growth, and (3) to provide a national framework for coordinating all employment and related initiatives and activities in the public and private sectors and civil society (MIFOTRA, 2014).

7.8 Government initiatives.

The government strives to achieve decent jobs through various policies and strategies. For example, to achieve the employment objectives of the second-generation the Government launched the National Employment Programme (NEProg) in 2014 as a framework for coordinated implementation of employment and labour market policies. The NEProg comprises three substantive pillars: employability skills development; entrepreneurship and business development, and labour market interventions. These are supported by a fourth pillar: Coordination and M&E (ILO 2015).

7.9 Legal framework.

While Rwanda appears to have an implicit policy in favour of private employment services providers, there is no supporting legal framework to regulate their operations indicating the gap. The public employment centres likewise do not have a legal backing, as there is currently no law that provides for their mandate. There is thus a limited role for the unemployed youth to benefit from public investments or government driven infrastructure investment projects. This limits the size and role of government in influencing jobs directly. In many developing countries such as Ethiopia government led infrastructure developments and low-cost housing serve as important tools for job creation.

The relevant policies related to employment and jobs in Rwanda include but not limited to public employment services (PES), Labour mobility policy, national small and medium enterprise strategy, workplace learning policy. There is a need for all these policy frameworks to align with the national development plan and the national employment policy.

7.10 Strategic options for job creation and local economic development in Kinyinya

For the GCK and from the perspective of jobs a local economic development approach that embraces the local community, the government and the private sector should work together. This is discussed as the LED framework and its strategic options as below.

7.11 The Local Economic Development (LED) Framework for Kinyinya: the Players

Three players are identified for Kinyinya as a vehicle to bring local economic development and create jobs: (i) the government, (ii) the private sector and (iii) the community. The government provides public investment in infrastructure, increased investment in soft infrastructure (skills and human development), reduce barriers to entry for small enterprises, facilitate finance. The private sector transfers technologies and discharges corporate social responsibilities in the local economy. The community participates in facilitating participation, identifying main needs of the disadvantaged groups in the community, engaging in resource mobilization.

7.12 Key factors needed for job creation and Local Economic Development in Kinyinya

The following key issues are regarded as a requirement for sustainable job creation in the pilot area:

<u>Access to Capital</u>

i. Whether businesses in the local area or community can get money

ii. How easy is it for local companies, or perhaps a company planning to move to the community, to get financing?

iii. Who lends money, where they are located, and what amount of money is available in what form?

<u>Doing Business Environment</u>

i. Attitude of the community towards the Local Businesses: Supportive and encourages business confidence

ii. Entrepreneurship and risk taking

iii. A good doing business environment: Licensing, registration, start-up procedures, one stop shop services.

Infrastructure

i. Public facilities including streets, utilities, water, and waste disposal services

ii. Reliable roads, bridges, water, sewer systems, and other public facilities

iii. Infrastructure initiatives that create massive job opportunities for job seekers during construction phase but also during the operation.

Human resources

i. Availability of different types of skills, education, and attitudes of the labour force

ii. The culture of workers towards work and easily trainable and employable skills is an asset

7.13 Strategic Options/solutions for Job creation and LED in Kinyinya

Considering the above criteria, the following strategic options/solutions are proposed for Kinyinya:

Install training centres and skill enhancement programs

Kinyinya Hill would benefit from training centres such as for TVET (Technical and Vocational Education and Training) and Agriculture and integrated polytechnic regional centres. They would enhance the skill of the unemployed, or unskilled and increase the chance of employability. Activities would include: masonry, mechanical, hospitality and food processing, veterinary services, electrical skills, carpentry, hairdressing and tailoring etc. The Kinyinya Hill does not have these training centres.

Help existing local businesses improve and expand

Through sponsoring management training programs. Encouraging local leaders to visit businesses regularly and learning what community efforts could help local businesses prosper. Identifying sources of capital to meet local business needs and promoting greater capital availability for smaller businesses. Keeping local businesses informed about technological improvements that can increase efficiency. Improving the overall capabilities of local workers through vocational training and supportive services

Encourage the formation of new businesses from within the community.

Through forming pools of private local capital for debt or equity investment for new businesses unable to obtain additional capital from financial institutions. Providing first-time entrepreneurs with needed training in management, marketing, and business planning skills. Using data assessment to identify overlooked production and market potential in the community. Extending the same services available to existing businesses to fledgling businesses.

Improve the community's ability to retain income within the local economy.

Through helping businesses identify local market potential through surveys and business analyses.. Coordinating revitalization of the community's business district. Assisting businesses to improve their customer service. Using promotion and advertising to attract visitors and residents of nearby communities to purchase local products and services. Informing residents and businesses about local purchasing options. Reviving a downtown area as a place to meet friends and enjoy time together;

Attract basic Employers from other Locations

Identifying appropriate industrial/commercial zones and ensuring the availability of necessary services. Promoting a unique feature of the locality enjoyed by local citizens. Helping to stimulate capital availability through lower-interest revenue bonds. Investigating the benefits of having new public sector offices or facilities locate nearby. Forming organizations, such as industrial development corporations, to facilitate property acquisition for business use.

Job Creating Activities to be implemented on the Hill

Considering the strategic options above and the LED framework, a closer look was made into the existing resources (goods and services) based on personal observation and secondary data. The potential jobs in the Hill has been estimated from the planned infrastructure developments and its potential comparative advantages. Given a population size of about 185,000 persons on the Hill, several service-based activities can also create jobs, besides the agriculture and manufacturing activity. The strategy we follow to create more jobs on the Hill is the one of local economic development framework which emphasizes: I) help existing local businesses improve and expand, II) encourage the formation of new businesses within the community III) improve the community's ability to retain income within the local economy and IV) attract employers from other locations. V) use TVETs and training institute programs as a vehicle for skill enhancement.

7.14 Infrastructure Investment

The physical infrastructure and equipment for the employment creating activities are so vital that they make a crucial component of the feasibility for the GCK. Jobseekers, particularly the young, unemployed and unskilled need to have facilities adapted to their needs. Training centres and other government led skill enhancement institutions could help match the jobs and job seekers, given appropriate intervention. The following assumptions and estimations were made:

<u>Assumptions for the infrastructure investment requirements</u>

i. The City of Kigali has a labour force participation rate of about 67.5% (Labour Force Survey (LFS) 2018). The unemployment rate for the city of Kigali, according to the LFS (2018) is 18.7%

ii. From the above the total persons unemployed in the Hill equals 22,720 persons.

iii. The GCK targets unemployment level on the Hill to be about 5% of total labour force participation (which is 6,075 persons). A zero-unemployment level does not exist.

iv. From the above the total number of jobs expected of the GCK on the Hill is thus 16,645 persons.

v. The job creation activities follow the existing goods and services but also assumes other urban based services will come to the Hill, given the GCK.

vi. Type of infrastructure investments follow the type of activities.

vii. The proportion of job distribution across the various activities is based on the 2018 National LFS

viii. Accordingly, the following activities and Infrastructure requirements are proposed on the Hill

ix. See full sector report in the annexures

8.0 CROSS CUTTING ISSUES

Cross-cutting issues like the Environment and Gender equality are relevant to all aspects of development. In this Feasibility Study they have been a focus for all the sectors, however in this section they will be described in more detail. The cross-cutting issues include the Preliminary Environmental and Social impacts of the proposed solutions, also how the aspirations of women and youth have been considered as well as how a climate resilient development can be achieved. The following cross-cutting issues are considered: (i) environment, (ii) women and youth and (iii) climate change.

8.1 Environmental and Social Impact

With the Feasibility Study the potential environmental and social impacts of the future development has been evaluated on a high level. A full ESIA will be carried out in a later stage of the project as it is a requirement for the application to GCF. In the preparation of the high level environmental and social impact assessment the relevant national laws and public policy setting and compliant to international standards (WB) has been mapped and analysed, this is included in the sector report which is an annex to the Feasibility Study. Below follows a brief summary of the regulatory framework, present physical, biological and socioeconomic situation and a summary of expected impacts.

Policy, Legal and Institutional Framework

The GCK Project is consistent with Rwanda policies, legal and institutional frameworks addressing the environmental, social and economic aspects of green and resilient urban development infrastructures. The project will be implemented in a context of environmental sustainability, ensuring that environmental impacts are mitigated to ensure a clean environment to the parties affected.

The full ESIA study that will be conducted after the project is categorized will be consistent with policies and legal frameworks. To comply with the law governing Biodiversity in Rwanda, critically endangered species, vulnerable species or other species with conservation value shall be identified and options for conservation proposed. A specific focus will be on Deutsche Well site and the surrounding wetlands.

The GCK project design will consider protection of ecological functions of the different sensitive ecosystems on the site, and especially the wetland located around Kinyinya Hill. By avoiding any encroachment in forest reserves, the project contributes to promotion of the National Forest Policy's objectives Water and Sanitation infrastructures will consider using technologies that do not deplete water resources and optimize the use of water resources with very adequate and clean infrastructures.

The proposed GCK project will consider a PPP development, therefore, allowing the private sector to be involved in the implementation and monitoring for efficient management of resources and infrastructures. During the project implementation, the following environmental compliance will be required all time: Waste management; Aerial emissions, Effluent discharge practices; Excessive noise and vibrations; Social disruption control; Excavations and soil loss; Adverse interference with natural resources including forest, wetlands and water resources.

The developer and the contractor on the ground will closely work with local authorities and environmental committees. All health and safety measures should be in place to ensure the workers and the neighbouring communities are not exposed to risks.

As per the project details and its screening, the project will be classified as per categorization of World Bank guidelines and Rwanda EIA guidelines. Therefore, the ESIA will be undertaken through that consideration and submitted for approval.

The Project will comply with orientations of the National Land Policy and Expropriation law by implementing a Resettlement Action Plan (RAP) if needed and the Environmental and Social Monitoring Plan (ESMP) to ensure biotic environment and biodiversity are guaranteed.

A detailed list of relevant policies, legal and institutional frameworks is appended in Part II of this MT Feasibility Study; GCK- ESIA Final Report: Baseline, Policies & Potential Impacts Analysis.

Present Physical Environment: topography, climate, geology and solid waste.

The project area is located within the fastest growing area of Kigali in the Kinyinya Sector. Kinyinya hill and the surroundings are characterized by undulating hills, with average altitude of 1,504 m, mainly located in the rural zone, sloping basins and valleys.

The southern part of the proposed planning area is dominated by a wetland that regulates the flow and flooding of the valleys around Kinyinya. The wetlands are connected to the Nyabarongo River and could contribute to the river overflow during rainy season.

There are two major climatic seasons in a year, the dry and rainy seasons. The temperature throughout the year is quite stable with an average of 21.1 °C, August is the warmest month. At 19.9 °C on average, June is the coldest month of the year. The driest month is July with 7 mm of rainfall. In April, the precipitation reaches its peak, with an average of 158 mm.

Kinyinya Hill geology is dominated by granite and pegmatite. In essences this indicates average storage and transmission properties resulting in low groundwater recharge rates and baseline flows.

The soil on Kinyinya Hill mostly consists of Cambisols and Alisols which are moderately deep and more fertile than Ferrasols. On steep slopes the soil is susceptible to erosion. Along the valley bottoms the wetlands manly consist of clay soils with moderate fertility and low infiltration capacity.

Rwanda has seismically active zones, according to USGS (2008) and MIDIMAR (2013), the areas most impacted by seismic hazards are in the western and northern provinces, causing deaths and damages. Earthquakes in the western and northern provinces are sometimes felt in Gasabo District and Kinyinya sector at lower levels. These seismic activities are not likely to cause damages of well-constructed housing infrastructures up to G+1 or more.

The Kinyinya Sector water resource has over 30 wetlands and small rivers traversing through the valleys. There are no water sources on the Kinyinya hill. However, small creaks are meandering within the wetlands surrounding the proposed Green City project site.

Solid waste is currently managed by the Isuku Kinyinya Company Ltd, a waste collection company is operating in the project area. Households have waste collection once a week and businesses as often as needed (mostly daily). There are currently no large waste generators on the hill, the main commercial activities generating waste are hotels and waste from tax park bus station. There are no waste treatment facilities like community composts at the hill, nor small scale recyclers or scrap workers.

8.2 Biological Environment: Flora and Fauna

Gasabo district has the largest forest cover of the districts in Kigali City and is well linked to large rural zone area. The district and Kinyinya Sector's natural flora have been depleted and is being replaced with artificial vegetation mainly of eucalyptus trees. The few remaining natural vegetation is found in the Deutsche Welle site and uncultivated small areas in the wetlands.

Eucalyptus dominates the tree species that are visible in the area. The wetlands are a critical system. They act as a filter of waste from the different top areas and regulates the flow and flooding in the area. Another important area with a pleasant environment (including fauna and flora) is the former Deutsche Welle site. Although it is a mixed used land, the trees planted dominate on the land cover.

The fauna is characterized by a large diversity of bird species and small wild animals compatible with the existing vegetation cover in the Sector.

8.3 Social-Economic Setting

The Kinyinya GCK planning area is currently made up by residential areas (mostly informal) and pockets of commercial activity, farming lands and public and social infrastructures such as schools, churches and health centres. The public infrastructures include roads, side drains, water supply networks and street lights in a few areas. The houses are mixed with low, medium and few high standing houses.

Population and demography: According to the preliminary results of the 4th Population and Housing Census (2012) indicated that Kinyinya sector had a population of 57,185 representing 10.7% of the total population for Gasabo District (530,907, population) and 5% of the total population of Kigali City (1,135,428)24. The population of Kinyinya has a higher proportion of men: 29,740 are men corresponding to 52% of the total population Gasabo district.

The EICV 3 (2012) survey results similarly indicated that Gasabo District's labour force is 280,000 people constituting 4.8% of the country's labour (5,888,000 people). The results showed the district has the biggest labour force in Kigali city.

Gasabo District's agriculture sector is mostly based on cultivation of Avocado (42.9%) and French beans (36.1%) as well as on export crops like Sugar Cane (5%) and Coffee (2.8%). On national level, the majority of households are growing French beans (65.8%), Avocado (37.4%), Squash (26.2%), Cane Sugar (10.9%) and Coffee (10.8%).

Preliminary potential impact analysis

The GCK design should consider the Green City Standards and low adverse impacts for smart cities. Parties such as the health sector, businesses, engineers, designers, the building sector, developers, cities / local governments and of course the residents themselves can all gain from green in the city.

Below, is a summary of potential significant positive and negative impacts related to the development of Kinyinya GCK project.

Positive impacts

i. Improved Human Health through improved housing and public infrastructure

ii. Employment, skills and economic development as Green jobs and learning facilities will be created

iii. The cost of green is an investment with a climate resilience added value

iv. Businesses benefit from quality public projects as they are more attractive to new talents and innovation

v. Increased Land Values and neighbouring Real estates to the Green City are more valuable because of housing quality

vi. Regulation incentives encourage good development for businesses to locate their business in the Green City

vii. Reduced impact on Climate Change as green infrastructures reduce stormwater flows, lower heat stress, create greater biodiversity, conserve energy and sequester carbon

viii. Increased carbon sequestration as green infrastructures serve as sources of carbon sink where carbon dioxide is captured and removed from the atmosphere via photosynthesis and other natural processes

ix. Ecosystem services as Green roofs and walls, allotment gardens, parks, private gardens, street trees will all provide habitat for thriving ecological communities and help to boost biodiversity in the city

x. Social interaction as greener environments encourage people to spend more time in outdoor spaces which in turn increases the rates of social interaction and mixing

xi. Improved air quality as trees and vegetation absorb certain air-borne pollutants through leaf uptake and contact removal

xii. Heat mitigation and reduced energy demands as tall buildings and narrow streets trap and concentrate waste heat from vehicles, factories, and air conditioners

xiii. Reduced and delayed Stormwater Runoff volumes and lowered peak flows through using the natural retention and absorption capabilities of vegetation and soils

xiv. Reduced localized flooding as green infrastructures recommend rainwater harvesting and local management in ponds or constructed wetlands to minimize water volume in roadways

xv. Enhanced Groundwater Recharge through natural infiltration capabilities of green infrastructure technologies

xvi. Stormwater pollutant reductions as green infrastructures infiltrate runoff close to its source and help prevent pollutants from being transported to nearby surface waters

xvii. Reduced sewer overflow events by minimizing runoff volumes and delaying stormwater discharges

xviii. Additional wildlife habitat and recreational space such as greenways, parks, forests and wetlands

xix. Increased cost efficiency since the city would reduce grey infrastructure and reduce wastewater pumping and treatment costs per year by employing green infrastructure techniques

Adverse impacts

i. Involuntary resettlement due to new green and blue infrastructures such as roads, recreational areas

ii. Loss of vegetation and Biodiversity through vegetation clearance during the construction phase

iii. Visual impact on existing scenery due to construction of multi-storey buildings

iv. Drainage and stormwater will increase as paved and house roofs surface areas augment which will impact water quality downstream in surrounding wetlands

v. Microclimate modification as the buildings will reflect the sun heat thus modifying the area microclimate

vi. Fire hazards outburst in buildings will inevitably have an environmental bearing on the atmosphere

vii. Electric installations within and outside the facilities present a potential environmental hazard if not properly addressed.

viii. Water consumption for city dwellers will be an additional water demand which may cause water shortage in the project area and immediate surroundings of Kinyinya hill.

ix. Seismicity may intensify and reach the project area

x. Landslides and soil erosion may be increased due to high slopes and increased runoff

xi. Sewage treatment as wastewater generated may pollute the groundwater and surface water

xii. Energy consumption may create a shortage of power supply from the national grid and increase emissions due to the use of non-renewable energy

xiii. Increased traffic may reduce accessibility and safe transport for non-motorized systems which will have also an impact on air quality

8.4 Gender and Youth

The Government of Rwanda has made it a priority of promoting gender mainstreaming as a cross-cutting catalyst to changing the game of inclusion, improving the welfare of Rwandans (women, men, youth, children and people living with disabilities), speeding up economic development, improving access to public goods and resources. The registered achievements with regards to female participation in leadership and decision making, more women engaged in doing business, accessing education and safety in public places is not an end, rather serves as a benchmark look further into all other sectors where gender mainstreaming is still required the most.

When a new urban redevelopment scheme is proposed, like the Green City Kigali Project, developers and city officials typically take three primary concerns into account

i. How the development will be financed, and in turn, what economic benefits it can bring

ii. Urban infrastructure's environmental impact and sometimes its own sustainability

iii. How to gain the support of local stakeholders to implement the project

With the environmental, economic and governance dimensions of sustainable development is considered, the gender dimension is often a lower priority. Developers sometimes assess the social and health impacts of established plans but often do not integrate social factors into planning and design to take into account how facilities and services affect women, men, youth, children and the old differently. Cities are dynamic places. Public areas, housing, and transport hubs all offer unique opportunities for developers to create potential positive social impacts and benefits that include strengthening community bonds, enabling access to jobs, and making streets safer for all among other benefits they offer.

Planners, designers and builders can therefore integrate gender mainstreaming objectives into key stages of development plans, from scheme conception, design choices, to ongoing monitoring and evaluation to bring lasting social benefits among community members. This idea of ensuring successful functioning and long-term existence of communities – is evolving.

There are few clear examples of how this emerging paradigm can work to improve urban development practices in a world where poor and middle class can share available resources for purposes of improving the way of life for the underprivileged. Some of the factors to deal with are such as quality of housing, local services and living environment, experienced health and security, people's ways of life, gentrification or segregation, conditions of transportation etc. The current situation at Kinyinya Hill is that the poor and middle-class families are on different locations on the Hill.

Most of the gender specific challenges are deeply entrenched in patterns of patriarchy which require women to concede to men's prerogatives in respect of enjoying a fair share of owning and accessing assets, especially land, leave women less bargaining power over such matters. This then raises common explanations for gender disparities in shelter and the tendency for land and housing to be registered in the name of (male) "household heads" leaving women's limited access to stable employment and earnings, finance and credit as most of the people use it for collateral in banks to acquire more money to finance their projects.

Another aspect to address in gender mainstreaming is quality of environment. – whether driven by economic constraints or sociocultural norms, women frequently make substantial contributions of time, money and labour to the housing stock but the conditions under which they operate are less likely to be favourable. The injustice of this situation is further underscored by the fact that even simple adjustments to a situation that can bring about change is not usually prioritized.

Women's access to different spaces in the city – especially public space – is generally more limited than for men, not only on account of the association of reproductive labour with the home, which impinges on the time and ability to engage in extra-domestic activity, but also because of strong symbolic dimensions surrounding the use of spaces governed by patriarchal power relations and norms of female propriety, which may require certain modes of dress, behaviour and limitations on social interaction to render women withdrawn.

Another crucial gender issue in public transport is personal safety and security. Where transport connections are situated in isolated or poorly lit areas, or bus carriages are heavily overcrowded and/or inadequately or ineffectively staffed, women and girls face verbal, sexual and physical harassment and even assault, resulting in physical harm, psychological anxiety and fear of moving around the city.

The "gender lens" brought up for this assessment, calls for looking into these matters differently which comprises a range of multi-dimensional and multi-spatial perspectives on urbanization, hinders women's immediate prospects of benefiting from "urban prosperity". Accordingly, diverse interventions are required on several fronts and levels.

The following design parameters have been a part of the Feasibility Study of the Green City Kigali Project:

Proximity and Mixed-Use Development

Ensure that Kinyinya Hill and its neighbourhoods are well served by facilities supporting daily activities, such as healthcare, education, sports, leisure, and shopping.

Develop a variety of specific facilities for child and elder people care.

Promote employment options in locations accessible to residential areas.

Ensure that essential services are integrated into employment areas especially for women and youth.

Transport

Define public transportation infrastructure and routes that will consider trip-chaining and commuting patterns for women and men who combine employment, household, and caring duties.

Analyse sex and gender in relations to ergonomics and safety in the design of vehicles, routes, stations, and pedestrian paths leading to them.

Develop transport services suited to the specific needs of women, the young, elderly, disabled, and other groups.

Public Space and Safety

Monitor, plan, and implement specific measures for the different safety needs of women and men in public space design and maintenance, using gender aware methods.

Housing

Explore housing designs that address the needs of working mothers and fathers, youth and of older people, and integrate common facilities as well as provide flexible spaces.

Ensure a mixed and diverse stock of housing typologies, tenure regimes, and prices that are affordable to women and men equally.

Educational, Health, Commercial, Leisure and Other Facilities

Consider women's and men's needs and desires with respect to family care as well as the specific needs of the elderly and people with different degrees of functional ability in the design of community facilities.

The project has undertaken additional surveys and workshops to deepen the gender and youth context of the Project in preparation of the ESIA.

8.5 Climate Change Resilience

The main issues on climate change adaptation and drainage for Kinyinya Hill are related to the sloped topography. In urban sloped environments, storm water generally does not have enough time to infiltrate, resulting in high runoff speeds. In turn this leads to erosion and downstream flooding and siltation. When water is unable to infiltrate, groundwater tables are also insufficiently supplemented compared to a location with flat terrain. This in turn results in plant degradation (trees etc.), reduced baseflow in downstream rivers and reduced ability to use groundwater as a potable water resource.

These problems are aggravated by climate change. Climate change will result in increased rainfall intensities and increased periods of drought. This causes increased runoff and lowering groundwater tables. Climate change adaptation and drainage measures should focus on preserving (as much as possible) the exiting runoff situation whilst considering the increased periods of drought and increasing rainfall intensities. In addition, measures should be considered to reduce the heat island effect and minimize the risk of flooding and landslides (which is also a component in the Rwanda Green Building Minimum Compliance System, RHA 2019).

Existing Situation

The existing climate in Kigali is characterized by two rainy seasons and temperatures that are rather stable throughout the year. The Mean Annual precipitation in Kigali is around 1000mm a year[25][26]. The Computed Rainfall Intensity-Duration-Frequency for Kigali for one hour with a return period of 100 years is with 60mm average.

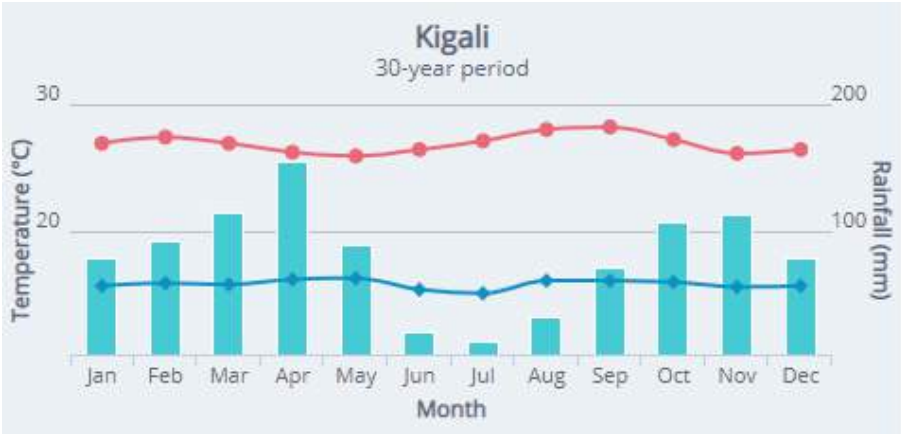

Figure 39: Average monthly rainfall (shown by blue bars) and temperature (average high temperature shown by red dots and average low temperature shown by blue dots)

The changing climate affects rainfall patterns and temperature. These changes have highly diverse impacts which current cities are not built for. Therefore, for each new development, changes in the climate should be considered. For Rwanda the following changes in climate are expected.

[25] WMO (2019) World Meteorological Organisation
[26] Wagesho, N.; Claire, M.U. (2016) Analysis of Rainfall Intensity-Duration-Frequency Relationship for Rwanda.

Aspect	Change by 2050	Impacts for Kinyinya Hill
Temperature	Increase average annual temperature of 1.4 – 2.3 degrees Celsius.	Decreasing water quality, increase vector borne diseases, impact on biodiversity, heat stress and increasing electricity demand due to increased demand to cool buildings.
	Increased duration of heat waves by 7-22 days.	
Rainfall patterns	Increase in average rainfall (range -3 to +9 percent).	Flooding, landslides, damage to houses, roads and other infrastructure, water shortages, power cuts, pollution of water resources.
	Increased heavy rainfall event frequency (7-40 percent) and intensity (2-11 percent).	
Droughts	Likely increase in the duration of dry spells with a range of 0 to +7 days.	Water shortages, habitat degradation, decreased air quality.

Table 21: Climate change impacts[27]

Proposed measures

The following concepts for climate adaptive design are to be considered when designing the new development.

Climate aspect	
Heavy Rainfall - Flooding	Multi-level safety → where to build and where not to build. Retain - store – drain Disconnecting paved surfaces from sewer system
Droughts	Retain - store – drain Native/drought-resistant species Improve infiltration / use soil storage capacity Disconnecting paved surfaces from sewer system
Heat	Create shadow Add green Building materials that minimize heat gains Optimize orientation to wind and sun
Disasters – Landslides	Do not build on unstable ground (usually steep slopes) Strategically infiltrate or drain water (only when unavoidable) stabilize slopes

Table 22: Guiding principles for a climate adaptive design on Kinyinya Hill.

The climate resilient drainage plan considered for this Feasibility Study is based on the basic principles Retain, Store and Drain. It consists of a storage and infiltration area on top of the hill and a circular green street ditch that conveys water to green drainage swales with check dams. On the building plots we propose various measures that reduce runoff from these plots to a minimum amount. Plot measures focus on retention and infiltration and rainwater harvesting and usage. Rainwater harvesting is mandatory under the Rwanda Green Building Minimum Compliance System.

i. Retain and store water on or in the buildings

ii. Retain and store water in the gardens

iii. Infiltrate water in the roads

27 USAID (2019) Climate Risk Profile: Rwanda

iv. Retain and store water in swales and wadi's

v. Drain water into check dams where it can infiltrate

vi. Drain the water via channels into the wetlands.

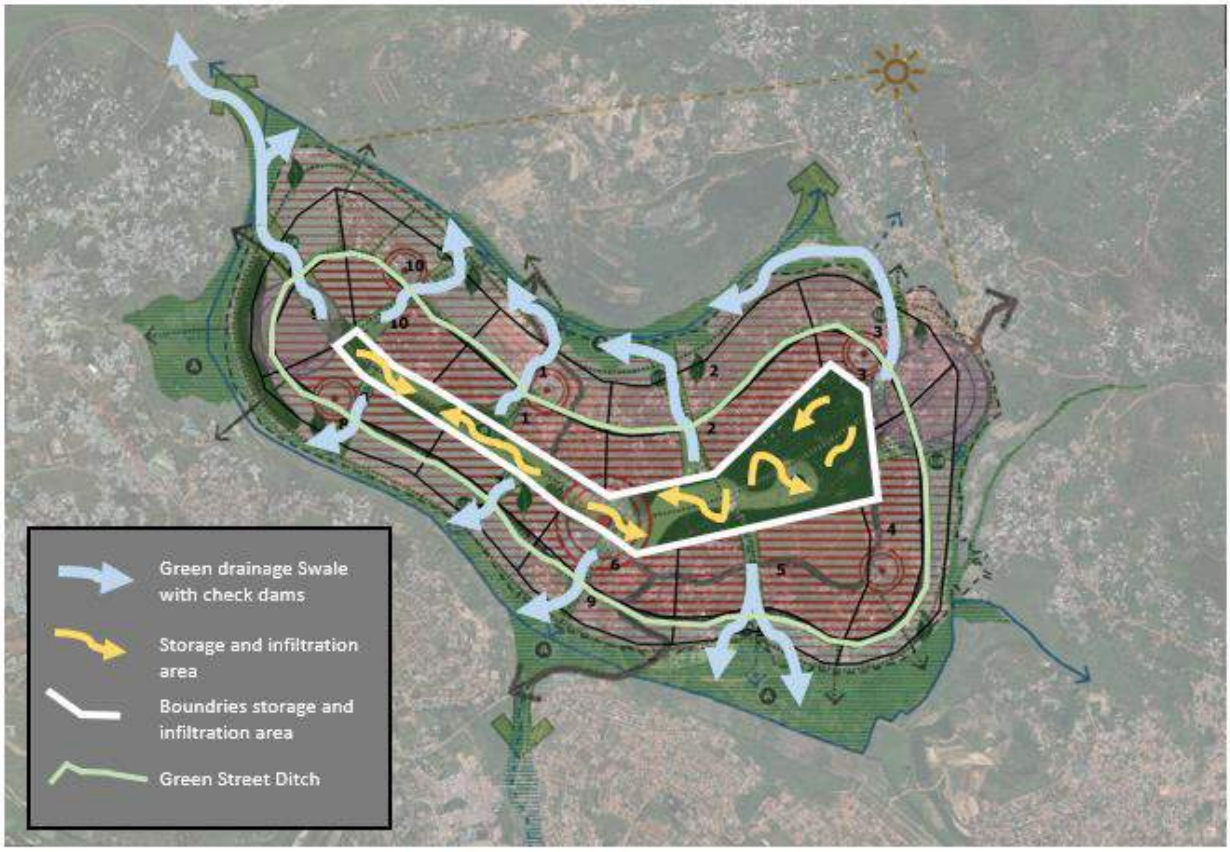

Figure 40: Conceptual drainage Design on Kinyinya Hill.

The sections below outline solutions that are proposed for designing the climate resilient plan.

Public Park

In the climate resilient version all the rain water that falls in the park is to be buffered and kept in the area. This helps to ease the pressure on the surrounding neighbourhoods in the case of heavy rain. It also provides a change for infiltration and recharge of the water supply of the area.

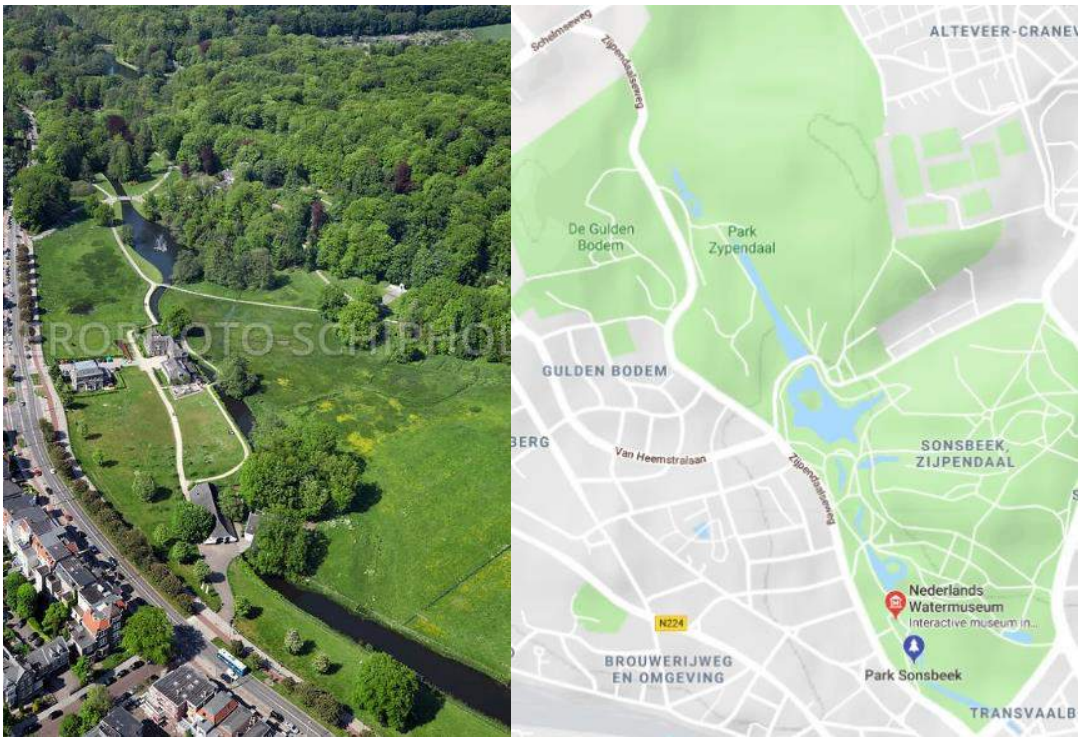

Figure 41: Public park

A series of sand dams can also be used to retain water in public parks. In this case there is no open water. The water infiltrates into the sand bed behind the dam and can be pumped up when there is a shortage of water. If the soil behind the dam is saturated the water will just flow over the edge of the impermeable dam into the next.

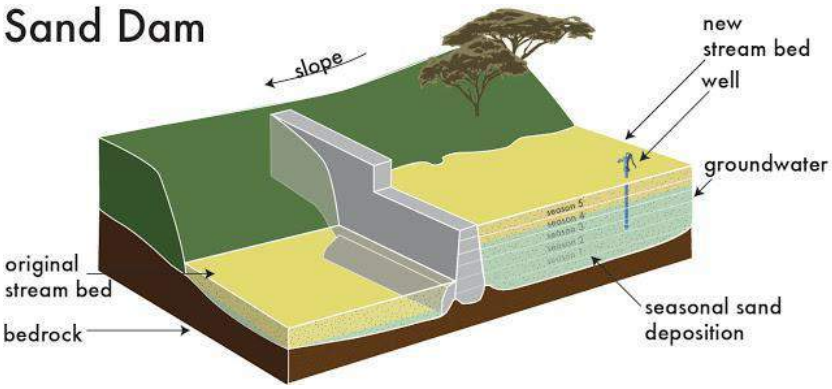

Figure 42: Sand dam

A bioswale is similar to a sand dam with the exception that it isn't intended for water storage. A depression of the ground level is made where water can flow to. It is often combined with a drainage system when the soil has a low permeability and natural infiltration isn't possible. An outlet is often included so that the surplus water can flow into a sewage or drainage system.

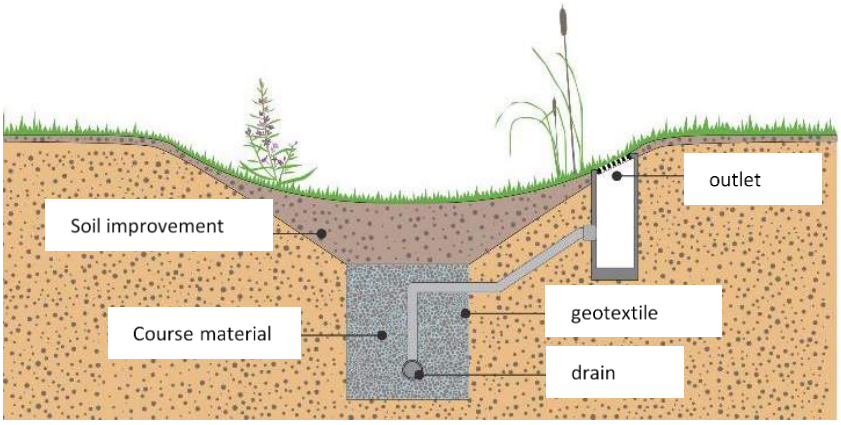

Figure 43: Bioswale

Green street ditch

The green street ditch is an example how a green drainage channel can be integrated into the design of a street section. The green street ditch reduces runoff speeds, improves drainage, increases green area, reduces city temperatures and allows for an attractive and healthy city scape.

Figure 44: Cross Section Green Drain[28].

[28] OZ architects (2010) Sustainable Urbanism Kigali Sub Area Plan.

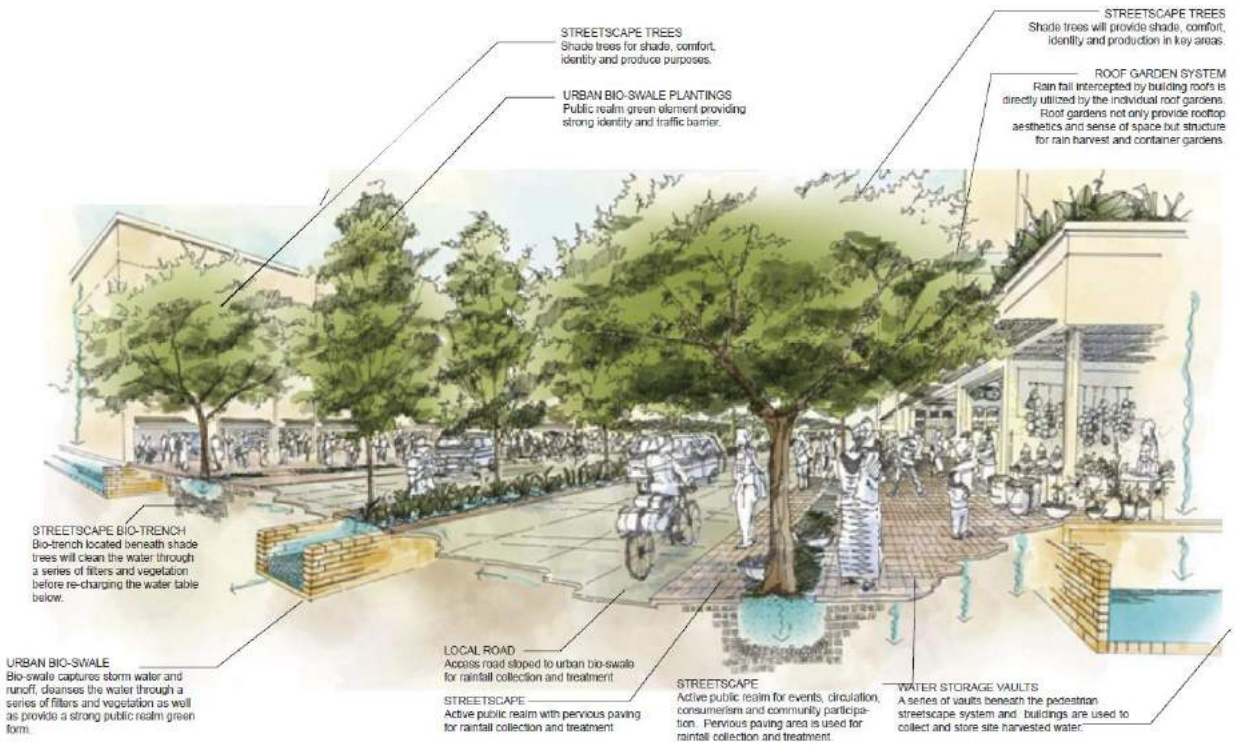

Figure 45: Cross Section Green streetscape with climate adaptive measures[29].

Measures Preventing Landslides

To prevent landslides from occurring, construction should be located on suitable areas. Guidelines are in the below table.

Slope	Guideline
0-10%	Suitable
10-20%	Suitable in combination with low tech measures to prevent soil erosion and stream sedimentation.
>20%	Unsuitable (Rwanda Urban Planning Code)

Table 23: Guidelines for building on slopes.

Water retention on private plots

Precipitation on private properties is assumed to be handled locally. Depending on the underlying soil several options could be used. A part of the property could be lowered and function as a bioswale or retention pond. This would create space to keep the water temporarily and infiltrate or release it with a delay. Also, it would be possible to dig in storm water retention tanks or let the gutter flow to rain barrels above ground. It is necessary that the rain barrels can empty out, otherwise no water can be stored during a precipitation event. A similar measure is to drill a deep vertical hole filled with gravel that allows water to slowly infiltrate. The latter measure could contribute to restoring water levels in aquifers that might function as a water source for the development on Kinyinya Hill.

[29] OZ architects (2010) Sustainable Urbanism Kigali Sub Area Plan.

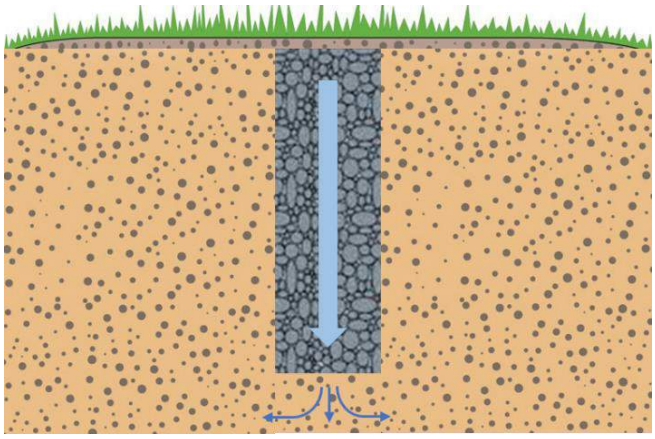

Figure 46: Vertical drain filled with gravel

Regular drainage channels

For this Feasibility Study, the climate resilient drainage plan slows down the water with check dams.

Figure 47: Climate resilient channels allowing for infiltration

The proposed measures for the drainage system are focused on storing water in the soil (soil dams or bioswales) or preventing water from becoming stagnant (check dam structure). These should be designed to not result in stagnating water, and therefore an increased risk of vector borne diseases.

Only the measures proposed here that involve creating open ponds on top of Kinyinya hill increase the risk of vector borne diseases as it provides ideal breeding locations for mosquitoes. For these ponds additional measures are required to control larval development. The following measures can be considered30:

i. The ponds should be deeper than 60 cm

ii. The pond ridges should be steep, preferably vertical

iii. Improve water circulation by adding a fountain, waterfall, or other devices

iv. Remove excess vegetation and organic debris that provide mosquito larvae with food, shelter from sun, and hiding places from predators

v. Introduce (native) fish that eat mosquito larvae

The required measures to prevent larvae development will increase maintenance costs of these structures. However, such landmarks could improve the urban landscape and reduce the urban heat island effect.

[30] Metzger M.E. (2004) Managing mosquitoes in stormwater treatment devices. UCANR Publications

9.0 SUSTAINABLE SYNERGIES

This section draws together elements of the sector specialisms in previous chapters to identify 10 sustainable strategies for the development which are underpinned by synergies among and between sectors. In summary, they are as follows:

11. The Smart Cycle of Local Wealth Creation
12. The Green-Blue network and Land Efficiency
13. TOD and Sustainable Communities
14. A Roadmap to Zero Carbon
15. Water Autonomy
16. Sustainable Wastewater Treatment
17. Waste Management and the Circular Economy
18. Information and Communications Technology
19. Urban Heat Island Mitigation
20. Spatial Synergies and Placemaking

9.1 The GCK 'Smart' Cycle of Local Wealth Creation

The overarching aim of the GCK project is to bring sustainable housing and liveable communities within reach of all income sectors in Kigali – particularly the lower to middle income sectors who at the current time are excluded due to constraints on affordability and supply. By undertaking this study along with its various outreach initiatives, knowledge and capacity is enhanced to make the point of entry to liveability urban communities more accessible; thereby sparking a virtuous cycle which creates more opportunities to a far greater proportion of the population who have the ability to stay and reinvest in their own communities and further build knowledge, wealth and capacity. We call this the GCK 'smart' cycle.

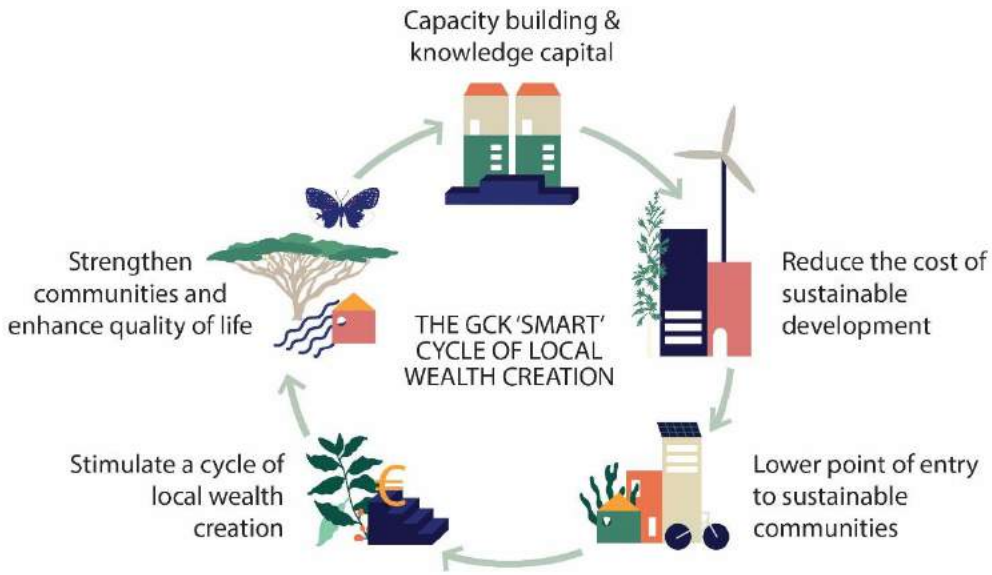

Figure 48: The GCK 'Smart' Cycle of Local Wealth Creation. Source: Sweco

9.2 The Green-Blue Network and Land Efficiency

Approximately 20% of the site area of GCK is undevelopable due to topographic constraints. Further, green (and blue) area must be maximised to ensure permeability to replenish the ground water resource, urban heat island mitigation, safe walking and cycling routes, protect natural habitats and create public open amenity space among

other aspects. Synergies can be found to overlap these land uses where appropriate thereby maximising developable area and increasing housing capacity elsewhere within the developable area.

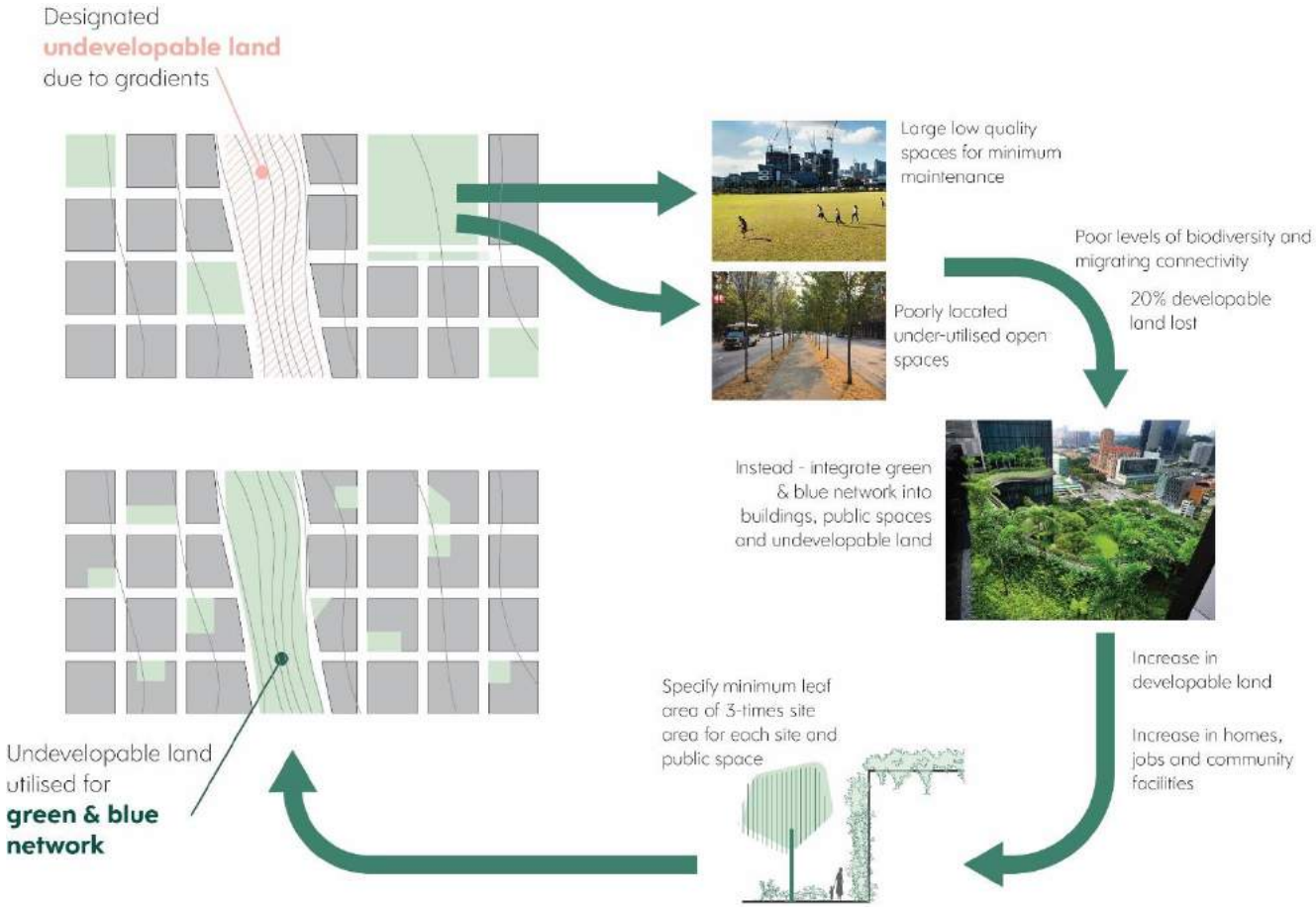

Figure 49: Green and blue network strategy

9.3 TOD and Sustainable Communities

Transit oriented development (TOD) is characterised by high density, compact mixed-use development focused around public transit corridors, with strong walking and cycling links to transit stops and reduced use of private cars. TOD supports liveable, sustainable communities in many ways. In conventional cities, roads and footways occupy typically as high as 30% of the surface area. In GCK however, a key aim is to radically improve conditions for walking, cycling and greener mobility modes to mitigate against the increase in private car use. Consequently, the project aims to reduce the road land-use allocation to about 16%.

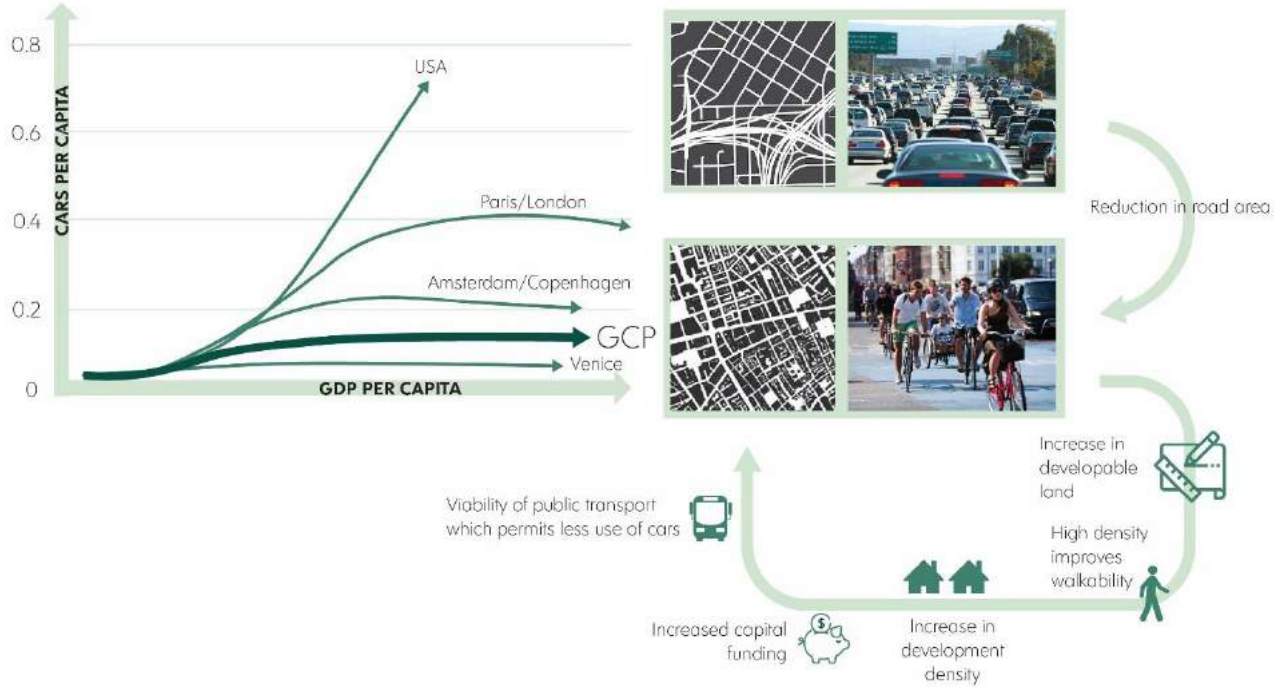

Figure 50: Sustainable transport strategy

By designing for modest levels of car use (roads and parking), land area is freed up to provide significantly more development. This enhanced development value and increased resident population helps to make better, greener community infrastructure including more viable, which includes high frequency public transport. This in turn supports a strong local economy still further.

Figure 51: A Local Economic Cycle stimulated by Transit Oriented Development (TOD)

TOD has significant wider sustainability and amenity advantages. As examples, it also feeds into Urban Heat Island mitigation by avoiding the large waste heat output from conventional road vehicles and reduces solar reflexivity from hard road surfacing while increasing evapotranspiration from residential areas (which can be soft surfaced). Reduced vehicle use and more walking and cycling also reduces road noise and air quality pollution, and hence avoids sealed building facades and allows year-round natural ventilation in Kigali's benign climate.

9.4 Roadmap to Zero Carbon

Energy use in Kigali is expected to increase rapidly as prosperity increases. In Rwanda this may not be a challenge in the short-term given its centralised excess generating capacity. In the medium to longer term however, when coupled with the need to turn away from carbon emitting fuel sources, a means of detaching economic development from carbon emissions is needed. Coupled with this is the current tendency of coping with demand peaks with heavy fuel oil and gensets.

The GCK proposes a roadmap and timeline to Zero Carbon using demand reduction coupled to onsite renewable electricity generation. It seeks to demonstrate that future increasing urban development and prosperity growth can be delivered without the high capital investment in centralised power generation and associated infrastructure. Key to this is showing how modern lifestyles can be achieved using significantly less energy use than would be the business-as-usual case.

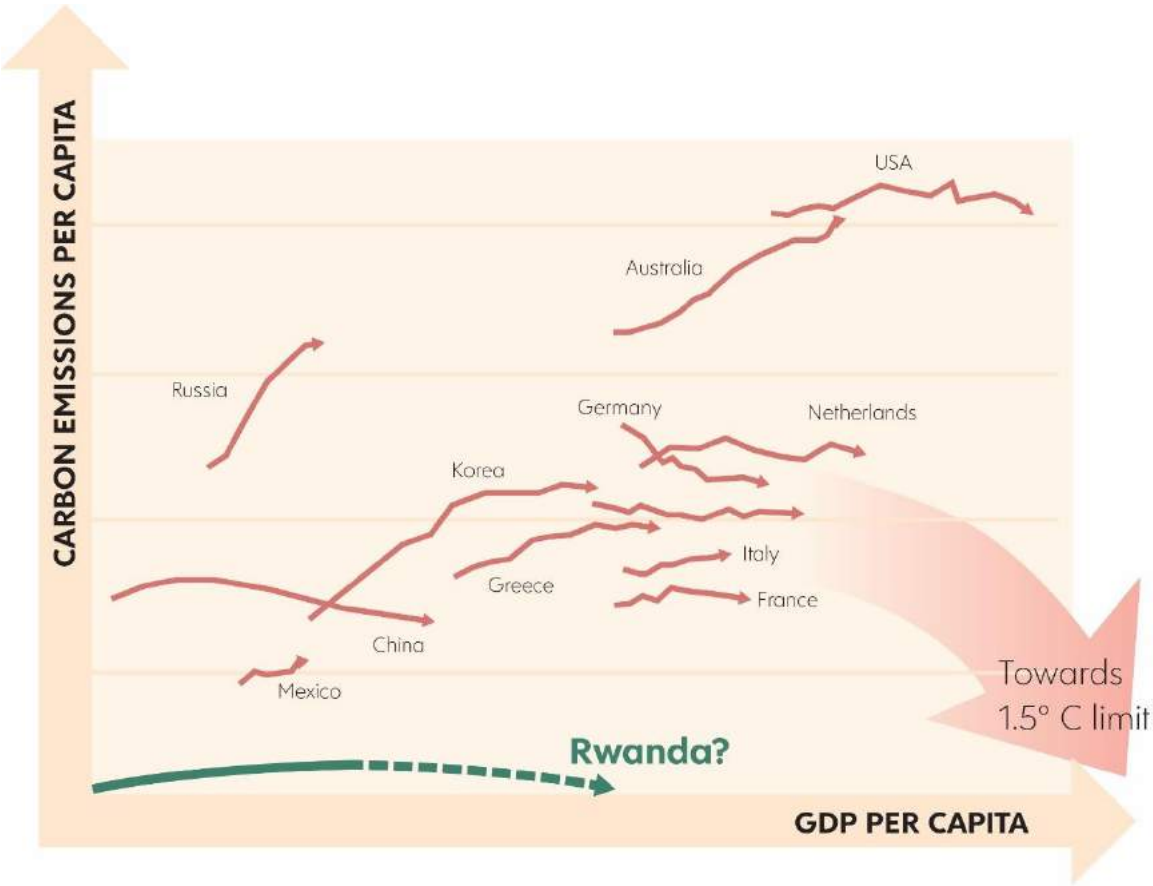

Figure 52: Future carbon emissions trajectory

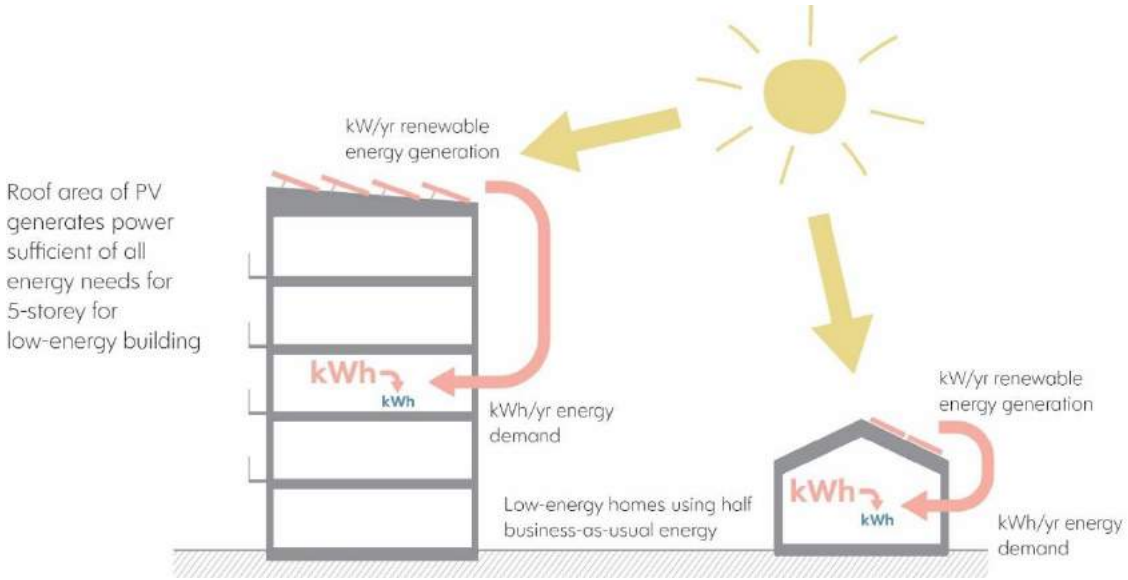

Figure 53: Zero carbon buildings

Resource Modelling has shown how building energy use can be more than halved using largely passive design and simple measures with collective paybacks of less than a year. This in turn means that the roof area of the buildings of up to 5 storeys can generate more than enough renewable energy to meet their overall energy needs and so become zero carbon. With many buildings being of fewer storeys, there is the potential for their roof area solar panels to feed excess power into the Grid for use by the infrastructure and for a future of electric transport. The need to implement local net-metering regulations or use third party ESCO arrangements is acknowledged for the shorter term.

There is significant potential to reduce the capacity of the local electrical Grid based on the building reduced demand. Subsequent detailed design is expected to focus on ensuring this reduced demand potential results in reduced peak demand and hence deliver reduced Grid capacity and capital cost needs. As outlined in the Resource Modelling section ensuring the correct governance is in place is crucial - requiring the land contracts, design and site implementation to deliver on this potential.

Figure 54: air-conditioning powered by PV

If air-conditioning is installed, then PV sufficient to power it should be installed to avoid adding peaks to the electrical Grid

Part of community governance is being able to accommodate a range of lifestyle expectations. The modelling indicates little need for air-conditioning; however, experience suggests that a modest proportion of occupants will wish to install it. Consequent requirements should be put in place for any air-conditioning to be installed with associated solar panel renewable energy generation on the building being sufficient to power the full demands of the air-conditioning. This avoids added peak demands being imposed on the Grid.

A timeline for GCK to become zero carbon is proposed. All buildings are to have solar hot water. The building roof designs are to enable the complete roof area to be ready for future installation of PV panels. Initially limited PV is installed for internal building use until net-metering regulations are in place.

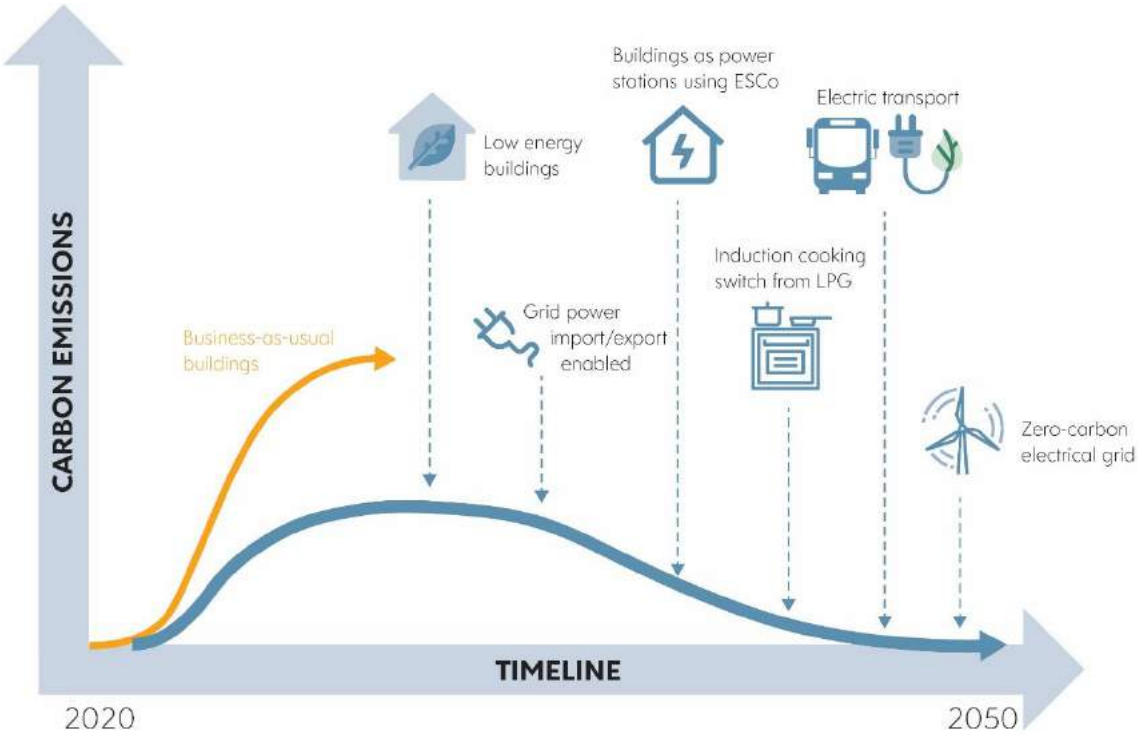

Figure 55: GCK Timeline to zero carbon

Initially LPG for cooking is anticipated in line with the Rwandan policy of moving away from charcoal. LPG is viewed as a short-term solution given it is a fossil fuel and an imported resource. The future aim is for a switch to induction electric hob cooking. This reflects the expectation that induction prices will fall significantly being a simple solid-state device amenable to manufacturing scale cost reductions.

9.5 Water Autonomy

The provision of good quality water supply to all buildings is a high priority given the variable quality and current availability. With a fixed supply to each building, water use is expected to increase rapidly as prosperity increases. Sourcing sufficient clean water, with treatment and its complete distribution can be costly both in capital and running terms compared with the existing situation. GCK aims to reduce water use to less than half of business-as-usual level to ensure the site can achieve Water Autonomy.

Water Autonomy is achieved for GCK by ensuing enough rainfall is absorbed into the ground to recharge the freshwater extraction. This avoids the need for importing water from remote finite sources and avoids local extraction sources drying up. Using managed groundwater in this way allows periods of draught to have less impact because percolation into the groundwater tends to be on a longer timescale. The master planning is expected to designate water catchment and ground percolation areas and to define the government systems needed to ensure these are implemented. This in turn is expected to support extensive vegetation greening amenity and associated microclimate benefits.

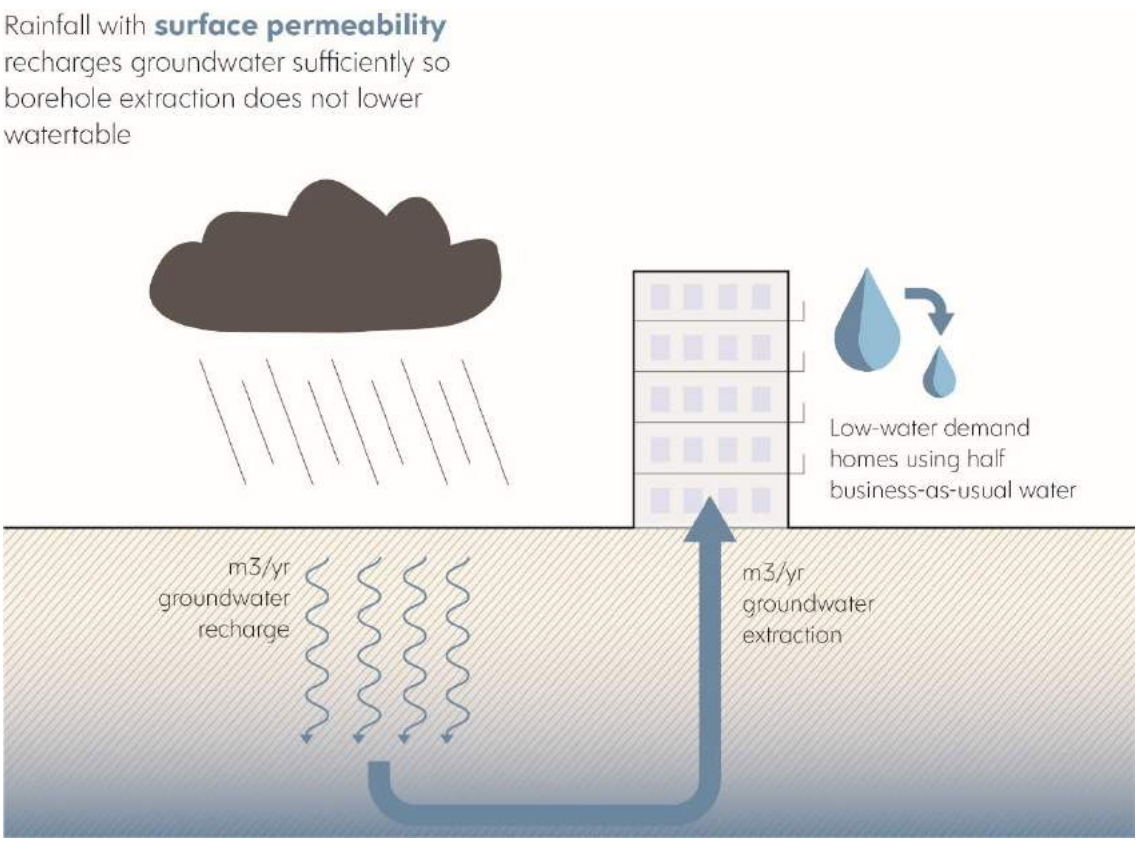

Figure 56: GCK Water autonomy

Resource Modelling has shown how building water use can be more than halved using low cost and simple measures with collective paybacks of less than a year. In line with Rwandan policy it includes extensive on-building rainwater collection and non-potable use. No in-building greywater or blackwater recycling is intended due to its extra cost and its on-going maintenance risks. A small potable supply is piped from community sized treatment and borehole extraction plants. This infrastructure is expected to be more than two thirds smaller capacity compared with a business-as-usual development.

9.6 Sustainable Wastewater Treatment

The provision of good quality mains sewage system to all buildings is a high priority given the variable quality of the current systems and their susceptibility to stormwater surcharging and periodic contaminated discharges. Community based mains sewage collection and treatment is proposed. Options for the most appropriate primary treatment system will be considered during the next stage of design. This may involve an energy (biogas or similar) generating system if funding permits. The liquid tertiary treatment is to be a natural constructed wetlands system. Just as the water use reduction targets permit capacity and cost reductions in the water supply system, similarly they permit reductions in the capacity and costs of the sewage collection and treatment compared with normal provision. This includes the area of constructed wetlands treatment where the area needed per person served can be reduced in area by the order of 50%.

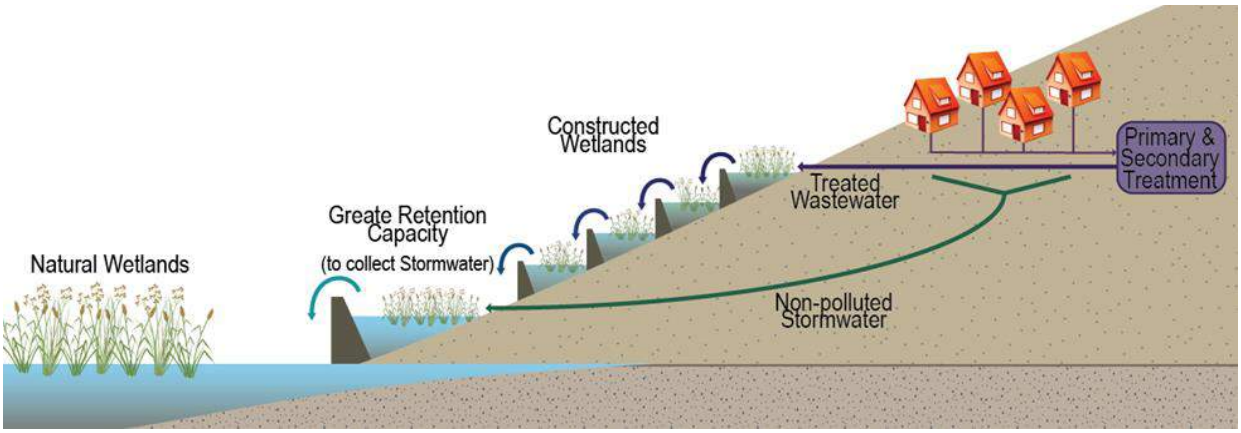

Figure 57: Water autonomy

9.7 Waste Management and the Circular Economy

The lack of modern solid waste treatment in Kigali is a key issue for improving the overall performance of the solid waste management (SWM) system. Initial efforts have been made to improve waste management with mixed results. This is the start of a long-term process to improve collection, separation and then develop processes and businesses able to use separated fractions as potential raw material inputs. This is the start of establishing a local Circular Economy and eventually to create additional employment, strengthen local community ties, build knowledge and capacity and radically reduce imported virgin materials. To revive confidence in source separation the inhabitants need to see that their contribution (source separation) will improve the environment and they need to have further understanding of the value that can be derived from waste. Proposals for achieving these initial steps are proposed. Options like energy from waste are considered.

Figure 58: Waste management and the circular economy

9.8 Information and Communications Technology (ICT)

ICT is an essential service for creating an uplift in value of all aspects of sustainable and liveable communities. App-based green technologies, social media platforms and many other opportunities are key to capacity and knowledge building, fostering sustainable lifestyles and finding further efficiencies in the sustainable infrastructure itself. Further, innovation is probably most dynamic in this of all areas of sustainable development. Therefore, provision of internet and associated ICT services provided via mobile phones is a high priority and considered a basic provision.

The ability to enhance this with higher capacity systems is expected as demand grows. Currently most Kinyinya Hill households have access ICT services via mobile solutions. Mobile phones are used to communicate with each other, but also to receive various services including banking, money transfers, and information sharing. Television and radio are accessible via antenna, but many stations also broadcast via social media and internet. The Kinyinya Hill development is intended to enable smart solutions and internet of things solutions based on dedicated or mobile solutions. The Rwanda Building Code for urban areas mentions that access to ICT should be considered in designing the building (RHA 2019). Smart ICT provision is expected to include an interface with the public transport information systems to allows real-time information on public transport services as part of the standard mobility option for travel around and beyond Kinyinya Hill. It is anticipated that the GCK will work closely with the various ICT commercial service providers to provide appropriate capacity and ensure futureproofing as new technology develops during the GCK build-out.

Figure 59: Ticketless public transport

To include real-time timetable information © SYDNEY MUGERWA

9.9 Urban Heat Island Mitigation

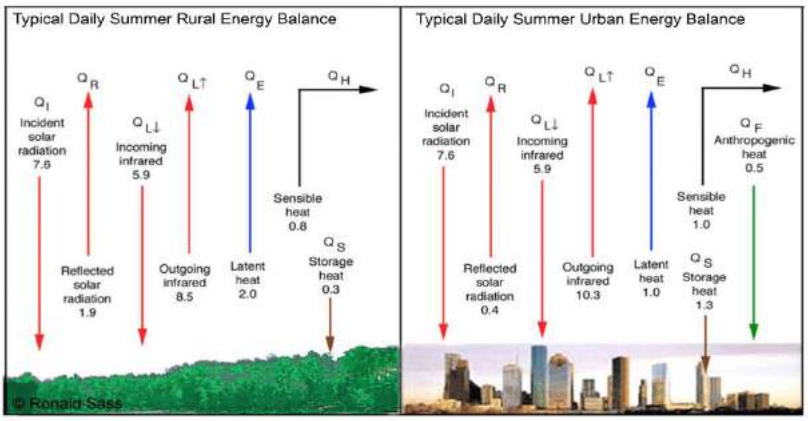

Figure 60: Daily summer energy balances, rural and urban

Urban Heat Island (UHI) mitigation and its ability to mitigate future Climate Change is an important multi-facetted opportunity for urban infrastructure. Many aspects of urban infrastructure contribute to increased urban temperatures, but they can also be designed to reduce urban microclimate effects and make temperature headroom for future climate change. Recommended key measures for reducing UHI effects include[31]:

i. Switch to electric vehicles - they reduce heat output by some 80%
ii. Walkability and cycling - eliminates heat output of vehicles
iii. Quiet and pollution free streets - promotes natural ventilation and avoids the need for air-conditioning outdoor units with their heat rejected and noise.
iv. Low energy buildings - 50% energy savings means 50% less heat lost to the surrounding microclimate
v. Extensive urban vegetation on buildings - excellent at reflecting solar heat and providing transpiration cooling
vi. Continuous tree canopy – creates comfortable low temperature shaded microclimate for walking and cycling
vii. Ground permeability for rainwater infiltration – feeds luscious trees and vegetation and transpiration cooling.
viii. Avoidance of dark building surfaces - these absorb more solar heat gain.

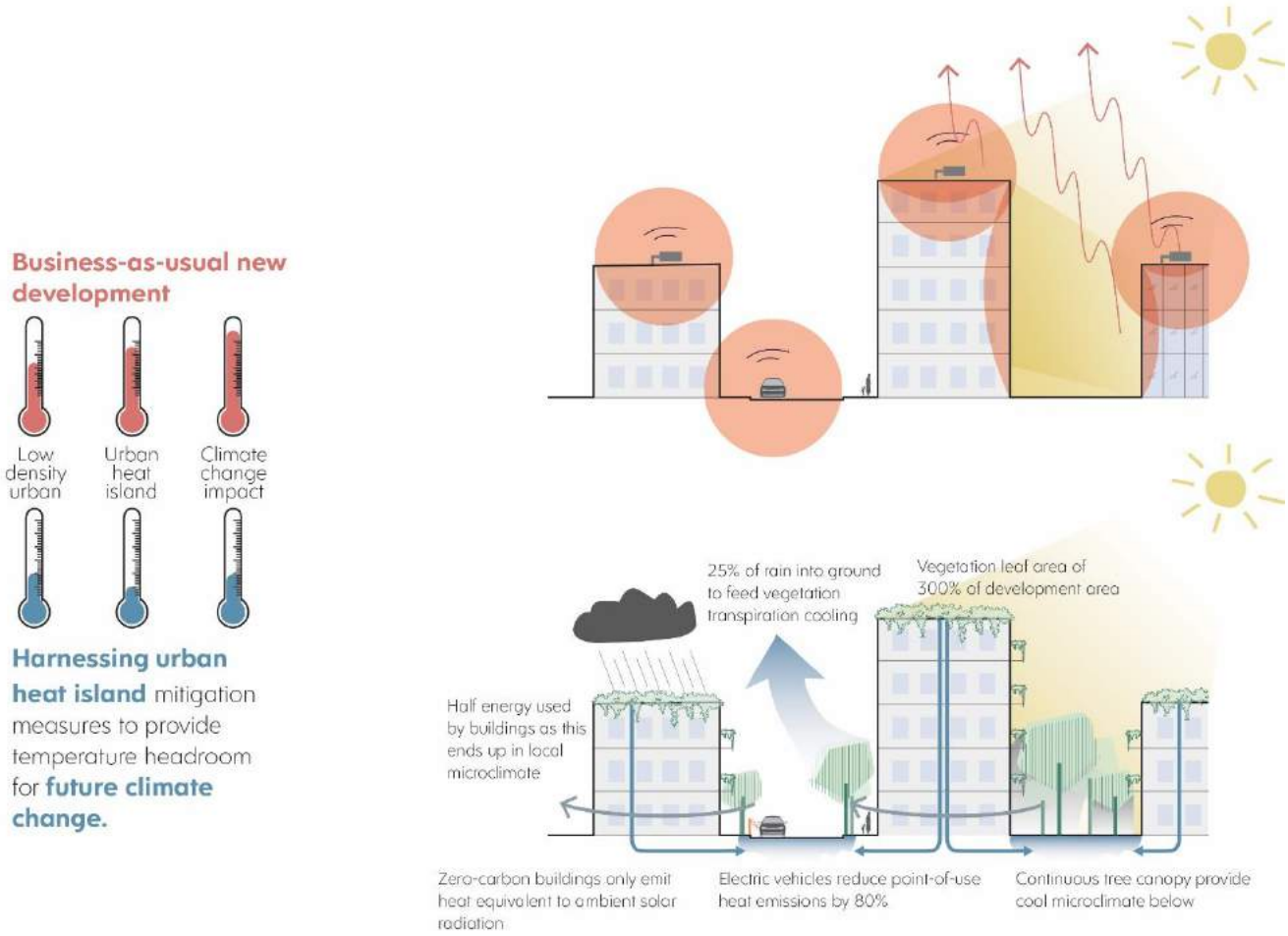

Figure 61: Using urban heat island mitigation to counter future climate change

[31] Urban heat island mitigation is an optional indicator under the Green Building Minimum Compliance System

9.10 Spatial Synergies and Placemaking

A placemaking approach places strong focus on finding synergies between social, economic and environmental systems and boldly celebrating them through spatial planning and urban design. In this way, the sustainable features of a community begin to define its physical character and identity in the city, as well as life within it. For example, strategic views and spaces are coordinated with the sustainable green and blue infrastructure (such as constructed wetlands) and TOD focal points to enhance orientation, sense of place and create a characteristic skyline on the hill. Public open spaces and landmark buildings are located at local centres to promote community cohesion, safe streets and a dynamic and vibrant urban life. These centres should contain sustainable infrastructure such as recycling points and transit stops.

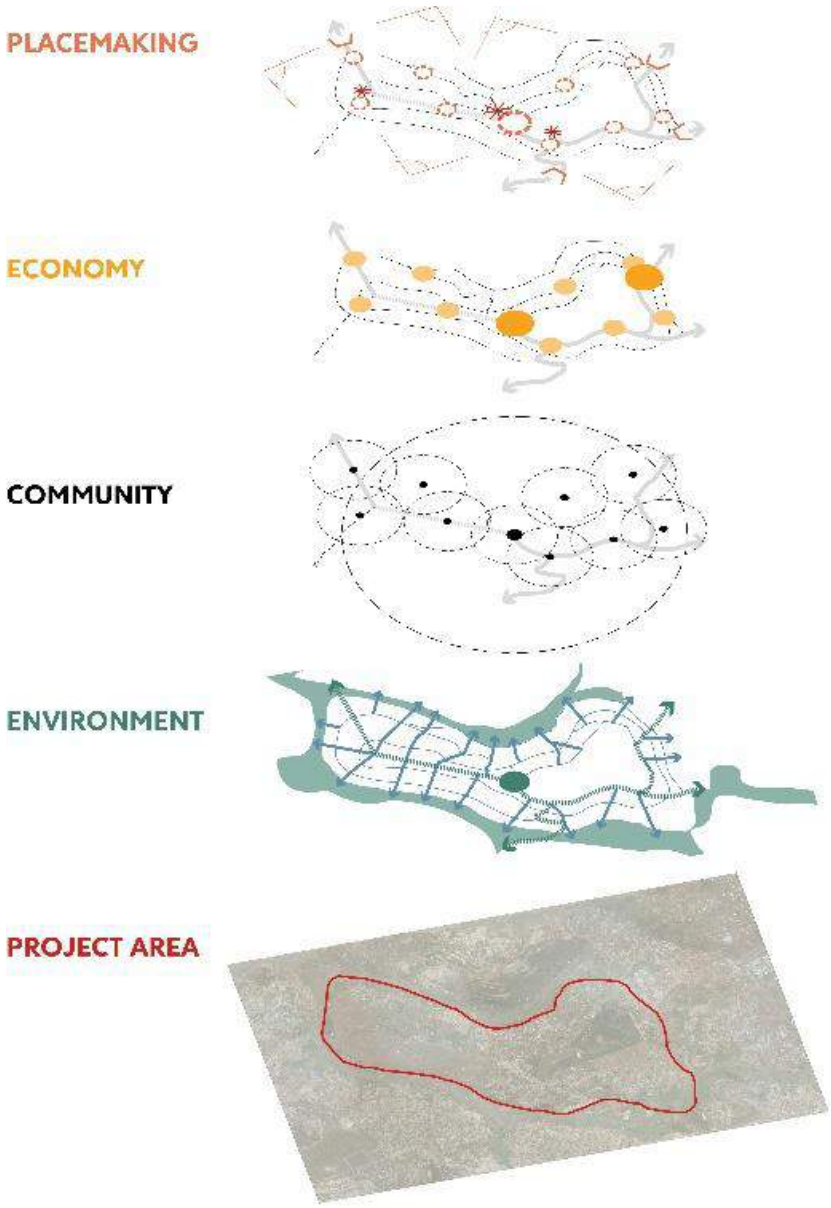

Figure 62: Spatial Synergies and Placemaking. Source: Sweco

9.11 Sustainability Standards and Parameters

The following set of sustainability standards and parameters have been written to ensure that key targets are met for Phase B of the project. These will be used as a framework to create performance indicators in the design brief for the competition.

	SUSTAINABILITY STANDARDS	PARAMETERS
1	3-Fold More Homes	Innovate to deliver circa 3 times more homes than the 2013 masterplan, such as: i. Higher density transit-oriented development increases land efficiency and supports local community services. ii. Synergies between land uses in buildings and open spaces and avoidance of single use zoning
2	Affordable Homes for All	Combine innovative building design, urban planning and financial tools so that 80% DU are within reach of low-middle income households.
3	Zero Carbon Buildings	Design, materials and technical systems for halving energy demand and 100% renewable generation: i. Passive design to avoid air-conditioning ii. On-site solar PV iii. Solar water heating iv. LED lighting throughout v. Single phase 10 Amp electrical power infrastructure connection to each low energy home vi. Max 1-year payback period against new-build BAU baseline plus 2.5-year for PV vii. Transition to LPG / biogas for cooking viii. Reduced electrical infrastructure requirement Reduce embodied energy: i. Minimise concrete usage using locally sourced clay-based wall and flooring products ii. Reinforced brickwork for structural components iii. Steel instead of aluminium for window framing iv. Steel / timber roof framing with sheet steel roof covering
4	Water Autonomy	Design, materials and technical systems to meet 100% non-potable water demand from on-site rainfall: i. Rainwater harvesting ii. Point-of-use demand reductions by low-flow high-performance fittings Potable water sourced from local on-site boreholes. Maximise permeable ground surface area to allow for groundwater recharge. Onsite sewerage – liquid discharge from sceptic tanks into engineered wetland to avoid site contamination of ground water. (System capacity is reduced from BAU due to demand reductions).
5	Sustainable Mobility	Prioritise provision of sustainable and more affordable transport options and innovate to keep car ownership and parking at significantly low levels, to achieve project sustainability goals and meet project financial feasibility. Leads to more efficient use of land and increased urban livability. Locate a local or neighbourhood centre within 500m walking distance of every home. Create a permeable walking & cycling network throughout. Create Transit Oriented Development densities around centres to support public transport and community services. Smart public transport systems. On-street EV charging for moto taxis and e-bikes etc, possibly e-cars.
6	Luscious Green & Blue	Continual green & blue network integrated into streets, public spaces and buildings. Integration of sustainable drainage systems (SUDS) to respond to existing contours

7	Urban Heat Island	Minimise heat transfer to and solar radiation in the street canyon. Building heat emissions reduced by 80% Maximise evapotranspiration, solar reflection and wind transfer in the street canyon. Continual shaded walking routes Minimise use of non-electric motorized vehicles
8	Reduce, Reuse, Recycle, Recover	Introduction of source separation points per 60 households – organic, recyclable, residual. Upcycling rooms to encourage reuse of waste materials Potable water via boreholes (no disposable plastics)
9	Liveable Communities	Local jobs and training Mixed tenure communities Mobile phone-based ICT

Table 24: Sustainability Standards and Parameters.

GREEN CITY KIGALI

10.0 COST ESTIMATES

FONERWA For a Green & Resilient Rwanda

Implemented by: KFW

SWECO

10.1 Development Cost Estimate 18ha.

Cost estimates for the 18 ha site are calculated based on the Financial Model including discounts, financing options and green enhancements.

Net Residential Development Area = 12,6ha

DU		m2	total m2	USD/m2	USD
Housing for Poor					
1 bed apartments	93	45	4 185	329	1 376 865
Single storey buildings	93	45	4 185	329	1 376 865
Low & Middle Income					
1 bed apartments	491	45	22 095	329	7 269 255
2 bed apartments	491	60	29 460	329	9 692 340
3 bed apartments	491	80	39 280	329	12 923 120
Market Sale					
3 bed 2 storey build	60	100	6 000	450	2 700 000
4 bed 2 storey build	60	120	7 200	450	3 240 000
5 bed 2 storey build	60	150	9 000	450	4 050 000
	1839		121 405		42 628 445
Education			6 000	400	2 400 000
Healthcare			700	400	280 000
Commercial	shell only		22 302	170	3 791 340
Football Pitch			4050	20	81 000
Community facilities, youth,meeting			1 400	400	560 000
Market Square			2 500	200	500 000
			36 952		7 612 340
Green Enhancements					
Drainage	1659			400	663 600
Solar Heating	1659			1000	1 659 000
Solar Electricity	1659			3500	5 806 500
					8 129 100
Public realm Blue Green network		2,4ha	24 000		
Enhanced blue green network area		25%	6 000	150	900 000
Road systems, both on site and off-site supporting systems					2 084 659
Infrastructure	water sewage power inclusive of equipment		6,5%		3 988 045
Preliminaries - Mobilization			10%		6 534 259
Ground Work & Site Improvement			6,50%		4 247 268
Land cost	12,6ha net Development area		126 000	20	2 520 000
Municipal fees, licences, tax etc.			6%		4 567 447
Provision fee Consultants			12%		9 134 849
					33 976 782

Contingency			5%		3 267 129
Total development cost excluding finance					95 613 587
Estimated Setup/Legals/SPV etc					2 000 000
Estimated Financing Costs Interest rate 12% for three years					7 028 178
Total Project Cost					104 641 765
Contributions and Credits					
Green Climate fund					13 669 924
Government infrastructure fund for affordable housing (70% of cost)					10 800 000
VAT relief (18%) on housing for poor and middle income					5 000 000
Revenue from education and market square					6 000 000
Projected revenues from sales of affordable and market					58 317 824
Projected revenues from commercial sales					12 300 000
Total Contributions and Credits					106 087 748
Estimated Total Project Surplus/(Deficit)					1 445 982

Table 25: Construction Cost estimate for 18 ha site

The unit rate pricing build up include the following assumptions,

i. Residential construction cost only, low cost materials

ii. Education, Healthcare construction cost only, low cost materials

iii. Commercial, low cost material construction shell and core only

iv. Community construction cost only, low cost materials

v. Market square, hard and soft landscape with covered market

vi. Blue green network, hard and soft landscape, play equipment, lighting, drainage

vii. Roads, vehicle roads, foot paths and green corridors and associated equipment.

viii. Infrastructure, water, sewage, power, inclusive of equipment

ix. Preliminaries and Mobilization. General contractor, site facilities, security, plant and equipment

x. Groundwork and Site improvement. Earth moving, trenches, ground stabilization

xi. Land purchase based on net Development area.

xii. Fees, licenses, taxes. Municipal and governmental charges

xiii. Consultant fees. Design and Supervision

xiv. Contingencies

10.2 Component Cost Estimate 600ha

Key elements in the spectrum of cost items needed to deliver the entire Green City Kigali project. Gross Residential Development Area 362,5ha.

DU		m2	total m2	USD/m2	USD
Housing for Poor					
1 bed apartments	1488	45	66 960	329	22 029 840
Single storey buildings	1488	45	66 960	329	22 029 840
Low & Middle Income					
1 bed apartments	7856	45	353 520	329	116 308 080
2 bed apartments	7856	60	471 360	329	155 077 440
3 bed apartments	7856	80	628 480	329	206 769 920
Market Sale					
3 bed 2 storey build	960	100	96 000	450	43 200 000
4 bed 2 storey build	960	120	115 200	450	51 840 000
5 bed 2 storey build	960	150	144 000	450	64 800 000
	29 424		1 942 480		682 055 120
Education (est. 50% for full site)			60 000	400	24 000 000
Healthcare			14 000	400	5 600 000
Commercial	shell only		446 040	170	75 826 800
Football Pitch			81 000	20	1 620 000
Urban Centre Parks			75 000	45	3 375 000
Community facilities, youth,meeting			28 000	400	11 200 000
Market Square (est. 50% for full site)			25 000	200	5 000 000
			729 040		126 621 800
Green Enhancements					
Drainage	26544			400	10 617 600
Solar Heating	26544			1000	26 544 000
Solar Electricity	26544			3500	92 904 000
					130 065 600
Public realm Blue Green network		48,3ha	483 000		
Enhanced blue green network area		25%	120 750	150	18 112 500
Road systems, both onsite and off-site supporting systems					65 000 000
Infrastructure	water sewage power inclusive of equipment		6,5%		66 420 576
Preliminaries - Mobilization			10%		108 827 560
Ground Work & Site Improvement			6,50%		70 737 914
Land cost	362,5ha net Development area		3 625 000	20	72 500 000
municipal fees, licences, tax etc.			6%		76 070 464
Provision fee Consultants			12%		152 140 928

					629 809 942
Contingency			5%		54 413 780
Total development cost excluding finance					1 622 966 242
Estimated Setup/Legals/SPV etc					32 000 000
Estimated Financing Costs Interest rate 12% for three years					119 157 569
Total Project Cost					1 774 123 811
Contributions and Credits					
Green Climate fund					199 479 063
Government infrastructure fund for affordable housing (70% of cost)					222 627 745
VAT relief (18%) on housing for poor and middle income					79 659 934
Revenue from education and market square					45 250 000
Projected revenues from sales of affordable and market					933 085 181
Projected revenues from Community sales					10 500 000
Projected revenues from commercial sales					245 322 000
Total Contributions and Credits					1 735 923 923
Estimated Total Project Surplus/(Deficit)					(38 199 888)

Table 26: 600 Hectares Global Costs

The global costs for the 600 hectares site have been extrapolated from the Phase 1 costs. This is a best estimate based on the development parameters established in the Urban Design Handbook which accompanies this document. This calculation is to test the model and provide an initial understanding of the viability, and to come up with targeted cost information from the different sectors. The net effect if the cost estimates increase, would be increase in the cashflow deficit.

As the computations used above are at this stage a very rough estimate and will be refined when more information becomes available. Also, that a net deficit of $38m over the whole 362,5 hectare GRDA could be offset by relatively small adjustments in the assumptions so that a combination of only a small part of some or all of the following would bring the project into breakeven or profit:

i. A reduction in the number of 'free' housing units

ii. The number of subsidised and affordable housing per phase was reduced from 90% to 85%

iii. A 5% increase in commercial property development and a reduction of the social and community in each phase

iv. Additional funding from government for infrastructure or a higher contribution to infrastructure from the Green Climate Fund

v. A soft loan to support the working capital

vi. A faster pace of sales to reduce interest costs

<u>The key assumptions of the financial model</u>

i. Gross and Net development areas are based on the information contained in the Urban Design Handbook which accompanies this document.

ii. In each phase a third is constructed each year and on average sold or occupied 12 months' later

iii. Infrastructure costs are spread evenly over the three-year period

iv. Phase 1 consists of 1,839 (pro rata) with a housing tenure mix outlined above

v. Baseline construction costs are estimated at $329 per square meter affordable and $450 for market villas with VAT relief on affordable

vi. All costings in the model are at today's prices. Cost inflation as regards interest rates can be estimated at CPI (6% per annum)

vii. Sales prices for residential units range from c. RWF 17.7 million to 31.4 million for affordable units

viii. Estate charges will be levied on all but social housing at a rate of .5% per annum of the market value (a break-even value)

ix. A mortgage interest rate of 16%

x. Borrowing by the GCK to fund upfront land assembly, infrastructure costs and for the Help to Buy element of the affordable sales programme and the holding of rental properties, both residential and commercial 12.0% (capital markets).

xi. Affordable sales are made to be affordable by low income households using Help to Own for households with monthly incomes between 215 and 800 USD where affordability is defined as 35% of household income on a mortgage tenor of 20 years.

xii. For households earning above 800 USD per month the Help to own support may not be reduced or not provided.

xiii. If it assumed that each phase of the Green City Kigali is completed before the next phase takes place, then the maximum likely borrowing will be around $25m for working capital (excluding the holding costs for Help To Buy mortgages and rented properties) but this will rapidly increase if phases are run concurrently.

With the proxy and estimate costings currently used, GCK will require significant upfront financing as well ongoing sustainable revenue from sales and rental receipts. This is due to relatively high construction costs compared to the affordability of low to middle-income target demand groups.

Recommendation: State, municipal or agency support will be required for the successful delivery of the project

This means that to make affordable housing truly affordable, GCK will need to consider innovative finance solutions to facilitate both supply and demand, including low-start mortgage models such as the UK Help to Buy model. This is summarised below:

- Government or other non-commercial discretionary interest loan (eg World Bank 3% loan) for part of the cost of the home (typically 40%). To the borrower this is stepped/ index linked after 5 years and repaid by 20 years. The balance is funded by a conventional mortgage.
- The government loan is interest free for, say, 5 years and then is repayable with the annual repayment going up in steps over a 15-year period for both the mortgage loan and the government loan to mature at the same time, enabling a single security and title.
- The government loan is based on an interest rate linked to government borrowing.

Recommendation: Engage in follow-up work on 'Help to Buy' as a demand side intervention to make mortgages more affordable for target demand groups.

11.0 PROJECT IMPLEMENTATION

This section outlines the current work plan, risks and mitigation identified for the project. The section also identifies the main options (Governance and Delivery Vehicle Options) for implementing the Green City Kigali.

11.1 Work plan and flow chart

The GCK project includes three phases namely Phase A - Feasibility Study, Phase B - Design Competition and Phase C - Detailed Design. This report, approved by FONERWA and KfW, concludes Phase A. Phase B follows and comprises the following tasks (i) Urban Planning and Architectural Design Competition, (ii) Preparation of Green Climate Fund (GCF) funding proposal for submission by FONERWA and it includes (iii) Support to FONERWA and Management of Feasibility Study, is an on activity during the Feasibility Study Phase and the Design Competition Phase. The different tasks of Phase B and C are shown in the schedule with key dates for Phases B and C in the Annex at the end of this document.

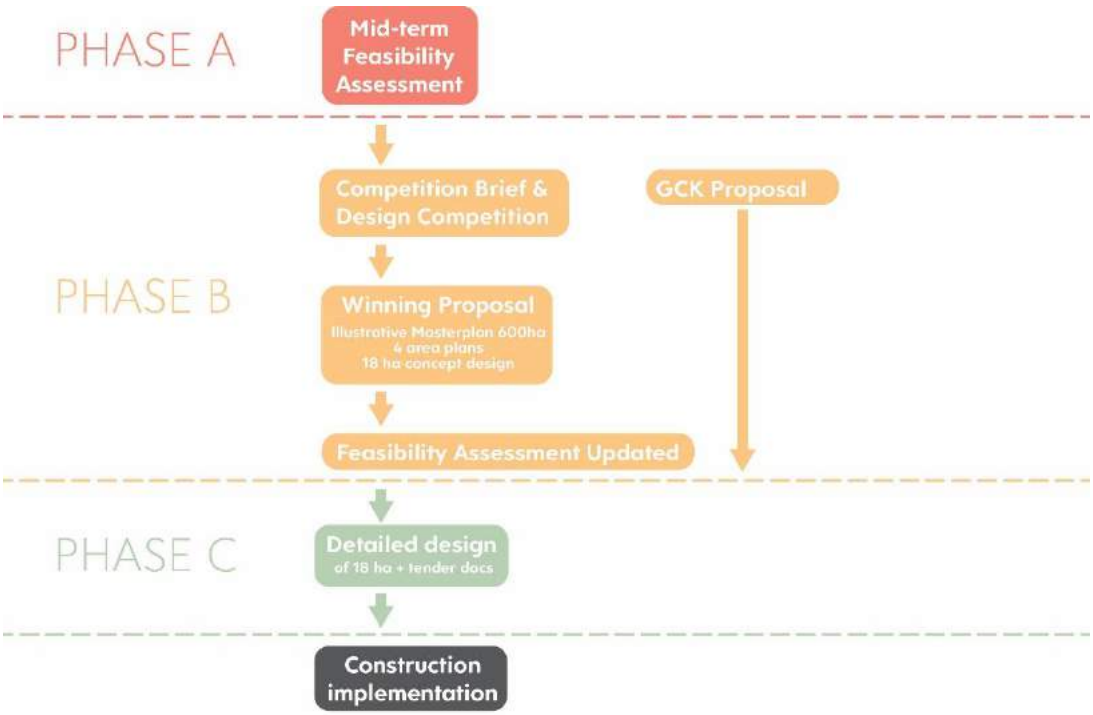

Figure 63: GCK implementation process

The table below shows risks and assumption that are aligned with in the GCK ToR.

Expected Result / Assumption & Risk	Mitigating Measures	Responsibilities	Milestones
Module Objective (Project Outcome)			
18 ha parcel not available for the GCK project jeopardizing the design competition	Another parcel to be identified	FONERWA	Pending
Funding of 18ha parcel cannot be clearly demonstrated, jeopardizing the design competition	Funding sources to identified by all stakeholders Including GCF and funds of private developers indicated	All stakeholders	30 08 2019

Expected Result / Assumption & Risk	Mitigating Measures	Responsibilities	Milestones
Exact demarcation of the 600ha project site to be defined	Confirm the proposed boundary and resolve possible conflicts	GoK FONERWA GCF Team	01 08 2019
A Suitable Full Proposal is submitted to the GCF for the initial implementation project			
A suitable project is identified for a Full GCK proposal.	Funding proposal (options) to be identified	FONERWA	15 11 2019
The financial structure of the projects aligns to the accreditation status and allowable financial cap of the Accredited Entity.	Accredited Entity to be reviewed	FONERWA KfW	01 08 2019
The full proposal can be completed with the information obtained in Phase A and B of the project.	High quality FS	FONERWA GCF Team	15 01 2020
Project Output			
The Architectural Design Competition as part of the FS financed by BMZ through KfW and PPF/GCF ("KfW/PPF FS") has been successfully completed and the design brief is in place.	Competent design competition manager operational	SWECO KFW	01 07 2020
The following outputs of the "KfW/PPF FS" are available:	Design competition is successful and competent firms join. Success factors: Quality design brief Appropriate rules Competent firm appointed to guide process Limited number of 'un-knows' (18ha site; finance in placed; etc)	SWECO KFW	31 05 2020
Master Plan Kinyinya Hill			
Sub-area Detail Plans			
Housing and community facility typologies			
Urban development Plan and Building Designs for 18 ha parcel			
Development & Design Guidelines			
Key Activities in the Module			
The winning design firm is adequately supported by FONERWA and the FS consultant.	FS consultant is appointed. Political will assured	FONERWA Stakeholders SWECO	Phase C
The designs receive required approvals by relevant Rwandan authorities.	Draft design in co-production with authorities.	FONERWA Stakeholders SWECO	Phase C
There is close interaction / communication between the winning designs firm, FONERWA and all relevant stakeholders	Participative structure / lines of communication and measures put in place.	FONERWA Stakeholders SWECO	Phase C

Table 27: GCK Risks and Assumptions

11.2 Governance Structure

The GCK should agree a governance structure that is flexible enough to work within the government's housing strategy but able to implement commercial deals with developers, develop innovative finance to provide social housing, and apply for external funds, such as the GCF.

This is likely to be public corporation but with wider statutory powers and independent expertise. Any option will need statutory powers of land assembly.

Recommendation: Implement a flexible governance structure

The suggested structure of the SPV is set out in the figure below:

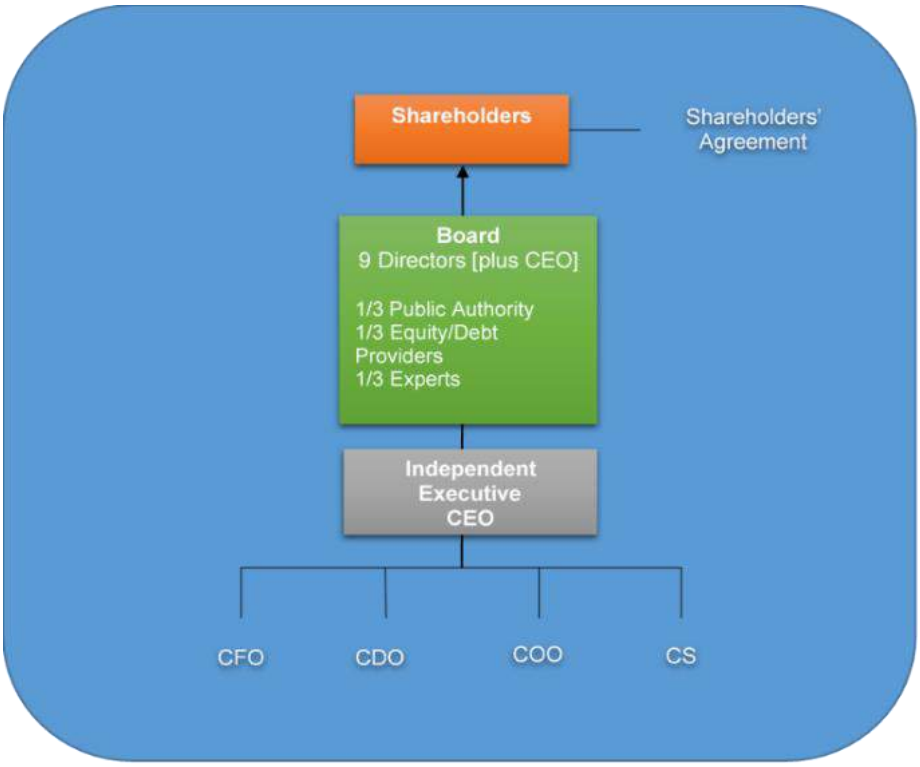

Figure 64: SPV Structure

11.3 Development phase SPV Structure Options

We considered four development phase structure options, including:

Option 1

National Government delivers land acquisition and basic infrastructure and SPV delivers development and City Management.

Option 2

Specialist agency delivers land acquisition and basic infrastructure and SPV delivers development.

Option 3.

A new statutory development corporation is established to manage land acquisition, infrastructure and development.

Option 4

A PPP structure established to deliver land acquisition, infrastructure, development and management.

The first option is considered optimal for the GCK because it does not require drafting of primary legislation and it works within existing statutory frameworks.

Recommendation: We recommend a development SPV model which sees GoR delivering land acquisition and basic infrastructure and the SPV delivering development and City Management.

The model of option one is included in the figure below

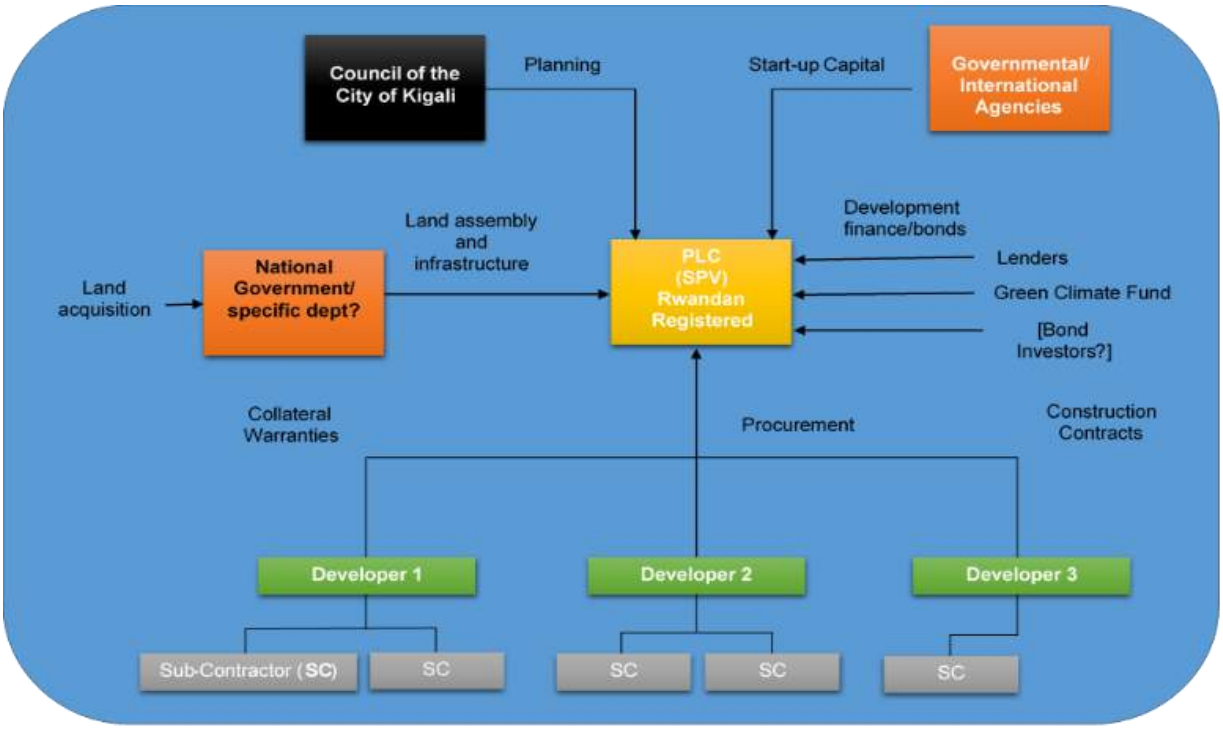

Figure 65: SPV Option 1 Structure

Post development of each key phase of the project and at the end of the programme a legal entity needs to be responsible for the maintenance and management of services, common areas and public realm. The entity will be responsible for agreement of roles and responsibilities as it relates to management and maintenance of public facilities.

We have separated out the management phase vehicle from the development phase vehicle because once the initial development and sales phase is completed, the legal structure and relationships will need to adapt to management. This is because the SPV will then need to manage relationships with the different occupiers of the Green City in order to ensure that its likely continuing debt commitments can be met.

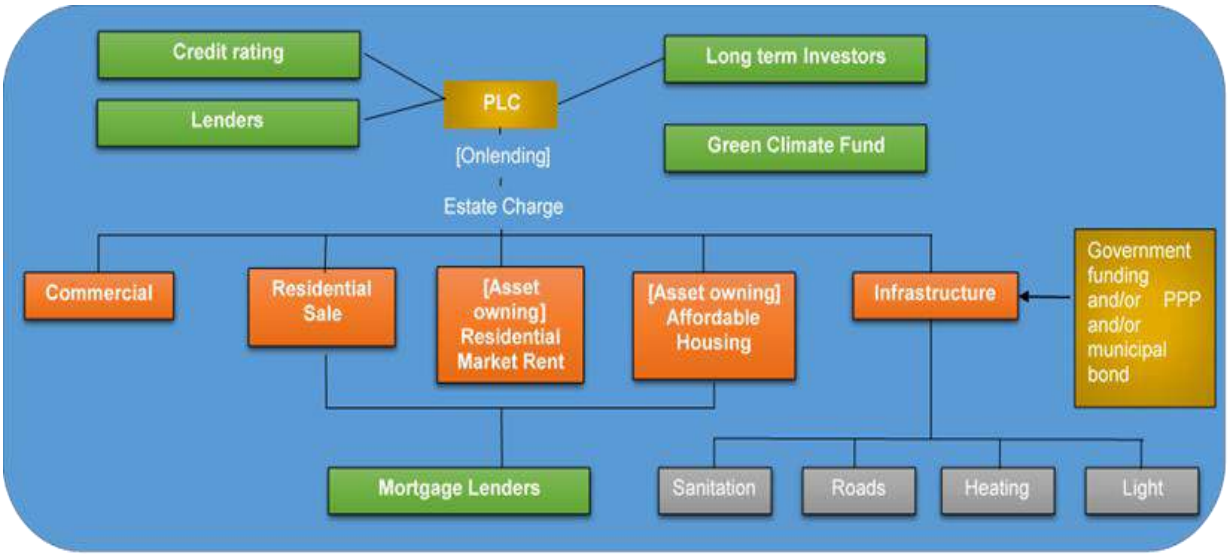

Figure 66: Management Phase SPV Structure

If the SPV is to raise funds for the management and maintenance of the estate, then it will need the legal power to do this. This could be by contract with residents or through the agency arrangement with the relevant authorities.

Recommendation: A management phase SPV should be created.

11.4 Legal Considerations

Land value capture is essentially the benefit to the wider local community or the organisation doing the development of an area from future increases in the value of land and buildings. We have considered whether this would be best held in the SPV or in a series of subsidiaries for each segment. The latter would permit the more effective segmentation of funding but would be more complex (and expensive) to establish and maintain.

Recommendation: We propose that land value capture would be best held in the SPV. The law should enable land value capture rights to be enforces through some form of charge on the title of the properties involved.

11.5 Vehicle Options

There are several potential governances, legal and funding structures based on the overall goals of the GCK. We considered the following types of entity:

i. A private company

ii. A public company

iii. A co-operative

iv. A new statutory body

Funding considerations cascade from these arrangements, as some income streams or specific receipts are only available to government or a commercial entity. The determined body will need to be able to work within statutory or regulatory powers such as land assembly procedures as well as having governance including independent expertise and distant from political influences.

We believe that with the exception of a public company, the private company and the co-operative entities would not be best suited for the project for the following reasons:

A private company has legal limitations which may not suit the project; in particular linked to a public debt issuance and limitations on the numbers of shareholders and transference of shares.

i. A co-operative structure may be well suited to the formation of resident-based structures. But it would be less well suited to commercial developments obtaining a credit rating and public debt issuance

ii. A statutory body would have advantages and limitations but may conflict with the role of the City of Kigali and may create confusion as an overlapping statutory body

iii. We believe a public limited company would be better suited to the delivery of the project. This is because:

iv. It can act as a special purpose vehicle (SPV). By SPV we mean that the entity is created for a specific purpose and can have a number of participants with varying degrees of exposure

v. Stakeholders and investors can take shares in the SPV. Shares could be grouped into different classes – offering different rights and returns or through a group structure. Convertible securities could also potentially be made available. Potentially the SPV could at some stage become listed on the Rwandan Stock Exchange permitting the open trading of these shares

vi. The SPV would be legally capable of borrowing and obtaining a credit rating, listing on the Rwandan Stock Exchange, being audited in accordance with International Accounting Standards, and demonstrating compliance with any lending conditions of the Green Climate Fund

vii. A PLC structure is familiar to foreign investors and the Green Climate Fund

viii. The SPV can contract with the developers, consultants and manage the estate and infrastructure and enter into PPPs, as required

Recommendation: Of the options considered, we recommend a public limited company as the type of legal entity structure best suited for the delivery of this project.

11.6 Financial modelling

The funding of a new city will normally respond to a 'land use plan' and 'master plan' which designates what can be created in each area, whether it would be part of the public or private domain and in addition describes the requirements and deliverables of that area of the city and what contribution the development or developer will need to make to the rest of the city. This includes the infrastructure and either implicitly or contractual what the Special Purpose Vehicle[32] (SPV) will provide, such as roads, public services and similar. The SPV could be a local authority or could be a company or some other incorporated body set up to manage the process.

The SPV will have created a financial plan for the city identifying the different sources of capital and where relevant how they will be repaid to fund the elements.

The financial model developed as part of this mid-term report currently provides a template for determining the costs and revenue for the GCK that can be later interpreted and updated by the SPV upon inception of the GCK. It is based on the following characteristics of the GCK:

i. The site will need to have land assembled

ii. A portion of market sale that will act as a revenue source

iii. Affordable and social development will include some revenue and loss

iv. Commercial development will be included, with a mix of type, size and construction

v. The site will have designated residential zones for self-build or collective development

vi. The site will have public areas and similar

32 A Special Purpose Vehicle (SPV) is a separate legal entity created by an organization. The SPV is a distinct company with its own assets.

vii. The site will have health, education and similar

viii. The site may have a special economic zone

Consideration will need to be given as to whether the optimal funding structure would involve segregated asset pools – say commercial, sale, affordable, rented or pooled loans. The same could apply to equity investors. For this phase, we have assumed a simple structure of pooled funding and investment. But we have also assumed that there would be a distinction between development and post development financing.

The financial model has several inputs, which may or may not be populated by precise costings. At this stage in the Feasibility Study, no urban city planning, or master planning has been completed for the GCK site, and so proxy and best estimate costings and revenue streams have been used where necessary.

Where available, sources of financing for the project were considered ranging from support from the Government to cover costs such as infrastructure, land assembly to proceeds from sales of residential, commercial units and plots, funds from international development agencies including green climate fund, capital raised from capital markets, loan and debts from banks.

12.0 NEXT STEPS - DESIGN COMPETITION

12.1 Design competition

Design competition format and management

The GCK will be working with the Royal Institute of British Architects (RIBA) to prepare an invitation for design firms to develop an Illustrated Master Plan for Kinyinya Hill (600 ha) and a Concept Master Plan for a mixed housing development on a 18ha model land parcel. A full detail scope for the design competition will be made available during the Pre-Qualification and Invitation of the Competition.

The proposed format will be a competition in two stages.

Phase 1 Pre-Qualification

At the Prequalification phase, applications are sought from prospective applicants in accordance with the requirements outlined in the Memorandum of Information and accompanying prequalification document issued separately to this document as part of the Competition process. The applications will be used to select a short-list of to proceed to the Invitation to Bid phase.

Phase 2: Invitation to Bid

Shortlisted applicants (bid teams) will be invited to develop the masterplan proposals in response to the requirements of the competition Request for Proposal (RfP) document together with an accompanying tender return. A site visit and briefing session for short-listed bid teams will be held in Kigali at the beginning of the design phase.

Teams would be required to outline their design proposals to address land use strategies, pedestrian and vehicular movement, public open space, sustainability, infrastructure and a financial analysis. The concept and proposed approach shall be prepared with illustrations, visualisations to support the submission.

Following appraisal of the design submissions, the bid teams will be invited to present their proposals to the Adjudication Panel at a clarification interview to be held in Kigali in April 2020. The purpose of the interviews will be to provide Bid teams with an opportunity to explain their proposals as tendered, and to enable Panel members to seek clarification on any issues that are un-clear from their initial appraisal of the submission return. A flow chart of the design competition process is outlined below.

Figure 67: Overview of design competition (RIBA, 2019)

Proposed competition timetable

Prequalification Phase	
Deadline for receipt of Prequalification Applications	Fri. 06 December 2019 14.00hrs (GMT) 33
Short-listed Bid teams notified	w/c 27 January 2020
Notifications to unsuccessful Applicants	w/c 03 February 2020
Tender / Competition Phase	
Issue of RfP document & Outline Design Brief to Short-listed Participants	w/c 27 January 2020
Site visit & open briefing session for Short-listed Bid Teams	w/c 17 February 2020
Deadline for submission of Final Tenders (with design concepts)	Fri. 27 March 2020
Clarification interview presentations (to be held in Kigali) leading to identification of preferred Bid Team	w/c 20 April 2020
Issue of Intention to Award Contract notifications	w/c 11 May 2020
Confirmation of Contract Award	Date Tbc
Public announcement of result	Date Tbc

Table 28: Proposed Competition timetable.

12.2 Modelling Assessment

The design competitors will be asked to evaluate design proposals using the IFC EDGE-buildings online tools further outlined in this report. The EDGE-buildings tool is focused on the specifics of energy consumption, water consumption and construction materials impact, and allows hard targets to be set, while allowing flexibility on how these targets are met. The Mid-Term Feasibility Study indicates the targets that have been developed by the project infrastructure and housing teams. They will serve as parameters for the design competitors. The competitors will also be asked to model their designs using the EDGE online tool. This will allow for transparent evaluation of the competition submissions.

[33] The official deadline for submission of applications is indicated in the special provisions of the PQD

GREEN CITY KIGALI

13.0 ANNEXURES

13.1 Annex 1: Comments from stakeholders

The Urban Lab included working sessions with the communities and with the authorities. A summary of their comments is presented below.

13.1.1 Communities

Urban Planning

i. Communities made proposals/requests about

ii. Residents would like all urban functions on the Hill including a better bus station with a large market; a cinema, etc

iii. Coordination between the various ministries is essential for a good design in the future.

Housing and housing finance

i. Communities expressed concerns about:
Worry that master plans don't allow improving their houses;
Need for larger houses and more comfort;
Sharing of outdoor space for example for cooking is not a possibility, this does not exist. They don't trust their neighbour to keep it clean;
People have real problems to finance the houses. Even cheap and affordable houses are too expensive. Some estates are simply not bought as they are too expensive. Houses should be constructed to fit the financial situation of the people;

ii. Communities made proposals/requests about:
Houses require two toilets, one inside (private) and a guest toilet outside the house, a kitchen inside;
A single person apartment requires three rooms: a bathroom, kitchen and bedroom;
The man with 9 children would have 3 children share a room, a guest room, kitchen outside, two toilets 1 inside and one outside, a storage room.

iii. There is an array of opinions on location (as opposed to authorities' proposals/requests):
Some prefer lowest income at the toe of the hill and the wealthy on the top (and middle income in between) over 'rich in the east, poor in the west'. This is in line with the perceived building construction economy: steep slopes require more expensive building substructure as opposed to building at the base of the hill

Infrastructure (energy, water, security, public utilities)

i. Communities informed about:
Most, but not all of the community members interviewed have water and electricity. Family size is 3-4 children;
They are not using solar energy as this is too expensive;
For cooking, they use propane and charcoal. Propane is leaner in the house; they receive a loan for the installation/ equipment to facilitate the switch; it is easier when you arrive late from work. However, slow cooking food such as beans and cassava are still cooked on charcoal;
They collect rainwater in plastic (PE) tanks of 1,000 to 5,000 litres. Rainwater is used for all domestic purposes;
Most rainwater is retained on the Hill and used for agriculture. Some collect the water from the roof and then they cook it;
Electricity supply is fine. Electricity lines are underground. It is more environmentally friendly and more cost effective;
Some people have gas. They prefer it because it is cleaner and faster. but there is a risk of explosion;
They do get good instructions.

ii. Communities expressed concerns about:
Problems with storm water: solution to capture the water on the hill needed, for example for house hold use;

Need for a new market near new bus station;
Most don't have tap water. They go to water springs in the valley for their water. It is advised to boil the water before drinking or cooking, but the cost of cooking the water is high;
They pay about 4000 RWF per month for piped water (?);
Security is an issue especially for woman. Woman who are working in the city centre have to get home before dark since there are no street lights on the west side and taxi's or motorcycles don't go there because of the bad infrastructure so they have no choice but to walk. It means they have limited options for jobs because they cannot work late;
The infrastructure is so bad that there is very little supply from outside Kinyinya so they can hardly do any shopping here.

iii. Communities made proposals/requests about:
They should have lighting (in the house or public lighting?) as it will improve their safety;
They would like an open covered market with shops underneath, clothes and groceries.

Transport & Mobility

i. Communities informed about:
Most residents walk to the bus station and use public transport which is cheaper than motorcycle taxi if they want to go to town;
Walking is most popular means of transport.

ii. Communities expressed concerns about:
Kinyinya is really badly connected to other parts of the capital;
They walk to the bus station (often longer than thirty minutes) and then take a bus to the centre;
It's really normal to walk mostly because there is no other choice

iii. Communities made proposals/requests about:
Residents welcome further road development for pedestrians; to walk straight up- and downhill instead of using the regular road. Especially the many residents working in the wetlands welcome these footpaths;
Better connections with other parts of Kigali is definitely possible;
Better developed and more decent main road structure: backbone in existing urban structure and south west side;
New bus station in north west side, walking distance to existing bus station is too far

Socio-economic functions, jobs including agriculture

i. Communities informed about:
Agriculture. In the wetlands, water levels are controlled. They harvest all year around;
Government supplies fertiliser at 50% of the cost;
Not so many people on the hill use the wetlands;
They are using the empty RSSB land for farming. For sure more than 100 people are using this land;
There is only one farmer farming in the west of the wetlands. The farmers in the other parts of the wetlands are joined in a cooperation.

ii. Communities expressed concerns about:
They do not use manure because transport is too costly;
They do not own cattle as this is not allowed in the city. Many residents would prefer to move to the countryside to do livestock farming. They do not have the means;
Many people make their livelihood from renting out a spare room and worry they will not be able to do so anymore if they are relocated.

iii. Communities made proposals/requests about:
Jobs. Residents are looking forward for better job creation opportunities;
With regards to jobs in construction; they are not looking forward to this as these jobs make too little money

(5,000 RWF per day) while construction management jobs would be welcomed;
Avoid big commercial functions (people on the hill have low income);
Every programme should generate more jobs including investments by government

Social development (health, education, poverty)

i. Communities informed about:
Health. They receive most medical care from small specialised shops on the Hill;
There are enough churches on the hill. These are used by multiple 'sects/ congregations';
Schooling: there is one school, it has 3,500 pupils and up to 105 kids per class;
Private school "Amis des Enfants" is most important community function (kind of contradiction because it is private);
When they have money, they will buy charcoal. The cooking place it is outside;
Charcoal is 8000 RWF per month for one bag which is sufficient for a household of 5 people depending on how rich you are. If you have money you can afford 3 meals a day;
Rich people have separate rooms and a separate kitchen and toilet in the house;
Poorer people have the kitchen and toilet outside;
The poorest cook inside as they don't have an outside space.

ii. Communities expressed concerns about:
The cost of living is rising faster than income, they can hardly keep up

iii. Communities made proposals/requests about:
There are not enough schools, it's a 30-50 minute walk to go to school. That's too far. The school at Kinyinya is full with 2000-3000 children, 200 per class. Some people need to send their kids to a school even further away;
There are not enough health facilities. They only have one health centre serving everybody. Because of flooding they cannot go to the health centre on the neighbouring hill in rainy season. It is a primary health centre. A primary hospital is located closer to the city centre.

Gender

i. Communities expressed concerns about:
Security is an issue especially for woman. Woman who are working in the city centre have to get home before dark since there are no street lights on the west side and taxi's or motorcycles don't go there because of the bad infrastructure so they have no choice but to walk. It means they have limited options for jobs because they cannot work late.

Climate change & Environment (waste, microclimate, sanitation, nature)

i. Communities informed about:
Waste water. They use soak pits;
We have a good climate, clean air, clear view...;
Agriculture. In the wetlands, water levels are controlled. They harvest all year around;
Drought is not an issue;
Solid waste is collected once a week;
Household waste/biomass is put into a black bag or it is immediately used on the land. They pay 2000 RWF for waste collection at home. 20% of the people are not using public waste collection;
Metal is often collected by children who dropped out of school and who reuse it in some way.

ii. Communities expressed concerns about:
After heavy rains, some houses can be destroyed, but mostly because of poor/no drainage systems and poor building materials. This mostly happens in the North West;
The few storm water drains are deeply eroded and transport surplus water to the wetlands. Only in the wetlands they experience floods;

The main issue in the wetlands is the transportation of sediments down the hill. They experience a lot of erosion as a result of heavy rain;

iii. Communities made proposals/requests about:
Park area. They welcome the idea of converting of the Deutsche Welle into a public park; other functions could be combined on that site;
There is no need for 'classic' parks, but need for playgrounds;
Green fingers: agricultural function is better than green park function, generates more benefits (food – income);
The green qualities of the Deutsche Welle should be preserved, but the non-forested area can be developed. They would like to use it as a park. They can see birds from the Deutche Welle site taking their harvest and crops;
More parks with open spaces;
One type of park should be a water park because it is tradition to take pictures near a fountain on their wedding day and now they have to move far away for that. It would be an attraction for people of the neighbourhood as well.

13.1.2 Authorities

Urban Planning

i. Authorities proposed ideas or intentions about:

ii. Mix all urban functions into self-sustaining hubs, including social infrastructures, job creations, non-housing infrastructures, and a recreational area. Combine slow network, water collection, drainage within the proposed Green fingers, while green fingers need to be reduced;

iii. Tailor facilities to the neighbourhood level, minimum vehicle, more green spaces, increase walkability and create a green network including the forests and the wetlands;

iv. Link the fishing and farming activities to the market;

v. Main street to incorporate retail/commercial activation to street-facing ground floor;

vi. Build 1st stage pilot phase (18 ha) closest to existing N-S road;

vii. 1st stage should have 'extreme green' criteria e.g. private car constraints. Subsequent phases can be less radical if pilot phase considered too radical;

viii. Coordination and discussion with RSSB and IFC (developing Affordable Housing), City of Kigali (COK) and among the various ministries considered mandatory;

ix. Decentralization of Commercial and Service nodes: two at extreme end of the site and another in the centre;

x. Locate the Light Industries next or within the commercial nodes to avoid people from converting their residential houses into commercial (e.g. food outlets) to cater for those in the light industry zones;

xi. Local authorities to be open to suggestions on changes to the zoning plan;

xii. Wetlands: Nobody owns the wetlands; the government is leasing it out. Consult with the relevant authorities: Housing, REMA (having a wetland masterplan), City of Kigali;

xiii. Communities sometimes come together to build their own roads if the government takes too long. They can ask the government to sponsor for example drainage or lighting.

Housing and housing finance

i. Authorities informed about:

ii. Current houses for sale are not paid with mortgages. Mortgaging stopped with that early on with Vision city;

iii. Apartments sell as well as villas due to less maintenance and less security concerns. Younger generation more amenable to high-density typologies

iv. Authorities proposed ideas or intentions about:

v. People in Rwanda don't like high rise buildings, allegedly because they are afraid of heights. Maximum is 6 floors;

vi. There is an array of opinions on location (as opposed to the communities)

vii. Some prefer proximity of housing to trading environment, healthcare more than being within school catchment area, particularly for low-income housing;

viii. Some see low-income housing closest to main street, higher-income housing closest to hill crest and hill-base (with view of cultivated valley);

ix. Higher-income housing subsidising lower-income housing via SPV;

x. Lower status associated with housing lower downhill, also with pepper-potted mix of social and private housing but attractive pricing will compensate;

xi. Include exclusive high-end residential housing;

xii. The key for affordable housing is reducing the cost of construction;

xiii. If you want people to buy houses, make sure the facilities are:

xiv. near Kigali

xv. accessible to work

xvi. add a green area to have a cool place to rest

xvii. near market place

xviii. near hospital, health centre

xix. have water and rainwater harvesting infrastructure

xx. near affordable schools

xxi. benefit of good air quality.

<u>Infrastructure (energy, water, security, public utilities)</u>

i. Authorities informed about:

ii. Energy for cooking: Charcoal and biomass is largely used in Kinyinya;

iii. Recreation and cultural infrastructures: Community sports are football, basketball and volleyball. Community halls offer activities such as theatre, dance and meetings after Umuganda;

iv. Gas infrastructure is a possibility as they want to reduce their reliance on biofuels;

v. Electricity lines are located underground. It is more environmentally friendly and more cost effective

vi. Authorities proposed ideas or intentions about:

vii. Markets: A new market facility with warehouse should be put in place;

viii. Newly built infrastructure should be adaptable as maybe in the future piped gas will be an opportunity;

ix. Consider connecting to the Kigali Water Supply network;

x. Kigali Water Supply map. The ESRI experts could provide an overlay.

Transport & Mobility

i. Authorities expressed concerns about:

ii. Roads, a big issue: Today, the roads are in poor conditions which make people walk long distance to reach public transport points to get to their destinations. There is an important road that crosses Kinyinya Hill. Another alternative road on the northern part of the area takes double miles but minimizes the transport in and through Kinyinya.

iii. Authorities proposed ideas or intentions about:

iv. Maintaining north-south road thoroughfare through site from adjacent communities essential to Kigali;

v. Main transport and services artery to run E-W halfway up the hill;

vi. A good public transport system with bus connections to improve connectivity and providing access to the proposed commercial nodes and neighbourhoods on the site especially with a proposed road running across the mid-section of the site and ending at a bus stop at the top North East part of the hill;

vii. Construct a road that has little impact on the natural area. Follow the natural slope. That would be the most logical;

viii. Consider the larger scale to make roads integrated in the larger network;

ix. Consider the social connection;

x. It is possible to build a pathway/bridge through the wetlands.

Socio-economic functions, jobs including agriculture

i. Authorities informed about:

ii. Manufacturing: Agakiriro (wealth centre) is a good practice to encourage since it enables job creations, vocational training and trade for unskilled youth. Multipurpose workshops units could be integrated to the markets

iii. Authorities proposed ideas or intentions about:

iv. A concept of urban agriculture of smaller gardens located next to the residential houses to grow vegetables with the slow network running along these gardens. These gardens can in the end be developed as the green finger network;

v. There is a need to provide for Job creation on the site, proposing Labour Intensive jobs and intensifying Agricultural production but also provision of construction jobs during development of housing projects.

Social development (health, education, poverty)

i. Authorities proposed ideas or intentions about:

ii. Add two new health centres/health posts;

iii. A need to develop a technical training school (TVET) on site to help youth get relevant skills and either create their own jobs or make them employable.

Climate change & Environment (waste, microclimate, sanitation, nature)

Authorities informed about:

iv. Drainage/sewerage system: There are two formal settlements, one real estate development and a genocide survivors' settlement, but with poor rain drainage and sewerage systems that use septic tanks and open ditches which may impact on groundwater sources.

v. Authorities proposed ideas or intentions about:

vi. Drainage/sewerage system: Model given a construction measure how much water flows through the wetlands. It's better to use constructed wetlands which use gravity and is currently practiced in Rwanda;

vii. Forest: 20% of the areas should be green, hence there is a strong intention to keep the existing forested areas and create new parks on the hill. Establish green corridors and create links to the wetlands. Continue the green the ridge extending the DW site into a green corridor running E-W along length of site ridge. A green area is attractive and could be the identity of the hill and people would come to Kinyinya Hill;

viii. The wetlands: create recreation areas, water parks, vegetable farming, fish ponds and use the existing roads networks along the wetlands for recreation, outdoor fitness, biking roads, …;

ix. Add water features e.g. ponds on the DW site which will improve the ecological structure;

x. Semi centralized effluent systems are being developed. Look into the development of this plan and integrate it. Authorities are thinking of bigger WWTP;

xi. It's a regulation to separate sewage water from storm water drainage. When you have a development for more than 100 people you need to separate sewage and WWTP. Smaller developments are still allowed a septic tank;

xii. The government does not maintain green spaces but communities can organize this?;

xiii. The tourism department could be a stakeholder when deciding to make parks.

13.2 Annex 2: Bibliography

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13.3 Annex 3: List of persons interviewed

Please refer to the full sector reports in Part 2

13.4 Annex 4: Tentative implementation schedule for Phases B and C