Floods and Landslides Impact Assessment and Description of at-Risk Areas in Four Urban Sub-catchments in Rwanda

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EXECUTIVE SUMMARY

In the context of National Adaptation Planning (NAP), the Rwanda Environment Management Authority (REMA) in collaboration with the Global Green Growth Institute (GGGI) has commissioned a study on floods and landslide risk assessment and mitigation in some sub-catchments of the City of Kigali, Kamonyi, Huye and Rusizi Districts. The present report concerns the assessment of impacts of flood and landslide events over the last ten years (loss of life, livelihoods and physical assets) for the four selected sub-catchments and the description of the catchment areas at risk to inform a cost- benefit assessment.

The main objective of the study it "to provide an input essential to enhancing Rwanda's capacity to respond to climate change in high-risk zones and will enable key stakeholders to address urgent needs for mitigating climate-induced hazards".

The specific objective of this report is to assess environmental and social impacts of floods and landslides and to describe at-risk areas to inform cost-benefit analysis.

The methodology adopted for the preparation of this report includes the review of relevant documents such as national and international regulations related to environmental and social safeguards, districts development plans, field observations as well as consultations with local authorities of the study area. For the properties valuation exercise, different methods were used to estimate the value. For buildings, crops and forests, the properties were not valued one by one, samples of each category of properties were taken and their value was applied to the remaining properties depending on their location. The total surface area of the land at risk (where buildings, crops and forests are) was calculated using GIS software.

The findings of the study revealed that floods and landslides have several negative impacts on the physical environment such as destruction of the built environment, disturbance of the habitat of living organisms. The social environment is also affected (loss of lives, loss of agricultural produce, loss of livestock and loss of houses). Poverty is also reported as a result of floods and landslides.

The population at risk was estimated at 4,512 persons for Rwandex-Magerwa sub-catchment, at 5,101 for Bishenyi sub-catchment, at 55 for Rwabayanga sub-catchment and at 1,071 persons for Kamembe-Gihundwe sub-catchment. The total population at risk of landslides and floods for the year 2021 was estimated at 10,739 persons.

The properties valuation exercise was carried out in the four sub-catchments. Land, buildings, crops, forests and roads at risk of landslides and floods were estimated separately.

The total value estimated for properties in the landslide zone (using the mean land reference prices at cell level) is **Rwf 112,712,600,268** and the total value estimated of properties at risk in the flood zones (using the mean land reference prices) is **Rwf 31,225,152,273**. Both values combined are equal to **Rwf 143,937,752,541**.

The total value estimated for properties in the landslide zone (using the maximum land reference prices at cell level) is **Rwf 225,841,526,613** and the total value estimated of properties at risk in the flood zones (using the maximum land reference prices) is **Rwf 54,727,050,623**. Both values combined are equal to **Rwf 280,568,577,236**.

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INTRODUCTION

2.1 Background information

Natural hazards like floods and landslides can lead to major disasters, which hinder the development of a nation, and these affect many areas in the world. Some countries do not have adequate methodology of estimation of losses due to the occurrence of natural disasters. The information about loss estimation caused by floods and landslides of different magnitudes and the loss return period are crucial to develop policies for rational flood and landslide alleviation based on cost effective measures.

Rwanda is currently vulnerable to climate change as it is strongly reliant on rain-fed agriculture both for rural and city livelihoods where we experience emergency situation from flooding and landslides disasters. Rwanda is located in East-Central Africa, with shortage of data to produce robust climate projections. Temperature rise is uncertain while future rainfall patterns are even more uncertain, making it difficult to plan for the future. This is particularly important for agriculture, where crop yields are affected by temperature and rainfall. It is recommended that climate data for Rwanda be improved to contribute Rwanda's adaptation planning.

With the above background, the Rwanda Environment Management Authority (REMA) in collaboration with the Global Green Growth Institute (GGGI) has commissioned a study on floods and landslide risk assessment and mitigation in some sub-catchments of the City of Kigali, Kamonyi, Huye and Rusizi Districts. The present report aims at illustrating the induced social and environmental effects of floods and landslides over the last ten years, as well as providing an estimating of value of at-risk areas.

2.2 Objectives

The objectives of this study is to assess environmental and social impacts of floods and landslides in the four selected sub-catchments for the last ten years and to estimate the value of properties (land, buildings, crops, forests) at risk.

2.3 Approach and Methodology

The assignment was undertaken in several related and complementary phases, which included the following:
- Desk study and review of relevant documents;
- Consultations with local authorities of the study areas;
- Field visits and surveys;
- Identification of environmental and social impacts of flood and landslide events over the last 10 years;
- Preparation of value estimations and report writing.

2.3.1 Desk study and review of relevant documents

The Consultant identified, collected, reviewed and collated all the relevant information and documents related to the project. This information enabled the Consultant to determine an orientation and approach specific for the study. It also informed on various aspects of the study areas and provided pertinent data that served in the assignment. The documents reviewed the following:

- Relevant national policies and regulations governing environmental management;
- Relevant national policies on gender and poverty;
- Relevant Districts Development Plans (focusing on socio economic data);
- Flood and landslide data (acquired from the Ministry in charge of Emergency Management, MINEMA);
- GGGI Policy

2.3.2 Consultations with local authorities of the study areas

The local authorities of the respective Districts/ Sectors or Cells where the sub-catchments are located were consulted. The objectives of the consultations were to gather information on social issues of the population of the study area (gender status, poverty status and social inclusion issues).

It was expected that the Consultant will request the local authorities to invite representatives of local communities and private investors to take part in the consultations, ensuring consideration of gender and social inclusion. However, given the planning and logistics required during the current Covid-19 pandemic, it was decided not to conduct these focused public consultations because they required more time for planning and obtaining public meeting authorisations than was available during field visits. Nevertheless, the required information on environmental and social impacts of floods and landslides was acquired during meetings with local authorities at cell and sector levels.

2.3.3 Field visits and surveys

Field visits were conducted to the four sub-catchments to collect necessary data. An estimation of value of at risk buildings and other infrastructure was carried out using national valuation guidelines. The outputs of the flood hazard mapping and landslide risk assessment were used to inform the surveys and description of at risk areas.

2.3.4 Value estimation

The Consultant produced a value estimation of existing physical assets at risk of flooding and landslides. This was carried out using national guidelines for value estimation. Land was valued according to the prices of land per cell, available on the website of the Institute of Real Property Valuers (www.irpv.rw).

POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

This chapter describes the relevant policies and strategies, legal instruments, institutional arrangement and international framework applicable to the management of floods and landslides in Rwanda.

The awareness of environmental issues started as early as 1920. Thereafter were created respectively Albert Park (1925), the National Forest of Nyungwe as a reserved forest (1933) and Akagera National Park (1935). The environmental friendly initiatives were also supported by vast campaigns for soil conservation from 1947. In 1977, action programs of environmental nature were launched such as: human settlement (1977), stockbreeding (1978), soil protection and conservation (1980), water supply in rural areas (1981), erosion control (1982) and reforestation (1983). However, it is only in 2003 that the Government of Rwanda established an elaborate National Environment Policy.

3.1   Relevant Policies and Strategies

This section will elaborate on the relevant policy and regulations in relation to the core principles of environment and social safeguards.

3.1.1 National Disaster Management Policy of 2012

This policy is an effort to put in place a systematic disaster prevention, mitigation, preparedness and management framework for the country. Natural hazards in Rwanda are categorized in two main groups:

- Hydro meteorological, namely floods, including those combined with landslides and droughts; and
- Geological, including earthquakes and volcanic eruptions.

Of these, floods and droughts have been the most impactful in terms of the number of people affected. Disasters have had significant environmental and socio-economic impacts, posing a serious threat to livelihoods, food security and economic growth.

3.1.2 National Water Resources Management Policy of 2011

This policy aims at a fair and sustainable access to water, and improvement of the management of water resources through reforestation on hillsides and water catchments areas.

The policy statement on water resources conservation states that the water resources of Rwanda will be conserved, protected and managed in order to secure and enhance its availability for, and utility to, the present and future generations. One of its strategic actions focus is instituting measures for managing water related disasters and stresses arising from climate change, floods, droughts and demographic trends.

The policy also identifies institutions that govern the Rwanda water sector and their functions and responsibilities. The Ministry of Disaster Management and Refugees Affairs (MIDIMAR) was then in charge of coordination and policy formulation on disasters preparedness including floods, landslides and droughts. Those responsibilities are now under the Ministry in charge of Emergency Management (MINEMA).

3.1.3 National Land Policy of 2019

This revised land policy builds on the achievements of the 2004 land policy and ensures continuity of the unfinished agenda in different land thematic areas such as land use planning, land use management and land administration. The 2004 land policy focused mainly on land administration (e.g. Land law reform, securing land rights and tenure, administration of land fees and taxes, land registration and decentralization of land services), but left important gaps on new emerging issues related to efficient land management for sustainable development.

The revised land policy focuses on efficient use and management of land to support the national transformation goals without compromising the benefits of future generations. For this purpose, actions proposed to be implemented in the course of this policy are organized around three main pillars: land use planning, surveying and mapping.

3.1.4 National Environment and Climate Change Policy of 2019

Within the path of development, Rwanda has recognized the importance of the environment and climate change in sustainable development. In 2003, the Government of Rwanda adopted the first ever environment policy to guide the management of environment and natural resources. It was revised in 2019.

Although the environmental policy of 2003 brought about significant achievements in the establishment of the necessary institutions as well as the legal and strategic frameworks, its revision was necessary because significant development and reforms have considerably changed the sector context. Despite this progress, there is still a lack of appropriate and effective mainstreaming response to provisions of the environmental policy in some sectoral activities (e.g. unsustainable use of wetlands; unsustainable land use and farming systems; lack of response to initiatives that promote green technologies, environmental budgeting in the sectoral plans and budgets, etc.).

It is observed that there is a need now to focus on the core mission of regulation, protection, preservation, environmental awareness, education and research. Moreover, the policies (e.g. forest policy, biodiversity policy, etc.) catered for issues that were partly covered by the existing policy of environment.

This policy plays an important role by providing the guidance for identification of negative impact that could be generated during the implementation of the project.

3.1.5 National Strategy for Transformation NST1

NST1 is a Seven Year Government Programme (7YGP) from 2017 to 2024, and is a cross over from Vision 2020 to Vision 2050.
In terms of Disaster Management, the strategy highlights significant progress that has been registered including the development of institutional, policy and legal frameworks and infrastructure for improving preparedness response and mitigation. To sustain progress and strengthen capacities for disaster management, the strategy provides the following actions that will be undertaken:

- Strengthening capacities for weather forecasting and early warning systems to increase reliability and accuracy of information for informed decision making;
- Improving coordination and engagement of all stakeholders to enhance information sharing, timely response and joint delivery of interventions; and
- Continuing implementation of the disaster management plans and tools including district disaster management plans and other contingency plans.

NST1 areas of interventions in disaster management will focus on key sectors such as agriculture, infrastructure, education, environment and natural resources, information and communication technology, health, the private sector and youth and social protection.

3.1.6 Global Green Growth Institute Strategy 2030

There are different national legislations developed to protect the environment. The legislations cited below are relevant to this study. The strategy 2030 sets the course for GGGI's effort to effectively support its member's needs in transforming their economies towards environmentally sustainable and socially inclusive green growth.

The Paris Agreement aims to strengthen the abilities of countries to deal with the impacts of climate change combined with their obligations under the 2030 Development Agenda's Sustainable Development Goals to promote sustainable and inclusive development.

GGGI supports its members to take action in implementing their Nationally Determined Contributions (NDCs) under the Paris Agreement as well as their obligations under the 2030 Sustainable Development Goals (SDGs).

Under the Strategy, GGGI will grow and expand its vision to achieve a low-carbon, resilient world of strong, inclusive and sustainable growth. It will also be able to generate development results that demonstrate that it works to expand and scale-up green growth implementation and catalyse partnerships as well as delivering impacts to the benefits of its members and the global community.

3.2　Legal Instruments

There are different national legislations developed to protect the environment. The legislations cited below are relevant to this study.

3.2.1 Rwanda Constitution of 2003 as amended in 2015

As the supreme law of the country, the constitution of the Republic of Rwanda stipulates that the state shall protect important natural resources including land, water, wetlands, mineral, oil, fauna and flora on behalf of the people of Rwanda. The constitution entrusts the Government with the duty of ensuring that Rwandans enjoy a clean and healthy environment. Article 22 stipulates that "everyone has the right to live in a clean and healthy environment". Article 53 provides that: "the State ensures the protection of the environment". A law determines modalities for protecting, conserving and promoting the environment.

The Rwandan Constitution being the supreme law, its provision and guidelines are mandatory to be complied with.

3.2.2 Law No 27/2021 of 10/06/2021 governing land in Rwanda

The law on land determines how land should be used in Rwanda. It also institutes the principles that are respected on land legal rights accepted on any land in the country as well as all other appendages whether natural or artificial.

Chapter V of the law provides the planning of land use, fundamental principles governing use of lands and the development, adoption , establishment and standards of a land use and development master plan. It also provides for the compliance and monitoring compliance with the land use and development master plan.

3.2.3 Law No 32/2015 of 11/06/2015 relating to expropriation in the public interest

Article 3 of the law stipulates that it is only the government that has authority to carryout expropriation. However, the project, at any level, which intends to carry out acts of expropriation in public interest, shall provide funds for inventory of assets of the person to be expropriated and for just compensation on its budget. This law determines the procedures relating to expropriation of land in the interest of the public.

According to the above expropriation law, no person shall hinder the implementation of the program of expropriation on pretext of self-centred justifications and no land owner shall oppose any underground or surface activity carried out on his or her land with an aim of public interest. In case it causes any loss to him or her, he or she shall receive just compensation for it. The Chapter IV of the Law deals with valuation of land earmarked for expropriation. The law identifies properties to be valued for just compensation to be land and activities that were carried out on the land including different crops, forests, buildings or any other activity aimed at efficient use of land or its productivity. Here the law is silent on access to economic activities on the land.

If the output of this study leads to implementation of works that might require expropriation, it will be done considering the provisions of this law.

3.2.4 Law No 48/2018 of 13/08/2018 on environment in Rwanda

This law regulates the protection of the environment in Rwanda. It sets out the general legal framework for environmental protection and management in Rwanda. It also identifies environmental protection and management as one of the priority action areas for the Government of Rwanda. Article 21 of this law highlights the mainstreaming of environmental management and climate change in the planning process for developments.

3.2.5 International environmental related conventions signed by Rwanda

Rwanda has approved and signed several international conventions, which are in one, or another way related to the management of the floods and landslides.

- Convention on Biological Diversity aiming at conserving biodiversity, using it sustainably and fairly and equitably sharing benefits arising from genetic resources;
- The CARTAGENA protocol on Biosafety, which is a supplement to the Convention of Biodiversity signed in NAIROBI from May 15, to 26, 2000 and in NEW YORK from June 5, 2000 to June 4, 2001 as authorized to be ratified by Law n° 38/2003 of 29 December 2003;
- The KYOTO Protocol to the Framework Convention on Climate Change adopted at KYOTO on March 6, 1998 as authorised to be ratified by Law n° 36/ 2003 of 29 December 2003;
- The RAMSAR International Convention of February 2, 1971 on Wetlands of International importance.

This shows the commitment of Rwanda to fulfil all the requirements at international level in terms of environmental protection toward sustainable development.

3.3   Institutional Framework

The main institutions involved in the management of floods and landslides and their roles are summarised in Table 1 below.

Table 1 : Key Institutions and stakeholders in floods and landslides management

Institution / Agency	Responsibilities
1. Rwanda Environment Management Authority (REMA)	National authority responsible for environmental protection, conservation and promotion in Rwanda. REMA, as the Nationally Determined Authority, plays a role in implementation of the National Adaptation Planning (NAP) Project which aims to increase the government, private sector and communities' planning, funding, implementing and monitoring climate change adaptation across the country.
2. Global Green Growth Institute (GGGI)	Intergovernmental organization, which catalyzes and accelerates access to climate finance/green investments for its members. For the National Adaptation Readiness and Preparatory Support, GGGI plays the role of Delivery P artner for developing a proposal on building flood resilience capacity in Rwanda.
3. Ministry in charge of Emergency Management (MINEMA)	In charge of management of disasters, f loods and landslides included. It provides support to the affected population according to the damages
4. Ministry of Environment (MoE)	Formulating policies and regulations for environmental protection and natural resources utilization.
5. Ministry of Local Government (MINALOC).	Formulating national policies and laws on decentral isation and local governance and supervising d istrict authorities which are responsible for the management of floods and landslides
6. Districts	Districts are responsible for reporting data on floods and landslides to MINEMA and for providing the support needed to affected people.
7. Rwanda Land Management and Use Authority (RLMUA)	Land registration, land use planning and management throughout the country. Compensation and resettlement depend on legal ownership.

DESCRIPTION OF THE STUDY AREAS

Rwanda, the world's 149th largest country, has a surface area of 26,338 square kilometres (10,169 square miles). Rwanda has four provinces (East, West, North and South) and the City of Kigali.

This study concerns four different sub-catchments located in the City of Kigali, Kicukiro District (Rwandex-Magerwa sub-catchment); in the Southern Province, Kamonyi District (Bishenyi sub-catchment) and Huye District (Rwabayanga sub-catchment) and in the Western Province, Rusizi District (Kamembe-Gihundwe sub-catchment).

4.1 General description of the sub-catchments

4.1.1 Rwandex-Magerwa

The Rwandex-Magerwa sub-catchment is located to the centre-south of Kigali City, in Kicukiro District and it forms part of the larger Kinamba sub-catchment, which drains to Nyabugogo River. Hill top and slope areas of the sub catchment are predominantly residential, including planned settlements in Gikondo and Kicukiro and unplanned settlements in Gatenga and Karambo. The transition zone comprises of business and commercial complexes as well as other public buildings. There is a small wetland at the lower sections of the sub-catchment, to which runoff is channeled and discharged farther downstream to the Gikondo wetland.

Kicukiro District is situated in the south-east of the City of Kigali. The District borders with Bugesera District in the South, Nyarugenge District in the West, Gasabo District in the North and Rwamagana District in the East. Kicukiro District is made of 10 Sectors, among which Gatenga, Gikondo, Kicukiro and Kagarama Sectors are concerned with the present study.

The flood zone touches three sectors of Kicukiro District, namely Gatenga Sector (Karambo Cell), Gikondo Sector (Kagunga and Kinunga cells) and Kicukiro Sector (Ngoma Cell). The landslide zones of Rwandex- Magerwa sub-catchment are located in Gatenga Sector (Karambo, Nyanza and Gatenga Cells); in Gikondo Sector (Kagunga Cell) and in Kicukiro Sector (Gasharu and Ngoma Cells) and in Kagarama Sector (Rukatsa Cell).

Figure 1 below shows the location of Rwandex-Magerwa flood and landslide zones. The thick red contour line shows the flood zone where many offices and commercial buildings are located; and landslide zones are shown in thin red and blue contour lines. Thin red contour lines represent landslide hazard areas with an average landslide hazard rate of 365m2/year/km2, whereas areas with blue contour lines represent landslides hazards areas with an average landslide hazard rate of 90 m2/year/km^2.
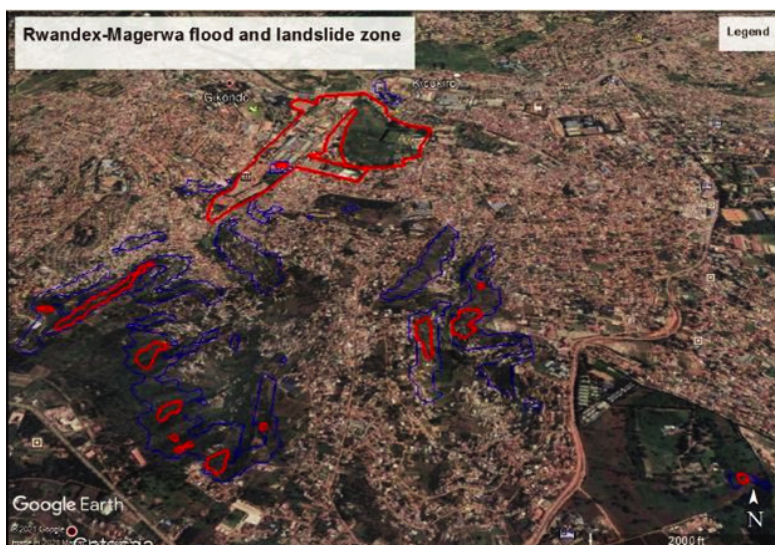
Figure 1: Google map showing RWANDEX-MAGERWA flood and landslide zones

4.1.2 Bishenyi

The Bishenyi sub-catchment is located in Kamonyi District. It drains the areas of Bishenyi, Runda, Ruyenzi, Sheli and Rugarika. Land use in the sub-catchment is predominantly agricultural, but there has been large-scale construction of residential homes on hilltops and slope sections during the last 10 years, especially in the Ruyenzi area.

Kamonyi District is situated in the Southern Province of the Country. The District borders with Ruhango District in the South, Muhanga District in the West, Gakenke and Rulindo Districts in the North and Nyarugenge and Bugesera Districts in the East. The distance between Kigali and Kamonyi is about 32 Km (Kamonyi District office) on National Road 1. Travel time from Kigali is about 30 minutes.

Figure 2 below shows the location of Bishenyi flood and landslide zones, with the brown contour line showing the flood zone; and landslide zones shown in red and blue contour lines. Red contour lines represent landslide hazard areas with an average landslide hazard rate of 365m²/year/km², whereas areas with blue contour lines represent landslides hazards areas with an average landslide hazard rate of 90 m²/year/km².
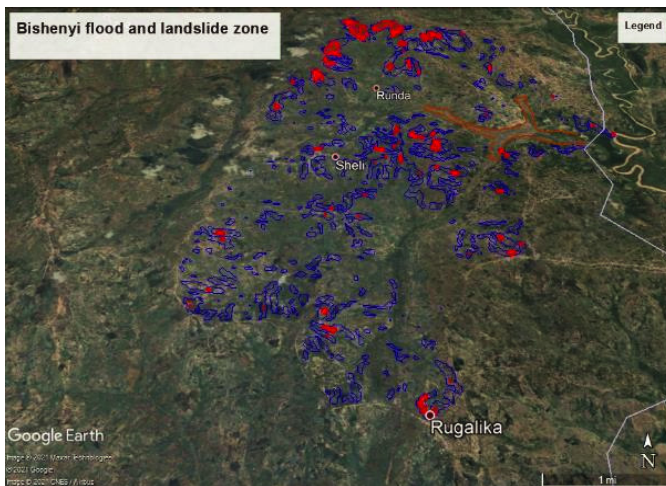
The flood zone touches two sectors of Kamonyi District namely Runda Sector (Ruyenzi and Muganza Cells) and Rugarika Sector (Kigese and Sheli Cells).

The landslide zones of this sub-catchment are located in Runda Sector (Kabagesera, Muganza and Ruyenzi Cells) and in Rugarika Sector (Sheli, Kigese, Bihembe and Nyarubuye Cells)

Figure 2: Google map showing BISHENYI flood and landslide zones

4.1.3 Rwabayanga

The Rwabayanga sub-catchment is located in Huye District. The eastern and northern sides of the sub-catchment are urbanized, part of Huye City; whilst the western and southern sides are predominantly rural and agricultural areas.

Huye District is situated in the Southern Province of the Country. The District borders with Nyaruguru District in the South, Nyamagabe District in the West, Nyanza District in the North and Gisagara District and Nyaruguru Districts in the East. The distance between Kigali and Huye is about 125 Km on National Road 1. It is reachable by road in three hours from Kigali.

Figure 3 below shows the location of Rwabayanga flood and landslide zones, with the brown contour line showing the flood zone; and landslide zones shown in red and blue contour lines. Red contour lines represent landslide hazard areas with an average landslide hazard rate class of 365m²/year/km², whereas areas with blue contour lines represent landslides hazards areas with an average landslide hazard rate of 90 m²/year/km².
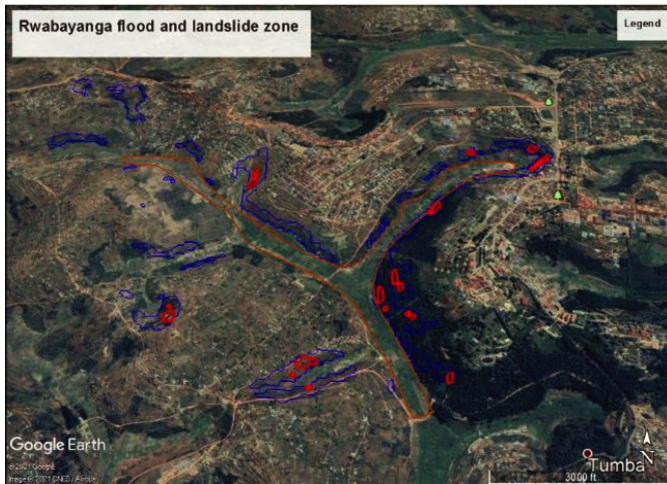
Figure 3: Google map showing RWABAYANGA flood and landslide zones

The flood zone touches two sectors of Huye District namely Ngoma Sector (Ngoma, Matyazo and Kaburemera Cells) and Tumba Sector (Mpare Cell).

The landslide zones of this sub-catchment are located in Ngoma Sector (Matyazo, Kaburemera, Ngoma and Butare Cells) and in Tumba Sector (Mpare Cells).

4.1.4 Kamembe- Gihundwe

The Kamembe-Gihundwe sub-catchment is located in Rusizi District. This site is not a 'sub-catchment' per se, but it is composed of several small sub-catchments distributed across Cyangugu, Ruganda and Burunga cells.

Rusizi District is situated in the Western Province of the Country. The District borders with Burundi in the South, Democratic Republic of Congo in the West, Nyamasheke District in the North and Nyamagage and Nyaruguru Districts in the East. The distance between Kigali and Rusizi is about 222 Km via National Road 1 and National Road 6. It is approachable by road in six hours from Kigali. Rusizi District is made of 18 Sectors, among which Gihundwe and Kamembe Sectors are concerned with the present study.

Figure 4 below shows the location of Kamembe-Gihundwe flood and landslide zones, with the brown contour line showing the flood zone; and landslide zones shown in red and blue contour lines. Red contour lines represent landslide hazard areas with an average landslide hazard rate class of 365m²/year/km², whereas areas with blue contour lines represent landslides hazards areas with an average landslide hazard rate of 90 m²/year/km².
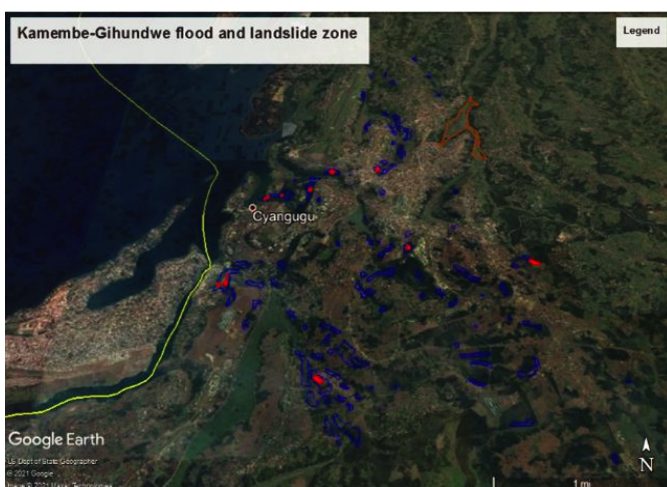
Figure 4: Google map showing KAMEMBE-GIHUNDWE flood and landslide zones

The flood zone of Kamembe- Gihundwe sub-catchment is Cyunyu Wetland, located in Rusizi District, Gihundwe Sector (Burunga and Shagasha Cells).

The landslide zones of this sub-catchment are located in Gihundwe Sector (Burunga Cell) and in Kamembe Sector (Kamashangi II, Cyangugu, Kamurera and Ruganda II Cells).

4.2   Social and gender profile

The outcome of this study might influence the socio-economic and gender aspects in the concerned study areas and population/ demography and economic trends in the four sub-catchments and in their neighborhoods. In general, demographic data shows that rural districts have a higher household size than urban districts. However, some urban districts have higher household size than rural districts mainly due to some peri-urban and rural areas, which are administratively included in those urban districts.

The main objective of socio-economic activities in the study areas is to contribute to sustainable economic growth and the wellbeing of local population by improving habitat and urban infrastructure. Specifically, the urbanization objective is to achieve modernization of cities, especially in the habitat areas, with interventions to curb the proliferation of unplanned housing and to improve living standards in informal neighborhoods (a good number of unplanned houses is found in Rwandex- Magerwa sub-catchment).

4.2.1 Rwandex-Magerwa (Kicukiro District)

The Integrated Household Living Conditions Survey (EICV3) results show that the total population of Kicukiro District in 2010–2011 was 301,000 inhabitants, spread over an area of 167 km² with a population density of 1802 hab./km² (country density is 415 person/km²).

The population of Kicukiro District represents 28% of the total population of Kigali City and 2.8% of the total population of Rwanda. Females comprised 49.8% of the population of the district. The majority of the population is young, with 87% of the population aged less than 40 years old. The poverty rate was 22.3% in 2016-2017 (EICV 5). The average size of the household is 4.7 (about 5 persons per household) for Kicukiro District, which is a slightly below the national average

According to the results of EICV5, in Kicukiro District, 17.3% of households were headed by females and 72.5% headed by males. Also, the total number of households cultivating land for crop production was estimated at 23,000 households.

In Rwandex- Magerwa sub-catchment, there are 210 houses in the planned settlements category and 444 houses in unplanned settlements category located in the flood / landslide hazard zones. Planned settlements are mostly found in Nyanza Cell of Gatenga Sector and in Kagunga Cell of Gikondo Sector; while the majority of unplanned settlements are found in Karambo Cell of Gatenga Sector.

From 2002-2012, the rate of population change was 48.4%. As there is no other population census conducted since 2012, the same rate was used to estimate the average population of Kicukiro District in 2022, and thereof estimate the average household size in order to get the population at risk. The population of Kicukiro District is estimated at 446,684 inhabitants in 2022.

According to EICV 3, the average household size of Kicukiro District was 4.7 individuals per household. The population at risk of landslides and floods in Rwandex-Magerwa sub-catchment was estimated at 4,512 persons (we used the estimated household size of 6.9 persons in 2022).

4.2.2 Bishenyi (Kamonyi District)

The Integrated Household Living Conditions Survey (EICV3) results show that the total population of Kamonyi District in 2010–2011 was 330,000 inhabitants spread over an area of 655 km2, with a population density of 503 persons/km2. Females comprised 52 % of the population of Kamonyi District. The majority of the population is young, with 78 % of the population aged less than 40 years old. The poverty rate was 22.3% in 2016-2017 (EICV 5).

According to the results of EICV5, in Kamonyi District, 24.6 % of households were headed by females and 68.7% headed by males. Also, the total number of households cultivating land for crop production was estimated at 85,000 households.

In Bishenyi sub-catchment, there are 231 houses in the planned settlements category and 604 houses in unplanned settlements category located in the flood / landslide hazard zones. Planned settlements are mostly found in Muganza and Ruyenzi Cells of Runda Sector; while the majority of unplanned settlements are found in Sheli Cell of Rugarika Sector.

From 2002-2012, the rate of population change was 31.2%. As there is no other population census conducted since 2012, the same rate was used to estimate the average population of Kamonyi District in 2022 and thereof estimate the average household size in order to get the population at risk. The population of Kamonyi District is estimated at 432,960 inhabitants in 2022.

According to EICV 3, the average household size of Kamonyi District was 4.6 individuals per household. The population at risk of landslides and floods in Bishenyi sub-catchment was estimated at 5,010 persons (we used the estimated household size of 6 persons in 2022).

4.2.3 Rwabayanga (Huye District)

The Integrated Household Living Conditions Survey (EICV3) results show that the total population of Huye District in 2010–2011 was 319,000 inhabitants spread over an area of 581.5 km². It has a population density of 548 persons/km². About 54 % of the population of Huye District is females. The majority of the population is young, with 80 % of the population aged less than 40 years old. The poverty rate was 40.2% (EICV5 conducted in 2016-2017).

Huye District is made of 14 Sectors, among which Ngoma and Tumba Sectors are concerned with the present study.

According to the results of EICV5, in Huye District, 31.6 % of households were headed by females and 72.1 % headed by males. Also, the total number of households cultivating land for crop production was estimated at 75,000 households.

In Rwabayanga sub-catchment, there are only 11 houses in the planned settlements category and no house in unplanned settlements at risk. Planned settlements are mostly found in Mpare Cell of Tumba Sector.

From 2002-2012, the rate of population change was 12%. As there is no other population census conducted since 2012, the same rate was used to estimate the average population of Huye District in 2022 and thereof estimate the average household size in order to get the population at risk. The population of Huye District is estimated at 357,280 inhabitants in 2022.

According to EICV 3, the average household size of Huye District was 4.6 individuals per household. The population at risk of landslides and floods in Rwabayanga sub-catchment was estimated at 55 persons (we used the estimated household size of 5 persons in 2022).

4.2.4 Kamembe - Gihundwe (Rusizi District)

The Integrated Household Living Conditions Survey (EICV3) results show that the total population of Rusizi District in 2010–2011 was 417,000 inhabitants spread over an area of 959 km2. It has a population density of 434 persons/km2 (country density is 415 person/km2). About 53 % of the population of Rusizi District is female. The majority of the population is young, with 82 % of the population aged less than 40 years old. The poverty rate was 33.5% (EICV5 conducted in 2016-2017).

Rusizi District is made of 18 Sectors, among which Kamembe and Gihundwe Sectors are concerned with the present study.

According to the results of EICV5, in Rusizi District, 22.7% of households were headed by females and 72.1% headed by males. Also, the total number of households cultivating land for crop production was estimated at 87,000 households.

In Kamembe-Gihundwe sub-catchment, there are 121 houses in the planned settlements category and 32 houses in unplanned settlements category located in the flood / landslide hazard zones. Planned settlements are mostly found in Kamatita Cell of Gihundwe Sector and unplanned settlements are found in Kamashangi II and Gihundwe cells of Kamembe Sector.

From 2002-2012, the rate of population change was 29%. As there is no other population census conducted since 2012, the same rate was used to estimate the average population of Rusizi District in 2022 and thereof estimate the average household size in order to get the population at risk. The population of Rusizi District is estimated at 537,930 inhabitants in 2022.

According to EICV 3, the average household size of Rusizi District was 5.4 individuals per household (higher than the national average and the highest in the Western Province). The population at risk of landslides and floods in Kamembe- Gihundwe sub-catchment was estimated at 1071 persons (we used the estimated household size of 7 persons in 2022).

5

IMPACT IDENTIFICATION AND ASSESSMENT

Rwanda has a very mountainous topography giving landscapes with slopy hillsides where rainfalls cause erosion on soils that often lack anti-erosion measures. These heavy rainfalls sometimes bring about deadly landslides that damage road infrastructure or sweep away houses in rural areas as well as in urban areas (mostly in unplanned settlements). Erosion also contributes to loss of agricultural yield, causing food insecurity problems and poverty in general.

In urban areas, flood risks are more significant for human settlements located in lowlands and near wetlands. The overpopulated areas in these zones are threatened by epidemics like malaria and diarrheic diseases.

Urban infrastructure is also affected by flooding due to runoff that washes away soil, gravel and other materials, causing sedimentation of drainage systems (drains and culverts), resulting in loss of conveyance capacity and water overflows, placing roads and houses at great risk of damage.

Site visits to the four sub-catchments and data collected from meetings with local authorities gave an insight on several impacts of landslides and floods on the physical and social environment as detailed in Table 2.

5.1   Impacts of landslides

Landslides are destructive agents. They change and modify the landscape and they disturb it. Destruction and disturbance is costly for the built environment, it is costly for natural resources and yet it is essential for ecosystems cycling in the natural environment.
Landslides affect the following elements of the environment:
- the topography of the earth's surface;
- the character and quality of rivers and streams and groundwater flow;
- forests that cover much of the earth's surface; and
- habitats of natural wildlife that exist on the earth's surface including its rivers, lakes, and oceans.

5.2   Impacts of floods

The phenomenon of flooding is a natural event that can bring both adverse and beneficial environmental change. Both the risk and impact of flooding can, however, be modified by human agency. Changes in the upper catchment response to precipitation, river flow controls and building in flood risk areas can all complicate the natural flood regime, causing symptoms, which can trigger further works and added complexity.

Coping structurally with the complex flood risk caused by such changes in land use can imply high implementation costs, which require investment justification. In cases where the quantifiable estimate of direct and indirect flood damage does not exceed the cost of remedial works, attention is drawn to the intangible damage caused by floods. This is environmental justification for taking action, but also a better appreciation of the mitigation measures necessary to provide a scheme, which supports the principles of sustainable development

Although floods are common in Rwanda, they have increased in frequency over the past decade.

Occurrences in 2018 and in previous years in different parts of the country resulted in the damage of infrastructure, agricultural losses, led to environmental degradation, population displacement and fatalities.

Floods in Rwanda usually originate from heavy rainfall, which causes rapid and unpredictable surges in the flow of rivers downstream. The two predominant types of floods are:
(i) Localized floods caused by exceptionally heavy rains and run-offs; and
(ii) Widespread floods caused by overflowing rivers and their tributaries.

Floods can also trigger outbreaks of water borne diseases and malaria, hence exposing local communities to health hazards. They also cause physical damage by washing away structures, crops, animals and submerging human settlements. The impact of floods can be minimized by the forecasting, studying seasonal patterns as well as the construction and maintenance of sufficient drainage systems. Rwanda experiences both slow and rapid onset floods.

5.3   Feedback from local authorities on floods and landslides

Preliminary studies have shown areas prone to floods and landslides in the four sub-catchments and maps were produced. We used the maps to localize sites and visit them.

What is reported in Table 2 below is the feedback from local authorities at sector and cell levels (depending on their availability), on the impacts of floods and landslides over the past 10 years.

The observation made is that there is no record keeping of the data on floods and landslides. The authorities reported the events they remembered. In some cases, the executive secretaries or other relevant staff of sectors or cells were new in their position and they did not have enough information.

The meetings were attended by sector/cell staff in different position namely: Executive Secretaries, Social Officers, Environmental officers, Land managers, CNF (in charge of gender), Security officers (DASSO) and Agronomists.

The following table highlights the impacts of floods and landslides per sub-catchment over the last ten years, triggering factors noted and information provided by the local authorities and proposed coping mechanisms.

Table 2 : Impacts reported by local authorities and proposed mitigation measures

Sub-catchment	Sector/ Cell	Adverse impact reported	Triggering factor	Proposed mitigation measures
Rwandex-Magerwa	Nyanza Cell/ Gatenga Sector	Personal injury due to house collapse, and destruction of house This causes loss of livelihoods when houses are damaged or destroyed, landlords lose their tenants and fail to pay bank loans	Heavy rain that caused landslides	Improve settlements Improve the building structures that are structurally resilient, and respect the building codes
		Injury (a student fell in a drainage channel and got injured)	Drainage from Nyanza Bus station is party constructed (it is only constructed from Juru Village)	Construct and if possible cover the drainage channels. Upgrade informal settlements. RUDPII World Bank project will be implemented in very steep villages of Juru, Murambi Ihuriro, Isonga and Sabaganga villages Community initiatives to build roads on their own

Sub-catchment	Sector/ Cell	Adverse impact reported	Triggering factor	Proposed mitigation measures
		Heavy burden on women when houses are damaged or collapse. Sometimes, in such circumstances, men abandon their families, leave their wives alone with the children. They come back when the house is repaired	Floods and landslides	Sensitize men on taking their responsibilities of protecting their families instead of leaving.
	Karambo cell/ Gatenga Sector	Loss of property Poverty caused by the loss of properties	Very steep slopes Lack of appropriate drainage systems. The new road of Rebero has drainage that is not channeled all the way downstream to the valley.	Provide appropriate drainage systems where they are not available (World Bank project might solve the issues of floods in Ruhuka Cell, Kamabuye, Gwiza,Rugwiro and Sangwa Villages). Proper construction of drainage channels.
	Gatenga Cell/ Gatenga Sector	Floods	The drainage channel from Nyanza bus station brings a lot of water that is not conveyed by the existing drainage channel. Unplanned settlements that lack rainwater collection structures	Planned settlements Appropriate rainwater harvesting or collection infrastructure
Rwabayanga	Tumba Sector/ Huye District	Landslide occurred in Mpare cell in August 2020 but no one died	Poor drainage of rainwater from the roads	Proper drainage of roads
	Ngoma Sector/ Huye District	Landslides	Mostly caused by roads that are not properly drained	Proper drainage of storm water from the roads

Sub-catchment	Sector/ Cell	Adverse impact reported	Triggering factor	Proposed mitigation measures
		Loss of agricultural produces. In Kaburemera Cell towards Nyaruguru District, people are no longer cultivating their fields due to storm water that enter their fields	Poor drainage of rainwater from the roads	Proper drainage of storm water from the roads Increase people capacities to buy rainwater harvesting tanks(subsidies)
Bishenyi	Sheli Cell/ Rugarika Sector	Water from Rugarika, Runda and Gacurabwenge caused floods in Bishenyi marshland due to rapid urbanisation	There is no existing drainage system to manage stormwater	There is now a physical plan that is guiding urbanization in Kamonyi District. Those who lived in flood prone areas were relocated
	Rugarika Sector	Landslide in Kigarama Villace/ Sheli Cell. Loss of agriculture produce	Heavy rain	
	Runda Sector	Loss of life and properties	Rapid urbanization and lack of physical plan	Now the physical plan is available and implemented.
		Floods that affected mostly women head of families with low income.	Rapid urbanization	Runda sector gives land for free to those whose houses were destroyed (who are in Category 1 and 2 of Ubudehe). But that land is almost fully occupied

Sub-catchment	Sector/ Cell	Adverse impact reported	Triggering factor	Proposed mitigation measures
		Heavy rains of 2018 caused floods and loss of 2.5 ha of farm land	Rapid urbanization	Houses on steep slopes were instructed to retain their water Progressive terraces to control erosion Buffer zones of 3m from rivers to fields. Sugar canes were planted in those buffer zones to strengthen the soil Insurance for farmers (e.g. the cooperatives of farmers of Bishenyi wetland that were insured by SONARWA were compensated)
Kamembe-Gihundwe	Kamembe Sector	Landslide occurred in Ntemabiti village, Kamashangi Cell. Some houses collapsed and others damaged.	Heavy rains and unstable soil.	People were moved to Nyakarenzi
		Poverty when people are moved from towns to rural areas, when they were depending on commerce	Landslides	Provide financial support to those who are moved to rural areas to support them in starting new businesses
	Gihundwe Sector	Crops damaged in Cyunyu wetland Undrained storm water between Kamashangi and Burunga(ku Kabasazi)	Floods of April 2021	Cooperatives are advised to have insurance for their crops GGGI proposed 3 sites where they can build a drainage system (Karushaririza). Three houses will be expropriated

5.4 Historical data on floods and landslides

Rwanda has witnessed a number of natural and man-induced disasters that have culminated into the loss of lives and property and the displacement of people. Famine as a result of drought, traffic accident, earthquake, epidemics, floods, landslide, environmental degradation, technological accident, fire outbreak and lightning have been prevalent. The general objective of the overall study, therefore, is to assess impacts and mitigation measures for floods and landslides.

Natural hazards in Rwanda are categorized in two main groups: (i) hydro meteorological, namely floods, including those combined with landslides and droughts; and (ii) geological, including earthquakes and volcanic eruptions. Of these, floods and droughts have caused the most serious disasters in terms of the number of people affected. Disasters have had significant environmental and socio-economic impacts, posing a serious threat to livelihoods, food security and economic growth.

The scope of the study is limited to the assessment of impacts of flood and landslide events over the last ten years (loss of life, livelihoods, physical assets, etc.) for the four selected sub-catchments.

5.4.1 Damages caused by landslides

Preliminary studies have shown areas that have a high landslide hazard rate (365 m2/year/km2) and those in the next category of landslide hazard rate of 90 m2/year/km2. We requested data regarding damages caused by landslides in the last 10 years in specific study area districts, sectors and cells. We managed to acquire data from 2 September 2013 to 25 May 2021, available at District level only. This means that the data is not specific for the selected sub-catchments locations.

Table 3 : Damages caused by landslides in the districts of the four sub-catchments

DISTRICT	Number of people dead	Number of people Injured	Number of houses destroyed	Number of houses damaged	Damages in crops (ha)	Lost cattle	Other livestock	Roads	Bridges
Kicukiro	0	0	0	1	0	0	0	0	0
Kamonyi	2	2	0	102	30	0	0	3	4
Huye	0	0	0	1	0	0	0	1	0
Rusizi	3	4	0	51	433	0	0	8	1
TOTAL	5	6	0	155	463	0	0	12	5

Data source: Ministry in charge of Emergency Management (MINEMA)

The above historical data for the last eight years, landslides have had more adverse impacts on crop production than other damages that can be given monetary value. Using the average estimation of cost per square meter of crops found in the four districts (552 Rwf/sqm of crops), the estimated loss incurred is estimated at 2,555,760,000 Rwf.

5.4.2 Damages caused by floods

The following damages were caused by floods in the districts where our study areas are located. They were recorded by MINEMA from 2 September 2013 to 25 May 2021.

Table 4 : Damages caused by floods in the districts of the four sub-catchments

DISTRICT	Number of people dead	Number of people Injured	Number of houses destroyed	Number of houses damaged	Damages in crops (ha)	Lost cattle	Other livestock	Roads	Bridges
Kicukiro	1	0	0	7	5	0	0	0	1
Kamonyi	4	0	0	2	377	0	0	1	0
Huye	0	0	0	1	155	0	0	0	2
Rusizi	8	10	0	67	25	0	0	0	2
TOTAL	13	10	0	77	562	0	0	1	5

Data source: Ministry in charge of Emergency Management (MINEMA)

The historical data for the last eight years show that floods have had more adverse impacts on crop production than other damages that can be expressed in monetary value. Using the average estimation of cost per square meter of crops found in the four districts (552 RWF/sqm of crops), the estimated loss incurred is estimated at 3,102,240,000 RWF.

VALUE ESTIMATION

6.1 Rationale

The scope of this study includes a description of the catchment area at risk to inform cost-benefit assessment (population at risk and estimated value of existing and planned physical assets at risk) and thereof estimate the cost of not investing in the proposed infrastructure.

The "Sample Properties" were located in four sites namely Rwandex-Magerwa in Kicukiro District, Bishenyi in Kamonyi District, Rwabayanga in Huye District and Kamembe- Gihundwe in Rusizi District.

6.2 Methodology

Physical assets valued were in five categories namely land, buildings, crops, forests (trees) and roads. Their valuation was based on their location, their condition, the value of the surrounding properties and the market conditions in the area.

Regarding the valuation of land, the Institute of Real Property Valuers of Rwanda (IRVP) has set land prices at the sector level, cell level and village level. Valuation at village level is done when the valuation objective is to get the exact value of properties for different reasons such as expropriation, use of a property as a guarantee to acquire a bank loan, etc.

For this assessment, we have decided to use the land reference prices at cell level (at which land parcels were sold in the subject area during the year 2015-2017 as provided by the Institute of Real Property Valuers in Rwanda). The time allocated to the valuation assessment part of the study was not sufficient allow going deep at the village level, measure property by property and compute the value of properties. An overall estimation was carried out based on two comparable methods:

- The first uses "mean land reference prices at cell level"(see annexes for reference) for each sub-catchment, which are prices derived from an average of prices of land sales conducted in the years 2015-2017.
- The second uses "maximum land reference prices at cell level" (see annexes for reference) for each sub-catchment, which are maximum prices derived from land sales conducted in the years 2015-2017

The following are the methods used and the physical assets to which they were applied.

6.2.1 Market value method

Market value is defined as" the estimated amount for which a property should exchange on the date of valuation between a willing seller in an arm's length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently and without compulsion".

This method was used to determining value of land and houses.

6.2.2 Sampling method

Sampling method is a method used in giving a value to physical assets that are hard to count one by one (for example trees in a forest and crops). It is done by taking two or three samples of a forest, counting the number of trees in that surface area, and computing the average number of trees of those samples. That average number is applied to the total surface area of the forest. Sampling method was used to determine the quantities of trees and crops.

6.2.3 Comparison method

Comparison method is an approach which uses the value of recent sold comparable assets (available on the website of the Institute of Real Property Valuers) to determine the value of a property. In real terms this will mean looking at a similar property within the area and using the sale prices they achieved to guide a valuation decision. We used this method to determine value of houses, focusing on construction materials and the types of house (storey building, simple house, industrial house).

6.3 Valuation of properties in the landslide zone

The physical assets for which an estimate of value was determined in the landslide zones of the four sub-catchments are land, crops, houses and forests. Every asset was valued according to its unit of measurement with the unit prices. The properties valued in all site are classified into 139 hectares of forest, 591.9 hectares of crops, 1080 houses in unplanned settlements, and 573 houses in planned settlements.

6.3.1 Valuation of land in the landslide zones

Each cell in Rwanda has a minimum and maximum estimated value of land per square meter (sqm). The average of those prices per cell was used to get the value of one square meter of land in each district/sub-catchment and 30% was applied to that average to get a realistic value (more explanations were given in point 6.2)

Table 5 below shows the provinces, districts, sectors and cells where the sub-catchments under study are located. It also shows the minimum and maximum prices of land per square meter at cell level, the total surface area at risk and the total price of land per district.

Table 5 : Total estimated cost of land in the landslide zones

S/N	DISTRICT	SECTOR	CELL	MEAN LAND PRICE AT CELL LEVEL PER SQM (Rwf)	MAX. LAND PRICE AT CELL LEVEL PER SQM (Rwf)	AVERAGE OF MEAN LAND PRICES (Rwf) A	AVERAGE OF MAX. LAND PRICES (Rwf) B	SURFACE AREA AFFECTED BY LANDSLIDES (sqm) C	TOTAL VALUE USING MEAN LAND PRICES AT CELL LEVEL (Rwf) D = A*C	TOTAL VALUE USING MAX. LAND PRICES AT CELL LEVEL (Rwf) E = B*C
1	RUSIZI	GIHUNDWE	BURUNGA	4,029	14,573					
2	RUSIZI	GIHUNDWE	SHAGASHA	1,644	7,494					
3	RUSIZI	KAMEMBE	KAMASHANGI II	3,660	12,047	2,963	12,592	684,100	2,026,760,267	8,614,529,250
4	RUSIZI	KAMEMBE	CYANGUGU	2,992	16,964					
5	RUSIZI	KAMEMBE	KAMURERA	2,356	8,987					
6	RUSIZI	KAMEMBE	RUGANDA	3,095	15,490					
7	KICUKIRO	KICUKIRO	NGOMA	55,950	76,467					
8	KICUKIRO	GIKONDO	KINUNGA	25,148	43,092					
9	KICUKIRO	GIKONDO	KAGUNGA	18,284	34,581					
10	KICUKIRO	GATENGA	KARAMBO	9,965	60,649	28,535	69,954	763,300	21,781,147,150	53,395,983,612
11	KICUKIRO	GATENGA	NYANZA	13,989	78,161					
12	KICUKIRO	GATENGA	GATENGA	24,777	95,364					
13	KICUKIRO	KAGARAMA	RUKATSA	28,534	98,571					
14	KICUKIRO	KICUKIRO	GASHARU	51,637	72,748					
15	HUYE	TUMBA	MPARE	538	1,535					
16	HUYE	NGOMA	BUTARE	3,119	15,780					
17	HUYE	NGOMA	KABUREMERA	790	9,182	2,206	12,458	623,100	1,374,433,980	7,762,455,180
18	HUYE	NGOMA	MATYAZO	3,170	23,676					
19	HUYE	NGOMA	NGOMA	3,412	12,116					
20	KAMONYI	RUNDA	MUGANZA	3,071	12,932					
21	KAMONYI	RUNDA	RUYENZI	4,955	24,492	2,844	13,101	6,682,100	19,002,221,875	87,540,521,575
22	KAMONYI	RUGARIKA	KIGESE	1,663	7,778					
23	KAMONYI	RUGARIKA	SHELI	1,686	7,201					
			TOTAL					8,752,600	44,184,563,272	157,313,489,617

Note:

For a total land surface area of 875.26 ha in the landslide zones (all the four sub-catchments combined), 1 hectare of land is estimated at Rwf 50,481,643 using the mean land reference prices at cell level and at Rwf 179,733,439 using maximum land reference prices at cell level.

- Considering an average of recent land sales prices in the urban of Huye District area (Karubanda and Butare villages of Ngoma Sector), one hectare of land cost Rwf 24,193,548
- Considering an average of recent land sales prices in the peri-urban area of Huye District (Cyeru and Buvumu villages of Mukura Sector), one hectare cost Rwf 1,958,863

6.3.2 Valuation of forests in landslide zones

The estimated value of forests was determined using the sampling method. The majority of trees found in the study area are eucalyptus. Few forests were made of pinus trees

Two different samples were taken for each sub-catchment (one sample in the 365 m²/year/km² hazard rate zones per site, and one sample in the 90 m²/year/km² hazard rate zone per site).

Table 6 : Total estimated cost of trees in the landslide zone

SAMPLE CATEGORIES	SUB-CATCHMENT	LANDSLIDE HAZARD RATE (m²/year/km²)	NUMBER OF TREES	AREA (SQM)	TOTAL NUMBER OF TREES	UNIT PRICE (RWF)	TOTAL VALUE (RWF)
(5*5) sqm contains 4 trees	Bishenyi	365	67sqm = 10 trees	170,000	25,373	4,500	114,179,104
(6*7) sqm contains 6 trees							
(8*8) sqm contains 3 trees	Bishenyi	90	104sqm = 8 trees	435,000	33,462	4,500	150,576,923
(4*10) sqm contains 5 trees							
(10*3) sqm contains 5 trees	Rwabayanga	365	79 sqm = 9 Trees	20,000	2,278	4,500	10,253,165
(7*7) sqm contains 4 trees							
(5*4) sqm contains 3 trees	Rwabayanga	90	45sqm= 6 trees	166,000	26,560	4,500	119,520,000
(5*5) sqm contains 3 trees							
(6*5) sqm contains 6 trees	Rwandex-Magerwa	365	57sqm = 11 trees	13,000	2,509	4,500	11,289,474
(3*9) sqm contains 5 trees							
(6*5) sqm contains 3 trees	Rwandex-Magerwa	90	66sqm= 7 trees	103,000	10,924	4,500	49,159,091
(4*9) sqm contains 4 trees							
(4*1) sqm contains 7 trees	Kamembe-Gihundwe	365	75sqm= 12 trees	13,000	2,600	4,500	11,700,000
(5*7) sqm contains 5 trees							
(5*10) sqm contains 11 trees	Kamembe-Gihundwe	90	86sqm= 19 trees	469,000	103,616	4,500	466,273,256
(6*6) sqm contains 8 trees							
TOTAL							932,951,013

6.3.3 Valuation of crops in the landslide zones

The valuation of crops was done using the sampling method. Different types of crops were found in the study area, namely vegetables (tomatoes, cabbage, carrots, onions, pepper, etc.), maize, rice, sweet potatoes, sugarcanes, beans, cassava, banana, potatoes, yams, etc.

The Institute of Real Property Valuers of Rwanda has also set prices per square meter per crop. Looking at different crops found in the four sub-catchments, an average of 250 Rwf per square meter of crops was used as shown in table 7.

Table 7 : Estimated cost of crops in the landslide zone

SUB-CATCHMENT	CULTIVATED SURFACE AREA (SQM)		AVERAGE UNIT PRICE PER SQM (RWF)	TOTAL VALUE RWF)
	Landslide zone $90\,m^2/year/km^2$	Landslide zone $365\,m^2/year/km^2$		
Rwandex-Magerwa	180,000	27,000	250	51,750,000
Bishenyi	4,662,000	486,000	250	1,287,000,000
Rwabayanga	348,000	23,000	250	92,750,000
Kamembe-Gihundwe	186,000	9,000	250	48,750,000
TOTAL				1,480,250,000

6.3.4 Valuation of buildings in the landslide zone

The buildings at risk in the landslide area were categorized into residential buildings and commercial properties. The buildings were classified according to their location. Some are located in planned settlements and others in unplanned settlements. The valuation was done using the market value method. Table 8 below shows the cost of residential buildings, classified per their location (planned and unplanned settlements).

Table 8 : Estimated cost of residential buildings in the landslide zone

NAME	BUILDING LOCATION	NUMBER OF UNITS	UNIT PRICE	TOTAL VALUE (RWF)
RWANDEX-MAGERWA	Planned settlement	210	68,490,000	14,382,900,000
	Unplanned settlement	444	40,560,550	18,008,884,200
	National archive building and Discentre Petrol Station	5	The 5 units have different price estimations	3,005,460,000
	Fondation Olangi-Wosho Church	1		266,750,000
BISHENYI	Planned settlement	231	27,347,100	6,317,180,100
	Unplanned settlement	604	9,798,800	5,918,475,200
RWABAYANGA	Planned settlement	11	27,347,100	300,818,100
	Unplanned settlement	0	-	-
KAMEMBE-GIHUNDWE	Planned settlement	121	27,347,100	3,308,999,100
	Unplanned settlement	32	9,798,800	313,561,600
TOTAL				48,550,818,300

6.4   Valuation of properties in the flood zone

Properties found in the flood zones of the four sub-catchments are land, crops and buildings. The methods and unit prices used to estimate the prices are the same as those used for the valuation of properties in the landslide areas. The tables below give details on how the total prices were calculated.

6.4.1 Valuation of land in the flood zones

Table 9 : Total estimated cost of land in the flood zones

S/N	DISTRICT	SECTOR	CELL	MEAN LAND PRICE AT CELL LEVEL PER SQM (Rwf)	MAX .LAND PRICE AT CELL LEVEL PER SQM (Rwf)	AVERAGE OF MEAN LAND PRICES (Rwf) A	AVERAGE OF MAXIMUM LAND PRICES (Rwf) B	AREA AFFECTED (sqm) C	TOTAL VALUE USING MEAN LAND PRICES (Rwf) D = A*C	TOTAL VALUE USING MAX. PRICES E = B*C
1	RUSIZI	GIHUNDWE	BURUNGA	4,029	14,573	2,836	11,033	132,340	375,382,410	1,460,173,390
2	RUSIZI	GIHUNDWE	SHAGASHA	1,644	7,494					
3	KICUKIRO	KICUKIRO	NGOMA	55,950	76,467	27,337	53,697	227,940	6,231,138,795	12,239,751,165
4	KICUKIRO	GIKONDO	KINUNGA	25,148	43,092					
5	KICUKIRO	GIKONDO	KAGUNGA	18,284	34,581					
6	KICUKIRO	GATENGA	KARAMBO	9,965	60,649					
7	HUYE	TUMBA	MPARE	538	1,535	2,206	12,458	541,000	1,193,337,800	6,739,669,800
8	HUYE	NGOMA	BUTARE	3,119	15,780					
9	HUYE	NGOMA	KABUREMERA	790	9,182					
10	HUYE	NGOMA	MATYAZO	3,170	23,676					
11	HUYE	NGOMA	NGOMA	3,412	12,116					
12	KAMONYI	RUNDA	MUGANZA	3,071	12,932	2,844	26,201	1,059,000	3,011,531,250	13,873,694,250
13	KAMONYI	RUNDA	RUYENZI	4,955	24,492					
14	KAMONYI	RUGARIKA	KIGESE	1,663	7,778					
15	KAMONYI	RUGARIKA	SHELI	1,686	7,201					
	TOTAL							**1,960,280**	**10,811,390,255**	**34,313,288,605**

6.4.2 Valuation of forests in flood zones

The types of trees found in Rwandex-Magerwa sub-catchment are "Imisave" and Eucalyptus in Kamembe-Gihundwe sub-catchment.

Table 10 : Total estimated cost of trees in the flood zone

SAMPLE CATEGORIES	SUB-CATCHMENT	NUMBER OF TREES	AREA (SQM)	TOTAL NUMBER OF TREES	UNIT PRICE (RWF)	TOTAL VALUE (RWF)
(12*5) sqm contains 4 trees (IMISAVE TREE)	Rwandex-Magerwa	60sqm = 9 trees	8,230	1,234	5,500	**6,789,750**
(15*6) sqm contains trees (EUCALYPTUS)	Kamembe-Gihundwe	90sqm = 18 trees	7,750	1,550	4,500	**6,975,000**
TOTAL						**13,764,750**

6.4.3 Valuation of crops in the flood zones

Apart from Rwandex- Magerwa flood zone, which is mainly occupied by commercial buildings and offices, the other three flood zones located in Bishenyi, Rwabayanga and Cyunyu marshlands (Gihundwe) are almost entirely occupied by crops. The following table shows the total surface area of respective flood zones, the percentage occupied by crops and the cultivated surface area.

Table 11 : Surface area occupied by crops in different flood zones

S/N	FLOOD ZONE	TOTAL SURFACE AREA (Ha)	PERCENTAGE OF AREA OCCUPIED BY CROPS	AREA OCCUPIED BY CROPS (Ha)
1	Rwandex- Magerwa	22.794	20%	4.5
2	Bishenyi	105.9	95%	100.6
3	Rwabayanga	54.1	95%	51.4
4	Kamembe-Gihundwe	13.234	95%	12.57

Table 12 : Estimated cost of crops in the flood zone

SUB-CATCHMENT	CULTIVATED SURFACE AREA IN THE FLOOD ZONE (sqm)	AVERAGE UNIT PRICE PER SQUARE METER OF CROPS (Rwf)	TOTAL VALUE (Rwf)
Rwandex-Magerwa	45,000	250	11,250,000
Bishenyi	1,006,000	250	251,500,000
Rwabayanga	514,000	250	128,500,000
Kamembe-Gihundwe	125,700	250	31,425,000
TOTAL			**422,675,000**

6.4.4 Valuation of buildings in the flood zones

The buildings at risk in the flood zones area are categorized into residential, commercial, administrative and religious buildings.

Table 13 : Estimated value of industrial, commercial and residential buildings in the flood zone

S/N	NAME	NUMBER OF UNITS	ESTIMATED VALUE (RWF)
1	PSF EXPO GROUND	11	2,757,185,260
2	SULFO RWANDA COMPOUND	5	1,086,498,600
3	MININFRA/RTDA/NATIONAL LABORATORY OF PUBLIC WORKS	4	204,226,500
4	RBC/ VACCINE PREVENTABLE DISEASES DIVISION	3	229,438,140
5	TRAFFIC POLICE	3	91,943,200
6	TRACTAFRICA	3	732,782,600
7	PETROL STATION WITH 2 CANOPIES	1	123,067,800
8	BIG COMMERCIAL BUILDING	7	2,303,964,950
9	HYUNDAI	5	1,019,964,500
10	COSTA COMPOUND	4	900,170,220
11	MIRONKO	3	221,835,500
12	NAEB	2	2,152,872,880
13	COMPOUND NEAR HYUNDAI	3	241,330,560
14	NEAR TRACTAFRICA	3	474,656,220
15	MAGERWA OFFICES AND WAREHOUSES	18	4,036,215,938
16	THREE STOREY BUILDING BEHIND SULFO	2	649,667,100
17	TWO STOREY BUILDING ON THE MAIN ROAD	3	189,162,000
18	BISHENYI PETROL STATION (HASHI)	3	186,500,000
19	CARLOS GARAGE AND SCHOOLS CLOSE TO THE GARAGE	13	517,156,000
20	IHURIRO VILLAGE, KARAMBO CELL, GATENGA SECTOR	83	1,715,327,000
21	RESIDENTIAL HOUSE AND A COOPERATIVE STORE IN BISHENYI MARSHLAND	6	51,367,500
22	RESIDENTIAL HOUSES AND A FARM IN CYUNYU MARSHLAND (GIHUNDWE)	14	61,333,200
23	RESIDENTIAL HOUSES IN RWABAYANGA WETLAND	4	30,666,600
	TOTAL		**19,977,322,268**

6.5   Valuation of roads

In the four sub-catchments under study, a number of roads are located in the risk zone. An estimation of the monetary value of these roads was done using reference costs of selected national and district roads from the Rwanda Transport Development Agency (RTDA). Lengths of roads and their costs were provided and were used to compute the cost per kilometer (for national and district roads).

That cost was used to estimate the value of national roads, district roads and other roads (unclassified) in the sub-catchments under study, as detailed below in table 14, table 15 and table 16.

6.5.1 Valuation of national roads

There are roads classified as national roads in the four sub-catchments under study. The national roads found in the study area were compared to roads on the RTDA list of national, which are located more or less in the same area.

Table 14 : Estimated value of national roads in the four sub catchments

S/N	RTDA Reference road/ Comparable roads in a sub-catchment	Total cost of the RTDA reference road (Rwf)	Length of the RTDA reference road (Km)	Cost per Km of the RTDA reference road (Rwf)	Calculated length of national roads in the sub-catchments (km)	Estimated cost of road (Rwf)
1	Kigali-Muhanga-Nyanza-Huye-Akanyaru (NR1) / Bishenyi sub-catchment national road	49,906,034,163	157.839	316,183,162	7.92	2,504,170,646
2	Huye-Kibeho-Ndago-Munini-Bitare (NR9) / Rwabayanga sub-catchment national road	7,497,633,823	77.236	97,074,341	3.53	342,672,424
3.	Kicukiro-Nyamata-Nemba (NR5) / Rwandex-Magerwa sub-catchment	31,494,633,824	61.980	508,141,881	2.14	1,087,423,627
4.	Huye-Nyamagabe-Kitabi-Pindura-Buhinga (NR10) Kamembe- Gihundwe sub-catchment	62,353,785,489	116	537,532,633	9.83	5,283,945,787
	TOTAL					**9,218,212,485**

6.5.2 Valuation of district roads

There are no roads classified as district roads in Bishenyi and Rwandex-Magerwa sub-catchments. They were only found in Rwabayanga and Kamembe-Gihundwe sub-catchments. The district roads found in Rwabayanga and Kamembe-Gihundwe sub-catchments were compared to roads on the RTDA list, which are located more or less in the same area.

Table 15 : Estimated value of district roads in the four sub catchments

S/N	RTDA Reference road/ Comparable roads in a sub - catchment	Total cost of the RTDA reference Road (Rwf)	Length of the RTDA reference road (Km)	Cost per Km of the RTDA reference road (Rwf)	Calculated length of district roads in the sub-catchments (km)	Estimated cost of road (Rwf)
1	Bishenyi sub catchment	N/A	N/A	N/A	0	0
2.	Budiki-Kamembe-Airport-Kamatita-Busekanka (DR7)/Kamembe Gihundwe sub-catchment district roads	2,460,719,066	12.805	203,617,630	7.71	1,569,891,932
3	Gisagara-Huye-Nyakibanda-Nyagisozi (DR104) / Rwabayanga sub-catchment district road	1,839,312,089	40.296	45,645,029	1.22	55,686,935
4.	Rwandex-Magerwa sub-catchment	N/A	N/A	N/A	0	0
	TOTAL					**1,625,578,867**

6.5.3 Valuation of other roads (unclassified)

The data obtained from RTDA does not include length and cost details of unclassified roads. For these "other roads" found in the risk zone of the four sub-catchments under study, we opted to use DR23 (Gihango-Murunda -Gishwati-Gatindore-Mahoko road), which is the least costly road per km on the list of roads classified as District Roads Class 1. The reason behind choosing the least costly road is that most of the unclassified roads have a smaller width compared to District roads class 1.

Table 16 : Estimated value of other roads (unclassified) in the four sub catchments

S/N	RTDA Reference road/ Comparable roads in a sub-catchment	Total cost of the RTDA reference Road (Rwf)	Length of the RTDA reference road (Km)	Cost per Km of the RTDA reference road (Rwf)	Calculated length of district roads in the sub-catchments (km)	Estimated cost of road (Rwf)
1	Gihango Murunda Gishwati-Gatindore-Mahoko road (DR23) / Bishenyi sub-catchment	2,213,966,487	80.84	27,387,017	55.87	1,530,112,662
2.	Gihango Murunda-Gishwati-Gatindore-Mahoko road (DR23)/Kamembe-Gihundwe sub-catchment	2,213,966,487	80.84	27,387,017	74.16	2,031,021,211
3	Gihango Murunda-Gishwati-Gatindore-Mahoko road (DR23)/Rwabayanga sub-catchment	2,213,966,487	80.84	27,387,017	37.81	1,035,503,128
4.	Gihango Murunda-Gishwati-Gatindore-Mahoko road (DR23) / Rwandex Magerwa sub-catchment	2,213,966,487	80.84	27,387,017	77.54	2,123,589,329
	TOTAL					6,720,226,330

6.5.4 Total value of roads in the four sub-catchments

The total value of national roads, district roads and other unclassified roads found in the four sub-catchments under study is found in table 17 below.

Table 17 : Total value of roads in the four sub catchments

S/N	Road classification	Estimated value
1	National roads	9,218,212,485
2	District roads	1,625,578,867
3	Other roads (unclassified)	6,720,226,330
TOTAL ESTIMATED VALUE OF ROADS		**17,564,017,683**

6.6 Total value of properties in the flood and landslide zones

For all the four sub-catchments under study, we have identified different types of physical assets at risk of floods and landslides. These assets have been divided into four categories namely land, buildings, crops, forests (trees) and roads. Table 18 below shows the types of physical assets and their estimated value for all the sub-catchments.

Table 18: Summary of the total estimated value of all properties in the four sub-catchments

TYPES OF PROPERTIES IN THE LANDSLIDE AND FLOOD ZONES	TOTAL ESTIMATED PRICE OF PROPERTIES IN THE LANDSLIDE ZONES (Rwf)		TOTAL ESTIMATED PRICE OF PROPERTIES IN THE FLOOD ZONES (Rwf)	
Land	*Using mean land reference prices*	*Using maximum land reference prices*	*Using mean land reference prices*	*Using maximum land reference prices*
	44,184,563,272	157,313,489,617	10,811,390,255	34,313,288,605
Forests (Eucalyptus and Imisave trees)	932,951,013		13,764,750	
Crops (vegetables, rice, maize, beans, cassava, sugar canes, potatoes, sweet potatoes, amateke, banana, etc..)	1,480,250,000		422,675,000	
Buildings (residential, commercial, administrative, church)	48,550,818,300		19,977,322,268	
Roads	17,564,017,683			
TOTAL	*Using mean land reference prices*	*Using maximum land reference prices*	*Using mean land reference prices*	*Using maximum land reference prices*
	112,712,600,268	225,841,526,613	31,225,152,273	54,727,050,623
GRAND TOTAL (PROPERTIES IN LANDSLIDE AND FLOOD ZONES COMBINED)	*Using mean land reference prices*		*Using maximum land reference prices*	
	143,937,752,541		**280,568,577,236**	

The total estimated value of all the physical assets in both landslide and flood zones is:

Rwf 143,937,752,541 (One hundred forty three Billion nine hundred thirty seven Million seven hundred and fifty two Thousands five hundred and forty one Rwandan Francs) using option 1 of calculating the value of land using the mean reference prices per cell;

OR

Rwf 280,568,577,236 (Two hundred and eighty Billion five hundred and sixty eight Million five hundred seventy seven Thousands and two hundred and thirty six Rwandan Francs); using option 2 of calculating the value of land using the maximum reference prices per cell.

6.7   Estimated value of properties for the year 2050

The valuation of properties was carried out based on the land use plan of the year 2018. There is a need to estimate the value of the properties for the year 2050 using the proposed land use masterplan of 2050. Table 19 below shows the landuse categories, the cost or value of current landuse categories at risk of floods and landslides as well as the estimated value of the properties in 2050.
The estimated value is the cost of damages that might be caused by landslides and floods in case no mitigation measures are put in place.

Table 19: Summary of the total estimated value of all properties at risk in the year 2050

Sub-catchment	Comparable land use categories	Cost / Value of current landuse at risk of floods and landslides (2018) in Rwf A	Change factor B	Cost/ Value of proposed landuse (2050) in Rwf C= (A*B)
Bishenyi	Agriculture	1,538,500,000	0.76	1,171,752,945
	Settlement and Buildings	12,287,022,800	6.64	81,546,289,509
	Forests	264,756,027	2.16	573,076,064
	Roads	2,504,170,646	1.62	4,048,127,873
Rwabayanga	Agriculture	221,250,000	0.53	117,594,300
	Settlement and Buildings	331,484,700	3.75	1,242,397,751
	Forests	129,773,165	1.02	132,053,947
	Roads	398,359,359	1.62	643,945,311
Kamembe-Gihundwe	Agriculture	80,185,000	0.45	36,177,870
	Settlement and Buildings	3,683,893,900	22.63	83,348,416,848
	Forests	484,948,256	0.50	244,447,721
	Roads	6,853,837,719	1.11	7,604,211,471
Rwandex-Magerwa	Agriculture	63,000,000	0.04	2,389,141
	Settlement and Buildings	55,497,949,168	1.74	96,364,751,546
	Forests	67,238,315	1.05	70,265,117
	Roads	1,087,423,627	1.00	1,087,419,54
	TOTAL			278,233,316,967

7

REFERENCES

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National Strategy for Transformation, 2017

Global Green Growth Institute Strategy, 2030

Kicukiro District Development Plan, 2013-2018.

Kamonyi District Development Plan, 2013-2018.

Huye District Profile, National Institute of Statistics, 2013

Rusizi District Profile, National Institute of Statistics, 2013

Integrated Household Living Survey, EICV 3

EICV 5 Districts Profile

www.gggi.org
www.irpv.rw

8

SAMPLE PHOTOGRAPHS

PSF EXPO GROUND

HYUNDAI

COSTA COMPOUND

THREE STOREY BUILDING BEHIND SULFO

RTDA LABORATORY

COMMERCIAL BUILDING

MAGERWA OFFICES

SULFO WAREHOUSE

RESIDENTIAL HOUSES IN PLANNED SETTLEMENTS IN RWANDEX-MAGERWA SUB-CATCHMENT

RESIDENTAL HOUSES IN PLANNED SETTLEMENTS IN KAMEMBE-GIHUNDWE SUB-CATCHMENT

RESIDENTIAL HOUSES IN UNPLANNED SETTLEMENT IN BISHENYI SUB-CATCHMENT

RESIDENTIAL HOUSES IN UNPLANNED SETTLEMENT IN RWANDEX-MAGERWA

LANDSLIDE PRONE ZONE IN BISHENYI

AGRICULTURE FIELDS IN RWABAYANGA MARSHLAND

9 ANNEXES

9.1 Land reference prices at Cell level from the Institute of Real Property Valuers

INSTITUTE OF REAL PROPERTY VALUERS IN RWANDA

ORDRE DES EVALUATEURS DES BIENS IMMOBILIERS AU RWANDA

	Rwezamenyoi	1	13 144	13 144	13 144

2.2 SECONDARY CITIES

2.2.1 HUYE DISTRICT

		price_sqm			
		count	mean	min	max
sector	cell				
Gishamvu	Nyakibanda	5	143	33	513
	Nyumba	6	306	52	716
	Ryakibogo	8	221	85	496
	Shori	7	256	40	545
Huye	Muyogoro	7	364	63	1 328
	Nyakagezi	8	409	132	893
	Rukira	108	1 177	94	8 410
	Sovu	42	1 587	129	11 587
Karama	Buhoro	3	669	47	1 471
	Bunazi	7	342	20	2 034
	Gahororo	11	959	32	4 192
	Kibingo	3	481	76	1 147
	Muhembe	2	698	54	1 342
Kigoma	Gishihe	1	52	52	52
	Kabatwa	3	417	52	931
	Kabuga	4	746	93	1 547
	Karambi	10	455	25	1 305
	Musebeya	5	527	63	1 818
	Nyabisindu	2	100	14	187
	Rugarama	1	132	132	132
	Shanga	5	239	101	481
Kinazi	Byinza	7	378	105	1 332
	Gahana	61	755	62	12 974
	Gitovu	30	1 033	69	4 453
	Kabona	27	351	48	1 496
	Sazange	20	274	91	588
Maraba	Buremera	9	495	11	2 826
	Gasumba	11	231	44	508
	Kabuye	1	169	169	169
	Kanyinya	8	285	37	524
	Shanga	18	729	30	3 027
	Shyembe	14	702	122	2 422
Mbazi	Gatobotobo	159	1 540	106	8 136
	Kabuga	87	555	39	8 223
	Mutunda	21	512	53	3 235
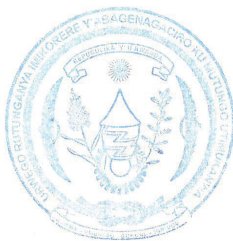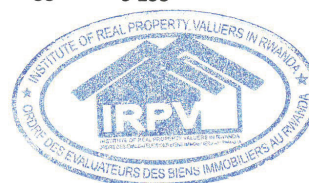
	Mwulire	45	633	63	1 999
	Rugango	25	536	25	4 951
	Rusagara	7	373	62	1 357
	Tare	28	1 000	15	3 231
Mukura	Bukomeye	43	642	34	5 601
	Buvumu	17	578	73	4 446
	Icyeru	48	554	90	1 488
	Rango a	183	2 044	140	11 167
Ngoma	Butare	84	3 119	19	15 780
	Kaburemera	33	790	88	9 182
	Matyazo	22	3 170	169	23 676
	Ngoma	9	3 412	330	12 116
Ruhashya	Busheshi	17	443	7	3 290
	Gatovu	6	121	41	222
	Karama	34	1 194	55	5 984
	Mara	14	185	36	538
	Muhororo	15	605	85	2 219
	Rugogwe	9	387	42	2 209
	Ruhashya	11	177	19	577
Rusatira	Buhimba	47	1 144	10	10 558
	Gafumba	10	201	104	454
	Kimirehe	20	305	64	1 102
	Kimuna	9	355	91	986
	Kiruhura	31	621	38	1 646
	Mugogwe	10	750	31	4 467
Rwaniro	Gatwaro	13	153	32	517
	Kamwambi	11	821	43	7 083
	Kibiraro	4	142	77	246
	Mwendo	19	129	24	451
	Nyamabuye	19	266	43	560
	Nyaruhombo	14	172	30	566
	Shyunga	25	108	27	308
Simbi	Cyendajuru	13	241	53	538
	Gisakura	13	201	10	582
	Kabusanza	20	203	20	604
	Mugobore	19	138	17	316
	Nyangazi	7	428	47	797
Tumba	Cyarwa	133	2 113	110	19 126
	Cyimana	68	2 084	173	12 171
	Gitwa	51	2 772	138	10 342
	Mpare	22	538	47	1 535
	Rango b	58	3 930	235	10 074
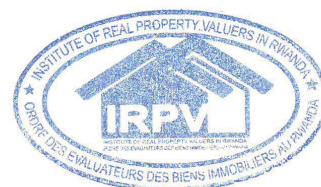
2.3.7   KAMONYI DISTRICT

sector	cell	price_sqm count	mean	min	max
Gacurabwenge	Gihinga	267	1 603	53	8 439
	Gihira	53	787	21	9 536
	Kigembe	129	1 157	53	7 487
	Nkingo	197	1 342	11	11 911
Karama	Bitare	44	611	8	4 493
	Bunyonga	29	411	17	4 189
	Muganza	55	522	16	3 457
	Nyamirembe	43	554	38	4 347
Kayenzi	Bugarama	34	927	32	5 823
	Cubi	7	93	11	159
	Kayonza	7	299	19	534
	Kirwa	18	620	38	5 349
	Mataba	35	1 240	85	4 802
	Nyamirama	5	656	300	1 503
Kayumbu	Busoro	23	939	5	5 490
	Gaseke	18	412	77	1 414
	Giko	14	817	167	5 549
	Muyange	4	437	166	634
Mugina	Jenda	34	306	43	1 465
	Kabugondo	20	213	90	466
	Mbati	74	680	11	5 151
	Mugina	23	1 201	28	3 806
	Nteko	37	528	16	3 300
Musambira	Buhoro	86	859	78	8 438
	Cyambwe	58	816	11	8 634
	Karengera	85	1 013	17	5 134
	Kivumu	46	1 006	55	6 444
	Mpushi	23	515	5	2 517
	Rukambura	29	723	33	3 166
Ngamba	Kabuga	27	633	83	2 805
	Kazirabonde	32	790	17	3 359
	Marembo	20	575	105	1 237
Nyamiyaga	Bibungo	38	345	31	2 507
	Kabashumba	54	392	17	2 871
	Kidahwe	52	409	60	2 134
	Mukinga	49	340	9	2 280
	Ngoma	23	363	22	1 609
Nyarubaka	Gitare	30	840	21	4 931
	Kambyeyi	29	753	83	5 509

	Kigusa	11	426	57	1 117
	Nyagishubi	23	907	58	2 181
	Ruyanza	22	846	78	3 091
Rugarika	Bihembe	61	644	18	3 811
	Kigese	210	1 663	30	7 778
	Masaka	45	876	1	3 653
	Nyarubuye	31	516	73	1 936
	Sheli	329	1 686	12	7 201
Rukoma	Bugoba	47	735	219	2 080
	Buguri	27	1 114	57	3 983
	Gishyeshye	41	750	29	2 703
	Murehe	21	666	104	1 893
	Mwirute	27	1 018	59	5 459
	Remera	56	1 047	123	5 193
	Taba	71	1 156	66	4 694
Runda	Gihara	205	2 772	146	10 804
	Kabagesera	243	1 739	45	10 985
	Kagina	43	1 738	73	8 692
	Muganza	487	3 071	106	12 932
	Ruyenzi	439	4 955	193	24 492

49
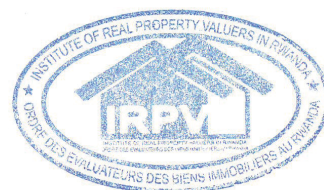
	Rubona	85	3 319	220	29 478
Nyundo	Bahimba	4	789	553	921
	Gatovu	4	1 107	519	2 154
	Kavomo	5	2 349	748	6 074
	Kigarama	2	1 630	1 316	1 943
	Mukondo	16	1 333	368	2 446
	Nyundo	40	1 686	392	10 580
	Terimbere	201	2 468	278	9 191
Rubavu	Buhaza	43	3 315	161	8 082
	Burinda	39	1 299	186	5 207
	Byahi	92	5 690	307	38 286
	Gikombe	177	3 192	185	15 806
	Murambi	169	2 050	148	8 769
	Murara	101	1 930	98	8 814
	Rukoko	153	2 597	6	9 210
Rugerero	Basa	94	1 348	88	3 821
	Gisa	127	3 554	220	11 161
	Kabilizi	68	1 905	367	8 056
	Muhira	223	2 549	137	18 234
	Rugerero	188	3 260	78	14 321
	Rushubi	24	1 803	480	12 236
	Rwaza	33	2 925	248	10 831

2.2.7 RUSIZI DISTRICT

		price_sqm			
		count	mean	min	max
sector	cell				
Bugarama	Nyange	23	1 766	81	6 524
	Pera	18	1 291	31	5 054
	Ryankana	42	381	33	1 221
Butare	Butanda	5	148	67	189
	Gatereri	5	252	92	459
	Rwambogo	1	123	123	123
Bweyeye	Gikungu	11	161	77	279
	Kiyabo	11	199	33	444
	Murwa	6	170	15	535
	Nyamuzi	3	126	100	156
	Rasano	4	286	66	903
Gashonga	Birembo	3	456	113	929
	Buhokoro	4	561	224	1 321
	Kabakobwa	18	380	29	1 056
	Kacyuma	11	462	117	1 320
	Kamurehe	7	327	2	710

	Karemereye	8	492	99	1 430
	Muti	1	218	218	218
	Rusayo	23	557	84	1 964
Giheke	Cyendajuru	9	315	118	614
	Gakomeye	4	282	140	400
	Giheke	11	591	54	3 727
	Kamashangi	3	285	194	412
	Kigenge	15	460	130	1 075
	Ntura	13	536	84	2 101
	Rwega	11	657	93	1 496
	Turambi	28	619	148	3 264
Gihundwe	Burunga	175	4 029	162	14 573
	Gatsiro	17	1 194	172	4 310
	Gihaya	26	3 479	433	19 530
	Kagara	17	1 513	33	5 438
	Kamatita	36	2 014	119	8 047
	Shagasha	74	1 644	37	7 494
Gikundamvura	Kizura	9	217	50	461
	Mpinga	5	265	52	671
	Nyamigina	7	220	96	360
Gitambi	Cyingwa	5	291	172	413
	Gahungeri	10	419	150	1 008
	Hangabashi	21	411	115	1 459
	Mashesha	6	509	174	889
Kamembe	Cyangugu	40	2 992	2	16 964
	Gihundwe	13	4 898	442	13 253
	Kamashangi	34	3 660	515	12 047
	Kamurera	45	2 356	3	8 987
	Ruganda	89	3 095	4	15 490
Muganza	Cyarukara	8	1 687	211	3 463
	Gakoni	30	862	91	3 329
	Shara	34	646	50	2 615
Mururu	Gahinga	19	1 204	99	2 985
	Kabahinda	21	292	121	660
	Kabasigirira	9	376	141	1 278
	Kagarama	27	625	35	2 842
	Karambi	4	1 088	433	2 620
	Miko	11	527	83	1 819
	Tara	31	1 331	228	6 106
Nkanka	Gitwa	12	706	250	1 614
	Kamanyenga	17	655	221	1 296
	Kangazi	12	515	219	1 085
	Kinyaga	6	624	144	1 038

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