Research report

Contribution of model green village to the livelihoods of people and Ruhondo ecosystem conservation

"Case study Gakoro green model village"

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Executive Summary

The integrated development program (IDP) green model village project was introduced by the Government of Rwanda, from 2009 to improve the rural settlements. The program intended to rationalize land use and regroup the human settlements in rural areas on serviced sites equipped with the basic infrastructure and community amenities and contribute to their resilience to climate change impacts. The objective of our study is to assess the contribution of the IDP model green village to the livelihoods of people and Ruhondo ecosystem conservation through Ecosystem-based Adaptation (EbA) approaches. The data were collected through focus-group discussions, questionnaires, and direct field observation. A total number of 62 participants (one representing each household) were surveyed using a structured survey questionnaire but only 58 responded to the questionnaire. Direct observation was carried out during the field visits in the study area. It included actual identification and assessment of trees or shrubs planted focusing on surviving trees in Gakoro IDP green model village and Lake Ruhondo ecosystem. Agroforestry species that are dominating in Gakoro green model village were Grevillea robusta (36.1 %), and Citrus sinensis (Oranges) (23.8%). Fruit trees (23.8%), food crops (43%), livestock (31%), and fishing (14%) activities in Ruhondo Lake are the major source of income that improved people's livelihood. Despite people's livelihood improvement, some few people said they were still lacking good and domestic water in the dry season, transport facilities in Lake Ruhondo. Both Gakoro IDP Green model village and Lake Ruhondo ecosystem have been conserved through a multi-sectoral collaboration of Village population, local government, REMA, and NGOs, each sector has the task to protect, conserve, manage and harmonize ecosystem through its daily activities.

Keywords: Agroforestry practice, Climate change mitigation, and adaptive capacity.

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Chapter 1. Introduction

1.1. Background of the study

Rwanda is a landlocked country with a high population estimated at 12,012,589 (Kolowe, 2014). Sustainable human settlement must focus on environmental requirements. National goals for sustainable development targeted in social-economic development are contained by the framework of a safe environment which must constantly be protected (MININFRA, 2009). The development of IDP (Integrated Development Program) Green Model Villages should enhance the economic and social development of vulnerable communities with emphasis on climate change resilience. A Green Village is a procedure for attaining sustainable development where the local residents can be able to live in an agreeable environment. In addition, Green village we understand a village which can be developed economically by using natural resources without affecting the natural environment (REMA, 2015).

Technologies implemented in Green Villages extend to agroforestry practices, rainwater harvesting and biogas systems and terracing, that play a role in improvement of the quality of life and enhancement sustainable environment (REMA, 2015).

Several IDP Model Villages have been built for groups of households without adequate shelter and for group of people who live-in high-risk zones. Gakoro IDP Green Model Village has been built for households living in different Ruhondo islands and along Lake Ruhondo. The households in these islands rely on agriculture and other human activities leading to alarming degradation of the Lake Ruhondo ecosystem.

Many IDP Model villages face with climate change and poverty challenges due to inadequate home gardening, lack of integration of agroforestry and fruits trees(Maradan, 2017). Lack of clean water and inadequate area for waste disposal in the village and poor rainwater harvesting causing different kind of erosion (Odai, 2009). Other challenges include small area for livestock keeping followed by inadequate maintenance of biogaz and lack of integration of environmentally sustainable development interventions (Maradan, 2017).

1.2. Problem of statement

Movement of population from their actual residents to the IDPs model village can have both positive and negative impacts on socioeconomic activities (IRP, 2015). Effects can further be extended to the ecosystem located where they are coming from and those around model villages (Li et al., 2018). Availing the amenity around and in new resettlements is one of the relevant strategies to mitigate climate change issues affecting IDP.

Besides climate changes, some other important issues could be established around IDPs model villages before relocating people. These include market, clean water, roads, health centers, schools among others. Considering the fact that relocated people depended on the lake for different activities mainly agriculture and for different services such as food (fishes), water cited among others, some people still want to go back in the previous villages, mainly because in the new model villages they can't get all issues that they used to get in the lake and its islands. Further, less is known about how local people are commuted to contribute to the effective management and conservation of the lake as well as its islands. This research tends

to examine the contribution of a model green village to the livelihoods of relocated people, and assess the impacts of relocation on Ruhondo lake and its conservation of the ecosystems.

1.3. Objectives of the Study

1.3.1. General objective

The general objective of this research is to assess the Contribution of IDP model green village to the livelihoods of people and Ruhondo ecosystem conservation. This study was conducted in Gakoro IDP green model village.

1.3.2. Specific objectives of the study.

1. To assess the contribution of Gakoro IDP Green Model Village to climate change resilience at Ruhondo Islands and lakeshore.
2. To evaluate the agroforestry species planted at Gakoro Green Model Village and conservation of Ruhondo Islands and lakeshore
3. To assess the socio-economic development activities and income of households settled at Gakoro IDP Green Model Village

1.3.3. Research questions

1. What is the benefit of Gakoro IDP Green Model Village in to climate change resilience at Ruhondo Islands and lakeshore?
2. What are the agroforestry species planted in Gakoro IDP Green Model Village and Ruhondo islands and lakeshore?
3. Do socio-economic development activities improve the income and livelihoods of households settled at Gakoro IDP Green Model Village?

Chapter 2. Literature review

2.1. Definition of Key Concepts

2.1.1. Climate change

Climate change refers to the change of climate which is attributed directly or indirectly to human activity that modifies the composition of the global atmosphere and which is in addition to natural climate variability detected over comparable time periods (UNFCCC, 1992). Climate change had been effect significantly on ecosystem functioning and well-being of different societies, climatic pressure leads to a reduction in the distribution of natural species and affects society through health-related effects and socio-economic impacts by augmented droughts, numbers of heat waves, and flooding events (Kabisch et al., 2017). The climate change has substantial impact on the ecosystem and biodiversity functioning through threatening the existing habitat conditions due to heat and water stress (EEA, 2012)

2.1.2. Climate change impacts

Recent reports on climate change, impacts and vulnerability in Europe, such as those by (EEA, 2012) define Climate change impacts as the projection and observation of the effects of climate change on natural and human systems. In the situation of anticipated effects, these anticipations regularly refer to 'potential impacts', which are those impacts that may happen given a projected change in climate, without considering adaptation.

Climate change impacts have consequences on natural and human systems. It's depending on the adaptation to be considered, it must differentiate between residual impacts and potential impacts. Thus, Residual impacts: The climate change impact that can occur after adaptation but Potential impacts: All impacts that can occur for given a predictable change in climate, without considering adaptation (REMA, 2010).

2.1.3. Climate resilience

As stated by (Denton et al., 2015) in book whose title" Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development "defined that: "climate resilience is the outcomes of evolutionary processes of managing change in order to reduce disruptions and enhance opportunities". (Field et al., 2011) define resilience as the capability of a system and its component parts to absorb, anticipate, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the protection, rebuilding, or improvement of its essential basic structures and functions.

Thus, climate resilience is the ability of an individual, community or institution to dynamically and effectively respond to fluctuating climate circumstances although continuing to function at a satisfactory level. This definition includes the capability to resist or endure impacts, as well as the ability to recover and re-organize in order to establish the necessary functionality to prevent catastrophic failure at a minimum and the ability to thrive at best. Resilience is thus a spectrum, ranging from avoidance of breakdown to a state where transformational change is possible (Meerow & Stults, 2016).

As indicated in the previous section, integrated strategies for climate resilience can benefit from considering possibilities to develop new options through social, institutional, and technological innovation (Denton et al., 2015).

2.2. Climate change adaptation and mitigation

2.2.1. Adaptation

The most population in Rwanda depend on rain, us breastfed of agriculture for their livings, and the effects of variability in climate patterns are exactly being felt. Therefore, opportunities for enhanced food security, availability of water and livelihoods, when they are programs contributed to the implementation of climate change adaptation. Rwanda is the one of many countries signed the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, those for minimize the damage from disaster rising from the effects of climate change (Greenheck, 2009).

According to (REMA, 2009), Rwanda recognizes the six priority areas for climate change adaptation: i) Integrated Water Resource Management (IWRM), ii) Setting up an information system for early warning of hydrological and agro-meteorological systems and rapid intervention mechanisms, iii) Promotion of intensive agro-pastoral activities, iv) Promotion of non-agricultural income generating activities, v) Introduction of species resistant to extreme conditions, vi) Development of alternative sources of energy to firewood.

2.2.2. Mitigation

The current researchers such as those by (Field et al., 2011) define mitigation as the reduction of the degree of climate change through the management of its causal factors (the emission of greenhouse gases from fossil fuel combustion, agriculture, land use changes, cement production, etc.). The climate mitigation reduced the area over which there was a significant increase in drought but had little impact on the area over which there was a significant decrease in time spent in drought (Taylor et al., 2013). Thus Interactions between the goals of mitigation and adaptation in particular will play out locally, but have global consequences (Field et al., 2011).

Mitigation options are existing in every major segment (areas). Mitigation can be more economical when using an integrated approach that combine measures to decrease the energy use and the greenhouse gas intensity of end-use segments, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors (IPCC, 2014)

2.3. Understanding ecosystem services

The ecosystem services are defined as the conditions and processes through which natural ecosystems, and the species that make them up, withstand and satisfy human life (Daily, 1998). According to (Boyd & Banzhaf, 2006), the ecosystem services are the constituents of nature which are directly liked, consumed, utilized to improve the human well-being.

Therefore, the authors (Anthony McMichael, 2021) in the article of Ecosystem Services and Human Well-Being, classify the ecosystem services into four categories: provisioning (products acquired from ecosystem such as food, wood product, etc.), regulating (benefits gained from ecosystem like climate regulation, water purification, etc.), Cultural (Non-product gained in ecosystems like aesthetics value and educations) and supporting (e.g. production of atmospheric oxygen and soil formation). Provisioning, regulating and cultural services directly contribute to all the components of human well-being, but all the ecosystem services cannot function without the supporting service of the ecosystem.

2.4. Livelihoods and ecosystem conservation

Protecting our Ecosystem services through upper to down approach is often easier and less time consuming than engaging communities in participatory approaches, however developing long-term environmental sustainability and ecosystem resilience increasingly requires grassroots community commitment (Cowling et al., 2008)

Sustainable management plans can be involved in communities by assessing each community's abilities, incentives and externalities, as well provide motivations to use natural resources in a sustainable way. Rural and urban livelihoods depend on the natural resources, rapid community and environmental change can fracture central socio-ecological links creating vulnerabilities among local communities (Wisely et al., 2018).

The link between the ecosystem services and livelihoods is hugely diverse across the specific region. For providing effective conservation planning, the forces that attach and decouple those linkages must be understood at multiple scales. At the wide-ranging scale, equitable conservation planning must understand how certain industry practices, such as pesticide application in agroindustry or exclusion fencing in ecotourism, disrupt livelihoods by diminishing regulatory or provisioning ecosystem services. At the local scale, conservation planning must improve and well understand how folks use these resources and deliver platforms for communicating those resource use and needs across multiple stakeholder groups (Wisely et al., 2018) .

2.5. A model green village

Model Green village refers to the development of correspondence to the economic, social, and ecological environment, with the purpose of using the resources efficiently, where people and nature live in harmony to accomplish the target of technology and nature absolutely bonded. These targets are energy conservation, land saving, water saving, materials saving, and environmental protection among others, we can maximize the village productivity and creativity to satisfy residents to live healthy and comfortable(Yang, Xiaolin, 2016)

2.5.1. Principle and concept of model green village

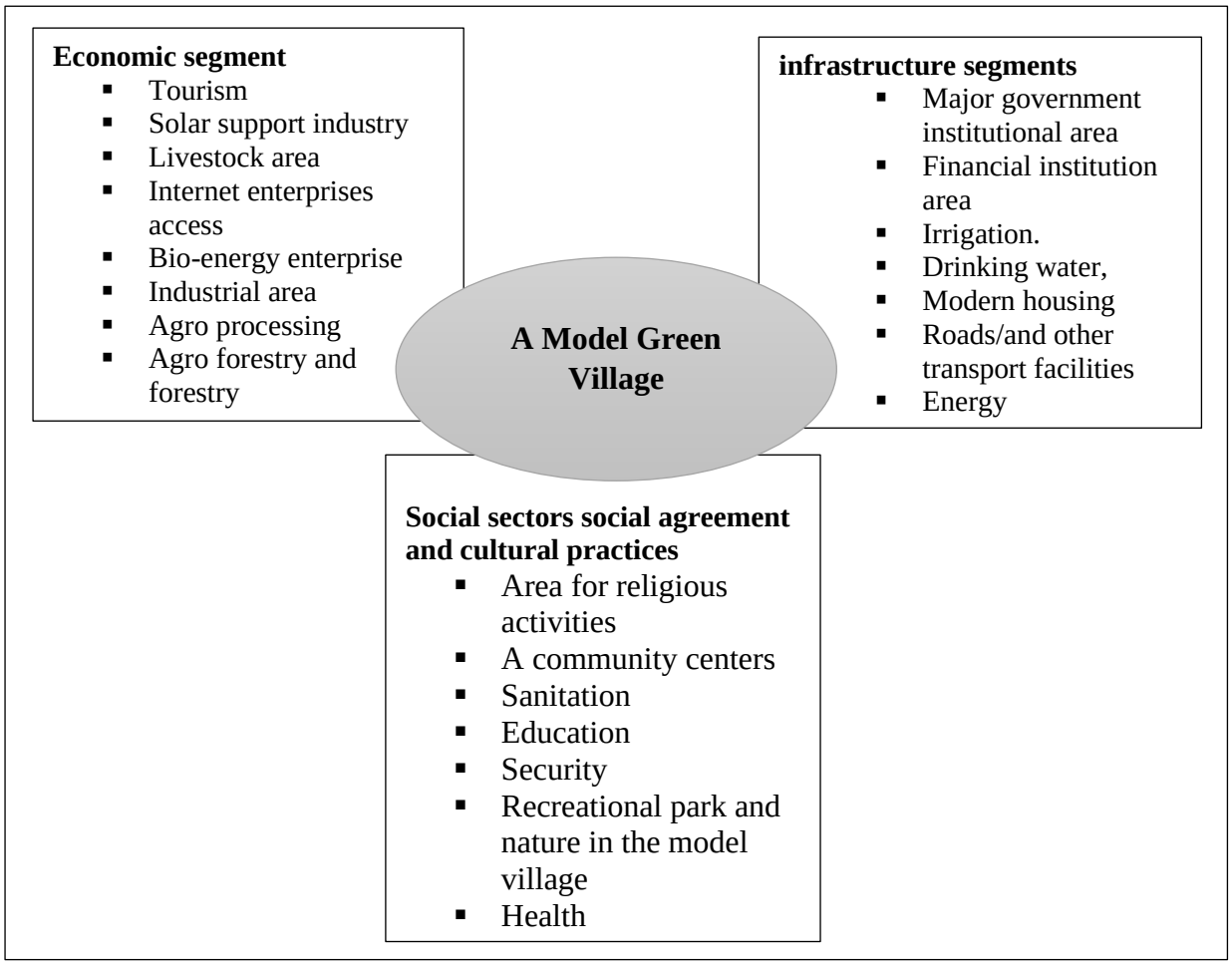
The theory of the model green village is based on the principles of sustainable development and ecology as a fundamental discipline. it is focused on the implementation of a strategy of human settlement, which can be well integrated into the surrounding environment. The theory of the model green village has also been building an economy-based ecosystem conservation approach as well as accumulation of reuse, and recycling facilities(Indira, 2017). Therefore, the development of model green village or rural sustainable development can be classified in seven principles of sustainable living as follows: Sustainable living, Waste management, Environment improvement, Optimal management of energy resources, Optimal management of water and agriculture, Improvement of health, and Cultural, social development(Abioudin & Oladeji, 2018)

A model green village is a village that can be developed economically by the use of its resources with promoting the local ecosystem, without affecting the natural environment. According to (Kadave et al., 2012) illustrate the five concepts of model green village contents following points from environmental science and engineering journal.

1. **Water Supply:** Community rain water harvesting with protected storm water drainage leading to storage pond will help to recharge the sub soil water table /fresh water aquifers.
2. **Sewage Treatment and Disposal:** Villages with toilets are signs of civilization, individual toilets for homes or group toilets for communities can support for health and hygiene among the users and will help to avert for water borne diseases.
3. **Energy Recovery:** The biological sludge, sewage, and cow dungs must be used to produce anaerobic digestion will be able to generate Bio-Gas energy.
4. **Solid Waste Management:** About 70% of the waste will be organic in nature and can be suitably composted to generate a number of kilograms of manure.
5. **Rain Water Harvesting:** Rainwater is the ultimate source of freshwater. The activity of collecting rainwater directly or recharging it into the ground to improve the groundwater storage in the aquifer.

Component of model Green Villages

The component of model green villages is divided into three segment; social, infrastructure, and economic segment. Those segment are summarized in the graphic bellow



2.5. Overview history of model village in Rwanda

Green building has been fast familiar for its contribution towards sustainable development (Peng Wu, 2018). The population settlement in Rwanda can be grouped into three different periods: pre-colonial; during colonization; and post-colonization (Ngoga, 2015).

During the pre-colonial period, human settlement were presented by agro-pastoral activities where agriculture and livestock were developed and thus influenced the human settlement (MININFRA, 2009).

After the 1994 genocide against Tutsi, the housing shortage became more apparent. Many returnees who had fled the country over the previous 30 years were back in a short period of time. Urban and rural areas needed more houses to accommodate these people as well as internally displaced people. The housing issue was exacerbated by the shortage of land for resettlement. Many villages settlements were built by the government and some NGOs for vulnerable groups, mainly orphans, widows, returnees, disabled and homeless people (Ngoga, 2015).

According to MINALOC (2012), the UN predicts that the assistance through the Rwanda Integrated Development Initiative could introduce eight main activities in the particular trial areas:

(1) Provide technical and financial support to carry out a participatory feasibility study, including agriculture, land use, employment opportunities, institutional organization, energy, introduction of new appropriate technologies and industries.
(2) Support the establishment of a multipurpose hall that could accommodate an ICT Kiosk and be used for various activities and Health Centre.
(3) Provide technical assistance to the Ministry of Local Government in support of the IDP project.
(4) Provide technical support to Umurenge SACCOS in financial management, business plan analysis.
(5) Establish two greenhouses in each of the targeted villages, with the production of vegetables and training of selected beneficiaries (including women and youth) in appropriate farming techniques.
(6) Put in place a monitoring system for food security and nutrition.
(7) Support the expansion of Mutobo mini-hydro power to the capacity of 300 KW, and
(8) Contribute to job creation for youth, women and other vulnerable groups through mobilization and skills development and support to women & youth cooperatives in Musanze and Kayonza Districts (MINALOC, 2012).

2.6. Advantages and challenges of living in Model Villages

Heidger (2018) in the report of examining rural resettlement planning as a driver for poverty reduction in Rwanda, post-conflict asserted that the benefits of Villages is to deliver houses to particular households living in high-risk zones. Villages can develop social harmony between the inhabitants, and those living in the settlements have improved livings conditions than those living in degraded areas (Ngoga, 2015) and also the communities of IDP villages has benefit to the same access in common keeping animals space called "*igikumba*".

With reference to Ngoga (2015) and MININFRA, (2009), the challenges of living in improper Villages include inefficiency of rain water harvesting systems leading to the deterioration of houses and roads in the village; the whole community is easily contaminated when a disease occurs; lack of infrastructures like markets, schools and other basic facilities in the locality; IDP model Villages households, on the whole are still far- from farm lands and causing problems of transport of input for agriculture like fertilizers and soil amendments; and inadequate area for domesticating animals.

Chapter 3. Materials and methods

3.1. Description of the study area

Gakoro Model Green village is located nearby Ruhondo Lake in Gakoro cell, Gacaca sector, Musanze District in the Northern Province of Rwanda (Figure 1). The total area of Musanze district is 530,4 km² among which 60 km^2 of the Volcanoes National Park and 28 km^2 of Lake Ruhondo. It borders with Uganda and DR Congo in the North, Gakenke District in the South, Burera District in the East and Nyabihu District in the West (MDDS, 2018)

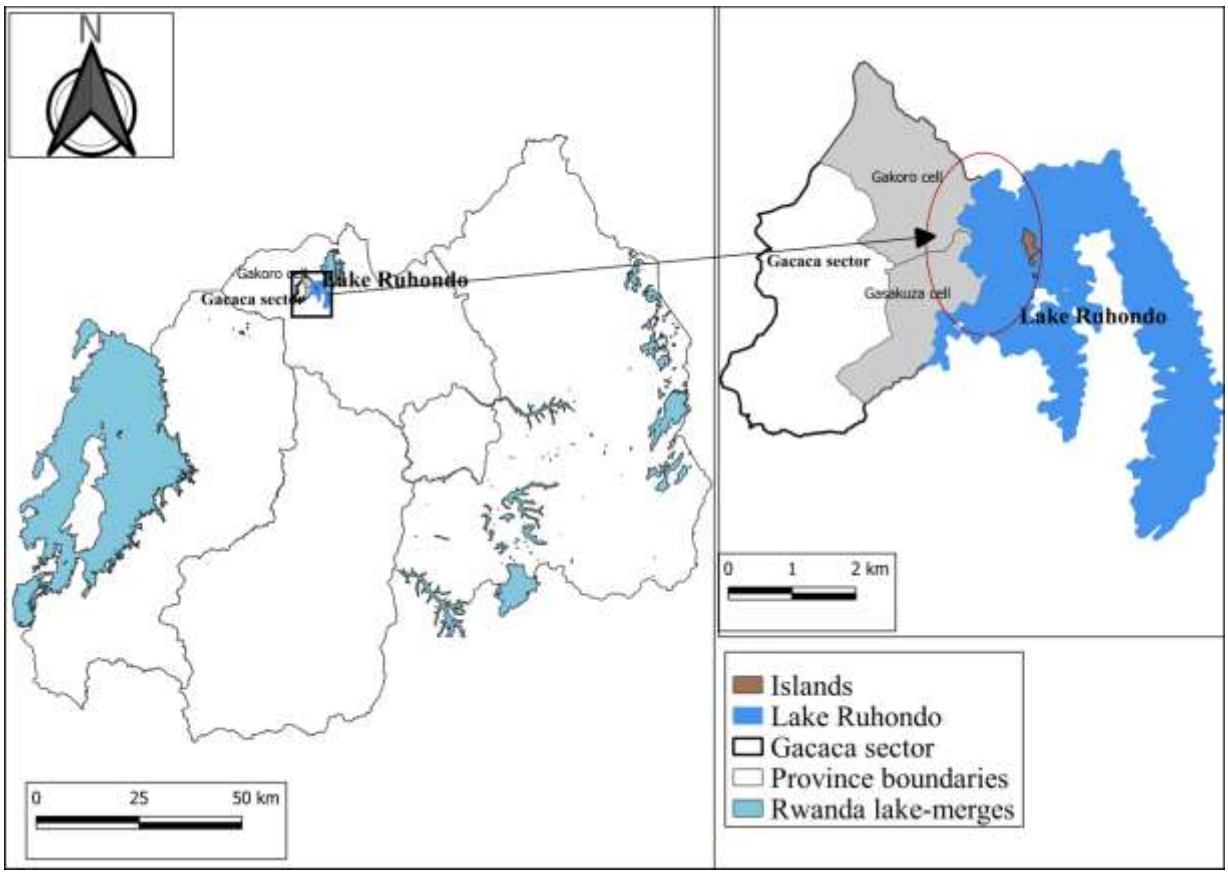


Figure 1. Map showing the study area in cycle red color

Musanze district has mountain gorillas (*Gorilla beringei beringei*) which are found in the Volcanoes National Park, making Musanze District the most popular tourist destination in the country. Musanze district has 15 administrative sectors, 68 cells and 432 villages. Musanze City is about 110 km from Kigali on the major Kigali-Musanze-Rubavu-Goma road.

Musanze Population counted 368,267 inhabitants with a density of 694 Inhabitants/Km^2. About 27.7% of Musanze population live in urban areas and 72.3% live in rural areas(UNEP, 2016)

3.2. Research design

The target population was composed of local community and Authorities in Gakoro IDP Green Model village. In this study, no sampling method was used because all households in the village (62) were included in the survey.

3.3. Data collection method

The survey method was used to collect data in Gakoro IDP Green Model village and Lake Ruhondo in Musanze District from November 2019 to February 2020. During the survey, the observation method firstly was used first as the basis for preparing a specific questionnaire for households and focus group discussion. The questionnaires were designed as open, structured and easy questions to generate unbiased and dependable data that can provide answers to the research questions. The questions were also designed to address the objectives of the study.

The primary data were collected through household questionnaire surveys and focus group discussion. The questionnaire was given to the representative members of 62 households but only 58 questionnaires were filled and given back. The questionnaire was translated in Kinyarwanda to better communicate with all the participants.

With reference to Onwuegbuzie &Anthony (2009), focus groups discussion are typically made between one and two hours and is composed of persons with common characteristics relevant to the study and involve between 6 and 10 participants who are strangers to everyone (all members) (Powell & Single, 1996). In this research, 62 participants from 62 households composed of 30 men and 32 women in Gakoro (IDP) Green Model Village participated in seven (7) organized focus-group discussions in the village in other to validate data obtained in the surveyed questionnaire.

3.4. Data management and analysis

Referring to Nsengimana et al (2016), qualitative data were analyzed in the focus-group discussions, and quantitative data were analyzed from survey results. During focus group data analysis, a structured topic approach was used, but in survey data analysis, the statistical analysis software (STATA) version 16 computer software was used. Quantitative data were analyzed using descriptive statistics. The step involved the generation of frequencies, percentages, and means to get tables that were useful to present useful information of findings. Tree species distribution and building footprint data were collected using GPS handheld.

Chapter 4. Results

4.1. Characterization of the respondents in Gakoro model green village.

The socio-economic characteristics of the surveyed households are presented in Table 1. There were slightly more men (51.72%) than women among the respondents (Table 1). The highest proportion of respondents were in the age range between 39 and 46 years (29.3%) (Table 1). This is probably due to the fact that the people of 39-46 years are highly engaged in agricultural production for the sake of their families. The class of above 63 had also high proportion among the respondents because this category of people was prioritized during the relocation from the high-risk zones (islands). Normally, 39-46 is the age where people are working hard with a positive mind set. Therefore, they highly participated in questionnaires filling during the survey tour.

The married respondents with 67.2% dominate this village (Table 1). This is probably explained by the fact that the translocation was done to the already established families and this is simply for the married people. In terms of education, the number of people whose primary education is higher (53.5%) than any other type of education (Table 1).

Many of the respondents (50%) are in the second category of Ubudehe and the lowest percentage (4%) is in the third category (Table 1). Before the resettlement in the village, most were very poor (no land, livestock and lake advantages) in category 1 but they are slowly moving ahead in the upper categories with 4% in category 3 and 29 in category 2. The households with land size of 1-2ha (52.6%) are more than other land size class (Table 1).

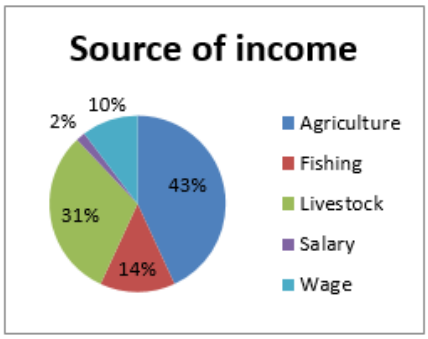
Table 1: Socio-economic characteristics of the respondents

Socio-economic characteristics		Frequency	Percentage (%)
Gender	Male	30	51.7
	Females	28	48.3
Age	23-30	7	12.1
	31-38	7	12.1
	39-46	17	29.3
	47-54	6	10.3
	55-62	5	8.6
	> 63	16	27.6
Marital status	Married	39	67.2
	Single	8	13.8
	Widowed	11	19.0
Education level	University	1	1.7
	None	20	34.5
	Primary	31	53.5
	Secondary	6	10.3
Ubudehe categories	1	25	43.1
	2	29	50.0
	3	4	6.9
Land size	More than 2ha	3	5.2
	1-2ha	30	51.7
	0.5-1ha	21	36.2
	Less than 0.5Ha	4	6.9

4.2 Source of income and energy of the households in Gakoro model green village

The main source of income generation in Gakoro model green village is dominated by agriculture (43%) (Figure 2). This is because all the households were given an agricultural land to survive and even their daily livelihood relies on agriculture. The least source of income is salary (2%) (Figure 2). Based on other benefits in Gakoro model green village, the main source of domestic energy is Biogas (79%) followed by firewood and charcoal (Figure 3).

Biogas is the highly dominating source of energy because the LDCF project has established the biogas in every family of the village and this is enhanced by the fact that the row materials for refilling biogas are available due to the impact of GIRINKA program, which was delivered to each of the families of the village.



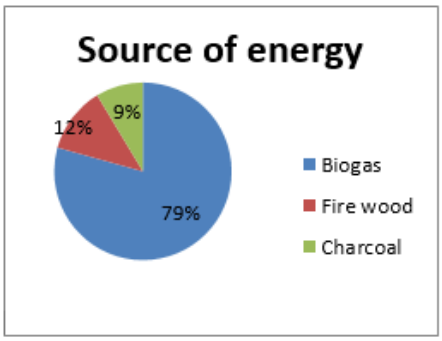


Figure 2: Source of income **Figure 3: Source of energy**

4.3. Source of seedlings planted in Gakoro village and around Ruhondo Lake Island

Many seedlings in Gakoro village and around Ruhondo Lake Island planted by people were given by REMA (69%) (Figure 4). REMA provided these seedlings in order to make GAKORO village green and susceptible to mitigate and adapt to climate change impact and enhance the food security as well

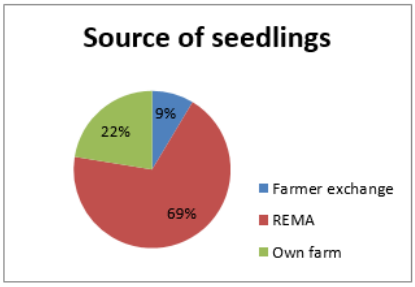


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Figure 4 Source of tree seedlings at Gokoro model green village

4.4. The types of livestock adopted in Gakoro model green village

The most dominant type of livestock in Gakoro model green village is cattle (81.03%) based on the answers from the respondents (Table 2). This is a result of the"GIRINKA Program" that aims to reduce poverty, livelihoods improvement and income generation, environment protection, improving agricultural productivity through utilisation of manure as fertilizer.

Table 2: Types of livestock possessed by households in Gakoro model green model village

Livestock Type	**Frequency (number of respondents)**	**Percentage (%)**
Cattles	47	81.0
Cattle, goat & sheep	1	1.7
Cattle & pigs	2	3.5
Cattle & sheep	1	1.7
Cattle, sheep & goats	2	3.5
Cattle & chicken	3	5.2
Pigs	2	3.5
Total	**58**	**100.0**

4.5. Climate change impact perception in the village

The impact of climate change before the establishment of Gakoro model green village are summarized in Table 3. The most and serious impact of the climate change is the variation in crop growing season (48.3%) and the lowest encountered impact is erosion (1.7%). It is well understood that the growing season is changing due to the erratic rainfall and high temperature, which affect the plant growing cycle. This impact is not only for Gakoro model green village but also it is spreading all over the country. Erosion is not a big issue because of the gentle land slope at Gakoro model green village.

Table 3: Climate change impact perception in Gakoro model green village

Climate change hazards	Frequency of respondents	% of respondents
Drown	2	3.4
Erosion	1	1.7
Flooding	2	3.4
Growing season change	28	48.3
High precipitation	16	27.6
None	9	15.5
Total	**58**	**100.0**

4.6. Perception of climate change mitigation measures in Gakoro model green village

4.6.1 Adoption of agroforestry

The majority of households have adopted agroforestry practices in Gakoro model green model village. The most dominant agroforestry tree was *Grevillea robusta* followed by *Persea Americana* (Avocadoes), *Citrus sinensis* (Oranges), and *Mangifera indica (*Mangoes) that are the other tree species. Grevillea is the most adopted agroforestry species because it grows well in the village and produces timber and pruned branches are used for firewood, stakes, and leaves for mulching.

Table 4: Dominants fruits and agroforestry tree species in Gakoro model green village.

No	Agroforestry species	Frequency	Percent (%)
1	*Persea americana* (Avocado)	25	19.2
2	*Citrus sinensis* (Oranges)	31	23.8
3	*Citrus meyeri* (Lemons)	3	2.3
4	Calliandra callothyrsus	1	0.8
5	*Mangifera indica* (Mangoes)	21	16.1
6	*Alnus acuminate*	1	0.8
7	*Grevillea robusta*	47	36.1
8	*Psidium guajava* (Guava)	1	0.8
Total		**130**	**100.0**

4.6.2 Common agroforestry practace in Gakoro Model Green village farms

Most dominated agroforestry system in the Gakoro Model Green village forms are Agrisilvicultural System (50.0%) followed by home garden (27.6%) (Table 5).

Table 5: Agroforestry practace in Gakoro Green Model Village farms

No	Agroforestry System	Frequency	Percent (%)
1	Home garden	16	27.6
2	Live fences around farmlands	8	13.8
3	Silvo-pasture system	1	1.7
4	Agrisilvicultural System	29	50.0
5	Others	4	6.9
Total		**58**	**100.0**

4.6.3. Dominant species in Ruhondo Islands and around lakeshore

The dominant trees and shrubs or grass species planted or growing around Ruhondo Lake were *Bambusa vulgaris* (bamboo), *Phragmites australis* (common reed), and *Grevillea robusta (Table 6). Vernonia amygdalina* was the only indigenous species inventoried in the study area. This could have happened because bamboo can stabilize and expand more in the planted area along with high ability to survive whereas *Vernonia* was planted as medicinal plant.

Table 6: Dominant species planted in Ruhondo Islands and around lakeshore

Ruhondo sp	Frequency	Percent
Eucalyptus sp	2	1.1
Bambusa vulgaris (Bamboo)	55	29.7
Alnus acuminate	9	4.9
Calliandra callotrus	11	6.0
Cedrella serata	1	0.5
Markhamia lutea	6	3.2
Grevellea robusta	47	25.5
Pinus sp	1	0.5
Venonia amygdalina	1	0.5
Phragmites australis (common reed)	52	28.1
Total	185	100.0

4.6.4 Benefits of Agroforestry in Gakoro model green village

The benefits of agroforestry are diverse (Table 7). Timber, erosion control and fruits dominate others because of their direct values and influence to the people livelihood and the whole ecosystem. Fruits are direct food that can help people to cope with food security problems and can be sold for money as timbers. This is the reason why fruits and timber are mostly highlighted as the first benefits of agroforestry in Gakoro model green village.

Table 7: Benefits of Agroforestry in Gakoro IDP green model village

Agroforestry_benefits	Number of respondents	Percent (%)
Erosion control	10	17.2
Fruits	6	10.3
Fruits & aesthetic	8	13.8
Fruits erosion control	1	1.7
Fruits fuel	3	5.2
Fruits_fuel_erosion	1	1.7
Fruits_fuel_shelter	1	1.7
Fruits_shelter	9	15.5
Fruits_timber	14	24.1
Fuel	2	3.4
Fuel _timber	1	1.7
Timber	2	3.4
Total	**58**	**100.0**

4.6.5 Perception of Contribution of Gakoro Model Green village to the conservation of the lake Ruhondo ecosystem.

The results of Table 8 indicate that 70.7% of the respondents have agreed that Gakoro Green model village has positively affected the lake Ruhondo ecosystem. This could have happened through the reduction of siltation, improvement of water quality, reduction of eutrophication that in turn improved fishing production in the lake and the agricultural activities of its marshland.

Table 8: Contribution of Gakoro Model Green village to the lake Ruhondo ecosystem.

Contribution of Gakoro IDP model village to lake Ruhondo	Frequency (number of respondents)	Percentage (%)
Improved	41	70.7
Unaffected	12	20.7
Water quality	2	3.4
Other	1	1.7
None	2	3.4
Total	**58**	**100.0**

4.7. Livelihoods of people in Gakoro Model Green Village

4.7.1. Contribution of Lake Ruhondo on the livelihoods of the people of Gakoro Model Green Village.

The most prevalent benefits of Ruhondo Lake to the Gakoro people's livelihoods are cropping and fishing (Table 9).

Table 9: Contribution of Lake Ruhondo on the livelihoods of Gakoro Village inhabitants

Ruhondo lake role in livelihoods of people	**Number of the respondents**	**Percentage (%)**
Crops	12	20.7
Crops & fish	18	31.0
Electricity & fish	1	1.72
Fish	16	21.5
Fishes_air quality	1	1.7
Fishes_swimming	1	1.7
Fishes_water	1	1.7
Money &fish	1	1.7
None	7	12.1
Total	**58**	**100.00**

4.7.2. Logistic regression model of Ruhondo ecosystem conservation

Table 9 illustrates the impact of both climate resilience and agroforestry tree species on the Ruhondo ecosystem sustainability. The results showed that both climate resilience and agroforestry tree species are highly correlated (r >0) to the Ruhondo ecosystem sustainability. This could be due to the fact that the climate has been regulated and stabilized by agroforestry tree species, which in turn stabilizes the Ruhondo ecosystem sustainability to mean that the ecosystem is not changing in whatever ways.

Table 9: Logistic regression model of Ruhondo ecosystem conservation

Ruhondo_Eco	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
c_resilience	1.1509	.8131	1.42	0.157	-.4428	2.744
Tree_sp	1.3676	.8236	1.66	0.097	-.2467	2.982
_cons	0.2282	.6146	0.37	0.710	-.9764	1.432

4.7.3. Impact of Gakoro village on adaptive capacity of households

Table 10 shows the comparison of household's adaptive capacity before and after three years of establishment of Gakoro green model village (from 2017). It is clear that the population of low level of living standard has reduced after the establishment of Gakoro model green village since it has shifted from 6.9% to 0.0% due to the advantages of the model green village like livestock, agroforestry and the contribution of Ruhondo Lake resources.

Table 10. Impact of Gakoro village on adaptive capacity of households

	Before IDP (N=58)				After IDP (N=58)			
	Low	Moderate	Good	Excellent	Low	Moderate	Good	Excellent
Frequency	4	16	34	4	0	15	38	5
Percentage (%)	6.9	27.6	58.6	6.9	0	25.9	65.5	8.6

Source: Fieldwork, February 2020

Chapter 5. Discussion

5.1 Contribution of Gakoro model green village to climate resilience

Climate change in Gakoro model green village and Ruhondo Islands is characterized by increased precipitation amount and the intensity of rainfall along with a strong change in crop growing seasons. The rainfall is high and fluctuate more, which is the driving factor of soil erosion. In addition, the crop growing cycle is also affected due to the rainfall fluctuation. Thus, farmers are no longer able to master the crop-growing period and consequently lead them to the food security problem.

Trees can stabilize the climate through the fact that trees regulate water cycle by soil water infiltration enhancement and cool down the warm atmosphere by releasing the oxygen in the surrounding atmosphere. Different tree species planted in various agroforestry systems like home garden, agri-silviculture and live fencing. A similar study conducted by (Nguyen et al., 2013) found that agriculture plays an important role in coping with the variability of atmospheric weather parameters like high rainfall, high temperature and wind behaviours if a good selection and adoption of agroforestry tree species is made. According to (Nguyen et al., 2013), the enhancement of resilience to climate variability and change is achieved through well-established agroforestry practices. Moreover Masson et al., (2013) researching on regional landscape change along with the city greening activities for further adaptation to the climate warming, found that after three years the atmospheric temperature tend to become normal. This led to reverse the way of thinking urban planning: the geographic and natural aspects should replace the urban infrastructure as a driver for planning urban development.

5.2 Contribution of Gakoro model green village to the ecosystem conservation

The results showed that Gakoro IDP Green Model village has positively influenced to Lake Ruhondo ecosystem. Based on the farmer's interview and the self-observation, Gakoro IDP green village could affect Ruhondo ecosystem through the siltation reduction, good water quality, eutrophication reduction that in turn influences the good fishing in the lake and the agricultural activities of its marshland. This study findings are in line with Lin et al. (2017) that an Integrated Development program has highly attempted to conserve the ecosystem services that benefit the ecological systems. This could be due to the fact that the climate has been regulated and stabilized by agroforestry tree species which in turn stabilizes the Ruhondo ecosystem sustainability to mean that the ecosystem is not changing in whatever ways as stated by (Nguyen et al., 2013). Climate resilience is a positive ability of the climate to recover quickly from the severe and annoying state and become again conducive specifically to the living organisms. This is a key factor which promote the ecosystem conservation through the fact that erosion hazard is no longer a severe threat and hence both the upland and down slope productivity are improved physically and biologically. Floods and siltation also get controlled which promote the aquatic animal species welfare.

5.3 Contribution of Gakoro model green village to people's livelihood improvement

In this study, the results indicate that the number of people with the highest living standard has increased after the creation of the village since it has shifted from 6.9% to 8.62% due to the advantages of Gakoro model green village like livestock, the availability and accessibility of fruits, timbers, erosion control and sheltering services, fodder, agricultural activities of food

provision and fishing activities in the Lake Ruhondo (Table 9) and (Table 10). This is also highlighted in the Table one of the social economic classes that many of the respondents (50%) are included in category 2 of Ubudehe and the lowest percentage (6.9%) is found in category 3. Before to access the village, most were very poor (no land, livestock and lack of some advantages) in category 1 but slowly by slowly they are moving ahead in the upper categories with four households in category 3 and 29 households in category 2.

(Zhou et al., 2018) conducted a study of sustainable village mountain construction adapted to livelihood, topography and hydrology and found that the natural resources of soil, water and atmosphere were highly conserved. The people benefited more from agriculture where their income doubled after the establishment of the green village because the soil was more fertile with no erosion and water for irrigation was quite enough. Similarly, (Quandt, 2019) conducted a study on the variability in perceptions of household livelihood resilience and drought at the intersection of gender and ethnicity and found that the people livelihood is more resilient within the drought free environment and consequently food security was no longer a challenge for the people and natural resources are being conserved even for the future generation.

Chapter 6: Conclusion and Recommendations

6.1. Conclusion

The establishment of Gakoro model green village has positively contributed to the climate resilience of the whole watershed. This resilience was positively correlated to both fruits and agroforestry tree species along with agroforestry systems (agrisiliviculture, homegarden and live fencing) (Table 6). The people's livelihood in Gakoro model green village was improved as they benefit from fruits, livestock, timber, fuel, fodder and the natural resources conservation in which people are deriving their daily income mainly from agriculture. Ruhondo Lake plays a big role in people livelihood improvement as it provides fish, crops are cultivated in its marshland and they provide land for cultivating fodder for animals.

The agroforestry was well adopted in Gakoro model green village (95% of households) and fruit and agroforestry trees are planted around every house and everywhere in Gakoro IDP green model Village. The Lake Ruhondo ecosystem had been conserved through planting agroforestry trees in islands and around Ruhondo Lake creating ditches to minimize runoff and reduce concentration of fertile soil in water that led water eutrophication. This could be caused by the fact that most of the people of the Gakoro model green village earn their income from agricultural activities. A small number of people are also deriving their income from the lake activities.

The livelihoods of people in Gakoro model green village had improved because every family was given a cow throughout GIRINKA program, obtained land for cultivation and fodder plantation area, biogas and solar energy had established, rain water collection tank were set in every house in other to use rain water for domestic purposes. The most and serious impact of climate change is the change in growing season and the lowest encountered impact is erosion. It is well understood that the growing season is changing due to the erratic rainfall and high temperature, which affects the plant growing cycle. This impact is not only for Gakoro IDP Green model village but also it is spreading all over the country. Erosion is not a big issue there because of the gentle land slope at Gakoro model green village.

6.2 Recommendations

The following recommendations are provided to all stakeholders and beneficiaries of Gakoro IDP green model village based on these research findings:

- Ruhondo lake ecosystem has been conserved through multi-sectoral collaboration of Gakoro IDP green model Village population, local government, REMA and NGOs each sector has a task to continue protecting, conserving, and managing sustainably the Ruhondo lake ecosystem through their daily activities.
- Planted agroforestry and fruits trees in Gakoro IDP green model village should be protected and well managed by the people for better provision of income and maintaining environment.
- Continue capacity building of Gakoro IDP green model village population to increase its awareness in ecosystem-based adaptation solutions.
- Gakoro IDP green model village population should be contributed to the protection of agroforestry planted in this village and also better use of biogas.

- The government should avail health facilities at the proximity of Gakoro IDP green village model to handle the problems related to health because this survey showed that diseases are also hindering the people development.
- The government should provide other economical facilities in Gakoro IDP green village model to reduce circulation of people across Lake Ruhondo moving from the islands to search households needed resources.
- Responsible authorities should help Gakoro IDP green model population to increase the fodder production for their livestock mainly cattle.
- Farmers should also grow not only cattle but also sheep, goat and chicken, as they do not require much feeding like cattle.

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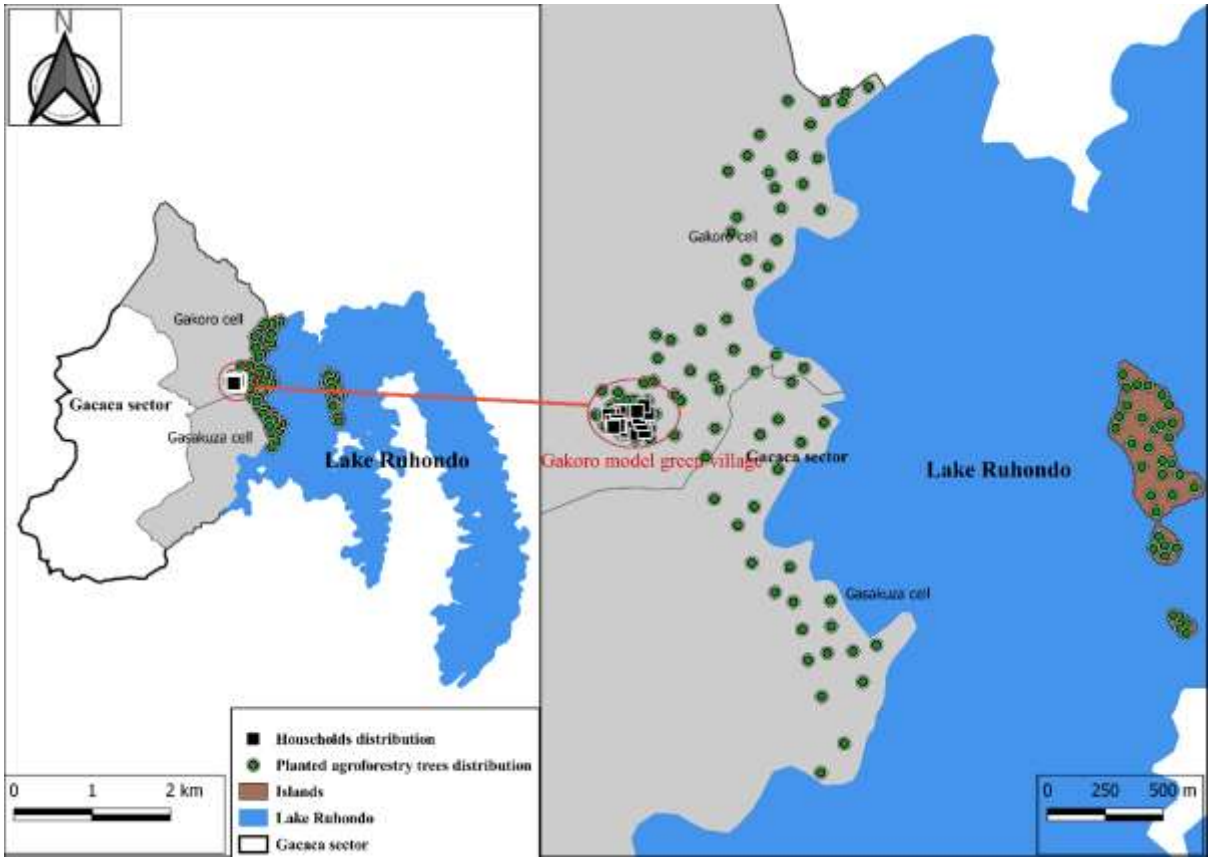
APPENDICES

Appendix I: Households surveyed in red cycle and distribution of agroforestry planted in Gakoro IDP green model village and along the Lake and island Ruhondo.



Appendix II: Gakoro IDP green model village modern houses

Source: Field Survey (February 2020)

Appendix III: View of Lake Ruhondo, islands and lakeshore

Source: Field Survey (February 2020)

Appendix IV: Questionnaire

SURVEY QUESTIONNAIRE

On ……/……/2020

1. Respondent's Identification

1.1 Location

A Names of respondent:

B Village :

D Sector :

C Cell :

E District :

1.2 Sex

A Male :

B Female :

1.3 Marital status:

A Single:

D Separated :

B Married:

E Widowed :

C Divorced:

1.4 Age

A 23-30:

C 39-46:

55-62:

B 31-38:

D 47-54:

63≤:

1.5 Level of education

A Primary:

C University:

B Secondary:

D None:

1.6 House hold relation code

A Household head:

C Son/daughte:

B Wife:

D Servant:

1.7 Ubudehe categries

A 1:

B 2:

C 3:

D 4:

1.8 House Hold Size

A 1:

B 1-5 :

C 5-10:

D More than 10:

1.9 Income sources

A Agriculture :

C Labor :

B Business:

D Any other :

C Service :

2. Socio-economic assessment

1. What level of living standard have you attained?

A Extend : D Moderate:

B Good : E Lower:

2. Gakoro IDP Green Model village has a contribution to the development of settled households?

A Yes: B Not :

2.1.If "**Yes**"at which level?

A Excellent : C Moderate :

B Good : D Lower :

3. Have you a livestock animals?

A Yes: B Not:

3.1.If" Yes" what are these animals in the following?

A Cattle: C Pegs : E Others(specify):

B Goats & sheeps : D Chicken & rabbit :

3.2.How many animals do you have?

A Cattle:……. C Pegs :……. E Others(specify):……

B Goats & sheeps :…….. D Chicken & rabbit :…….

3.3.Where do you get the fodder for animals?

1.....

2.....

3.....

4.....

5.....

4. Is there any service the lake Ruhondo ecosystem provide to local community surrounded and households settled in Gakoro IDP Green Model village?

A Yes : B Not :

2

4.1.If "**Yes** "what are these?

1.....

2.....

3.....

4:.....

5:.....

6:.....

5. How did Gakoro IDP Green Model village affect the adaptive capacity of local population?

A Improved : ☐ B Unaffected : ☐ C Reduced : ☐

3. **Agroforestry practices**

6. Are there agroforestry and fruits trees species planted in Gakoro IDP green model village?

A Yes : ☐ B Not : ☐

6.1.If "**Yes**" what are these species?

1.....

2.....

3.....

4.....

5.....

6.....

6.2.What are the benefits that agroforestry and fruits trees provide in your livelihood condition?

A Provision of fuel : ☐ F Shelter : ☐

B Fodder : ☐ G Timber : ☐

C Fruits prevision : ☐ H Aesthetic : ☐

D Erosion control : ☐ I Soil fertility : ☐

E Climate mitigation : ☐ J Other product : ☐

6.3.Where did you find agroforestry and fruits seedlings?

A Yourself: ☐ C Government: ☐ E Others (specify): ☐

B Private sector: ☐ D NGOs Project: ☐

3

6.4.How many agroforestry and fruit trees planted in the respondent's household land?

A 1-3: ☐ B 3-5: ☐ C 5-10: ☐ D More than 10 : ☐

6.5.How do agroforestry and fruit trees contribute to poverty eradication?

1.....

2.....

3.....

4.....

6.6.What are the size of your land planted agroforestry and fruits trees?

A Less than0.5Ha: ☐ B 0.5-1Ha: ☐ C 1-2Ha: ☐ D More than 2Ha: ☐

6.7.What are the agroforestry systems found on your farm land

A Home garden: ☐

B Live fences around farmlands: ☐

C Silvo-pasture system: ☐

D Agrisilvicultural System: ☐

E Others : ☐

7. Does agroforestry contribute to soil erosion control?

A Yes: B Not:

7.1.If Yes, How can agroforestry contribute to soil erosion control

A Permanent soil cover: ☐

B Wind and runoff breaking: ☐

C Improved tree diversity: ☐

D Reduced deforestation: ☐

E Availability of pasture: ☐

F Others : ☐

7.2.Is there any other activities use to control soil erosion rather than use agroforestry?

A Yes B Not

7.3.If "**Yes**" what are these among the following?

A Terracing : ☐

B Creating ditches : ☐

D Planting Grasses : ☐

E Other : ☐

8. Is there any other alternative cooking energy sources do you use than firewood and other biomass?

A Yes : ☐ B Not : ☐

4

8.1.If "Yes" what are they among the following sources of energy?

A Solar energy : ☐

B Biogas or otherkind of gas (LPG) : ☐

C Electricity : ☐

D Others (specify): ☐

4. Climate change and ecosystem impact and adaptation

9. What is the contribution of Gakoro IDP Green Model village to Ruhondo island ecosystem restoration?

1.....

2.....

3.....

4.....

10. Is there any project support local community to the restoration of Ruhondo ecosystem?

A Yes: ☐ B Not : ☐

10.1. If "Yes" what are these among this

A Private instititions : ☐ C NGOs: ☐

B Gouvernment : ☐ D Others : ☐

10.2. Tell us any ?

1.....

2.....

11. What are the main climate change impacts in the region?

A Temperature change ☐ D Erosion & Flooding ☐ G Fire ☐

B Precipitation change ☐ E Change in growing season ☐ H Others ☐

C Drought ☐ F Air &water quality ☐

12. How has Gakoro IDP Green Model village affected the resilience to climate change in local area ?

A Improved : ☐ C Declined: ☐

B Unaffected: ☐

13. How has Gakoro IDP Green model affected vulnerable households' income?

A Reduced : ☐ C Increased : ☐

B Unaffected : ☐

5

14. After constructingGakoro IDP Green model village, how has LakeRuhondo ecosystem changed?

A Improved: ☐ C Declined: ☐

B Unaffected: ☐

15. Have you any strategic measures to harvest water during precipitation in order to minimize effect of rain water runoff in the village?

A Yes: ☐ B Not: ☐

15.1. If "**Yes**" what are these among the following?

A Use of Water Tanks: ☐ C Water pits: ☐

B Creation of dams : ☐ D Others: ☐

16. Are there riparian species planted in and around the Lake Ruhondo ecosystem?

A Yes: ☐ B Not: ☐

16.1. If "**Yes**" what are these species

1.....

2.....

3.....

4.....

5.....

6.....

7.....

17. What are the intervention measures uses to protect and take care of those species?

1.....

2.....

3.....

4 .....

5.....

6.....

7.....

6

18. How do you think agroforestry and fruits trees contribute to climate change mitigation?

1.....

2.....

3.....

4.....

5.....

19. What are the challenges facing family settled in Gakoro IDP Green Model Village?

1.....

2.....

3.....

4.....

5.....

20. Would you be happy with us to contact you further on this?

A Yes : ☐ B Not : ☐

20.1. If "Yes" tell us your phone Number (if any): :.....

Thank you!

2. FOCUS GROUP DISCUSSION

CHECKLIST OF QUESTIONS

On…...../……../2020

1. What are the strategic measures that the government has initiated to protect Lake Ruhondo ecosystems?
2. What are the strategic measures Gakoro people have taken to support government to protect Lake Ruhondo ecosystem and island?
3. How does Gakoro IDP Green Model help vulnerable households to cope with local climate change impact?
4. In which manner does Lake Ruhondo ecosystem provide benefits to the local community?
5. How has Gakoro IDP Green Model village contributed to the improvement of livelihoods standard of settled households?