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CURRENT ENVIRONMENT AND CLIMATE CHANGE ISSUES, COOKING TECHNOLOGIES, ENERGY SUPPLY AND DEMAND IN BURERA, KARONGI, NGORORERO AND RUTSIRO DISTRICTS IN RWANDA

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ABSTRACT

The study was commissioned to investigate on cooking technologies, energy supply and demand, current environment and climate change issues in Karongi, Ngororero and Rutsiro Districts (Western province) and Burera district in Northern Province of Rwanda. The study's sample size was 400 individuals, including 142 females (64.5 percent) and 142 men (64.5 percent) (35.5 percent). The survey aimed to assess key environment and climate change related issues in the study area, investigate biomass energy supply and demand in the target area and ascertain citizens' attitudes and perceptions towards building resilience to climate change, discover practices implemented to safeguard the environment and mitigate effects of climate change in the study area; examine cooking technologies that are used by citizens in the study area, and propose recommendations to bridge identified gaps /challenges. In this study, a hybrid method (quantitative and qualitative) was employed, and the main findings are described in the following key points:

Key environment and climate change related issues in the study area:

The study found that the majority of respondents (53%) stated that they had heard of climate change, while 47% stated that they were unfamiliar with the subject. Tubibe Amahoro, via its existing networks like the Rwanda Climate Change and Development Network (RCCDN) and the University of Rwanda (UR- CAVM) is suggested to improve community awareness about climate change, its impacts, mitigation, and adaptation approaches, deforestation, and landslides were pointed as the most serious climatic concerns in the whole study region with 87.25% and 89 % respectively, lLow agricultural productivity due to soil degradation, misuse of available land, solid waste created in the surveyed communities is improperly disposed of, either in open dumpsites or directly in the environment (KIIs), limited awareness around Nationally Determined Contributions- NDCs among rural communities, limitations in Citizens' Consultation on Climate Change Policy Planning and Implementation, as reported by (91%) of respondents in the surveyed area, the widespread use of open firewood stoves/ three stone stoves for cooking and boiling drinking water in the surveyed area was notable, limitations towards enhancing wetland preservation, as well as restore and rehab damaged wetlands and raise public knowledge about biosafety through programs involving the community, policymakers, and the corporate sector, limitations in forest management (afforestation, deforestation) in water management (floods, draught) and

in rainy water management (DDS 20218-2024), limitations in the promotion of waste management system to reduce greenhouse gas emissions and limited public awareness on biosafety through initiatives involving the community, policy makers and the private sector (KIIs), despite several worrying trends, such as soil erosion, land degradation, biodiversity loss and land scarcity, the government and other actors have made major efforts to prevent, mitigate, minimize and adapt to the environmental problems and changes. Moreover, Rwanda shows impressive achievements in terms of sustained economic growth (around 7% growth in Gross Domestic Product (GDP) over the last decade) and per capita economic growth (4.7% annually 2008-2018), reductions in poverty and improvements in public health. However, much of this growth is based on natural resource extraction and depletion, and is closely linked with emissions of pollutants into lands/soils, waters and the air.[1]

Concerning biomass energy supply and demand in the target area and Citizens attitudes and perceptions towards building resilience to climate change, the study found that firewood is usually accessible, as evidenced by 69.7% of respondents, and to some extent available in the community through gathering in bushes and woods (62 %). In Rwanda, it is thought that fuelwood comes from forests and woods, contributing to large-scale deforestation. This assumption is supported by available research on fuelwood demand and availability, which show a steadily increasing need for fuelwood, particularly from forest plantations, households that utilize inefficient cooking technologies and do not own a woodlot spend an average of Rwfr 600 (12 kg or 4 pieces of wood x Rwfr 150) per day on wood purchases, thus, making Frw 18 000 per month and rough estimation of annual cost is at Rwf 216,000. However, a household that uses Improved Cooking Stove (ICS) utilizes a third of fuel consumption thus making Rwf 6,000 per month with a saving of 12,000 Frw and 144,000 Rwf per annum. The money saved is allocated to other household needs to mention payment of Mutual Health Insurance, scholastic materials, contributions into saving and loans groups at community level, and purchase of other household items. More so, households who will have adopted improved cooking stoves use the time saved towards other household chores and even participate in government created spaces especially for women who are usually prone to Unpaid Care Word (UCW). Respondents have agreed that climate change is a reality and that they can do whatever it takes to reduce its adverse effects at their level, confirmed by (93.25%), on the other hand, (97.5%) of respondents stated that caring for environment is a moral duty and that they feel obliged to do so.

As for practices implemented to safeguard the environment and mitigate effects of climate change in the study area, it was found that respondents in the surveyed area mentioned about avoidance of plastic bags (97.75 %), 72% cited to have dug trenches for preventing soil erosion, 63.5% planted trees and shrubs around gardens, agro forestry, proper waste management practices (45%), establishing radical terraces (29%), rain water harvesting (29%), cooking with non-biomass fuels (2.7%). Concerning cooking technologies that are used by citizens in the study area, the current study established that Rwanda's energy balance shows that about 85 percent of its overall primary energy consumption is based on biomass (99% of all households use biomass for cooking).[2],most households (92.6%) in the surveyed

[1] REMA, 2018

[2] *The Republic of Rwanda (2016), Ministry of Infrastructure, Final report and action plan for improvement of charcoal value chain in Rwanda*

area use three-stone cook stoves or traditional cooking stoves, four point seven percent (4.7%) use various models of improved cooking stoves including clay charcoal stove, metal charcoal stove, pipe stove, Tekavuba, Canamake, Canarumwe stoves among other models/ types, one point two percent (1.2%) use biogas for coking practices while one point five use Gaz/ LPG for cooking (1.5%)

1.0 CHAPTER I. INTRODUCTION

1.1. Background and Context analysis

Rwanda, like many other countries, is becoming increasingly vulnerable to the effects of climate change. Rainfall has been more intense, and variability is expected to rise by 5% to 10% this year (GoR, 2018a). Changes in temperature and precipitation, as well as their distributions, are the primary causes of climate and weather-related disasters that harm Rwandans and the economy, such as droughts, floods, and landslides, which have caused infrastructure damage, loss of life and property (including crops), and contributed to soil erosion and water pollution. The country is highly reliant on rain-fed agriculture both for rural livelihoods and exports of tea and coffee, in addition to depending on hydropower for half of its electricity generation.

Nevertheless, the government of Rwanda envisages reducing the reliance on wood fuel for cooking from 83 percent of the households to 42 % by 2024 (source). There is a high dependency on inefficient and unclean biomass cooking energy sources has resulted in many adverse such as environment, socio-economic and the health of the population. The government of Rwanda has to put more effort into creating more cooking technologies that use less combustible, like improved stoves, biogas, including making Liquefied Petroleum Gas (LPG) available to people depending on their means of income. As a result of the reduction of the use of woods and save trees harvested before maturity for cooking purposes and protected forest. (Ministry of infrastructure, third Rwanda energy sector development policy financing, report in rural communities where Tubibe Amahoro organization operates, firewood is the most commonly used source of biomass for cooking. About 93% of rural households utilize firewood as it is largely considered freely available.

More than half of the firewood stoves used nationwide are 3-stones stoves. Among the major issues that challenge the environment in Rwanda is the wide use of open firewood stoves for cooking and for boiling drinking water. Similarly, the hunting, cutting, fetching and carrying of the tree logs and branches by man primarily living in rural communities have caused increasing deforestation despite the government's forestation and tree planting efforts. Yet, the organization perceived that introducing an improved cook stoves project in this area can benefit mainly vulnerable communities and beneficiaries including widows, households headed by children, widows, historically marginalized people and the poorest households in both urban and Rural Rwanda, with an ultimate mission of reducing indoor air pollution and lower time, cost and effort requirements for collecting firewood and saving the already degrading forests across the country. Besides this issue, the area is constrained with the problem of landslides, deforestation and soil erosion.

1.2. Research Problem

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1.3. Study Objectives

1.3.1. General objective

The baseline survey aimed to investigate on cooking technologies, energy supply and demand, current environment and climate change issues in Burera, Karongi, Ngororero and Rutsiro Districts.

1.3.2. Specific objectives

The study intended to:

1. Assess key environment and climate change related issues in the study area;
2. Investigate biomass energy supply and demand in the target area and ascertain citizens' attitudes and perceptions towards building resilience to climate change

[3] MINISTRY OF INFRASTRUCTURE, THIRD RWANDA ENERGY SECTOR DEVELOPMENT POLICY FINANCING, Report

No: PGD68

3. Discover practices implemented to safeguard the environment and mitigate effects of climate change in the study area;
4. Examine cooking technologies that are used by citizens in the study area;
5. Propose recommendations to bridge identified gaps /challenges.

1.4. Study area:

The study was conducted in 4 districts tomention Burera, Karongi, Ngorero and Rutsiro. The study area is shaded in blue.

2.0 CHAPTER II. Literature Review

2.1. Environment and Climate change in Rwanda

2.1.1. Sector Overview

Rwanda, located in the tropical belt, sits astride two key climatic regions, East Africa and Central Africa, each with contrasting controls and drivers on climate. There is a lack of sufficient climate data in equatorial Africa and these factors make Rwanda troublesome to simulate in climate models. Within the region of East Africa one climate centre exists currently, the IGAD (Inter-Governmental Authority on Development) Prediction and Climate Applications Centre (ICPAC) in Nairobi, Kenya. There is also a pan African centre, the African Centre of Meteorological Applications for Development (ACMAD) in Niamey, Niger. Both centres provide meteorological and climate information that covers Rwanda, mainly in the form of observational information and seasonal forecasts. Neither centre provides detailed spatial and sectoral interpretation of the information, which remains the responsibility of individual countries. In Rwanda, this function lies with the Rwanda Meteorological Service (RMS).

However, the country's policy frameworks are by and large adequate and the institutional set-up for managing environmental challenges is quite robust. Main problems relate to implementation and enforcement of existing legislation, rules, regulations and policies. For more than a decade, Rwanda has taken a proactive approach to address environment and climate change issues in most of the country's policies, programmes and plans. For instance, the country's commitment can be seen in the conservation of the environment through the protection and restoration of degraded ecosystems such as wetlands, lakes and natural forests. Moreover, Rwanda was one of the first countries in the world to ban plastic bags. To become a climate-resilient, low-carbon economy by 2050, Rwanda has initiated Green Fund (FONERWA). The purpose of FONERWA is to provide technical and financial support to the best public and private projects that align with Rwanda's commitment to a green economy[4].

2.1.2. Key Underlying Issues and Emerging Challenges

- **Climate change, climate variability and extreme weather events**: Although Rwanda has one of the world's lowest per capita emissions of greenhouse gases, it is highly vulnerable to the impacts of temperature and rainfall variability. The country's average temperature has increased by 1.4°C since 1970, higher than the global average, and by the 2050s, it is likely to rise by up to 2.5°C from the 1970 average (GoR, 2011).
- **High population density:** Rwanda has one of the highest population densities in Africa. Approximately 12 million people live in an area of 26,338 square kilometres, resulting in a population density of 456 inhabitants per square kilometre that largely depend on natural resources (NISR, 2017). In addition, the population is projected to double by 2050 and 70% of people will live in urban areas. Compared to 2012 levels, by 2032 the total number of households is expected to increase from 2.4 million to 5.3 million - a more than 100% increase (NISR, 2017). Population growth, along with other interrelated drivers of increased standards of living and economic development, will add pressure to the already strained environmental capital resources such as agricultural land, forests with high dependence on biomass for fuel, wetlands, rivers and lakes, among others. If not properly planned and managed, this will likely lead to further encroachment of economic

[4] Government of Rwanda, 2016

activities to protected and critical ecosystems, land fragmentation and productivity constraints, especially in rural areas.

- **Sustainability of urbanisation and rural settlements**: Rwanda's urban areas are growing rapidly, and the NST1 target is to accelerate urbanisation from 17.3% (2013/14) to 35% by 2024 (GoR, 2017). However, meeting the needs of this growing concentration of people living in urban areas poses a critical environmental challenge. This includes lack of low-carbon materials for housing and green infrastructure development, inadequate waste treatment for both solid and liquid waste as well as insufficient treatment plants for industrial effluents and storm-water drainage systems. Furthermore, there are still many people living in unplanned settlements and high-risk zones with poor environmental conditions in both rural and urban areas.
- **Limited environmentally friendly transport systems**: Existing transportation systems contribute significantly to air pollution as demonstrated in the inventory of sources of air pollution conducted in 2018 (REMA, 2018). Key issues include high densities of vehicles in Kigali (especially old vehicles), inadequate maintenance facilities, poor traffic management systems and road conditions and lack of mass and low-carbon transport systems such as trains and metro. In addition, there is still a lack of efficient infrastructure for non-motorised transport modes, especially in urban areas.
- **Air Pollution:** Poor air quality is considered the world's 'largest single environmental health risk. In Rwanda, 2,227 deaths were attributed to ambient air pollution in 2012 (REMA, 2018). This has also affected long-term health conditions in the same period where acute respiratory infections were registered as the top cause of morbidity in health centers and the largest cause of death of children under the age of five in Rwanda (REMA, 2018).
- **Soil Degradation**: Insufficient resilient soil conservation practices, use of chemical fertilisers, over-cultivation and associated agriculture low yields are resulting into soil degradation and pollution. The impact has been a vicious cycle of erosion and reduced soil fertility and productive capacity. It is also estimated that half the country's farmland suffers moderate to severe erosion. Increasing intensity of agricultural land use and ongoing gradual agricultural transformation further increase the threat of soil degradation (GoR, 2015).
- **Vulnerability of Natural Ecosystems**: Rwanda's natural resources are being subjected to overwhelming pressure from competing land uses activities such as agriculture, industry, human settlement and infrastructure development that deplete natural wealth and ecosystems. Rwanda's landscapes and natural forests in particular are very rich in biodiversity including numerous species that are endemic. Rwanda's biodiversity has, over the years, been subjected to various threats causing loss within species richness, population sizes and ecosystems degradation.

2.1.3 National Responses to Climate Change in Rwanda

The GoR has devised a number of policies and institutional responses to support smallholder farmers adapt to climate change and climate variability. Some of the key policies and programmes include:

1. The National Adaptation and Programmes of Action (NAPA): Rwanda has finalized its report on National Adaptation Programmes of Action to climate change, NAPA, and which

was adopted by the November 2001 Assembly of the Conference of Parties to the United Nations Framework Convention on Climate Change (MINITERE, 2006). Rwanda National Adaptation Programmes of Action to Climate Change (NAPA*)* is articulated on six priority adaptation options to climate change which include an Integrated Water Resource Management – IWRM; setting up an information systems to early warning of hydro-agro meteorological system and rapid intervention mechanisms; promotion of non-agricultural income generating activities; promotion of intensive agro-pastoral activities; introduction of species resisting to environmental conditions; development of firewood alternative sources of energy.

The NAPA contains an overview of climate changes and impacts in the country, with results of this process focused on identification of high vulnerabilities to climate change of the population and sectors of agriculture, water resources and energy due to mutual influences and cumulative impacts floods on steep slopes; Desertification trend in agro-bio climate regions of the East and South-East; The lowering of level of lakes and water flows due to pluviometric deficit and prolonged droughts; and degradation of forests. This is complemented with a gradual shifting of the rainy seasons, accompanied by severe erosion, decreases in agricultural productivity, and the resulting poverty.[5]

2. The Comprehensive African Agriculture Development Programme (CAADP): Rwanda ratified and domesticated CAADP objectives into the national policies in 2007. The CAADP programme supports policies geared toward accelerating growth and elimination of poverty and hunger through agriculture-led development. At the Rwandan national level, the CAADP programme is linked to the implementation of the Strategic Plan for the Transformation of Agriculture (SPAT) as implemented under the Economic Development and Poverty Reduction Strategy (EDPRS), geared toward strengthening and adding value to the country's agricultural productivity which is part of vision 2020 agenda.

3. Green Growth Strategy: The Republic of Rwanda released its Green Growth and Climate Resilience National Strategy for Climate Change and Low Carbon Development in 2011. The Strategy aims to build upon work that is already being done in Rwanda on climate change, focusing on the various projects and policies in a holistic national document which encompasses the long-term direction as well as short-term priority actions. The Strategy is one of the initial steps on a pathway which leads to a sustainable, secure future where Rwanda is prepared for the risks associated with climate change, population growth and rising oil prices but clearly holds out the promise of a green and clean future.

4. The National Fund for Environment in Rwanda – FONERWA is the National Fund for Environment and Climate Change Strategies in Rwanda. The formation of the fund was provided for under Organic Law No 04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda (REMA, 2010). The fund serves to promote sustainable financing for environmental management and climate change resilience. Its prime aim is to manage both locally and externally sourced funds and channel them for a better and sustainable environmental use. The institutionalization of FONERWA comes at an

[5] UNEP (n.d) Final evaluation of National Adaptation Programmes of Action. Country Report Rwanda. http://www.unep.org/eou/Portals/52/Reports/Annex_9a-Rwanda_Country_Report.pdf

opportune time when Rwanda has just developed a cross sectoral climate change strategy, green growth and climate resilient: the Climate Change and Low Carbon Development strategy in which FONERWA was identified and proposed as the primary vehicle to uptake climate change financing to address national priorities.

5. The National Strategy for Transformation (NST1): it is a seven Years Government Program (2017-2024) which sets the priority for a green economy approach in its Economic Transformation pillar that promotes "Sustainable Management of Natural Resources and Environment to Transition Rwanda towards a Green Economy". Moreover, environment and climate change were highlighted in NST1 as cross-cutting areas of policy concern which can be positively impacted by a range of development activities with priority given to agriculture, urbanisation, industries and energy.

2.1.4. Improved Cooking Technologies in Rwanda

Rwanda Energy Group (REG), in partnership with its stakeholders, is carrying out a countrywide awareness campaign on the use of safe, effective and clean cooking technologies to ensure that Rwanda meets its targets to reduce the use of biomass energies to cook in households. Currently, around 83 percent of Rwandans still use firewood for cooking but by 2024. The performance of a cook stove is characterized by three processes: Heat-transfer efficiency depends primarily on the geometry of the cook stove and the flow of hot gases around the bottom and sides of the pot. Combustion efficiency, by contrast, depends primarily on the temperature in the cook stove and the characteristics of the combustion chamber that affects the circulation of air. Overall thermal efficiency can be raised by improving either combustion efficiency or heat-transfer efficiency. The use of improved cook stoves that are up to three times more efficient than the traditional 3-stone stove and can reduce biomass consumption by anywhere between 68-94% (source?). The transition from traditional cooking to modern energy cooking solution is shown[6] in the above figure 4.

2.1.5. Types and penetration of cooking technologies in Rwanda

Firewood is the most common cooking fuel in Rwanda and it is used in various types of woodstoves: 93% of rural households utilise firewood as it is considered in most cases still freely available. More than half of the firewood stoves operating nationwide are 3-stones stoves. Approximately 65% of households living in major urban areas like Kigali, Butare, and Rwamagana, use charcoal to meet most of their cooking needs, through both traditional and improved cook stoves. In urban areas, charcoal is the most preferred fuel due to its long-life storage and low-cost transportation, as it is smaller in volume and weight and has higher heat content compared to firewood. Most of the charcoal is produced locally. In Rwanda, most charcoal (86%) is produced by use of traditional earth mound kilns with average thermal efficiency of about 12% (air dry kg of charcoal/ air dry kg of wood). [7]

[6] Venkataraman, C., A. D. Sagar, G. Habib, N. Lam, K. Smith.(2010). "The Indian National Initiative for Advanced Biomass Cookstoves: The Benefits of Clean Combustion." Energy for Sustainable Development 14 (2010) 63–72, DOI: 10.1016/j.esd.2010.04.005

[7] The Republic of Rwanda (2014), Ministry of Infrastructure, Sustainable Energy for All. Rapid Assessment and Gap Analysis, Supported by African Development Bank (AfDB)

Agricultural residues used to constitute only a small percentage of fuels used by the households, but their use has increased year after year as a substitute due to wood scarcity, particularly among the poorest households of rural areas. In Rwanda, the most used agricultural residues at household level are cereals (maize, sorghum, stalks and rachis), wheat and rice straws and husks, tubes like cassava stalks, banana leaves, coffee husks, vegetable wastes (beans, groundnuts, soya, coffee pulps and dried cow dung). Rice husk is used as a fuel mainly for brick firing in the major rice growing areas. Sugar bagasse, coffee husks, rice husks and wheat husks are also used in brick making industries. In urban areas, poor households use sawdust and other end-cuts from wood processing industries using appropriate cook stoves. The use of **biogas** as a substitute for firewood and charcoal began in 2007 through the 5-Year National Domestic Biogas Programme (NDBP). Biogas requires the user to have access to domestic animals such as cow. Biogas is rarely used as a primary fuel for cooking. Most biogas users often have a main stove, which is either a traditional stove or an improved biomass stove. The high price tag placed for acquisition of the digesters has been a key reason behind the limited adoption, despite the achievement of customer satisfaction once the digester is installed[8].

Pellets and **Briquettes** are currently the most advanced biomass-based options being implemented in the latest years in Rwanda. They are produced from by-products of wood processing industries (sawdust or wood shavings) or from forest residue. However, wood is not the only suitable feedstock for pellets fuel: a wide range of biomass materials can be used to manufacture pellets and briquettes, most notably some perennial grasses, e.g., Miscanthus or Switch grass. Raw materials needed to produce pellets and briquettes are available at a variety of sizes and scales that allow for both small, medium and large-scale manufacturing. Despite these favourable conditions, the uptake of these technologies at present is limited due to the infrastructure investment required for production of these fuels and the requirement of specific stoves to ensure efficiency. Woody pellet production, for which forest concessions have to be customised accordingly, is a key solution for replacing charcoal in urban households and providing highly efficient fuel to the wealthier end of rural population.

Penetration of LPG in Rwanda is still relatively limited, but its availability and adoption are evolving rapidly, demonstrated by the sharp increase of imports in the last few years.

2.1.6. Challenges to the adoption of clean cooking technologies

An analysis undertaken by Rwanda Electricity Group (REG) concluded that alternative technologies targeted at reducing the demand for biomass for cooking have not been adopted to a satisfactory extent, due to various challenges which are summarised below:

Technology	Challenges to adoption
Biogas	• Some of the existing biogas plants are no longer in use • Limited know-how of operation and maintenance • Inappropriate feeding due to unavailability of feedstock

[8] Source: SE4All, 2015

	• Low rate of dissemination due to budget constraints • Underfed cows • Insufficient of promotion and follow-up
Liquefied Petroleum Gas	• Higher upfront costs for equipment • Limited distribution capacity of companies due to low presence outside Kigali • Limited awareness • All key components and accessories are imported; this has a direct impact on cost • Storage capacity is limited
Pellets and Briquettes	• Limited production and awareness • Producers are not identified and not coordinated • Production and business management skills for most producers are limited • There are no production lines that ensure standardised production • Use is limited to users living around the production sites.
Charcoal	• Most of the producers use inefficient traditional carbonization techniques • Few trainings were provided to producers on modern carbonization techniques • Taxation not harmonized • Charcoal production not regulated; no framework to guide producers
Improved cook stoves	• Users still use stoves with low efficiency • Most stoves on the market are not standardized and not tested by an accredited institution • Low demand • Uptake entirely voluntary, with no enforcement measures in place
Electricity for cooking	• High energy cost, affordable to only high-income earners • Access to electricity • Limited awareness

Source: Biomass Energy Strategy (2018 - 2030)- Rwanda

3.0 CHAPTER III: METHODOLOGY

3.1. Approach

A mixed approach (quantitative and qualitative) was used in this study. According to Creswell (year). A quantitative approach is one in which the investigator primarily uses post-positivist claims for developing knowledge (i.e., cause and effect thinking, reduction to

specific variables hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data.

3.2. The Sampling Framework

Our sampling framework was based on the nature of the baseline survey. Participants to the survey were carefully considered on the basis of their relevance to objectives of the study.

3.3. General information about study districts

Table 1: Total population of the study area disaggregated by sex

Districts	Male	Female	Total (Male and Female)	Total Sectors	Total Cells
Ngororero	154,591	179,122	333,713	13	73
Rutsiro	154,044	170,610	324,654	13	62
Burera	160,395	176,187	336,582	17	69
Karongi	155,887	175,684	331,571	13	88
Total	**624,917**	**701,603**	**1,326,520**	**56**	**292**

Source : Districts websites

3.4. Sample size and distribution per study area

In order to calculate the sample size, the following formula was used (source):

$$n = \frac{\frac{z^2 p(1-p)}{e^2}}{1 + \left(\frac{z^2\, p(1-p)}{e^2\, N}\right)}$$

Where,

n stands for ***sample size***;

e stands for ***margin of error***;

N stands for ***Population;***

z stands for ***z-score***

p stands for ***sample proportion (or response distribution);***

- Given:
- The ***confidence interval*** of **95%** and the ***margin of error of 5%,***
- The ***sample proportion of 50%,***
- The ***population of*** **1,326,520** total populations for the 4 districts;

- The **z-score of 1.960**;
- Then, the sample size is:

$$n = \frac{\left(\frac{(1.960)^2\,(0.5)(1-0.5)}{(0.05)^2}\right)}{1+\left(\frac{(1.960)^2\,(0.5)(1-0.5)}{(0.05)^2\,(1{,}326{,}520)}\right)}$$

n = 385

Therefore, a sample size of 385 individuals was rounded up to 400 people and distributed across the 4 districts; this made 100 individuals per each district. Then, 400 copies of questionnaires were randomly distributed to 400 individuals. After administering the questionnaire, questions well-answered and considered for interpretation and analysis. Statistically, the sample size was representative of all the four districts and findings were extrapolated to all the districts.

4.0 CHAPTER IV: DATA ANALYSIS AND DISCUSSION

Table 1: Effects of Climate Change

Effects of climate change	Burera	Karongi	Ngororero	Rutsiro	Average
Landslides	83	93	84	89	**87.25 %**
Drought	41	52	43	37	**43.25**
Volcanic eruption	44	0	0	0	**11%**
Strong winds	56	63	48	67	**58.5%**
Earthquakes	62	51	39	49	**50.25%**
Flood	11	7	9	13	**10 %**
Erosion	91	88	93	96	**92 %**
Unpredictable precipitations	76	49	52	48	**56.25%**
Heavy rains	82	49	52	62	**61.25%**
Land degradation	72	75	78	83	**77%**
Deforestation	84	92	87	93	**89%**

Overpopulation	52	63	66	63	**61%**
More diseases/malaria	37	21	18	29	**83.25%**
Conflicts	32	42	38	31	**43.75%**
Domestic animal stocks may decline	17	21	11	23	**18%**
Private businesses and houses may get damaged	56	71	49	64	**60%**
Government public utilities may get damaged eg, roads,	81	69	63	72	**71.25%**

Data source: Primary data, 2021

Landslides were rated at 87.25%, drought were rated at 43.25%, volcanic eruption was rated at 11%, strong winds were rated at 58.25%, earthquakes were rated at 50.25%, flood was rated at 10%, erosion was rated at 92%, unpredictable precipitations rated at 56.25%, heavy rains were rated at 61.25 %, land degradation was rated at 77% while deforestation was rated at 89%. Overpopulation was rated at 61%, more diseases or malaria was rated at 83.25%, conflicts were rated at 43.75%, domestic animal stocks which may decline were rated at 18%, private business and houses that may get damaged were rated at 60%, government public utilities which may get damaged were rated at 71.25% (Table 6).

Key informants in Burera district outlined the issue pertaining with the lakes of Burera and Ruhondo whereby waters surpass the borders of the lakes and destroy crops and plants in the valleys. The broad understanding from Key Informants Interviews (KIIs) was that when it rains it is heavy for short period interspersed with dry spells. This had led to negative effects on the livelihoods of the local communities. For example, respondents noted that several wetlands and seasonal river basins had been drained into agriculture land. In study areas crop farming survives mostly on rain which is no longer predictable as it does not fall continuously in a year. In all the four districts of the study, farming is also affected by people's limited knowledge and skills for adapting to the changing seasons. In Rutsiro and Karongi district, the issue of land slide, soil degradation and soil erosion were articulated during focus group discussions and Key Informants Interviews: "*Soil erosion is currently the major contributor to the degradation of the soil resource, the on-site and off-site effects attributed to soil erosion include decline of soil productivity, and environmental damage through sedimentation, pollution and increased flooding. The loss of soil due to water erosion degrades the arable land and eventually renders it unproductive, consequently resulting in a drop in potential agricultural productivity and giving rise"*

In all surveyed districts, the issue related to deforestation was also highlighted as an issue whereby only 30% of the district soil is covered by forest in Rutsiro yet, the district plans to have 5,260 ha of land planted with forestry and agroforestry trees. For Karongi the forest covered area is at 23,915 ha including natural forests, shrubs, forest plantations and bamboo. In Ngororero forest at 25% of the total district land however the area to be planted covers 22%. Rutsiro District Environmental Officer stated: *"During 2021-2022 financial year we will continue to plant trees and maintain the existing forests, we will construct terraces (radical and progressive), we will restore liver sides, and increase the level of rain water harvesting in order to minimize the disaster related to rain water, in addition we will continue to mobilize the population to relocate from high risk zones and provide assistance to those affected by disasters".*

Table 2. Types of cooking technologies used in surveyed families

Cooking technology	Burera	Karongi	Ngororero	Rutsiro	Average
Three stone fire/traditional stove	88	81	79	83	**92.6%**
Biogas burner	4	7	4	8	**1.2%**
Liquefied Petroleum Gases (LPG)	6	8	6	8	**1.5%**
Cooker	0	1	2	4	**1.75%**
Improved cook stoves	0	3	1	3	**1.75%**
Cylindrical frying pan made in metal	18	11	13	16	**14.75%**
Local type Stove	26	29	34	42	**32.75%**
Clay charcoal stove	6	9	2	3	**5%**
Metal charcoal stove	7	8	3	6	**6%**
Pipe stove	14	8	9	12	**10.75%**
Darfur stove	9	10	7	12	**9.5%**
Tubura stove	9	18	13	18	**14,5%**
Songa stove	23	17	14	8	**15.5%**
Canarumwe stove	11	8	21	6	**11.5%**
Canamake stove	3	2	3	0	**2%**
Petrol cooking stove	4	7	4	8	**5.75%**

Data source: Primary data, 2021

As per the above table, 92.3 % of respondents use firewood, 94.0 % use small sticks for cooking, 82.5 % use Banana leaves (ibishangara), 80.3 % use maize cobs, 73.5% use maize and cassava stems, 82.5 % use dried weed (imbagara), 61 percent use cow dung, and 66.25 % use leaves or twigs (ibikori). According to studies, biomass energy is the most major source of energy in Rwanda, accounting for 85 % of total energy consumption. Households consume 91 percent of biomass, with the remainder divided among industry (4 percent), non-energy usage (2 percent), and commercial and public sectors (both 1 percent). Industrial use is largely in tea industries and small-scale brick making, with biomass used for drying. A national survey showed that 83.3% of households use firewood for their cooking needs (reference/source). The use of firewood by rural households is an attractive option as it is freely available to most households. In urban areas, charcoal is the preferred fuel.

This is due to its long-life storage and relatively low-cost transportation, given its smaller volume and weight compared to firewood. Experience across Africa suggests that demand for charcoal will increase rapidly with urbanization trends. Households will first use it as a complementary fuel to firewood but gradually shift entirely as it is more convenient. Alternatives such as LPG and electricity are currently expensive, with a recent Multi-Tier Framework survey showing that they are used by only 0.5% of households. However, pay as-you-go LPG is increasingly being offered by private companies. This model removes a significant barrier to LPG uptake by removing the requirement to purchase a canister and fuel up front. Customers pay a canister deposit and then use their mobile phone to pre-pay for LPG as they require it. Purchasing LPG in this way can result in lower costs than for charcoal. This approach follows the successful expansion of off-grid electricity access seen in recent years. Similar business models are in place for pellets, with consumers agreeing to purchase a set number of pellets from a supplier, with a high-efficiency stove provided for no initial cost.[9]

Table 3. Adaptation to climate change

[9] Energy Sector Strategic Plan 2018/19 - 2023/24

Practices for safeguarding the environment and mitigating the effects of climate change in the district	Burera	Karongi	Ngororero	Rutsiro	Average
Rain water harvesting	31	29	33	23	29%
Dig trenches	75	81	87	93	72%
Use of improved cooking stoves	17	21	18	20	19%
Establishing radical terraces	16	24	13	17	29%
Switch off bulbs when they are not in need	64	72	77	80	73.25%
Avoid air pollutants	84	82	79	75	80%
Caring for water sources	32	41	48	53	43.5%
Avoidance of plastic bags	92	90	96	97	97.75 %
Planted trees and bushes around gardens	42	38	44	49	63.5%
Cutting off mature trees	73	69	59	64	66.25%
Stopped damaging the swamps	44	38	61	58	50.25%
Used modern farming methods	26	30	43	29	32%
Cooking with non-biomass fuels	18	21	19	22	2.7%
I did nothing	12	16	11	14	13.25%

The majority of respondents 93.75% claimed to have avoided plastic bags, 84% mentioned to have dug trenches for preventing soil erosion, 80% avoided air pollutants, 86.5% planted trees and bushes around gardens (Table 8). It is true trees and forests can provide part of the solution to limiting climate change, and to helping people to adapt to the changes. Trees are helping to adapt as they provide shade, alleviate flooding, and reduce on depletion of existing forests through providing more fuel wood.

However, planting trees and new forests can largely be part of mitigating climate change. How to adapt and build resilience to the impacts of climate change on the other hand, should be activities that identify and address the impacts. So, from this study area's household perspective, response to climate change should be about building resilience by putting in

place plans that will minimise interruption in food security and livelihoods such as improving agriculture. Only 32% of respondents used modern farming methods (organic manure, modern/improved seeds.

Table 4. Cooking fuels used by surveyed families

	Burera (%)	**Karongi (%)**	**Ngororero (%)**	**Rutsiro (%)**	Average
Firewood (imyase)	**98**	**93**	**87**	**91**	**92.25**
Small sticks (inshari)	**99**	**87**	**92**	**98**	**94**
Charcoal	**2**	**7**	**13**	**9**	**7.75**
Banna leaves (ibishangara)	**99**	**95**	**47**	**89**	**82.5**
Maize cobs	**90**	**92**	**83**	**56**	**80.25**
Maize and cassava stems	**91**	**97**	**63**	**43**	**73.5**
Dried weed Imbagara)	**97**	**72**	**79**	**82**	**82.5**
Cow dung	**48**	**79**	**38**	**79**	**61**
Leaves or twigs	**66**	**74**	**36**	**89**	**66.25**

Data source: Primary data, 2021

Figure 3.6 shows that firewood is usually accessible, as evidenced by 69.7 percent of respondents, and to some extent available in the community through gathering in bushes and woods (62 percent). In Rwanda, it is thought that fuelwood comes from forests and woods, contributing to large-scale deforestation. This assumption is supported by available research on fuelwood demand and availability, which show a steadily increasing need for fuelwood, particularly from forest plantations.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The increased need for firewood for cooking appears to be a serious environmental and economic concern. The use of tree stones open stoves and traditional charcoal manufacture contribute considerably to an increase in the quantity of fuel used for cooking and charcoal manufacturing. The most affected are women and children who are responsible for collecting firewood and cooking. This takes time that could be spent on more productive tasks for women or education for children. Furthermore, the exposure of a woman and her kid while cooking causes respiratory and ocular illnesses, as well as cancellations in rare cases. Ninety-

five percent of the time 95 percent of families rely only on firewood for cooking, while 5 percent utilize charcoal. Cooking is done with vegetables and plant wastes in some areas.

A mixed approach (quantitative and qualitative) was used in this study. According to Creswell (year). A quantitative approach is one in which the investigator primarily uses post-positivist claims for developing knowledge (i.e., cause and effect thinking, reduction to specific variables hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data.

The researcher collected open-ended, emerging data with the primary intent of developing themes from the data. The rationale of using mixed methods approaches resided in the assumption that collecting both qualitative and quantitative data best provides a comprehensive and deeper understanding of a research problem than either research approach alone (Bulsara, year). The quantitative part involved the collection and analysis of quantitative data from the sampled respondents. As for the qualitative one, data was collected and analyzed from targeted participants (focus group discussions) and relevant documents. Tubibe Amahoro determined a list of all relevant stakeholders and respondents within the four (4) districts where the baseline survey was conducted.

5.1 Recommendations to the Civil Society/ NGOs

- TA and RCCDN[10] network must help constituencies to develop resilience against climate change adverse impacts.
- Community organizations networks also have a role to increase community-based groups effectiveness through analytical and adaptive capacity building. To this end, it's important for CSOs to play an important role in supporting vulnerable groups especially women to challenge customs and beliefs which perpetuate unequal gender relations
- Civil society should mainstream climate change and development policy advocacy in their thematic work, however, climate change policy advocacy should be looked at.
- In order to accomplish long-term change, civil society should expand its engagement in climate change policy processes at all levels. It is the responsibility of civil society organizations (CSOs) to encourage citizens' greater policy engagement and discussion on important development and climate change issues.
- Raise citizens' awareness around Nationally Determined Contributions- NDCs
- Conduct comprehensive research on appropriate improved stoves, taking into account the amount of wood saved, cooking habits, raw materials for improved stove manufacture accessible in each location, and household income.

5.2 Recommendations to Local Government

- The local government in the surveyed districts have to put more effort into creating more cooking technologies that use less combustible, like improved cooking stoves, biogas, including making Liquefied Petroleum Gas (LPG) available to people depending on their means of income.

[10] RCCDN: Rwanda Climate Change and Development Network

- Adaptation activities should undertake a bottom-up approach to diversified development activities that is gendered; premised on ensuring equitable energy access; and recognizing that poverty alleviation requires energy services that are based on secure and reliable supplies and stable prices.
- There is a need to promote and enhance wetland preservation, as well as restore and rehabilitate damaged wetlands and raise public knowledge about biosafety through programs involving the community, policymakers, and the corporate sector.
- Streamline waste management practices at district level
- The community should be taught on climate change mitigation and adaptation strategies in order to safe guard the environment hence work towards sustainable community livelihoods.

5.2 Recommendations to Community Members

- To plant more trees: A stress has to be put in the mobilization of planting trees in and around their premises where applicable and keep sensitizing local population around rules of cutting trees. This has to be conducted at the same time with establishment of tree nurseries made up especially by agro-forestry trees, fruit trees and forest trees where applicable.
- It is advised that efforts be made to encourage adoption of the use of energy-saving stoves as well as other affordable improved cooking technologies in order to relieve the problem of deforestation, indoor air pollution, eye diseases, soil erosion, and landslides.
- Community members should improve their usual practices around waste management.

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