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Quantitative Analysis of Resilience Factors Associated with Floods and Landslides in Northern and Western Districts of Rwanda



Prepared by EA RILab_RWANDA
 In collaboration with the RAN Secretariat

Collaborating Universities/Countries

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Table of Contents

LIST OF TABLES.....	5
LIST OF FIGURES.....	5
LIST OF APPENDICES.....	5
ACRONYMS	6
Acknowledgement.....	7
Abstract.....	8
Chapter One. Introduction and Background.....	10
Chapter Two. Literature Review	12
2.0. General background of disaster in Eastern Africa	12
2.1. Resilience challenges for Rwanda.....	13
Chapter Three. Problem statement and justification.....	16
Chapter Four. Research objectives.....	18
4.1 Goal/General objective.....	18
4.2 Specific objectives.....	18
4.3 Research questions and/or hypotheses	18
Chapter Five. Methods.....	19
5.1 Study site(s) and study population(s)	19
5.2 Study Design	20
5.3 Sample Size	20
5.4 Sampling/Selection procedures	20
5.5 Data collection procedures and tools.....	21
5.6 Quality control measures	23
5.7 Variables and Measurements.....	24
5.8 Data management and analysis	25
5.9 Ethical considerations.....	26
Chapter Six. Results	29
6.1. Socio-demographic characteristics of the respondents.....	29



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UNIVERSITY OF RWANDA



6.2. Resilience dimensions by districts 30

6.3. Principal Component Analysis (CPA) 33

6.4. Multivariate analysis..... 36

Chapter seven. Results discussion.....37

7.1. Discussion 37

7.2. Limitations of the study..... 38

CONCLUSION AND RECOMMENDATIONS.....40

References41

APPENDICES Error! Bookmark not defined.



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LIST OF TABLES

Table 1: Summary of the study areas	19
Table 2: Number of target respondents for quantitative assessment on the resilience dimensions in Rwanda.....	21
Table 3. Respondents’ socio-demographics characteristics	29
Table 4. Distribution of respondents’ characteristics by district and sector.....	30
Table 5. Dimensions comparison by districts.....	32
Table 6. Principal components (eigenvectors) for wealth dimension.....	33
Table 7. Binary logistic regression for Psychosocial dimension, Engagement as a proxy.....	36
Table 8. Poisson logistic regression for Health dimension, health related resources as a proxy	36

LIST OF FIGURES

Figure 1. Conceptual framework.....	16
Figure 2. Average dimension scores by district in the context of floods/landslides Rwanda	35

LIST OF APPENDICES

Appendice 1. Informed Consent Form – English version	Error! Bookmark not defined.
Appendice 2. Informed Consent Form – Kinyarwanda version	Error! Bookmark not defined.
Appendice 3. RAN quantitative research study tools - English version.....	Error! Bookmark not defined.
Appendice 4. RAN quantitative research study tools-Kinyarwanda version	Error! Bookmark not defined.



ACRONYMS

CS	Civil Society
DDMC	District Disaster Management Committees
DM	Disaster Management
DRR	Disaster Risk Reduction
EIA	Environmental impact assessment
EWS	Early Warning System
GoR	Government of Rwanda
HFA	Hyogo Framework for Action
MIDIMAR	Ministry of Disaster Management and Refugee Affairs
MINADEF	Ministry of Defense
MINAFFET	Ministry of Foreign Affairs and Cooperation
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MININTER	Ministry of Internal Security
MINISANTE/MOH	Ministry of Health
MININFRA	Ministry of Infrastructure
NDMP	National Disaster Management policy
NGO	Non-Governmental Organizations
RBS	Rwanda Bureau of Standards
RDB	Rwanda development Board
REMA	Rwanda Environmental Management Agency
RDF	Rwanda Defense Forces
RNP	Rwanda National Police
SDMC	Sector Disaster Management Committee
UN	United Nations
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization





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Abstract

Background: Rwanda is prone to a wide range of natural hazards. Areas of the north western part of the country experience recurrent floods and landslides, aggravated by steep slopes, soil instability, heavy rains and poor drainage. Rainy seasons in Rwanda are becoming shorter and more intense, leading to decreased agricultural production, droughts in dry areas and floods and landslides in areas experiencing heavy rains, especially in Northern and Western provinces. These heavy rains, coupled with a loss of ecosystems resulting from deforestation and poor agricultural practices, have resulted in destruction of crops, houses and other infrastructure as well as loss of life and livestock. This study aimed to analyze the determinants of the community resilience to floods/Landslides and to obtain the baseline status of key resilience indicators, as well as to identify possible entry points for innovations to improve resilience in that part of Rwanda.

Methods: A cross sectional study was conducted in 2015 in Busogo sector of Musanze District in Northern Province, Jenda and Jomba sectors of Nyabihu District and Rugerero sector of Rubavu District in Western Province. A set of quantitative questions were asked about the eight resilience dimensions developed through the qualitative rapid appraisal of resilience conducted in 2013 within the same communities; in other words the used questions were a quantitative version of the qualitative assessment that preceded this study. Epidata was used for data entry and validation, and Stata version 13.0 was used to clean and analyze data. Descriptive statistics were plotted for socio-demographics of participants; bivariate analysis was done for the same characteristics and dimensions related variables across districts. A principal component analysis was performed to show the contribution of variables to the dimensions, composite score were calculated and standardized to make a comparison across districts via a spider graph. The whole analysis was guided by tying both qualitative and quantitative findings to inform possible entry for innovations.

Results: Out of 423 respondents, almost 55% are female; the big proportion is aged 51 years and older, almost 80% are literate, 54% are not employed, 52% are legally married and all these characteristics were statistically across settings (districts and sectors) with the $p < 0.05$, except for marital status. All the eight dimensions related variables were also statistically different across districts and sectors, except human capital which was expressed by education of the head of household as a proxy. The standardized average dimension index scores showed that Musanze was the most resilient district in infrastructure and health





related resources, Rubavu district the most resilient in psychosocial and natural resources/environmental protection; while all dimensions were almost equally distributed in Nyabihu district. No dimension was associated with psychosocial status of victims; while infrastructure and wealth dimensions were associated with health status ($p=0.013$ and 0.045 respectively).

Conclusion: The analysis of determinants of the Musanze, Nyabihu and Rubavu districts’ community resilience to floods/Landslides found that Musanze was the most resilient in infrastructure and health related resources, Rubavu the most resilient in psychosocial and natural resources/environmental protection; while all dimensions were almost equally distributed in Nyabihu district. To effectively strengthen these communities’ resilience capacities, innovative solutions/strategies would be oriented towards strengthening the public infrastructure (roads, bridges, classrooms, etc) and wealth status of victims to make them resist any possible similar shock once it happens again.





Chapter One. Introduction and Background

Over the last few decades, the burden of disaster related shocks has been on the increase in Eastern Africa(EM-DAT 2013). Almost all recent disaster situations are underlined by human factors, either in contributing to the cause of the disaster or to its effects. The result of disaster are sudden ‘shocks’ that disrupt the livelihoods of communities, infrastructure and institutions (Shoaf 2000).

Even without sudden damaging events, communities face slow onset and persisting stresses impacting on their day-to-day livelihoods and well-being. Very often community resilience to the adverse effects short term climate variability is sub-optimal, yet these events occur cyclically and repetitively in many communities in Eastern Africa. Such events often lead to loss of economic livelihood, increased morbidity and mortality and displacement, yet they are predictable. On a longer term perspective, climate change is set to slowly increase the stresses that communities face, especially with regard to economic production (IPCC 2012). This and other slow onset events are already taking a significant toll on the resilience of communities.

Over the last few decades, the global approach to adverse events, shock and stresses has been focused on ‘response’. However, it has become increasingly clear that risk reduction should be the priority for such programs. There is therefore an increasing focus on prevention, mitigation and preparedness(FAO 2008). Evidence is also emerging that despite our best efforts at mitigation and prevention, the frequency and scale of adverse events, shocks and stresses shall remain and even increase (IPCC 2012). Risk reduction programs should therefore have a strong component of building resilience of affected and potentially affected communities to overcome their vulnerabilities and cope with shocks and stresses in a way that enhances their stock of wellbeing (Marschke and Berkes 2006). From the qualitative study conducted May 2014 the main resilience domain was found to be psychological and health dimensions as outcome dimensions; natural resources/environment and infrastructures as immediate causes dimensions; wealth and human capital as underlying drivers of vulnerability and adaptive capacity while governance and social networks are enabling dimensions.





The Resilient Africa Network (abbreviated as RAN) is a USAID funded program, bringing together a network of 20 African universities in 16 countries. RAN supports the resilience of communities by nurturing and scaling up innovations from the network universities. In order to identify resilience priorities in target communities, qualitative and quantitative assessments are conducted to provide evidence for the resolution; using innovators which provide solutions to the beneficiaries challenges using science and technology.

The ultimate aim of these innovations is to strengthen the resilience of African communities to priority shocks and stresses.

To explore resilience factors and the impact of innovations on resilience of communities, RAN has identified seven sentinel surveillance communities across Eastern Africa. These communities will be used to monitor change in resilience factors over time, and to test hypotheses about the effectiveness and efficiency of proposed solutions on individuals, households and communities.

In Rwanda, RAN will target one community: Western Province (the districts of Rubavu and Nyabihu) and Northern Province (Musanze district) where the main issue is *“resilience to recurrent landslides and floods as a result of climate variability”*.

Selection of this priority them was based on the frequency of the shock/stress, its magnitude, effects of the shock/stress, vulnerability of the population and existing adaptive capacities in the communities as well as potential ways in which RAN can contribute to mitigating the vulnerability factors. These factors were explored and validated in qualitative study which contributed to the evidence base in understanding the underlying drivers of resilience in the three districts target communities.



Chapter Two. Literature Review

2.0. General background of disaster in Eastern Africa

The Eastern Africa region is prone to many adverse events (Toole and Waldman 1993) that manifest either as sudden shocks or chronic stresses in different communities. The region's location and climate interact with several human factors to provide optimum conditions for occurrence of epidemics, floods, drought and famine and other natural stresses (USAID 2010; USAID 2011) as well as environmental degradation, acute and chronic conflict, terrorism, fires and transportation crashes (Office of the Prime Minister 2004). Rapid population growth, and the increasing urbanisation have contributed to the increase in disaster hazard risk and socio-economic stresses in the region (UBOS 2012). Lack of livelihoods diversification in many communities results in persistent poverty that exacerbates the effects of other shocks and stresses.

A formative literature review resulted in the identification of six priority issues of focus for target communities in Eastern Africa: 1) Resilience to recurrent epidemics and floods as a result of climate variability in the Albertine region of Uganda; 2) resilience to recurrent floods alternating with drought as a result of climate variability in the Teso region of Uganda; 3) resilience to recurrent landslides and floods as a result of climate variability in the Elgon region of Uganda and the Western region of Rwanda; 4) resilience to the effects of chronic conflict on livelihoods, manifested in the slow pace of socio-economic recovery in the Northern region of Uganda; 5) resilience to the effects of chronic displacement among Congolese refugees in camps in Rwanda and; 6) resilience to the effects of acute conflict especially sexual and gender-based violence in North and South Kivu provinces in DRC. From these six priorities, RAN has identified two priority thematic issues of focus: 1) Resilience to the effects of climate variability in the region; and 2) Resilience to acute and chronic conflict and/or its effects in the region. In this section, we provide a review of literature on the manifestations of the priority thematic areas of focus for selected communities in Rwanda.



2.1. Resilience challenges for Rwanda

Rwanda is one of five countries in the East African Community. It has a surface area of 26,338 square kilometers and is divided into four geographic provinces (Northern, Southern, Eastern, Western and Kigali City). Rwanda has a population of 10.5 million, with a population growth rate of 2.6%.

The major economic activity in Rwanda is agriculture. However, the majority of farmers depend on small subsistence-based holdings. Rwanda's GDP per capita (on a purchasing power parity basis) stands at 1251 USD in 2011 (Source: World Bank); 58% of the population live under the national poverty line. Rwanda's non-income Human Development Index stands at 0.476, ranking it 167th globally. Rwanda's life expectancy at birth is 55.7 years. Under-five mortality rate is 54 per 1,000 live births and Maternal Mortality Rate is 340 per 100,000 live births (World Bank 2011). The average years of schooling (for adults) is 3.3 years while the GNI per capita (in PPP terms) stands at 1,147 USD. The Inequality adjusted HDI value stands at 0.287, the Gender Inequality Index at 0.414 and the Multi-dimensional Poverty Index at 0.350 (All figures quoted from the UNDP 2011).

Analysis of rainfall trends in Rwanda shows that rainy seasons are tending to become shorter with higher intensity. This tendency has led to decreases in agricultural production and events such as droughts in dry areas; and floods or landslides in areas experiencing heavy rains. Heavy rains have been observed especially in the northern and the western province. These heavy rains coupled with a loss of ecosystems services resulting from deforestation and poor agricultural practices have resulted in soil erosion, rock falls, landslides and floods which destroy crops, houses and other infrastructure (roads, bridges and schools) as well as loss of human and animal lives.

In 2011, at least 10 people were killed and hundreds more displaced due to flooding following the heavy rains. The most affected districts were Rubavu, Nyabihu of Western province and Musanze district of Northern Province (MIDIMAR Report, 2011). Furthermore in 2011, around 14 people lost their lives due to a heavy landslide that struck the steep slope in Gakoro cell, Rugera Sector of Nyabihu District in the Western Province (MIDIMAR 2011).



The primary effects of floods and landslides are loss of lives (MIDIMAR-Sept 2011) and displacement of survivors. In the recent flooding in Rwanda, 1854 houses were destroyed leaving survivors homeless (MIDIMAR-Sept 2011). Other primary effects include: destruction of large farms with crops and livestock. For instance, about 3,000 hectares of farmland was destroyed in the recent flooding in Rwanda (MIDIMAR Report, 2011). Other infrastructure like buildings, schools, health centres and electricity poles were also destroyed leading to electricity cut-offs and disrupted normal health care services. The secondary effects include: resettlement of displaced people in Internally Displaced Peoples' (IDP) camps. However, people are reluctant to leave high risk areas due to socio-cultural attachment to these areas. There is also usually a long dry spell after the heavy rain which leads to shortage of water and food hence famine.

Musanze, Nyabihu and Rubavu districts are vulnerable to the effects of the floods and landslides because of the following factors: Topography which affects communities living on the slopes and valleys (REMA 2009); geology since the soil from these three districts is volcanic and cannot resist the rains (REMA 2009); poor farming practices as many lands are not protected with anti-erosive plants (REMA 2009); heavy rains and this is very pronounced in volcanic regions and Gishwati forest. Other factors include: climate change since unpredicted rain causes massive damage; urbanization as it lowers water infiltration, increases runoff and soil erosion with increased potential for floods; deforestation of Gishwati natural forest has led to more floods in Gishwati. The driver of vulnerability is the socio-economic status since poverty limits people's capacity to cope with the effects of such disasters.

Some adaptive strategies that have been tried include: resettlement where people change their living location to the most secure areas, not exposed to floods and landslides; afforestation and re-afforestation like in Gishwati natural forest (REMA 2009) and good agricultural (anti-erosive) practices, for instance, terracing, mulching and agro-cropping.

The government of Rwanda has taken a bold step in re-settlement of the populations at highest risk of floods and landslides in Rwanda. There is need to explore trends in resilience factors in



communities that have been displaced and re-located as a result of floods and landslides in Rwanda and how these communities can be helped to build livelihoods resilience after the mandatory re-location.

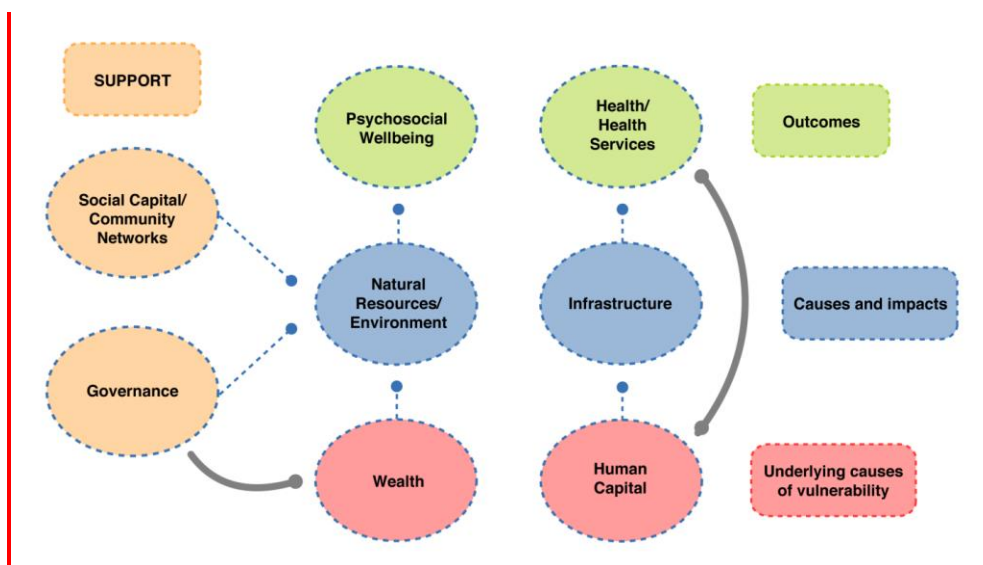
Chapter Three. Problem statement and justification

Efforts put in place to support victims of climate variability shocks have saved lives and met immediate needs, but these support they have not increased the capacity of affected populations to withstand future shocks and stresses and building permanent resilience. This is the reason why the same shocks and stresses often result in the same consequences on affected communities when they recur. Qualitative study contributed to the evidence base in understanding the underlying drivers of resilience in the three districts target communities, the information from the quantitative study will help to understand the magnitude of those drivers to develop innovative solutions that build the resilience of targeted communities.

This survey aimed at obtaining the baseline status of key resilience indicators; identifying specific sets of problem that will be used to call for innovations to address challenges in the target communities.

The below framework present a summary of RAN’s resilience and key dimensions emerging from qualitative assessment.

Figure 1. Conceptual framework





Evidence from qualitative research on resilience dimensions highlight eight dimensions: health, Psychosocial (as outcomes), natural resources and infrastructure (as immediate causes), wealth and human capital as underlying drivers and governance and social networking as support or enabling domains. Although evidence from the qualitative study highlighted those major dimensions for the resilience; the findings did not emphasize on which dimension Rwanda can work to comprehensively address effects related to floods and landslides.

Chapter Four. Research objectives

4.1 Goal/General objective

The study aim is to analyze the determinants of the community resilience to floods/Landslides and at obtain the baseline status of key resilience indicators

4.2 Specific objectives

- Identify the dimensions of resilience in the communities affected by recurrent Floods/Landslides
- Describe the links between the different dimension of resilience
- Describe the epidemiological triad of the resilience: “Who” is resilient? Where and why?
- Identify entry points for innovative interventions to enhance the resilience of the communities(Identify specific sets of problem that will be used to call for innovations to address challenges in the target communities)

4.3 Research questions and/or hypotheses

The main research question are:

- Who is resilient?/ non-resilient? How many are they?
- Where are they?
- Why are they resilient? / Non-resilient?
- What can be done to improve communities’ resilience?

Chapter Five. Methods

5.1 Study site(s) and study population(s)

Ascertaining the assessment of resilient and no resilient and how many require a comprehensive approach, tools and special techniques in collecting data. In this regard, administration sectors will be used as a basis for selecting the subjects for the survey.

The primary study population will be the households that have experienced floods and landslides in Musanze, Nyabihu and Rubavu districts.

Three sectors which have been most affected by floods and landslides have been purposely selected during the qualitative assessment, then, a list of imidugudu (villages) affected will be established. 2 imidugudu will be randomly selected.

From Imidugudu (villages) selected, a list of households which have been affected by floods and landslides will be established; from that list, household will be randomly selected. One most affected sector was selected from each district and the affected households, represented by the head of household were included into the study

. The study communities are summarized in the table below:

Table 1: Summary of the study areas

Regions	Administrative Units (district)	Study areas (sector)
Flood/Landslide prone areas	Rubavu district Nyabihu district Musanze district	Rugerero Sector Jomba and Jenda Sectors Busogo Sector
<i>Total</i>	<i>3 Districts</i>	<i>4 Sectors/camps</i>

5.2 Study Design

This study will be a simple-cross-sectional design and it will use quantitative methods and secondary data analysis methods.

- A population based survey will be conducted mi-November
- Analysis of secondary datasets will be done using desk review

5.3 Sample Size

For computing the sample size, we will use the following formula, as it is a cross section study

$$n = \frac{z^2 * p(1 - p)}{\delta^2}$$

z = z-score for the standard normal distribution at the significance level of 95 %

p = anticipated proportion of households by floods and landslides effects (= 0.50)

δ = desired precision (= 5%)

$$n = \frac{1.96^2 * 0.5(1 - 0.5)}{0.05^2} = 385$$

Considering the 5% of non-respondent, we can estimate the sample size to:

$$n = \frac{385}{1 - 0.04} = 405$$

The final sample size required will be equal to 401 households affected by floods and landslides.

5.4 Sampling/Selection procedures

Three sectors which have been most affected by floods and landslides have been purposely selected during the qualitative assessment, then, a list of imidugudu (villages) affected will be established. 2 imidugudu will be randomly selected.

From Imidugudu (villages) selected, a list of households, which have been affected by floods and landslides, will be established; from that list, household will be randomly selected.

The head of the household will be interviewed.

Table 2: Number of target respondents for quantitative assessment on the resilience dimensions in Rwanda

Administrative Unit	Study areas	Number of Households
Rubavu district	Rugerero Sector	102
Nyabihu district	Jomba Sector	101
	Jenda sector	101
Musanze district	Busogo Sector	101
	Total	405

5.5 Data collection procedures and tools

Quantitative data collected through survey will help to gather information regarding respondents' vulnerability factors, attitudes, opinions, perceptions, adaptive and coping mechanisms to recurrent flood/landslides.

Data will be collected by qualified and experienced enumerators (men and women) who will be trained prior to the beginning of data collection.

The research includes two main methods of data collection:

- ✓ Desk review
- ✓ Survey

These two components will allow triangulation of data collection methods and sources in order to provide a more complete picture of the resilience determinants and victims recommendations for resilient to shocks/stress caused by floods/landslides. Particularly, data and findings from other studies will be examined and triangulated to determine changes and trends. The data obtained from multiple sources will be examined in relation to each other to provide the most complete picture of the relationship between the resilience dimensions.

Below is a description of some of the major steps in data collection for each method.

a) Desk review:

The desk review will include documents and key materials including past research and studies on the eight identified priority resilient dimensions (Psychosocial, Health, Natural resources/environment, infrastructure, wealth, human capital, social networks and governance) in Rwanda, and data, reports, guidelines and policy documents used.

b) Survey:

The survey is a critical part of this research. It will be used to elicit information regarding respondents' vulnerability drivers, attitudes, opinions, perceptions, coping and adaptive mechanisms to recurrent effects of floods and landslides.

At this stage researchers will have had the research protocol approved by the relevant ethical committees, which included the informed consent form and the data collection tools. The study population has been defined, the sampling approach decided, and the research questions, indicators and outcomes measures selected.

Four key actions in planning out the survey will be:

- ✓ Community meetings
- ✓ Translating and testing the questionnaire
- ✓ Training of interviewers.
- ✓ Scheduling the interview

The **data collection process** will begin once the sample has been drawn, the instruments have been designed and piloted, and the teams have been trained. Attrition and non-response rates provide a good indicator of survey quality. The researchers will conduct quality checks during fieldwork to ensure the completeness of questionnaires, appropriate data entry and relevant data outputs.

The instrument / tool: This is a structured survey administered in person by trained interviewers. It will be conducted in a private setting. A mix of interviewers will be chosen to respect gender sensitivities and cultural knowledge.

Data collection was done by qualified and trained enumerators, including officially hired enumerators in SPH database, interns and master students who benefited from this opportunity with an exposure on field about disaster resilience. Data entry was also done by officially hired data entry who are in SPH database, together with SPH interns. All activities were coordinated by SPH team lead by Dr Etienne Rugigana, the project PI. The who study was coordinated by Albert Ndagijimana.

5.6 Quality control measures

Quality control in research takes many forms and is applied at all levels of the process. Four important elements of quality control related to data collection and field work are:

- ✓ *Thorough training of data gatherers,*
- ✓ *Close supervision of field work,*
- ✓ *Checking and verifying the correct completion of questionnaires by data gatherers, and*
- ✓ *Verification of correct data entry by computer data clerks.*

The **implementation** of this study is the responsibility of the research team led by the principal investigator in accordance with the parameters and conditions agreed upon with RAN and UR-CMHS-SPH the agency that has commissioned the research. The principal investigator will provide research oversight. The research team will share responsibility for technical quality on the overall study design, sampling and methods selection; questionnaire design or adaptation, translation and field-testing; interviewer training and supervision; fieldwork logistics; data quality checks, processing and analysis; findings verification and report production; and research findings dissemination-the latter in collaboration with the RAN.

Data collection involves a complex sequence of operations. First, the researchers will select the indicators that need to be measured and the measurements using local and international best practice. A matrix with the core indicators and measures for this research will be used. Being



selective will help to limit data collection costs, simplify the task of data collection and improve the data collected by minimizing demands on the respondent's time. Second, the final survey instrument will be formatted with codes so that it is ready for data entry.

After the data have been collected, data entry and data management, including "data cleaning" becomes the focus of quality control. This process will continue up to the preparation of the research report.

Another important aspect of quality control is thorough documentation - from the moment the research protocol is completed and cleared by the appropriate ethical committees to the safe keeping of data and consent forms to the confidentiality of the data and of the interviewees.

5.7 Variables and Measurements

OUTCOME INDICATORS

Psychosocial: Victims' engagement in reproductive work after floods/landslides

Health: Human deaths, injuries due to the shock, Health insurance coverage among, victims Access to Health care services by victims (Distance to the nearest health facility), WASH (Type of water source for the HH, Distance to the nearest water source point

IMMEDIATE CAUSES/EFFECTS

Natural resources/Environment: Anti erosion facilities (ditches, radical terraces, bamboos, holes to retain rain water), Existence of plant pests, Deforestation /existence of terraces, Training on environmental conservation, Crop loss due to floods/landslides, Existence of Early Warning System (EWS)

Infrastructure: Destruction of roads/bridges, destruction of schools, destruction of health facilities, destruction of churches, destruction of playground.

UNDERLYING DRIVERS OF VULNERABILITY

Wealth: Households assets (electricity, radio, mobile phone, television, bicycle, land), Possession of livestock (cows, sheep, goats, chicken, pigs, rabbits), Building materials (roof and floor), Type of toilet owned, HH business to get money to survive, Price fluctuation that to the crops, Saving (in banks, micro-finance institutions), Number of houses destroyed, House destruction.

Human capital: Education level of the head of HH

SUPPORT AND ENABLING

Governance: Government support in relocation, building materials, HH furniture/equipment, information on EWS, Umuganda, food assistance, crop seeds, health insurance, school fees, radical terraces creation, anti erosion ditches.

Social networks /Community networks: Victims who group themselves to effectively address the financial effects of the shock, victims are supported by NGO, CBOs (churches).

5.8 Data management and analysis

Desk review analysis.

For the analysis of desk review, the analysis will rely on secondary data from surveys, service statistics and agency records and assess “desired” or “optimal” performance against the current situation. The depth of the analysis will depend in great measure on the quality of documentary sources or the quality of existing statistical or financial data.

Researchers will use descriptive statistics to summarise data. The measures of central tendency, which describe a group of data to indicate the central point, most commonly used are the mean, median and mode. The measures of dispersion, which describe a group of data to indicate how spread-out the data are, most commonly used are the range, frequency distribution and the standard deviation. The standard deviation measures how closely the data cluster around the mean. In addition, percentages, rates, ratios, trends and rates of change can be used, as well as other statistical means of presenting the data.

Whereas the frequency distribution and standard deviation provides the distribution for one variable, cross tabulations display the joint distribution of two or more variables simultaneously, usually presented in a matrix. Each cell shows the percentage and the number of respondents who give a specific combination of responses. Additionally, correlations among relevant domains will be relevant to detect associations.

The key output of this research will be a research report with the key findings. However, one critical action at this stage will be the validation of findings. Once the data have been analysed and the preliminary findings known, researchers will plan a meeting with stakeholders in collaboration with the RAN. A brief summary of findings or a power point presentation will be prepared for purposes of validating the findings with stakeholders at the country level. Sharing this information with stakeholders in written form will help maintain the discussion focused. Feedback from the stakeholders would be compared with the findings to determine areas of agreement as well as areas of divergence, and the reasons will be discussed. This information will enrich the final report. Stakeholders can also be helpful in identifying gaps in knowledge, trends and good practices. Most importantly, stakeholders can help formulate recommendations that are relevant --actionable and/or aspirational-- in the country context for resilience.

5.9 Ethical considerations

Before starting any activities, we will seek approbation of the IRB.

Confidentiality

All respondents will be told that all information that they give during the course of the study will be strictly confidential, will be used only by the research investigators and will not be available



for other purposes. The results of the study may be published for scientific purposes, but will be written in such a way that an individual cannot be recognized.

To ensure further confidentiality, each subject enrolled in the survey will be assigned a unique identification number (ID), and this code will be the only identification used on all study materials. The records linking the names and IDs will be kept locked in a secure storage facility. After data are entered into a computer file, these computer records will be password protected to limit access. The data files used for analyses will not include information that can be used to identify individual households or individuals.

Data obtained from the surveys will be stored in locked, password-protected locations until sufficient identifiers have been stripped from the data so as to make identification of individual households and individuals impossible. The completed questionnaires will be locked in a secure location.

Informed consent

Before the interview begins, an interviewer will administer to each potential respondent to the survey a consent form and give respondents an opportunity to decide whether they would like to participate in the study. The consent form covers why the respondent was selected, the purpose of the questionnaire, the approximate length of time it takes to respond to the interview, and reassurance that all the information they provide will be treated confidentially. In case, the respondent is illiterate a witness will read the consent form for the respondent.

Remuneration

There will be no financial payment to participants enrolled in the study.

Ethical approval

Privacy risks will be minimized and any adverse impact on the rights and welfare of the subject's files will be prevented.



This assessment was expected to have limited inquiry into individual experiences and is therefore not inherently designed to measure attributes of individuals. Issues were discussed with the community as the reference. The privacy and confidentiality were assured in a way that names were not taken, but rather, anonymous codes were used, and referred to during the discussions. No possible harm will be identified during the whole data collection process and the assumed negative feelings were referred to as enabling a clear understanding of the actual problems and challenges that communities face in their day-to-day life.

Chapter Six. Results

6.1. Socio-demographic characteristics of the respondents

This study targeted 405 respondents across three districts (Musanze, Nyabihu and Rubavu) and four sectors, and fortunately we reached all them and surpassed the target by 18 respondents because they came among key respondents and we could not refuse their responses (Table 5).

Out of 423 respondents, almost 55% are female; the big proportion is aged 51 years and older, almost 80% are literate, 54% are not employed, 52% are legally married (Table 4).

Table 3. Respondents' socio-demographics characteristics

Variable	n	%
Sex		
Male	191	45.15
Female	232	54.85
Age group		
17-30 Years	83	19.62
31-40 years	103	24.35
41-50years	91	21.51
51 years and +	146	34.52
Education level		
Illiterate	89	21.04
Primary	263	62.17
Secondary and Higher	69	16.31
Missing	2	0.47
Occupation		
Unemployed	229	54.14
Employed	193	45.63
Missing	1	0.24
Marital status		
Single	28	6.62
Currently married	224	52.96
Divorced/Separated	17	4.02
Widow	102	24.11
Cohabiting	52	12.29

Across the districts and sectors, sex, age, education, and main occupation of the head of HH are statistically different ($p < 0.05$), but the marital status was not. Nyabihu district had the most female respondents and more 51 years old respondents, Musanze and Nyabihu had more primary schooled respondents; Musanze had more unemployed and Rubavu more employed respondents; Musanze and Nyabihu had more married respondents (Table 5).

Table 4. Distribution of respondents' characteristics by district and sector

Respondent characteristics	District		Musanze		Nyabihu				Rubavu		p-Value
	Sector		Busogo		Jomba		Jenda		Rugerero		
	N		n	%	n	%	n	%	n	%	
Sex											0.025
Male	191		34	17.8	55	28.8	57	29.84	45	23.56	
Female	232		69	29.74	51	21.98	56	24.14	56	24.14	
Total	423		103	24.35	106	25.06	113	26.71	101	23.88	
Age											0.03
17-30 Years	83		25	30.12	16	19.28	15	18.07	27	32.53	
31-40 years	103		28	27.18	25	24.27	32	31.07	18	17.48	
41-50years	91		23	25.27	24	26.37	30	32.97	14	15.38	
51 years and +	146		27	18.49	41	28.08	36	24.66	42	28.77	
Total	423		103	24.35	106	25.06	113	26.71	101	23.88	
Education											0.001
Illiterate	89		15	16.85	21	23.6	20	22.47	33	37.08	
Primary	263		74	28.14	72	27.38	64	24.33	53	20.15	
Secondary and Higher	69		14	20.29	12	17.39	29	42.03	14	20.29	
Total	421		105	24.47	105	24.94	113	26.84	100	23.75	
Occupation											<0.001
Unemployed	229		75	32.75	69	30.13	57	24.89	28	12.23	
Employed	193		28	14.51	37	19.17	55	28.5	73	37.82	
Total	422		103	24.41	106	25.12	112	26.54	101	23.93	
Marital status											0.065
Single	28		6	21.43	7	25	6	21.43	9	32.14	
Currently married	224		60	26.79	65	29.02	51	22.77	48	21.43	
Divorced/Separated	17		2	11.76	2	11.76	11	64.71	2	11.76	
Widow	102		24	23.53	21	20.59	29	28.43	28	27.45	
Cohabiting	52		11	21.15	11	21.15	16	30.77	14	26.92	
Total	423		103	24.35	106	25.06	113	26.71	101	23.88	

6.2. Resilience dimensions by districts

Qualitative community consultation on resilience capacity showed eight resilience dimensions. Wealth and human capitals have fallen under underlying causes of vulnerability; natural resources/environment and infrastructure were immediately being affected by the shocks (causes and impact), psychosocial and health/health services were qualified as outcome dimensions whereby some people were psychologically affected until they could not embark on their daily work . With the support from government and social network whereby people used to group themselves to effectively address the effects of floods/landslides; resilience capacities were strengthened.



With this quantitative version of the same assessment towards entry points for innovation, the findings collaborate well with qualitative findings whereby seven dimensions are statistically comparable across the three districts, especially health, natural resources, infrastructure and social network/support. Within dimensions, the wealth index is equally distributed across its five categories ($p: 0.001$); 80.38% of the households fall under poor and fair health status in terms of capacity to address the effects of floods/landslides in a more resilient way; one third of the households have strong mitigation facilities in place; 52.03% reported that public infrastructures are weak to resist the effects of the shocks; 26.24% have received government support to their optimal satisfaction; half of them have supported each another through grouping themselves together for synergy to be able to address the effects of the shocks, almost 60% have been to embark on their usual work without psychological affect (Table 6).



Table 5. Dimensions comparison by districts

Dimension	Total		Musanze		Nyabihu		Rubavu		χ^2 Test	p-value
	N	%	n	%	n	%	n	%		
Wealth									26.015	0.001
Very low	70	20.06	28	28.57	26	14.29	16	23.19		
Low	70	20.06	23	23.47	31	17.03	16	23.19		
Fair	70	20.06	24	24.49	32	17.58	14	20.29		
Good	70	20.06	14	14.29	42	23.08	14	20.29		
High	69	19.77	9	9.18	51	28.02	9	13.04		
Total	349	100.00	98	100.00	182	100.00	69	100.00		
Health									92.4797	<0.001
Poor	162	38.30	20	19.42	64	29.22	78	77.23		
Fair	178	42.08	62	60.19	98	44.75	18	17.82		
Good	83	19.62	21	20.39	57	26.03	5	4.95		
Total	423	100.00	103	100.00	219	100.00	101	100.00		
Natural resources									44.1705	<0.001
Poor mitigation	139	33.41	58	56.86	56	25.93	25	25.51		
Fair mitigation	139	33.41	31	30.39	67	31.02	41	41.84		
Good mitigation	138	33.17	13	12.75	93	43.06	32	32.65		
Total	416	100.00	102	100.00	216	100.00	98	100.00		
Infrastructure									71.5063	<0.001
Weak infrastructure	218	52.03	23	22.55	113	52.07	82	82.00		
Fair infrastructure	201	47.97	79	77.45	104	47.93	18	18.00		
Total	419	100.00	102	100.00	217	100.00	100	100.00		
Governance									13.5766	0.001
Minimal support	312	73.16	88	85.44	146	66.67	78	77.23		
Some support	111	26.24	15	14.56	73	33.33	23	22.77		
Total	423	100.00	103	100.00	219	100.00	101	100.00		
Human capital									3.3220	0.190
Enough capacity	287	71.22	78	77.23	139	67.48	70	72.92		
Incapacity	116	28.78	23	22.77	67	32.52	26	27.08		
Total	403	100.00	101	26.06	206	51.12	96	23.82		
Social support									9.2306	<0.010
Weak network	211	50.84	57	55.34	95	43.98	59	61.46		
Strong network	204	49.16	46	44.66	121	56.02	37	38.54		
Total	415	100.00	103	100.00	216	100.00	96	100.00		
Psychosocial (engagement in reproductive work after the shock)									6.6954	0.035
Not engaged	176	41.61	54	52.43	85	38.81	37	36.63		
Engaged	247	58.39	49	47.57	134	61.19	64	63.37		
Total	423	100.00	103	24.35	219	51.77	101	2308.00		

6.3. Principal Component Analysis (CPA)

As we have many variables under reach dimension, the Resilient Africa Network (RAN) and partners thought that the Principal Component Analysis (PCA) would be the best fit data reduction method for this study to really identify key variables explaining each dimension by assessing their loading into the model and by looking at Cronbach's alpha coefficient (α) to assess the reliability or consistency into the model. The dimensions with α less than 50% would be considered as not consistent to our PCA. The standardized score for each dimension would serve as a comparison between settings –district in our context- through a spider graph.

We have tried all dimensions through a PCA and reliability test by looking at alpha, and saw that almost all dimensions were poorly loading in such a way we could not use them for SEM. The only one that could work was wealth.

For the wealth dimension, the qualitative part of this assessment found that the socioeconomic status of affected households determined their level of vulnerability to the effects of floods/landslides, and those in a poor wealth quintile were of course the most affected (orphan headed households, disabled people, etc).

The quantitative part assessed the households' assets including livestock, house status and other variables translating wealth. The quantitative model was explained by six components which accounted for 51.52% of the cumulative variance among 415 respondents to the related questions. The first three components were poorly correlated with any variable in the dimension; the fourth component was correlated with roofing materials and negatively with the type of toilet, the fifth negatively with running a business for the households and the sixth with raising sheep (Table 7). Overall, the loading of these variables was very good in our situation (α : 0.6317).

Table 6. Principal components (eigenvectors) for wealth dimension

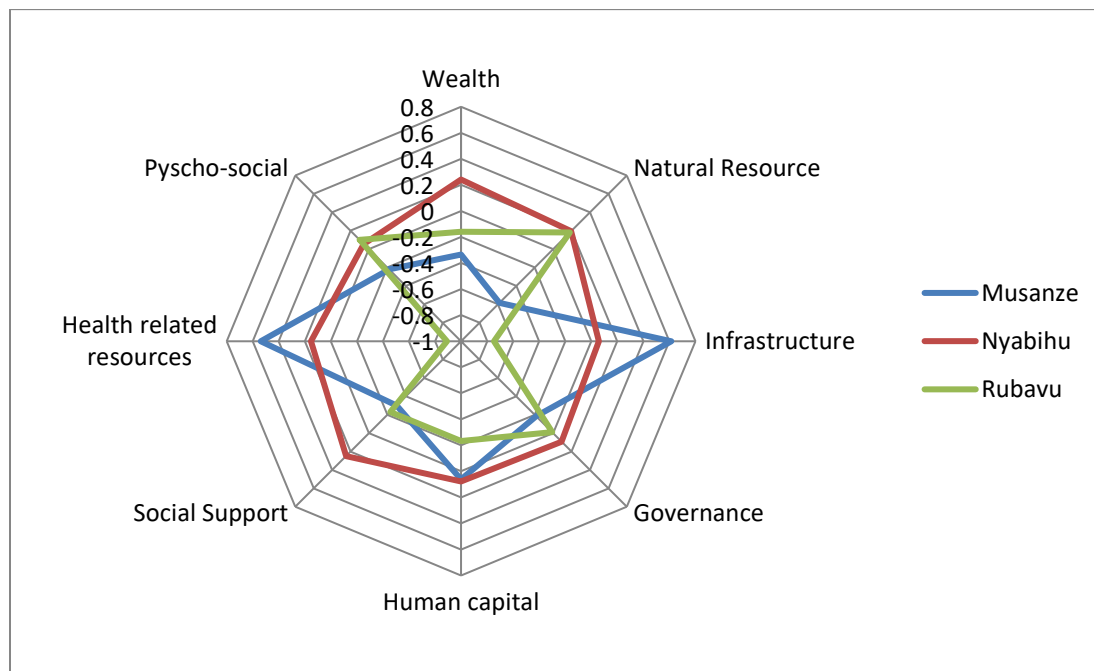
Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
House destruction	0.1382	-0.1562	0.3987	0.3269	0.0253	0.1583	0.565
Electricity	0.3501	-0.3602	-0.1129	-0.1428	0.2024	0.1502	0.3586
Radio	0.3949	-0.1238	0.0974	-0.0071	-0.2989	0.0216	0.4477
Phone	0.3065	-0.2386	0.221	0.0093	-0.2808	-0.1329	0.4914
TV	0.2569	0.0369	-0.4956	0.002	0.244	0.2333	0.3874
Bicycle	0.2843	-0.0179	-0.1384	-0.0151	-0.0608	-0.4127	0.5754
Land	0.1635	0.1733	0.1152	0.2969	0.0809	-0.4527	0.546
Cows	0.2587	0.2815	0.1773	-0.1543	0.1424	-0.1766	0.5741
Sheep	0.1397	0.2162	0.2669	-0.2775	-0.1564	0.5448	0.3618
Goats	0.1944	0.2514	0.0649	0.2431	-0.1937	0.2596	0.6175
Chicken	0.3049	0.2275	0.1033	-0.0838	0.0388	-0.0429	0.6434
Pigs	0.1696	0.4149	0.1189	-0.1113	0.3631	-0.1533	0.4513
Rabbits	0.1242	0.4637	-0.2364	0.1329	-0.0256	0.2019	0.4839
Floor	0.3303	-0.2953	-0.2144	-0.087	0.331	0.0684	0.3787
Roof	0.1131	-0.1404	0.2495	0.5346	0.2986	0.1712	0.4172
Business	0.2187	0.0276	-0.314	0.0941	-0.5523	-0.0723	0.4006
Toilet	0.0616	-0.0784	0.3122	-0.5339	0.0195	-0.0625	0.5416

Qualitatively, on human capital side, the survey found out that those who did not go to school were the ones most suffering, as well as the ones without a permanent job; because it was highlighted issues about giving up too the normal work as they were psychologically affected and could not see their future as promising, when everything is gone (human lives, houses, properties, land, public infrastructures, etc). Natural resources (soil, water, forests) maintaining and enhancing were stated key strategies to effectively mitigate the effects floods/landslides once they would occur in the future, as the environmental degradation was seen as the main contributor to the occurrence of these shocks. Floods/landslides destroyed key infrastructures such as road/bridges, health facilities, classrooms and playgrounds. To overcome all these shocks, victims stated that they group themselves in small groups on another to effectively address the effects of floods/landslides. But also, some private organizations and churches were supporting them to recover from the shocks. The government supported victims with in-kind assistance (home goods, iron sheets, seeds, clothing, furniture, etc). Through Umuganda, destroyed houses were repaired, radical terraces made and anti-erosion ditches planted.

Quantitatively, after calculating the mean score for each of the eight index dimensions through a sum up of all variables in under each dimension, - except wealth whereby the PCA was run and was statistically loading well -, we wanted to see their distribution across the three surveyed districts, and this would inform the innovation focus.

The standardized average dimension index scores showed that across districts, Musanze appeared the most resilient in infrastructure and health related resources, and the weakest in natural resources/environmental protection and social support. All dimensions were almost equally distributed in Nyabihu district, and it appeared the most resilient in wealth, natural resources/environmental protection, governance, human capital and social support among victims. Rubavu appeared the most resilient in psychosocial and natural resources/environmental protection and weakest in both health related resources and infrastructure (Figure 1).

Figure 2. Average dimension scores by district in the context of floods/landslides Rwanda



6.4. Multivariate analysis

Generally, no variable was associated with psychosocial dimension (respondents' engagement in reproductive work), both through normal binary logistic regression and stepwise process ($p > 0.05$) (Table 7).

Table 7. Binary logistic regression for Psychosocial dimension, Engagement as a proxy

Engagement	Coefficient.	Std. Err.	z	P>z	[95% Conf. Interval]	
Government support	0.276355	0.234813	1.18	0.239	-0.18387	0.736581
Education level	0.135845	0.19592	0.69	0.488	-0.24815	0.519841
Infrastructure	-0.06307	0.092522	-0.68	0.495	-0.24441	0.118265
Natural resources	-0.04408	0.078555	-0.56	0.575	-0.19805	0.109885
Social support	-0.05832	0.247159	-0.24	0.813	-0.54274	0.426103
Wealth	-0.00454	0.083758	-0.05	0.957	-0.16871	0.15962

With regard to health dimension with health related resources as a composite index variable; the study found that both public infrastructures and wealth status of floods/landslides victims with p value of 0.013 and 0.045 respectively (Table 8).

Table 8. Poisson logistic regression for Health dimension, health related resources as a proxy

Health related resources	Coefficient.	Std. Err.	z	P>z	[95% Conf. Interval]	
Infrastructure	0.059372	0.024029	2.47	0.013	0.012276	0.106469
Wealth	0.042711	0.021274	2.01	0.045	0.001014	0.084407
Social support	-0.05949	0.063346	-0.94	0.348	-0.18365	0.064667
Natural resources	-0.01067	0.019905	-0.54	0.592	-0.04968	0.028344
Education level	0.02113	0.049506	0.43	0.67	-0.0759	0.11816
Government support	0.013296	0.059216	0.22	0.822	-0.10276	0.129357

Chapter seven. Results discussion

7.1. Discussion

This study aimed at analyzing the determinants of the community resilience to floods/Landslides and at obtaining the benchmark for key resilience indicators and entry points for innovation. It consisted in quantifying the findings from the qualitative assessment done in the same community. Overall, the quantitative assessment findings support/confirm the qualitative findings, in such a way all the seven dimensions are statistically comparable across the three districts, except human capital.

The survey found that 80.38% of the households fall under poor and fair health status in terms of capacity to address the effects of floods/landslides in a more resilient way; and this was also reported in qualitative survey whereby the relatively poor people (in low socioeconomic category, widowed, orphans, etc) are the one most suffering from the effects of the shocks. Roof materials were seen to resist the heavy winds during rain, and this made many houses resist especially in Nyabihu district; and this was linked with households which had people running any business to have money to help address the effects, with households headed by literate people, with considerable work/employment (i.e 71.22% of the households had human capital capacity).

One third of the households had strong mitigation facilities in place; 52.03% reported that public infrastructures were weak to resist the effects of the shocks. Musanze appeared the most resilient district in infrastructure, but the weakest in natural resources/environmental conservation. Nyabihu was more resilient in natural resources/environmental conservation. The location of infrastructure in Musanze made it resistant to the shock. Unfortunately, this was not good in Rubavu whereby people saw cell offices, coffee processing plant, and playgrounds collapsing due to Sebeya river flooding.

To effectively address the effects of floods/landslides, victims had to find solutions among themselves and they have thought about grouping themselves into tontines, churches' affiliates had to help one another and even the civil society, local and international organizations were

bringing the required emergency support which help them to continue enjoy life despite their owns collapsing. In addition to the population own initiatives, there was of course the government support mainly from the Ministry of MIDIMAR in terms of foods, building materials such as metal sheets, relocating people from high risk area, seeds, EWS, Umuganda support, etc; and 26.24% have received government support to their optimal satisfaction. The quantitative survey found that half of them have supported each another through grouping themselves together for synergy to be able to address the effects of the shocks.

All the above dimensions would be qualified through their contribution towards psychosocial and health status of the victims. Qualitatively, some victims were hopeless when they saw all their properties even relatives being taken away by floods/landslides, but others kept embarking to normal productive work and then could effectively address the effects of the shock, which was much supported by quantitative survey whereby almost 60% have been to embark on their usual work without psychological affect. Many people have been to continue enjoy normal life as the health facilities are not far from their residence with health insurance to address the financial access to health services, few died and few were injured. Many could access improved water between 0-1 hour.

This is supporting qualitative findings which stated that social networks (social support) have recovered many victims from the effects of the shocks by helping in rebuilding/repairing their houses, digging holes to retain water, and the governance role was key here, because without the local administration coordination, we could not see this done, mainly through Umuganda. As public infrastructures were destroyed, it affected people as they could not channel/bring their crops to the market due to destruction of roads/bridges, etc.

7.2. Limitations of the study

The qualitative assessment of these communities was done in 2013-2014 and the quantitative assessment was done in end 2015. This probably brought in a recall bias and history bias since people have undergone many events; some might have forgotten what they experienced or would not be able to express it the way it should due to the time period between the two assessments.



As a cross-sectional study, we could not measure the behavioural change over time and this is crucial in terms of resilience capacity building. We could demonstrate associations, but could not identify cause-and-effect relationships. We have not been able to measure all variables necessary to estimate each dimension from the qualitative assessment theoretical framework. Due to financial limitations, this study was not able to collect information from many respondents to show the variability of variables across categories. The statistical generalizability of findings was limited to the populations participating in the study as the sample was not country representative.



CONCLUSION AND RECOMMENDATIONS

The analysis of determinants of the Musanze, Nyabihu and Rubavu districts' community resilience to floods/Landslides found that Musanze was the most resilient in infrastructure and health related resources, Rubavu the most resilient in psychosocial and natural resources/environmental protection; while all dimensions were almost equally distributed in Nyabihu district. To effectively strengthen these communities' resilience capacities, innovative solutions/strategies would be oriented towards strengthening the public infrastructure (roads, bridges, classrooms, etc) and wealth status of victims to make them resist any possible similar shock once it happens again.

A further study with a big sample would give the best snapshot of the resilience situation in these districts. The same assessment in other districts prone to climate change shocks, such as Rutsiro which is more susceptible to lightning, Gakenke which is prone to landslides; would also allow the Government of Rwanda and partners implement resilience strengthening solutions at the same time to avert many losses of human lives and properties which the country is even currently experiencing.



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