REPUBLIC OF RWANDA

MINISTRY OF DISASTER MANAGEMENT AND REFUGEE AFFAIRS
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UNIT OF RESEARCH AND PUBLIC AWARENESS

DISASTER HIGH RISK ZONES ON FLOODS AND LANDSLIDES

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Contents

FOREWORD

Floods and Landslides have been amongst the major disasters in Rwanda and have had a great impact on human development, properties, infrastructures as well as environment. There are no available detailed studies on the effects of these hazards in Rwanda and that is the rationale to conduct a countrywide survey identifying high risk zones to both floods and landslides.

The primary objective of this document is to display all areas in Rwanda, prone to floods and landslides. Through the risk management process, hazard identification comes in the first stage since it provides definite information on the nature and characteristics of the hazardous event in the community.

Activities to prevent and mitigate floods and landslide will focus on all identified areas with collaboration of relevant stakeholders to reduce disaster risks. It has been thoroughly observed that triggering factors such as heavy rains, climate change, building in prone areas, steep slopes, soil instability and many others play a major role.

The Natural hazards by themselves do not cause disasters. It is the combination of an exposed, vulnerable and unwell prepared population or community with a hazard event that results in a disaster. In fact, disasters undermine development achievements, impoverishing people, nations and states. In the absence of combined efforts to address root causes, disasters represent an increasingly serious obstacle to the achievement of the Millennium Development Goals.

In Rwanda, different areas are prone to floods and landslides and this is due to various aspects such as geo-aspects, land-use type and others. Therefore, the priority of identifying all disaster risk zones on floods and landslides is paramount. The information provided in this document will inform all prone areas, with the ultimate aim to reduce floods and landslides risks.

EXECUTIVE SUMMARY

Disaster risk management as an issue at stake worldwide shifts its emphases from post disaster to pre-disaster phases. Management activities required in pre-disaster phases, such as risk assessment, hazard identification, preparedness or preventive measures needs detailed information about hazard characteristics, social, economic, structural vulnerability and capacity. That information is not usually available in many different countries, as is the case in Rwanda. Based on the international experiences and practices, knowledge of disaster prone areas can be assumed as an alternative for detailed information acquisition, thus contributing to effective disaster risk management.

Identification of disaster higher risk zones on floods and landslides, can lead to better understanding of disaster risk and putting in place measures for risk reduction. Consequently, as Rwanda is prone to a wide range of natural hazards with lack of adequate information that is essential for effective disaster risk management, due to limited scientific researches. This study aims therefore to address that gap.

The results revealed that some areas of the North-Western part of Rwanda are highly prone to floods and landslides, namely Burera, Musanze, Nyabihu, and Rubavu Districts. This is aggravated by some triggering factors such as steep slopes, soil instability, heavy rains, low level of drainage system, land-use type, land tenure type and others (customary land tenure type). Intensity and frequency of disaster events vary from region to region (Sector to Sector) and this geographical dispersal confirms the non-spatial clustering of risks due to uneven level of vulnerabilities whereby lack of normal distribution of hazards all over Districts and Sectors.

Conclusively, disasters vary in time and space due to a combination of triggering factors and this goes hand in hand with induced effects.

CHAP. I GENERAL INTRODUCTION

1.1. RESEARCH BACKGROUND

The frequency, intensity and impact of natural hazard events are growing and causing more disasters with negative impacts on humans, economy and environment. Many areas in the world are prone to one or several natural hazards. Hazard events result in disasters when risk factors such as hazard, vulnerability and inadequate capacity (coping capacities) overlaps in space and time. Avoiding or reducing the impact of disasters can be reached by reducing the Disaster risks. Consequently, focusing on Disaster Risk Reduction is an issue at stake worldwide (*UN/ISDR, 2005*). DRR is linked to sustainable development as both are linked to problems related to the same issues like environmental protection, economic growth and social equity (*Encyclopedia of sustainable development, 2001).*

Natural hazards by themselves do not cause disasters. It is the combination of an exposed, vulnerable and ill prepared population or community with a hazard event that results in a disaster. Disasters undermine development achievements, impoverishing people and nations and states. In the absence of combined efforts to address root causes, disasters represent an increasingly serious obstacle to the achievement of the Millennium Development Goals.

Rwanda is vulnerable to a range of disasters and emergency situations. Floods and landslide are key disasters that frequently affect localized areas of the country (*MIDIMAR, 2001*) and most of the affected people do not have efficient mechanisms to cope with natural hazards. In addition, the hilly topography and high annual precipitation rates with overexploitation of the natural environment such as deforestation, inappropriate farming and poor housing techniques accelerate the disaster risks and hence result into losses of lives and damages to property from the community exposed to these disaster risks.

Therefore, in Rwanda, most vulnerable areas prone to landslides and floods are located in the North-Western part namely Nyabihu, Rubavu, and Musanze, Burera, Gakenke, Ngororero and many others. This situation calls upon the Ministry of Disaster Management and Refugee (MIDIMAR) to conduct a scientific field study to identify the areas mostly prone to floods and landslides all over the country and this will contribute a lot in the process of sustainable management of disaster risks.

Based on Rwanda disaster profile, landslides as well as floods cause many losses of lives and property damages in localized hilly areas of the country. Furthermore, this happens in those areas depending on their geographical aspects. This is the main reason to identify all areas prone to floods and landslides for effective prevention, mitigation and preparedness planning mechanisms.

1.2. Disaster risk Context in Rwanda

Most of countries in Africa are regularly affected by severe and often multi-year disasters including landslides and floods. However, all areas within Africa are not equally vulnerable to these disasters. Rwanda, because f its geographical feature and climatic profile is one of the sub-Sahara African countries prone to disasters and especially localized landslides and floods. Many cases of disasters underlined in this research project, are particularly linked to the geographic characteristics, historical and socio-cultural aspects of the country. Rwanda experiences disaster cases resulting from natural hazard including flooding, landslides, strong winds, heavy rains and storms. The causes of vulnerabilities to disasters include geographic characteristics such as steep slopes and others.

At least 10 people have been killed and hundreds more displaced due to flooding after heavy rains in North-western of Rwanda in 2011, floods also destroyed around 354 houses in the Western Province and damaged about 3,000 hectares of farmland, forcing farmers to seek refuge on higher ground (*MIDIMAR Report, 2011*).

On 07th May 2011, around 14 people lost lives due to a heavy landslide that stroke the steep slope in Gakoro cell, Rugera Sector of Nyabihu District in the Western Province (*MIDIMAR report, May 2011*). In November 2011, Torrential rains caused flooding and landslides which affected community and livelihoods in two Sectors of Burera District including Kinyababa and Burera and huge losses were basically composed of human lives and enormous agricultural farms collapsed. For all these emergencies, MIDIMAR and partners responded with relief items to assist victims and the cost of interventions in these events were estimated to eleven Million Rwanda francs (MIDIMAR Reports, 2011).

Within a period of ten months (Dec/2010-Sept 2011), disasters produced a complex web of impacts, which spans various sectors of the economy. During this same period, Rwanda registered 43 losses of lives and 73 people were injured. Besides, 1854 houses were destroyed,

2, 989, 9 Ha of crops were damaged and one hundred (100) school classrooms were seriously destroyed. As a result, the cost of the intervention activities in terms of disaster response and recovery to assist the victims was more than 515,520,000 Rwandan francs (*MIDIMAR reports, May -September 2011*). Above mentioned reasons is the justification to conduct a scientific study so as to identify all areas mostly affected by floods and landslides in Rwanda.

1.3. Glossary of key terms

1.3.1. Floods

A flood is a great flowing or overflowing of water onto land that is not usually submerged. A flood happens when too much rain, brought by storms and strong winds, falls and cannot be absorbed by the soil. Rivers burst their banks and the water spills onto the land. Strong winds blowing across the sea make huge waves that surge onto the land and flood coastal areas. (*Encyclopedia of natural disasters*).

1.3.1.1. Types of Floods

River Floods: Rivers floods happen when rivers and streams cannot carry away all the extra water that falls as rain or comes from melting snow. The water rises in the rivers and streams and overflows onto normally dry land. Floods destroy farmland, wash away people's houses and drown people and animals. Towns and cities are flooded too.

Flash floods: A flash flood is a quick flood caused by a sudden cloud burst or thunder storm. Huge amounts of water fall in a short time and in cities and towns the drains overflow and roads become flooded. Flash floods also happen in mountainous areas, where steep slopes cause the water to travel at high speeds. The rushing water erodes the soil, washing it away down the slopes. Flash floods often occur rapidly and with little warning.

Coastal flooding: Can be caused by strong winds blowing waves onto the land. Hurricanes and major storms produce most coastal floods. Very high tides and tsunamis also flood the coasts. In many countries, large groups of people live along the coasts and for these people coastal flooding can be very serious. Thousands of people have been drowned in coastal flooding in many parts of the world.

1.3.2. Landslide

The term' landslide' includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along of separation by falling, sliding and flowing, either slowly or quickly from one place to another (*Fabio Vittorio De Blasio, 2008*) .

Landslides are various types of gravitational mass movements of the Earth's surface that pose the Earth-system risk; they are triggered by earthquakes, rainfall, volcanic eruptions and human activities. Landslides cause many deaths and injuries and great economic loss to society by destroying buildings, roads, life lines and other infrastructures; they also pose irrecoverable damage to our cultural and natural heritage. Landslide disaster reduction requires cooperation of a wide variety of natural, social, and cultural sciences (*Kyoji Sassa et.al. 2005*).

1.3.2.1. Types of landslides

Many types of mass movement are included in the general term "landslide." The two major types of landslides are rotational slides and translational landslides.

Rotational landslide: The surface of rupture is curved concavely upward (spoon shaped), and the slide movement is more or less rotational. A slump is an example of a small rotational landslide.

Translational landslide: The mass of soil and rock moves out or down and outward with little rotational movement or backward tilting. Translational landslide material may range from loose, unconsolidated soils to extensive slabs of rock and may progress over great distances under certain conditions.

Topple: A block of rock that tilts or rotates forward and falls, bounces, or rolls down the slope. *(http://landslides.usgs.gov/learningeducation/majorls)*

1.3.3. Climate change

For most people, the expression "climate change" means the alteration of the world's climate that we humans are causing, through fossil fuel burning, clearing forests and other practices that increase the concentration of greenhouse gases (GHG) in the atmosphere. This is in line with the official definition by the United Nations Framework Convention on Climate Change (UNFCCC) that climate change is the change that can be attributed "*directly or indirectly to*

human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

1.3.4. Disaster

A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk *(ISDR, 2007)*

1.3.5. Disaster Risk Reduction

The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) adverse impact of hazards, within the broad context of sustainable development (*ISDR, 2007*).

1.3.6. Disaster prone areas

A disaster area is a region or a local frequently damaged by either natural hazards, such as landslides, floods, heavy rain, tornadoes, hurricanes, tsunamis,earthquakes, technological hazards including nuclear and radiation accidents, or sociological hazards like riots, terrorism or war. The population living there often experiences frequently a loss of energy supply, food, services, and an increasing risk of disease. Declarations of disaster prone areas open up the affected areas for national or international aid.

1.3.7. Hazard

A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation (*ISDR, 2007*). This can include latent conditions that may represent future threats and can have different origins: natural (geological, hydro-meteorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency and probability.

1.3.8. Preparedness

The capacities and knowledge developed by governments, professional response organizations, communities and individuals to anticipate and respond effectively to the impact of likely, imminent or current hazard events or conditions.

1.3.9. Resilience

The capacity to absorb stress or destructive forces through resistance or adaptation; to manage or maintain certain basic functions and structures during disastrous events; and to recover or 'bounce back' after an event (*John Twigg / DFID DRR Interagency Coordination Group, 2007*).

1.3.10. Risk

The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable conditions *(ISDR, 2007).*

Risk is often also expressed as the equation: Risk = (Hazard x Vulnerability)-Response Capacity (IASC 2007).

1.3.11. Vulnerability

The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards (*ISDR, 2007*).

Contingency planning: Contingency planning is a management tool used to analyze the impact of potential crises so that adequate and appropriate arrangements are made in advance to respond in a timely, effective and appropriate way to the needs of affected populations. Contingency planning is a tool to anticipate and solve problems that typically arise during a humanitarian response (*IASC, 2007*).

1.4. SIGNIFICANCE OF THE STUDY

For effective disaster management in Rwanda, hazard identification and risk assessment are core processes to be prioritized by the Ministry of Disaster Management. It is in the same line that a study was organized to identify all disaster prone areas on floods and landslides countrywide. As a solution, necessary collected information on hazards, vulnerability and capacity will be of paramount interest in disaster risk reduction.

1.5. EXPECTED OUTCOMES

1. To identify and map all areas prone to floods and landslides,
2. Increase knowledge on areas at risk in the country for effective Disaster Risk Reduction in Rwanda.
3. Create scientifically driven explanations on the main causes of vulnerability caused by floods and landslides,
4. Help the local community to understand the natural phenomena/hazards that they are exposed to and raise their awareness for disaster risk reduction.

1.6. RESEARCH OBJECTIVES

1.6.1. General Objective

The main objective of this research is to identify areas prone landslides and floods in Rwanda.

1.6.2. Specific objectives

The specific objectives for this research are as the following:

1. To collect and analyze reliable data on the various areas prone to mudslides /landslides and come up with concrete information on possible causes that may lead to loss of lives, injuries and damage to property,
2. To assess the likelihood and potential impact of floods and landslides in order to reduce the number of deaths and damages caused by these kinds of hazards,
3. To produce a list of areas prone to floods and landslides r including the key causes.
4. To produce the maps of areas hit by floods and landslides in Rwanda.

CHAP II. RESEARCH METHODOLOGY

The research on identifying areas prone to landslides and floods was carried out using mainly perceptions of hazards by local authorities/local population and local authorities, intensity and frequency of floods/landslides coupled with caused damages and triggering factors. Thus, methodology combined: literature review, field observations, interviews, questionnaires and spatial techniques (GPS /GIS tools) to collect data.

Table 1. Field visits were organized and conducted as follows (For Primary and Secondary data collection)

PROVINCE	DISTRICTS	PROVINCE	DISTRICTS
Northern Province	Musanze Burera Gakenke Rulindo Gicumbi	**Eastern Province**	Bugesera Gatsibo Kayonza Kirehe Ngoma Nyagatare Rwagamana
PROVINCE	**DISTRICTS**	**PROVINCE**	**DISTRICTS**
Western Province	Rusizi Nyamasheke Rutsiro Karongi Ngorero Nyabihu Rubavu	**Southern Province**	Gisagara Huye Kamonyi Muhanga Nyamagabe Nyanza Nyaruguru Ruhango
City of Kigali	Gasabo Kicukiro Nyarugenge		

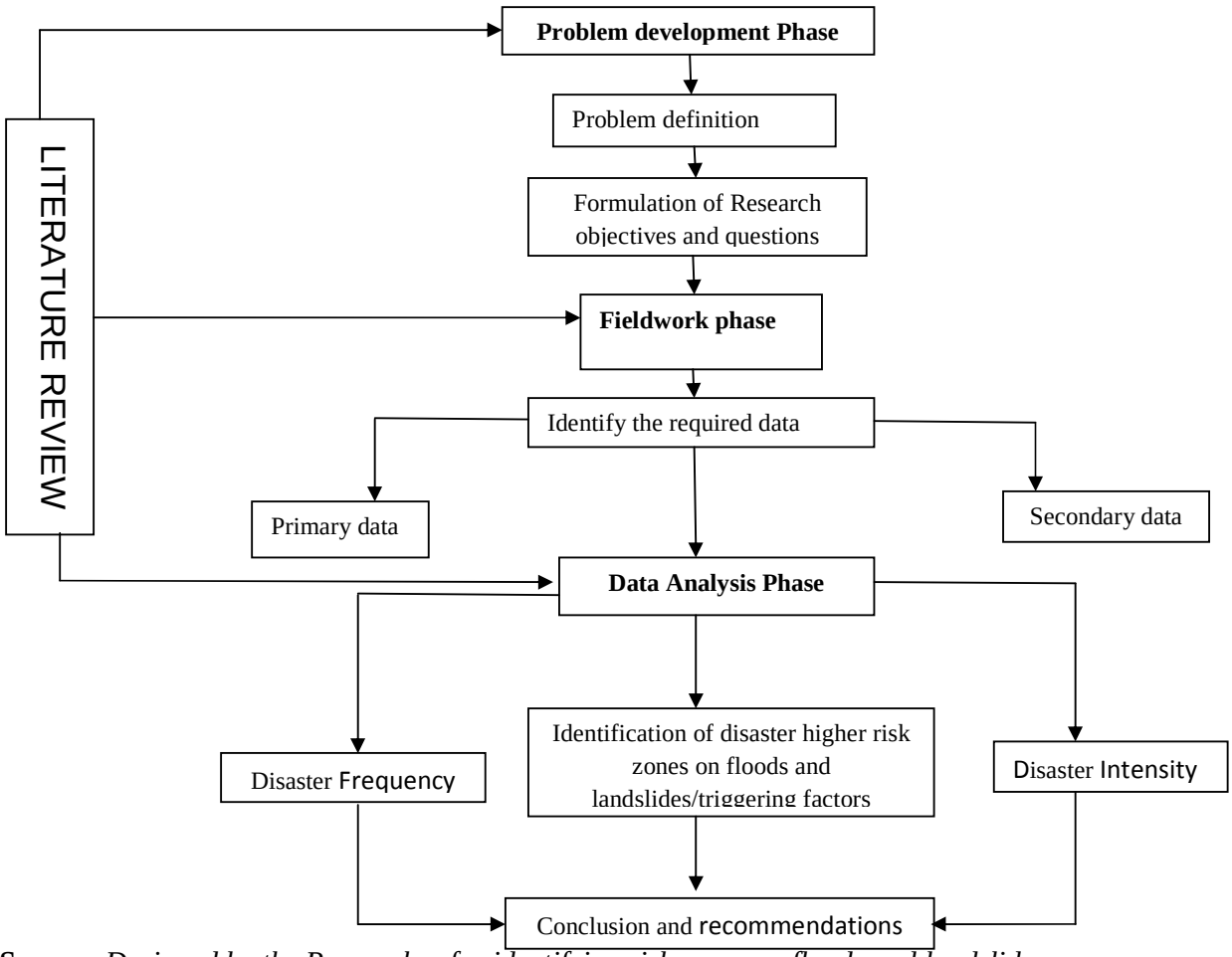
Source*: Designed by the Researcher for data collection, October- November 2011*

2.1. Research Design

The research is initiated with a literature review in relation to the objective. The review is carried out with the purpose of establishing a theoretical framework to more fully understand the concept of floods, landslides and the principles and criteria used to assess the vulnerability in the prone areas. Phase one is the development of the research proposal which includes the

formulation of research objectives and associated research questions. The pre-field work phase focused on developing criteria for identifying prone areas on floods and landslides. In the third phase, the data collected in the prone areas were analyzed against the intended goals. The process of the research approach is illustrated in the following figure.

Fig.1: **Research design for identification of disaster high risk zones**



Source*: Designed by the Researcher for identifying risk zones on floods and landslides*

CHAP. III DATA ANALYSIS

3.1. Hazard Identification

Hazards identification provides specific information on the nature and characteristics of the hazardous event and the community. It further examines an event's potential for causing injury to life or damage to property and the environment. Hazard identification takes advantage of the use of environmental modeling to characterize hazards and disaster impacts (*John C. Pine, 2009*).

3.2. Hazard identification Process

Hazard identification involves the process of describing the hazard in its local context and provides a description and historical background of potential environmental hazards that could impact the community. This process results in a clarification of the magnitude of a hazard that may pose a threat to the human, built, or natural environments. Comprehensive historic data on all hazards are critical in understanding what hazards have impacted a community in the past and their likelihood for the future. The hazard identification process thus includes an examination of past disasters and the potential for future disasters within the community. It is stressed that even an insignificant hazard could trigger a much larger secondary hazard. It should be noted that hazards are part of our lives and all communities face hazards of many types (*Smith, 2004*).

Our capacity to minimize adverse effects of disasters depends on our human adaptation to natural events, including our building codes, land use regulation, and the design of our critical infrastructure. Our resiliency or capacity to withstand or to recover from a disaster is influenced by human adaptive actions.

Therefore, we must examine our natural, human, economic and constructed systems to fully understand what actions may be taken to reduce our vulnerability and enhance our resilience to natural hazards. Fundamental to this process is an identification of the hazards that face our communities and organizations. Hazard identification clarifies natural and human-caused events that threaten a community. This process results in information that reveals a community's capacity to deal with a disaster. It provides an opportunity to identify the physical characteristics of buildings, the social characteristics of community and local response capabilities. Hazard identification may be directly used in preparedness activities by

clarifying hazard zones for response, but Doyle et al. (*1998*) note that it can be used for establishing setbacks and zoning classifications. The comprehensive identification of hazards can support hazard risk management policies and programs and determine benefits of alternative policies to reduce the vulnerability.

Figure 2.Floods and landslides per District (in terms of affected sectors)

Source: Field visits conducted by RPA/MIDIMAR, November 2011

According to the figure above, some Districts are highly prone to floods and landslides than others. This is due to many different reasons such geo-aspects, soil type and other triggering factors etc. Most affected Districts are Burera, Rubavu, Gicumbi, Nyabihu, Ngororero, Musanze, Rutsiro, Nyamagabe, Muhanga, Kamonyi and Bugesera and this is exacerbated by high level of vulnerability and exposure. For other Districts, the level of vulnerability is not very high.

It is obvious that floods and landslides are increasing due to different triggering factors. Except natural triggering factors such as heavy rains, deforestation, land use change, climate

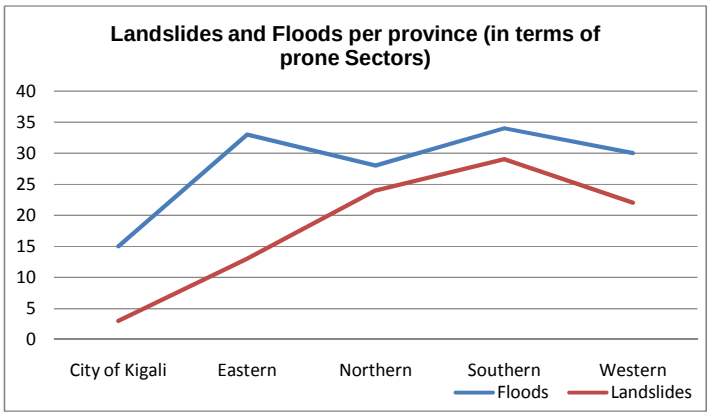
change, etc, researchers also give anthropogenic triggering factors. The main anthropogenic factor is land use change. So, the combination of natural and anthropogenic factors increases the trends in floods and landslides hazards all over the world.

Table 2: Floods and landslides per District in Rwanda (2010-2011)

District	Floods (Number of affected sectors)	Landslides (Number of affected Sectors)
Rulindo	5	5
Bugesera	12	0
Burera	6	6
Gakenke	4	6
Gasabo	7	0
Gatsibo	2	0
Gicumbi	6	6
Gisagara	5	0
Huye	4	2
Kamonyi	7	7
Karongi	5	4
Kayonza	7	4
Kicukiro	4	0
Kirehe	4	2
Muhanga	5	5
Musanze	7	1
Ngoma	3	4
Ngororero	5	7
Nyabihu	6	4
Nyagatare	2	0
Nyamagabe	5	7
Nyamasheke	0	1
Nyanza	1	2
Nyarugenge	4	3
Nyaruguru	4	5
Rubavu	5	2
Ruhango	3	1
Rusizi	1	2
Rutsiro	8	2
Rwamagana	3	3

Designed by the Researcher, from data analysis (SPSS)

Figure 2: Floods and landslides per Province

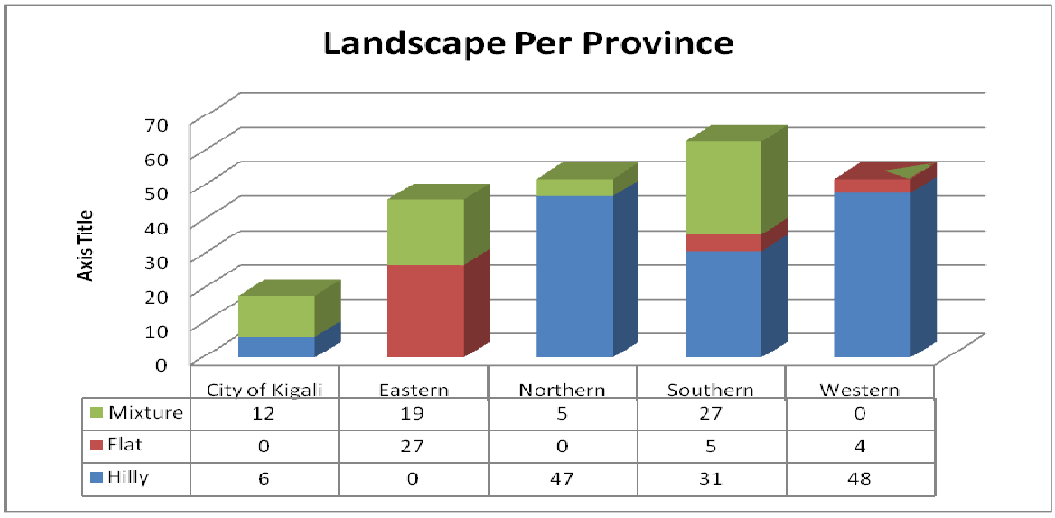


Province	Floods	Landslides
City of Kigali	15	3
Eastern	33	13
Northern	28	24
Southern	34	29
Western	30	22

Source: MIDIMAR Survey 2011

For some Provinces, the level of exposure differs from floods to landslides. In general, flooding areas are many comparing to landslides affected zones. For the Eastern province, the level of being prone to floods was increased by Bugesera District, whereby almost all sectors are regularly flooding due to Nyabarongo River. In fact, even though some Provinces are highly prone to floods and landslides, the vulnerability differs from area to another due to many different factors

Figure 4. Landscape type per Province



Source: *Data Analyis, MIDIMAR/RPA, 2011*

Landscape as a natural aspect, differs from region to region. For Rwanda, some areas are hilly; others flat like the Eastern province but majority of the country regions are dominated by mixed landscape. Landslides are likely to happen in hilly topography whilst floods happen in low elevated lands.

The best predictor of future floods and landslides is past floods and landslides, because they tend to occur in the same places (*FEMA, 2001*). However, caution should be used because of the complexity of geotechnical factors that determine flood and landslide risk. Prediction requires the expertise of geologists and engineers, who must conduct surveys of soil conditions, slopes, drainage, climate, prevalence of earthquakes and volcanic eruptions, flora cover, erosion, industry-induced vibrations, construction, and other alterations to terrain, among many other factors. The primary elements that help understand landslides include (1) areas that appear to have failed due to landslides, including debris flows and cut-and-fill failures; (2) areas that have the potential for landslides, by correlating some of the principal factors that contribute to landslides, steep slopes, geologic units that lose strength when saturated and poorly drained rock or soil with the past distribution of landslides; and (3) areas where landslides have occurred in the past, are likely to occur now, and could occur in the future.

***Source**: Picture taken in Nyabihu/ Flooding areas, 2011.*

***Source**: Picture taken in Nyabihu District (flooding area), 2011*

The pictures above show different areas damaged by flooding in Nyabihu District. The situation shows that not only the loss of infrastructure, facilities, etc.; but also other related issues can occur. For example, when there is a destruction of an education facility; pupils may stop to study or may continue their studies but in very bad conditions (exposed to the sun or rain); if it is during the rainy season, pupils will have to study fewer hours than usual, so that they are discouraged; hence reducing the quality of education. In addition, this destructed facility will need to be reconstructed or rehabilitated; therefore, too much expenditure is mobilized from the Government instead of investing in other development activities. The following chart illustrates the problem analysis with logical framework approach.

3.3. Characteristics of the sample population (Districts)

The availability of similarities and discordance in the physical structures of various locations visited including mountainous or hilly , steep slopes, types of soil dictates the types of disasters such as flash flooding and river flooding or landslide cases that may occur in these different District areas. The various causes of flooding in all of thirty (30) Districts of the country lies predominantly on climate change which result into heavy rain with storms and impact on river and flash flooding through overflowing of various streams passing through different districts .

The analysis from the Table below, reveals that Districts are affected by river flooding as well as flash flooding and threatening river from the top to the bottom are as follows,

i. River flooding (2010-2011)

N0	Districts	Number of affected sectors	Threatening river	Triggering factor
1.	Bugesera	12	Nyabarongo river	Heavy rain and low drainage system
2.	Rutsiro	8	Nyabarongo river and its affluent	Heavy rain
3.	Gasabo	7	Nyabugogo river	Heavy rain and low drainage system
4.	Musanze	7	Base, Mukungwa rivers	Heavy rain and low drainage system
4.	Muhanga	5	Nyabarongo river	Heavy rain
5.	Kamonyi	5	Nyabarongo river	Heavy rain
6.	Gisagara	5	Akanyaru river	Heavy rain and low drainage system
7.	Nyamagabe	5	Mwogo, Sebeya and Mbirurume rivers (Nyabarongo tributaries)	Heavy rain and low drainage system
8.	Nyaruguru	4	Mwogo, Sebeya and Mbirurume rivers (Nyabarongo tributaries)	Heavy rain and low drainage system
9.	Kicukiro (Masaka swamp area)	4	Nyabarongo river	Heavy rain and low drainage system
10.	Kirehe	4	Akagera river	Heavy rain and low drainage system

ii. Flash flooding& river flooding

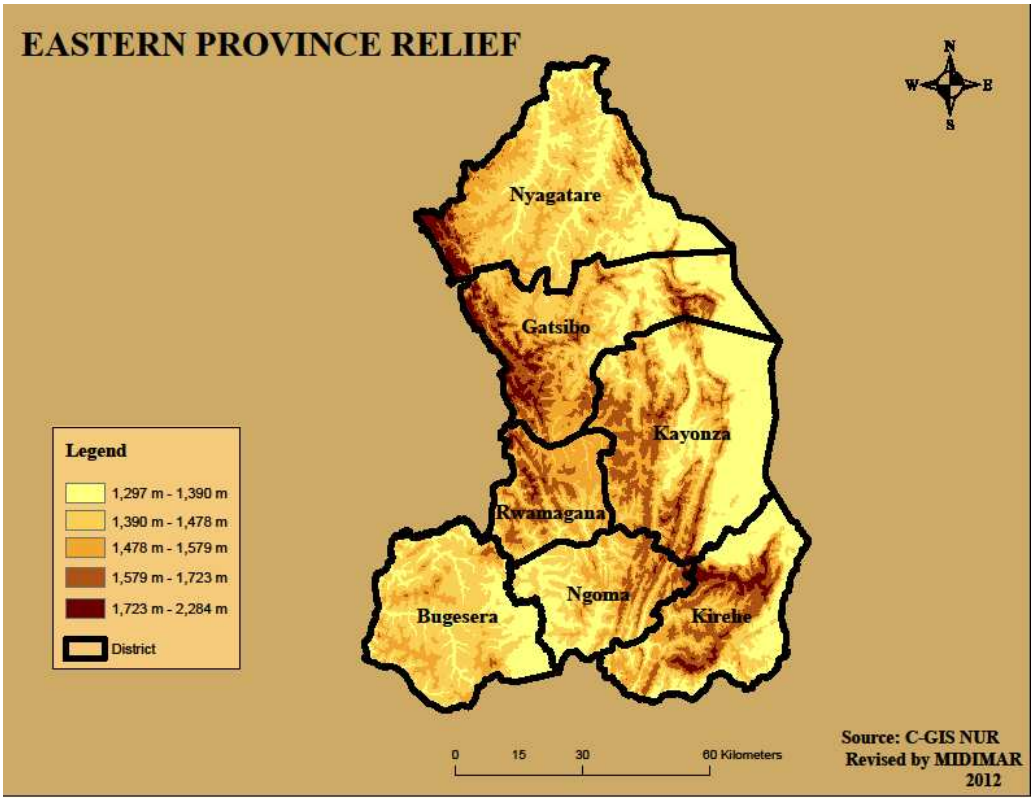
N0	Districts	Flooding type	Triggering factor	Intensity
1.	Rulindo	Flash	Heavy rain and steep slopes	High
2.	Nyabihu	Both	Heavy rain which overlap various streams in the area	High
3.	Nyamagabe	Both	Heavy rain which overlap various streams in the area	High
4.	Ngororero	Both	Heavy rain which overlap various streams in the area including Nyabarongo river	High
5.	Rubavu	Both	Heavy rain which overlap various streams in the area including Sebeya river	High

iii. Landslide cases and their prone areas

No.	Districts	Number of Landslide cases	Triggering factor	Damages
1.	Kamonyi, Ngororero, Nyamagabe.	7 cases to each District	Heavy rain, Illegal mining, steep slopes	Environmental degradation, loss of lives and farmlands collapse.
2.	Rulindo, Muhanga	5 cases	Heavy rain water, steep slopes,	Environmental degradation, loss of lives and farmlands collapse.
3.	Gicumbi	6cases	Heavy rain water, steep slopes	Environmental degradation, loss of lives and farmlands collapse
4.	Karongi, Nyabihu	4 cases	Heavy rain and steep slopes.	Environmental degradation, loss of lives and farmlands collapse

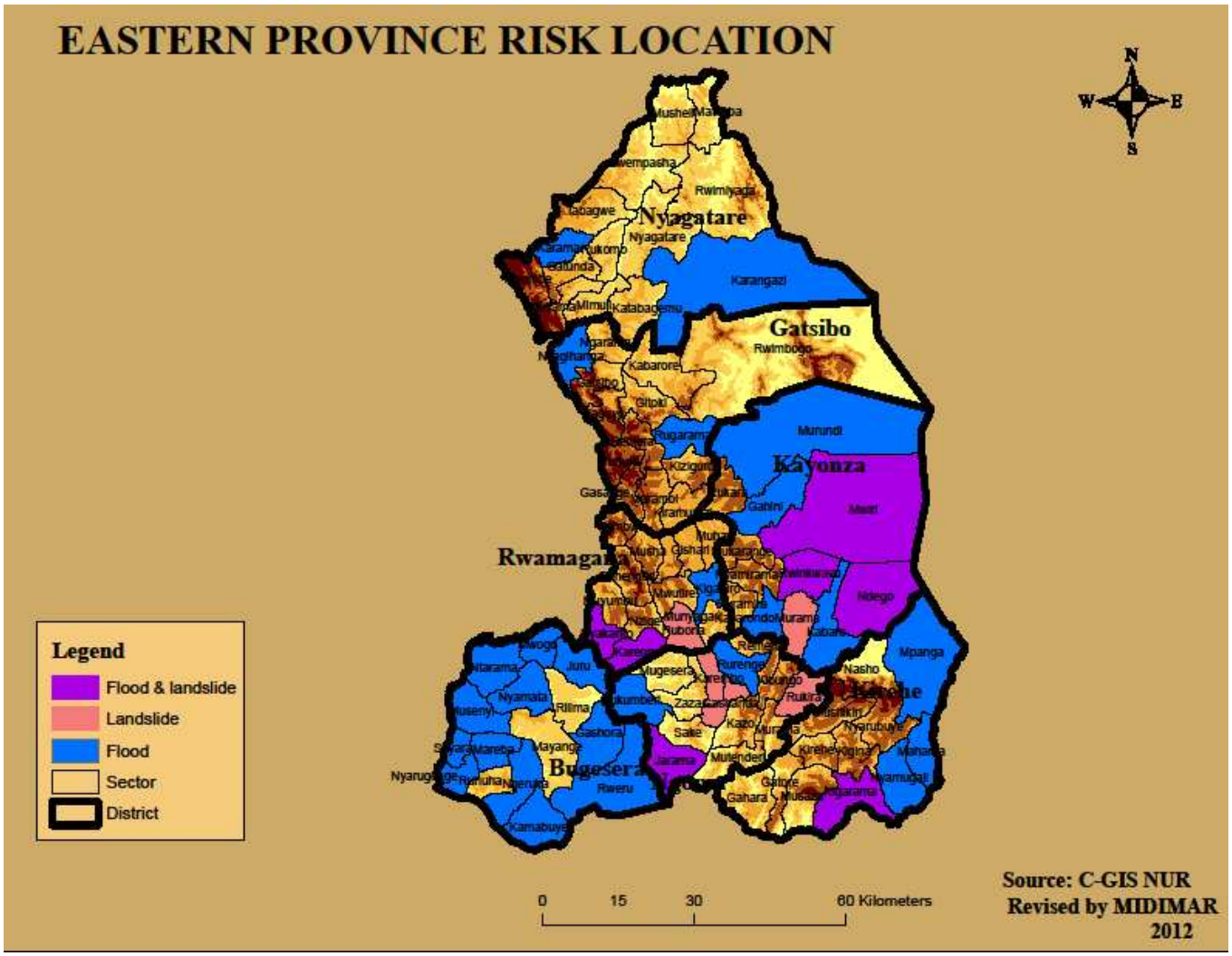
Source: Field survey, November 2011.

iv. Spatial representation of the areas Prone to Floods and Landslides per Province

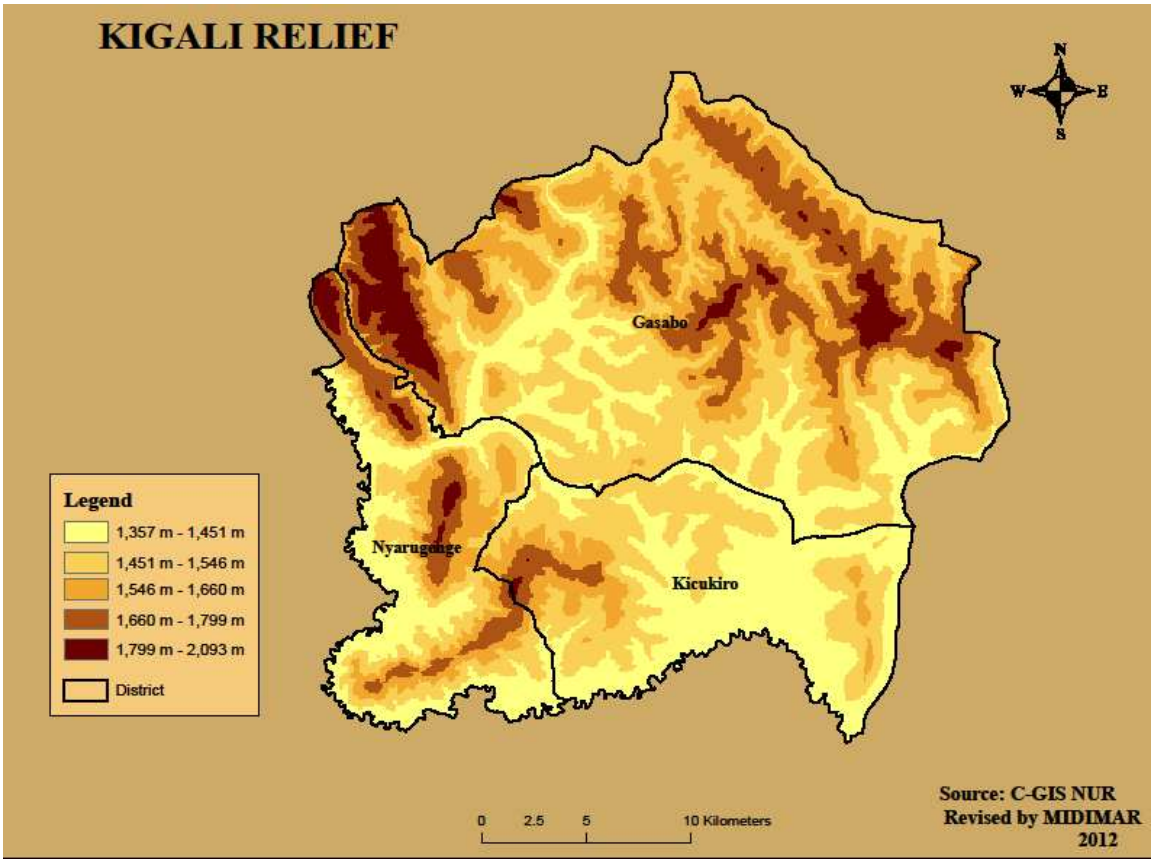


In order to localize the landslide prone areas GIS environment was used. Data in the form of thematic layers such as slope, soil and land use were input into GIS. Most of Districts in the Eastern Province have a relief between 1,297 and 1,390 m, and this stresses the flat landscape of the area.

Management of the landslides disasters can be successful only when detailed knowledge is obtained about the expected frequency, character and magnitude of the mass movement in an area. The zonation of landslide hazard must be the basis for any landslide mitigation strategy and should supply planners and decision-makers with adequate and understandable information.



Very few areas in the East are prone to flood and landslides but the level of vulnerability is too low as illustrated in the map.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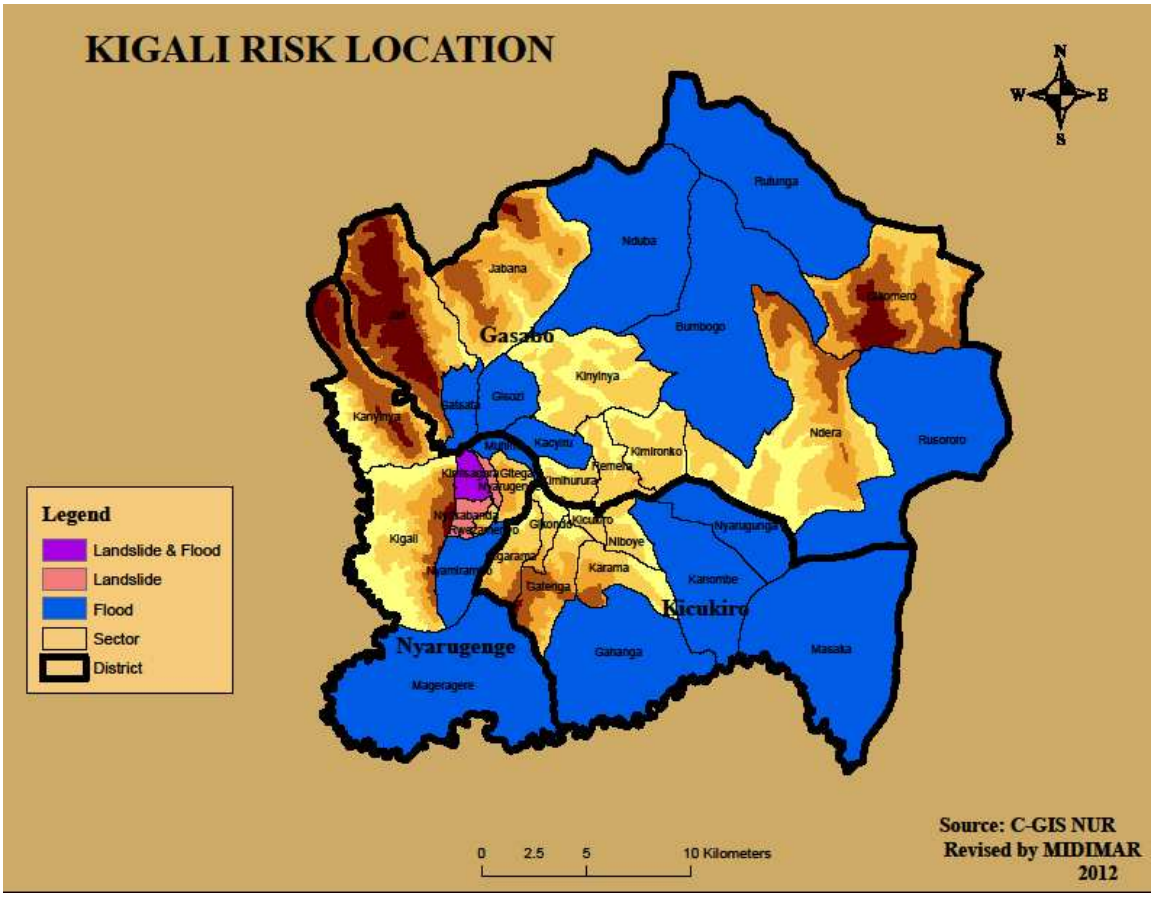
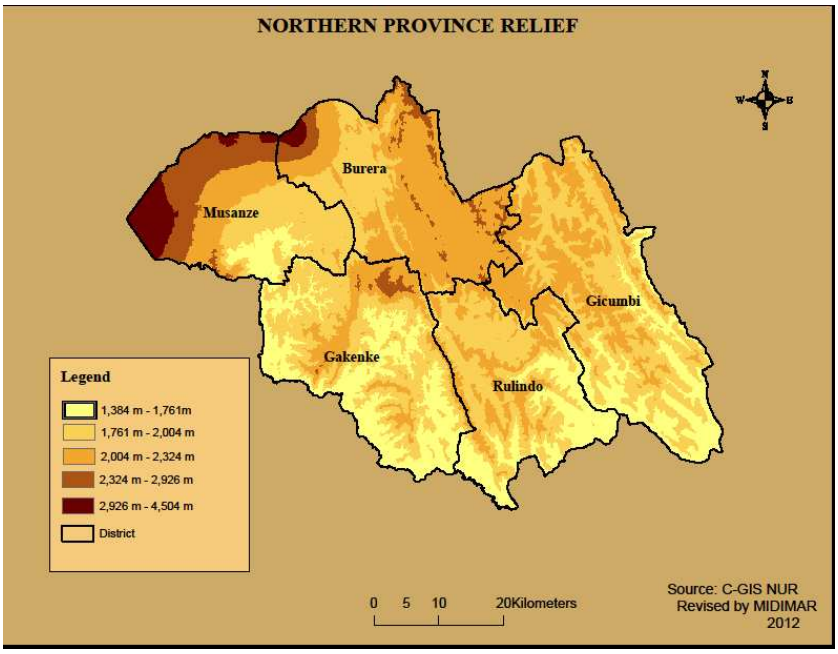
Source: C-GIS NUR
Revised by MIDIMAR
2012

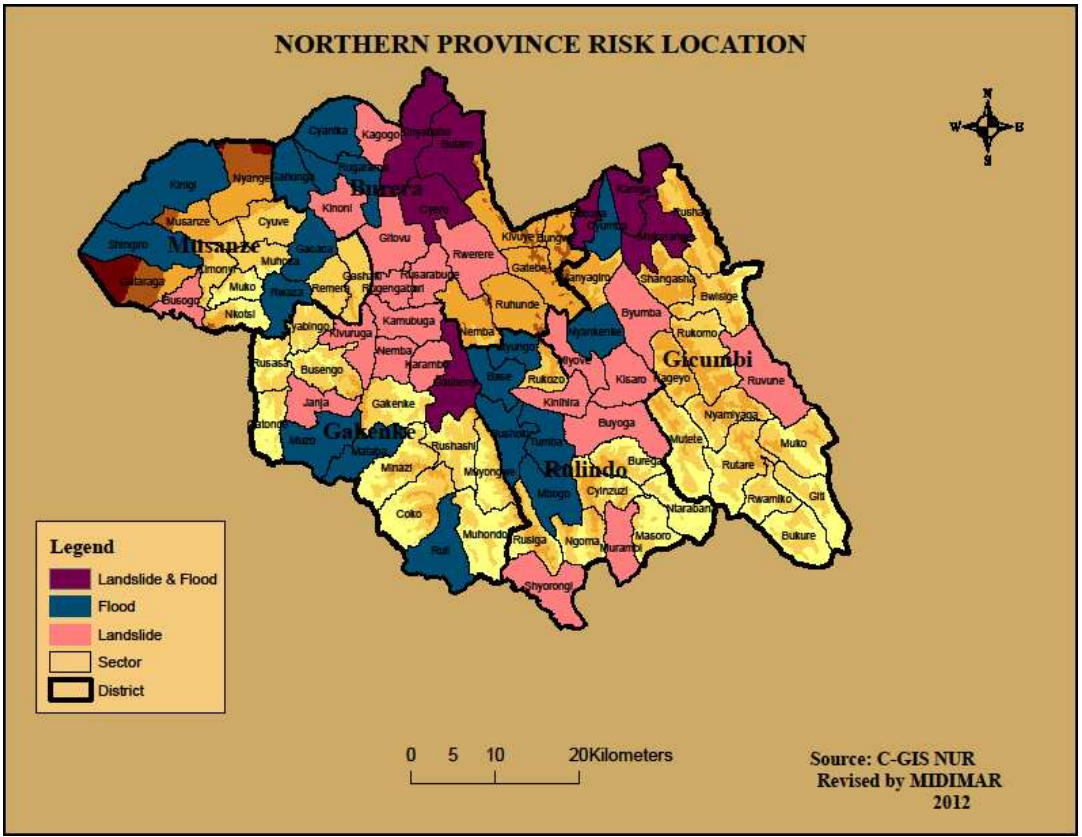

KIGALI RISK LOCATION
N
W
E
S
Rulinga
Nduba
Jabana
Bumbogo
Gasabo
Kinyinya
Gikomero
Gisozi
Kanyinya
Kacyiru
Kimironko
Remera
Kimihurura
Ndera
Rusororo
Kigali
Nyarugunga
Niboye
Karama
Kanombe
Kicukiro
Gatenga
Nyarugenge
Gahanga
Masaka
Mageragere
Legend
Landslide & Flood
Landslide
Flood
Sector
District
0 2.5 5 10 Kilometers
Source: C-GIS NUR
Revised by MIDIMAR
2012

In Kigali, some sectors like Jali, Rutunga, Gikomera, Nduba, Bumbogo and Jabana have an elevation between 1,799 and 2,093. It is possible to have Floods or landslides in the sectors. All depends on how much vulnerable the area is.



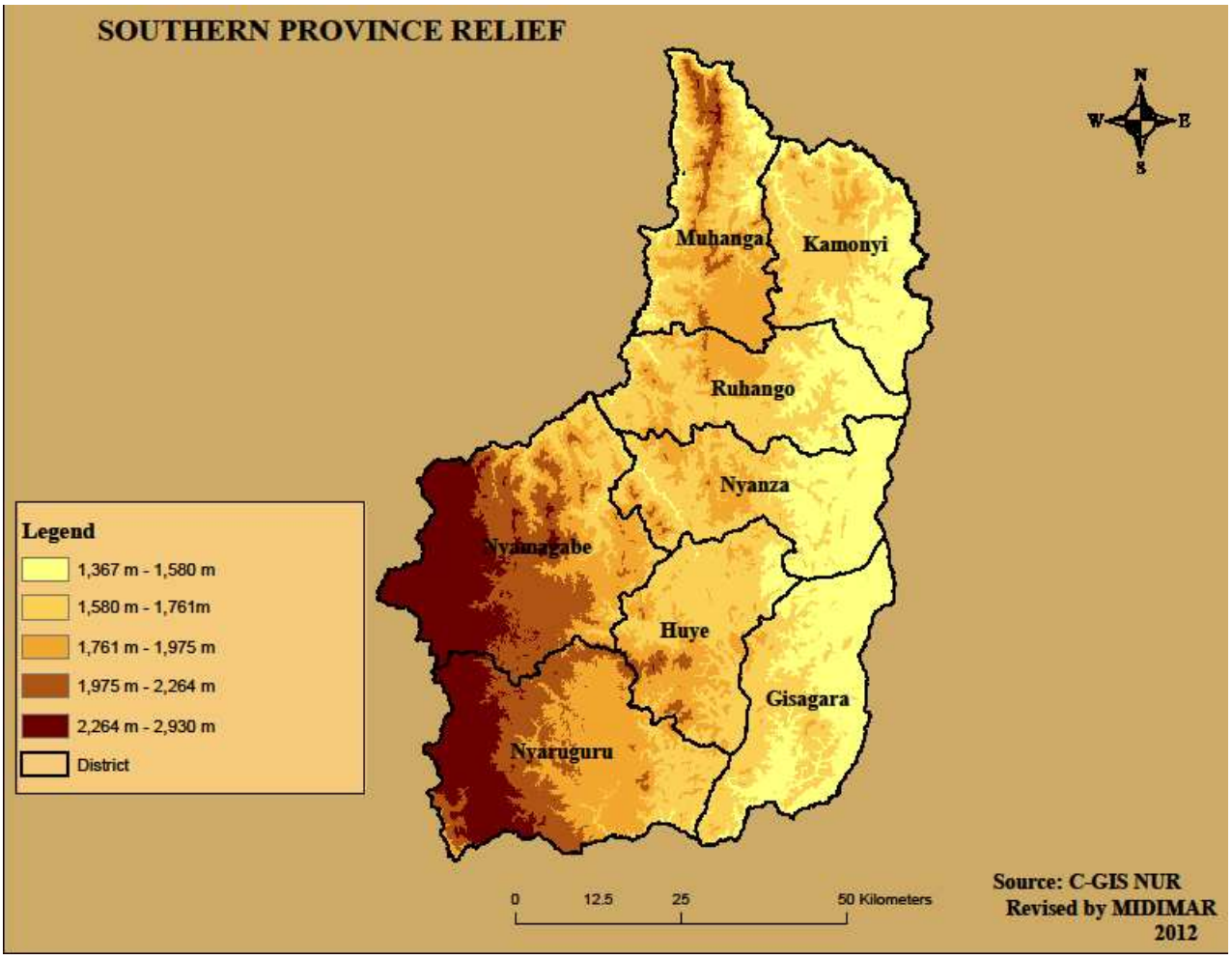
Source: *Designed by the Researcher, MIDIMAR 2011*

There is no reason to believe that the number of natural hazards will soon start to decrease, nor that we will witness a radical change in the vulnerability of societies. This means that the social causes of natural disasters will be even more obvious in the years to come, as the

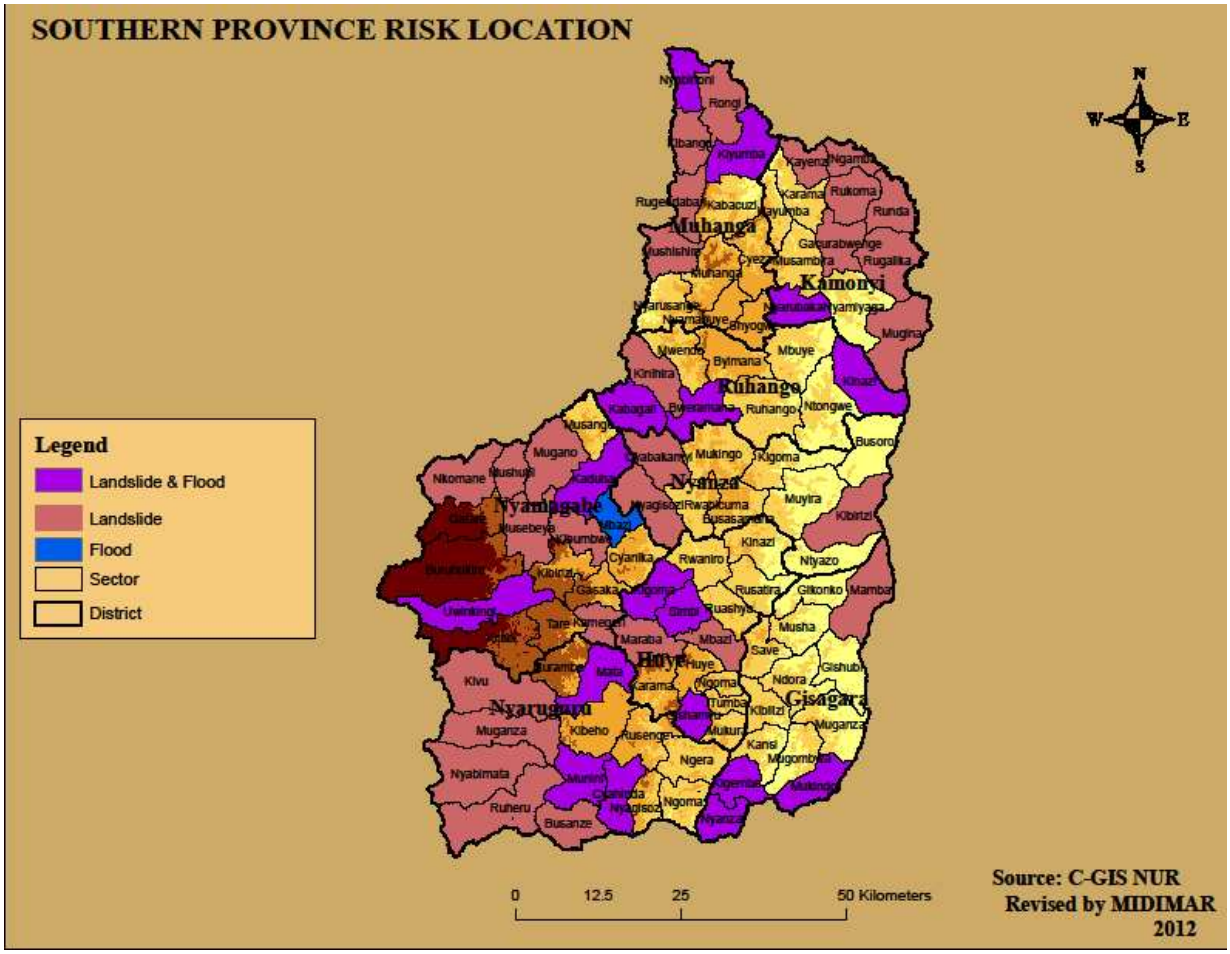


climate changes (*Henrik Svensen, 2006*).The Nothern province is characterized by a mixture of landscape which triggers the level of vulnerability to floods and landslides.

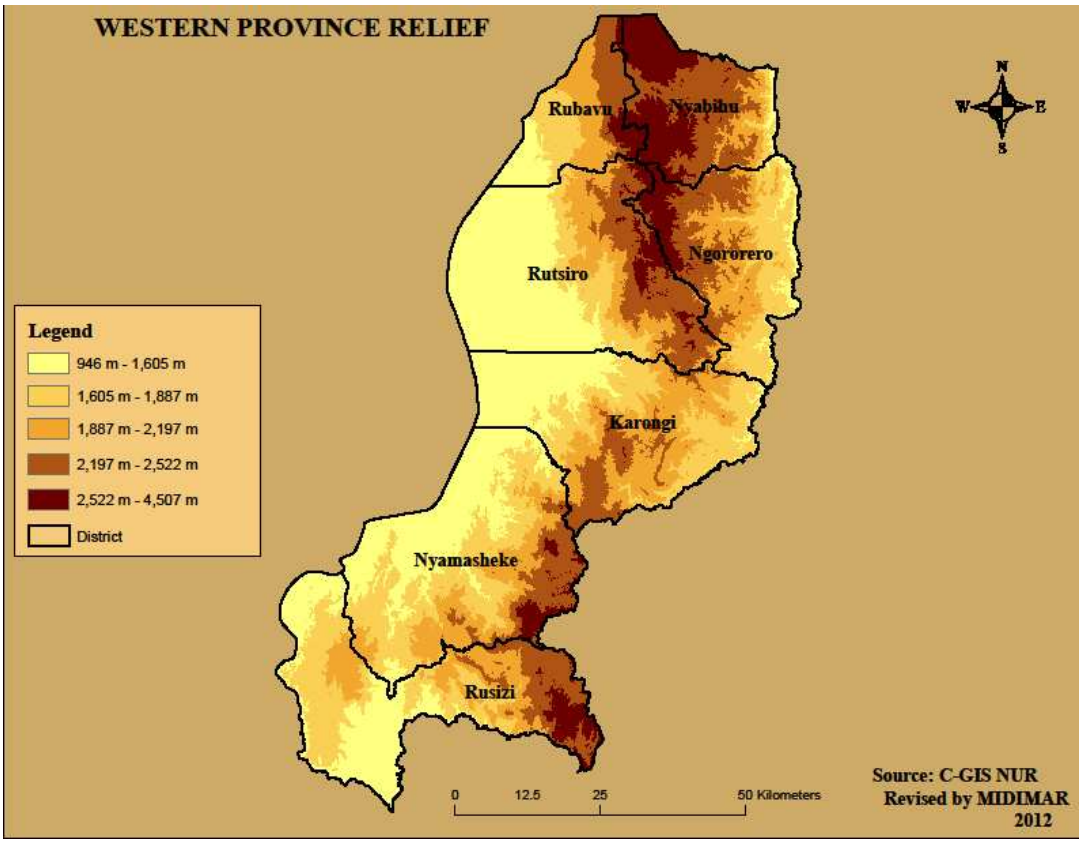
Landscape and Floods are major disasters known in the Nothern Province due to its geo-aspects. This area is very vulnerable and periodically, both disasters cause several damages. But all sectors are not hit at the same level.

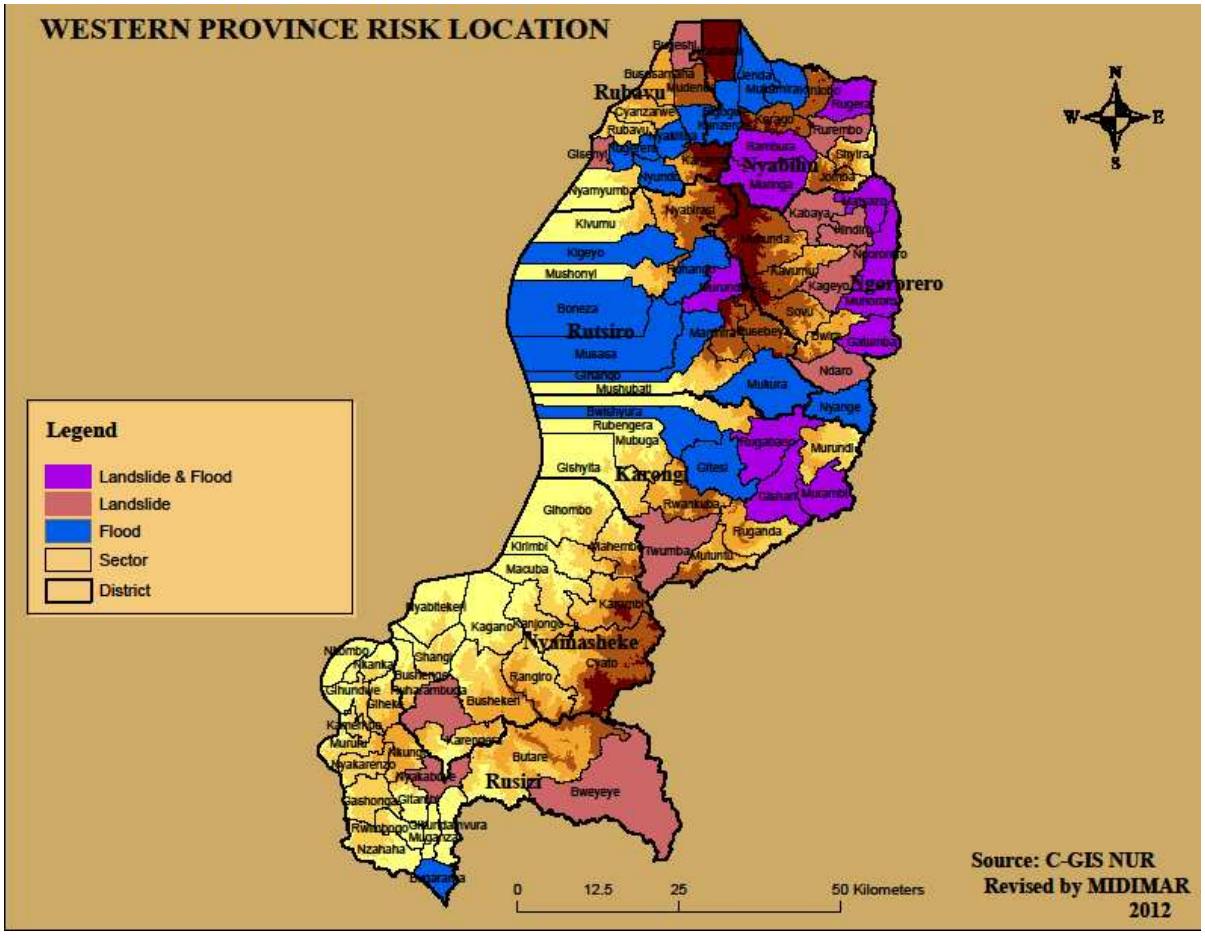


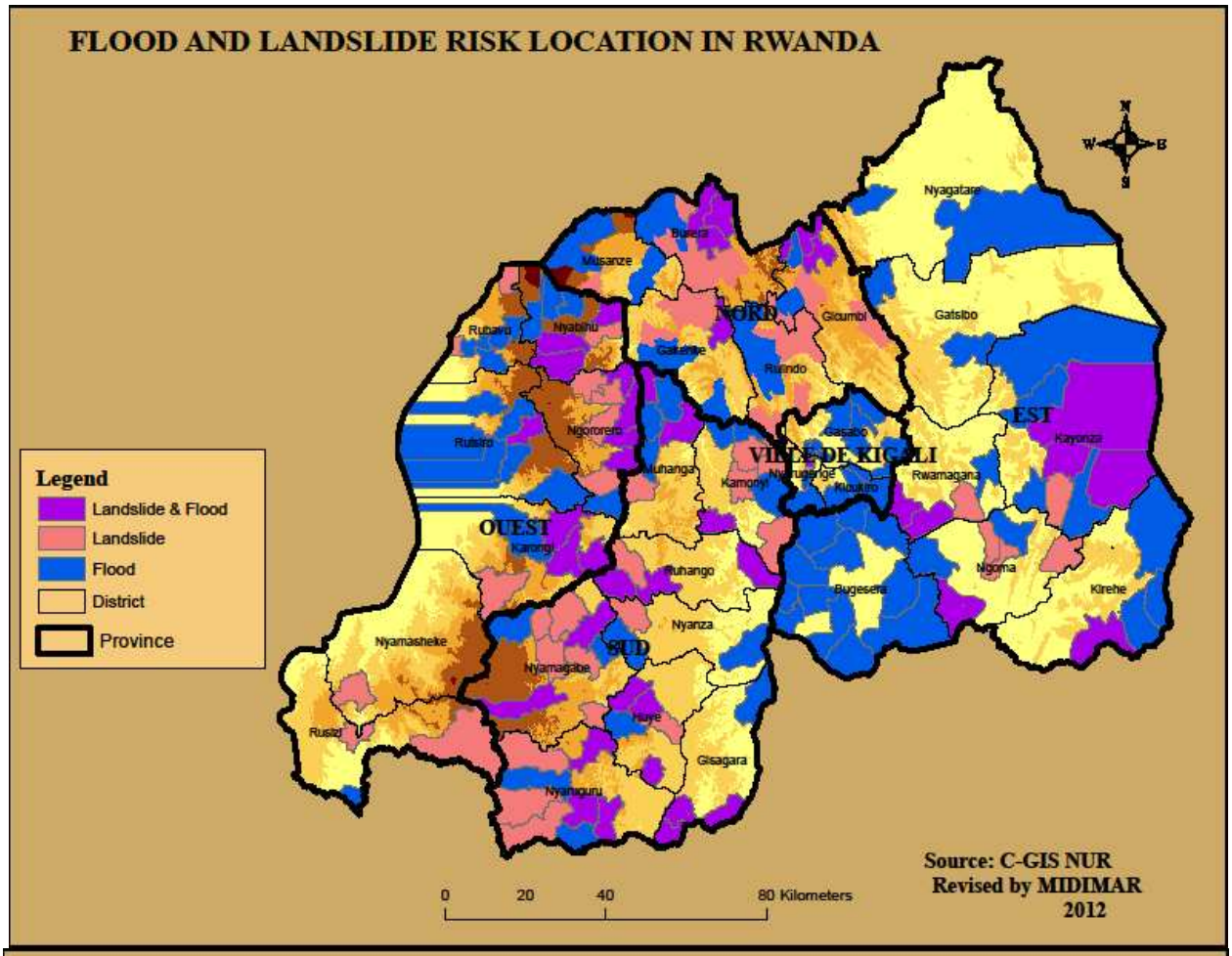
Different sectors of the Southern Province have been hit by floods and landslides though vulnerability level differs from Sector to Sector. The elevation varies from 1,367 m to 2,930 m which testifies how much vulnerable the Province is.

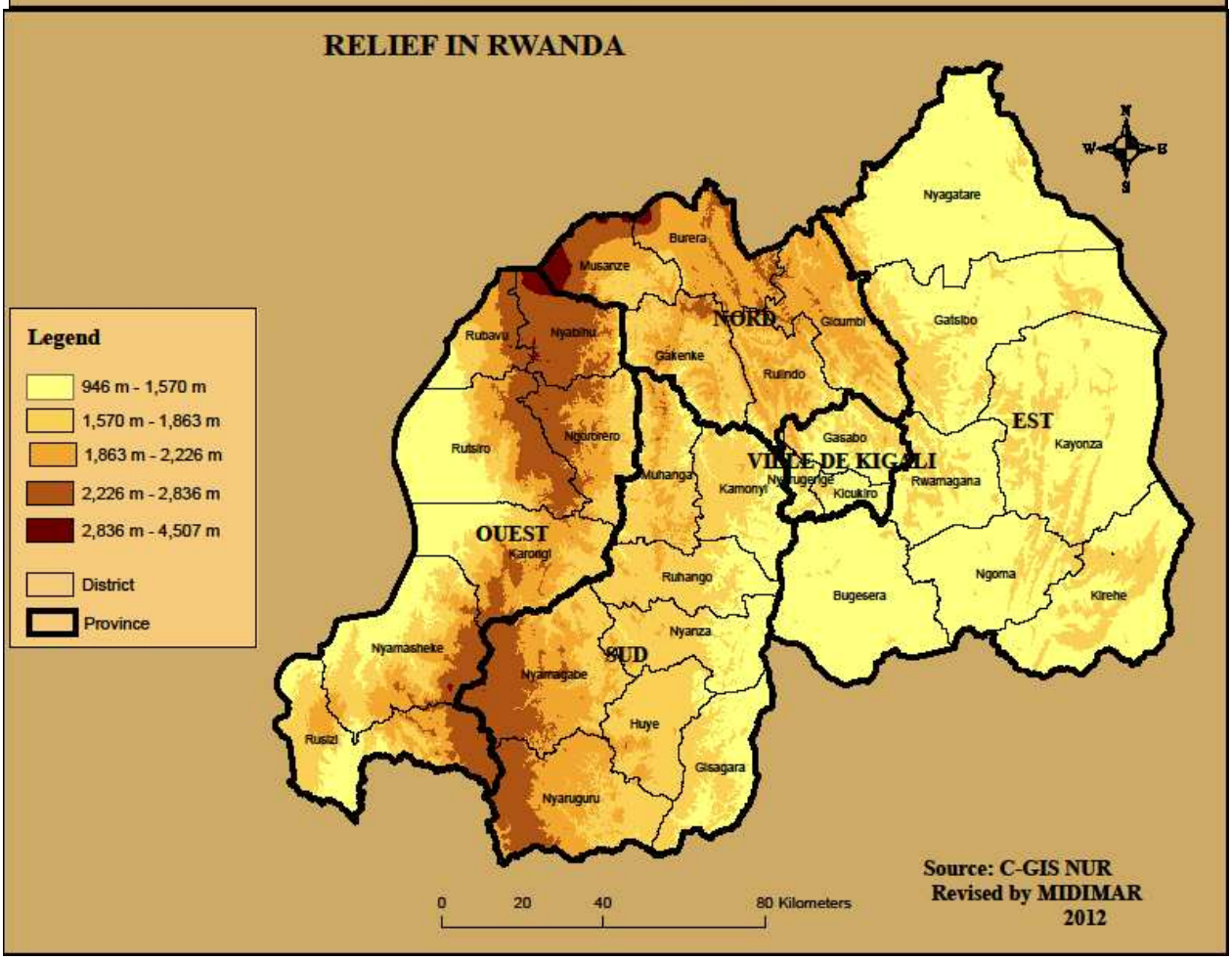


A big number of sectors in the southern province is exposed to floods and landslides. This due to various triggering factors such as steep slopes, low level of drainage system, soil instability and also nyabarongo river plays a big role in flooding the area. Induced effects is deaths, injuries, damades of crops, destructuction of infrastructures including roads, classrooms, bridhes and many others.


WESTERN PROVINCE RELIEF
Rubavu
Nyabihu
Ngororero
Rutsiro
Karongi
Nyamasheke
Rusizi
Legend
946 m - 1,605 m
1,605 m - 1,887 m
1,887 m - 2,197 m
2,197 m - 2,522 m
2,522 m - 4,507 m
District
N
W
E
S
0
12.5
25
50 Kilometers
Source: C-GIS NUR
Revised by MIDIMAR
2012


WESTERN PROVINCE RISK LOCATION
Rubavu
Nyabihu
Ngororero
Rutsiro
Karongi
Nyamasheke
Rusizi
Legend
Landslide & Flood
Landslide
Flood
Sector
District
N
W
E
S
0
12.5
25
50 Kilometers
Source: C-GIS NUR
Revised by MIDIMAR
2012


FLOOD AND LANDSLIDE RISK LOCATION IN RWANDA
Legend
Landslide & Flood
Landslide
Flood
District
Province
Nyagatare
Burera
Musanze
NORD
Gicumbi
Gatsibo
Rubavu
Nyabihu
Gakenke
Rulindo
EST
Kayonza
Rutsiro
Ngororero
Gasabo
VILLE DE KIGALI
Muhanga
Kamonyi
Nyarugenge
Kicukiro
Rwamagana
OUEST
Karongi
Ruhango
Ngoma
Bugesera
Kirehe
Nyanza
Nyamasheke
SUD
Nyamagabe
Huye
Rusizi
Gisagara
Nyaruguru
0 20 40 80 Kilometers
Source: C-GIS NUR
Revised by MIDIMAR
2012


RELIEF IN RWANDA
Legend
946 m - 1,570 m
1,570 m - 1,863 m
1,863 m - 2,226 m
2,226 m - 2,836 m
2,836 m - 4,507 m
District
Province
Nyagatare
Burera
Musanze
NORD
Gicumbi
Gatsibo
Rubavu
Nyabihu
Gakenke
Rulindo
EST
Kayonza
Rutsiro
Ngororero
Gasabo
VILLE DE KIGALI
Muhanga
Kamonyi
Nyarugenge
Kicukiro
Rwamagana
OUEST
Karongi
Ruhango
Ngoma
Bugesera
Kirehe
Nyanza
Nyamasheke
SUD
Nyamagabe
Huye
Rusizi
Gisagara
Nyaruguru
0 20 40 80 Kilometers
Source: C-GIS NUR
Revised by MIDIMAR
2012

Hazards are always prevalent, but the hazard becomes a disaster only when there is greater vulnerability and less of capacity to cope with it. In other words the frequency or likelihood of a hazard and the vulnerability of the community increases the risk of being severely affected.

A large number of people will probably thus be affected by more extreme weather and natural hazards linked to floods, landslides and storms. Since 1970 almost five billion people have been hit by natural disasters. Over two million people have lost their lives. Behind these figures lies information of great relevance to our future (*Henrik Svensen*, 2006).

Ideally, extreme natural phenomena do not lead to natural disasters if societies are invulnerable. But all societies are vulnerable to various degrees, depending on various factors. Furthermore, the distribution of vulnerability in many societies is uneven. The extent of natural disasters can be defined on the basis of various criteria. They can be divided according to the size of the affected area, the number killed, what these deaths were caused by, the societal consequences or the economic losses.

CONCLUSION

First and foremost, the identification of high risk zones on floods and landslides in all over the country intends to show the critical zones, prone to landslide and floods for effective disaster prevention, preparedness and planning.

During this research, some challenges and opportunities have been identified at the grassroots level whereas the difficulties from the community to cope with natural as well as man-made disasters especially when it happens such as lack of effective disaster awareness and public education among the livelihoods. This lack of awareness and public education for disaster risk reduction influence more deaths and injuries and other damages when disasters hit the areas. It is imperative to strengthen this public education and awareness culture among the communities in the field of disaster risk reduction.

Other challenges encountered, include the communities living in very critical zones which may influence hazards risk in a very critical momentum and result into disasters. For examples some people, in hilly regions are still living and build their houses in areas characterized by steep slopes, swamp areas, and the policy is to relocate the community living at Disaster high risk zones to the areas of less impacts from natural Hazards.

Therefore, the identification of high risk zones on floods and landslides will serve as a tool for other researches aimed at reducing the impacts of disasters such as for developing mitigation strategies, conducting risk assessment etc.

RECOMMENDATIONS

The following are recommendations from the identification of disaster high risk zones on floods and landslides in Rwanda:

- The community needs to be trained about Disaster risk reduction at their places for effective Disaster Management and disaster risk reduction,
- The public education, trainings and awareness at all levels are in special need to strengthen the Institutional capacity building,
- All identified critical zones on landslides and floods should be mapped and other researches aimed at addressing the issues of being prone to these hazards could continue such as reforestation, relocate the community at risk, land use planning where needed,
- The existing coping mechanisms for Disasters like landslides and floods at the community levels must be supported by formal institutional, legal and budgetary capacities. It may includes contingency planning, stock piling of equipment and supplies, emergency services and stand-by arrangements, communications, information management and coordination arrangements, personnel training, community drills and exercises, and public education,
- Preparedness action has to be carried out within the context of disaster risk management and should be based on a sound analysis of disaster risks and be well linked to early warning systems.
- Drainage system is recommended on the rivers that sometimes Influence River flooding when a heavy rain occurred. These rivers are namely Nyabarongo, Akanyaru, Mukungwa, Base, and many others,

- Determine flood-lines / hazard zones, as well as mapping (detail mapping) and updating on a regular basis,
- There is a critical need to determine all high risk zones for various hazards other than those of landslides and floods here pinpointed. This will play a big role in reducing vulnerabilities from the communities at Disaster risks and strengthening to their sustainable development in the country,
- Conduct a countrywide extensive risk assessment and this could help to reduce disaster risks,
- Conduct vulnerability analysis as a measure of a community's propensity to incur loss,
- Assessment of the likelihood (probability) of an accidental release of a hazardous material and the consequences that might occur, based on the estimated vulnerable zones (RISK = LIKELIHOOD × CONSEQUENCE).

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3. http://landslides.usgs.gov/learningeducation/majorls (accessed on 8thNovember 2011).
4. http://www.irinnews.org./report.aspx?reportid=88319 (Visited on the 1st October 2011)
5. 5. http://wwwcolorado.edu/hazards/resources/landslides.html/ (Visited on 22nd October 2011).
6. http//www.isdr.org (visited on 25th October 2011).
7. ITC- Faculty of Geo-Information Sciences and Earth Observation, University of Twente, the Netherlands (visited on 22nd October 2011)