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# THE CONTRIBUTION OF COMPUTER TECHNOLOGY IN ANALYSIS OF FLOODING DISASTER IMPACTS A LONG MUVUMBA RIVER USING GIS IN NYAGATARE DISTRICT. Case study Karama sector.

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## Abstract

Flooding disaster results into loss of lives, crops distruction, loss of land as well as economic deterioration due to the affected bridges across the rivers. Karama sector in Nyagatare district is the most area affected by flooding seasonally in a year along Muvumba river. The topography of the area is not high steep but medium slope and low sloping, heavy rainfall in the bordering region such as Gicumbi and Uganda as the source of river Muvumba creates erosive power of the river when it is raining, due to the topography of high mountains of Gicumbi and Uganda causing flooding in Karama sector along Muvumba river even when it is not raining in Nyagatare as well as destruct crops, infrastructures and loss of land in the areas surrounding the river. This research analysed the triggering factors of flooding and the flooding impacts along the Muvumba river in Karama sector, Nyagatare district where it has been recorded a number of flooding. After extraction by mastk the slope was calculated and later classified into three categories (0.0-5.5 (low slope), 5.5-14.6 (Medium slope) and 14.6-36.0 (High slope). The analysis reveals that, the stipness of some area of Karama sector are directly corelated with the flooding disaster when it is raining. After integration of spatial data of rivers, basic facilities and infrastructure into ArcMap, the network analysis tools in Arc tool box was used to analyse the impacts of flooding disaster on accessibility of basic facilities, we found that people from Ndego cell and Kabuga cells tends to move long Distance to access basic facilities during flooding period. Throuh the field observation the impacts of flooding disaster on agriculture production has been observed and the photography was taken to document the extent of flooding impacts on agriculture production, we found that, Beans, Maize Sugarcane, Sorghum, Potatoes, Carrote and Bannana plantation are major crops that are

likely to be affected by the floods. Although assistance are provided to the affected households, flood mitigation and adaptation measures need to be highlited to cope with the flooding disaster. Floodwalls and floodgate should be constructed to reduce the volume, and erossive power of water, terraces and planting trees need to be encouraged as well as capturing water that may acceralate flooding disaster in the river Muvumba. In addition, constractuion of Dums are issential in flood risk management along the river muvumba in Karama.

**Keywords:** Flooding disaster, Flood mitigation, Flood adaptaion, Floodwalls and floodgate

## I. INTRODUCTION

Disaster is defined as an events happening with or without warning causing serious disruption to the functioning of community or society, means of causing or threatening death, injury or diseases, damage to property, economic or environmental losses which exceeds the ability of affected community or society to cope using its own resources (DKKV, 2004). The frequently poor conditions of families are consequently worsened by the impacts of disaster ( A. Lorenzetti, 2013). Natural disaster is an increasing problem all over the world causing a huge loss of human life. They are result of sudden change in state of natural elements due to the natural forces and the most of natural disaster are beyond of human control and cannot be predicted accurately before it occurs (Junghyun Cho, 2012)

Floods are the common natural disaster affecting human life and their surrounding environment (Hewitt, 1997 cited in Junghyun Cho, 2012). Flood is an excessive water flow in the rivers that makes exceeded water beyond the river banks to occupy the normal land and damage the environments directly. According to Malcolm and Parkin (1997) flooding problems are of two aspects; flood hazard and communities' vulnerability to the flood hazard. They are many occurrence of flooding in the world that devastate the human life, destruction of crops, loss of livestock and deterioration of health conditions owing to waterborne disease. Communication links and infrastructures are damaged and disrupted. Economic activities reduce as well as people forced to move from their homes. Flood problems damage agriculture land and crops results into a serious reduction in agriculture products and

stresses economy (Scott, 1997). People in rural areas and small urban centers lost their homes and business but also wells and inundated septic system are contaminated (Stewart & Candidate, 2004). Poverty in families, increase in population rate, and poor urban and rural planning are the major force of people to settle in flood prone areas. Poor people illegally occupy public land or purchase cheap land in flood prone areas as they have no ability to own land of high prices (Montoya, 2006 cited in Bizimana JP & Schillin M, 2016). Flooding events has a significant impact on rural household that frequently increases the rate of poverty in many families lies on agriculture and income from the products are lowered hence reduce the standards of living. Meeting basic needs such as food, accommodations and new seed are prerequisite to cope with the flooding impacts to the rural households. Flood forecasting and warning system, management of floodplains, land use planning, social and economic measure are the major sustainable solutions to cope with the flooding impacts (U Nations, 2004). According to Twigger-Rosess (2005) reducing the incidence of flooding hazards, rural land management practice is essential to ameliorate the level of run-off.

According to the united nation (2003) the flooding in china happened in 1998 and 223 million were affected, 3004 people gets dead as well as 15 million of people were homeless. In 2010, the consequences of flooding have been recorded in Pakistan with the high damage of infrastructures, households, property and human life (Irambona, 2012). For the last 10 there has been catastrophic flooding in Bangladesh, India, Mozambique, Poland and the united states and agriculture production was affected as well as the economy in these country devastated(U. Nations, 2004). In August 2002, the Elbe river flooded and the area of 200 $Km^2$ on the right side of Elbe river including the proposed detention site was flooded due to the several dikes failures (Forster et al., 2008)

Rwanda is vulnerable to the range of disaster and emergency situation. Flooding is the key disaster that frequently affect localized areas of the country (MIDIMAR, 2012). And the most rural households are more affected compared to those employed in business as they have no power and ability to handle the mass flooding effects. Flooding disaster are linked to the climate change and variability as they are considered as the most important environmental issues that impacts on most issues directly or indirectly (Nsengimana &

Rwanyiziri, 2011). In the face of climate change, the events of flooding can become more frequent and can threaten the economic developments (Tsinda et al., 2019). The main accelerators of the flooding impacts are hilly topography, high annually precipitation rate, deforestation, poor farming and housing techniques that do not facilitate in water infiltration making the easy flow of water when it rains. They are several flooding occurrences in Rwanda, at least 10 people have been killed and hundreds more displaced due to the flooding in north-western Rwanda. The same case in 2011 floods destroy 354 houses in western province and damage 3000 hectors of farmland (MIDIMAR Report, 2011). On 25$^{th}$ Dec 2019 the same case of flooding occurred in Kigali city and many of property, infrastructures such as roads and houses was devastated.

Nyagatare district experience the flooding impact like other district in Rwanda although it not at high rate compared to the district of Gakenke, Rubavu, Nyabihu and Musanze. The major sectors affected by flooding in Nyagatare district are Karama, Gatunda and Karangazi (MIDIMAR, 2012). In 2016 farmers in Nyagatare district Rwempasha sector gets losses due to the heavy rains coupled with wind as well as the over 300 hectors of crops devastated and 64 houses was destroyed (RAB, 2016). Seasonal flood is one of the major types of flooding that occur when there is a combination of rainwater and river water that uplift the levels of water at certain time of year (Mendel, 2006 Cited in Bizimana J.P & Schiling M, 2016). Karama is the most sector that experience seasonal flooding impact as the river Muvumba cross the whole sector and it flooded seasonally hence leading to the destruction agriculture production and many people are affected as most of them depend on agriculture. property and infrastructures are destroyed as well as floods impacts on land making the low production of the next agriculture seasons.

Rwanda is one of the most country in east Africa that experience flooding disaster in most north-west part of the country. Flooding results into loss lives, crops distraction, loss of land as well as economic deterioration due to the affected bridges across the rivers. Karama sector in Nyagatare district is the most area affected by flooding seasonally in a year along Muvumba river. The topography of the area is not high steep but medium slope and low sloping, heavy rainfall in the bordering region such as Gicumbi and Uganda as the source of river Muvumba creates erosive power of the river when it is

raining due to the topography of high mountains of Gicumbi and Uganda causing flooding in Karama sector along Muvumba river even when it is not raining in Nyagatare as well as destruct crops, infrastructures and loss of land in the areas surrounding the river.

**Fig. 1** Impacts of flooding disaster along the river Muvumba in Karama sector, April 2020

*Source: Photo taken by François Murwanashyaka April 21, 2020, 3:43:49 PM*

Accessibility of basic facilities and services is one of the most impact of the flooding disaster along the river as many of residents in this sector are likely to be limited on health facilities and young students gets absents due to the flooding that destroys bridges and roads connecting their homes and schools. properties, infrastructures are devastated as well as the flooding creates a strong impact on land by washing away the fertile soil leading the low production of the next agriculture season.



This research analysed the flooding impacts along the Muvumba river in Karama sector, Nyagatare district where it has been recorded a number of flooding (MIDIMAR, 2012) by using ArcGIS software as well as provided more information on adaptation and mitigation measures that have been put in place to cope with the flooding disaster to the affected population and infrastructures affected.

## II. MATERIAL AND METHODS

The study is based on primary and secondary data collected through intensively deep interview with cells executive secretaries and local people in which the river Muvumba cross, spatial data analysis where collected data are displayed into maps using ArcGIS

software. Through the field observation it was easy to observe the physical aspect of the area and Photographs was taken to document the extent of flooding impacts.

## Study area

## Description of Karama

Karama sector is one of 14 sectors in Nyagatare district located in south west of Nyagatare district. The sector is made of seven cells called Utugali in local language and fifty-one villages (Imidugudu in local language). Cells of Karama sector including Bushara, Cyenkwanzi, Gikagati, Gikundamvura, Kabuga, Ndego and Nyakiga. The total area of the sector is 53 $Km^2$ and the population changes from 19,727 in 2002 to 26,727 in 2012 with the population density of 499 (National population census, 2012). Karama sector border with Tabagwe sector in the north, Rukomo in east, Gatunda in south, Kiyombe in south-west and the country of Uganda in west.

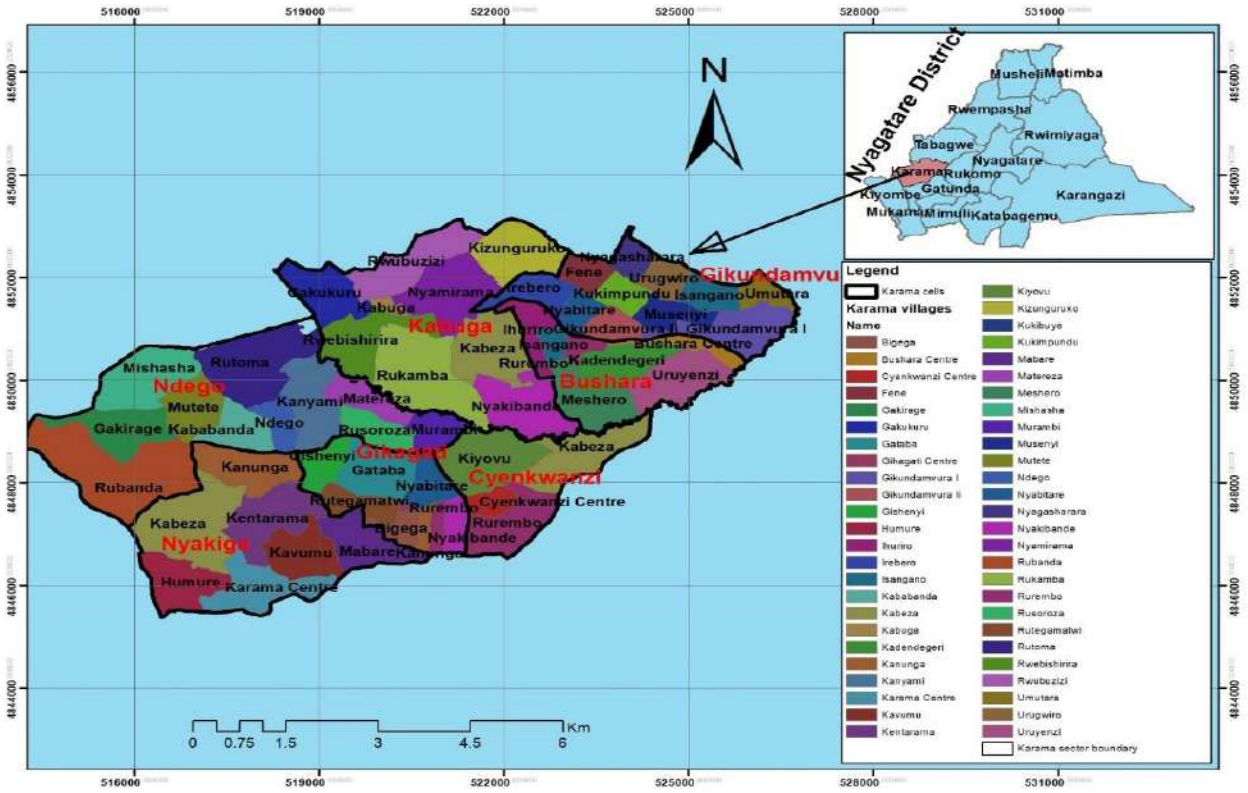


Fig.2 Location of Karama Sector and its Administrative boundary (*Data Source: CGIS/UR*)

**Muvumba river**

Muvumba river is in the north-eastern of Rwanda and south-west Uganda. It is part of the upper headwater of the Nile as it one of the major river of Rwanda both in size and economic importance with total length of 170 Km and the basin size of 3500 $Km^2$. The river takes it source at Rukomo in Gicumbi district close to the town of Byumba in the high mountain of northern Rwanda at the source called Milindi river (Eric, 2018). This river is important to economy as its valley and valleys of its tributaries are firtile and contain major tea plantation as well as mulindi factory is located at this river and it is the lagerst tea factory in Rwanda. Mulindi river flows in north for 28 Km and enter in Uganda as well as changes its name from mulindi river to Rwabakazi river. The river continue northwards, then upon reaching the city of Kabale in Uganda, the river changes it cource and flows in general south-east direction towards Rwanda. This section of Rwabakazi river is 55 Km long, the river re-enter Rwanda in Nyagatare district passing through karama sector and take the name Muvumba river it then flows in the nort-east direction for 87 Km and empties into Akagera river at Kagitumba (RNRA, 2012). The river occupy a big part of karama as it passes into five cells namely Ndego, Kabuga, Cyenkwanzi, Bushara and Gikundamvura and their villages respectivelly

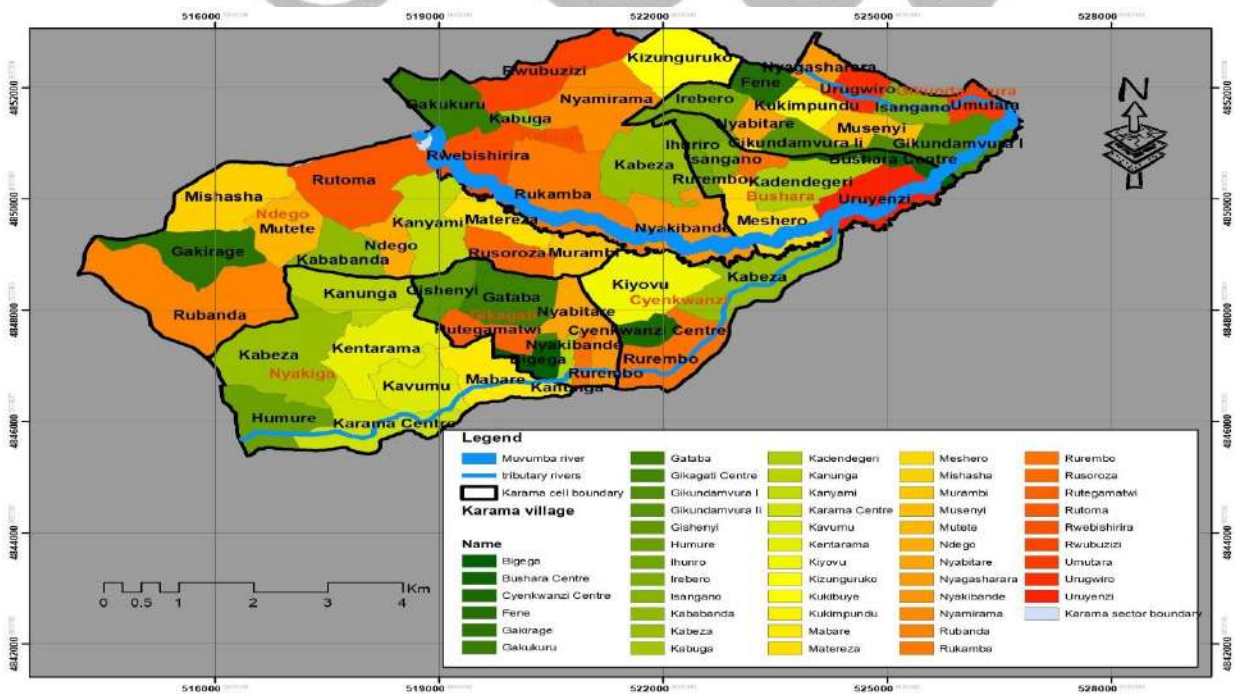

Fig.3 Location of Muvumba river and the Cells it crosses in Karama Sector *(Data source: CGIS/UR)*

**Spatial data analysis**

ArcGIS 10.6 software and it analysis tools was used in this research, by using the spatial data from CGIS UR it was possible to create map showing the study area and the area prone to the flooding along the river Muvumba river. Through ArcGIS 10.6, Network analysis tools in Arc toolbox was used to analyse the extent of flooding impacts on accessibility of basic facilities. After integration of spatial data of rivers, basic facilities and infrastructure into ArcMap, the distance in Meters (M) and time taken by the residents to access basic facilities was calculated to analyse how long they move during floods. In ArcGIS 10.6, DEM was used to analyze the steepness of the Karama sector in order to observe the area of high slope and low slope. After extraction by mask in Arc toolbox, the slope was calculated and later classified it into four categories.

**Sample size and Sampling techniques**

Purposive sampling method was used in this research as it provided more information on the impacts of flooding disaster along the river Muvumba. We used a total freedom in selecting of people to be a part of our research and all target people was eligible to be surveyed. Among the 7 cells of Karama 5 cells in which the river cross was selected to be interviewed. Depending on barriers of time and Covide-19 prevention strategies, 3 executive secretaries was chosen in the selected cells and 2 people in each selected cells.

## III. RESULTS AND DISCUSION

**Factors that trigger the flooding disaster along the river Muvumba**

The topography of Karama sector was anlysed as one of the triggering factor of flooding disaster along the river Muvumba. After extraction by mastk the slope was calculated and later classified into three categories (0.0-5.5 (low slope), 5.5-14.6 (Medium slope) and 14.6-36.0 (High slope). The analysis reveals that, the stipness of some area of Karama sector are directly corelated with the flooding disaster when it is raining. We reveals that cells like Ndego and Nyakiga are the ones with high slope whereas other cells are medium and low sloping. The stipness of Ndego and Nyakiga cell increase run-off of water when it is raining and creates errossive power in Karuruma river ( Kagona river from Kavu in Uganda) and Karama river (Kayihenda river from Kiyombe

sector). The increase in volume of water from these small rivers are combined with runoff water from medium slope of Kabuga cell and the small parts of Ndego cell (Urwuri and Kabahigi Hills) increase the errossive power of water in Muvumba river hence leads to flooding disaster. In general, the stipness of Karama sector is not enough to influence flooding disaster along the river muvumba, heavy rainfall in the bordering region like Gicumbi and Uganda as the source of river Muvumba creates erosive power of the river when it is raining due to the topography of high mountains of Gicumbi and Uganda causing flooding Disaster in Karama sector along Muvumba river in the absence of rainfall in Nyagatare.

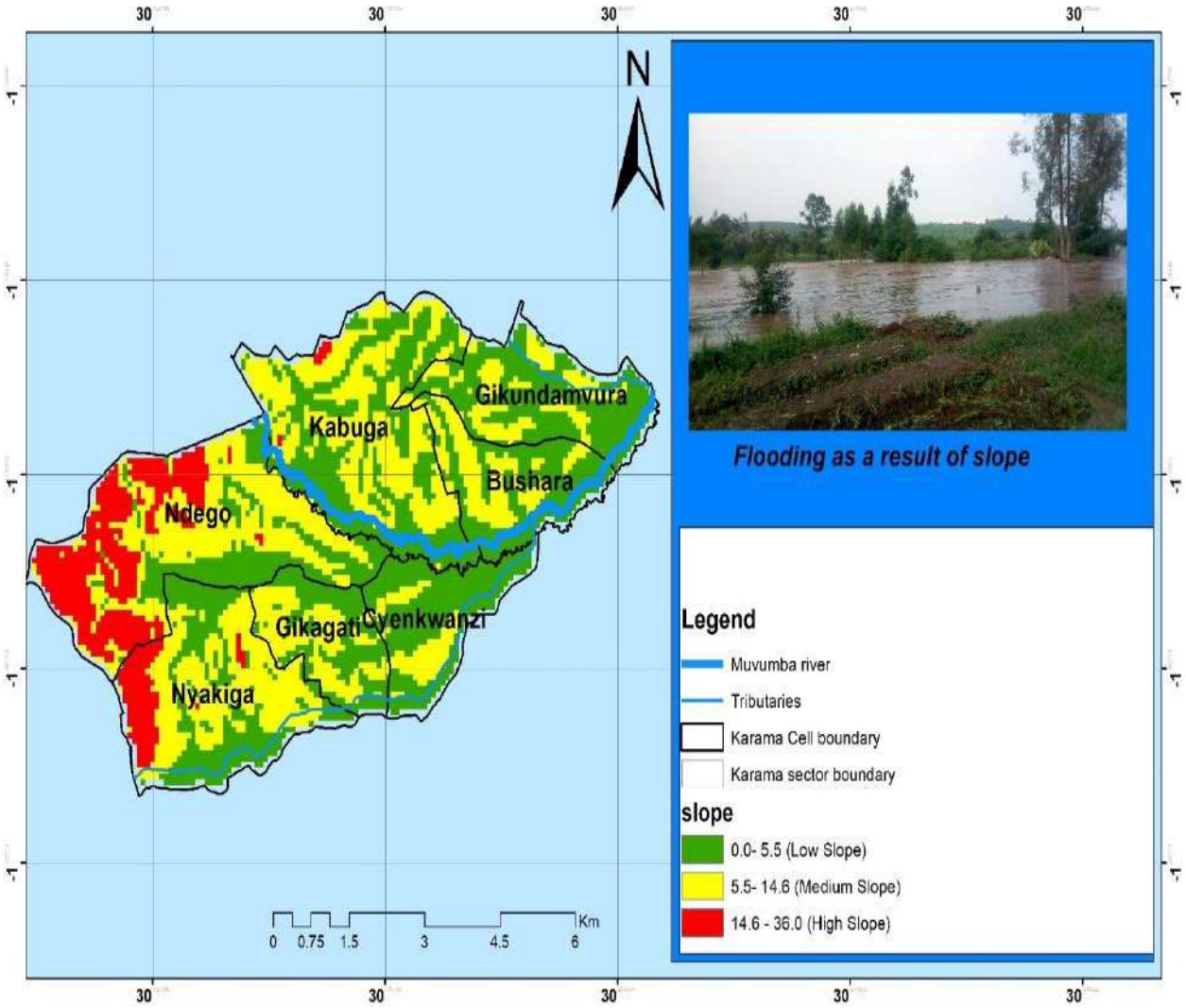


Fig4: Relationship between slope and accurance of Flooding a long Muvumba river (*Data source: CGIS/UR)*

The City of Kabare in Uganda and Kabuga town in Rwanda are the major accerarators of flooding disaster along the river Muvumba, Paved areas such as roads and car parks in Kabare city and uncaptuted water from houses and other building in kabare do not allow easy infiltration of water when it is raining as well water run-off increase. The increased run-off water when reaches to the Maziba waterfall in Uganda the errossive power increase in Rwabakazi river (Muvumba river in Rwanda) as well as creates flooding disaster in Karama sector along Muvumba river. Houses without septic tanks to capture water in Kabuga town also increase the easy movement of water when it raining and directly move towards muvumber river and creates Flooding disaster along this river.

**Impacts of flooding disaster on agriculture production along the river muvumba**.

Agriculture is the most important economic activity in Karama sector as the area is domonated by agriculture and most of people live in agriculture life. Throuh the field observation the impacts of flooding disaster on agriculture production has been observed, we found that, Beans, Maize Sugarcane, Sorghum, Potatoes, Carrote and Bannana plantation are major crops that are likely to be affected by the floods. Referring to the interview with the local people they urgued that floods along the river Muvumber make them suffering from hunger and poverty as they invest in agricultute to cater for their families and ends up being deverstated by floods.



Fig5. Major crops affected by flooding disaster along the River Muvumba in karama sector. Apri, 2020

*Sources: Photo taken by Francois Murwanashyaka, Tuesday, April 21, 2020, 4:03:58 PM*

Flooding disaster plays a big role in transportation of fertility soil and soil deposition in the areas surounding the river Muvumber. This has greatly impacts the next season of agriculture production, in the interview with the local people, we reveals that when the fertile soil are washed away by the floods, the next agricultures season tends to be reduced due to the fact that fertile soil are deposited in another areas. This has been comfarmed by one the farmer in Matereza village in Ndego cell, that he used to harvest 52 tons of Maize and 25 tons of Beans in the absence of floods but during the flooding season, fertile soil washed away and the production directly reduced from 52 tons of Maize and 25 of Beans to 31 tons of Maize and 10 tons of Beans.

## IV. Impacts of flooding disaster on accessebility of basic facilities along the river muvumba

Basic facilities such as education, health centers and markets are needed in daily life of a given community. In general seven cells of Karama sector have access to health center, education and markets although some villages in each cell like Mishasha in Ndego cell, Rwubuzizi in Kabuga cell and Umutara in Gikundamvura cell have limited access to Kabuga health center and education facilities in general. Although the sectors have acces to basic facilities, Flooding disaster a long Muvumba river creates adiverse impacts on accessiblity health facilities, Markets and education facilities. The most affeted areas are those villages that cross the river while seeking for facilities such as Kanyami, Matereza, Murambi and Rutoma in Ndego cell and Gakukuru, Rwebishirira, Rukamba, Nyakibande and Meshero in Kabuga cell and some villages of remaining cells. As responded by residents in Matereza and Murambi village in Ndego cell, floods along Muvumba river increased the distance from their homes to the Kabuga health center. Residents urgued from Ndego cell urgued that, they used to access health facilitie by crossing the river with their feet but when the floods occur they tend to move long distance to access health facities. Flooding along the river Muvumber also impacts on accessibilities of education facilities, as responded by parents in Kabuga cell, when floods occur brigdes and roads are distroyed and young students gets absents and sometimes fail to reach their homes when they are coming to school.

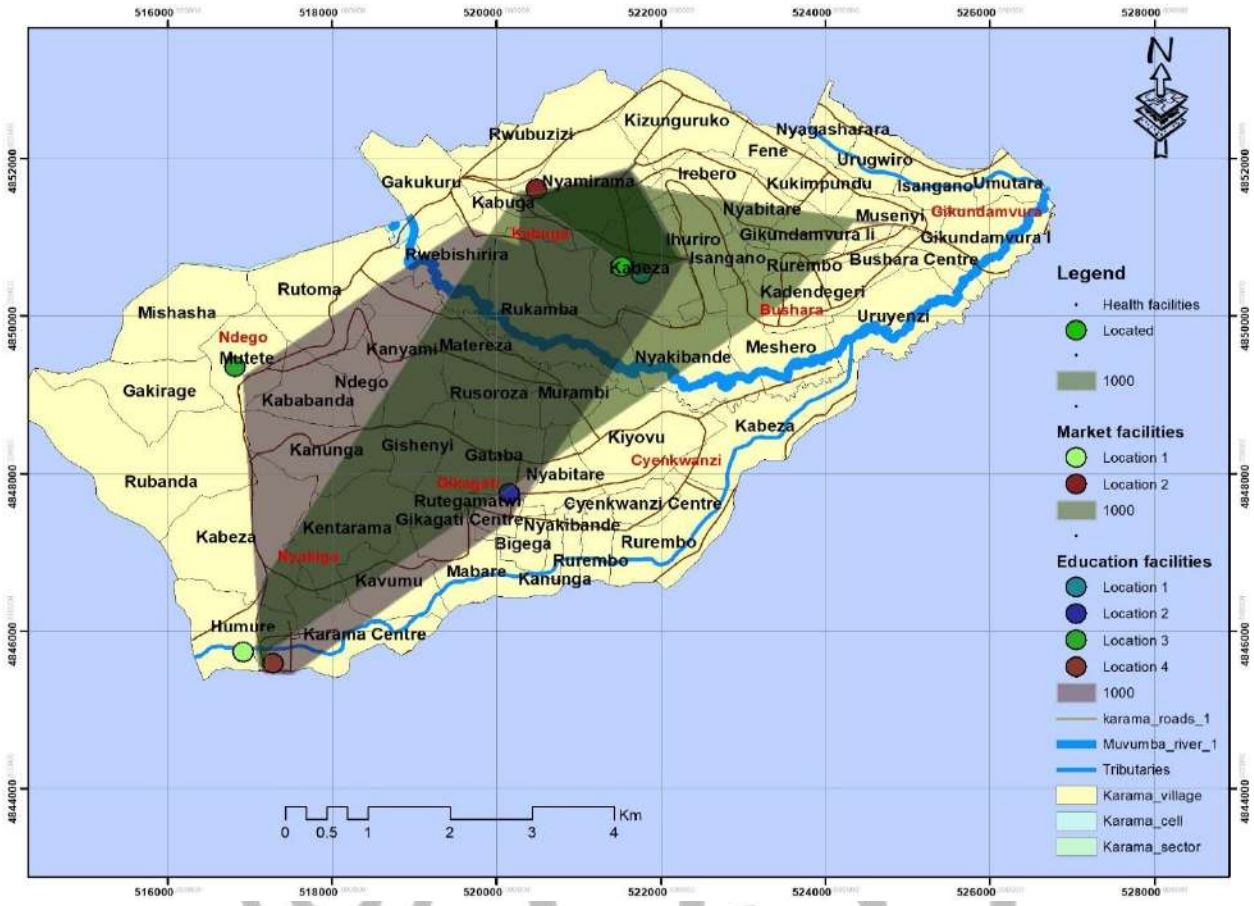


Fig6. Impacts of flooding disaster on accessibility of basic facilities (*Data source: CGIS/UR*)

**Assistance given to the households affected by the flooding disaster**

Flooding disaster along the river Muvumba in Karama sector creates a diverse impact on agriculture production and accessibility of basic facilities and services. This impacts on living condition of people in Karama sector however, some assistance are provided to the families affected by the floods. In the interview with different cells executive secretaries in which the river cross, they afirms that some assistance are provided to the households affected by floods. People affected by flooding disaster are recorded and later sent to the Ministry of Disaster Management and Refugee Affairs (MIDIMAR) to be assisted in terms finacial and food provision. Other people from the cells in wich the river Muvumba do not cross such as Gikagati and Nyakiga cell are advised to help their friends affected by floods in terms of food provision. The affected infrasrtuctures such roads and bridges are reported to the Ministry of Infrasrtuctures

(MINIFRA) to be assistes in terms rehabilitation

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## V. CONCLUSION

In fact, Flooding disaster creates a diverse impacts along the river Muvumba in Karama sector as the river cross the whole sector. Seasonally flooding impacts on agriculture products and many people have been affected as most of them depends on agriculture as abackborn of their economy. Accessibility to basic facilities such as health and education facilities became aserious issue during flooding period. This research reveals that stepness of some areas in Karama sector and neighboring region such Gicumbi and montains of Uganda are directly corelated with the increase of erossive power of the river muvumba hence leading flooding and its associative impacts along the river. Most of dwellers met with economic reduction due to flooding impact that diversitate their agriculture production and some times they fail to take their goods to the markets because of roads and bridges destroyed by flooding disaster.

In the interview with the local leader, they afirms that some assistance are provided to the households affected by floods such financial support, food support and rehabilitation of affected infrastructures. Although assistance are provided, flood mitigation and adaptation measures need to be highlited to cope with the flooding disaster. Floodwalls and floodgate should be constructed to reduce the volume, and erossive power of water, terraces and planting trees need to be encouraged as well as capturing water that may acceralate flooding disaster in the river Muvumba. In addition, constractuion of Dums are issential in flood risk management along the river muvumba in Karama.

## REFERRENCES

Bizimana, J. P., & Schilling, M. (2016). Geo-Information Technology for Infrastructural Flood Risk Analysis in Unplanned Settlements: A Case Study of Informal Settlement Flood Risk in the Nyabugogo Flood Plain, Kigali City, Rwanda.Chapter 6 (Issue January 2010). https://doi.org/10.1007/978-90-481-2238-7

DKKV - German Committee for Disaster Reduction. (2004). Flood Risk Reduction in Germany - Lessons learned from the 2002 disaster in the Elbe Region. http://www.dkkv.org/fileadmin/user_upload/Veroeffentlichungen/Publikationen/DKKV_29_Lessons_Learned.pdf

Eric, U. (2018). Spatial and Temporal Variability of Streamflow in Catchments Spatial and Temporal Variability of StreamflowiIn Catchments Areas of Rwanda Focus on Muvumba and Sebeya catchments.

Forster, S., Kuhlmann, B., Lindenschmidt, K. E., & Bronstert, A. (2008). Assessing flood risk for a rural detention area. Natural Hazards and Earth System Science, 8(2), 311–322. https://doi.org/10.5194/nhess-8-311-2008

Irambona, E. M. (2012). Analysis of flooding using Gis. Case study Bigogwe sector, Nyabihu District. 2012.

Lorenzett, A. (2013). Social Analysis of Rural Communities Living in Disaster Prone Areas of Zambezia .

MIDIMAR. (2012). Identification of Disaster Higher Risk Zones on Floods and Landslides in Rwanda Republic of Rwanda Ministry of Disaster Management and Refugee Affairs Unit of Research and Public Awareness Disaster High Risk Zones on. March, 1–33.

MoE. (2018). Muvumba Catchment Management Plan (2018-2024). Republic of Rwanda. Ministry of Environment. October.

Nations, U. (2004). Guidelines for Reducing Flood Losses. Case Studies, United Nations Development Programme, Vietnam, Disaster Management Unit RANET. www.unisdr.org

Nsengimana, H., & Rwanyiziri, G. (2016). Rwanda Environmental Research Strategy. Rwanda Environment Management Authority ( REMA ), July.

RNRA. (2012). Water Resources Information Bulletin No 6. Water Resources Information Bulletin, 6, 1–9.

Scott, J. A. L. and D. F. (1997). Economic Impact of Flooding on Agricultural Production in Northeast Central North Dakota.

Stewart, J., & Candidate, L. L. M. (2004). Summary of the Workshop Feedback : Flooding in Rural Areas : Perspectives ,

Strategies , and Way Forward prepared by Healthy Resilient Watershed Informed Active Citizens. 1–15.

Tsinda, A., Kind, C., Hess, J. S., Mugsiha, R., & Bizoza, A. R. (2019). Estimating damage costs of flooding on small- and medium-sized enterprises in Kigali, Rwanda. Jàmbá Journal of Disaster Risk Studies, 11(1), 1–11. https://doi.org/10.4102/jamba.v11i1.755

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