Assessment of farmer's perception to climate change adaptation in the agriculture practices: Case of Kirehe District-Rwanda

PRESENTED BY

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The research submitted is partially fulfilling minimum the requirements for the degree of master of sciences in atmospheric and climate science in the college of science and technology

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October, 2023

DECLARATION

I declare and conform that this Thesis contains my own proper work except where I have specifically referenced

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Signed………………………………………..

Date…………………………………………..

CERTIFICATION

I, NIZEYIMANA JEAN PIERRE, student from University of Rwanda, College of Science and Technology, with registration number **221027901**, hereby declare and confirm that ,this project entitlet as Assessment of farmer's perception to climate change adaptation in the agriculture practices: Case of Kirehe district-Rwanda . It is my original work and I have never been submitted or presented in any University of Institution of higher learning for academic purposes or otherwise. This thesis was conducted under the supervision of Prof. Bonfils Safari from Department of Physics at University of Rwanda

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Signature:

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Supervisor: Prof. Bonfils Safari

Signature:

Date :………./………./…2023

DEDICATION

This work is dedicated to my wife MUBERARUGO Grace, Son MANZI Julien Prince, my parents, brothers and sisters.

ACKNOWLEDGEMENT

I am highly thankful to Almighty God for make me strong to study throughout the long journey of this course at the University of Rwanda in the the College of Science and Technology(CST).

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ABSTRACT

Climate change and variability are measures challenges that hinder the economic development of more than 90% of Rwandans that are relying on rain-fed agriculture practices. In Kirehe, the land is insufficient for the farmers with an average of 0.3 ha per smallholder farmer per household as well as the whole country. The scarcity of cultivated land associated with its degradation due to climate change and the population growth rate cause the land to be extremely highly exploited. Environment degradation coupled with temperature trends and rainfall variability both with low correlation coefficients in four decades provides a shift of rainfall seasons to the prolonged dry season in a great part of the Kirehe district where certain sectors pass almost two months without rain in the period that they could have rainfall. Climate change accelerates the level of vulnerability to agriculture practices in the Kirehe district, therefore, I have decided to assess the farmers 'perception of climate change's impact on adaptation in agriculture practices.

The main objective of this work is to improve the kill and knowledge of farmers to the rainfall variability, in the seasonal forecast and temperature time series trends prediction over the Kirehe district that has a huge implication for the provision of food security, promote the use of biodiversity,water resource planning and exploiting ecosystem services to ensure food security and sustainability of better agriculture practices.

The date used in works were collected by using structured Questionnaire contains climate change impact statement, and distributed within 206 farmers across twelve sectors of kirehe district, meteorological data such as rainfall and temperature time series from Rwanda meteorological Agency, where data from 8 eight stations were collected rainfall and temperature of kirehe district of period 1983 – 2021.

The methodologies used to analyses the data collected and verifying hypothesis test are following ANOVA to test farmers knowledge to climate change for each sample taken from sectors, Chi-Square test analysis to test effectiveness of applied adaptation strategies that are current implemented throughout the farmers. The Mann-Kendall statistics test and Theil Sen's slop estimator are used to determine the significance and magnitude of the temperature and rainfall time series trend .

The results reveal that farmers from all twelve sectors responded the Questions so that the test hypothesis done for each sector we have rejected the null hypothesis, meaning that P-value calculated or critical value are much smaller than P =0.05 obtained by using ANOVA, therefore farmers have significance perception to climate change impact. The temperature and rainfall time series trends have significance

statistics trends such as table 3 and table 4 ,the regression line reveals different change of rainfall in percentage for annually rainfall   -4.008 and correlation coefficient of rainfall is 0.0524 for the temperature change regards graph 20.

THE LISTS OF SYMBOLS AND ACRONYMS

MAM: March to May

OND: October to December

REMA: Rwanda Environmental Management Agency

RSB: Rwanda Standards Board

HEC: High Education Council

IPCC: Inter-governmental panel of Climate Change

CST : College of Sciences and Technology

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CHAPTER ONE GENERAL INTRODUCTION

1.1. Background

Globally the socioeconomic development of emerging nations is hindered by agricultural methods that undermine crop development, which increase food insecurity and the effects of climate change [1]. A high degree of climatic vulnerability in African agricultural methods has a considerable impact on biodiversity loss, water shortages, and the incidence of infectious diseases among farmers[2][3]. When farmers' perception of rainfall variability takes into account meteorological data and trends gathered from the climate monitoring center, seasonally cropping decisions are made[4]. It makes it easier to apply the right adaptation strategies to boost agricultural output [5]. Farmers in a large number of African nations predict onset and cessation using conventional techniques that are compatible with seasonality [6]. Farmers in a large number of African nations predict onset and cessation using conventional techniques that are compatible with seasonality [6]. Investments in contemporary climate information services and adaptation have been put to use to put into practice local expertise in seasonal rainfall forecasting[7][6]

1.2. Problems Statements

Climate change in Rwanda puts farmers, especially those in the Eastern area, at high risk. The Kirehe district is experiencing a prolonged drought, which contributes to food shortage issues, as a result, there are other obvious challenges, such as farmers' lack of understanding of climate variability and their decision to sow crops without taking accurate meteorological data into account. Low agricultural yields are caused by a lack of access to trustworthy climate information during the cropping season. Due to the farmers' extensive misunderstanding during the agricultural season, this region experiences deficiency rainfall, undermined crops, and loss of socioeconomic growth and agricultural production[12]. In comparison to other regions, the eastern portion of Rwanda receives less rain than 900 mm yearly, despite the fact that the national average for rainfall is 1,250 mm [12]. The majority of studies on the effects of the climate on the Kirehe district did not evaluate how well farmers were able to adjust to climate change and how well their forecasting techniques handled early and delayed rainfall star

1.3. Hypothesis of the study

Over the past period of 39 years, the population of food insecurity from central, eastern and southern Africa has almost doubled per capita in each country due to climate change impact and lack of effective adaptation strategies measure [9]. The farmers do not have enough knowledge to cope climate change impact that lead to the cropped area in these countries to decline by 33% due the climate variability impacts such as drought and degradation of the ecosystem therefore several millions of undernourished persons increased by 80% State of food insecurity in the world[4] [6]**.** This study will come up with making known the farmers ‘expertize in the forecast of the rainy season that should reduce confusion and the impact due to early and delay of rainfall onset, length of growing period and cessation as well as agriculture seasonality [10].It will improve the farmers ‘ perception to climate change impact that eventually will help to shift from the use traditional and local knowledge to the trends recorded and information provided by the meteorological observation Agency.

1.4. General Objectives

The main objective of this study is the assessment of farmers’ perception to climate change adaptation in agriculture practices.

1.5. Specific Objectives

1. To assess farmers’ knowledge to climate variability with related impacts in the agriculture sector.
2. To assess the trend of temperature and rainfall variability of time specific MAM and OND.
3. To assess effectiveness adaptation strategies to be adopted, recommended to the community and local authorities areas.
4. To assess the methods by which farmers apply to forecast the onset rainy seasons and effect of climate change to the farmers.

1.6. Research Questions

The objective 1, to assess farmers’ knowledge to climate variability with related impacts in the agriculture sector.

i. What are the challenges of climate variability farmers have due to rainfall onset date, and cessation date for agriculture practices and production?
ii. What are impact the climate variability on the local community for agriculture practices?
iii. What are the available measures to local citizens themselves and district level to ensure continual improvement and strategic plan to ensure that people can be withstand to reduce the vulnerability of agriculture practices and crop harvest as well?

For objective 2. To assess the trend of temperature and rainfall variability of time specific MAM and OND ,

i. What are meteorological data such as rainfall and temperature of concerning kirehe district adequate measures and action undertaken to the resilient of delays to the rainy season, short of length growing periods, and early rainy cessation to improve crop production?
ii. In which ways farmers do get information concerning starting and end periods of agriculture and skills concerning climate variability and its adaptation?

For objective 3. To identify effective adaptation strategies to be adopted, recommended to the community and local authorities areas..

i. What are the modern technologies in agriculture practices and its effectiveness to the farmers and government initiatives in your community to adapt with climate variability impact ?

The objective 4: To assess the methods by which farmers apply to forecast the onset rainy seasons and effect of climate change to the farmers.

i. Have you heard about the concept of climate change? if yes specify most resource do you use

1.7. Scope of the study

This research focuses on assessment of climate variability impact facing the farmers of Kirehe district, assessing adaptation strategies that are used for agriculture management information through twelve sectors in the Kirehe District. The rehabilitated sectors supported by Rwanda Environmental Management Agency are considered including others sectors. The work also investigate farmers' perceptions to climate change effects and their methodologies in prediction of agriculture season.

1.8. Research Significance

This study shall be a responsiveness to the adaptation processes of agricultural management that will help policies makers, local government institutions and other government institution such as Rwanda Environment Management Agency to plan for change, review available programs and re-strategic planning for environment management activities[12]. It will promote existing farmers 'adaptation and effectiveness of adaptation to climate change such as the use of biodiversity and ecosystem approach services such as regulation, provisioning, supporting, and cultural portion of all adaptations technics to help people to adapt to the negative effects of climate change. Government institutions and citizens shall be able to review and empower existences and measure the implementation of projects and strategic plans to enhance performance of national and local institutions.

1.9. Case study Justification

The Kirehe district was selected as a case study for the following reasons: first, it is a region of the nation that has been impacted by a protracted drought and ecological degradation, including wetland loss, migrating forest loss, and the extinction of several plant species . Second, it used to be one of the key food producers for the nation, but since 2012 [13], the area has experienced food insecurity as well as water scarcity that has hampered agricultural activities owing to the intense sun. Kirehe has been designated as the area most afflicted by acute food insecurity in Rwanda, which affects over 18% of the country's population [13]. Thirdly, Kirehe is an area that requires significant government attention because it frequently experiences children who are malnourished.

CHAPTER TWO: LITERATURE REVIEW

2.1 Resiliency to climate variability

An adaptation approach to climate variability for agricultural systems considers the implementation of agricultural management practices. It would be better to use or take advantage of biodiversity, ecosystem services, and ecological processes such as the plot, farm, and landscape level and help increase the ability of crops or livestock to adapt to climate change and variability [13]. Agricultural practices have experienced changes in rainfall amount, intensity, and spatial temporal distributions that pose critical challenges to agricultural production [11]. Variability of rainfall amount is widely documented and published but shifts in rainfall seasonality such as onset and cessation have received less attention even though it determines the timeline of cropping calendar activities[9]. The spatial and temporal variability of rainfall for the farmer is a measure to determine the period of cropping calendar in rain-fed farming activities[3]. It is also defined by using three stages the onset, cessation dates, and the length of the growing period. The onset and cessation dates refer to the day of the year when rainfall starts and ends[13].

Agricultural production is predominantly rain-fed, most subsaharien countries, they are also highly vulnerable to climate variability due to the prevalence of poverty, rapidly increasing population, and few technological developments. The increasing variability of rainfall amount and seasonality destabilizes the progress of young crops, and the ecosystem and threatens food production and livelihoods. Therefore, the climate variability of rainfall amount, in general, has attracted more attention compared to seasonal distribution[13]. The effective ways that recent help citizens in developed countries to adapt to climate impact are the following:

i. increase access to information about climate impact and weather extremes events,
ii. increase the technical capacity to incorporate information on climate impact,
iii. increase legal and administrative capacity to adapt to climate change

Ecosystem-based approaches to climate change and variability is a good choice to use natural resource to and adapt to climate impacts, and use of biodiversity and ecosystem services such as regulation, provisioning, support, and cultural part of an overall adaptation strategy to help people adapt to the adverse effects of climate change[9]**.** The use of biodiversity and ecosystem services aims to help people to recover and restore from climate change-related disasters and allows citizens to withstand these impacts by decreasing their vulnerability, through the sustainable use of natural resources and restoring or improving the biodiversity and ecosystem services provided [9]**.**

Generally, the observed and expected impacts of climate variability on farmers are factors by which developed countries, non- Governmental Organizations, and multilateral organizations are now actively promoting initiatives to help smallholder farmers adapt to climate change[4][9]**.** They also have initiatives for empowering, strengthening, and expanding the following four main categories of agriculture activities that are deemed to improve and bust the perception of farmers to manage climate risks and namely:

i. availing and developing modern technologies, such as collecting information by satellite-based early warning systems,
ii. give and facilitate government support such as subsidies, insurance, technical assistance, and among of others
iii. Providing and assisting the farmers in accessing credit, capital, risk-insurance, and adapting farm management practices[13] [14].

There are other adaptation practices that take advantage of existing ecological processes and biological diversity to provide adaptation benefits to agricultural producers.

2.3. Rainfall variability impact on Agriculture practices

Agricultural performance and land productivity in sub-Saharan Africa, despite its recent positive record, remain lower than in other countries [16]. However, in these countries, the vulnerability of agriculture production in many sub-Saharan countries that depend on rain-fed agricultural production is often attributed to rainfall shocks [17].

The three possible mechanisms through which rainfall shocks may influence agricultural productivity. First, rainfall shock is defined by the historically recorded rainfall and could be considered a direct input for crop production. Secondly, rainfall variability can also affect farmers' decisions regarding the use of productivity-enhancing external inputs and the barriers to input use, increasing the risk of crop loss, which in turn affects agricultural productivity [17]**.**

The suitable mathematical analysis to adopt the conventional measure of rainfall shock as a deviation of the previous year's rainfall during the agricultural season from the historical averages for 30 years during the crop-growing season for the same locality. The amount of the rainfall shock or effect variable as log-deviation, from past time average as follows .

$$RS_{it} = \log\left(\frac{\bar{R}_i - R_{it-1}}{R_i^{SD}} \right) \quad (1)$$

where RS_{it} is the rainfall shock or effect coefficient at time t and locationi,

$\bar{R}_i$ is the historical average rainfall for 30 years during the agriculture season at the location i.

R_{it-1} is the previous year's rainfall during the agriculture season at the location of household i for year t.

R_i^{SD} is the standard deviation of the amount of rainfall during the agriculture season at location i of household i (calculated over the 30 years).

For any deviation from the long-term mean is not necessarily a shock. Thus, we measure rainfall shocks using a dummy variable designed to capture extreme events as follows:

if $\left(\frac{\overline{R_i} - R_{it}}{R_i^{SD}} \right) < -0.5,$

there is negative rainfall shock (NRS)= 1

if , $\left(\frac{\overline{R_i} - R_{it}}{R_i^{SD}} \right) > +0.5$,

there is positive rainfall shock (PRS) = 1

The work and research done on agriculture research by using an instrumental variables regression approach, where agricultural productivity is instrumented with rainfall shock[18]. A negative rainfall shock decreases agricultural productivity and hence decrease household consumption.

2 .5. Farmers ‘perception to climate variability

The Farmers’ perceptions on climate variability such as variation of rainfall determines annual cropping decisions during agriculture seasons [11]. When the farmers’ perceptions are related with the trends recorded by the global , nation observation metrological center , means that they have information of prevalent trends and a higher likelihood of applying appropriate adaptive measures in order to ensure agricultural better practice[6]. The trend for increasing in temperatures accompanied with variability of rainfall and uncertainties about the onset of the rains have significant implications for the living style of hundreds of millions of people .Applying appropriate adaptation strategies to climate change will reduce vulnerabilities and cause significant challenges for many rural households[19] .

An increase of the temperature and extreme weather events has been projected across all ecological zones of subsaharien countries, based on General Circulation Models and using 1960s as the baseline, the country’s temperature has been projected to increase by in average 2.0 °C, rainfall is projected to decrease by 10.9%, Such changes will shorten the of growing season, delay rainfall of onset and early offset with implications for the agricultural and fisheries sectors as well as hydropower generation[20].

The recent studies conducted concerning farmers ‘perception on climate change impacts, the methods used including key informant interviews, focus group discussions and household questionnaire surveys were adopted to gain local insights into the complexity of climate variability and how it affects rural livelihoods[5][21].

With considering three agricultural seasons such as rainfall onset, cessation and length of growing the Period in northern Ghana is highly variable due to inconsistencies of rainfall onset and cessation dates, For instance, considering the reported early-onset dates of the rain season of the following rate -0.3 to -0.5 days/year means that the earlier onset of 7.5 to 12.5 days in this period ranging from 1986–2010 in northern region of Ghana[22]. Even though some research findings with content show a significant delay up to 0.88 days/year in the Volta basin located in northern Ghana, which translates to late onset by 35 days over 40 period of years[5][7].

The most available studies of climate change by using gauge observations have demonstrated that late onset or early cessation of rains and many frequency of dry spells within the growing season in northern Ghana cause a significant decrease of crop yields[8]. The rainfall variability of onset and mid-season breaks in the rain makes the agricultural calendar unpredictable and complicates decisions on sowing time, crop choice, and species to grows.

Accurate in forecast and prediction of the onset, cessation, and length of rainy days dates in agricultures practices is essential for the farmers to synchronize timing of cropping calendar activities. Exact necessary information on the rainfall onset and cessation can reduce the risks and costs of re-sowing seeds, means that replacing seeds when the previous are damage due to the season's false onset[10] .

The delay of onset of rains results the first outlook of a rainy season and it could be taken as an reliable early communication and warning of food insecurity during the time before harvesting. Two or more weeks' delay of onset of the rainy season makes drought conditions more likely. Getting information, Early identification and warning of drought conditions can inform farmers, policy makers for interventions to save lives and livelihoods[10].

The most challenges caused by climate variabilities, scientific researches and prediction and modeling have come in handy in mitigating and adaptation the effects. Thus, scientific prediction and modeling have taken center stage in the quest to minimize climate variability and change effects[19]. The scientific studies, indicate that climate variability and change impacts assessed through rigorous quantitative data and modeling. However, most farmers, given their peculiarities in rural spaces, do not readily obtain information on scientific weather prediction to guide their farming activities. They tend to rely heavily on their perception in predicting climate variables such as rainfall, temperature, and sunshine intensity[7].

Specifically in contexts where meteorological data are limited in access ,and, in some instances, unavailable for the rural folks, farmers perception proves useful [7]**.** Smallholders farmers tend to depend on their indigenous available knowledge in making such predictions, given their experience in farming. Indeed, indicated that the indigenous knowledge base of farmers proved useful in climate prediction and hence should be harnessed with scientific data in climate prediction in their study in Ghana[3]. Other studies cast doubt on the reliability and accuracy of farmer's predictions and perceptions concerning climate variability and change prediction. For instance,[6] found a variation between farmers' perceptions of decreases in rainfall with the scientific data in Uganda. [23]Observed variation in farmer perception of decreased rainfall and the objective scientific data in southern Ghana. The other literature prove that farmers' climate variability and its adaptation strategies are shaped by their perceptions and interpretation of climate variability data . For instance, Imran et al. Indicated that farmers' perceptions about increases in temperature aligned with objective data from the meteorological services in Pakistan.[3] Also found consistency between farmers' perceptions and scientific data. Krishna Bahadur et al. Argued for integration of scientific data with the subjective perception of farmers since a single reliance on subjective perception alone limits the reliability given the subjectivities and biases.

For instance, compared farmers' perceptions of climate variables such as temperature and rainfall in South Africa and observed an alignment of farmers' perceptions with the scientific data from the meteorological agency. [9]compared farmers' perceptions with the objective data in Pakistan, while undertook such a comparison in Tanzania. Found an alignment between farmers' perceptions of temperature increase with the scientific data in Uganda. In the specific case of Ghana, Yaro (2013) examined farmer perception of rainfall and temperature and found agreement in farmers' perceptions and the objective scientific data in southern Ghana. Most studies do not examine sunshine in the climate variables, even though it remains an important variable for plant growth and productivity.

Most studies have heavily made analysis of scientific historical data on climate variables, especially rainfall, temperature and sunshine[6] . Others have based on solely on farmer's traditional perceptions of climate variability and change. For instance, in Ghana, examined general conclusion from the related literature shows mixed conclusions between farmers 'perception of climate variables and the scientific data[11]. In particular, variations exist between the perception of temperature and rainfall relative to the scientific data. While some studies found agreement, others showed variations[9].

2.6. Farmers 'knowledge on rainfall variability

Inadequate weather observation networks hamper timely and accurate rainfall forecasts that can guide farmers on cropping calendar decisions [2]. The observation gauge network in country is characterized by low density, skewed distribution, short-term records, and significant data gaps [6]. The information generated from a few gauge stations with long-term data is applied to generate agro-advisories over a large area beyond the 50km^2 recommended by World Meteorological Organization .

Most gauge networks and distribution are in the main urban centers, resulting in inadequate coverage in rural areas where agricultural activities take place [12]. Satellite-derived rainfall can complement the sparse gauge network to produce spatially explicit layers representing the onset, cessation, and length of the rain season. In agriculture practices, policy makers and government institution use and avail the data generated from remote sensing platforms and then they are applied to identify critical area where agricultural production experiences a high risk of climate change and variability[2]. The knowledge of the locations that are more vulnerable to shifts in seasonal calendars associated with climate change and variability is essential to in guide the evidence-based decision of appropriate climate-smart technologies and agriculture management best practice [17].

2.7. Determination method of onset and cessation rainy seasons

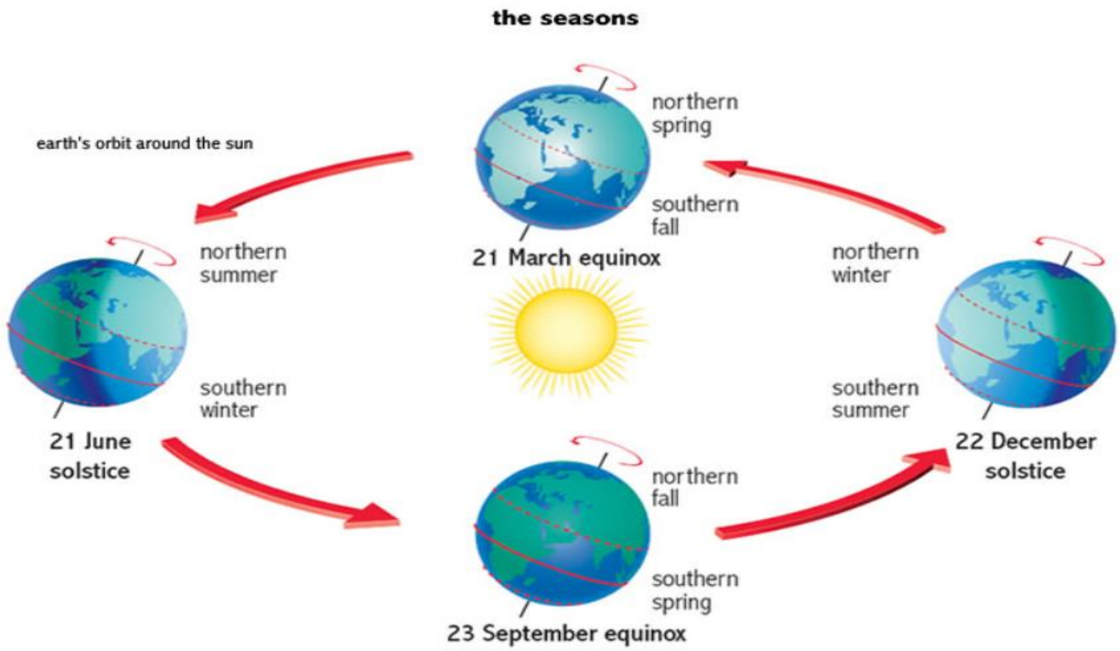
Globally there are several methods to determine rainy season onset and cessation dates; at least 18 methods have been applied to west Africa alone [10]**.** The most suitable definition of thresholds, the onset rainfall is referred as the moment corresponding with first of two consecutive days receiving at least 1 mm of rain whose total is greater than 20mm [14]. At the same time as an additional criterion considered if there is no seven days or on week of period of total rainfall receiving less than 5 mm or average gauge data of station during twenty consecutive days is added to avoid confusion of detecting false onset[19]. Threshold-based measures are appropriate for local agronomic studies based on station data, as they are designed to take into account availability of soil moisture.

2.8. The Climatology of Rwanda

In general the seasonally rainfall timescales of Rwanda , rainfall in tropic East Africa within about 10^o of the equator is typically bimodal in most regional environments from humid uplands in East Africa to arid lowlands of it . However, the timing of the bimodality depends on latitude and the annual evolution of the Intertropical Convergence Zone[24] around to the equator even Rwanda tend to have two rain-seasons in March–May that is considered as the long rains period and September–December that is considered as the short rains period , while regionals further from the equator have climates closer to a unimodal rainfall pattern. Locations a little north of the equator tend to have a longer dry period during the boreal winter and receive comparatively little rain from December to February while having a shorter and/or less dry period during the boreal summer (June–August)[24]. Locations that is a little south of the equator including Rwanda tend to have a longer dry period during the austral winter with comparatively little rain from June to August while having a shorter and/or less dry period during the austral summer [25]**.** For Rwanda specifically, one study of historical station rain gauge data found that a little over 40% of the annual rainfall occurred in the March–May season, between 30 and 40% occurred in the September–December season, and about 15–20% occurred in January and February with June–August typically having only about 5% of the annual rain[9].

The Rwanda‘s agricultural activities and crop production are subjected to risks of various types such as, meteorological challenges like irregular of rainfall and air temperature , economic and price-related risks, climatic and weather, environmental, pests and diseases, at different scales .Climate variability impacts the agriculture sector through increased climate variability with regard to air temperature, rain, frequency and intensity of extreme weather events flood and landslade, changes in rain patterns and in water availability.

Climate variability impacts of significance for agriculture and food security are likely to be temperature increases and more frequent droughts, with the nature and timing of impacts varying across regions such Eastern Provinces like. Climate impacts may alter the extent of areas suitable for agriculture and the length of growing seasons, affecting crop yields as well as hunger and nutrition. In addition, climate change may alter the occurrence and distribution of pests that may harm or ruin crops and livestock[9]. Globally, the annual seasons of the years are explained most cultures as Spring, Summer, Fall (Autumn), and Winter.



The picture 1 : ***Meteorological and Astronomical seasons mapping***

The astronomical definition uses the dates of solstices and equinoxes to define the start and end of the seasons. Spring and Fall (Autumn) begin on the Spring (vernal) and fall equinoxes, and Summer and Winter begin on the Summer and Winter solstices. The Summer and Winter Solstices mark the longest and shortest days of the year where the Earth is tilted the most towards the Sun during the Summer solstice in north hemisphere, and furthest away from the sun during the Winter Solstice.

The season for Northern hemisphere the summer solstice occurs around June 21st, at the same time,the winter solstice around December 22nd . The metrological season such Spring (Vernal) equinox occur around March 21st, and the Fall (Autumnal) equinox around September 22nd. In the Southern hemisphere the seasons are reversed but begin on the same dates as shown in the image above. However, the timings of the equinoxes and solstices vary each year, which changes the length of the astronomical seasons.

2.9. Efficient adaptation to climate change

Globally available researches and scientific have begun to address adaptation and have made several important contributions to evaluate efficiency of undertaken activities[21]. First, adaptation will reduce damages of crops and forestry in agriculture sector, improve water resource management benefit to the farmers and their health as well. The most agronomic studies of agriculture in the United States reveal that efficient adaptation will reduce damages cropping system from climate change on the world[26]. The most studies available on climate change effects and its effectiveness adaptation on other sectors of the United States economy also make known the importance of adaptation [20]. Some adaptations are initiated after effect, they can be undertaken after climate has changed whereas other adaptations are before extreme weather events and climate change, they require an ability to anticipate and forecast climate [21].

Table 1 : Global sectors' adaptation to climate change

affected sector	public/private	adaptation
The climate variables and their changes affect agriculture	Private	Alter crop species to improve yield
		Irrigation practices in the area of rainfall deficit and drought
		Alter the timing of sowing in the current season relative to the previous preferable date.
	Public	Plants breeding
Climate change impact affects Forestry	Private	Action to harvest vulnerable trees and sustain the young ones.
		Intensify management system
		Activities to Plant new trees
Water	Public	Shift water to high-value uses
		Divert/store more water
		Flood zoning

The energy sector is a key that should help citizens	Private	Invest in water efficiency
Climate variability degrades Biodiversity	Public	Move endangered species
		Manage landscapes
		Plant adapted species
Climate change affects the Health system of livings things	Public	Control disease carriers
		Treat infected people
		Control diseased ecosystems by using pesticide
	Private	Prepare for extreme weather events
The climate change impact the Sea level to rise	Private	Depreciate vulnerable buildings Public
	public	Sea walls as needed

Climate change adaptation is efficient practically only if the cost of making the effort is less than the resulting benefits, we argue that public policy should encourage efficient adaptation. The impact literature has generally not examined the efficiency of adaptation [26]**.** On the wide world many models of impacts were constructed that either ignored potential responses by both individuals and societies or introduced these responses. As it is explained efficient adaptation responses can reduce the overall costs associated with climate change, but inefficient responses can actually increase costs[21].

2.10. The benefit analysis of adaptation activities.

Analysis to implement adaptation uses the simple model of an economic sector explaining adaptation to climate change impact. Consider that an individual can engage in an investment that shall tend to decrease the damages or increase the benefits from climate change. we define reduced damages and increased benefits in terms of a benefit as a given function with variable arises the number of adaptation activities, A, and the e temperature change, T :

$$B = f(A, T) \qquad (2)$$

where $dB = dA > 0$ and $d^2B/dA^2 < 0$, (3)

$$dB = dT > 0 \text{ and } d^2B/dT^2 > 0. \qquad (4)$$

The Benefits of the investment activities are assumed to increase at a decreasing rate with adaptation relative to the above equation. The profit and benefits are greater with a high increase in temperature. Even though adaptation is rarely free. There is also a cost of function or investments associated with adaptation either from lost opportunities, The loss in the cost function is the following :

$$C = g(A),$$

where $dC = dA > 0$ and $d^2C = dA^2 > 0$. (5)

The cost rises with adaptation. It is not a function of the temperature change but this could be included if relevant. The purpose of the individual is to maximize net benefits, to choose a level of A which maximizes benefits minus loss in costs,

$$B\,(A, T) \; - C(A) \qquad (6)$$

In Sub-Saharan Africa countries, many researches on climate change observations by subsistence-oriented communities. The farmers' adaptation activities and responses in mountain regions have been conducted in East Africa countries [3], like Tanzania with much less is known about the Albertine Rift, the western branch of the East African Rift, which covers parts of Uganda, Rwanda, Burundi, DR Congo, and Tanzania [11].. The region as Albertine Rift is a climatically complexity region comprising both bimodal and unimodal rainfall regime zones, as well as important rain shadow impact related to irregular topography [12].

Rwanda [17], and DR Congo [19] have increased our understanding of climate change impacts and farmers' adaptation responses for this region, but limited information is not available for Burundi. A recent analysis of rainfall amounts and distribution over Burundi showed decreasing trends for both annual and seasonal rainfall, even though the mountainous region. [20], and an increase in extreme weather events, particularly since the early 2000s [21].

These works highlighted that extreme weather events often lead to crop failure and socioeconomic losses, but they did not give details on the impacts on different crops nor the adaptation strategies implemented by smallholder farmers. Smallholder farmers can employ a wide range of adaptation strategies, including:

(i) Proactive adaptations activities and decisions made before a growing season to provide risks managements

(ii) Reactive adaptation activities responses to perceived and forecasted weather conditions that drive adjustments to crops or cultivation practices)

(iii) Pre-post adaptation activities are responses that are implemented to reduce the negative impacts of climate shocks which have already occurred) [22].

Adaptation strategies can also be clustered as follows, on-farm and off-farm strategies. The most common on-farm strategies are the maintenance of high agrobiodiversity with a purpose to spread the risk of crop failure among species and varieties which are susceptible to different climatic stresses, and soil or water conservation practices [23].

Two other in most prominent off-farm strategies are off-farm labour and membership in farmers' Organizations, which can facilitate improved seeds, inputs, credit and subsidies, or technical support; see [24]. Above 20 different adaptation strategies are used by Tanzanian mountain farmers [11].

In general, as wealthier families have greater access to land, more resources to invest in irrigation or inputs and/or better access to information and technologies, they tend to employ a wider range of adaptation strategies [26]. Recent work from Rwanda has highlighted that agricultural intensification policies can also affect farmers' adaptation, with positive or negative effects depending on household wealth [17,25]. The Crop Intensification Program of Rwanda, implemented in 2008, aims at increasing agricultural productivity through the promotion of hybrid seeds and the increased use of agrochemicals and agro-engineering techniques, such as draining marshland and constructing terraces [25][26]. Across sectorial levels, the performance contracts of households submit written agreements in which they state that they will cultivate selected crops several months before the growing season begins.

The farmers failing to meet their contracts or found planting non-approved crops can be publicly disgraced and even penalized [17]. The climate intensification programs discourage crop sharing between farmers, the cultivation of multiple small areas located at different elevations, polyculture, and the cultivation of certain crops such as sweet potato, cassava, ciraza, or sorghum [16]. Although polyculture contributes to households' food security throughout the year for example, while cassava is ripening, beans can be eaten, see [11]), sweet potato, cassava, ciraza, and sorghum are perceived by local farmers as being more drought- and flood-tolerant crops than the government-approved maize or beans [23]. Although the CIP has raised crop yields, and the conventionally measured poverty rates have fallen in Rwanda in the past few years, some authors have highlighted that such agricultural intensification policies appear to be exacerbating rural landlessness, inequality, and food insecurity [27].

2.11. Temperature effect on crop production

Climate variability and change have significantly adversely affected global agriculture production[27,28]. The temperature in agriculture sectors is one of the major environment factors affecting the growth, development and yields of crops, especially the rate of development and constraint to the socioeconomic. On one hand, crops have a basic requirement for Temperature to complete a specific phenophase or the whole life cycle[,27][29].In the 21st century, the Intergovernmental Panel on Climate Change (IPCC) assessment report indicates that most countries will experience an increase in average temperature, more frequent heat waves, more stressed water resources, desertification, and periods of heavy rainfall[28]. Climate parameter especially temperature has a great negative effect on some crop such as maize revenues but a positive one on tea, while rainfall has a negative effect on tea. We find that some in upland and lowland areas crop relies on stable temperatures and consistent rainfall patterns and any excess would negatively affect production[26][30].

Three decades ago have been the warmest in world history, with each decade the rate of warming increases more than the preceding one[27][31]. for coming future impacts in agriculture production are projected to worsen as the temperature continues to rise and precipitation becomes more unreliable[27][31]. The rising temperature would expose millions of people to drought and hunger.

The crops damaged rise from changes in climate and sea-level changes associated with global temperature change, and frequently reflect prediction to changes in precipitation and other climate variables in addition to temperature[27]. In mid-to high-upland regions, moderate warming benefits cereal crop and pasture yields, but even slight warming decrease yields in seasonally dry and tropical regions.

Modelling results for a range of sites find that, in temperate regions, moderate to medium increases in local mean temperature (1 to 3°C), along with associated CO_2 increase and rainfall changes, can have small beneficial impacts on crop yields[4][21]. At lower latitudes, especially the seasonally dry, tropics, even moderate temperature increases (1 to 2°C) are likely to have negative yield impacts for major cereals, which would increase the risk of hunger. Further warming has increasingly negative impacts in all regions[4][19].

2.12 . Temperature thresholds effect on crop production.

In a global scale in agricultural practice, the temperature thresholds for a range of crops from cereal crops to horticultural crops and then to legume crops were identified through an extensive literature review[29][32]. Identification of temperature thresholds provides a basis for quantifying the probability of exceeding temperature thresholds which is a very important aspect of climate change risk assessment[30]. Improve farmers' knowledge on how hot temperature, affect crop yields now, and in the future, should contribute to the current and future management of risk in cropping systems [33] Different research have investigated how the warmer temperatures and elevated atmospheric CO2 concentrations expected under climate change scenarios affect crop plants .

In general, an increase in mean seasonal temperature of 2–4◦C cause a decreases the yield of annual crops such as wheat. Much of this decline in yield is due to shorter crop durations at these warmer temperatures[28][29].

CHAPTER THREE: METHODOLOGY

This chapter gives a brief overview of the study area and focuses on appropriate data with associated methods, tools, items, and suited techniques to collect and analyze them. In the end will have expertise knowledge and information about the farmers' perception of climate change from the Kirehe district.

3.1 Description of the Study Area

The Kirehe district is in of Eastern Province part with a 1,192 km^2 surface area and 460,860 population with 84,424 households that have at least one farmer [34]. It comprises areas in the far south-eastern corner of Rwanda, bordering Tanzania on the East side and south is Burundi. The district has faced crucial challenges in the previous years where there were recognizable lower levels of agricultural output and insufficient processing units for agricultural transformation, weak level of investments of private investors, a limited number of different infrastructures for development such as roads among others . The average annual temperature is 19.4 °C, the rainfall here is lowest relative to other district where an averages of 898 mm and an average of 20.2 °C, September is the warmest month. June has the lowest average temperature, which is 18.9 °C while the precipitation varies 148 mm between the driest month and the wettest month. During the year, the average temperatures vary by 1.3 °C.

The district is characterized savanna, acacia trees, few natural forests, and the existence of the Kagera River contributes to a temperate climate in the region .The percentage of the land under consolidation is 33%, the land under protection against soil erosion is 73.6%, the land under irrigation 5.8%, the percentage of household using improved water source 84% and electricity of lighting 40.6% (NISR, EICV5) ,energy for kerosene lamp (3.8%); candle (3.3%) and firewood for lighting (1.4%),However a high percentage of the households (0.4%) use an unspecified source of energy for their lighting. The energy for cooking 83.6% of population firewood, 3% charcoal and 11% Gas.

3.2. Data collection

This study uses monthly and annual rainfall and temperature data (maximum and minimum) from Rwanda meteorological center in specific eight stations in Kirehe District for 39 years from 1981 to 2021. We have to assess the long-term trends of the temperatures for almost four decades. Moreover, survey data are used to explore the farmer's perceptions to the climate changes on two rainfall season MAM, OND and their coping strategies. The implementation of specific objectives of this study include but are not limited to the following activities: examine the methods farmers apply to forecast the onset of rainy seasons, assess the crop management practices applied as adaptation strategies and climate vulnerability effects farming activities.

3.3 Methodologies and Research Design

This research applies a survey embracing farmers' cropping activities and climate change effects through a questionnaire structured in accordance with research objectives. The survey on the field enables quantitative analysis of trends in temperature and rainfall, knowledge, opinions, perception and the determination of relationships among climate information data for farmers**.** A developed structured questionnaire facilitates finding out the responses of farmers concerning climate variability indicators such as temperature, rainfall and the effect of their trends and variability to farming processes.

There four questions structured on questionnaires see **appendix E** where the first Question concerns what change farmers observed in climate over the past 10-25 years in their community therefore to grad the responses from farmers, there is scoring technics used such as extremely high = 5, very high =4, moderate =3, Neutral =2 and low =1 with the same question like in your opinion how does climate change affect livelihood and property in this community. For the second question concerning what types of adaptation measures and strategies farmers taking to protect the crop from climate change impact for this we glad as the following excellent effective =5, very effective =4, effective=3 , Neutral effective=2 and low effective =1 as well as the question concerning what are the method farmers used to forecast onset of rain in agricultural season.

To achieve the target simple random sampling method was used to give farmers in the targeted sample an equal chance of being selected . Simple random sampling was using to select respondents because of its representativeness and reduction in biases.

To determine the proportion of farmers to be sampled and interviewed, we consider households that do agriculture activities, agricultural household refers to households that have at least one person engaged in agricultural activities; that is, either in crop or animal husbandry that working towards sustainable food production in Kirehe. The distribution number of farmers in the district area who do agriculture for this study, the formula below should be employed by **Singh and Masuku 2014** [30][30]**.**

$$n = Z^2 \times \left(P\frac{1-P}{e^2}\right) + \left[Z^2 \times \frac{P(1-P)}{e^2N}\right] \quad (7)$$

Where n= the number of sampled farmers in case study, *Z* = 90% confidence level, with corresponding standards normal value of 1.65] , *N* = Household with at least one farmer is 84,424 to be sampled [*N* = 84,424, assuming that 75% of whole population of Kirehe district are farmers that have no perception to climate change and been affected by climate their agriculture practices where 4,852 are urban farmer and 79 572 are rural farmer and less knowledge to it [30][34].

e = margin of error [e = 5%, = 0.05]. *P* = percentage probability of falsely rejecting the null hypothesis [*p* = 75%, = 0.75]. Therefore, after replacing the values into (1), the sample size will be, the following number[25].

$$n = 1.65^2 \times \left(0.75\frac{1-0.75}{0.05^2}\right) + \left[1.65^2 \times \frac{0.75(1-0.75)}{0.05^2 84{,}424}\right] = 206 ,$$

, n is the sampled farmers that represent the whole study areas, to get scientific significant and understand the context of the climate change problems, risks and opportunities related to climate variability to the farmers, associated adaptation measures will be considered. The sampling methods was randomly sampling strategy[30].

Table 2: Sampling design for each Primary Sampling unit in Kirehe' sectors

District	Sectors	Households	Formula	Sample size
Kirehe	Gahara	44,462	$\frac{44{,}462 \times 206}{460{,}860} = 19.87$	20
	Gatore	31687	$\frac{31687 \times 206}{460{,}860} = 14.16$	14
	Kigarama	37136	$\frac{37136 \times 206}{460{,}860} = 16.59$	17
	Kigina	34642	$\frac{34642 \times 206}{460{,}860} = 15.57$	16
	Kirehe	29547	$\frac{29{,}547 \times 206}{460{,}860} = 13.20$	13
	Mahama	81,014	$\frac{81{,}014 \times 206}{460{,}860} = 36.2$	36

	Mpanga	40,173	$\frac{40{,}173 \times 206}{460{,}860} = 17.95$	18
	Musaza	30,095	$\frac{30{,}095 \times 206}{460{,}860} = 13.45$	13
	Mushikiri	32,841	$\frac{32{,}841 \times 206}{460{,}860} = 14{,}67$	15
	Nasho	33,665	$\frac{33{,}665 \times 206}{460{,}860} = 15.05$	15
	Nyamugari	42,938	$\frac{42{,}938 \times 206}{460{,}860} = 19{,}29$	19
	Nyarubuye	22,660	$\frac{22660 \times 206}{460{,}860} = 10{,}12$	10
Total sectors	12sectors	460,860		206

Table 2 give the sample size per each sector of district is a Primary Sampling Unit . They are obtained by calculating by using inverse proportion because the selection probability for each element in a sector was set to be proportional to its size measure up to a maximum While selecting a sample I took into consideration the varying size of each PSU within the study area. The sample size was calculated based on the population itself.

3.3. Acquisition of Data on Climate Variability

To assess the climate variability and trend in the case study area, data concerning the rainfall from 1981-2021 means that 39 years in past are essential and be recognized. The rainfall and temperature records were collected in the form of excel sheet from the Rwanda Meteorological Centre of eight stations see Appendix E All of these data helped to evaluate and analyze the climate variability, its significance and its related impacts on study area.

Table 3: Datasets used in case study

No	Types of data	Usage Tools Analysis	Government Institutional Resources
01	The Rainfall and temperature records	Analysis of historical rainfall variability in recent 39 year ago	Rwanda meteorological center
03	Administrative boundaries	Being familiar with the case study	National Institute of Statistics in Rwanda (NISR)

04	Rate of crop production	Identification of crop in accordance of species the sampling methodology	National Institute of Statistics in Rwanda (NISR)
05	Primary data of farmers perception	Questionnaires distributed to the filed	All sectors of Kirehe district

3. 3 .1. The Climate Variability Analysis

Temporal climate analysis was made up by using ANOVA, to achieve the first, the second and fourth specific objective which is to determine the climate variability such rainfall, temperature and their corresponding trend over Kirehe district.

The temporal analysis of seasonal to annual rainfall consisted of determining variability of agriculture rain seasonal and annual rainfall climatology. Temporal variability of rainfall was analyzed by using a time series analysis where seasonal and annual climatology were computed and subjected to a time series analysis using excel.

3.3.2. Rainfall variability and Temperature Trend Analysis

The most climatic researches have different methods to describe trends in meteorological variable. These methods can be named into different categories, such as graphical, regression equations , and statistical methods such as Mann-Kendall[35]. In this study, the trend analysis was established through a graphical plot while Statistical methods were used to test the statistical significance of the observed trends in a time series.

3.3.3. Graphical Method

The graphical method representation involves plotting agriculture rainfall seasons from March to May (MAM), October to December (OND) where more Rwandans farmers carried out agriculture activities and annual rainfall data against time[19][2]. The important of this strategies is to provides quick visual observation and knowledge of the presence trend in a given time series.

They are several methods to describe trends in climatological data, these methods can be grouped into different categories, including: graphical representation, polynomial representation, and statistical methods[35]. In this study, the trend analysis was established through a graphical plot while Statistical methods were used to test the statistical significance of the observed trends in a time series.

The data analysis used in this research has aimed to get information to assessment of the effect's climate change has on the farmers, to achieve this, descriptive and inferential statistics (**Forbes 2015**) were employed to these objectives. Descriptive statistical methods such as Chi-square test method , graphical charts, percentages, and tables were used to achieve objectives one and three while Inferential statistical methods such as cross-tabulations. The data collected from the field were organized , SPSS was used to manage the data collected. In order to judge the significance of association between two parameters, we have to make an use of Chi square test such Null Hypothesis and Alternative hypothesis by finding the value of Chi-square (χ^2) and using Chi-square distribution the value of χ^2can be worked out as following

$$\chi^2 = \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad (8)$$

$i = 1, 2, 3$

$j = 1, 2, 3 \ldots$

where

Oij = observed frequencies

Eij = expected frequencies.

Mann-kendall methods has been used and classified as parametric and non-Parametric tests. In the research, the Mann–Kendall, a nonparametric rank-based test used to determine the nature , magnitude of the trend of a given rainfall and temperature time series[35][24] . The MK test has been used in many researches at globall scale and the world as well. Positive values of MK coefficient denote an increasing upward trend whereas negative values denote a downward slope. To estimate the magnitude of rainfall change, the Theil–Sen's slope estimator was used, The statistical significance was reported on the basis of level of significance (p-value or alpha) of 0.05. The Mann-Kendall [31][36] were calculated as follows:

$$S = \sum_{i=1}^{n-1}\sum_{j=1+i}^{n} \text{sgn}(\ (\chi_j - \chi_i) \qquad (9)$$

The trend test is done to a time series χ_i, which is ranked from i = 1,2,3,…,n−1, which is ranked from j = i + 1,i + 2,i + 3…..n. Each of the data points xj is taken as a reference point,

In Equation (1), n stands for the number of data points whileχ_i and $\chi_j$are the ranked data point whose the values in the time series i and$j$, where ($j > i$) respectively, and $sgn(10)$ is the sign function as:

$$Sgn\,(\chi_j - \chi_i) = \begin{cases} +1 \;\; if \;\; (\chi_j - \chi_i) > 0\,, \\ 0 \quad if\; (\chi_j - \chi_i) = 0\;\;, \\ -1 \quad if\; (\chi_j - \chi_i) < 0, \end{cases} \qquad \textit{(10)}$$

The variance of Kendall score S would be determine by using the Equation (9) as:

$$\mathbf{Var(S)} = \frac{\mathbf{n(1-n)(2n+5)} - \sum_{\mathbf{t=1}}^{\mathbf{P}} \mathbf{t_i(t_i-1)(2t_i+5)}}{\mathbf{18}} \qquad \textbf{(11)}$$

The determination of statistically significant trend is evaluated considering the Z value. In This case statistic is used to test the null hypothesis such that no trend exists. The standardized test statistic Z is given by

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}} & if\; S > 0 \\ 0 & if\; S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} & if\; S < 0 \end{cases} \qquad (12)$$

A positive Z show that an increasing trend in time series of temperature and rain while a negative Z indicates a decreasing their trends. To test for either increasing or decreasing monotonic trend at P significant level, the null hypothesis H_0 is rejected when the absolute value of Z is greater than $Z_{(1-P/2)}$,where this $Z_{(1-P/2)}$ is obtained from the standards normal cumulative distribution table and P is the significant level for thee test[24][35].

The trend refers to the general movement of a series over an extended period of time or it is the long-term change in the dependent variable over a long period of time . The trend is determined by the relationship between the two variables of temperature, rainfall and their temporal resolution[19][35].

To assess magnitude and direction in the trend the statistical method such as regression analysis and coefficient of determination R^2 were used for the significance of trend of temperature and rainfall. The trend were derived and tested by Mann–Kendall (M–K) trend test and slope of the regression line using the least squares method. The mean, SD and coefficient of variation (CV) of rainfall and temperatures have been calculated to analyze the relationship[7][35].

The coefficient of variation is a critical because it measures the variability of the data or how dispersed the distribution of the data is from or around the mean. The higher the value of the coefficient of variation (CV), represent the higher or the degree in variability climate indicators .

3.3.3 . Coefficient of variation

The coefficient of variability determined by the following

$$\text{CV} = \frac{\sigma_{xi}}{\mu_{xi}} \quad \textbf{\textit{(13)}}$$

Where xi is the climate variability indicators (rainfall, temperature, and sunshine), μ is the mean, and σ is the standard deviation of each climate variability indicator.

3.4. The correlation coefficient(r)

The correlation coefficient $r(p, cp)$ was used to evaluate the level of association between the observed values and the model outputs means that relationship between rainfall with crop production in specific period and temperature with crop production in specific period[24][7].

$$r(p, cp) = \frac{\sum(P-\bar{P})(CP-\overline{CP})}{\sqrt{\sum(P-\bar{P})^2 \sum(CP-\overline{CP})^2}} \quad (14)$$

where P represent rainfall ,$\bar{P}$ is an average rainfall in specific period taken in case study, CP and $\overline{CP}$ crop production quantity .

$$r(p, cp) = \begin{cases} 1 \\ 0 \\ -1 \end{cases} \quad (15)$$

A correlation coefficient with value 1 denotes positive linear relation while correlation coefficient of -1 denotes a negative linear relationship in the observed and model outputs values. A correlation coefficient equal to 0.0 represents no association or impact between the two variables the observed values and the model outputs.

CHAPETER FOUR DATA ANALYSIS AND DISCUSSIONS OF RESULTS

In this sectional of research focus on the knowledge and how handling processes , level of understanding to climate change that affect agriculture practices Kirehe district. The social classes variables such as marital status, Ages, level of education, and experience were captured during the data collection. These classes with their characteristics are required to understand and contextualize the objectives of the study ,The research has been conducted across 12 sectors of Kirehe district . it is an area of the country where there was identified as district of most minimum rainfall and prolonged drought that hinder the performance of agriculture production and provide much confusion to the farmers relative to other

District of Rwanda . The result of respondents have been analyzed by using statistics tool chi square test or verifying hypothesis and graphical presentation . The farmers of Nasho sector have raising the following results

4.2. Farmers' perception to climate change at Nasho Sector

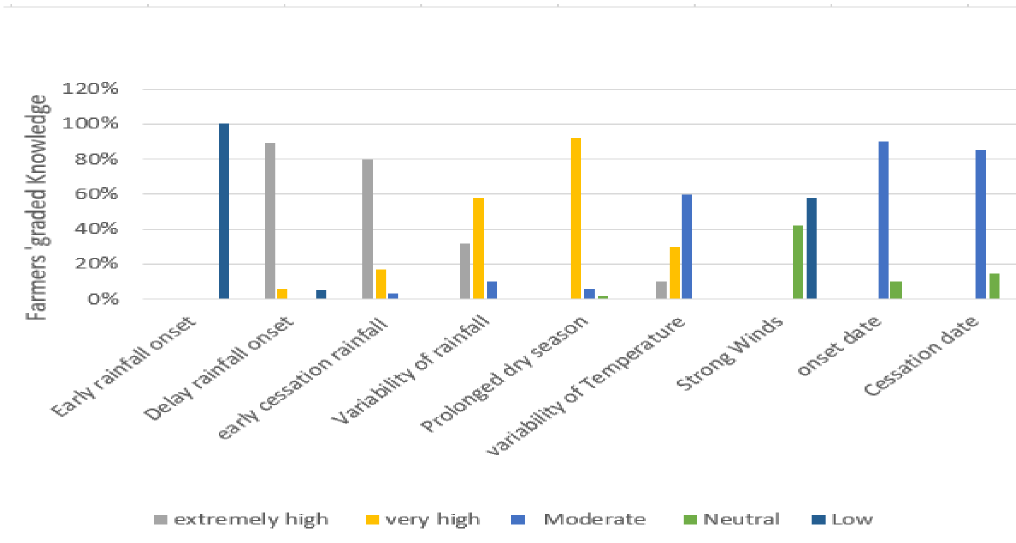


Figure:1 This graph represent farmers 'knowledge to climate variabilities and weather event at Nasho Sector

Referencing to the farmers responses and knowledge to climate change, the vulnerability to climate impact that have been identified are following, Early rainfall is score 100% as moderate, the delay of rainfall is 90% extremely high ,80% extremely high to early cessation of rainfall reveals that early cessation rainfall in this community is mostly likely happen. The most agriculture seasons face the poor agriculture yield, , meaning that during some agriculture seasons, the rain is much irregular in term of delay and other season the situation changes therefore they have made farmers more being confused to the time of sowing crops ,others crops dries up at immaturity moment, 90% very high is scored to the prolonged drought ,90% of respondent reveal that they are facing the prolonged drought that cause the lack food and persistence of famine in usually period, 82% moderate knowledge for onset date and, 80% moderate knowledge to the farmers,then the farmers are not aware and have not accuracy information to the prediction of rainfall date. The statistical analysis of farmer's responses are described below as following

Groups	*Count*	*Sum*	*Average*	*Variance*

extremely high	4	185	46.25	322.9167
very high	5	116	23.2	411.2
Moderate	8	127	15.875	322.9821
Neutral	5	22	4.4	6.8
Low	3	28	9.333333	32.33333

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4482.348	4	1120.587	4.512772	0.009244	2.866081
Within Groups	4966.292	20	248.3146			
Total	9448.64	24				

In order to conclude the relation between farmers' perception to climate change impact by using test analysis of data using test statistics for P-value calculated is 0.009244 less than $\alpha = 0.05$ therefore we reject Null Hypothesis , meaning that farmers have significance and clear evidences to perception to the climate change impact at Nasho sector .

4.3. Farmers' knowledge to climate change at Mushikiri Sector

Locally, the farmers from Mushikiri sector and their responses concerning knowledge to climate change impacts and specific vulnerably impact that have been identified are following , 60% moderate to the delay of rain fall, in this case the farmers lack precise time for starting period of rain fall in this community . In this area, the farmers reveal that early cessation rainfall has been scored at 93% as extremely high. The farmers of this community are suffering the loss crops due insufficient rainfall, crops dries up, it is mostly likely to happen in most agriculture season that lead to the poor agriculture yield and hinder socio-ecomic income of aspect of households.

,. For prolonged drought is graded by 40% very high and 60% extremely high respondent reveals that they are facing the prolonged drought that cause the lack food in usually period and famineThe 60% temperature variability and 60% is graded to Strong wings as extremely high that lead to destruction of crops in garden and lead own the trees and remove the ceiling of houses. The variability of rainfall is scored at 50% as extremely high, 30% very high and 20% moderate.

SUMMARY

Groups	*Sum*	*Average*	*Variance*
Extremely high	145	20.71428571	220.2380952
very high	280	31.11111111	307.1111111
Moderate	90	10	72
Neutral	30	6	25.5
Low	9	1.8	1.7

ANOVA

Source of Variation	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4	1010.463492	6.792092082	0.000512263	2.689628
Within Groups	30	148.770582			
Total	34				

In order to built up the correlation between farmers' perception with climate change impact using statistical analysis give P-value 0.000512263, Due to analysis the calculated P-value is less than α =0.05 value, therefore we have to reject Null Hypothesis, meaning that farmers in this sector have significance perception and knowledge at Mushikiri sector .

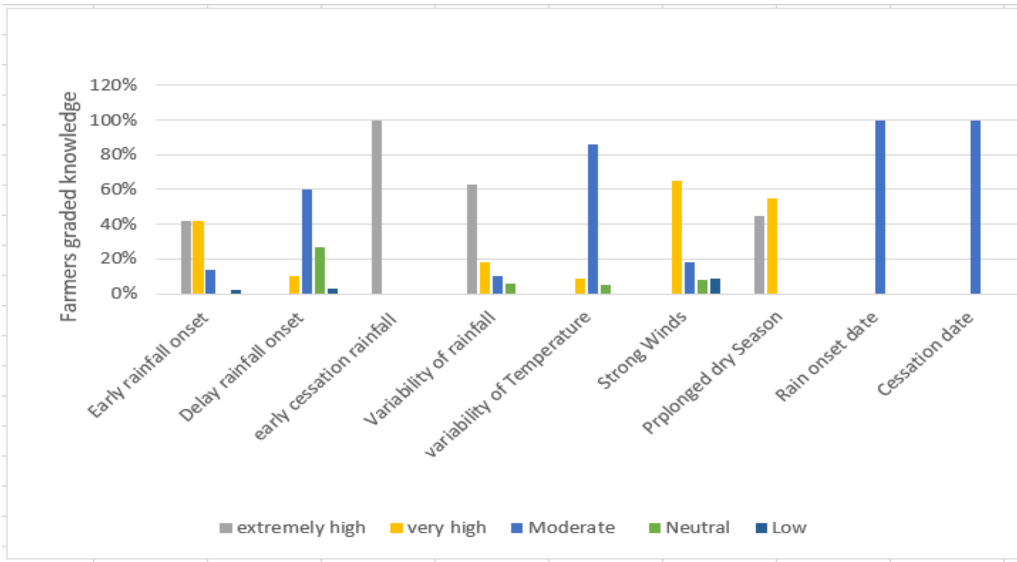


Figure :2 This graph represent farmers knowledge to climate variabilities and weather event at Mushikiri Sector.

4.3. Farmers' perception to climate change at Mpanga Sector

The Mpanga sector is among most sectors that is vulnerable for climate change impact of Kirehe district , where government institutional such as REMA Rwanda Environmental Management Agency and other private sector initiated adaptation activities to protected and restored ecosystem ,the different activities are carried out as following ,irrigation of small scale like 4000 ha of land used , practices of agroforest and restore degraded ecosystem . They are extremely sunshine, in this community farmer score 9% as extremely high and 75% very high to prolonged drought, the early cessation of rainfall is scored at 37% as extremely high and 40% very high level meaning that , there are a high risk concerning crops lost before coming mature and low yield, the strong wind is moderate at 65% level, variability of rainfall is 50% as extremely high and 40% as very high, the cessation date is 60% very high knowledgeable of farmers and 40% extremely high and 50% very high to onset rainfall knowledge of the farmers.

.the

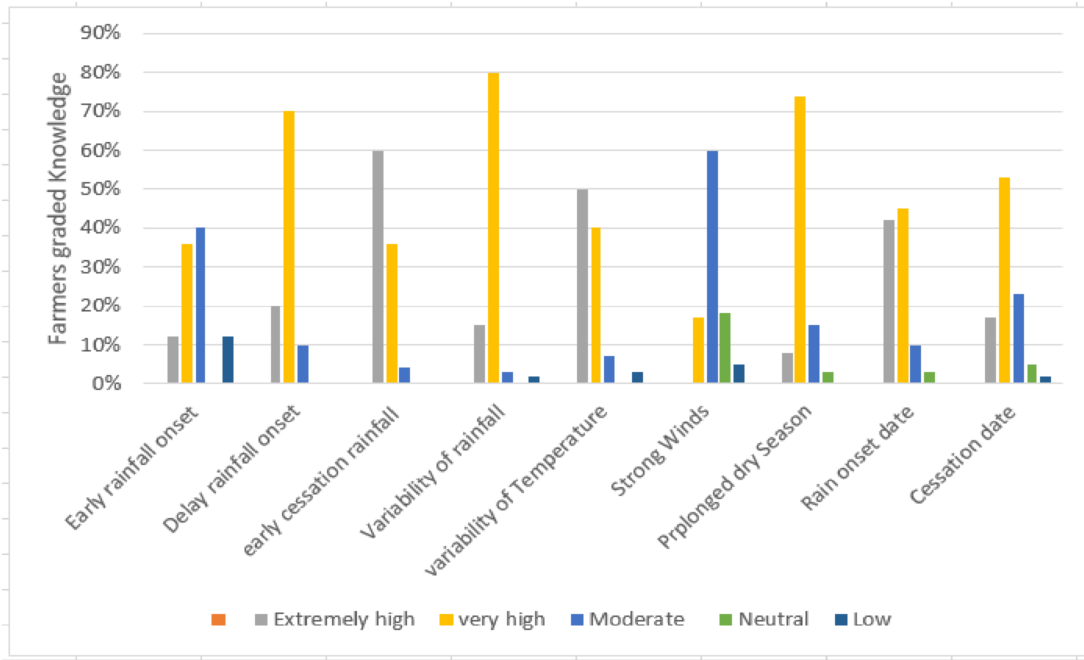


Figure :3. This graph represent farmers knowledge to climate variabilities and weather event at Mpanga Sector.

In order to built up the correlation between farmers' perception with climate change impact using statistical analysis ,it gives P-value 0.000512 with $\alpha = 0.05$

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	7	145	20.71429	220.2381
very high	9	280	31.11111	307.1111
Moderate	9	90	10	72
Neutral	5	30	6	25.5
Low	5	9	1.8	1.7

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4041.853968	4	1010.463	6.792092	0.000512	2.689628
Within Groups	4463.11746	30	148.7706			

Total	8504.971429	34

Due to analysis , we have to reject Null Hypothesis, meaning that farmers have significance perception and knowledge to climate change at Mpanga sector.

4.4. Farmers' perception to climate change at Mahama Sector

The Mahama sector is among most sectors that is vulnerable for climate change impact of Kirehe district , where government institutional such as REMA and other private sector initiated adaptation activities to protected and restored ecosystem ,the different activities are carried out as following ,irrigation of small scale like 7000 ha of land used , practices of agroforest and restore degraded ecosystem .

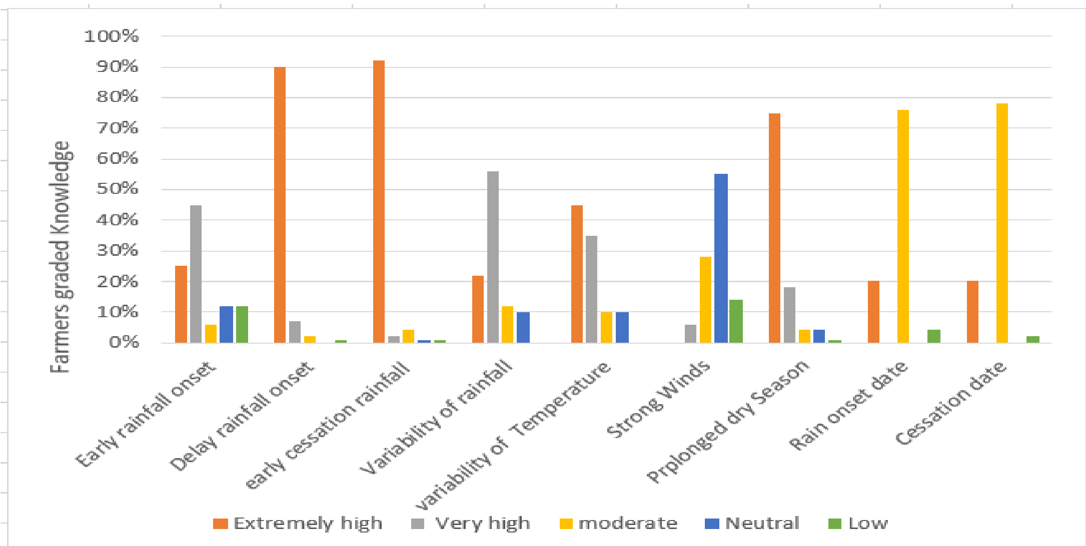


Figure :4. This graph represent farmers knowledge to climate variabilities and weather event at Mahama Sector

They are extremely sunshine, in this community farmer score 59% as extremely high and 16.6% very high to the prolonged drought, the early cessation of rainfall is scored at 83.3% as extremely high and 10% very high level meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur, the wind is moderate at 27.7% level, variability of rainfall is % as extremely high and % as very high ,the delay of rainfall is 77.7% at extremely high, temperature is graded as 33.3% extremely high and 33.3% very high, early rainfall onset 33.3% is very high and 13.3% is extremely high, the rainfall onset date and rainfall cessation date are at 80.3% as moderate level that reveal a great confusion of farmers during agriculture practices.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	8	545	68.125	3092.411
Very high	7	204	29.14286	585.1429
moderate	9	215	23.88889	890.8611
Neutral	6	76	12.66667	103.8667
Low	7	22	3.142857	6.809524

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18758.91822	4	4689.73	4.569104	0.004944	2.668437
Within Groups	32844.81151	32	1026.4			
Total	51603.72973	36				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , with P-value 0.004944 , therefore analysis show that if calculated P-value value is less than value $\alpha = 0.05$,then we do not accept Null Hypothesis, meaning that farmers have significance perception to climate change and knowledge at Mahama sector.

4.5. Farmers' perception to climate change at Kirehe Sector

The Kirehe sector is among most sectors that is less vulnerable for climate change impact of Kirehe district, they are no government institutional worked there and other private sector in the line of handling climate impact and initiated adaptation activities. They are extremely sunshine, in this community of farmers that is scoring early rainfall 15.3% as extremely high and 53.4% very high ,71.2% the prolonged drought is extremely high, the early cessation of rainfall is scored at 65.2% as extremely high and 23.2% very high level meaning that

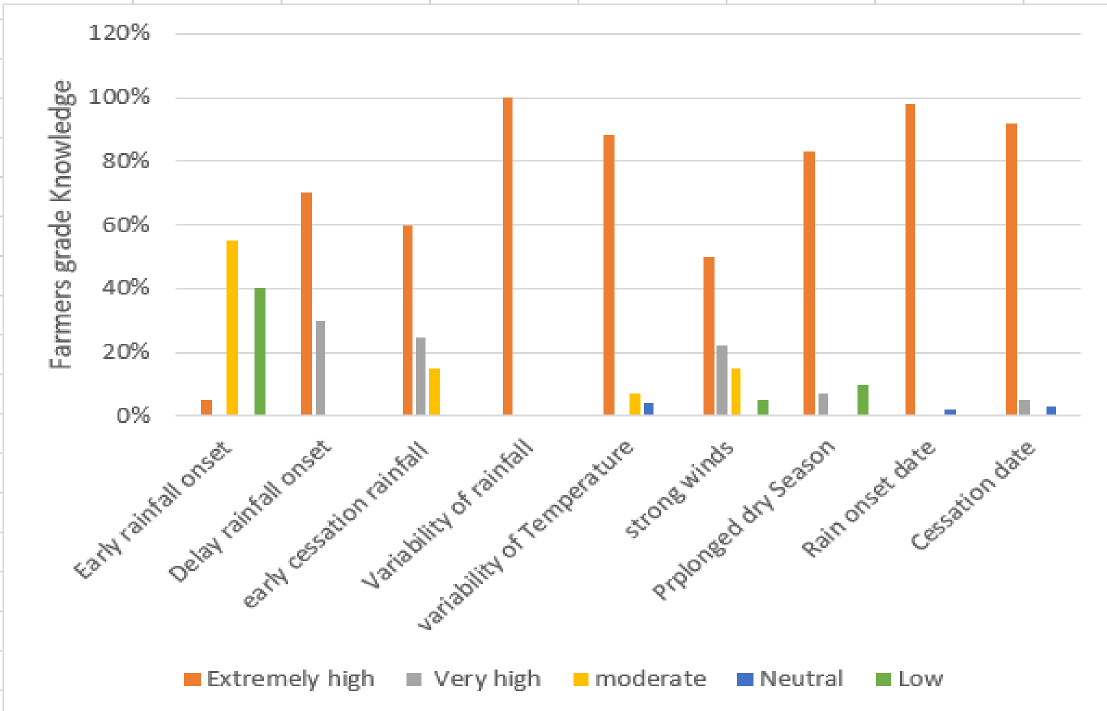


Figure 5: This graph represent farmers knowledge to climate variabilities and weather event at Kirehe Sector

, there are a high risk concerning crops lost before becoming mature and cause low yield to occur, the wind is moderate at 38.7% level, variability of rainfall is 100% as extremely high, the delay of rainfall is 69.9% at extremely high, temperature is graded as 92.3% extremely high and 92.3% very high, early rainfall onset 33.3% is very high and 13.3% is extremely high, the rainfall onset date and rainfall cessation date are at 92.3% as moderate level that reveal a great confusion of farmers during agriculture practices.

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	9	420	46.66667	393.75
Very high	6	80	13.33333	87.46666667
moderate	4	33	8.25	20.25
Neutral	3	6	2	0

Low	3	8	2.666667	2.333333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9003.89	4	2250.973	12.32481007	3.25273E-05	2.866081
Within Groups	3652.75	20	182.6375			
Total	12656.64	24				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , with P-value 3.25273E-05,$\alpha = 0.05$,therefore analysis show that if calculated chi square value is less than to critical value ,then we do no accept Null Hypothesis, meaning that farmers have significance perception to climate change and knowledge Kirehe Sector.

4.6. Farmers' perception to climate change at NYARUBUYE Sector

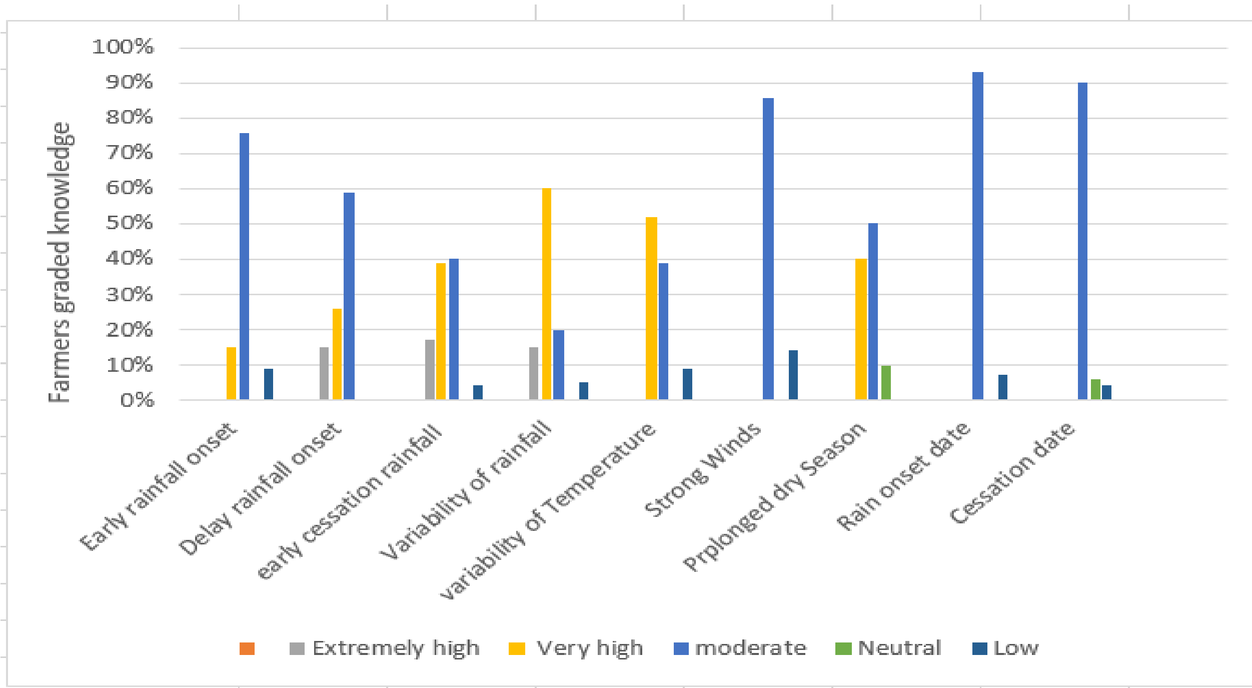


Figure:6 This graph represent farmers knowledge to climate variabilities and weather event at Nyarubuye Sector

Nyarubuye sector is among most sectors that is facing challenge of climate change impact of Kirehe district , They are government institutional contribution to habilitate degraded forest such as REMA and the other private sector in the line with handling climate impact and initiated adaptation activities.. They are extremely sunshine, in this community farmers score early rainfall onset 15% as extremely high and 75% moderate , the prolonged drought is 40% extremely high and 50% moderate , the early cessation of rainfall is scored at 15% as extremely high and 40% very high level meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur, the wind is moderate at 38.7% level, variability of rainfall is 70% as extremely high, the delay of rainfall is 50 % at extremely and very high level, the temperature is graded as 40% extremely high and 50% moderator ,the rainfall onset date and rainfall cessation date are at 92.3% as moderate level that reveal a great confusion of farmers during agriculture practices.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	9	420	46.66667	393.75
Very high	6	80	13.33333	87.46667
moderate	4	33	8.25	20.25
Neutral	3	6	2	0
Low	3	8	2.666667	2.333333

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9003.89	4	2250.973	12.32481	3.25E-05	2.866081
Within Groups	3652.75	20	182.6375			
Total	12656.64	24				

In order establish relation between farmers' perception with climate change impact by using statistical analysis ,therefore analysis show that if calculated chi square value is less than to critical value ,then we accept Null Hypothesis, meaning that farmers have not significance perception to climate change and no knowledge Nyarubuye sector.

4.7. Farmers' perception to climate change at Nyamugari Sector

Nyamuragira sector is that is facing challenge concerning climate change in recent years of Kirehe district , They are no adaption strategies and activities or no government institutional to habilitate degraded ecosystem .They are moderate sunshine, in this community farmers score early rainfall onset 75% as very high , 25% extremely high ,65% moderate to the prolonged drought an, 28% neutral , the early cessation of rainfall is scored at 60% as extremely high and 30% neutral meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur

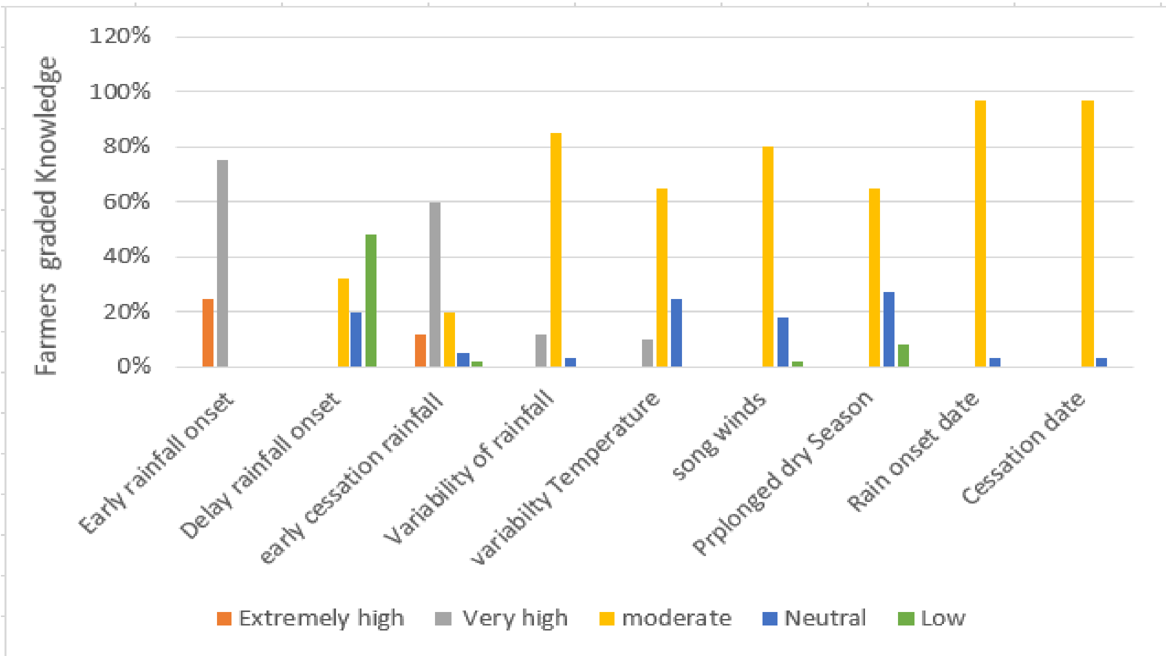


Figure :7 This graph represent farmers knowledge to climate variabilities at Nyamugari Sector

, 75% moderate to the strong wind, 90% moderate variability of rainfall, 45% low and 30% moderate to the delay of rainfall, 82% moderate to the temperature ,98% moderate to the rainfall onset date ,98% rainfall cessation date level that reveal a great confusion of farmers during agriculture practices.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	2	25	12.5	112.5
Very high	4	108	27	686.6666667
moderate	8	295	36.875	351.5535714
Neutral	8	46	5.75	14.21428571
Low	4	20	5	28.66666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*

Between Groups	5085.125	4	1271.281	5.540070296	0.003315094	2.8401
Within Groups	4818.875	21	229.4702			
Total	9904	25				

In order to establish relation between farmers' perception with climate change impact by using statistical analysis, Chi-square value 32.3 with P-value 0.003315094 with $\alpha = 0.5$ and square, then we do not accept Null Hypothesis, meaning that farmers have significance perception to climate change and clear evidences at Nyarubuye sector.

4.8. Farmers' perception to climate change at Musaza Sector

Musaza sector is that is facing challenge concerning climate change in recent years of Kirehe district , They are no adaption strategies and activities or no government institutional to habilitate degraded ecosystem in this communities and

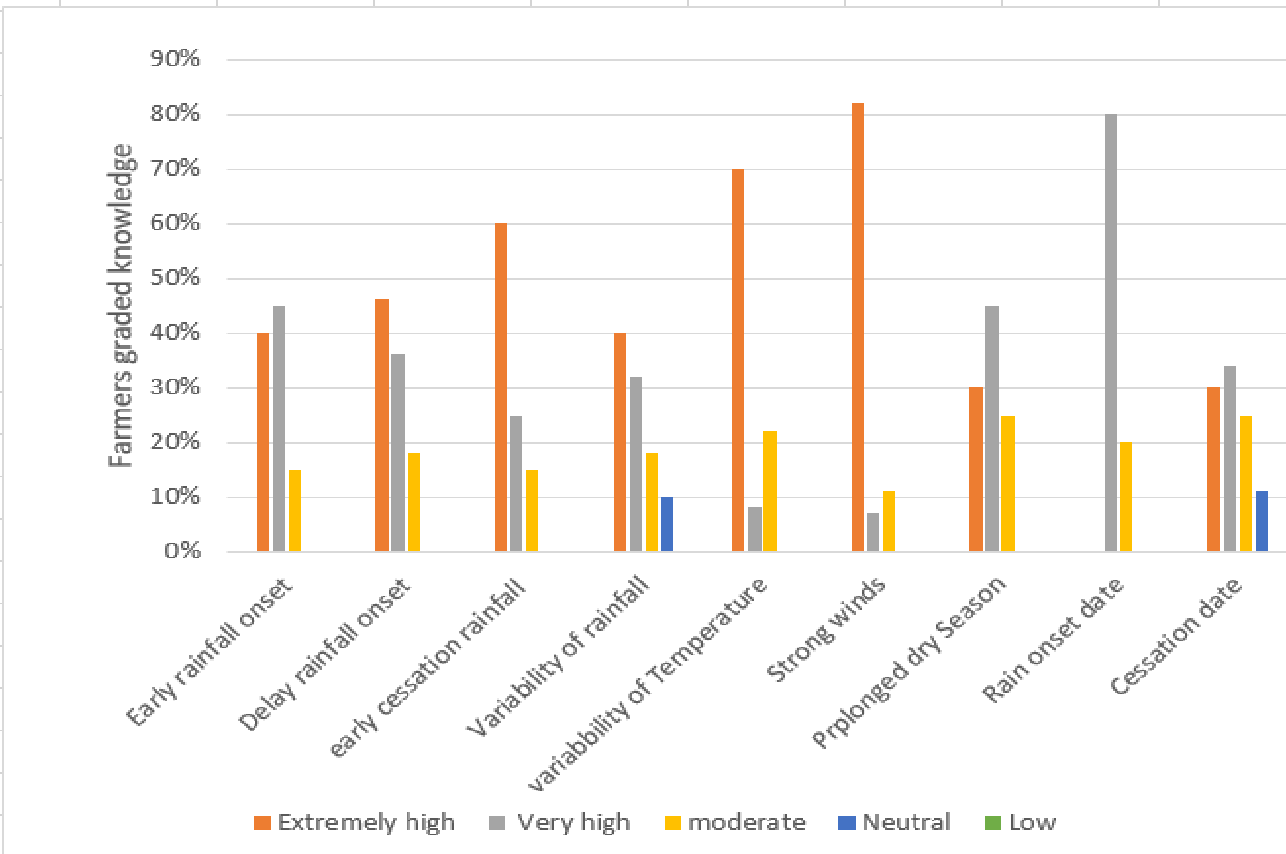


Figure :8 This graph represent farmers knowledge to climate variabilities and weather event at Musaza Sector

. There is 70% extremely high variability temperature and sunshine, in this community farmers score early rainfall onset 40% as very high and 45% extremely high ,45% very high and 30% extremely high to the prolonged drought , the early cessation of rainfall is scored at 58% as extremely high and 25% very high meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur, 83% extremely high to the strong wind, 40%extremely high and 50% very high variability of rainfall, 45% low and 30% moderate to the delay of rainfall ,70% moderate to the temperature 80% moderate to the rainfall onset date and 50% rainfall cessation date level that reveal a great confusion of farmers during agriculture practices.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	8	215	26.875	178.125
Very high	9	156	17.33333	104
moderate	9	81	9	6.75
Neutral	2	8	4	0
Low	1	0	0	

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1946.573	4	486.6433	5.475914	0.002806	2.776289
Within Groups	2132.875	24	88.86979			
Total	4079.448	28				

In order establish relation between farmers' perception with climate change impact by using statistical analysis with P-value 0.002806, $\alpha = 0.05$ a ,therefore analysis reveals that we fail to reject Null Hypothesis, meaning that farmers have not significance perception to climate change and no clear evidences at Musaza sector.

4.9. Farmers' perception to climate change at Kigina Sector

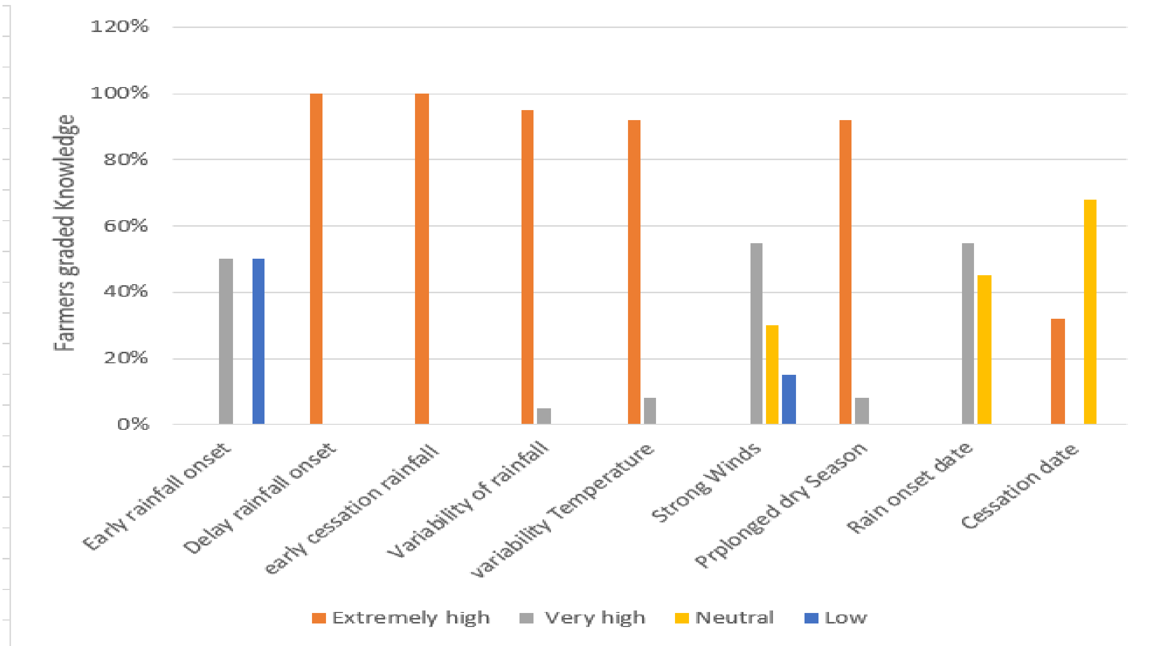


Figure 9 .This represent farmers knowledge to climate variabilities at Kigina Sector

Kigina sector has challenge concerning climate change in recent years of Kirehe district , They are no adaption strategies and activities or no government institutional to habilitate degraded ecosystem in this communities and . There is 90% extremely high temperature and sunshine, in this community farmers score early rainfall onset 50% as very high and 50% extremely high ,55% very high and 90% very high to the prolonged drought ,98% extremely high to early cessation rainfall, meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur, 60% moderate to the strong wind, 98% moderate variability of rainfall, 100% extremely high to delay of rainfall.

98% extremely high to the delay of rainfall , 70% moderate to the rainfall onset date and 40% rainfall cessation date level that reveal a great confusion of farmers during agriculture practices .

Groups	*Count*	*Sum*	*Average*	*Variance*
Extremely high	8	435	54.375	1567.410714
Very high	5	36	7.2	11.2
Neutral	4	32	8	8

Low	2	11	5.5	12.5

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10323.77	3	3441.257456	4.670048365	0.016965	3.287382
Within Groups	11053.18	15	736.8783333			
Total	21376.95	18				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , Chi-square value 62.5 and critical value 15.5 with P-value 1.52923E-10 , $\alpha = 0.05$ and Chi square critical value 15.5 therefore 8.7 is less that 15.5 ,therefore analysis show ,then we do not accept Null Hypothesis, meaning that farmers have significance perception to climate change and clear evidences at Kigina.

4.10. Farmers' perception to climate change at Gahara Sector

Gahara sector has also challenge concerning climate change in recent years of Kirehe district , They are no adaption strategies and activities or no government institutional to habilitate degraded ecosystem in this communities.

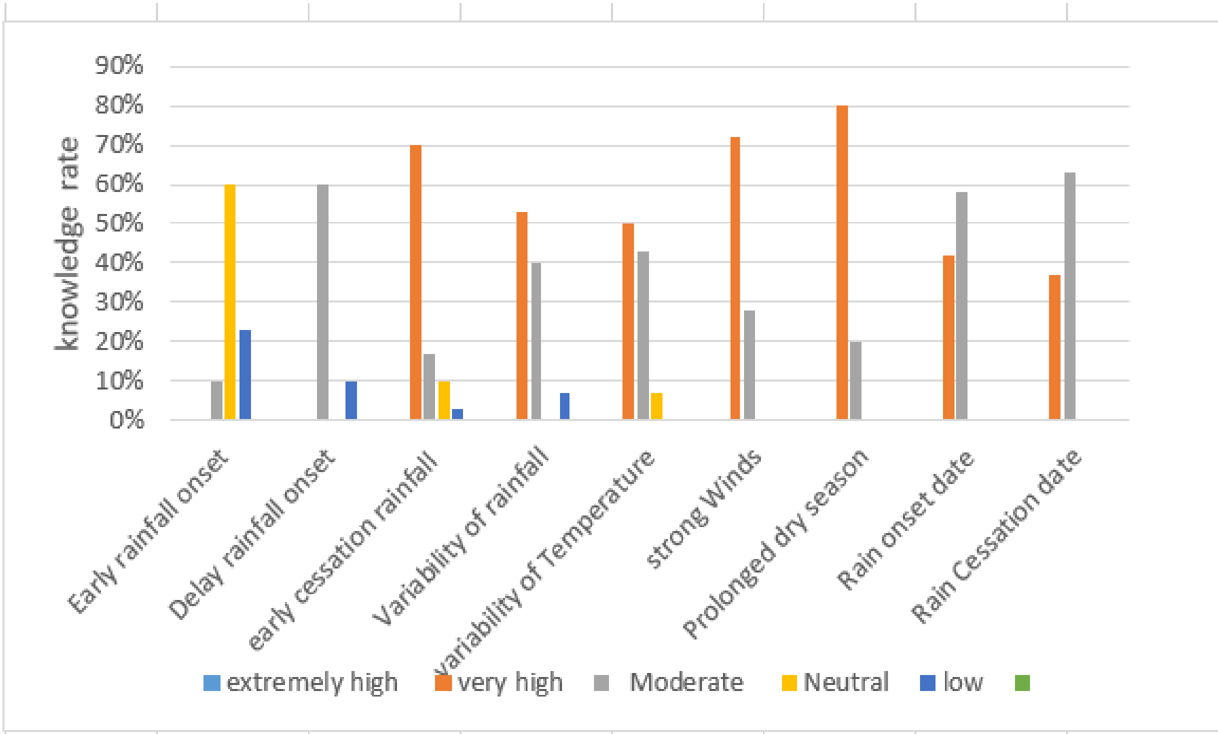


Figure 10: This graph represent farmers knowledge to climate variabilities at Gahara Sector

There is 42% extremely high and 55% moderate for temperature and sunshine, in this community farmers score 60% moderate early rainfall onset ,28% very high and 80% extremely hight for the prolonged drought , 70% very high and 15% extremely to early cessation rainfall, meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur, 60% moderate to the strong wind, 65% moderate and 40% very high variability of rainfall, 58% very high and 35% moderate for the delay of rainfall , 70% moderate to the rainfall onset date and 70% moderate rainfall cessation date level that reveal a great confusion of farmers during agriculture practices.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
extremely high	4	90	22.5	675
very high	4	116	29	345.3333

Moderate	9	190	21.11111	306.6111
Neutral	4	20	5	6.666667
Low	3	15	5	28

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1835.069	4	458.7674	1.559348	0.225689	2.895107
Within Groups	5589.889	19	294.2047			
Total	7424.958	23				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , with P-value 0.225689, $\alpha = 0.05$ therefore 0.05 is less that 0.225689,therefore analysis show that ,then we accept Null Hypothesis, meaning that farmers in this community have not significance perception to climate change impact and no clear evidences at Gahara.

4.11. Farmers' perception to climate change at Gatore Sector

Gatore sector has also challenge concerning climate change in recent years of Kirehe district , They are no adaption strategies and activities or no government institutional to habilitate degraded ecosystem in this community.

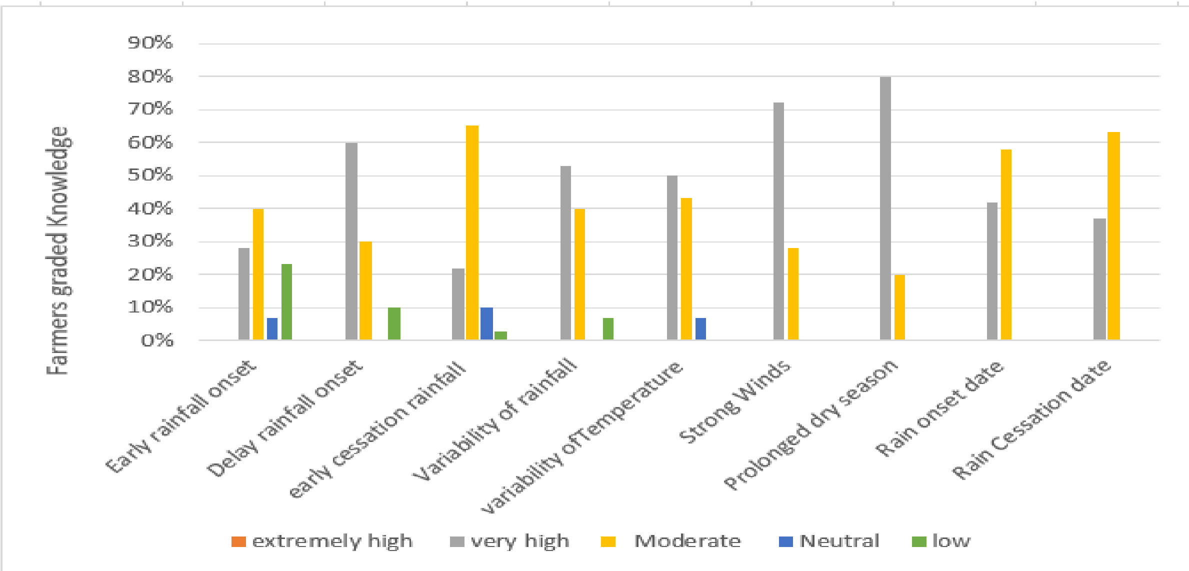


Figure :11 This graph represent farmers knowledge to climate variabilities at Gatore Sector

.There is 50% very high and 45% moderate for temperature a, in this community farmers score 28% moderate and 20% for early rainfall onset ,20% moderate 80% very high for the prolonged drought , 65% moderate and 20% very high to early cessation rainfall, meaning that , there are a high risk concerning crops lost before becoming mature and cause low yield to occur, 60% moderate to the strong wind, 65% moderate and 40% very high variability of rainfall, 58% very high and 35% moderate for the delay of rainfall , 40% very high 60% moderate to the rainfall onset date and 60% moderate and 40% very high for rainfall cessation date level that reveal a great confusion of farmers during agriculture practices.

Groups	*Count*	*Sum*	*Average*	*Variance*
extremely high	0	0	0	0
very high	9	188	20.88889	91.11111
Moderate	9	157	17.44444	48.52778
Neutral	3	9	3	1
low	4	15	3.75	6.25

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1302.699	4	325.6747	5.724332	0.003076	2.866081
Within Groups	1137.861	20	56.89306			
Total	2440.56	24				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , with P-value 0.003076, $\alpha = 0.05$ and ,therefore analysis show that , we do not accept Null Hypothesis, meaning that farmers in this community have significance perception to climate change impact and clear evidences at Gahara .

4.12 . Farmers' perception to climate change at Kigarama Sector

Kigarama sector is that is facing challenge concerning climate change impact such prolonged drought, much variability of rainfall, and change in temperature in recent years of Kirehe district, They are no adaption strategies and activities or no government institutional to rehabilitate degraded ecosystem in this communities and give technical assistant for agriculture practices.

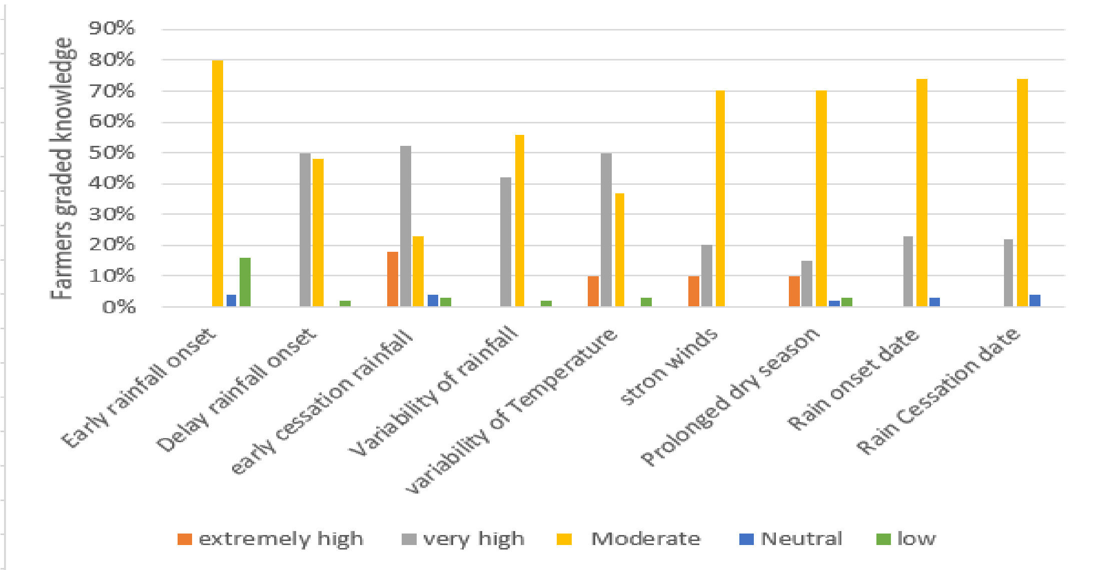


Figure:12 This represent farmers knowledge to climate variabilities at Kigarama Sector

There is 80 % moderate early rainfall onset, 50% very high and 48% moderate to the delay rainfall onset, 20% extremely high ,50% very high and 40% moderate for early cessation rainfall, 48% moderate and 45% very high to the variability of rainfall , 10%very extremely high ,42 % very high and 40% moderate for temperature.,65% moderate and 20% very high for the prolonged drought , 30% very high and 70% moderate to the rainfall onset date and 70% moderate and 30% very high for rainfall cessation date level that reveal a great confusion of farmers during agriculture practices.

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
extremely high	4	25	6.25	6.25
very high	8	152	19	76.57143
Moderate	9	276	30.66667	85
Neutral	5	10	2	0
Low	6	13	2.166667	5.766667

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4475.916667	4	1118.979	23.91013	1.54E-08	2.727765
Within Groups	1263.583333	27	46.79938			
Total	5739.5	31				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , with P-value 1.54E-08, $\alpha = 0.05$ therefore 1.54E-08 is less that 0.05, statistical analysis show that , we fail to reject the Null Hypothesis, meaning that farmers in this community have not significance perception to climate change impact and no clear evidences at Kigarama.

Through data analysis done throughout all sectors reveals that famers from six sectors have perception to climate change impacts while farmers form other six sectors have not perception to climate change impact.

The general climate change and variability impact at Kirehe district are presented below by different climate indicators as the mentioned in this graph. The Farmers have participated by responding questions corresponding to climate challenges by which they are facing, therefore the statistical test hypothesis done by using ANOVA reveals that the farmers have significance perception to climate change impact. Every Sector area have been affected differently by climate change impact, where some vulnerabilities are extremely high with significance percentage as they are mentioned in the **table 4**, extremely high, very high as they were graded the farmers who were interviewed, such ,prolonged dries season, Delay of early rainfall, the temperature changes and trends, rainfall variability and strong wind variation.

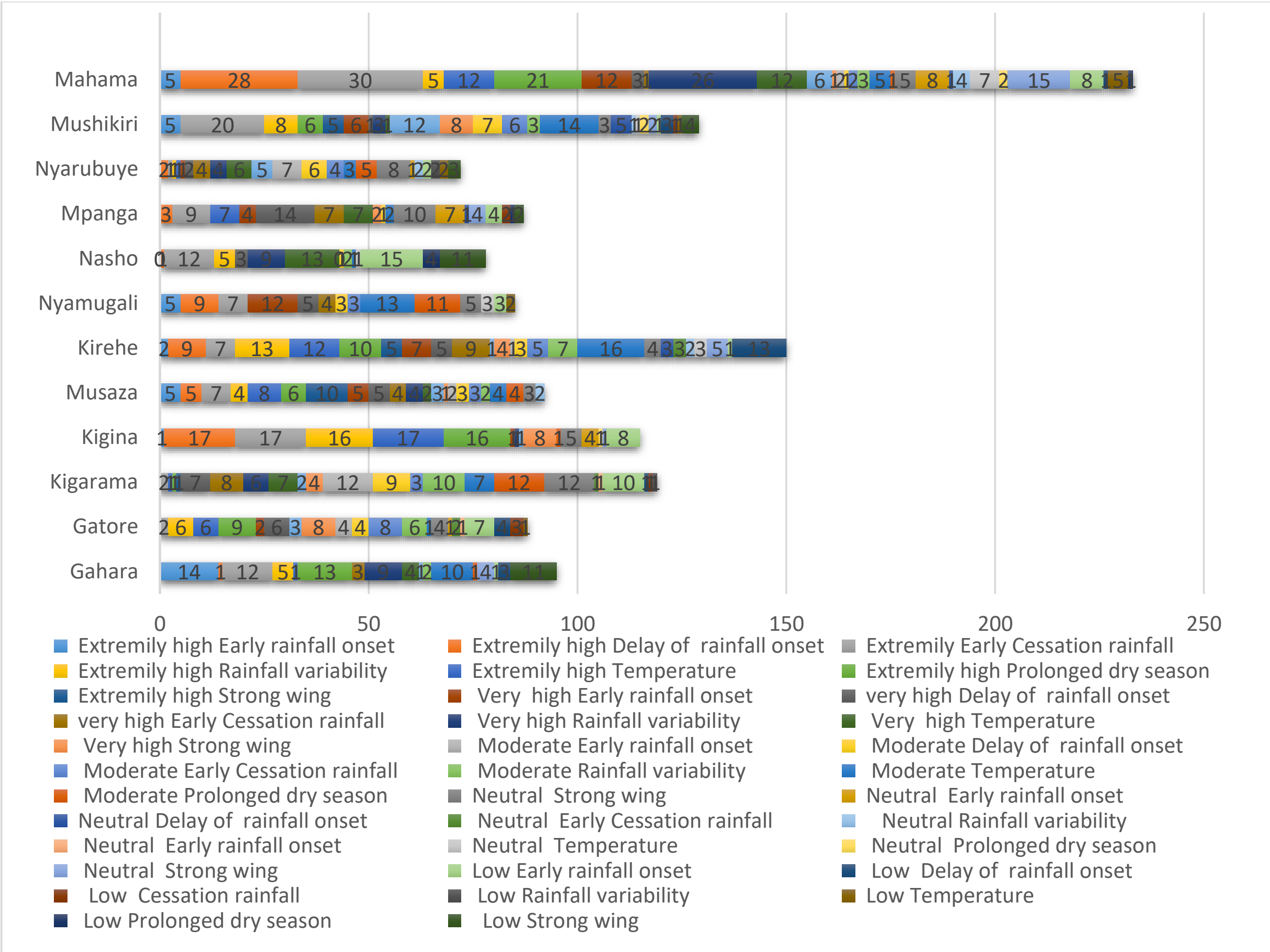


Figure13: This represent the number farmers interviewed and their correspond responses in Kirehe district

The information tabulated are 206 farmers answers to the climate change knowledge in percentage in accordance to degree of vulnerability, therefore the statement used to express vulnerability which farmers have faced is an increasing incremental sense and decreasing sense of variability. The table below summarizes the farmer's perception in the whole district and how they are grading the degree of climate change impact.

n/s	Climate indicator evaluated	Number farmers /responses	Percentage
01	Extremely high Early rainfall onset	36	18 %
02	Extremely high Delay of rainfall onset	72	36%
03	Extremely Early Cessation rainfall	126	63 %
04	Extremely high Rainfall variability	63	31%

05	Extremely high Temperature	65	32%
06	Extremely high Prolonged dry season	82	41%
07	Extremely high Strong wing	21	10.5%
08	Very high Early rainfall onset	48	24%
09	very high Early Cessation rainfall	40	20%
10	Very high Rainfall variability	62	31%
10	Very high delay of rainfall onset	50	25%
11	Very high Temperature	52	26%
12	Very high Prolonged dry season	32	16%
13	Very high Strong wing	36	18%
14	Moderate Early rainfall onset	27	13.5%
16	Moderate Delay of rainfall onset	38	19%
17	Moderate Early Cessation rainfall	35	17.5
18	Moderate Rainfall variability	35	17.5
19	Moderate Temperature	74	37%
20	Neutral Temperature	14	7%
21	Low Temperature	9	4%
22	Low Rainfall variability	6	3%

Table 4 : the farmers responses to the Knowledge the climate change of community

The statistical analysis to the farmers perception are described in accordance with each sector , the findings are following:

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Gahara	17	95	5.588235	22.75735
Gatore	21	88	4.190476	6.561905
Kigarama	23	119	5.173913	17.51383
Kigina	16	115	7.1875	48.5625
Musaza	22	92	4.181818	4.632035
Kirehe	25	150	6	17.75
Nyamugali	14	85	6.071429	13.76374
Nasho	15	78	5.2	28.02857
Mpanga	18	87	4.833333	13.44118

Nyarubuye	22	72	3.272727	4.493506
Mushikiri	26	129	4.961538	21.07846
Mahama	30	233	7.766667	70.32299

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	410.539	11	37.32173	1.581517	0.104858	1.829206
Within Groups	5592.891	237	23.5987			
Total	6003.43	248				

In order establish relation between farmers' perception with climate change impact by using statistical analysis , with P-value 0.104858 that is great than $\alpha = 0.05$ and ,therefore the statistical analysis show that , we have to accept Null Hypothesis, meaning that farmers in this community have not significance perception to climate change and its impact in agriculture practices.

4.12. Climate change vulnerabilities effect to the farmers

The vulnerability magnitude to the climate change are given from farmers responses, available challenges that the farmers are facing in their activities and livelihood are categorized in accordance with climate indicators such, excess rainfall, drought, strong wings and temperature. The effect climate change assessment reveals that each sectoral level and field has been affected differently to each other.

Picture 1. These pictures show effect of strong wind and excessive rainfall /erosion respectively to the famers likelihood in Kirehe district , source kirehe agriculture office

The climate variabilities indicators that are gathered in **Table 4** , such as high temperature hinders the farmer's expectations and their socio-economic income by withering the crops, increasing the incidence of diseases, causing human discomfort and increases pests diseases and evaporate water from streams and rivers have been assessed. The assessment results, some areas and landscape of Kirehe district has been challenged by the strong wing that is effecting farmer's activities like remove houses roofs, collapse buildings like event shown on the picture 1 cause accidents, affect farming activities and uproots Trees. The excessive rainfall and Drought causing different negative adversely effects low agriculture yields, bush fire, dries up stream, increase pests diseases, shift of livestock and hinder transport system. In general assessment results to classify the vulnerability effect of farmers to climate change are annexed as Appendix A.

4.13. The sources of climate change information

The source of climate change information within the community of farmers as well as citizens that are used in agriculture practices are categorized as follow government officials, parent, friends, school, radio, television, Workshop, farmers' association and Non-governmental organization. For affordable sources of information that has been considered to help farmers in agriculture seasons are mentioned in accordance to the farmers' responses through structured questionnaires across the twelve sectors of district. The government official is 65 % excellent affordable to the farmers, 17% very affordable,12% moderate affordable, meaning that government institution and their management especially local government such as sectors and district level update and inform the farmers the climate variability in beginning of agriculture season that are likely to occur. The second source of climate information that are assessed is parent where the young generation leant from elders the past charactestics and behaviors of climate data in their region as 33% excellent affordable, 20% very affordable and 20% moderate affordable from parent discussion with next generation.

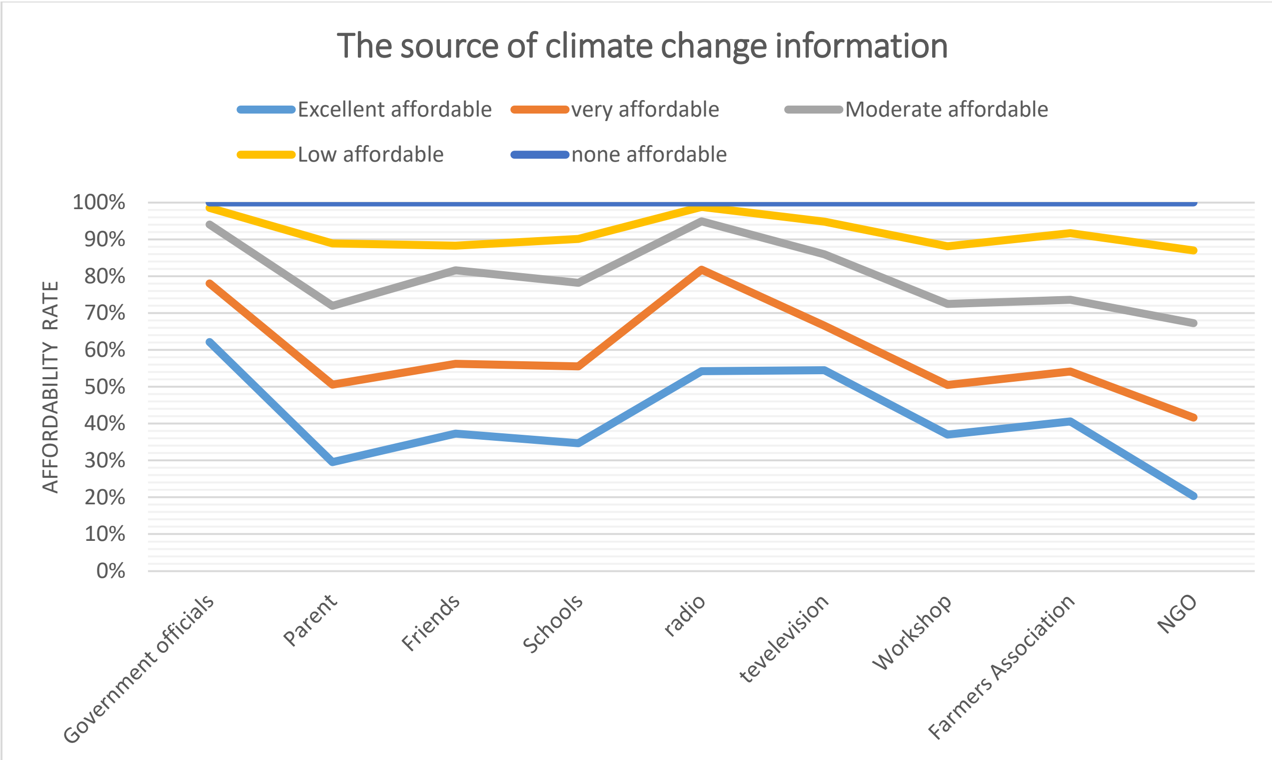


Figure 14. This graph represents the main source of climate change information to the farmers in Kirehe district

The peer group in community, one generations to another was considered as source of shared information concerning climate change where 35% excellent affordable, 20% very affordable, and 27% moderate affordable are scored to the Friends. The schools could have considered as the main channel of climate information where government establishes the curriculum that embrassing climate information where 35% excellent affordable, 25% very affordable, and 23% moderate affordable are scored to the school as its capability to teach young generation. The transmission of radio News should effective be a tools to use in agriculture practice like getting information of climate to enhance performance of agriculture practices by giving guidelines to farmers ,52% excellent affordable, 29% very affordable, and 14% moderate affordable are scored to the Radio.

The transmission of video and other broadcast News from television is used in agriculture practice like giving information of climate variability to the farmers in order to enhance farmers preparedness of agriculture activities ,52% excellent affordable, 12% very affordable, and 20% moderate affordable 16% low affordable are scored to the television. The workshop is the way that can effectively to inform the farmers adaptation strategies to climate change impact in agriculture as well as to set down adaptation measures 37% excellent affordable, 13% very affordable, and 22% moderate affordable 17% low affordable are scored to the workshop. The farmers' association can be used as social group to be easily afforded so that it should be tough where 40% excellent affordable, 14% very affordable, and 19% moderate affordable 16% low affordable are scored to Farmers association. Non-governmental organizations have been graded as following 20% excellent affordable, 22% very affordable, and 20% moderate affordable 20% low affordable and 18% non- affordable are scored to NGO.

4.14. The farmers' methods to forecast rainfall onset in agriculture season

In this part of works, we focus on the methods by which farmers are using to forecast rainfall onset and others climate variables to enhance agriculture practices. The decisions that leading the farmers to sow the crops, the harvest and making best agriculture practices are based on how farmers are capable in weather forecast . We have identified different methods that have recent been used such as traditional methods and scientific method to weather forecast for each cropping season. through the use those methods.

The community need for reorienting meteorological information, fine tuning of climatic analysis and propriety presentation for agricultural decision making and protecting the farming communities from weather vagaries has become the important measures and adaptation strategies to climate change. With this works, the present study was undertaken with the fundamental objective of finding out an alternative solution to mitigate the demands of farmers to help them in farm planning and decision-making. Traditional indigenous knowledge is not enough to satisfy each unique culture of community. The most important aspect regarding our ancient scriptures is that future weather of the coming year(s) together can be predicted with high percentage of accuracy even before the start of the years.

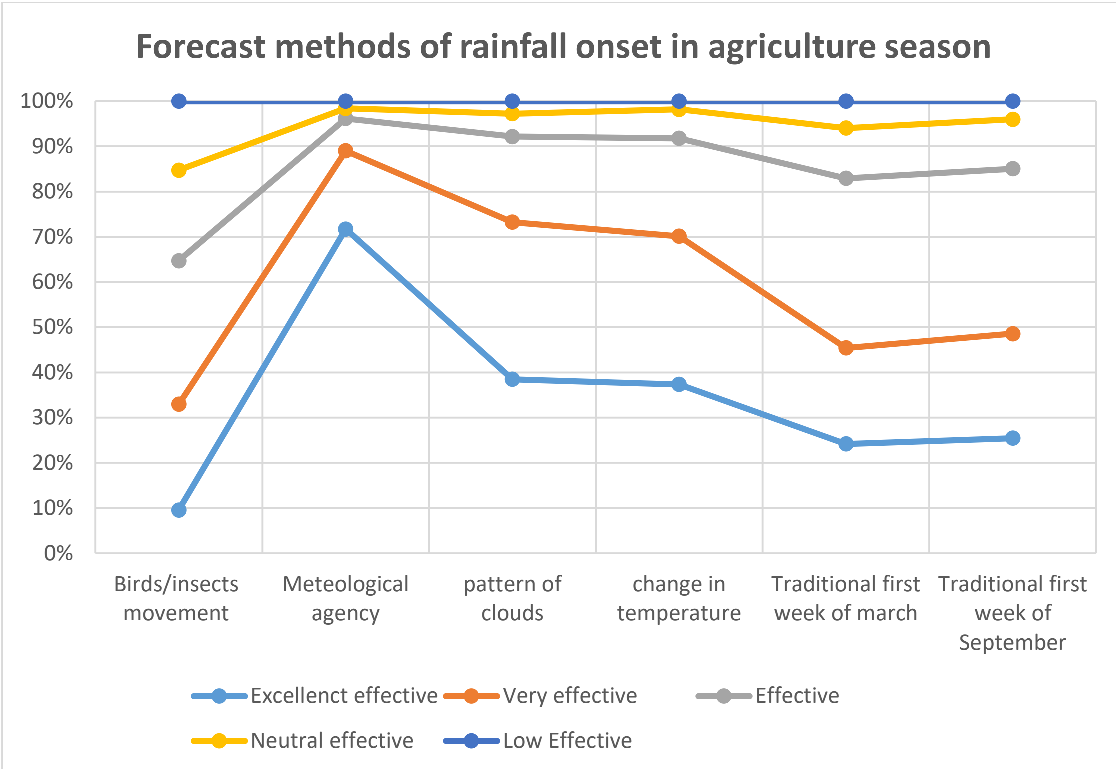


Figure 15. This represents the Forecast methods used by the Farmers

The important strategies that are mostly used by indigenous farmers in past and recent period . The birds and insects movement, Meteorological agency, pattern of clouds, change in temperature, traditional first weeks of March and September. For 10% excellent effective ,22% very effective 30% effective and 20% Neutral effect The birds/insect movements, For 70% excellent effective ,20% very effective 7% effective and 3% low effective is attributed to meteorological agency

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Excellenct effective	6	1430	238.3333	33886.67
Very effective	6	961	160.1667	2501.767
Effective	6	926	154.3333	4778.267
Neutral effective	6	317	52.83333	657.3667
Low Effective	6	170	28.33333	392.2667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	176867.1	4	44216.78	5.236928	0.003326	2.75871
Within Groups	211081.7	25	8443.267			
Total	387948.8	29				

The 40% excellent effective ,32% very effective 17% effective and 3% low effective is attributed to pattern of clouds, 38% excellent effective ,32% very effective 18% effective and 3% low effective is attributed to the change in temperature and 22% excellent effective ,20% very effective 36% effective and 12% low effective to the traditional first weeks of march and traditional first week of September.

4.15. Farmers' Adaptation Measures and Strategies

Adaptation measures that are relevant to the climate change impact in accordance with analyses based on research conducted at kirehe are described in the following sections. Most of the adaptation strategies that have been assessed to their effectiveness are already familiar to community and farmers' association, or are extensions of existing planning and management strategies. Assessed adaptation measure are following:

Intercropping	Early maturing cultivas,	Use climate data and forecast,
Water conservation,	Use climate data and forecast,	Disaster and diseases management,
Crop replanting ,	Agroforestry practices	Intensification agriculture
Irrigation,	Trees planting,	
Drought tolerant cultivars,	Rain water harvest,	

, This works supports the argument that adapting to climate change should a make use of existing tools and approaches although cause the challenge on which tools are used and how they are used. Note this research does not provide a detailed list of specific policies that should be changed, but it is showing various effectiveness of suggested adaptation activities in addressing projected impacts through the farmers of twelve sectors. Climate change adaptations activities assessed are intercropping that standing for mixing seeds and crops by the farmers to ensure security one if climate went wrong or by chance all growing together and give moderate yield. It has been graded as 40% excellent effective and 27% very effective meaning that some farmers in this region are still mixing crops even thought government policy prohibit them. The water conservation is a key strategy in order to protect environment such wetland, irrigation in small and wide scale for agriculture practices to some households during dry season and minimum rainfall, therefore it was evaluated as 25% excellent effective ,25% very effective,15% effective to water conservation. The crop replanting refers to alternative the farmers make when the first crops dries up pre-matured, they have been replaced within the same agriculture season, in this case there is a rework or repeated activity to sow crop that accompanied with a loss and low growth domestics products .it is scored as 60% excellent effective, 20% very effective and15% effective , therefore farmers have often replanted the crops. The graphical representation.

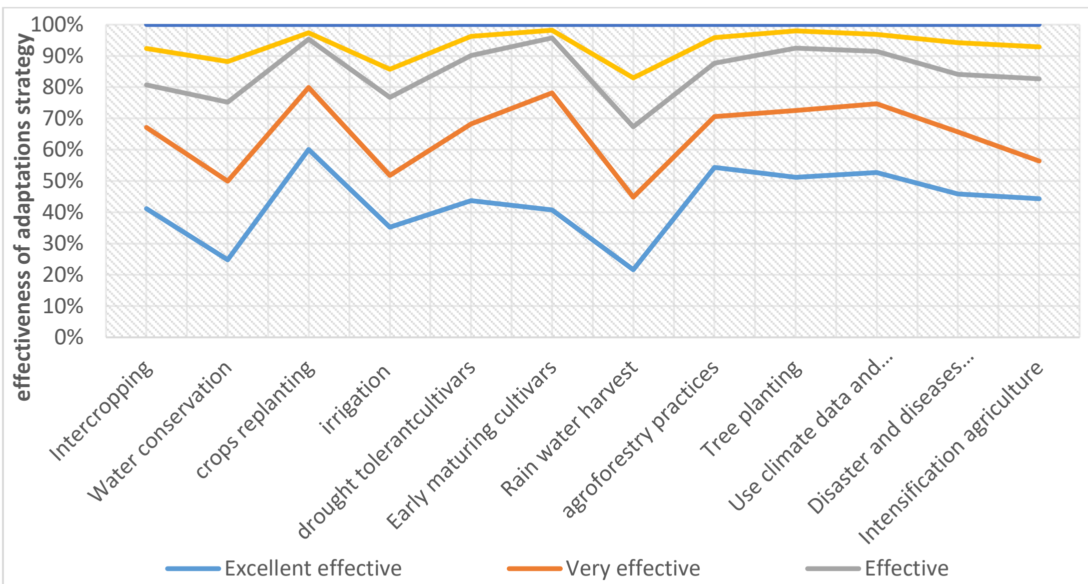


Figure 16. *This graph represents adaptation strategies to the farmers of Kirehe district*

Irrigation crops in small scale is an measure adaptation strategy that should help effectively the farmers to sustain agriculture of some seeds and crops during dry seasons. Irrigation system was official initiated in three sectors Kirehe district such Nasho and Mpanga sector, it is scored 35% excellent effective,17% very effective, 20% effective. The 42% excellent effective, 30% very effective and 30% effective to Drought tolerant cultivas. For 40% excellent effective ,38% very effective and 18% Neutral to early maturing cultivas, therefore farmers prefer to sow the seed that grow in short period that matched with rain days in order to minimize loss of crop and ensure availability foot security at planned time.

The rain water harvest should be used to minimize risks due the overflow of water and washed surface and then it can be taken as opportunities to adapt and resilience to climate change impact therefore the farmers is scoring 20% excellent effective, 20% very effective and 20% effective, meaning that this strategies has low practices in this region. For 55% excellent effective,18% very effective and 19% effective have been attribute to agroforest practices. 50% excellent effective ,23% very effective, 20% effective that have attributed to tree planting . The use of climate data and weather forecast adaptation should help the farmers to reduce the risks, proper planning and busting agriculture production due to accuracy information necessary to the agriculture season, therefore it is scored as 52% excellent effective, 23% very effective and 17% effective, actuary Rwanda meteorological agency need decentrized its serve so that local areas should afford information easily and reform their platform to facilitate communication with Rwandans communities of farmers.

Picture 2 . It represents irrigation activity of small scale for the farmers of Maize and Sweet potatoes garden of Mpanga sectors using Solar power generator source of energies

Agricultural intensification in kirehe district refers to the process of increasing the inputs of agricultural resources such as seeds, labor, fertilizers, pesticides, technologies, knowledge to increase the level of yield per unit of farmland or pasture. Agricultural intensification is not always clearly or consistently defined and is often confused with the term intensive agriculture. It is graded 44% excellent effective ,15% very effective, 28% effective to the agriculture intensification.

Disaster Management demands skilled, professionals who can respond to emergencies and manage both immediate and long-term results of disasters on human health. Disaster Management is a multidisciplinary field and brings professionals from several fields together as one team to respond to any kind of disaster. Organizations such as emergency services, international humanitarian agencies and societies, disaster response agencies, NGOs, government agencies, military, and volunteer groups are all involved in disaster management. In this works , the farmers have graded 42% excellent effective , 12% very effective and 20 % effective to disaster and diseases management.

In order to confirm effectiveness of existing adaptation measure and strategies to the farmers with climate change impact by using statistical analysis with chi square test value 210.81 and P-value 4.2232E-39,$\alpha = 0.05$ therefore 4.2232E-39 is less that 0.05, statistical analysis show that , we reject the Null Hypothesis, meaning that farmers in this community have effective adaptation measures and strategies that need to be strengthened and sustained to ensure the food security and maintenance of agriculture practices.

4.16. Trend of Temperature and Rainfall

The most Rwandans' farmers sow the crops in beginning of two greats rainfall season such March, April , May (MAM) and October ,November and December (OND)rainfall , therefore assessment made to the trend of temperature and rainfall variability time series data are ones concerning data from eights meteorological stations locate at Kirehe district in from 1983 to 2021. Almost three decades ago has a profound challenges due to climate change, the climate change due to change and variability in rainfall in this study are described by using statistical analysis, Mann-Kendell, graphical representation in the (table 2) and Appendix C from eight different meteorological stations across kirehe district area.

Due to the distinct difference topography location of kirehe district that influences and structure of sectors of district, all sector do not receive the same amount of rainfall at the same Seasonal therefore rainfall variability is not the equal. The trend significance are describe by Statistical Mann –Kendell of Test Z, in table below

Table 5: Represent Mann-Kendell rainfall statistical trend of time series data of MAM, OND and annually

				MAM /Rainfall Trend statistics			OND/Rainfall Trend statistics			Annual/Rainfall Trend statistics		
Time series	**First year**	**Last year**	**n**	**Test Z**	**Significance**	**Q**	**Test Z**	**Significance**	**Q**	**Test Z**	**Significance**	**Q**

GAHARA	1983	2021	39	-2.01	*	-3.100	0.17		0.190	-0.96		-2.600
RUSUMO	1983	2021	39	-3.21	**	-4.000	-1.81	*	-2.750	-2.69	**	-9.000
KIREHE	1983	2021	39	-0.74		-1.353	0.34		0.429	-0.06		-0.500
MPANGA	1983	2021	39	0.76		1.103	0.69		1.000	1.57		4.444
MUSAZA	1983	2021	39	-2.02	*	-2.778	-.0.67		-0.571	-1.68	+	-4.640
NYAMUGALI	1983	2021	39	-2.03	*	-3.371	-1.27		-2.118	-2.20	*	-6.455
BUKORA	1983	2021	39	-1.38		-2.591	-1.49		-2.588	-1.50		-6.185
NYARUBUYE	1983	2021	39	1.10		1.500	0.52		0.769	1.67	+	4.133

Considering Mann-Kendall statistical trends analysis, the results reveals that some sectors have signific trend other not such as Gahara sector has 95% rainfall trend analysis within period of MAM, Rusumo has 99% trends analysis at the MAM , 95% trends analysis at 95% at OND and 99% rainfall trend analysis during annually, Musaza has 95% statistical trends of rainfall at MAM and great 90% statistical trends annually and Nyamugali 95% during MAM and at annually. In general In this table the symbols **, * , + and empty are significance level of rainfall to the mentioned areas or sector at α to equal to 1%, 5%,10% and great than 10% respectively, Q is the sen's slope(mm/year, Z is test statistical of Mann-Kendal Trend n is the number of year observed 39.

Others Mann Kendell quantities magnitude of change and direction of variability are presented Test Z and Theil Sen'slop Q in table 5 and Appendix B and C. Annually rainfall trend analysis for entire district is present ed by regression line see **graph 1**

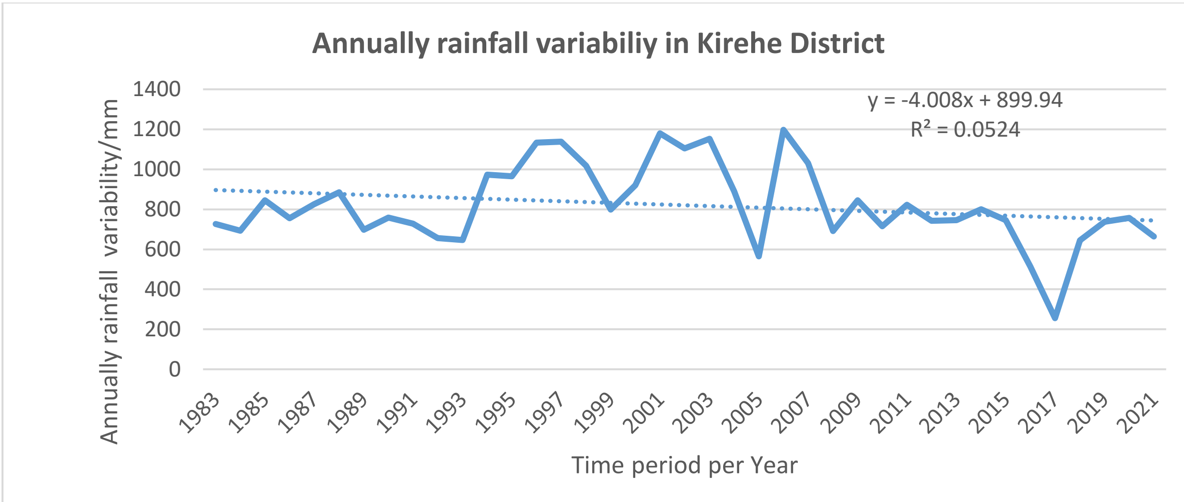
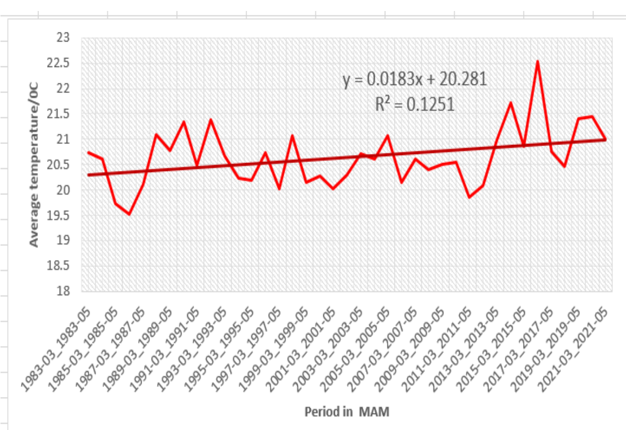


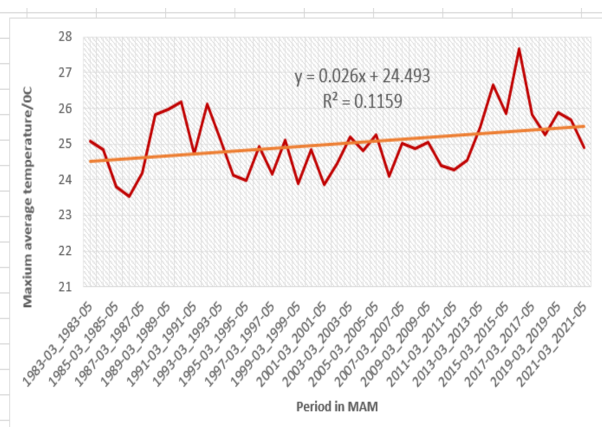
Figure 19. This graphs above represent annually variability of rainfall from 1983 to 2021 in kirehe

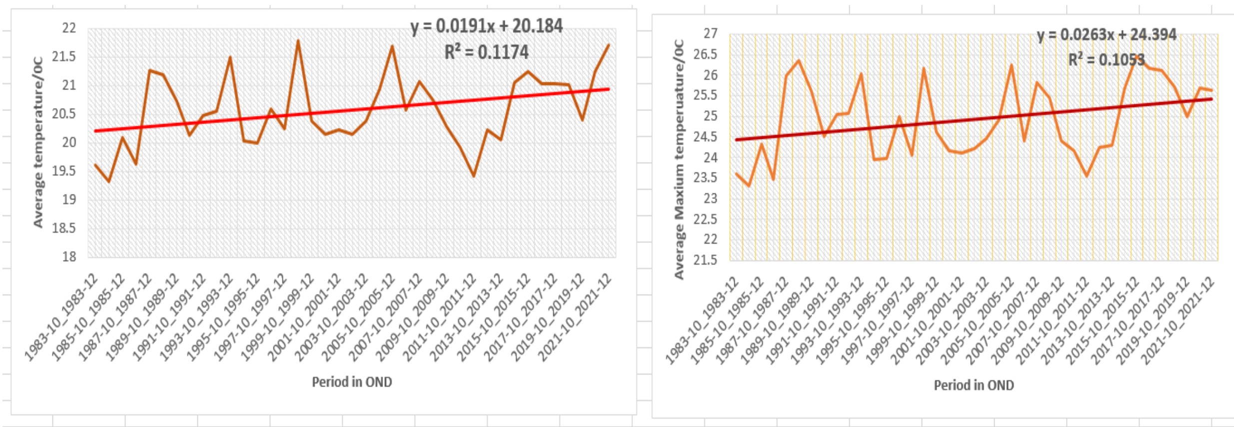
4.16 Maxium , Minimum and average temperatute Trends

The temperature trends analysis is mostly affecting the crop growth and development when water from rain or river for irrigation activities is available to optimize satisfaction, even though weather and climate had been never been constant they had always experienced changes either positive or negative but now atmospheric warming system was forecasted to minimize risks to farming activities.

In accordance to the ***graph 20 and 21, appendix D***, *it* shows that maximum temperature of March, April and May(MAM) has 2.6 % of trends and 11% of correlation level of time series data in 39 years ago that change in positive direction or increasing rate in rainfall season with correction relationships between rainfall points of 11.6% reliable to be forecasted to the next future climate data.







Graph: 20. The Seasonal average Maximum temperature trends of MAM and OND

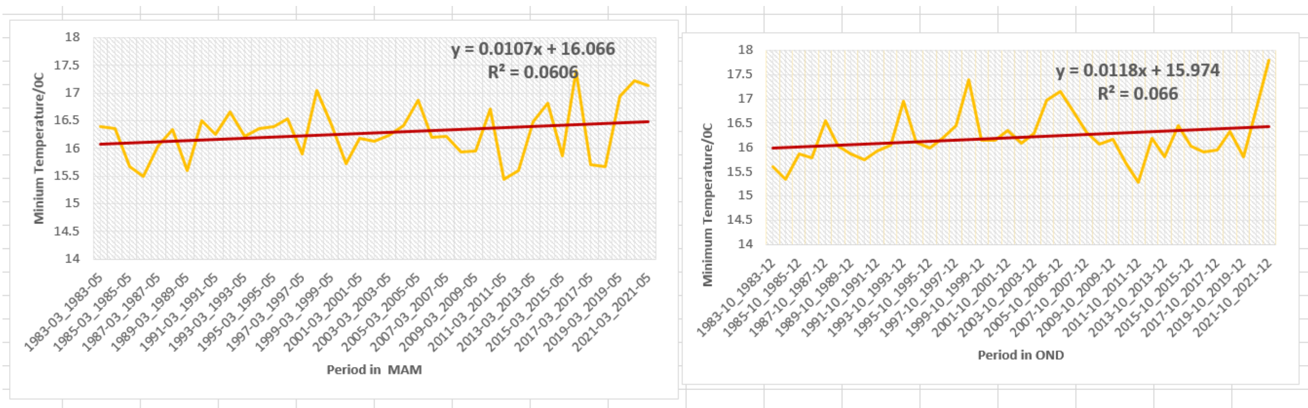


Figure21. The Seasonal average Minimum temperature trends of MAM and OND

For the same analysis to October, November and December (OND) that has maximum temperature of 1.18 % of trends in 39 years ago that change in positive direction or increasing rate in rainfall season with correction relationships between rainfall points of 10.53% reliable to be forecasted to the next future climate data. The correlation coefficient of 11.6% and 10.53% for both MAM and OND are much small enough for temperature to make great confusion to the farmers in agricultures seasons and little constant to amount rainfall and low forecast accuracy. Therefore minimum temperature Trends in ***graph 21*** that has been evaluated at Kirehe district during rainfall season such as MAM and OND in 39 years are 1.% and 1.07% for both MAM and OND respectively that are increasing in positive direction and 6% and 6.6% correlation coefficient of rainfall variability data in consecutive rainfall season also are much small to help in forecasting future temperature. Some specific crops should shift from one region areas to others due to the temperature changes in consecutive years in agriculture season

An Increase of the night temperatures have given rise to increase in respiration phenomenon hence reducing the net gain in the form of grain yield. Short time shoot up of air temperatures in early spring when wheat and other winter crops were at reproductive stage of their life cycle caused significant reductions in the grain yield despite affecting the apparent health of the crops.

4.17. Impact of Variability of Rainfall and temperature to the Ecosystem in Kirehe area

Considering the scientific data analysis trends determined regarding temperature and rainfall in four decades ago in Kirehe district sectors, as they are shown through the table 5, Appendix B, C and D , it is trial for some vegetation species are likely to be undermined by temperature and rainfall significance trends . The Animals will suffer if they lack food and eventually disappear from study areas and tree and glasses will be dried up to the high temperature variability or increasing direction of temperature. Knowing temperature trends and rainfall trends will provide accuracy information T policies makers and Government institutional to choose appropriates crops to cultivate, vegetation species to grow for environmental and ecosystem management Purpose

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

The main function of this works is to assess farmers' perception to climate change adaptation for agriculture practices in Kirehe , in line with continual improvement purposes, to achieve the target effectively, the set of objective were developed and therefore practically implemented. The methodologies and strategies used to achieve this ,through various interactive involved activities are scheduled through questionnaire containing climate change statements that express the degree of vulnebilities to the farming activities, graphical representation for data analysis ,ANOVA to verify test hypothesis of questions ,Mann-Kendall and Theil sen's slope estimator to determine magnitude of trends of temperature and rainfall time series data and increasing and decreasing direction of trend and magnitude to the change over eight stations of Kirehe district.

The climate variability assessed throughout twelve sectors , the survey carried out was related the degree of impacts of climate change affect the farmers ,available adaptation strategies such use Natural resources , biodiversity and ecosystem services applied in agriculture sector for coping purpose .

The results of work reveals that farmers in Kirehe district have not significance perception to climate change in accordance with statistical analysis to their answers on survey done, they have effective adaptation strategies, **graph 16** ,that could help them to cope with climate change impacts .

5. 1 . Comparison of Farmers perception with Meteorological data

Farmers knowledge to climate change	**Meteorological data analysis**	**Comparison statements**
The rainfall variability is scored 62% of farmers to be extremely and very high so that it should make them more confusion to the forecast and less reliable prediction for agriculture season by using tradition methods. The moderate rainfall variability is graded 17.5% by the whole farmers interview	The rainfall variability reveals -400,8 % coefficient of variance and 5.2 % correlation level of rainfall data ,meaning that during 39 years/almost four decades ,amount of rainfall has deeply changed in decreasing/downward direction as barrier of agriculture activities and hinder performance farming works	There is a much great approximation between farmers perception/tradition with scientific data to rainfall variability in kirehe district but exactness and accuracy is a challenge to the farmers to know timeframe for sowing the crops
The temperature time series variability is graded by 58% by the the farmers to extremely and very high to destroy crops and hinder crop development that lead to low of crop yield, dries up the stream (wetland). The temperature change is graded 37% therefore few number of farmers confirm small change in temperature while the great number confirm temperature change	The average temperature time series trend is 1.8% for MAM and 1.9% for OND coefficient of variance . The correlation coefficient for MAM and OND are 12.5% and 11.7% respectively, they are much small but should affect farmers by confusing to which suitable crops for any season destroy crops and hinder crop development that lead to low of crop yield	The farmers confirm that the change of rainfall and temperature at the level which 58% of graded knowledge recognize of upward high level temperature change while meteorological data gives 12.5% and 11.7% determined coefficient of both season MAM and OND, great variability of temperature in 39 years that should hinder increasing of agriculture yields

5.2. Recommendation to climate change adaptations

i. Local government especially district authorities, REMA and others Non-Government organization are recommended to establish platform that Contribute to the Communication on early warning system of meteorological data to the farmers and reliable weather forecasting system concerning agriculture activities at District and Sectors levels.

ii. Engage and cooperate with stakeholders involved scientific researches to identify suitable crops in accordance to the means temperature and rainfall for a given district and sectors level in currently appear to certain regional to each agriculture season.

iii. Organizing workshop with themes concerning with climate change Adaptation strategies such as Ecosystem Based Adaptation(EbA) use of biodiversity and ecosystem services such as regulation, provisioning, supporting, and cultural part of an overall adaptation strategy to help people adapt to the adverse effects of climate change

5.3. Effective adaptive strategies to climate change impact

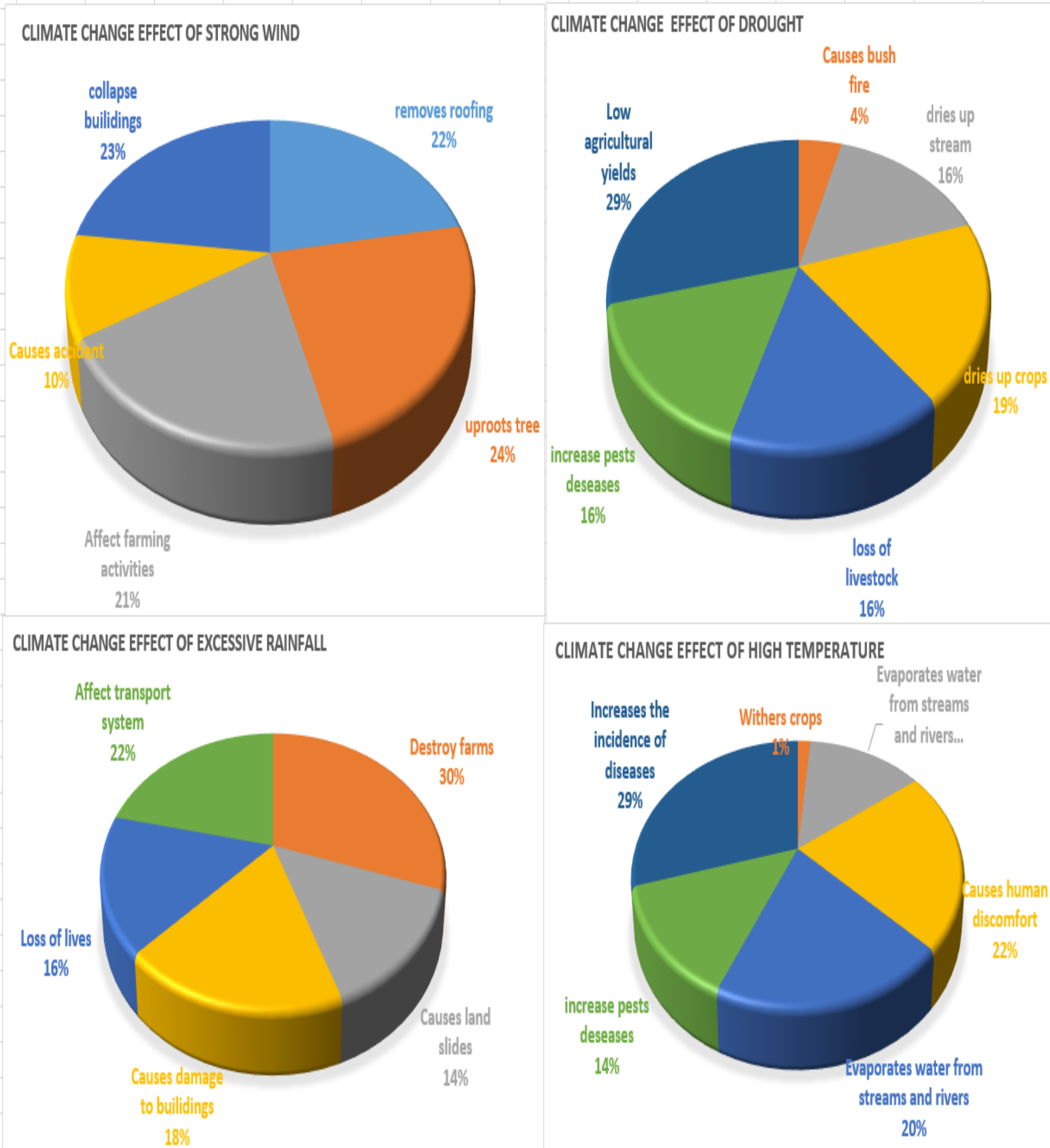
The adaptation measures that farmers currently use to adapt to climate change impact in Kirehe District are assessed ,the results are following ,the crops replanting 80% ,Early maturing cultivars' 80% are scored as extremely and very effective by the farmers as mostly used on agriculture seasonal basis, Irrigation 50%, Water conservation 50%, Use climate data Agroforestry practices and forecast 70%, Trees planting, Rain water harvest 45%, Drought tolerant cultivars 70%, Intercropping 70%, Disaster and diseases management 65% and Intensification agriculture 55% all strategies are entirely scored as extremely and very high usefull in respective percentage to the farmers score to their effectiveness levels to farming activities on agricultures seasonal basis. The following are raised recommendations in accordance to the assessments of adaptations strategies:

i. The Government of Rwanda through ministry of agriculture is requested to review existing policies, developing new ones that embracing and strengthening climate change resilience and adaptation strategies that should make farmers effective currently to cope with climate change impact.

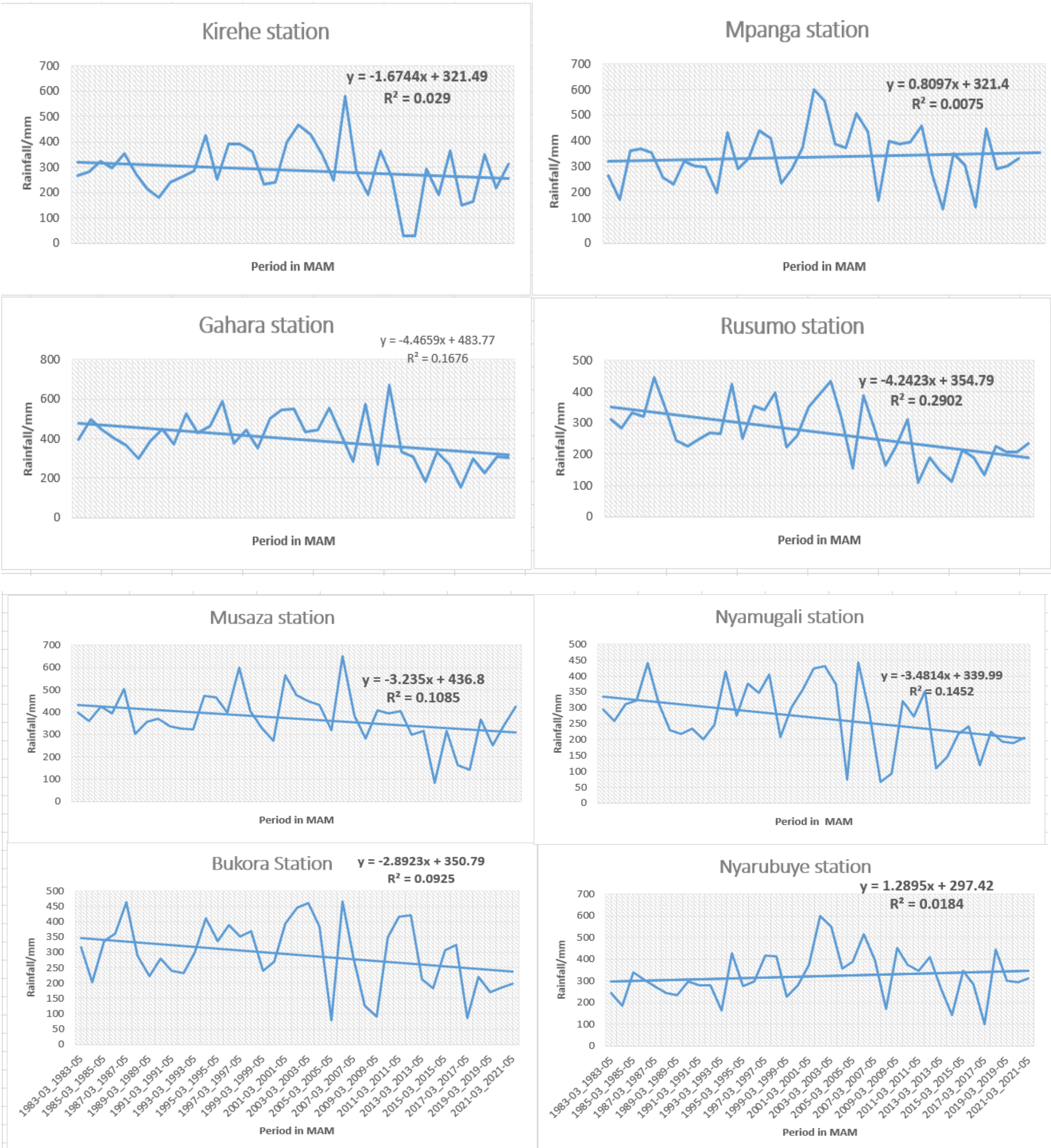
ii. The socio-economic growth have been hindered by financial means that is clear barrier to adapt to climate change impact therefore an easy access to funds and insurance policy should be availed to support farming's activities.

iii. To strengthen the culture of using irrigation system for small scale farming system with solar power generator pumping system to ensure farmers are safety for food security in currently and in future.

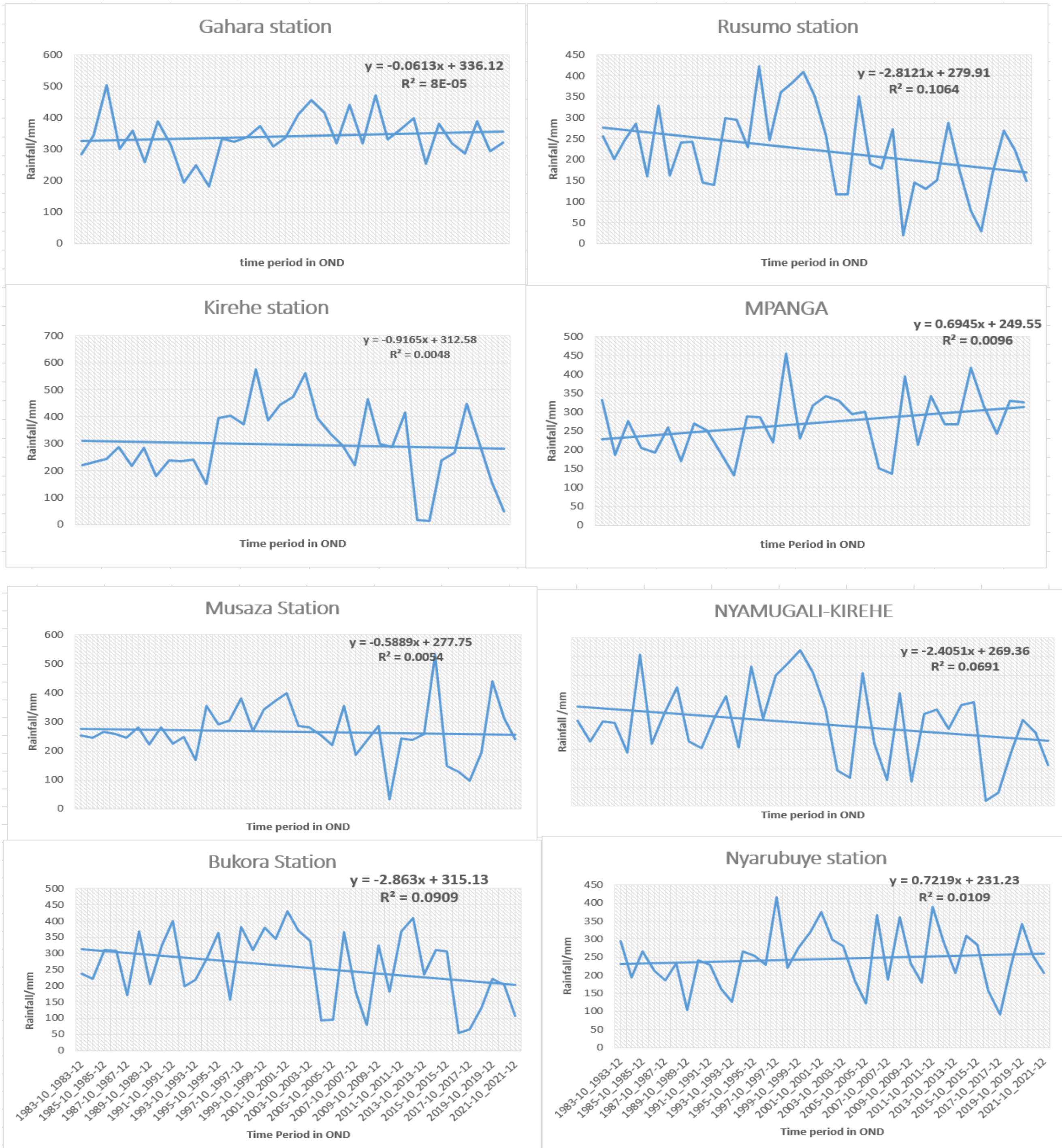
APPENDIX A : The Figure 4 represent assessment results to the effect of climate change



APPENDEX B: This Figure above represent variability of rainfall during Season of MAMA from 1983 to 2021 in Kirehe



APPENDIX C:This Figure above represent variability of rainfall during Season of OND from 1983 to 2021 in kerehe



APPENDIX D: Table 6. Maximum and minimum temperature Trends Statistics of MAM and OND of 39 years ago in Kirehe District

			MAM /Maximum temperature trend Statistics				OND/ Maximum temperature trend Statistics		
Time series	First year	Last Year	n	Test Z	Sign ific	**Sen's slope estimate** /Q	Test Z	Sign ific	**Sen's slope estimate** /Q
Gahara	1983	2021	39	-2.47	*	-0.049	-2.44	*	-0.042
Rusumo	1983	2021	39	3.05	**	0.050	2.53	*	0.035
Kirehe	1983	2021	39	2.37	*	0.030	1.50		0.026
Mpanga	1983	2021	39	2.04	*	0.027	2.49	*	0.035
Musaza	1983	2021	39	2.10	*	0.027	1.29		0.017
Nyamugali-kirehe	1983	2021	39	3.08	**	0.063	2.94	**	0.058
Bukora	1983	2021	39	-0.77		-0.013	-0.62		-0.004
Nyarubuye	1983	2021	39	2.40	*	0.034	2.78	**	0.049

				Minimum temperature Trend Statistics of MAM			Minimum temperature Trend Statistics of OND		
Time series	*First years*	Last year	n	Test Z	Signific	Sen's slope estimate Q	Test Z	Signific	Sen's slope estimate/Q
Gahara	*1983*	2021	39	3.02	**	0.032	4.23	***	0.036
Rusumo	*1983*	2021	39	-0.17		-0.001	1.74	+	0.011
Kirehe	*1983*	2021	39	0.07		0.000	2.40	*	0.014
Mpanga	*1983*	2021	39	0.60		0.005	-0.44		-0.006
Musaza	*1983*	2021	39	-0.48		-0.004	1.62		0.012
Nyamugali-	*1983*	2021	39	0.88		0.007	1.66	+	0.011
Bukora	*1983*	2021	39	2.98		0.030	4.16	***	0.035
Nyarubuye	*1983*	2021	39	0.04	**	0.000	-0.46		-0.006

APPENDIX E : The research Questionnaire

A. survey of perception, adaptation and knowledge of farmers to the effects of climate change on agriculture practices

A . Q**uestionnaires for households**
Questionnaire No.:……… ….Interviewed by … … … .. ……….. ……… …. Date: … … … … … . … .
Village… … .. …….. ……… … Time start … … …. … ………Time end … .

House No./Tel No .. …..
1.Name of respondent :……………
Sex: a. [ ] Male b. [ ] Female
2.Age of respondent:

a. [ ] 30-34 b. [ ] 35-39 c. [ ] 40-44 d. [ ] 45-49 e. [ ] 50-54 f. [ ] 55-59

3.What is the highest level of formal education completed?
a.[ ] None b. [ ] Primary c. [ ] Middle/JHS d. [ ] Secondary/SHS e. [ ] Tertiary

B. Farmers' knowledge of meteorological change over the last 25 years and perceptionon flood and drought.
This section seeks information on local Farmer's understanding and perception of climate change

01. what changes have farmers observed in the climate over the past 10-25 years in this community?. ***We consider keys words severity/impact and degree in frequency to happen for each climate indicator.***

Indicators	**Extremely high =5**	**Very High =4**	**Moderate = 3**	**Neutral =2**	**Low =1**
Early rainfall onset					
Delay rainfall onset					
Early Cessation rainfall					
Rainfall					
Temperatures					
Strong winds					
Prolonged dry season					

C. Effect of climate change to the farmers in Kirehe district

In your opinion how does climate change **(excessive rainfall, drought, strong wing ,high temperature**) affect life and property in this community? fill in bracket appriete answer due to the level of vulnerability, Extremely high = 5,very high = 4 ,moderate=3, Neutral=2, Low=1

Excessive rainfall/		**Drought**		**Strong wind**		**High**	

Flood						**temperature**	
Destroys farms	[ ]	Causes bush fires	[ ]	Removes roofing sheets from houses	[ ]	Withers crops	[ ]
Causes Landslides	[ ]	Dries up streamsand water bodies	[ ]	Uproots trees anddestroys farms	[ ]	Evaporates water fromstreams and rivers	[ ]
Causes damage to buildings, roads	[ ]	Dries up crops	[ ]	Affects farming activities	[ ]	Causes human discomfort	[ ]
Loss of lives	[ ]	Loss of livestock	[ ]	Causes accidents	[ ]	Increases the incidenceof diseases	[ ]
Affect transport system	[ ]	Increases Pests and diseases	[ ]	collapse of buildings	[ ]		

.

***E.* Farmers strategies and methods for adaptation responses toward climate change impacts**

01.What types of adaptation measures and strategies are you taking to protecting the crops from climate change impacts? Mention it, please.

Adaptation activity	excellent effective =5	Very effective = 4	Effective=3	Neutral effective=2	Low effective =1
Intercropping					
water conservation					
Replanting					
irrigation					
Drought-tolerant cultivars					
Early maturing cultivars					
Rain water harvest					
agroforestry practices					
tree planting					

02. Have you heard about the concept of climate change?if yes specify most resource do you use

Ressource	excellent affordable=5	Very affordable=4	moderate affordable =3	Low affordable	None affordable

Government officials					
Parents					
Friends					
School					
Radio					
Television					
Workshops					
Farmer Associations					
NGO					

03. What are the methods have you used to forecast onset of rain in agricultural seasonality?

Methods	excellent effective =5	Very effective = 4	Effective=3	Neutral effective=2
Birds/insect movements				
Meteorological agency				
Pattern of clouds				
Change in temperature				
Traditionally first week of Mach				
Traditionally first week of September				

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