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Climate Change Effects on Food Security in Rwanda: *Case Study of Wetland Rice Production in Bugesera District.*

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Abstract

The analysis of rainfall on past trends shows that, since 1992, Bugesera district has been characterized by a declining trend with a remarkable variability in rainfall frequencies and intensity which resulted into serious floods in 1997-1998 and a prolonged drought in 1999-2000. This study has been conducted to reveal the effects of climate change on rice productivity in Bugesera District. Rainfall and temperature patterns have been evaluated using the closest meteorological station (Kanombe Airport) that represents the study area. According to the results, the rise in temperature and changes in the amount of rainfall and its distribution have altered the availability of water resources, consequently affecting the productivity of rice. The variability in the onset of the rainy season has led to variation in the start of the planting season which has negatively affected the production of rice. Assessment of people's perceptions on ongoing change on rainfall and temperature patterns, and their adaptation strategies has been made. The respondents accept that there is a change happening in their area and have already started to feel its impacts. The study revealed that yields of rice have been distorted by changes in precipitation, temperature, as well as soil moisture. Flooding in lower zones of altitude along river Akanyaru have been reported for many times in the study area as causing the submergence of rice fields thereby damaging the growth and reducing the productivity of rice. In adaptation to climatic change effects, farmers have started to take on some adaptation measures. These measures include constructing water reservoir to collect water for irrigation use in the dry season, switching to new varieties of rice that resist to drought and flooding, and application of pesticides to combat with pests.

Key words: *Climate change, climate change effects, wetland management, rice production, food security, local community, Bugesera district.*

1. Introduction

The emission of greenhouse gases (especially carbon dioxide, methane, and nitrous oxide) into the earth's atmosphere from fossil fuel burning, intensive agriculture and the deforestation are considered to be the major contributors to global climate change (UNFCCC, 2007). Intergovernmental Panel on Climate Change estimates that worldwide temperatures have increased by more than 0.6°C in the past century and it is also estimated that by 2100, average temperatures will increase by between 1.4° and 5.8°C (IPCC, 2007).According to recent studies, Africa is particularly vulnerable to the effects of climate change because of multiple stresses and low adaptive capacities, arising from endemic poverty, weak institutions, and complex disasters and associated conflicts (ISDR, 2008).Almost all sectors of the African economy are expected to be at risk from the negative impacts of such climatic changes resulting in the loss of food security and livelihoods for millions of people (IPCC, 2007; Yanda et *al*., 2007).In many parts of Africa where rain fed agriculture is still considered as a major source of food and income, climate change impacts have been progressively becoming more and more severe in terms of frequency and severity and compounding food production within these areas (FAO, 2008; Mendelsohn *et al.*, 2000).Although Rwanda is a low-carbon economy, it is among those most vulnerable to climate change.

Located in the Eastern region of Africa, Rwanda has been faced with unusual irregularities in climate patterns including extreme temperatures, variability in rainfall frequencies and intensity over the last 30 years (RMS, 2004). The Analysis of rainfall trends showed that rainy seasons have tended to become shorter with higher intensity. The events such as droughts and floods associated with heavy rainfall and extreme temperatures have been reported ever more in Eastern and Northern parts of Rwanda. Droughts and extreme temperatures are known to affect the Eastern part whereas in the Northern floods are common. Due to this reason many areas within these regions are continually faced and affected by food shortage whenever climatic changes get worse (MINITERE and UNEP, 2006).

This research has been carried out in Bugesera District of the Eastern Province (Fig.1). This district was seriously affected by the drought in

1999 and 2000, and until 2007 no great change has been observed and the whole area would dry for almost six months every year. The droughts resulted into serious hunger and food shortage. However, as a response to this situation, the Government of Rwanda (GoR) tried to encourage the production of rice in Bugesera district as a strategy to maintain food security as well as food balance. Why? Because rice production can create a more self-reliant food balance and improved food security by offering a better trade value added prospects and high yields than the traditional food staples (IITA-FOODNET, 2003). But as for other crops, rice production is weighed down by constraints such as drought, flooding, salt stress and extreme temperatures, of all which are expected to worsen with climate change. Changes in rainfall patterns coupled with rising temperatures are likely to introduce unfavorable growing conditions and subsequently reduce the productivity of rice. Thus, the aim of this research was basically to understand these underlying processes, the short and long-term directions of such changes in order to analyze their effects on rice and as well on food security.

Within this research, five main priority sectors namely Shyara, Mareba, Nyarurugenge, and Ruhuha of Bugesera District were used in the survey. These sectors lie in the south west of District and have got nine wetlands used for rice cultivation. These wetlands include Ruvubu, Kadimbuzi, Mareba, Rwabikwano, Nyakariba, Nyaburiba, Tubumba, Kizanye and Kibaya. This is where rice is grown in the whole district. Almost all of these wetlands lie nearest the shores and borders of Lake Cyohoha south and around River Akanyaru as illustrated in the figure 1 below.

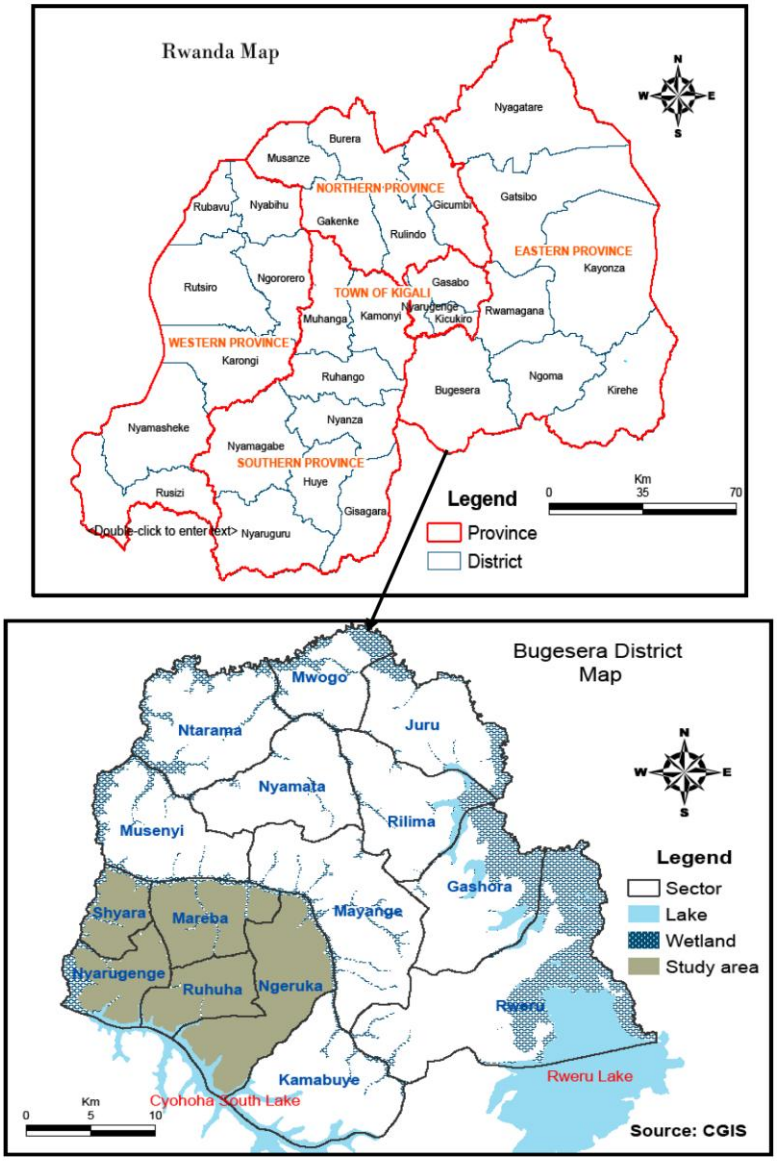

Fig.1: Geographical Location of the Study Area (MINITRACO/CGIS, 2001).

2. Materials and Methods

In order to achieve the research objectives, different data were used. These data were collected using different methods such as secondary

and primary methods of data acquisition. Secondary data were collected through conducting literature review of various published books, reports, scientific papers from libraries and internet. This was intended to deeply understand what climate change is and what impacts are related with it. Furthermore, literature in relation to rice productivity helped into making a link between rice production, food security and impacts of climate change.

Primary data, basically on rice productivity, weather patterns and people's perceptions about changing rainfall and temperature, were collected by use of questionnaires and interviews among the concerned people of selected sample size. Semi-structured questionnaire made it possible to prepare and generate realistic and accurate data during the field survey. The questionnaire was composed of semi-closed and open-ended questions designed for both rice farmers and the local leaders. The information obtained from local leaders and residents contributed to reveal the real situation of the study area and link between people's perceptions and statistical figures of weather obtained from surrounding weather station.

On the whole there were 96 questionnaires that were used in this research. 80 questionnaires were distributed in cells where wetlands and rice schemes are located within the district, whereas 16 questionnaires were distributed to the local authorities at cell, sector and district levels. The sampling technique which was used in this research is systematic sampling.

The presentation of the findings was done through tabulation using excel sheets. Later, the compiled data was analyzed, evaluated and presented in a wide range of cartographic methods such as maps, graphs, diagrams and images. The statistical tools such as mean, percentage and frequency were used for the data analysis. This analysis has been helpful in drawing out the conclusions and recommendations about the research.

3. Results and Discussion

Analysis of Rainfall and Temperature Patterns in Bugesera District

As the study area has no weather station which is operational, one meteorological station (Kigali Airport) closer to the study area was selected to know the variations in rainfall and temperature patterns. This station was selected simply because it is the closest functioning station and the climatic conditions are similar to those of Bugesera District.

Analysis of Rainfall Pattern

Kigali Airport Meteorological Station is located in Kicukiro District within 030° 07' longitude and 01° 57' latitude with an elevation of 1490 m above sea level. Kicukiro District where the station is located borders with Bugesera District in the North. This means that precipitation type in Kicukiro may not vary very much from that of Bugesera because they are in similar altitudinal ranges. The corresponding figures of Rainfall at Kigali Airport station are presented below in figure 2.

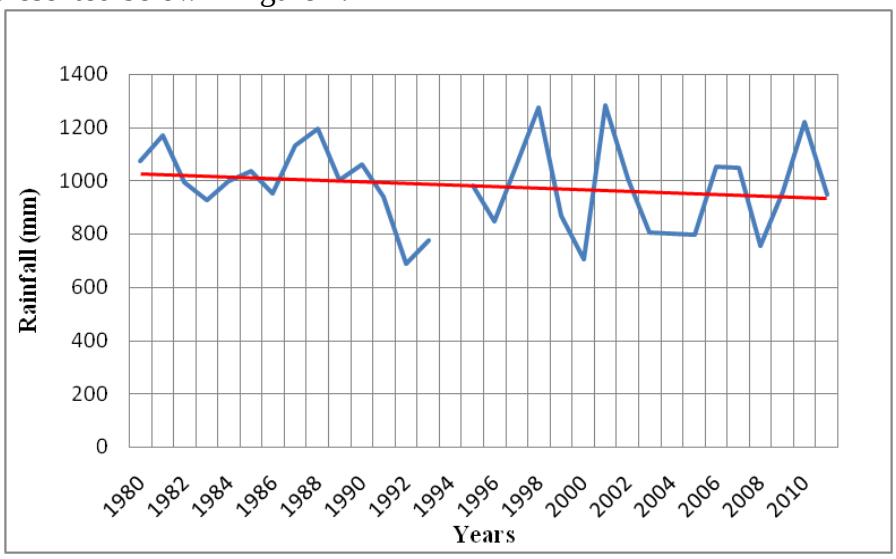

Fig. 2: Annual Mean Rainfall of Kigali Airport Meteorological Station (RMS, 2012)

Figure 2 shows that since 1992 the total annual rainfall has significantly changed and more unpredictable patterns of precipitation increased. The highest rainfall was observed in the year 1998, 2001, 2010 and the lowest in 1992, 2000 and 2008. In other years the amount is fluctuated. However, between 1980 and 1992 the amount of rainfall is generally decreasing and between 1992 and 2003 there is extremely high variability. From the year 2003 to 2011, the trend shows that the rainfall is increasing. Although the overall trend shows a declining trend, there is tendency towards increased precipitation seen from 2008 onwards. Due to1994 genocide against Tutsi the data for this year has not been represented in the analysis.

Analysis of Temperature

Analysis of annual mean temperature of Kigali Airport Station shows an increasing trend from 1982 to 2010. The highest temperature was recorded in the year 2005 and the lowest temperature was observed in the year 1982 similar to that of 1989. In the year 2005, temperature dropped abruptly and in the year 2010, it increased. Generally, the trend shows a gradual increase in annual average temperature.

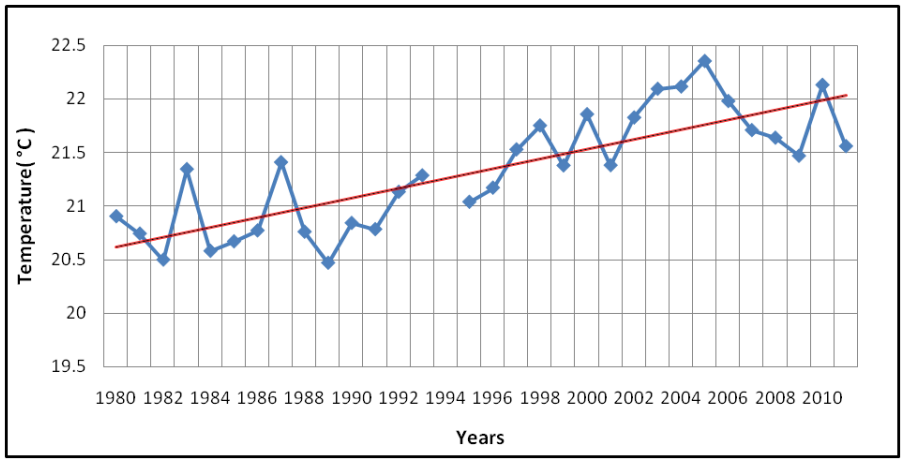

Fig. 3: Annual Mean Temperature at Kigali Airport Meteorological Station (RMS, 2012)

Generally, rainfall and temperature data analysis (Fig 2 and 3 respectively) shows the trend of rainfall and the temperature. In Kigali Airport Station, the annual mean temperature indicates an increasing trend and the annual mean rainfall is in the decreasing trend. From this

analysis, it can be noticed that there is emerging trend of increasing n rainfall fluctuations in Bugesera District. Therefore, the increased temperature and a tendency to increased rainfall might be the result of climate variability or change.

Local Community's Perceptions about Changing Rainfall and Temperature

Perceptions on Rainfall Pattern

The respondents from the study area confirmed that rainfall of Bugesera District has changed. They said that the onsets and offsets of the rainfall patterns are no longer predictable and that there is irregularity of rainfall every year. Variability in the onset of the rainy season has been reported in some of the responses indicating a delay in the start of the planting season of rice cultivation. They continued to argue that the rainfall has significantly increased over the last two years compared to the previous years.

In the Fig. 4 below, about 73% of the respondents accept that rainfall has increased and 25 % agreed that there is irregularity. Another 2% saw neither the increment nor the irregularity but rather they have seen a constant precipitation. However, none of the respondents has reported a decline in rainfall because it is now increasing compared to the past years. Most of the responses given by the respondents on increased rainfall show that rainfall started to rise from 2008 up to date. They reported that before that time, rainfall was still very low and there was a difficulty in water availability for the growth of rice**.** Although the respondents have agreed that water availability is no longer a problem, they still face the unpredictability of it and it has greatly affected production of rice.

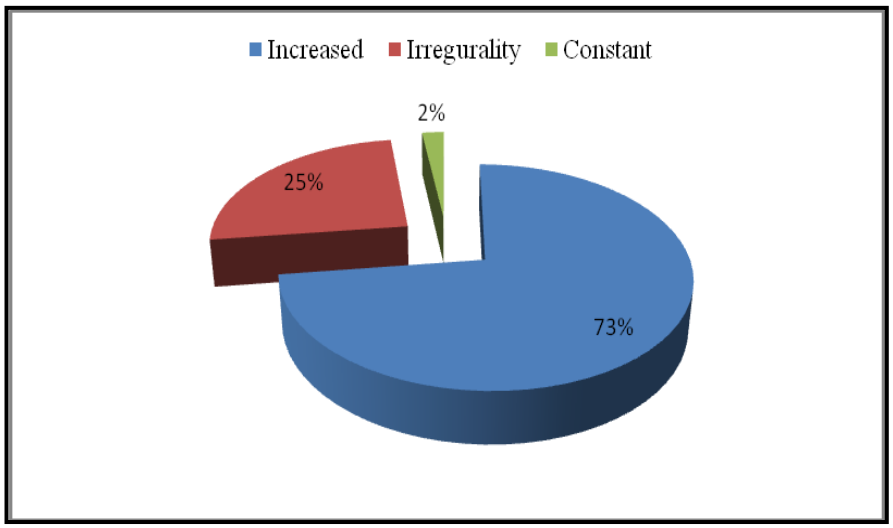

Fig. 4: **Local Community's Perceptions about Changing Rainfall** (Field Survey, 2012)

Perceptions on Temperature Change

About 50% of the respondents agreed that the temperature has increased, while 39% reported that temperature is generally constant and 11% of the respondents accepted that temperature has decreased compared to previous years (Fig.5). Those who agree that temperature has increased said that the hotness they feel in these days is quite different from that they used to occur in the past. They argue that today's hotness has increased and it is felt everywhere inside or outside house. Those who agreed that temperature is constant do not see any change in terms of temperature. They say that it is constant because the heavy sunshine they used to face did not stop and the temperature remains the same for the whole of the region. Other respondents observe that temperature has decreased because of increased rainfall that is emerging in that region. They realize that the increase of rainfall will reduce the number of hotter days and by doing so temperature will be decreased. The peoples' perception about the annual mean temperature in Bugesera District seems to be true when compared with the data from the meteorological stations. The records show that Bugesera's annual temperature has increased with a

tendency to decreased temperatures seen at Karama station from 2009 to 2011.

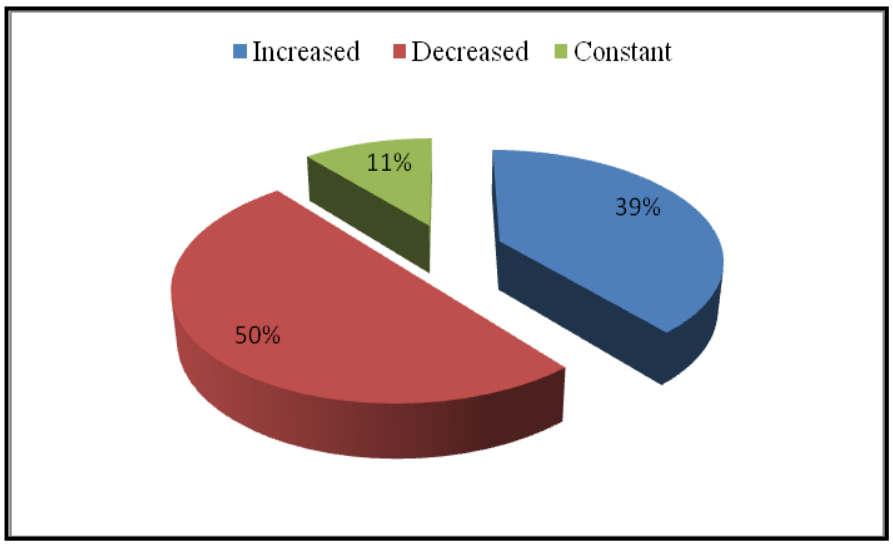

Fig. 5: Local Community's Perceptions about Temperature Change (RMS, 2012)

Reasons for Changes in Rainfall and Temperature Patterns

According to our findings, the major reasons that local community think are contributing to the changes in terms of rainfall and temperature patterns in the region are topography, increased forest area, deforestation and burning of bushes.

The above mentioned points indicate that local community have a general understanding of the changes occurring in their region but they do not link the changes with the changing climate scenario. The response could be taken as a reflection of what information is available at the local level. Most of the reasons pointed out by people are linked directly to increased forest cover which was emphasized in the mainstream environmental government policies for planting of trees at a large scale in the recent years.

Impacts of climate Change on Rice Production in Bugesera District

Impacts related to Rainfall Change

The change in the rainfall pattern (increasing or decreasing) in the study area has negatively affected production of rice. The changes in precipitation have altered the hydrological cycle and water sources in the study area. For instance, rice farmers agree that in the rainy seasons, water sources especially rivers are continuously filled up and cause flooding around the nearest rice fields due to the imbalance between discharge and natural recharge. Examples are seen in Ruvubu, Tubumba, Rwabikwano, Kiruhura and Nyakariba wetlands. Some parts of these wetlands have filled up by water and are no longer in use for rice production. According to the farmers, excessive rain fall which results in flooding entails important obstacle to the production of rice in study area. This is because, in case of flooding, submergence of fields occurs and leads to a complete loss of the plantations as well as the agricultural land which directly becomes water surface. They added that extreme rainfall also supports the development of pests and diseases such as what farmers have termed as "fungi" and the decay of the rice plants. On another hand, the shortage of water which is linked to the decreased rainfall and the decline in amount of water supply especially in the long dry seasons has far reaching effects on the production of rice. Shortage of water during the sowing period leads to the stunted growth and finally a decline in productivity (Table 1).

Impacts related to Temperature Change

The rice plant and temperature and other climatic conditions are mutually related components. Rice plant is influenced by climatic conditions including temperature. Thus, change in temperature result in the changes in rice production. For example farmers report that time of making nursery of rice seedlings, seed germination, germination rate, survival rates, seedling production, sowing and the time for maturity or ripening time are closely related with the temperature. For this reason, rice plantation should be done within a specific period when the temperature is favorable. According to Agronomist of Nyakariba rice station, a respondent from Nyarugenge sector, low temperatures may lead to grain sterility (*Kuramburura k'umuceri*) whereas high temperatures may lead to the development of pests.

Some of these effects which have been reported by the farmers and their corresponding percentages are illustrated in the table 1 below.

Table 1: Effects on Rice due to Changing Climatic Conditions

Effects on Rice	Frequency	%	Reasons
- Decaying	22	22.9	Excessive rainfall
- Grain sterility	8	8.3	Low temperatures
- Failure to germinate	6	6.3	Low rainfall or shortage of water
- Stunted growth	10	10.4	Shortage of water
- Complete loss of the rice plants	33	34.4	Flooding, excess rainfall
- Development of pests	17	17.7	Excessive rainfall
- **Total**	96	100%	

Source: **Field Survey** (June 2012).

Impacts of Climate Change on Household Food Security

Decline in Rice Production

One of the major effects of climate change on food security is the decline in the productivity of food. Flooding in the rainy seasons and droughts in the dry seasons have been affecting the growth of crops and sometimes leading to crop failures. However, as rice is increasingly becoming a major source of food for many households in the study area, the situation of food security gets worse when one of the climatic conditions exceeds or goes below the threshold values for growing of rice. That is to say when rain fall is very low or high and when temperature is very cold or hot. For instance, in comparison of the two growing seasons for the year 2011, farmers reported that in season II they lost crops and some parts of fields to flooding due to excessive rainfall received at that time. Rice yields decreased by 30% in season II and the annual productivity reduced as well (Table 2).

Table 2: Comparison of Season in terms of Rainfall and Rice Productivity

	Total Yields/Year			%
Year	**Season I**	**Season II**	**Comparison between I&II**	
2009	612 tones	717 tones	Increased	**7.2%**
2010	856 tones	904 tones	Increased	**10.5%**
2011	1037 tones	798 tones	**Decreased**	**30%**

Source: Bugesera District (2012).

In many periods of decreased productivity farmers have reported that they are strongly faced with increased food prices as result of decreased availability of rice at the market. Out of 96 interviewed respondents, 70 percent of them agreed that rice plays a great role in maintaining food availability and its balance among the population. As a result, farmers observe that, due to low rice yields which result from changing climate , households which only depend on rice production earn low income due to decreased productivity and their accessibility on other food varieties like maize, potatoes, etc happen to be limited.

Options for Climate Change Adaptation in Bugesera District

In the whole of the study area people in general have begun developing adaptation measures to deal with changing climate. For instance, on the changing rainfall pattern, about 11% of the total respondents stated that farmers have started to construct water reservoir to collect water for irrigation purpose during the dry seasons. Furthermore, about 47% accepted that they have started to switch to new rice varieties which resist to drought and flooding where as 16% agreed to have started applying pesticides in their fields to fight against pests and diseases that arise from increased temperatures. Farmers have also reported that in order to improve the security of food in their area, they have been using fertilizers to boost their productivity. Some of these fertilizers include NPK, UREA, etc. Other adaptations suggested by the respondents include erosion control and marsh or wetland reclamation. The table 3 below summarizes most of strategies that farmers have already started to practice in order to adapt to changing climate in their area.

Table 3: Adaptation Strategies as applied by Rice Farmers

Adaptation strategy	Frequency	%
- Adopting New Rice Varieties	45	47
- Construction of Water Dams	11	11
- Use of Fertilizers	24	25
- Use of Pesticides	16	17
Total	96	100%

Source: **Field Survey** (June 2012).

Conclusion

Though rice is a water demanding crop, it is grown in Bugesera as a rain fed crop because there are no reliable water sources for irrigation in most middle and upper parts of the study area. In the past few years farmers have not been able to plant rice in normal time because of droughts which had been chronic in this area. However, the emerging trend of rise in temperature and changes in the amount of rainfall and its distribution have altered availability of water resources for rice production. These changes have affected productivity of rice in Bugesera. The records of the rainfall stations from around the study area for thirty years show that there is a steady decline in the amount of rainfall but with a tendency to increased annual precipitation seen from 2008. Kigali Airport station shows a declining trend with tendency of increase in rainfall. Generally, based on the available records it can be said that the rainfall pattern has changed and there is a steady shift towards increased rainfall although the trend of the past few years indicates a different scenario with persistent droughts and long dry seasons.

Similarly there is a steady rise in temperature in the area. According to available data, the mean annual temperature has jumped from about 20.5 to more than 22 degree Celsius between 1985 and 2005. This trend is slightly increasing but shows a decreased tendency at the end of the trend.

The changes in rainfall and temperature patterns have been noticed by the farmers. They realize that there is a decline in rice production due to the changes in rain and temperature. Excessive rainfall which is often unpredictable has been a major source of flooding which destroys the crops and reduces the productivity. On the other hand, rainfall is very important factor for growth of rice in Bugesera district and in the absence of rain the total crop can fail with no yield at all. Therefore, even though other factors such as adequacy of fertilizer, timely weeding, and application of insecticides can be equally dependable for a good harvest, water is a prime factor and in absence of it, no other inputs for rice will be of much value. Farmers in Bugesera do apply amount of fertilizers, and carry out all other operations of weeding and hoeing, but when the rice land gets dry weed competes with rice more than any other thing taking all nutrients and available moisture.

Therefore, it can be concluded from the study and observation that the decline in rice production in Bugesera could be highly linked to the decreased rainfall or its fluctuation. Variation in rainfall pattern influences rice production adversely due to reduction in the quantity of water available. Yields of rice are always distorted by changes in precipitation, temperature. High temperatures and diminished rainfall reduce soil moisture in the study area, due to reduced water availability and hence damaging the plant growth. Policy support to rice research and development to widen or transfer appropriate and efficient technologies however, will be vital for sustainable rice production.

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