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# FARMERS PERCEPTION OF SUSTAINABLE AGRICULTURE: A CASE STUDY OF MUSANZE DISTRICT IN RWANDA

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## ABSTRACT

The objective of this study was to examine perceptions of the farmers in Musanze towards a sustainable agriculture. The researchers used the two steps for sample size by Cochran's formula both of which suites the categorical type of data the researcher had in order to determine a sample size of 173 respondents that was used to collect data for this study. the key findings showed that Musanze farmers consider Twenty-three (23) agricultural practices or polices like Umuganda and Girinka program among others to be of high importance (HI) in terms of a sustainable agriculture, three (3) practices or policies considered as of medium importance (MI) and two (2) were believed to be of low-importance (LI). For a transition to sustainable agricultural production to be scaled up, the government should give attractive incentives (Green payments) to farmers to practice more environmentally friendly practices otherwise, only environment protection programmes form government bodies like REMA's may be insufficient. The results of this research should be a starting point for identification of such practices.

**Keywords:** Sustainable Agriculture, Umuganda, Girinka and Rwanda.

## 1. INTRODUCTION

Rwanda is a small land locked country located in Sub-Saharan Africa within the center of Albertine Rift, at the heart of the great lakes region. It's neighbored by Democratic republic of Congo in the east, Uganda in the north, Tanzania in the west and Burundi in her south, it has the total surface area of 26,388 square kilometers out of which 1.38 million ha is arable.

Since the 1950s, Rwanda's population almost quadrupled leading to excessive pressure on land. In1934, the population was 1.5 million; by 2003, itmounted to 8.16 million. In the 1960s, agricultural land density was 121 persons per km2, rising to 166 persons per km2 within ten years and to approximately 262 persons per km2 in 1990, 8.1 Million in 2000, (Baechler, 1999), according to the 2012 world development indicator report by the world bank,

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Rwanda had an average 431 people per sq. km in 2010 (Binns et al., 2012). Making it the 3rd most densely populated country in Africa after Mayotte and Mauritius, its population is also projected to grow from 10.5 million in 2012 to 16.9 million (high scenario) to 16.3 million (medium scenario) or 15.4 million (low scenario) by 2032 (NISR,2012).

A rising population incites some societies to unsustainably use resources thus, land was intensively overused, and the marginal lands too were brought under cultivation which may have led to occurrence of environmental degradation among other consequences (Musahara and Huggins, 2005) and, ultimately, a societal collapse. It's because of this that Diamond quotes the 1994 Rwandan genocide against Tutsi tribe saying that it's a modern-day Malthusian crisis.

(Diamond, 2005, p. 313) However, Agriculture is key to development not only because it feeds Rwandese, but it also provides domestic capital, opportunities for foreign exchange, opens the additional labor markets, and provides rural welfare to Rwanda. (Norton and Alwang, 1993) The agriculture plays a major role in economic development (Yeshwanth, 2008).

Regardless of the fact that the confines of physical expansion of cultivable land is limited, Heavy investments are being made by the Rwandan government to facilitate inputs among other packages for enhancing the level of productivity in small farms.

(MINAGRI,2012). Agriculture has changed dramatically, Food and fiber productivity increased due to new technologies, mechanization, increased chemical use, specialization and government policies that favored maximizing production. Farmers, especially in developing countries as well as developed ones have used excessive agrochemicals in order to increase the crop yield at the expense of the endangering the needs of the future generation. Endangering the needs of the future generations It is felt that the high productivity of conventional agriculture had been achieved at the cost of massive damage to the natural environment and troublesome social disruptions.

Prominent among them include Water scarcity and pollution, with the rate of water consumption growing twice as fast as global population, agriculture's share of water could be drastically reduced. By 2025, an estimated 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be living under conditions of water stress (Mekonnen & Hoekstra, 2016).

Loss of living resources and biodiversity, the human system's level of consumption has grown to unprecedented levels, leading to the rapid depletion of natural resources and the disruption of ecosystem services through, for example, climate change and loss of biodiversity. (FAO, 2013). Deforestation poses one of the gravest threats to biodiversity, as forests harbor three-quarters of the world's terrestrial biodiversity. since agriculture is blamed directly for deforestation of closed tropical rainforests which may even account for the loss of 100 species a day (Brandon, 2014). also, runoffs from agricultural fields to negatively impacted the many deep-sea ecosystems by trawling (Rabotyagov et al, 2014).

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Climate change. Agriculture contributes significantly to climate change, which is the most serious environmental challenge facing humanity. It is estimated that 31 percent of total global greenhouse gas emissions are produced by crop and animal production and forestry (IPCC, 2006). Conversion of natural ecosystems to agriculture causes losses of soil organic carbon of as much as 80 tons per ha, most of it emitted into the atmosphere (Lal, 2004). On the other hand, agriculture will also suffer the consequences of climate change – rising temperatures, pest and disease pressures, water shortages, extreme weather events, loss of biodiversity and other impacts.

A rising population incites some societies to unsustainably use resources. Thus, land was intensively overused, and the marginal lands too were brought under cultivation which may have led to occurrence of environmental degradation among other consequences (Musahara, 2006) and ultimately a societal collapse. It's because of this that Diamond quotes the 1994 Rwandese genocide against Tutsi tribe saying that it's a modern day Malthusian crisis (Diamond, 2005). However, agriculture is key to development not only because it feeds Rwandese, but it also provides domestic capital, opportunities for foreign exchange, opens the additional labor markets, and provides rural welfare to Rwanda (Norton and Alwang, 1993). The agriculture plays a major role in economic development (Yeshwanth, 2008). Regardless of the fact that the confines of physical expansion of cultivable land are limited, heavy investments are being made by the Rwandese government to facilitate inputs among other packages for enhancing the level of productivity in small farms (MINAGRI,2012). Agriculture has changed dramatically, food and fiber productivity increased due to new technologies, mechanization, increased chemical use, specialization and government policies that favored maximizing production. Farmers, especially in developing countries as well as developed ones, have used excessive agrochemicals in order to increase the crop yield at the expense of the endangering the needs of the future generation.

Endangering the needs of the future generations. It is felt that the high productivity of conventional agriculture had been achieved at the cost of massive damage to the natural environment and troublesome social disruptions. Below are some of the prominent negative consequences of current agricultural production model. Water scarcity and pollution: Agriculture's current demands on the world's freshwater resources are unsustainable. Inefficient use of water for crop production depletes aquifers, reduces river flows, degrades wildlife habitats and has caused salinization of 20 percent of the global irrigated land area. By 2025, an estimated 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be living under conditions of water stress Mekonnen, & Hoekstra, 2016) With the rate of water consumption growing twice as fast as global population, agriculture's share of water could be drastically reduced.

Loss of living resources and biodiversity: The human system's level of consumption has grown to unprecedented levels, leading to the rapid depletion of natural resources and the disruption of ecosystem services through, for example, climate change and loss of biodiversity (FAO, 2013). Due to specialization in agricultural production activities, most of the world's major crops and animal breeds have a very narrow genetic base. Up to 75 percent of the genetic diversity of crops

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has already been lost, and another 15 to 37 percent is "committed to extinction" by 2015 (Thomas et al., 2004). In the oceans, close to 30 percent of stocks are overfished and 57 percent are fully exploited (FAO, 2012c).

Climate change: Agriculture contributes significantly to climate change, the production and distribution of food has been a major contributor to greenhouse gas emissions. It is estimated that 31 percent of total global greenhouse gas emissions are produced by crop, animal production and forestry (IPCC, 2007).

According to H ultgreen and Leduc (2003) concluded that the large increase in the use of nitrogen fertilizers for the production of crops like corn has dramatically increased the emission of nitrous oxide, a powerful greenhouse gas. Greenhouse gases which acts like a blanket that absorbs infrared radiations and stops them from escaping into the outer space. This causes a global warming process which is net effect of gradual

heating of the Earth's atmosphere. In order to reverse the negative consequences of conventional agriculture, different forms of sustainable agricultural systems have been suggested as alternatives for attaining the goal of an environmentally sound and economically profitable agricultural production system.

Rwanda's agricultural production would most probably fail sooner or later because in the long-term, these productions are not either environmentally or economically sustainable, there is a need for local researchers to think about sustainable agricultural practices that will allow current food needs to be met without compromising the ability of future generations to meet their food needs. If a farmer is to adopt any sustainable agricultural practice, the farmers first need to believe that this practice is important. Farmers' perception is among the many factors that determines a farmers' choice to take up a new agricultural innovation. The researcher's interest was to find out that, what are the perception of the farmers with regard to some of the selected sustainable agricultural technologies. The main aim of the study is to determine the farmer's attitude and perception of sustainable agriculture Musanze district of Rwanda. However, on the specific objectives of the study were (i) to describe the socioeconomic characteristics of farmers in study area, (ii)to explore the point of views of perceived by the farmers on importance of the selected sustainable agricultural practices or policies.

## 2.MATERIALS AND METHODS

Musanze District: Is a district found in the Northern Province of Rwanda. Five of the eight volcanoes of the Virunga chain (Karisimbi, Bisoke, Sabyinyo, Gahinga and Muhabura) are within the its boundaries. It's the most popular tourist destination in the country because most of Rwanda's mountain gorillas is where they are found.

Through consultations with Rwanda's agricultural researchers from University of Rwanda (UR), Food and Agricultural Organization of United Nation (FAO), a formal standardized questionnaire was designed that included open-ended and close-ended questions to easily

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encourage rural farmers to fully provide necessary data. The sample of the farmers were asked to participate voluntarily in this study and the farmers were randomly selected from Musanze District of Rwanda

To determine a sample size of this study the researchers used the two steps for sample size by Cochran's formula both of which suites the categorical type of data the researcher had. Random sample where each element of our population had an equal chance to be selected was used to collect data from some key 173 respondents and our sample size represents eighty percent of the total population in the surveyed rural Rwanda.

The questionnaire had sub-sections; in the first section there are questions about socio-economic characteristics such as age, gender, level of education, income from last season, household size and ownership status among others. The researcher assumed that these characteristics have positive effect on the transition towards sustainable agriculture. This was consistent with some other authors who made research on uptake of agricultural technologies. Personal characteristics such as age, gender, farming experience and education have also been found to influence the adoption of certain adaptation practices (Mlenga & Maseko,2015). The second part of the questionnaire included questions to explore the point of view of

farmers about the importance of sustainable agricultural. On average we spent 10-25 minutes with every farmer to complete a single questionnaire. An introductory letter authorized by the Rwanda Agricultural Board (RAB)-office of the head of crop production and food security department was used by the researchers as an evidence to the districts' director of agriculture and natural resource and sector agronomists to prove that the research was being conducted for the academic purposes only upon which they had it stamped. Face to face interviews were conducted in their farms and others were found at their stands in Byanga local market of Musanze district because it's one of the days of the week that Byangabo market gets many farmers bringing their produce to the market as advised by many farmers to wait for that ''ISOKO RYAREMYE-market-day''.

After collecting the data, it was processed and analyzed in such a way that they answered the objectives of our research, with the analysis of data both descriptive and inferential or statistical, it involved exploratory analysis, computation of certain indexes or measurers, looking for certain patterns of relationships that exist among data-groups and develop interpretation to values of unknown parameters and graphical presentation

## 3. FINDINGS

**Table1 showing the socio-economic characteristics of Musanze farmers;**

| Marital status | Frequency | Percent |
|---|---|---|
| Single | 26 | 15.0 |

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| | | |
|---|---|---|
| Married | 116 | 67.1 |
| Divorced | 10 | 5.8 |
| Widow or Widower | 19 | 11.0 |
| Total | 173 | 100.0 |
| **Age of the farmer (Years)** | | |
| <25yrs | 37 | 21.4 |
| 26-60 yrs | 115 | 66.5 |
| >60 yrs | 15 | 8.7 |
| Total | 167 | 96.5 |
| No answer | 6 | 3.5 |
| Total | 173 | 100.0 |
| **Level of education** | | |
| No education | 36 | 20.8 |
| At least attended Primary school | 111 | 64.2 |
| At least attended Vocational school | 1 | 0.6 |
| At least attended Secondary school | 17 | 9.8 |
| University graduate | 1 | 0.6 |
| No answer | 5 | 2.9 |
| Total | 173 | 100.0 |
| **Experience of the farm operator** | | |
| <10 | 57 | 32.9 |
| 11-21 | 54 | 31.2 |
| 22-31 | 17 | 9.8 |
| 32-41 | 9 | 5.2 |
| >42 | 14 | 8.1 |

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| | | |
|---|---|---|
| No answer | 22 | 12.7 |
| Total | 173 | 100.0 |
| **Size of the farm (ha)** | | |
| <.5ha | 59 | 34.1 |
| 0,5-1ha | 49 | 28.3 |
| >1ha | 3 | 1.7 |
| No answer | 59 | 34.1 |
| Total | 173 | 100.0 |
| **Total operational Land** | | |
| <0.5ha | 55 | 32.5 |
| 0.5-1ha | 56 | 33.0 |
| >1ha | 3 | 1.7 |
| No Answer | 57 | 31.6 |
| Total | 173 | 100.0 |
| **Type of farming** | | |
| Crop Farming | 65 | 37.6 |
| Dairy Farming | 1 | 0.6 |
| Mixed Farming | 93 | 53.8 |
| No answer | 14 | 8.1 |
| Total | 173 | 100.0 |

Source: Authors' field work

Majority of respondents were married with a percentage of 67.1 followed by singles with 15.0% and lastly 11 % of the Widow or Widower. The relevancy of marital status on agricultural production can be explained in terms of the supply of family labor for agricultural production. It is anticipated that family labor would be more available where the household heads are married. Due to expected responsibilities like providing food, school fees, shelter and medical insurance to family's dependents. Married people are expected to look from where to get them.

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The influence of age on farm productivity is very diverse. (Amaza et al., 2009), as per results in the Table 1. This shows that the surveyed respondents with age brackets 26-60 years had the highest percentage of 66.5% followed by those below 25 years of age. Showing that active and productive households dominate the farming activities which has a direct influence on readily available strong labor for agricultural production and ease adoption of new agricultural technologies. Still having a great likelihood for improving agricultural productivity, economic status and households' wellbeing. Age was found to have an affect the rate of household adoption of innovations, which in turn, affects household productivity and livelihood improvement strategies (Mwangi & Kariuki,2015).

Respondents who attended primary school had the highest percentage of 64.2% followed by 20.8% of those who never attended any school.

This is in correspondence with the report from the UNICEF, as a track to achieve universal access to primary education by 2015, ın 2012 Rwanda was reported to have the highest primary school enrolment rates in Africa. 73 % (2012) the overall completion for girls' rate at primary level and again being at 78 % in 2012 from 53 per cent in 2008 and this reflects Rwanda's success at increasing access and retention of children in primary school. (UNICEF, 2006). the high rate of primary school enrolment indicate that majority of the Rwandese farmers are literate. This is an advantage for adoption of new farm innovations as education has been shown to be a factor in the adoption of high yielding modern farm practices. Obinne (1991), posited that education is a vital factor influencing farm innovation adoption. In other words, the level of education of the surveyed households most likely makes farmers more responsive to how to adopt and integrate many new agricultural technologies and policies and, hence, farm productivity. in this research too agrees with an earlier study (Agwu and Anyanwu,1996) who opined that increase in education of farmers positively influence adoption of improved practices.

Farming experience is an important variable that determines both the production level, productivity and uptake of improve technologies in the farming business. Since experience is linked to the age of a farm operator, older farmers were found more likely to take up agricultural innovations than younger farmers (Ahearn, 2011). Table 1 shows that majority 32.9 percent of the surveyed households had an experience that was below 10 years of farming experience followed by those with years of farming experience that was between 11-21 years.

Table1 gives information of firm sizes in hectares. From the table its clearly evident that the largest percentage of the farm size appears of the farmers surveyed in the three districts located in different provinces had farm size that was below 0.5ha with a 34.1 percent with the smallest being. The average farm size in the region was also calculated and it was found to be 0.6795

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hectares (SD = 0.559). The finding is in consonance with Rapsomanikis, G. (2014). 59 percent of farmers were resistant to give farm size measurements most probably due to fear that it may have an impact on changes in land ownership or taxation consequences.

Considering the crop acreage with the new technology may be a superior measure to predict the rate and extent of adoption of technology (LowenbergDeBoer, 2000). Results from the table1 shows that most respondents had a total operational land or crop acreage that was between 0.5-1 ha with 33.0 percent followed by those with those less than 0.5ha of 32.5 percent. Byangabo village in Busogo sector in Musanze district where the data collection was done back in the days it had volcanic eruption which led to the piling of the volcanic lava stones in most of her cultivatable lands. It is common to find farmers in Byangabo having large farm size but too small cultivatable area. Thus, for a farmer to have any slight increase in a cultivatable area leads to an increased harvest.

In mixed farming livestock are reared with crop production simultaneously since animal manures available from livestock is used to maintain soil fertility pausing a positive impact on a sustained agricultural production. This in relation to this study's results that majority of the farmers in the research area had preferred Mixed farming followed by crop farming with 53.8 percent and 37.6 percent respectively

**Table 2; Perceived importance on the selected sustainable agricultural practices or polices**

| | Mean | Std Dev | Category |
|---|---|---|---|
| Reforestation of the less advantaged farm environments | 4,45 | 0,91 | HI |
| Zero grazing | 4,29 | 1,07 | HI |
| Umuganda | 4,28 | 1,24 | HI |
| Girinka | 4,24 | 1,35 | HI |
| Improved seeds | 4,24 | 1,26 | HI |
| Avoidance of early and excessive grazing on farm environments | 4,18 | 1,17 | HI |
| Crop rotation | 4,14 | 1,24 | HI |
| Integrated crop and livestock farming | 4,13 | 1,24 | HI |
| Purchasing few inputs like chemical fertilizers | 4,10 | 1,27 | HI |

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| | | | |
|---|---|---|---|
| Taking adequate measures to control soil erosion | 4,02 | 1,32 | HI |
| Government mandates and regulations | 4,02 | 1,31 | HI |
| Leaving the farm to only one hire (land fragmentation avoidance) | 4,02 | 1,26 | HI |
| Mulching | 3,93 | 1,31 | HI |
| Land use consolidation. | 3,91 | 1,34 | HI |
| Water retention ditches. | 3,90 | 1,29 | HI |
| Organic farming | 3,88 | 1,28 | HI |
| Farm yard manure | 3,79 | 1,25 | HI |
| Silvopastures | 3,73 | 1,31 | HI |
| Growing cover crops | 3,72 | 1,40 | HI |
| Riparian buffers | 3,70 | 1,32 | HI |
| Hedgerows | 3,68 | 1,35 | HI |
| Alley cropping | 3,65 | 1,38 | HI |
| Bench terraces | 3,42 | 1,68 | MI |
| Mixed cropping | 2,90 | 1,47 | MI |
| Integrated fish and rabbit farming | 2,83 | 2,10 | MI |
| Personal involvement in yield marketing | 2,77 | 1,62 | MI |
| Climate change | 1,75 | 1,72 | LI |
| Burning maize remains | 1,53 | 1,42 | LI |
| Valid N (list wise) | | | |

Table 2 shows the importance given by the farmers to each of the selected sustainable agricultural practices Based on the interpretive Likert scale that was named after its discoverer, Rensis Likert. Twenty-three (23) agricultural practices or polices belonged to the high importance (HI) response category, three (3) practices or policies belonged to medium importance (MI) response category, and two (2) in the low-importance (LI) category. No

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agricultural practice or policy belonged to either very high importance (VHI) or no importance (NI).

The following agricultural practices were the ones that belonged to HI response category: Reforestation of less advantaged farm environments, zero grazing, umuganda, girinka, water retention ditches, land use consolidation, hedgerows, improved seeds, avoidance of early and excessive grazing on farm environments, crop rotation, integrated crop and livestock farming, purchasing few inputs like chemical fertilizers, government mandates and regulations, taking adequate measures to control soil erosion, avoiding land fragmentation, mulching, , organic farming, farm yard manure, silvopastures, growing cover crops, riparian buffers, and lastly Alley cropping.

The following three (3) agricultural practices or polices were the ones that belonged to medium importance (MI) response category, bench terraces, mixed cropping and finally personal involvement in own yield marketing.

The following (2) agricultural practices or policies were the ones that belonged to the low-importance (LI) response category. Climate change and burning of the maize remains.

Farm yard manure (FYM): Rwandese farmers perceived FYM as a factor that is of a high importance (HI) for a sustainable agriculture. As per the Rwandese farmer, they decompose a mixture of cow dung and urine along with the left-over material from fodder fed to cattle. Depending on financial ability of a farmer to recycle and minimize the FYM nitrate (NO3-) pollution potentials to ground water or eutrophication, this piled mixture can either covered into the hole or left on ground before being used for fertilizing the farmlands.

Farmers admit that upon application of a decomposed FYM, it improves the soil organic matter along with a slight addition of industrial fertilizers results into sizeable increase in crop harvest without over dependence on costly off-farm inputs (Stockdale et al., 2001), which helps in achieving sustainable agricultural production and preserving the farm environment from the antagonistic effects of conventional farming at once.

Adequate measures to control soil erosion: Rwandese farmers considers adequate measures to control soil erosion as a factor that has a high importance (HI) in ensuring food production that will satisfy the needs of the present generation while compromising the future generations needs for food because of some of the undermentioned negative effects soil erosion. Either wind or water soil erosion a major environmental threat (severity of on-site and off-site impacts) to sustainability to productive capacity of agricultural lands.

Due to removal of vegetation cover which means removing the protection of plants and roots needed to lock soil in place. The top fertile soils are the most productive part of the soil profile for agricultural purposes since they contain high organic matter. When removed by erosion agents like wind and water, it leaves the soil more susceptible to a more weakened water holding capacity which translates into lower crop yields and higher costs of production. Transportation

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and deposition of top fertile soils from farmlands to other location leads to off-site problems like water pollution since such runoffs carry with its contaminants, like pesticides and fertilizers that negatively impacts the wildlife habitats and ecosystems of streams and wetlands with salinization and soil acidity.

Wind erosion too can totally destroy the crops in the field by damaging young seedlings or uncovering/ burying too deep seedlings leading to a decreased cropland productivity, loss of quality and market values.

Mulching: Rwanda farmers growing coffee and those growing tomatoes commonly place cut grass, straws and banana leaves on the soil surface to mitigate soil erosion and improve the water-holding capacity, maintain moisture in the soil facilitating infiltration, reduce weed growth, and improve soil conditions (Patil et al,.2013) which helps them to get improved crop yield Thus,, mulching is a sustainable agricultural practice and environmentally benign for a sustainable cultivation of the crops.

Organic agriculture: Since it relies upon compost from household waste, animal manures, crop residues like maize remains, legumes like beans and crop rotations among many other agricultural practices that alleviates a lot of the environmental effects of industrial agriculture as well as improving the productivity in small fields of Rwandese farmers.

Trewavas (2001) criticized organic agriculture of its lower yields but its many proponents argued that organic agriculture as well as other non-certified ‘organic’ or ‘sustainable’ management practices can lead to substantial yield increases in low-input farming systems in developing countries (Altieri 2002; Scialabba and Hattam 2002; IFAD 2003; IFAD 2005; Badgley et al., 2007; UNCTAD and UNEP 2008) at the same increasing the environmental performance of agriculture (Pretty and Hine 2001; Pretty et al.,2006).

Avoiding land fragmentation: The Rwanda’s farmers considered this factor to be of high importance due to its drawbacks like hindering planning for agricultural practices that are environmentally benign, limiting the farmers’ needs of modernizing their parcels by introducing new agricultural production technologies like irrigation systems and the would-be effectiveness of mechanization leading to a decrease in both productivity and profitability in the agriculture sector consequently a decrease in farmers’ income rising dangerous socio-economic widespread failure among all the stakeholders.

Purchasing few inputs like chemical fertilizers: Reduction but not necessarily elimination of chemical fertilizers, just like proposed by J.F. Parr et al., (1990), Rwandese farmers mix chemical fertilizers (an off-farm resource) with animal manure (on-farm resource) but the animal waste being in a higher proportion than inorganic fertilizers, applying an appropriate amount of chemical fertilizer and animal manure can raise the yields and improve on the soil fertility (Tittonell et al., 2008) lowering their costs of production ensuring reduced pesticide residues in food, farmer’s overall health risks too is reduced and increasing both short- and long- term farm profitability.

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some farmers confessed that when they use inorganic fertilizer in the first season and don't use it in the next season, you can hardly get a yield from that same piece of land unlike for animal manure which promises a sustained progress in agricultural productivity and profitability, since Rwandese farmers can save cash too, we can argue with confidence, purchasing few of these costly external inputs like chemical fertilizers as a practice with a sustainable agricultural implication since it enhances good harvests as well as avoiding environmental degradation at the same time achieving sustainable rural livelihoods.

Integrated crop and livestock farming: The integration of crop and livestock rural Rwandese have excreta from cattle used to enhance crop production and profitability while reducing the risks of soil degradation since it's important for improving fertility and soil physical, chemical and biological properties, maize residuals too are low-cost feed resources for feeding the animals, supplementing the scarce feed supplies. Thus, contributing to both improved animal nutrition and crop productivity-profitability. Thus, the integrated livestock-farming system maintains and improves agricultural productivity while also reducing negative environmental effects (Keating et al., 2010; Wilkins, 2008).

Crop rotation: Rwandese farmers rotate crops on the same farmland especially maize-cereal following beans-legume that is known to biologically replenish soil with nitrogen when their roots and green parts rot, it improves soil conditions and reducing weed from multiplying and Planting breaking their life cycle at the same time decreasing insect populations that build-up reduce the localization of insects the need of insecticide reduces unlike when one specie is continuously cropped steadily increasing yields profitability over time, crop rotation also may influence the rate of conversion of organic N to mineral N by modifying soil temperature, pH, soil moisture, tillage practices and plant residue. It also distributes the crop loss risk that would otherwise come from growing mono-cropping and weather, reduce the need for off-farm inputs like pesticides and chemical fertilizers among others meaning a reduction of the farmers' costs of production. Enhancing soil fertility and reducing sensitivity to pests and diseases (Thierfelder and Wall 2015). Thus, Rwandese farmers are able to reduce the usage of insecticides and chemical fertilizers, thereby saving money and protecting future productivity as well as the environment.

Growing cover crops: Rwandese farmers' consider grow appropriate cover crops of a high importance for sustainable agriculture because they help farmer and the environment to achieve benefits like enhancing soil quality, suppressing weeds and preventing soil erosion by holding soil particles in place and decrease sediments in waterways that could degrade habitats which means they reduce the need for chemical inputs like fertilizers herbicides and insecticides and Thus,, contributing to a sound ecological farm fields. Improve land productivity by increasing the soil fertility and its water holding capacity Thus, growing appropriate cover crops is sustainable agricultural practice since it provides high yields at the same time avoiding the unintended consequences like water and air pollutants that deteriorate the environment endangers the health of farm-workers and consumers which are incurred under chemical-based agriculture.

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Avoiding early and excessive grazing on farm environments: Early and excessive grazing both have negative effects that pause threat to many rare species farm environments, as it causes the degradation or reduction in habitat values for native wildlife species, the continued presence of cattle in these sensitive habitats causes significant destruction by trampling overexposure .during rainy seasons increased erosion and sedimentation in area aquatic ecosystems which means that many species dependent on aquatic are at risk due the presence of livestock an argument in line with (Oldeman et al., 1991). Excessive grazing has significant impacts on the growth of new tree growth as well. It leads to compacted soils and (organic matter content) leaf litter are removed decreased water infiltration capacity and fertility of the soil and water storage capacity, productivity and profitability of the land is reduced. this creates difficult conditions for root penetration of the germinating crop. Biodiversity is negatively affected too. Thus, Rwanda's rural farmers confessed avoiding early and excessive grazing on the farm environments as being a highly important factor for a sustainable agriculture.

Improved seeds: Improved seed varieties like maize, rice and beans best suited to set-up Rwanda's climate ensuring an improved production of crops, expanding the income of farmers finally increasing the farmers' chances of accessing other payable social services. Since in rural Rwanda they are grown using compost and cow dung instead of fossil fuel-derived fertilizer they enhance natural processes and cycles increasing organic matter in the soil, sequestering carbon and holding moisture Thus, allowing crops to naturally adapt to changing climate conditions (environmental benefits) also helping farmers reduce the risk of yield loss when prolonged dry season sets in. Now, since a reduced off-farm is used, the Rwandese farmers are saving on costs of off-farm inputs like herbicides and pesticides, as well as on labor and energy Thus, boosting the overall productivity. Therefore, sustainable agriculture is dependent on a lot of factors like improved seeds.

Hedgerows: Just like common objectives of the riparian buffers, silvopastures, and alley cropping, hedgerows are trees and forests or shrubs playing an important role in the livelihoods of rural areas of Rwanda. Trees give shade, shelter and protection from the winds (Lasco et al., 2014) fodder, fruit and fuel wood production can be increased, on the hand decreasing runoff or erosion and enhancing the soil fertility (Bernier et al., 2015). Woody species interplanted among or in proximity to the principle crops delivers a variety of benefits to the farmers for example supplementary income, food provision and even environmental services (Lasco et al., 2014). Grevillea robusta was the most dominant tree species on small farmlands, it has no major negative effects on the site. Actually, it is one of the main agroforestry species in the country (Harwood, 1992). Grevillea robusta can be intercropped in rows between small fields of crops such as coffee, maize, banana and beans. In Rwanda they are planted in rows or in between the small fields, and as scattered individuals over crops such as maize and coffee. It gives long-term economic sustainability in rural areas from the economic returns of the poles or timber, wood and fuel, G. robusta is also considered as a fodder supplement for cattle in the dry season when other fodder sources are scarce (Spiers and Stewart, 1992). As per the environmental sustainability, Grevillea robusta provide ecological services like wind breaks, erosion control by arresting sediment movements, carbon uptake and water penetration improving soil structure

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around the root zone and its thought to increase the plant's ability to take up nutrients (Skene et al., 1996) that's contributing to environmental sustainability.

Land use consolidation: In Rwanda, food crop production mainly depends on the productivity in smallholder farms. The government of Rwanda is persistently looking for policies to intensify production and raise the economic status of its farmers on the already existing small-holder farmlands. İt has made heavy investments to policy reforms and innovative programs like land use consolidation among other components of crop intensification programme initiated in September 2007 in order to raise the productivity of high priority food crops like maize, rice and wheat on their small farms and track the country's vision for a market-oriented agriculture. Under land use consolidation model, the concept behind is that joining these small plots together to farm as a single unit would deliver important economies of scale in the acquisition of inputs, processing and marketing as well as efficiencies in access to extension services while keeping their land rights intact. The finding is in line with Mbonigaba Muhinda and Dusengemungu. (2013) found that the current land use consolidation policy in Rwanda encourages crop specialization to realize economies of scale and to orient the agricultural sector more towards the commercial market. Ever since farmland use consolidation was launched in 2008, the area under land use consolidation (LUC) has grown by 18- fold from 28,016 ha in 2008 to 502,916.55 ha in 2011. The consolidated production of priority crops under CIP has also brought significant increases in production of food – maize by 5-folds; cassava and wheat by about 3 folds; Irish potato, beans and soybean by about 2-folds; rice by 30 percent. impressively, the productivity in consolidated land areas has steadily been higher for wheat and maize. Ever since its establishment LUC considerable changes have been recorded at macro level. The area under cultivation under LUC has increased by 18 times between 2008 and 2012 from 28,016 ha to 602,000 ha. Yield of maize has gone up 5 times, wheat and cassava 3 times Irish potatoes, soybeans and beans 2 times and rice by 30 per cent. (Musahara, 2014; Mbonigaba and Dusengemungu, 2013; Kathiresan, 2012; MINAGRI, 2012). The increased volumes of production prompt the associated need for investments in rural infrastructure, feeder roads, and access to finance in consolidated land areas through public-private partnerships (MINAGRI, 2012), it shows that there is always a positive correlation between the increase in volumes of production and increase in socioeconomics benefits of the farmers, As per the third household survey (EICV 3) which directly states that LUC has contributed to poverty reduction in Rwanda (GoR, 2012), agricultural practices like crop rotation and other technologies that reduces off-farm inputs usage like pesticides also supports the view that the land use consolidation promote the environmental sustainability.

Water retention ditches: Since food production must double by 2050 to Meet an increasing demand for agricultural products world's growing population, there is a necessity to build a strong and sustainable farms production. Farmers are always faced with unprecedented rainfalls, and sometimes floods and droughts. As one of the waters harvesting and also a water conservation method, water retention ditches have a long history dating back for centuries in Rwanda. Water retention ditches apart from managing the effects of extreme events like floods, it's an anti-erosion measure against heavy rains effects causing a decrease in the rate of runoff (a

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destructive force) of surface waters and thereby contributing to increasing the water retention capacity of agricultural lands for rain fed dependent farming production purposes as it significantly increases water availability for crop productions.

Successful crop yields can be made possible even in areas that are producing poorly under the already existing conditions that is to say that when runoff is temporarily trapped/stored and left to infiltrate at a controlled rate, the soil moisture availability increases and crops can therefore resist dry spells better, leading to higher yields, decreases the need for inputs leading to increased profits. Regarding to Senge, M. (2013) stated that, harvested water can be used for supplemental irrigation during dry spells to increase yield stability or for planting off-season cash crops to increase household income. Thus, the water retention ditches indirectly improve agricultural productivity and the livelihood of the rural Rwanda. Increasing of water retention seems to be among the most environmentally friendly and fulfilling conditions of a sustainable agricultural since it allows a reconstruction of the natural water retention of capacity (Mioduszewski, 2014.).

Umuganda: Just like any other government policy or mandates and regulations, it's a practice with sustainable agricultural implication, its activities among others include fixing erosion hit areas, terracing, reforestation as an environmental aspect of agricultural sustainability (Penine, 2012). We normally have farmers' meetings deciding to go to say consolidated farmlands to clear water courses or paths for irrigation so that it can also be accessed by farmlands far from the water sources which helps in getting a higher average harvest or they come together to make or maintain access roads (Rural roads) or bridges. From the report by IFRTD in 2006, evidence suggests that rural communities can be mobilized to manage and maintain their access roads if some financial incentives and an appropriate legal framework are made available by the government.

Road transport plays an important role in agricultural development all over the world. This is because it is the major means of transporting agricultural produce from the farms in the villages to the markets as well as to other various urban communities (Tunde, & Adeniyi, 2012). Since in most cases these roads networks joins to secondary roads, this makes farmers to have a profitable agricultural produces thereby getting ability to easily access health services and other social services which aren't found in their own villages making this Rwanda's homemade initiative-Umuganda a sustainable agricultural policy because it maximizes socioeconomic benefits, as well as soil degradation and environmental impacts are minimized.

Girinka: Girinka Program also known as "one cow per one poor family" as one of the many home-made initiatives taken from cultures and traditions of Rwanda, it's more than just a cow gained for free of charge (donation) as it has a lot of testimonies of success stories. The program aims at enabling every poor household throughout Rwanda to own and manage an improved dairy cow which would help the family to improve their living standards through increased milk and meat production and improving methods of farming whereby the available dung from the cows is used to fertilize small piece of land that could barely produce surplus food, improving soil fertility for better average crop yields. Thus, boosting their land productivity. The GIRINKA

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program also providing a stable income to poor family through savings on milk sales, which reduces dependency on government aids thereby improving farmers' access to annual medical insurance (mutuelle de santé) since they are able to pay for it by themselves. This program has also improved school enrolment rates because parents have more income to send their children to school.

Meanwhile the cow calves, the new born calf is handled to the neighbor who rears it and handled the next calf to a following neighbor and the rest. (Credit revolving scheme). Thus, program also gives them the opportunity to rebuild love Thus, playing an important role in implementing unity and reconciliation among Rwandese.

Bench terraces: Building bunds and terraces or changing of the slopes has the potential of slowing down the speed on the field and hence infiltration closer to the crops' roots and finally improving irrigation efficiency (Ali, 2010; Bernier et al.,2015)

## 4. CONCLUSION AND RECOMMENDATIONS

This study was Farmers perception of sustainable agriculture with Musanze district of Rwanda as an example, the key findings based on the Likert scale showwed that Musanze farmers consider Twenty-three (23) agricultural practices or polices like Umuganda and Girinka program among others to be of high importance (HI) in terms of a sustainable agriculture, three (3) practices or policies considered as of medium importance (MI) and two (2) were to believed to be of low-importance (LI). However, no agricultural practice or policy belonged to either very high importance (VHI) or no importance (NI).

Never the less, their perception would be changing from one farmer to another most probably due to differences in terms of social status, cultural backgrounds and economic characteristics.

Keeping in mind of the findings from this study, the review of literature, the researcher's experience from of this study if sustainable agricultural productions are to be scaled up, various key conclusions and recommendations are being suggested for the stakeholders like, policy makers, researchers, agricultural finance institutions, farmer cooperatives and non-governmental organization (NGO) like one-acre fund-Tubura. The researchers recommended the following that;

1) for a larger uptake of sustainable agricultural practices is to be successful, policy makers should build up related projects with bottom-up approaches since it creates the farmers to be real owners and committed. Otherwise, without such cooperation the uptake either not occur or it will occur but at a slower rate which delays the transition towards a Rwanda's sustainable agricultural production.

2) Green payments like government giving attractive incentives to the

farmers to practice more environmentally friendly practices for environmental sustainability. Otherwise, only environment protection programs form government bodies like REMA and alike

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may be insufficient. The results of this research should be a starting point for identification of such practices.

3) For a transition to sustainable agricultural production to be achieved, increased investments in public research and development on agriculture and food systems is needed to support Rwanda's scientists who understand the ecosystems, human culture and demands on local agricultural systems to be actively trained and sponsored into international scientific conferences. Or even sponsoring researches that aim at identifying sustainable agricultural practices.

4)This study demonstrates that researchers and policy-makers should, promote agricultural practices that minimize off-farm inputs, and enhancing agricultural production sustainability especially those that are suiting the political agenda.

5) During one data-collection session, farmers especially those who are not easy to reach were happily praising 'Twigire muhinzi' extension model to be reaching them in remote rural Rwanda. Thus, Policy makers should encourage the expansion of technical assistance through farmer-to-farmer extension to provide poor small farmers in remote areas with better information exchange about the use and scale up the adoption of agricultural practices that have sustainability implications.

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