THE EFFECT OF IMPROVED RURAL ROADS ON MAIZE FARMING IN KIREHE DISTRICT, RWANDA

Submitted by

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A thesis Submitted to the Department of Agriculture and Applied Economics in partial fulfillment of the requirements for the award of the degree of Master of Science in Agriculture and Applied Economics of Jomo Kenyatta University of Agriculture and Technology.

2016

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DECLARATION

This thesis is my original work and has not been presented in any other University for the award of a degree.

MUTAKO Vedasto Alphonsine

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Signature Date

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This proposal/thesis has been submitted for examination with our approval as University Supervisor

Dr. Jaya SHUKLA

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Signature Date

Dr. Peter MBABAZIZE

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Signature Date
DEDICATION

This thesis is dedicated to my mother, who brought me up and gave me the value of education; I will always love her and remain grateful to her. I also dedicate it to my role model and friend Mr. Stephen Ngarambe who dreamed about it long time ago.
ACKNOWLEDGEMENTS

I would like express my sincere thanks to the people of Kirehe who provided the valuable information required for the study. This study would not be possible without their cooperation. I wish to thank my supervisors Dr. SHUKLA and Dr. Mbabazize, who provided indispensable input into the realisation of this study. I want to express my special gratitude to the lecturers from Jomo Kenyatta University of Agriculture and Technology (JKUAT-Kigali campus) for training me. Thanks to my brothers, sister and friends for their decent support. I thank many other people who have in many small but significant ways contributed a lot in my work and whose names I may not have mentioned.
ABSTRACT

In its effort to accelerate agricultural transformation, the Government of Rwanda has in recent years invested heavily in road infrastructure and intensified agricultural input supplies. This study examined how improved road affect agricultural inputs use, maize production, and maize market participation in Kirehe District. The main objective of the study was to evaluate if indeed improved rural road infrastructure is significantly related with inputs use, level of maize output and market participation.

Purposive sampling was done which targeted farmers who pertained to three maize farming cooperatives found closer to the targeted road of our study. By stratification the sample size was 67 farmers, farmers of the three cooperatives were listed separately, and then purposively individual households were selected to participate in the interview basing on distance intervals. The sample was rounded up to 70 households because some would drop out and this would help to improve the quality of this work finding. Questionnaires were designed and used to obtain the qualitative and quantitative information. Data were analyzed using descriptive statistics, then regression analysis for objective one, Correlation and Regression analysis and including estimating a short-run maize production function for objective two, and finally regression analysis for objective three was conducted.

The research has revealed that every unit changes in distance to the household will cause a significant change of 0.05659 declines in fertilizer use. We also found that any unit increase in cost of fertilizer (an increase of 1Frw use, there is an increase in fertilizer use) will slightly increase the use of fertilizer by 2.91E-05 and this change is not statistically significant (p-value, 9.93E-08>0.05). We also found that, improved rural road measured in distance to the household
is not the most important factor in maize production in the study area but other factors of quantity of fertilizers, land size, and labor inputs are statistically significantly associated with change in level of maize output. It can be concluded that areas where fertilizer application is low then maize production will vary and become low significantly to their counterparts with good fertilizer application. Finally, the trips made to the nearby big market, was found to be significantly related to cost of transportation than any other factor, the unit increase in francs of transport caused significantly a decrease in trips to the nearby big market. The results therefore suggest that, more emphasis should be put on fertilizer input supply in particular and improvement of rural road infrastructure, which serves a wider population than just farmers, is important also and should continue.
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<tr>
<td>ADB:</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>ANOVA:</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>CIP:</td>
<td>Crop Intensification Program</td>
</tr>
<tr>
<td>COACMU:</td>
<td>Coopérative des Agriculteurs des Céréales de Musaza</td>
</tr>
<tr>
<td>COAIGA:</td>
<td>Coopérative des agriculteurs de Gahara</td>
</tr>
<tr>
<td>COOPAGA:</td>
<td>Coopérative des Agriculteurs de Gatore</td>
</tr>
<tr>
<td>DDP:</td>
<td>District Development Plan</td>
</tr>
<tr>
<td>GDP:</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>IFAD:</td>
<td>International Fund for Agriculture Development</td>
</tr>
<tr>
<td>KWAMP:</td>
<td>Kirehe Watershed Management Project</td>
</tr>
<tr>
<td>MDGs:</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MINAGRI:</td>
<td>Ministry of Agriculture and Animal Resources</td>
</tr>
<tr>
<td>NEPAD:</td>
<td>New Partnership for Africa Development</td>
</tr>
<tr>
<td>NISR:</td>
<td>National Institute of Statistics of Rwanda</td>
</tr>
<tr>
<td>OECD:</td>
<td>Organisation for Economic Cooperation and Development</td>
</tr>
<tr>
<td>PSTA III:</td>
<td>Plan Stratégique pour la Transformation Agricole, Phase III</td>
</tr>
<tr>
<td>RAB:</td>
<td>Rwanda Agriculture Board</td>
</tr>
<tr>
<td>RDB:</td>
<td>Rwanda Development Board</td>
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</tbody>
</table>
Definition of Key Terms

Cooperative
A cooperative is an autonomous association of people who voluntarily cooperate for their mutual social, economic, and cultural benefit.

Farming
Farming is growing crops or keeping animals by people for food and raw materials. Farming is a part of agriculture.

Improved Rural Road
For the context of our area of study an Improved Rural Road can be defined as a gravel road with curbs that has been treated with gravel and compacted to provide a relatively smooth driving surface.

Market
A market is one of the many varieties of systems, institutions, procedures, social relations and infrastructures whereby parties engage in exchange. While parties may exchange goods and services by barter, most markets rely on sellers offering their goods or services (including labor) in exchange for money from buyers. Markets are where, as producers, they buy their inputs and sell their products; and where, as consumers, they spend their income from the sale of crops or from their non-agricultural activities, to buy their food requirements and other consumption goods(IFAD, 2003).

Road
A road is a thoroughfare, route, or way on land between two places that has been paved or otherwise improved to allow travel by some conveyance, including a horse, cart, bicycle, or motor vehicle.
**Rural Road**

Rural road is defined as connecting road from village to main road, where it will lead the rural communities to markets and access to other economic and social service facilities.
CHAPTER 1

INTRODUCTION

1.0 Introduction

Smallholder farmers’ willingness to adopt productivity-enhancing technology is based on the state of infrastructure and market conditions with which they are faced. By improving rural connectivity through the rehabilitation of roads, the propensity to adopt productivity-enhancing technology and the intensification of fertilizer are bound to increase. The effect assumed to be realized through lower transportation costs of goods and services that raise smallholder farmers’ net output prices as well as lower production cost due to cheaper and more accessible farm inputs such as fertilizers, improved seeds and pesticides (Kiprono and Matsumoto, 2014).

1.1 Background

Investment in rural roads can have a positive impact in a range of areas. In India, for example, households escaping poverty have been found to be more likely to people who live in or near villages with better infrastructure and closer to towns. In Bangladesh, villages with better road access were associated with higher levels of input use and agricultural production, increased incomes, better indicators of access to health services and greater wage earning opportunities. A World Bank roads project in Morocco was found to have led to higher agricultural production and land productivity, increased use of agricultural inputs and extension services, and a shift towards high-value crops and off-farm employment opportunities. In India, every additional million rupees (around US$23,000) spent on rural roads during the 1990s was found to lift 881 people out of poverty (IFAD, 2011).
(Kiprono and Matsumoto, 2014) says that enhancing smallholder farmers’ capability to expand farm productivity as well as market participation in rural Africa through road rehabilitation is considered an important undertaking towards alleviating poverty. The International Fund for Agriculture Development, (2001) adds that, too many agricultural investments have failed because they only concentrated on increasing production while neglecting development of market links (IFAD,2001). Smallholder farming and effective market participation is sure pathway of pulling rural people out of poverty hence improving their income and food security (Kiprono and Matsumoto, 2014).

Isolation contributes to rural poverty. Rural life stagnates and local development prospects remain limited without a minimum of reliable and efficient access to locations of basic social and economic activities (Bhatta, 2004). Africa's rural infrastructure is generally inadequate, a fifth of Africa's population is landlocked and less than a third of Africans live within 100 Km of the sea compared to over 40% for other developing regions and they face the longest distances to the nearest large markets (NEPAD, 2003). Rural infrastructure is therefore a major priority for reducing rural poverty (Bhatta, 2004).

1.1.1 Growth in agriculture as an important driver of poverty reduction

The literature on poverty concludes that the potential to make a significant contribution to poverty reduction is related to the composition of, and growth in, economic sectors (agriculture, industry, services) in developing countries. Most studies also come to the conclusion that growth in agriculture is highly beneficial for poverty reduction, although the importance of agriculture diminishes as economies grow and become more diversified (Grewal et al., 2012).
1.1.2 Rural roads and agriculture development

Various studies have provided evidence that agriculture development is closely associated with road improvement. A poor transport network is shown to compound the subsistence burden in Sub-Saharan Africa where rural farmers are unable to transport their agricultural outputs for sale at the market (Davis, 2000). Inadequacy of roads and poor roads access in rural areas is shown to be transmitted into issues like accruing the cost of transportation, reducing ability to access and use high quality inputs and limiting the uses of local markets for rural smallholder farmers to sale their farm produces (Syviengxay, 2008).

Not only do transportation costs increase with the distance travelled, typically costs per kilometre are higher on dirt roads than on tarmac roads, and higher still where the dirt road turns into a footpath. The overall impact on marketing costs can be major. For instance, surveys from Benin, Madagascar and Malawi find that transport costs can account for 50 to 60 per cent of total marketing costs (IFAD, 2011). Our study follows the studies undertaken by Bhatta, (2004), IFAD, (2011) and Rutachokozibwa and Tagora, (1995).

1.1.3 Rwanda Agriculture Policy

Rwanda Ministry of Agriculture and animal resources (MINAGRI) aims to transform agriculture from subsistence to a productive, high value, market-oriented farming that is environmentally friendly and has an impact on other sectors of the economy. Also, the Government of Rwanda is implementing a set of reforms to enable Rwanda to evolve from subsistence agriculture and food insecurity towards market-oriented agriculture. In the recent past there has been significant expansion of interventions in Rwanda which drove productivity gains, including successful land consolidation, increased areas under irrigation and protected against soil erosion, and expansion
of cultivated terraces. There has been an increase in the use of inputs, including agrochemicals and improved seeds. As a result of these interventions, production of maize, wheat, roots and tubers, soybeans, rice, cassava, horticultural products and meat and milk has increased (MINAGRI, 2013). The government of Rwanda considers that, the rural farmers need the usable roads networks for timely and efficient transportation of their inputs to the farm as well as the transference of their farm produce out of the farm for accessible marketing of their farm produces (MINAGRI, 2012).

1.1.4 Rwanda road development for Agriculture transformation

Rwanda seeks to improve roads in selected areas across the country in order to boost the agricultural marketing and household incomes through The Ministry of Agriculture and Animal Resources- Feeder Roads Development Project (FRDP). FRDP is one of government’s strategic investments aimed at enhancing farmers’ access to markets, attracting competitive prices and increased incomes through improvements in rural infrastructure. This opens up commercial opportunities and services that make farming a more profitable livelihood for rural inhabitants and an important means of addressing food insecurity. Rwanda believes that, with the construction of rural feeder roads, farmers will be able to easily access markets to sell their produce hence improved livelihoods and incomes. Feeder roads are considered to be a critical factor to raise agriculture production and increase commercialization. Rural roads are a vital foundation to rural development in Rwanda. Better tertiary roads mean lower transport costs and improved agricultural marketing. The Project is comprised of the three components namely; rehabilitation, upgrading and maintenance of selected feeder roads, strategy Development for rural access, transport mobility improvement and institutional development and project management (MINAGRI, 2016).
1.2 Statement of the Problem

From recent years to current, the government of Rwanda and development partners has intensified their support to agriculture and infrastructure development. Among the investments undertaken are for improving rural roads network. One example is ‘The Ministry of Agriculture and Animal Resources- Feeder Roads Development Project (FRDP)’ which seeks to improve roads in selected areas across the country in order to boost the agricultural marketing and household incomes. It is generally believed that with the construction of rural feeder roads, farmers will be able to easily access markets to sell their produce hence improved livelihoods and incomes. Feeder roads are considered to be a critical factor to raise agriculture production and increase commercialization. Rural roads are a vital foundation to rural development in Rwanda. Better tertiary roads mean lower transport costs and improved agricultural marketing. Knowing how these efforts are impacting on agriculture is important for planning. However, not many studies have documented about the effect of improved rural roads in Rwanda on maize farming. Studies that have been carried out include those that covered the impact of increases in public expenditure on poverty in Rwanda (Mackinnon et al., 2003). This study was therefore carried as an attempt to generate this information and to fill the gap in research for Rwanda.

1.3 Objectives

1.3.1 General objective

The broad objective of this study was to determine the effect of improved rural roads on maize farming in Kirehe district, Rwanda.

1.3.2 Specific objectives

The specific objectives of the study were:
1. To determine the relationship between access to improved rural roads on level of fertilizer usage in maize farming;

2. To determine the relationship between distance to improved rural roads and level of maize output;

3. To determine the relationship between farm households location and participation in maize output markets.

1.4 Hypotheses of the Study

In view of the above specific objectives, the study tests the following null hypotheses:

**Null Hypothesis 1:** There is no relationship between improved rural roads and the quantity of fertilizer utilization.

**Null Hypothesis 2:** There is no relationship between improved rural roads and the level of maize output produced.

**Null Hypothesis 3:** There is no relationship between improved rural roads and farmers’ participation in the maize market.

1.5 Justification of the Study

Rwanda is giving priority in roads construction to improve standard of living of people particularly the rural community. The government is implementing a number of programs including Transport Sector Strategic Plan for EDPRS II with an assumption that there is a positive relationship between infrastructure development and agriculture development. The Ministry of Agriculture and Animal Resources (MINAGRI) is implementing many reforms for Agriculture development including land consolidation, increased areas under irrigation, protection against soil erosion, and expansion of cultivated terraces.
A significant number of empirical studies relating development of road transportation to socioeconomic development have been undertaken worldwide. In spite of its importance, the wealth of researches exploring the direct and indirect impact of the road transportation on socioeconomic development has been quite meagre in Rwanda. This study investigates whether the rural communities with good and poor access to road are different in terms of agriculture transformations. The study is therefore expected to be useful for rural transport planners, rural road agencies, donor agencies, local governments, and communities for planning, identifying, designing, maintenance and management of road networks so as to maximize benefits from the road transportation.

1.6 Scope of the study

This research on impact of improved rural roads on agricultural production in Rwanda’s rural maize farming cooperatives was conducted in Kirehe District in the Eastern province of Rwanda. The research has particularly focused three maize farming cooperatives members of COOPAGA, COAIGA and COACMU cooperatives which are located along the feeder road of Cyunuzi-Gahara-Musaza.

1.7 Limitation of the Study

Despite the fact that research work was successful; there were some limitations encountered during the research.

1.7.1 Time constraints

The time was not enough for collecting all necessary information in relation to the impact of rural roads on community livelihood of maize farming cooperatives of Kirehe District. In order
to overcome this problem, the researcher worked hard and reserved a big part of time to this issue with good management of the given time.

1.7.2 Limited information

Based on the time scope chosen by the researcher, the data cooperative leaders and management authorities for previous year data and some information were confidential and this limited and hampered the analysis process of the research. In order to overcome this problem, the researcher used the data which was available during the period of collecting data and the researcher was required to explain that all information would be kept confidential and only be used for the purpose of academic research.

1.7.3 Unwillingness of some farmers to respond

Some respondent were unwilling to respond to the researcher’s questions. Some complained of having no time to attend to the researcher’s questions. In order to overcome this problem, the researcher tried to give explanations for the motives and importance of the expected outcome of the study, to the cooperative, to agricultural sector and to the other interested parties in this study.

1.7.4 Limited financial resources

The financial resources were big challenges encountered by the researcher as she had many things requiring funds and the researcher tried to minimize the costs involved and well managed the available funds.
CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Developing a clear relationship between improved rural roads and agriculture production is not an easy task. Preponderance researches have been done on the benefits for rural transportation facilities on rural livelihood mostly by looking at improving the conditions of rural roads for the purpose of improving rural livelihoods. This chapter gives an overview of some of the main arguments in the debate about improved rural roads and agriculture production. It therefore, provides theoretical and empirical bases underlying the relationship between rural access versus agriculture production, farm inputs, and market participation. The chapter begins with a review of theoretical literature in the first section. The second section examines some of the important empirical studies relating agriculture to the rural accessibility. The third section outlines the Critiques of the existing literature review to the.

Many authors have defined the way rural roads improvement can directly or indirectly be translated into welfare of the communities that are targeted. The World Bank’s report stressed that the under-development of infrastructure has serious consequences for the country’s competitiveness and in particular for its growth and poverty reduction targets, including the Millennium Development Goals. Rural access is central to the alleviation of rural poverty and has a close synergy with rural livelihood outcomes such as increased incomes, lowering input prices, reduce the monopoly power of intermediaries (middlemen) in agrarian markets, declines cost of transport, travel time is saved hence more labor is available for production which is equivalent to an increase in labor supply. The overall result is reduced production costs resulting in increased
production (World Bank, 1996; Bhalla, 2000; World Bank, 2005; Asif et al., 2012). Regarding market opportunities, other researchers stress that, Rural Roads provide the important connectivity with growing markets adjacent to rural areas; they also lessen input costs and transaction costs of rural producers and consumers (Llanto et al., 2012). The marginal cost decreases as a result of improved transportation whereby local farmers can benefit from a road when the road reduces the cost of transporting agricultural products to markets and extends the distance to breakeven locations (Bhalla, 2000). Transport operations for marketing can be made more efficient, with the reduction in costs per trip to market. Operations can be combined, for example, by transporting farmers’ produces and people to market on the same trip (Tunde & Adeniyi, 2012).

### 2.1 Theoretical review

The logical framework guiding the researcher for the theme of improved rural roads on agriculture production therefore, argues that improving rural roads will contribute to improved agricultural production for the rural community. Taking transport as one of the factors of production, it is universally accepted that the provision or improvement of transport services results in reduction of transport costs. As transport cost decreases, the factor prices fall resulting in the increased demand for input use or more output supply according to microeconomic theory (Hal, 1992). Bhalla (2000) says that, the marginal cost decreases as a result of improved transportation. So the overall activities expand with the provision of transport services (Jerry, 2001). There is an assumption that a change in road conditions will be accompanied by an increase in demand for transport services and a corresponding decrease in the vehicle operating cost (Van De Walle, 2007). In the ideal case, this in turn will trigger competition and an associated decrease in transport prices (Howe, 2005). Improved transport, therefore, promotes
mobility and improving physical access to resources and markets (IFAD, 2001). Figure 2.1 is explaining the relationships among the variables of our research.

**Table 2.1:** Conceptual framework

<table>
<thead>
<tr>
<th>Independent variable (IV)</th>
<th>Dependent variable (DV)</th>
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<tbody>
<tr>
<td>Improved Rural Roads</td>
<td>- Increased level of agriculture input use</td>
</tr>
<tr>
<td></td>
<td>- Increased level of agricultural output,</td>
</tr>
<tr>
<td></td>
<td>- Input prices reduction</td>
</tr>
<tr>
<td></td>
<td>- Reduced transportation cost for inputs and outputs</td>
</tr>
<tr>
<td></td>
<td>- Increased price of outputs</td>
</tr>
<tr>
<td></td>
<td>- Increased market access and participation (measured by trips made)</td>
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**Intervening variables (IV)**
- Government policies, programs and strategies.

**Figure 2.1: Conceptual framework**

2.2 **Empirical studies relating agriculture to the rural accessibility**

Research in Kenya was done using longitudinal data together with geo-referenced roads data, the researchers implemented a difference-in-difference (D-I-D) estimation to assess the impact of the change in road access from 2004 to 2012 on the change in technology adoption, fertilizer intensification, farm productivity and market participation by smallholder farmers in Kenya in Sub-Saharan Africa (SSA). They constructed time distance variables by motor-vehicle to the nearest market and to the nearest big town as measurements of road access. Their results show that land allocated to hybrid maize, inorganic fertilizer intensification, maize yield and milk market participation increase more in areas with better road access improvement. It suggests that, since road access improvement occurs more in poorer road access areas in the initial period, the recent infrastructure investment contributes to the productivity enhancement especially in remote areas (Kiprono, 2014).
Another study which explored the issue from both theoretical and practical perspectives with household and village level data from Northern Ethiopia was conducted. Primary data were collected from a sample of 400 households in 16 tabias. Samples were selected adopting a stratified random sampling approach based on market access, population density, rainfall, and irrigation projects. First 16 tabias were selected for a household survey using a stratified sampling method. Lists of all the households were obtained from those tabias selected and simple random sampling approach was adopted to select 25 households from each tabia. The entire analysis considers 372 households only due to incompleteness of data and respondent dropouts. The survey was carried out in 2003. They obtained secondary data from Tigray Regional Planning and Economic Development Bureau which conducted a community survey (tabia level) in 2001. The data consist of price information of various manufactured goods and agricultural products for different tabias which have different degree of road accessibility in the region. The findings in this study, however, suggest that neither participation in major markets nor the amount of purchased agricultural inputs use are significantly different for households with respect to the degree of road accessibility in the study area. Nevertheless, the situation seems somewhat better in locations with good access to roads. On the other hand, the findings in this study confirm that road accessibility significantly contributes to reducing farm gate prices of manufactured goods and increasing farm gate prices of agricultural goods. There were significant price variations in locations with good and poor access to road. Households with poor access to road are confronted with wider price bands. Rural households in Tigray used very low purchased inputs such as herbicides, pesticides, animal medicines, etc. Use of purchased agricultural inputs was not significantly different for households with good and poor access to road, indicating that there may be many factors such as unobserved differences in natural endowments affecting the
households’ use of purchased agricultural inputs (Torbjørn, Bharat, & Bhatta, 2012). In India, using state-level data for 1970–93, a simultaneous equation model was developed to estimate the direct and indirect effects of different types of government expenditure on rural poverty and productivity growth. The findings showed that in order to reduce rural poverty, the Indian government should give highest priority to additional investments in rural roads and agricultural research. These types of investment not only have much larger poverty impacts per rupee spent than any other government investment, but also generate higher productivity growth (Fanet al., 2000).

In the study that examined the relationship between transport infrastructure and agriculture in Sub-Saharan Africa using new data obtained from geographic information systems (GIS), the authors analyzed the impact of road connectivity on crop production and choice of technology. Second, they explored the impact of investments that reduce road travel times. Finally, they showed how this type of analysis can be used to compare cost-benefit ratios for alternative road investments in terms of agricultural output per dollar invested. The authors found that agricultural production was highly correlated with proximity (as measured by travel time) to urban markets. Likewise, adoption of high-productive/high-input technology was negatively correlated with travel time to urban centers. They concluded that, there is therefore substantial scope for increasing agricultural production in Sub-Saharan Africa, particularly in more remote areas. In their findings, total crop production relative to potential production is 45 percent for areas within four hours travel time from a city of 100,000 people. In contrast, it is just 5 percent for areas more than eight hours away. Low population densities and long travel times to urban
centers sharply constrain production. Reducing transport costs and travel times to these areas would expand the feasible market size for these regions (Dorosh, 2010).

One of the most important aggregate studies was by Antle (1983), who undertook a cross-sectional study of 47 less developed countries. He used the Cobb-Douglas production function and found a strong positive relationship between infrastructure and aggregate agricultural productivity. His conclusion was that transport and communication infrastructure contributed to the explanation of aggregate agricultural productivity across a sample of developed countries.

The second aggregate study was done by Binswanger et al., (1987) which involved a cross-country analysis of annual data (1969-1978) collected from 58 countries. The authors found positive and significant correlation between aggregate and crop production functions and the two road variables in the pooled country analysis. The elasticity of fertilizer demand with respect to road density was found to be quite high and roads were also found to have directly contributed to both growth of output and use of fertilizers (Binswanger et al., 1987).

Evanson and Gollin (2003) used farm-level data for the Philippines from 1948 to 1984 to estimate the effect of public investment in farm level output supply and input demand. Roads were found to have a positive effect on aggregate output per farm, as well as on fertilizer use. The output elasticity with respect to roads worked out to be as high as 0.31. But strangely enough, he found negative elasticity of output with respect to rural electrification (Evanson & Gollin, 2003).
In their pioneering study of Bangladesh, Ahmed and Hossain (1990) chose a sample of 130 villages across all the agro-climatic zones of the country. These villages were divided into two groups according to the aggregate index of accessibility to village of various services like markets, schools, banks and administration. Villages with better access were found to be significantly better off in a number of areas including agricultural production, household incomes, wage incomes of the landless labour, health, and the participation of women in the economy. For example, they found that development of infrastructure had a positive effect on the marketing of agricultural produce. The development of infrastructure enabled cultivators to obtain a slightly higher price for their produce and to buy a larger proportion of consumption needs from the market as compared with the undeveloped villages (Ahmed and Hossain, 1990).

2.3 Critiques of the existing literature review to the study

Some of the research findings are showing the positive correlation between the rural access and economic development while others are opposing to this relationship. Taking the example of few typical researches discussed above, research in Bangladesh by Ahmed and Hossain (1990), villages with better access were found to be significantly better off in a number of areas including agricultural production, household incomes, and wage incomes of the landless labour, health, and the participation of women in the economy. Development of infrastructure had a positive effect on the marketing of agricultural produce. The development of infrastructure enabled cultivators to obtain a slightly higher price for their produce and to buy a larger proportion of consumption needs from the market as compared with the undeveloped villages (Ahmed and Hossain, 1990).
In Tigray, there were significant price variations in locations with good and poor access to road whereby, households with poor access to road are confronted with wider price bands. Rural households in Tigray used very low purchased inputs such as herbicides, pesticides, animal medicines, etc. However, use of purchased agricultural inputs was not significantly different for households with good and poor access to road, the researcher concluded that, there may be many factors such as unobserved differences in natural endowments affecting the households’ use of purchased agricultural inputs. Households located in remote areas were less likely to participate in markets so policies towards integrating remote areas with urban areas through infrastructure development are recommended (Torbjørn, Bharat, & Bhatta, 2012).

2.4 Gap to be filled by the research

Studies have examined the relationship between transport infrastructure and agriculture and some have found that agricultural production was highly correlated with proximity to households (as measured by travel time) and to urban markets, others found that adoption of high-productive/high-input technology was negatively correlated with travel time to urban centres. This is taking me back to my research problem statement to know if only road improvement can be taken as an overall factor for agriculture transformation or take it in conjunction with other factors (agriculture transformation as a result of integrated factors. The research is therefore trying to show how improved rural roads are impacting rural farming in the rural settings of Rwanda.
CHAPTER 3

METHODOLOGY

3.0 Introduction

This chapter focused on the description of the methods used in the study upon which findings and interpretations and conclusions in the subsequent chapter will be based. It specifies the research design, targeted population, sampling design and procedure, data collection tools, measurement of variables, methods for data processing and data analysis.

3.1 Description of the study site

Kirehe District is one of the seven districts making up the Eastern province. It is made up of twelve administrative sectors which are: Gatore, Kirehe, Kigina, Nyarubuye, Gahara, Gashongora, Musaza, Kigarama, Nyamugari, Mahama, Mpanga and Nasho, composed of 60 cells and 612 administrative villages (Imidugudu). Kirehe District extends over a total area of 1,118.5 Km$^2$ with about 162,388 male and 176,174 female inhabitants equaling to 338,562 of its total population (NISR, 2012). The Economy of the District is based on agriculture and livestock which is at least 90% of the population. The District borders with Tanzania in the East with the Districts of Ngara and Karagwe, in the South it borders with Burundi, Ngoma District in the South Western part and Kayonza District in the North (NISR, 2012).
3.1.1 Situation of roads in Kirehe District

The District has a very good network of roads that connect it to other District of Ngoma and Karagwe in Tanzania and to agriculture production areas, 39 km of tarmac road along Ngoma–Kirehe - Rusumo high. The District of Kirehe has also several roads connecting all the administrative Sectors in the District. The District has some bridges which play a big role in facilitating different administrative Sectors to be able to interact socially as well as economically (DDP, 2013).

3.2 Research design and Target population

In this study, the researcher surveyed 80 maize farmers from three cooperatives COAIGA, COOPAGA and COACIMU. This study purposively targeted three maize farming cooperatives of Kirehe District in the eastern province of Rwanda. The study was limited to the community of maize farmers found along the Cyunuzi- Gahara- Musaza feeder road linking three farmers’ cooperatives of COOPAGA, COAIGA and COACMU to as far as 35km from the Rusumo-Kigali tarmac road in Kirehe District (Appendix 2). The total population under study were 3423 people. The maize farming cooperatives are found in villages along this area whereby some were found in accessible areas and others in remote areas. Kirehe District is considered to best exemplify a community with a good road infrastructure and adequate public transport in a rural area of Rwanda due to the project of KWAMP. Farming is the chief sustainable livelihood strategy in this community and due to KWAMP farmers are able to diversify lives in doing various activities.
3.3 Sampling frame

Purposive sampling was done which targeted farmers who pertained to three maize farming cooperatives. The three selected cooperatives are found closer to the targeted road of our study. The total population for the cooperatives was used to get the sample size of 67 farmers, farmers of the three cooperatives were listed separately, and then purposively individual households were selected to participate in the interview basing on distance intervals. The sample was stratified among the cooperatives to get the ratio of sample to be drawn from each cooperative then distance intervals were set basing on the location of households from the main road along the road of interest. The sample was rounded up to 70 households because some would drop out and this would help to improve the quality of this work finding.

3.4 Sample size and sampling techniques

The sample size was determined by using the following formula adapted from Kothari (2004).

\[
 n = \frac{z^2 \times p \times q \times N}{d^2(N - 1) + z^2 \times p \times q}
\]

\[
 n = \frac{1.65^2 \times 0.5 \times 0.5 \times 3423}{0.1^2(3423 - 1) + 1.65^2 \times 0.5 \times 0.5} = 67
\]

Where: 

- \( n \) = sample size,
- \( N \) = size of population (number of household),
- \( Z \) = coefficient normal distribution,
- \( q \) = probability of failure,
- \( d \) = margin error,
- \( p \) = probability of success.

For (Kothari, 2004), the margin error varies between 5% and 10%. The researcher used a margin error of 10%, confidence level of 90%. The probability of success is \( p = 0.5 \), failure probability
of $q=0.5$, and $Z_{0.25}^2$ ($Z_{0.25}$ is 1.65). The sample size ($n$) was calculated based on the Kothari’s equation as. The calculated sample ($n$) was found to be 67 respondents.

3.5 Sampling techniques

The research used Stratified sampling techniques to determine the sample size in each of three cooperatives. Strata sample sizes were determined by the Neyman Allocation formula. With Neyman allocation, the best sample size for stratum $h$ would be:

$$nh = \frac{N_h \times N}{n}$$

Where:

- $n_h$ = the sample size for stratum $h$,
- $n$ = total sample size,
- $N_h$ = the population size for stratum $h$, and
- $S_h$ = the standard deviation of stratum $h$.

The details are provided in table 3.1

Table 3.1: Stratified Sample Size

<table>
<thead>
<tr>
<th>No</th>
<th>Cooperative</th>
<th>Total population in each cooperative</th>
<th>Number of sampled farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KOOPAGA</td>
<td>355</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>COAIGA</td>
<td>2338</td>
<td>46</td>
</tr>
<tr>
<td>3</td>
<td>COACMU</td>
<td>730</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>3423</td>
<td>67</td>
</tr>
</tbody>
</table>
3.6 Instrument used for data collection

i) Questionnaire

Questionnaires were designed and used to obtain the qualitative and quantitative information. The questionnaire was used because it was specific for the respondents to explain the exact situation.

3.7 Data collection

This study used both primary and secondary sources of data. Using the questionnaire, data were collected on the following variables: Gender and status of the respondent, age measured in years, marital status, size of the household, educational status measured by the number of years spent in school, size of the land in hectares, labor in man days, quantities of input (in Tonnes) and their costs in Rwandan Francs (organic fertilizer, chemical fertilizers, and improved seeds), level of maize output in Kilograms, number of trips made to the market, transport costs in Rwanda Francs and distance was measured in Kilometers.

   a) Primary source.

Primary data were collected from respondents through issuing of questionnaires. Respondents were guided by the researcher to understand the questions whereby they delivered the required information.

   b) Secondary source

During the process of documentary analysis, the researcher reviewed various documents relevant to the study topic. The researcher read documents such as books, reports, journals, newspapers and other publications to get secondary data related to improved roads on agriculture
production worldwide as well as for Rwanda where the current study is taking place. Libraries and internet sources were visited also to get information.

3.8 Pilot test
On reliability of the research instruments, the questionnaire was also pilot-tested. The Split-half procedure was used to test the reliability of the questionnaires. This procedure was chosen over other methods such as Kuder-Richardson approaches for its simplicity. Sixty seven pilot questionnaires were administered for this purpose.

3.9 Data processing, analysis, and presentation

i) Data processing
Qualitative data collected were first coded, a coding sheet was constructed and corresponding number on the coding sheet were assigned to each answer in the questionnaire using Statistical Package for Social Sciences.

ii) Data analysis and presentation
Primary data were collected from a random sample of 67 members of three maize growing cooperatives. Data were analyzed using descriptive statistics, then regression analysis for objective one, Correlation and Regression analysis and including estimating a short-run maize production function for objective two, and finally regression analysis for objective three was conducted. To test our three hypothesis we applied the specific methods for each one whereby for testing hypothesis one, location of the household was considered to contribute for fertilizers usage among households; hence, the researcher used data for quantities of fertilizer that were applied by each household and data for the distance to the household. The researcher
used Multiple Linear Regression Model and the observations $Y_i, X_1$ regression equation was explained as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \epsilon$$

Where:

- $Y$ = Quantity of fertilizer utilized
- $\beta_0$ = A constant
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are coefficients of the model
- $X_1$ = Total cost of seeds
- $X_2$ = Total cost of labor
- $X_3$ = Distance to the household
- $X_4$ = Total cost of fertilizer
- $X_5$ = Size of the land
- $X_6$ = Mean distance to the nearby fertilizer supplier
- $\epsilon$ = an error term

In this study the fertilizer usage of households is expected to decrease with increasing distance from main road to the household taking other factors constant.

Secondly, to test hypothesis two, the four variables were considered important in influencing maize output in the study area each was correlated against the level of maize output by Pearson correlation. Then the researcher performed regression analysis between maize output as the dependent variable and fertilizer, labor and land as the independent variables in order to get precise information about the nature of the cause and effect relationship between these variables. The regression model (a Cobb-Douglas type) that was used to estimate the relationship was:

$$Q_{maize} = a \text{Land}^b \text{Labor}^c \text{Fertilizer}^d e^u$$

The model was again restated in log form and was:
\[ \log Q_{\text{Maize}} = \log a + b_1 \log \text{Land} + b_2 \log \text{Labor} + b_3 \log \text{Fertilizer} + u \]

Where:

\( Q_{\text{Maize}} \) stands for Level of maize output

Finally relating number of trips made by farmers with distance to the nearby big market in Kirehe town, Cost of transportation for maize and time taken to the nearby big market were used as approach to test the hypotheses three. This hypothesis was proved by regression model as

\[ Y = f(\text{Distance to the market, Cost of transportation, Time to the market}) \]  
\[ Y = \rho_0 + \rho_1 X_1 + \rho_2 X_2 + \rho_3 X_3 + \varepsilon \]

Where:

\[ Y = \text{Trips to the market} \]
\[ X_1 = \text{distance to the market in (Km)} \]
\[ X_2 = \text{Cost of transportation in (Rwf/kg)} \]
\[ X_3 = \text{Time to the market (Hrs)} \]
\[ \varepsilon = \text{an error term} \]

This theme will primarily focus on the market access and participation behavior of small-scale maize farmers in the study area. It attempts to determine the factors influencing the decision of the farmers / farming households to participate in the market. Households nearby the main roads (Kigali- Rusumo) are expected to show a lot of participation in maize markets indicated by number of trips made to the market.

3.10. Validity and Reliability of the questionnaire

Content validity of the instruments was determined by expert judgments as supported by Fraenkel and Wallen (2000). The instruments were scrutinized/examined by at least two university lecturers including the supervisor of the study to judge the items on their
appropriateness of content, and to determine all the possible areas that need modification so as to achieve the objectives of the study. The experts determined whether the items in the questionnaires adequately represent all the areas to be investigated. In addition, the researcher also ensures validity of the collected data by administering the interview guides personally.

3.11 Ethical considerations

The researcher considers the research values of voluntary participation, anonymity and protection of respondents from any possible harm that could arise from participating in the study. Thus the researcher; introduced the purpose of the study and requested the respondents to participate in the study on a voluntary basis. The researcher also assures the respondents of confidentiality of the information given and protection from any possible harm that could arise from the study since the findings would be used for the intended purposes only.
CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

Improvement of rural roads seems to be a clear means by which large number of people especially rural people might acquire the opportunity to participate in the market economy for buying agriculture inputs at low prices and sell the agriculture outputs (Syviengxay, 2008), by improving rural connectivity through the rehabilitation of roads, it is expected that the propensity to adopt productivity-enhancing technology and the intensification of fertilizer are bound to increase, the effect assumed to be realized through lower transportation costs of goods and services that raise smallholder farmers’ net output prices as well as lower production cost due to cheaper and more accessible farm inputs such as fertilizers, improved seeds and pesticides. Enhancing smallholder farmers’ capability to expand farm productivity as well as market participation in rural Africa through road rehabilitation is considered an important undertaking towards alleviating poverty (Kiprono, 2014).

4.1 Respondents' Social, Demographic, and economic profile

Because households simultaneously take decisions regarding investment, production, consumption, and inputs use, a household perspective is the most appropriate to investigate the factors influencing rural households’ farm inputs use, output of produces and their access and participation in markets. In table 4.2 we presented and analyzed household characteristics including Social, Demographic, and Economic profile of the household (gender of respondents, age of the respondents and size of household, land size of respondents, education...
level, income level, marital status, and status of household head). We also analyzed distance from the tarmac road to the household with relation to the production using accessibility to farm inputs as a factor for measuring levels of outputs.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>Female</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-30 years</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>31-40 years</td>
<td>35</td>
<td>52.2</td>
</tr>
<tr>
<td>41-50 years</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>51-60 years</td>
<td>11</td>
<td>16.4</td>
</tr>
<tr>
<td>60-70 years</td>
<td>15</td>
<td>22.4</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td><strong>Family members</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Person</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>2-5 persons</td>
<td>16</td>
<td>23.9</td>
</tr>
<tr>
<td>6-9 persons</td>
<td>41</td>
<td>61.2</td>
</tr>
<tr>
<td>Above 10 Persons</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td><strong>Farm size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1 ha</td>
<td>55</td>
<td>82.1</td>
</tr>
<tr>
<td>1 -2 ha</td>
<td>10</td>
<td>14.9</td>
</tr>
<tr>
<td>3-4 ha</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>&gt;4 ha</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td><strong>Education status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school</td>
<td>59</td>
<td>88</td>
</tr>
<tr>
<td>Secondary education</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>&gt; Secondary school</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Illiterate</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Married</td>
<td>49</td>
<td>73</td>
</tr>
<tr>
<td>Divorced</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Widow/ widower</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.2: Respondents' Social, Demographic, and economic profile
Twenty seven respondents 27(40%) in our study area were males and 40(60%) were females. This implies that women are mostly the ones who participate in agriculture activities in our area of study as compared to males, age of respondents ranges between 20 and 70 years with a mean age of 38 years while the mode age group was 31-40 years age, which therefore implies that maize farmers in the study area are youth and most productive group. Majority of farmers in the study area had primary school education as represented by 59(88%), while 3(5%) had secondary education, 5(7%) were without formal education. The population is dominated by people with primary school education, this have great impact on the adoption of new agricultural production techniques like fertilizer, the population can read and write and new agriculture techniques can be disseminated to the community easily. Also 49(73%) of respondents were married, 3(4%) separated, 9(13%) widowed and 6(9%) were not married. Families comprised between 6-9 members are 41(61.2%) of all sampled maize farmers, followed by those who has the family members lying between 2-5 persons as represented by 16(23.9%). Then family of 1 person and that of 7-10 persons were recorded by 5(7.5%) respectively. These all could account for adaption of any farming technology like decision to buy inputs and sell of outputs. Families will tend to produce various quantities of maize basing on number of members of the family whereby the family with few members may produce less as compared to their counterparts. Regarding farm size distribution factor is supposed to have positive impact on output, all things being equal. Most farmers in the study area are small scale farmers as 55 (82.1%) reported farm size of less than an hectare while only 10(14.9%) had between 1.0 and 2 hectares of land and 1(1.5%) person had between 3 and 4 hectares while 1(1.5%) person had above 4 hectares. The production level is expected to be proportion to the size of the land that was used for maize farming. Finally, the level of production and number of people in the family will conduct the behaviour of household
to participate in the maize market whereby, families with high production will tend to take them
to the market and those with negligible volumes will not be able to take the production to the
market.

4.2 Descriptive findings of key variables for maize production

Four variables were considered important in answering the study’s objectives and testing its
hypotheses. The four variables are total maize output harvested during the 2014/2015 season,
and also the volume of inputs used in that season. Though neither an input nor output, data on the
distance between the respondent’s household are from the Rusumo-Kigali tarmac road were also
collected. Measures of central tendency for these five variables are presented in Table 4.3.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>VARIABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Maize Output in 2014/2015 (Tonnes)</td>
</tr>
<tr>
<td>N</td>
<td>67</td>
</tr>
<tr>
<td>Mean</td>
<td>2.606</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>3.181</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.200</td>
</tr>
<tr>
<td>Maximum</td>
<td>20.10</td>
</tr>
</tbody>
</table>

Table 4.3: Summary Statistics of the Key Variables

Table 4.3 is indicating that the means for maize output, fertilizer, land, labor and distance from
tarmac road to the households were 2.606Tonnes, 86.955Tonnes, 0.667Ha, 7.195Mandays, and
27.494Km respectively. For all the five variables, the response rate was 100 percent except for
land where two respondents did not indicate their maize hectare during the 2014/2015 season.
The response rate for this variable was however large enough 97 percent to permit the
interpretation of the results. A conspicuous observation to note from these statistics is the wide range between the minimum and the maximum values for all variables. Distance is the only exception but not surprising given that most of the farmers are located in virtually the same area. That some farmers do not seem to be using any fertilizer should also not be surprising. Though desirable, it is not mandatory to apply fertilizer in order for the maize to grow. The non-use of input by some farmers should however be attributed more to financial inability than to any other factor, and basing on the fact that farmers depend on agriculture as source of their daily livelihood and the income from farm is distributed among all the family needs.

While the measures of central tendency provide important information about the key variables in this study, they are nevertheless highly aggregated thus obscuring the nature of distribution of the variables. This shortcoming is overcome by providing frequency distributions of the variables in form of bar-charts ensuing in Figure 4.2 to Figure 4.5.

4.2.1 Distribution of levels of maize production
In figure 4.2, majority of the sampled farmers produced between one and two Tonnes of maize. In total, about three quarters of them are below three Tonnes while slightly half of them produced between one and three Tonnes over the reference seasons 2014/2015.

Figure 4.2: Distribution of Total Maize Output Across the farmers
According to Agricultural survey organized by (NISR, 2012), maize has become a leading crop in production and ranks first among pulse and grain crop production in Rwanda. In 2011, the total of 525,679 Tonnes of grain maize were produced on 223,414 Ha with an average yield of 2.35 T/Ha (NISR, 2012).

4.2.2 Fertilizer usage across the sampled households

Distribution on fertilizer usage across the sampled households is shown in the next figure 4.3. It should be recalled that the fertilizer input combines both the organic and the inorganic fertilizer though a very big proportion of it is the organic type. This largely explains why the levels of the fertilizer input are by common standards in farming fairly large. For example, a one tonne of inorganic fertilizer (about 1000 Kg) should be applied in a hectare bigger than the maximum hectare the sample farmers in this study have.

Figure 4.3: Distribution in Fertilizer Usage

<table>
<thead>
<tr>
<th>Percent of Respondents</th>
<th>32%</th>
<th>29%</th>
<th>20%</th>
<th>18%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fertilizer Usage (Tons)</td>
<td>Below 3</td>
<td>3 to 6</td>
<td>6.1 to 9</td>
<td>Above 9</td>
</tr>
</tbody>
</table>

The fertilizer usage chart above is indicating that 38% of our respondents used between 6 and 9 Tonnes of fertilizer in maize farming while 29% of them used between 3 and 6 Tonnes and 32% used below 3 Tonnes. All the sampled farmers use fertilizer in their maize farming with the quantity used varying positively and proportionately with the land size. For the sample farmers in this study, land elasticity of fertilizer usage was estimated and found to be 1.004, which is
virtually unitary. This was done by estimating the relationship between fertilizer and land size in logs. The relationship was found to be significant with p-value < 0.0001.

**4.2.3 Distribution of Respondents by Land Size**

In figure 4.4, maize was produced on the varying land size whereby 53.8% of households grow maize on a land less than 0.5 Ha, while 43.1% had a land size of between 0.6 Ha and 1 Ha, lastly 3.1% owns above 1 Ha. Land holdings in Rwanda are below one hectare whereby on average the land size is estimated to be 0.76 Ha as reported by (MINAGRI, 2013). The observation shows that, farmers use the available land for each season production whereby virtually all the land is allocated to maize production and rotated for another crop in the next season. The size of the land is small.

![Distribution of Respondents by Land Size](image)

**4.2.4 Labor distribution in the sampled household**

From figure 4.5 of labor distribution for the sampled household, 35 (52%) households used labor between 1 to 5 days, and only 4.5% of respondents used labor of between 21 and 25 man days. This is proportional to the land sizes whereby majority of households (53.8%) of the respondents grows maize on a land less than 0.5 Ha. Few respondents about 3.1% have greater than 1 Ha of land.
4.2.5 Distribution of households by Distance from Rusumo-Kigali Road

In figure 4.5 for the accessibility of households to the nearby road of Rusumo-Kigali, 18% of households live in less than 20 Km from the road while 10% lives in the distance between 20 and 25 Km, 27% are within 26 to 30 Km and the remaining 45% are found beyond 30 Km implying that above 45% of the surveyed households were not easily accessible.

Figure 4.6: Distribution of Respondents by Distance from Rusumo-Kigali Road
4.3 Findings from hypothesis test

4.3.1 Relating improved rural roads and fertilizers usage

Distance to the household was considered to contribute for fertilizers usage in our area of the study; hence, the researcher used data for quantities of fertilizer that were applied by households. The researcher used Multiple Linear Regression Model in which \((Y_i, X_1)\). The observations \((Y_i, X_1)\) regression equation was explained in the form as

\[
(4.3.1) \quad Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X + \beta_4 X_3 + \beta_5 X_5 + \varepsilon
\]

Where:

\(Y\) = Quantity of fertilizer utilized

\(\beta_0\) = A constant

\(\beta_1, \beta_2, \beta_3, \beta_4, \beta_5\) are coefficients of the model

\(X_1\) = Total cost of seeds

\(X_2\) = Total cost of labor

\(X_3\) = Distance to the household

\(X_4\) = Total cost of fertilizer

\(X_5\) = Size of the land

\(X_6\) = Mean distance to the nearby fertilizer supplier

\(\varepsilon\) = Is an error term

For this model to be varied, a number of assumptions were made referring to error terms. Error terms are normally distributed with mean zero and variance a constant.

(i) \(\varepsilon\) are independent, identically distributed

(ii) Their means are equal to zero, Variance \(\sigma^2\) is a constant

(iii) \(\varepsilon \sim N(0, \sigma^2)\)
Recalling that, the null hypothesis underlying this regression model implies that, the distance to the household, distance to the nearby fertilizer supplier from the household and total cost of fertilizer, will all influence the decision for the household to apply the quantity of fertilizer. This also implies that for our null hypothesis to be varied, all the coefficients $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$, or otherwise the alternative hypothesis $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 \neq 0$, or at least one of $\beta$s $\neq 0$. In this study the fertilizer usage are expected to decrease with distance from main road taking other factors constant. Fertilizer utilization will be a result of a combination of factors as a result of availability of improved rural road. The road will stimulate other opportunities among them total cost of seed, total cost of labor, distance to the household, total cost of fertilizer, size of the land, and mean distance to the nearby fertilizer suppliers. The ANOVA findings in table 4.4 are showing the p-value of 3E-44.

Table 4.4: Analysis of variance for the relationship between improved rural roads and fertilizer usage.

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>6</td>
<td>3088.752</td>
<td>514.792</td>
<td>336.5696</td>
<td>3E-44</td>
</tr>
<tr>
<td>Residual</td>
<td>60</td>
<td>91.77157</td>
<td>1.529526</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>3180.524</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results would lead us to reject $H_0$ and conclude that there was a significant effect of total cost of seed, total cost of labor, distance to the household, total cost of fertilizer, size of the land, and mean distance to the nearby fertilizer suppliers, $F = 336.5696$, $MS= 1.529526$, $p ( 3E-44<0.05 )$. We have statistically significant evidence at $\alpha=0.05$ (5% level of significance) to show that there is a difference in fertilizer usage among the six variables.

The regression statistics in table 4.5 tells about the quality of the model fit, the multiple R of 0.985467 is close to 1 meaning that the model is adequate. Also since R-Square is 0.971146,
implying that 97.11% of variability in fertilizer use is due to changes in the of total cost of seed, total cost of labor, distance to the household, total cost of fertilizer, size of the land, and changes in mean distance to the nearby fertilizer suppliers.

Table 4.5: Regression statistics

<table>
<thead>
<tr>
<th>Regression Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple R</td>
<td>0.985467</td>
</tr>
<tr>
<td>R Square</td>
<td>0.971146</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.96826</td>
</tr>
<tr>
<td>Standard Error</td>
<td>1.23674</td>
</tr>
<tr>
<td>Observations</td>
<td>67</td>
</tr>
</tbody>
</table>

The analysis has gone further to test statistics whereby the coefficients and p-values were obtained when the six variables were computed for fertilizer use in table 4.6.

Table 4.6: Test statistics of improved road on fertilizer use

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.75791</td>
<td>0.953288</td>
<td>1.844049</td>
</tr>
<tr>
<td>X1</td>
<td>5.93E-06</td>
<td>1.04E-05</td>
<td>0.570372</td>
</tr>
<tr>
<td>X2</td>
<td>-8.5E-05</td>
<td>5.79E-05</td>
<td>-1.47374</td>
</tr>
<tr>
<td>X3</td>
<td>-0.05659</td>
<td>0.02621</td>
<td>-2.15903</td>
</tr>
<tr>
<td>X4</td>
<td>2.91E-05</td>
<td>4.8E-06</td>
<td>6.055393</td>
</tr>
<tr>
<td>X5</td>
<td>3.719916</td>
<td>1.381039</td>
<td>2.693564</td>
</tr>
<tr>
<td>X6</td>
<td>-0.14319</td>
<td>0.168709</td>
<td>-0.84875</td>
</tr>
</tbody>
</table>

The findings can further be written in the model as in equation 4.3.1

\[
Y = 1.75791 + 5.93E-06X_1 - 8.5E-05X_2 - 0.05659X_3 + 2.91E-05X_4 + 3.719916X_5 - 0.14319X_5
\]

The findings basing on this model show that the level of fertilizer use stands at 1.75791 (Y-intercept). From table 4.6, variation caused by total cost of seed, total cost of labor, distance to the household, total cost of fertilizer, size of the land, and mean distance to the nearby fertilizer
suppliers on fertilizer usage in the area of the study shows that even without these six variables, farmers still can use fertilizer at 1.75791 level, this means that other factors like farmers having other sources of income to buy farm inputs and subsidies for facilitating farmers to get fertilizer must be playing a role in this area. Each variable that was tested seemed to behave on its own and analyzing individual variable is allowing the researcher to highlight the relationship of each variable with fertilizer usage. When we look at the coefficients of these variables individually and analyzing effect of each while keeping other factors constant, the model denotes that, the effect of cost of seeds will slightly increase the level of fertilizer usage by 5.93E-06, however this effect is not statistically significant due to p-value (0.570556 > 0.05). This therefore implies that, cost of seeds is not a crucial factor that households rely on when taking decision on growing maize. It is also obvious because it is an imperative that for the production of maize then crucially maize seeds must be obtained, therefore these two variables are twins in maize growing. Looking at another variable of total cost of labor, it is clear from our findings that this variable is negatively affecting the utilization of fertilizer whereby a change in unit of labor cost (1Frw) will decrease fertilizer use by 8.5E-05 lower from 1.75791 and this change is also not so significant, the p-value is 0.145778 > 0.05. This means the slight change in labor unit will not significantly result in change in fertilizer use. From the equation also, unit change in distance to the household will cause a 0.05659 decline in fertilizer use and this change is so significant where p-value is 0.034857 < 0.05, therefore, while the unit change in location of household in terms of distance from the main road (Rusumo-Kigali) will reduce fertilizer usage this change is so significant.
Further analysis of the variables takes us on the effect of total cost of fertilizer on its usage, here; we found that any unit increase in cost of fertilizer (For every 1Frw use, there is an increase in fertilizer use) will slightly increase the use of fertilizer by 2.91E-05 and this change is not statistically significant (p-value, 9.93E-08>0.05), implying that even if the fertilizer utilization is a must basing on the fact that Rwanda soil is small and exhausted with high need in nutrients and therefore command the fertilizer utilization even at an increasing price of fertilizer, this relationship is still not significant and households are not relying on it when deciding on fertilizer application. This also is possible when households have other sources of income which increase the capacity to afford buying agriculture inputs. Coming closer to the findings on relationship for the size of the land ad fertilizer use, we see that an increase in unit land size sharply cause an increase in fertilizer use by 3.719916 and this is statistically significant p-value, 0.009153<0.05 level of significance. The results are showing that, land size is the most affecting the level of fertilizer use, mostly due to the fact that, people with big lands will have opportunity in investing much in maize production than people with small plots of land who finds it a business in maize production and can decide to invest in other more productive areas like motorcycle driving and selling shops. Finally, the regression results for the relationship of mean distance to the fertilizer supplier with fertilizer usage was found that it decreased the level of fertilizer by 0.14319, meaning that a unit change in distance the supplier will affect in an significant way the use of fertilizer p-value of 0.399397>0.05. Therefore, from these findings, one can infer that for all variables, only the change in unit of distance and land size are significant different for fertilizer use when all other factors remain constant.
These findings come after other researches findings whereby use of purchased agricultural inputs was not significantly different for households with good and poor access to road, indicating that there may be many factors such as unobserved differences in natural endowments affecting the households’ use of purchased agricultural inputs in the research conducted in Rural households in Tigray (Torbjørn, Bharat, & Bhatta, 2012). The elasticity of fertilizer demand with respect to road density was found to be quite high and roads were also found to have directly contributed to both growth of output and use of fertilizers (Binswanger et al., 1987).

4.3.2 Findings on improved rural road and level of maize output

The four variables that were considered important associated with maize output in the study area were used to examine the association of variables. By Pearson’s correlation, the log Maize output was computed for each pair of variables namely, Log labor, Log distance, Log fertilizer, and Log land.

Let, \(LM\) denote Log Maize variable, \(LL\) stand for Log Labor, \(LD\) for Log Distance, \(LF\) for Log Fertilizer and \(Ll\) for Log Land, \(\rho_{LM,LL}\) denote the Pearson correlation Coefficient between \(LM\) and \(LL\) variable, \(\rho_{LM,LF}\) denote the Pearson correlation Coefficient between \(LM\) and \(LF\) variable, \(\rho_{LM,LD}\) the Pearson correlation Coefficient between \(LM\) and \(LD\) variable, and \(\rho_{LM,Ll}\) stand for the Pearson correlation Coefficient between \(LM\) and \(Ll\) variable. The results obtained are presented in table 4.7.
Table 4.7: Pearson’s correlation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Statistic</th>
<th>LM</th>
<th>LL</th>
<th>LD</th>
<th>LF</th>
<th>Ll</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM</td>
<td>Pearson Correlation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>Pearson Correlation</td>
<td>.597**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>Pearson Correlation</td>
<td>-.201</td>
<td>-.069</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.106</td>
<td>.583</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LF</td>
<td>Pearson Correlation</td>
<td>.882**</td>
<td>.873**</td>
<td>-.038</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ll</td>
<td>Pearson Correlation</td>
<td>.729**</td>
<td>.893**</td>
<td>-.064</td>
<td>.854**</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.615</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

Since $\rho_{LM,LL} = 0.597** > 0$, their association is positive implies that increase in LL will produce increase in LM and the association is quiet statistically significant (2-tailed) is 0.000. And since $\rho_{LM,LF} = 0.882** > 0$, their association is also positive, the increase in LD will produce an increase in LM, the association is statistically significant (2-tailed) is 0.000. Also for $\rho_{LM,LD} = -0.201$, their association is negative, implying that, an increase in LD will produce a decrease in LM, this association between LD and LM is statistically not significant (2-tailed) is 0.106, and finally, $\rho_{LM,Ll} = 0.729**$, it show that their association is positive whereby an increase in Ll will produce an increase in LM and the association between Ll and LM is statistically significant (2-tailed) is 0.000. From here then, apparently, road infrastructure is not the most important factor in maize production in the study area; instead, other factors including fertilizers, land size, and labor inputs are statistically significantly associated with change in level of maize output. The findings therefore reject the Alternative hypothesis in favor of the Null hypothesis by concluding that
there is no relationship between improved rural road and level of maize output, among the sample farmers.

The effect of these three variables (that is fertilizer, land and labor) then were further put to the regression analysis for the level of maize output. Regression analysis was performed between maize output as the dependent variable and fertilizer, labor and land as the independent variables in order to get precise information about the nature of the cause and effect relationship between these variables and also to test the rest of the study’s hypotheses. The regression model (a Cobb-Douglas type) was estimated.

\[(4.3.3) \quad Q_{\text{maize}} = a \text{Land}^b \text{Labor}^h \text{Fertilizer}^l \epsilon^n\]

To facilitate the estimation of the parameters, and their subsequent interpretation, the following log-linear model was instead estimated.

\[(4.3.4) \quad \log Q_{\text{maize}} = \log \text{a} + b_1 \log \text{Land} + b_2 \log \text{Labor} + b_3 \log \text{Fertilizer} + \epsilon\]

For this model to be varied, these are the assumptions.

(iv) \( \epsilon \) are independent, identically distributed

(v) Their means are equal to zero, Variance \( \sigma^2 \) is a constant

(vi) \( \epsilon \sim N(0, \sigma^2) \)

When the three inputs were regressed on maize output, the findings are shown in table 4.8.
Table 4.8: Regression analysis results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Constant</td>
<td>-.643</td>
<td>1.334</td>
</tr>
<tr>
<td>Log Labor</td>
<td>.643</td>
<td>.598</td>
</tr>
<tr>
<td>Log Fertilizer</td>
<td>.256</td>
<td>.085</td>
</tr>
<tr>
<td>Log Land</td>
<td>.068</td>
<td>.578</td>
</tr>
</tbody>
</table>

The regression model can then be written as

\[
(4.3.5) \quad \log Q_{\text{maize}} = -0.643 + 0.068 \log \text{Land} + 0.643 \log \text{Labor} + 0.256 \log \text{Fertilizer}
\]

This model show that without these variables then there is -0.643 level of production implying that there is no production, however with land effect the level of maize production will increase by 0.068, while with labor effect will lead to an increase by 0.643 and fertilizer will raise the level of production by 0.256. On the basis of the above observations, a second regression analysis was run with fertilizer as the only determinant. Labor and land inputs do not seem to be significant determinants of variation in the level of maize output in the study area. This is indicated by their p-values (significance levels) as well as their t-statistics. For labor, the p-value is 0.287>0.05 statistically not significant while that of land is 0.907>0.05. With fertilizer as the only one variable input that shows the significant relationship with level of maize output, the farmers can be said to be operating in the short-run. Typical short-run production functions of only one variable input are normally cubic. So a cubic function was estimated yielding the results that are presented in table 4.9 to 4.11.
Table 4.9: ANOVA for Regression Results with Fertilizer as the only Input

The analysis of variance shows that quantity of fertilizer is significantly contributing to level of maize production and therefore areas where fertilizer application is low then maize production will vary and become low significantly to their counterparts with good fertilizer application. This is so true for Rwandan settings where quality of soil is low and need nutrients addition for good agriculture production. The regression statistics results in table 4.10 telling about the quality of the model fit, R-Square was found to be 0.968, this value is close to 1 meaning that the model is adequate.

Table 4.10: Model summary for regression statistics

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>646.663</td>
<td>2</td>
<td>323.332</td>
<td>981.146</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>21.091</td>
<td>64</td>
<td>0.330</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>667.754</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since R-Square is 0.968, this implies that 96.8% of variability in level of maize output is due to changes in volumes of fertilizer applied. The regression analysis was then conducted, the fertilizer in its square and cubic form was computed against level of maize output and the findings were then presented in table 4.11.
Table 4.11: Regression Analysis Results

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Constant</td>
<td>.822</td>
<td>.087</td>
</tr>
<tr>
<td>F(^2)</td>
<td>.044</td>
<td>.002</td>
</tr>
<tr>
<td>F(^3)</td>
<td>-.0007</td>
<td>3.07E-5</td>
</tr>
</tbody>
</table>

From these results, estimated production function was then expressed as:

\[(4.3.6) \; Q = 0.822 + 0.044F^2 - 0.0007F^3\]

The model is showing that, even in the absence of fertilizer the level of maize output is positive at 0.822. Also the relationship is quiet significant (p-value, 0.000<0.05). We reject the null hypothesis in favor of alternative hypothesis. Given that the cubic-term of this function is negative, it is clear that the fundamental production law of diminishing marginal returns is obeyed. Moreover, the graphical representation of the estimated function in figure 4.7 is similar to the typical short-run production with only one variable input.

Figure 4.7: Estimated Maize Production Function
It is also clear that most farmers are operating in Stage I (area shaded yellow) while no farmer is operating in Stage II (area shared green) but one farmer seems to be operating in Stage III (area shaded red).

Other findings like (Khandker et al., 2006) in the impact study of rural roads in Bangladesh, there was a significant increase in agricultural production, wage and output prices, alongside decreasing input and transport costs. The World Bank examined the socioeconomic influence of improvement of rural roads in Morocco, they found higher outputs, changes in the agricultural output mix, and increased amount of higher value crops such as fruits and vegetables (World Bank, 1996). Research in Kenya found that, the use of maize hybrid seeds, chemical fertilizers, maize productivity and milk market participation increase more in areas with better road access improvement. The infrastructure investment in Kenya has contributed to productivity enhancement, especially in remote areas (Kiprono, 2014).

Roads improvement overall result was reduced production costs resulting in increased production (World Bank, 1996; Bhalla, 2000; World Bank, 2005; Faiz et al., 2012). Evanson and Gollin (2003) used farm-level data for the Philippines from 1948 to 1984 to estimate the effect of public investment in farm level output supply and input demand. Roads were found to have a positive effect on aggregate output per farm, as well as on fertilizer use. The output elasticity with respect to roads worked out to be as high as 0.31. But strangely enough, he found negative elasticity of output with respect to rural electrification (Evanson & Gollin, 2003).
4.3.3 Relating Improved Rural Roads and Markets access and participation.

This theme is primarily focused on the market access and participation behavior of small-scale maize farmers in the study area. It attempts to determine the factors influencing the decision of the farmers / farming households to participate in the market. Households nearby the main roads (Kigali- Rusumo) are expected to have greater participation in maize markets indicated by number of trips made. Combining distance to the nearby big market in Kirehe town, Cost of transportation for maize and time taken to the nearby big market with number of trips made by farmers we used it as approach to test the hypotheses across the study area. This hypothesis was estimated by regression model

\[ Y = f(\text{Distance to the market}, \text{Cost of transportation}, \text{Time to the market}) \]

(4.3.7) \[ Y = \rho_0 + \rho_1 X_1 + \rho_2 X_2 + \rho_3 X_3 + \varepsilon \]

\[ X_1 = \text{distance to the market in (Km)} \]
\[ X_2 = \text{Cost of transportation in (Rwf/kg)} \]
\[ X_3 = \text{Time to the market (Hrs)} \]

\[ Y = \text{Trips to the market} \]

For this model to be varied, a number of assumptions were made referring to error terms. Error terms are normally distributed with mean zero and variance a constant.

(vii) \( \varepsilon \) are independent, identically distributed

(viii) Their means are equal to zero, Variance \( \sigma^2 \) is a constant

(ix) \( \varepsilon \sim N(0, \sigma^2) \)

The ANOVA was performed to check for the relationship in distance and farmers participation to the nearby big market and the findings are in table 4.12
Table 4.12 Analysis of Variance in market access and participation

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3</td>
<td>22.94672</td>
<td>7.648908</td>
<td>6.880248</td>
<td>0.000442</td>
</tr>
<tr>
<td>Residual</td>
<td>63</td>
<td>70.03835</td>
<td>1.11172</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>92.98507</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the ANOVA table with F-test statistic of 6.880248 with p-value of 0.000442, since the p-value is less than 0.05 (0.000442<0.05), the researcher has rejected the null hypothesis in favor of alternative hypothesis and confirm that there is a significance difference for markets access and participations for maize farmers in accessible and remote areas in our area of the study. This means the most accessible area residents are participating to the Kirehe market as compared to their fellows in the remote area for selling their maize produces. Therefore providing farmers with good roads will facilitate them to take their produces to the market and be able to fetchopportunities for high price.

Our analysis for regression showed the findings in table 4.13

Table 4.13 Regression for markets access and participation in area of study

<table>
<thead>
<tr>
<th>Regression Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple R</td>
<td>0.496768</td>
</tr>
<tr>
<td>R Square</td>
<td>0.246779</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.210911</td>
</tr>
<tr>
<td>Standard Error</td>
<td>1.054381</td>
</tr>
<tr>
<td>Observations</td>
<td>67</td>
</tr>
</tbody>
</table>

The findings from this analysis showed that the $R^2$ is 0.247 (24.7%) which implies that the variable of road improvement contributes only 24.7% to market participation and the
remaining percentage depend on other factors. This is mainly due to the fact that many farmers sell their maize produces to the cooperatives which have signed contract with many potential buyers of maize in Rwanda. Findings from the regression were presented in Table 4.14 to show the strength of relationship for variables on the market participation.

Table 4.14: Analysis of regression of markets access and participation

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.495781</td>
<td>0.730114</td>
<td>4.787991</td>
<td>1.06E-05</td>
</tr>
<tr>
<td>X_1</td>
<td>0.239059</td>
<td>0.201917</td>
<td>1.183949</td>
<td>0.240881</td>
</tr>
<tr>
<td>X_2</td>
<td>-0.12798</td>
<td>0.035887</td>
<td>-3.56612</td>
<td>0.000698</td>
</tr>
<tr>
<td>X_3</td>
<td>0.008951</td>
<td>0.026634</td>
<td>0.336064</td>
<td>0.73794</td>
</tr>
</tbody>
</table>

The model was rewritten as

(4.3.8) \( Y = 3.495781 + 0.239059X_1 - 0.12798X_2 + 0.008951X_3 \)

This model is telling the relationship between our variables whereby, the trips made to the nearby big market (Y) was found to be significantly related to cost of transportation than any other factor, the unit increase in francs of transport caused significantly a decrease in trips made by 0.12798 at significant level 0.000698<0.05 taking other factors constant. Other variables of distance to the nearby big market and Time to the market did not significantly affect the trips that were made by farmers. Therefore we reject the null hypothesis that there is no relationship between distance to the nearby big market and participation by farmers and favor the alternative one saying that there exist a relationship between distance to the market and farmers participation in the market.
These findings are quite similar to other findings from other settings. In their study, (Bryceson et al., 2006) where they contrasted well-connected and remote regions in Ethiopia, Zambia and Vietnam which represented different levels of road density, and two regions one of which had been availed road improvements in the last 5 to 10 years and the other which had not. At one end of the spectrum the Vietnamese had a tendency to make more frequent shorter distance trips whereas at the opposite end Ethiopians were making far fewer but much longer journeys where they tended to stay for a relatively longer time at their destination before returning (Bryceson et al., 2006).

The findings by Kemisola et al., (2000) show that distance to the market negatively influences both the decision to participate in markets and the proportion of output sold. Thus, the variable transport costs per unit of distance increases with the potential marketable load size for farmers in very remote rural areas, geographic isolation through distance creates a wedge between farm gate and market prices. In the impact evaluation of the Njombe - Makete Road Project in Tanzania, the project undertook improvements of feeder roads, bridge construction, and rural road routine and spot maintenance. The impact study found an increased participation of vendors at local markets and an increased variety of available consumer goods and agricultural products. The geographic size of markets for agricultural products increased significantly. There were significant increases in the sale of all types of agricultural products as well as increased availability of agricultural inputs (Rutachokozibwa & Tagora, 1995). Ahmed and Hossain, (1990) they found that development of infrastructure had a positive effect on the marketing of agricultural produce. The development of infrastructure enabled cultivators to
obtain a slightly higher price for their produce and to buy a larger proportion of consumption needs from the market as compared with the undeveloped villages (Ahmed and Hossain, 1990).
CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter outlines the researcher’s summary of findings, conclusion and recommendations on findings of the research; they are based on the findings given in chapter four of the study and they are also based on comments given by some of the respondents during the period of gathering data from the study area. The global objective of the study was to determine the effect of improved rural roads on maize farming in Kirehe District, the research was also guided by the following specific objectives: to determine the relationship between access to improved rural roads on level of fertilizer usage in maize farming, the relationship between distance to improved rural roads and level of maize output; and finally, to determine the relationship between farm households location and participation in maize output markets. It tested the null hypothesis that ‘there is no relationship between improved rural roads and the quantity of fertilizer utilization, no relationship between improved rural roads and the level of maize output produced and no relationship between improved rural roads and farmers’ participation in the maize market.

5.1 Summary and conclusions

The research has revealed that every unit changes in distance to the household will cause a significant change of 0.05659 declines in fertilizer use. We also found that any unit increase in cost of fertilizer (an increase of 1Frw use, there is an increase in fertilizer use) will slightly increase the use of fertilizer by 2.91E-05 and this change is not statistically significant (p-value, 9.93E-08>0.05), these findings are un-usual whereby it show that even at increasing cost of fertilizers, farmers will still use fertilizer implying that fertilizer utilization is a must basing on the fact that Rwanda soil is small and exhausted with high need in nutrients and therefore command the fertilizer utilization even at an increasing price of fertilizer, however the findings
showed that this relationship is still not significant. Therefore households are not relying on cost of inputs factor when deciding on fertilizer application. This also is possible when households have other sources of income which increase the capacity to afford buying agriculture inputs.

Other findings have shown fertilizer as the only one variable input that shows the significant relationship with level of maize output. Improved rural road measured in distance to the household is not the most important factor in maize production in the study area; instead, other factors including fertilizers, land size, and labor inputs are statistically significantly associated with change in level of maize output. It can be concluded that areas where fertilizer application is low then maize production will vary and become low significantly to their counterparts with good fertilizer application. This is so true for Rwandan settings where quality of soil is low and need nutrients addition for good agriculture production. Also though most farmers in Rwanda are largely subsistence, few would choose to operate in stage I of production function if opportunities exist to operate in stage II. Even with the current land sizes, more output can be achieved by intensifying fertilizer usage up to the level where its marginal product is zero. These studies have shown that, this would occur at a level of fertilizer utilization of around 40 tonnes per hectare giving a yield of about 25 tonnes of maize output.

Given the severe scarcity of arable land in Rwanda coupled with high disguised employment especially in the rural areas, it is not surprising that fertilizer is a critical factor in maize production in the study area. Other factors thought significant in maize production (for example accessibility to road infrastructure) are not significant though there seems to be an inverse correlation between the spatial location of the farmers versus the nearest accessible roads. The
results of the study therefore seem to suggest that, more emphasis should be put on fertilizer input supply in particular. Improvement of road infrastructure, which serves a wider population than just farmers, is important also and should continue. Finally, the trips made to the nearby big market (Y) was found to be significantly related to cost of transportation than any other factor, the unit increase in francs of transport caused significantly a decrease in trips to the nearby big market. Other variables of distance to the nearby big market and time to the market did not significantly affect the trips that were made by farmers. These findings are also unusual the cost that is incurred to farmers are not related to time and distance measured to the household, we expected distance to affect trips through increased cost and time and this would affect trips made, this is so true because the farmers cooperatives are functioning in a way that it is supplying farmers with necessary inputs (fertilizer and improved seeds) and in turn it is becoming a market for farmers produces. This cut the necessity for making trips to the market basing on the calculated mean distance to the nearby inputs suppliers.

5.2Recommendations

The researcher would like to highlight the following recommendations:

1. Government policies towards prioritizing the construction and maintenance of roads to provide a minimum of reliable and efficient transport access to rural communities in developing countries could be the appropriate development strategy for socioeconomic transformations since road accessibility crowds in other basic social and economic services and activities;

2. The fact that roads are not seen as a significant factor for maize production, and market participation whereby farmers in the study area has virtually behaved equally is because of government policy of farmers’ cooperative, the effect of organising farmers into groups
have interfered with the perceived knowledge about roads prior to this study. Therefore, together with improving rural roads, governments and multinational organisations should put much effort in promoting farmers organisations so as to be able to provide services both vertically and horizontally by reducing burdens that could accrue to a single farmer and therefore generally cut high costs on farmers;

3. Farmers in Rwanda and elsewhere in developing countries are recommended to join the farmers groups so as to embrace the opportunities through easy transactions that would otherwise be high due to factors of poor infrastructures like cutting costs of production, sales of farm produces and associated costs;

5.3 Suggestions for further research

Further research is recommended in terms of using a larger sample and also covering other crops. Since the study used cross-sectional data, further research is also recommended using time-series data. This would most likely be able to capture the impact of road infrastructure better than this study has done. Also researchers in Rwanda should do more research about the impact of improved rural roads on agriculture in other rural areas of Rwanda taking into consideration of other agriculture commodities so as to improve on these findings.
REFERENCES


MINAGRI. (2013b). *Strategic Plan for Agricultural Transformation Phase III*.


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Appendix 1: A map to show Kigali-Rusumo tarmac road, Kirehe market, Cyunuzi center, and the feeder road.

Source: Application of Arc GIS 9.0 versions
Appendix 2: Administrative map of Kirehe District

Source: Application of Arc GIS, 3.2 Version
Appendix 3: Map showing principle routes in Rwanda

NOTE
The road numbers shown are for identification only. There is no official road numbering system in Rwanda.