Effects of Comprehensive Land Husbandry Technologies on Land Productivity in Rwanda.

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Abstract

Land husbandry technologies have been reported as one of the most important factors for land productivity in previous studies; the reason why the current study analyzed all Comprehensive Land-husbandry Technologies used for land productivity increase; assessed indicators of land productivity increase in the study area and finally the study established the relationship between land-husbandry technologies and land productivity. A questionnaire was used to collect primary data. Apart from descriptive analysis, correlation and regression analysis were conducted on the responses from a sample of 98 farmer respondents in Rwamagana terraced site (named RW-34). About the analysis of Comprehensive Land-husbandry Technologies used for land productivity increase; terracing, cut off drains, water ways, agroforestry, ditches and others were found to be the main land husbandry technologies used in Rwamagana intervention area. Beneficiaries combine both mechanical and biological measures; terraces and agroforestry with 70% and soil bund with agroforestry 25%. Research found out indicators of land productivity increase in the study area, where the results come out to be overcoming poverty and obtaining food security (33%), improvement of living conditions of farmers (36%), and increased production (29%).About the relationship between Land-husbandry technologies and Land productivity, the findings showed that the level of satisfaction of respondents towards land productivity is high where 32% confirmed increased soil fertility, improvement of living conditions of farmers defined by 25%, 16% for reduced soil erosion, 15% overcoming poverty and obtaining food security, while 12% declared improved crop yield. The results of the survey concluded that all beneficiaries practiced land husbandry technologies and the study also highlighted some of the reasons of not practicing Land husbandry technologies before and among them there are limited knowledge, lack of equipment, land tenure and poverty. In the due course, the study highlighted that terracing is the most practiced land husbandry technology like cut off drains, creation of water ways, agroforestry, soil bunds and ditches.

Key words: Land, Land Productivity, Land husbandry technologies.

1. Introduction

Enhancing agricultural productivity and preventing food insecurity has been a major concern worldwide (FAO, 2005). Land husbandry technologies may be vital tool for productivity increase. Papy et al. (1991) asserted that land husbandry technologies involves farming practices which uses land management techniques such as soil bunds, terraces, cut-off drains, water ways, forestation, reforestation and terraces with risers to develop appropriate practices for both rain-fed and irrigated agriculture and increase production of seasonal and perennial crops. Tato (1989) in his research argued that regions with no application of land husbandry technologies, land gets unproductive due to poor agricultural practices. Tato (1989) however reveals hundreds of thousands of poor rural farmers have been supported to overcome poverty due to the increase of productivity as results of the introduction of land husbandry technologies in farming system.

In Rwanda like other East African countries, the problem of land productivity is a concern due to absence of land husbandry technologies hence land degradation. This has significant effects on the environment, agronomic productivity (REMA, 2010). Stockholm Environment Institute (2009) reports the loss of 1.4 million tons of soil per year, equivalent to an economic loss equivalent to US 34,320,000, or almost 2% of GDP. Unsustainable land husbandry practices including deforestation, agricultural expansion into fragile ecosystems, overgrazing, and poor road construction resulted in catastrophic erosion and slope failure (REMA, 2010) and this has subjected to low productivity of land. NISAR (2011) suggested a practical way to break out of this, is to introduce land husbandry activities such as terracing, agro-forestry and progressive ditches at marginal lands and as a result land husbandry technologies like terracing, forestation and soil bunds have been significantly built and more than 21,300 ha of land have been treated in various parts of Rwanda including Rwamagana thereby the researcher's intention to conduct the current study.

Furthermore, Shaxson and Downes (2005) commented that land husbandry is the active process of implementing and managing preferred systems of land use and production in such ways that there will be increase of productivity, and avoid rapid degradation of land.

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While reporting the hindrances of land husbandry technologies for effective productivity Tenywa (2013) says that anti-erosion action has commonly taken a mechanical approach to reducing soil erosion, but this fails to ensure that soils remain sustainably productive. The long-held assumptions that mechanical land treatment methods would be automatically effective in hesitant erosion and maintaining productivity have proved deceptive, and land damage continues, particularly where rising population-pressure on land results in the opening and tillage of land whose characteristics indicate it is at greater risk of suffering rapid loss of productivity, Trapnell (2013).

Spurr (2011) added that with the ongoing increases in human populations and their rising density on potentially productive land, expansion of "traditional" knowledge alone now often proves to be insufficient to confront, avoid or ameliorate problems of increasing degradation of their lands' productive capacities. MINAGRI (2018) confirmed that with the same technologies, one can see that the land is not efficiently used and hence leading to poor productivity and substantially questionable sustainable production. Thereby the researcher's intention to carry out the current study to see whether there is any effect of comprehensive land husbandry technologies to land productivity, taking into consideration terraced site as the case study.

2. Materials and methods

2.1 Research design

Research design is a framework of methods and techniques chosen by a researcher to combine various components of research in a reasonably logical manner so that the research problem is efficiently handled. Kenneth (1978) asserts that a research design is the set of methods you have chosen for empirical part of your study. Under the current study, both descriptive and correlative research design were used to assess the effect of comprehensive land husbandry strategies to the productivity.

a) Descriptive research design

In a descriptive research design, a researcher is solely interested in describing the situation or case under his/her research study (Ramanath, 2010). It is a theory-based research design which is created by gathering, analyzing and presentation of collected data. By implementing an in-depth research design such as this, a researcher can provide insights into the why and how of research. However, Quantitative research

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approach is part of descriptive research design; and it was the concern in this study.

b) Quantitative research design

Quantitative research approach emphasizes objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon (Ramanath, 2010). This study adopted Quantitative research approach.

c) Correlative research design

Correlative research is a type of non-experimental research in which the researcher measures two variables and assesses the statistical relationship between them with little or no effort to control extraneous variables. Correlation between two variables is concluded using a correlation coefficient, whose value ranges between -1 and +1. If the correlation coefficient is towards +1, it indicates a positive relationship between the variables and -1 indicates a negative relationship between the two variables. In this line, Pearson Correlation coefficient was used to conclude whether the land husbandry strategies and land productivity are correlated or not (DHS, 2010).

2.2 Sampling design

a) **Study population**

According to Panneerselvam (2005), a study population refers to the total group of people from whom the information is needed. For the current, the study population comprises of 4,112 farmer beneficiaries of terraced land in the selected Sectors of Rwamagana district where land husbandry (terracing) has been implemented.

b) Sampling techniques

Basically, sampling techniques are divided into probability and non-probability sampling. Probability sampling provides an equal opportunity for each and every element of the population being selected. This method utilizes some form of random selection. But non- probability sampling does not involve random selection **(**Ramanath, 2010**).** In this context, purposive sampling techniques to determine the representative sample size.

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c) Purposive sampling

Purposive sampling is a non-probability sampling method and it occurs when "elements selected for the sample are chosen by the judgment of the researcher. Researchers often believe that they can obtain a representative sample by using a sound judgment, which will result in saving time and money" (Ramanath, 2010).

2.3 Sample size

Sample size determination is the act of choosing the number of observations. The sample size is an important feature of any empirical study in which the goal is to make inferences about a population from a sample (Bartlett et al., 2011).

If you take a population sample, you must use a formula to figure out what sample size you need to take. Therefore, Slovin's formula was used to figure out what sample size you need to take, which is written as:

$$n = \frac{N}{1+N(e)^2}$$

Where n = Sample Size,

N = Total population,

e = Error tolerance,

Assume that a confidence level of 90 percent (which give a margin error of 0.01 was used).

$$n = \frac{N}{1+N(e)^2}$$

$$n = \frac{4112}{1+4112(10\%)^2}$$

$$n = 98$$

The sample size of the study is 98.

2.4 Research Instruments

In order to collect their written reflections on the impact of comprehensive land husbandry to the productivity; questionnaire and documentation were used as data collection techniques.

a) Questionnaire

Williams (1994) defines a questionnaire as a set of written questions which calls for responses on the part of the client. In this study, a questionnaire was used for data collection from the respondents. A questionnaire was used because most ofrespondents know how to read and write. In addition, it facilitated them to think and rethink before answering for ensuring proper responses.

b) Documentation

In order to find the background and get the reliable data of this study, various literatures from which reports, published and unpublished documents, relevant laws,

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regulations and policy papers related to the topic under study were consulted, and these contributed a lot to the enrichment of the research.

2.5 Data processing and analysis

a) Data processing

Data collected were transformed into meaningful information for easy interpretation and understanding. Normally thedata collected from respondents are not in proper form which renders it difficult to interpret and analyze to draw conclusions. For making the collected data more clear and understandable, the raw data were presented in proper manner to facilitate the interpretation and analysis. This was done in sub-processes of editing, coding, tabulation and analysis. The processed data were further analyzed in SPSS version 20.

b) Editing

Babbie (1993) defined editing as a process where errors in completed questionnaires are identified and are eliminated whenever possible. Editing is done to check, completeness, accuracy, uniformity, legibility and comprehensibility. In other words, editing is a routine task which involves detecting and correcting errors.

For this study, editing discovered mistakes like unfilled spaces in questionnaires during the field study.

c)Coding

Coding responses and views helped in classifying the data into a meaningful form to derive essential patterns in the responses to ensure logical order and facilitate their analysis and interpretation. Here, responses and views of every respondent were entered in a unique way, and thereafter the researcher matches and compares the views of all respondents to every question.

d)Tabulation

Tabulation is all about putting data into statistical tables showing the number of occurrence of responses to particular question. Tables were constructed according to the questions asked in order.

2.6 Study area description

The concerned site is located in Musha (Sector of interventions) in Rwamagana District of Eastern Province of Rwanda. The district is divided into 14 sectors : Fumbwe, Gahengeri, Gishari, Karenge, Kigabiro, Muhazi, Munyaga, Munyiginya, Muyumbu, Mwulire, Nyakariro, Nzige and Rubona (NISR, 2011).

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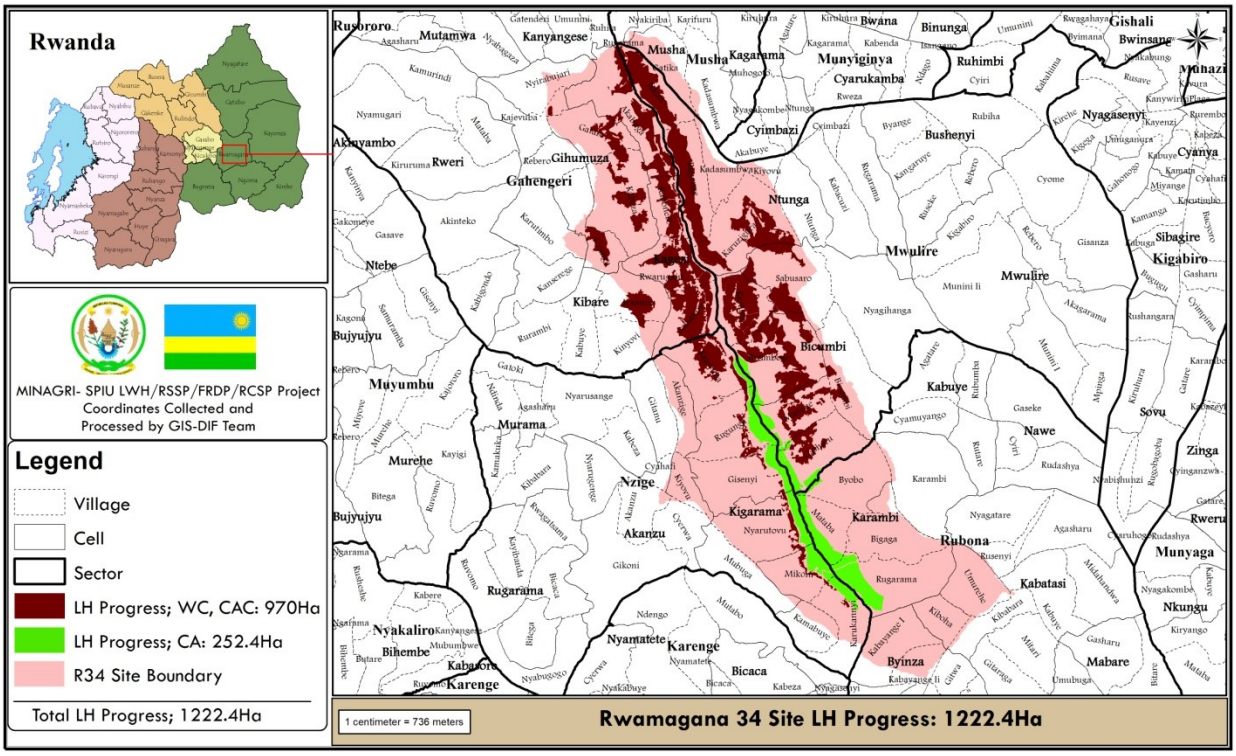
Rwamagana district covers an area of 682 km^2 (263 sq mi) with 313,461 of Population and population Density of 460/km^2 (1,200/sq mi) according to the 2012 census. RW-34 site is about 45min drive from Kigali city. The site is developed with comprehensive Land husbandry technologies in rain -fed area of 1,089 ha and irrigated area of 267ha.The total number of beneficiaries for RW-34 is 4,112(Rwamagana brief notes,2017).

Furthermore, Rwamagana district is situated between 1°57'2, 7''of south latitude and 30°26'8''of longitude, it experiences a moderate tropical climate with four seasons of which: two are cold and the rest dry (EDPRS self assessment district report,2013). It experiences relatively large quantities of rains especially in the months of April-May and October-December of every year. The average temperature ranges between 19° and 30° and it is constant all over the year (Rwamagana District EDPRS Self-Assessment, 2011).



Source; Rwamagana brief note-2017

Figure.1: RW-34 intervention area.

3. Results and Discussion

IFDC (2010) pointed out that erosion control programs are being aggressively applied, such as progressive or radical terraces; a

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comprehensive watershed approach to prevent soil erosion and improve productivity on hillsides has been used. It is also important to take into account the watershed slope and field location while selecting the appropriate land husbandry technology to apply. Figure.2 and Figure.2A shows the farm location and site elevation. Presented by 77% respondents most of fields are on steep slope.

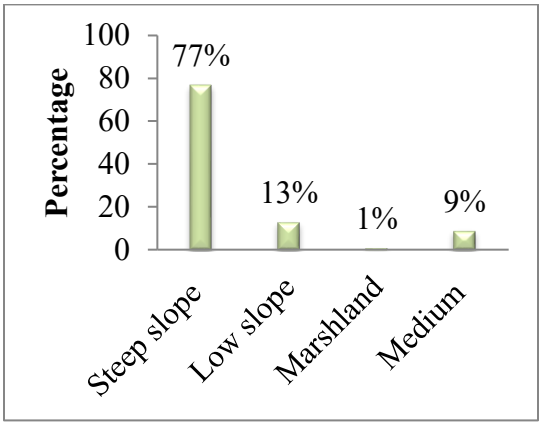

Figure 2: Farm Location

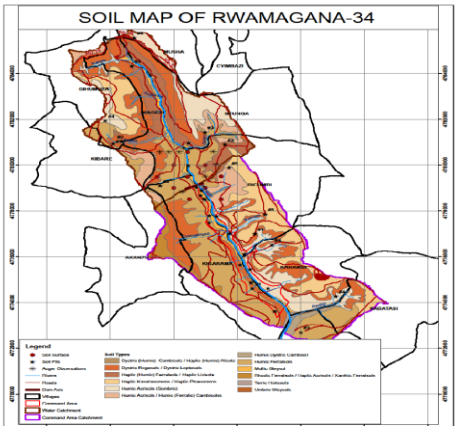

Figure 2A: Site elevation map

The farm location and field slope always reflect the status of land degradation (soil erosion). This is shown by results of the study as presented by Figure.3 below about problems in farming, which revealed that 92% of the surveyed beneficiaries have had problems in their farming, oppositely to 8% who did not, whereas Figure.4 showed that 55% of the beneficiaries have had soil erosion, 42% with low yield while 3% represent other types of problems.

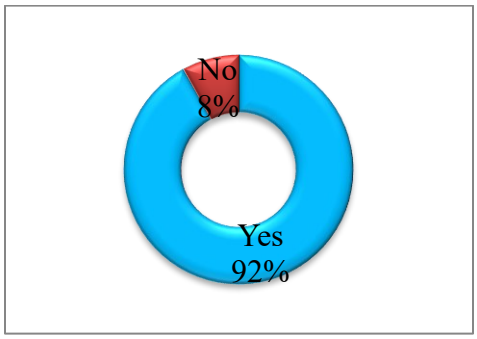

Figure 3: Problems in farming

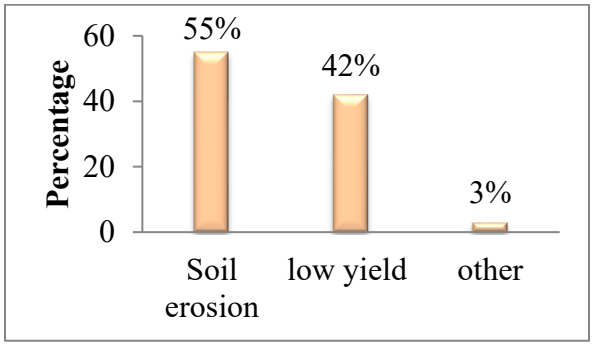

Figure 4: Types of Farm Problems

The availability of problems also reflects their sources where the study results showed that 54% claimed land slope, 23% declared intensive cultivation, 18% asserted rainfall as shown by Figure 5.

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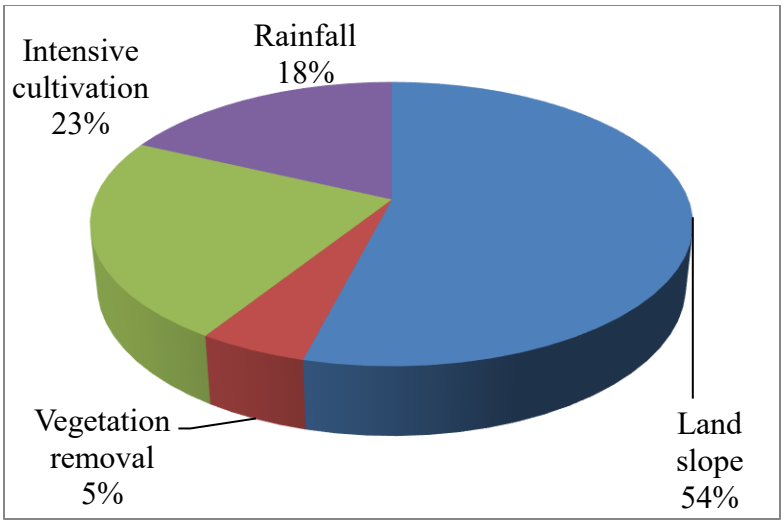

Figure 5 Source of those problems

Figure 6 , indicated that 32% of beneficiaries have been affected by low yield, 27% affected by land that become out of cultivation, 23% have experienced poverty, 11% experienced hunger while 7% experienced other types of problems.

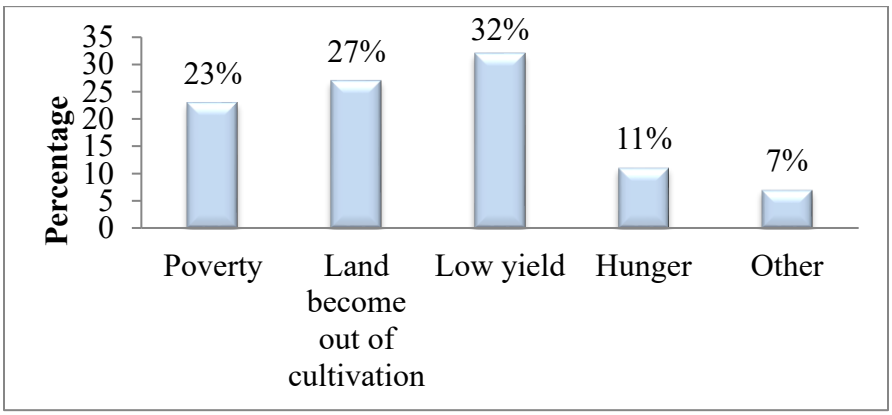

Figure 6 Associated Effects to Land Problems

3.1 Comprehensive Land-husbandry Technologies (CLT) used for land productivity increase

The analysis of the study on Comprehensive Land-husbandry Technologies used for land productivity increase as presented by Figure 7, the forms of land husbandry technologies were terracing 37%, cut off drains (29%); water ways (15%) agroforestry (8%); ditches and other (7%) respectively.

As the site was terraced, 37% of the respondents confirmed this form of land husbandry technology, followed by cut off drains 29% because the site has got steeped areas to channel the water that might enter in the scheme and damage the developed

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terraces and 15% of the respondents confirmed water ways form of CLT, where they built check dams in the water ways to curb down the run off velocity hence channeling the running water safely to the designated outlet.

Also from the analysis, terracing was confirmed number one land husbandry technology because it is a government funded initiative atleast every field was put under soil erosion protection which is complemented by Bennett (2009) while pointing out that the sense of soil degradation as a problem of land use has long been recognized and addressed by welcoming the land husbandry technologies.

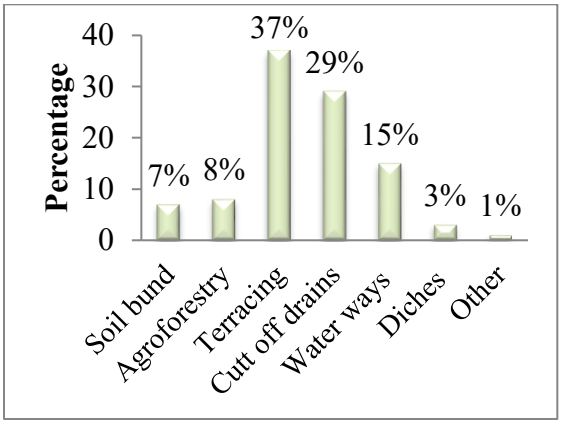

Figure 7: Practiced land husbandry Technologies

3.1.1Combination of Mechanical and biological measures

The study wished to capture the advantages of combining both mechanical and biological measures of erosion protection where Figure 8 presents 70% of respondents to have combined terracing with agroforestry and 25% for soil bunds with agroforestry

70% of interviewed respondents confirming terracing with agroforestry, selects it to be the right technology for the site because the site is steep and there was mechanical disturbance of the soil structure (terracing) so to replenish soil fertility, agroforestry species plays a bigger roll through litter. Therefore, these are the main factors behind the land productivity increase as said by Pandit (1965) while suggesting on increasing productivity resulted from more efficient use of some or all the factors of production comprising even technologies like those of land husbandry. Also, Pandit (2008) added that empowerment of farmers to solve their problems is achieved not only through training but also by introducing ideas and information from which farmers can make their own choices specifically land improvement though land husbandry technologies; and where conditions are suitable, increased residues and soil cover resulting from higher yields can generate an upward spiral of improvement in soil productivity.

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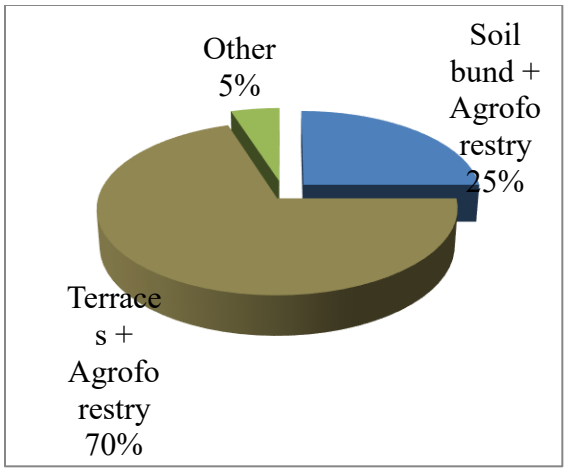

Figure 8: Combination of mechanical and biological measures

The results of the study as illustrated by the Figure 9 about realized advantages after adopting land husbandry technologies in farm showed that 32% confirmed that it helps to increase soil fertility, 25% observed improvement in living conditions of their households and 15% consider it as a way of overcoming poverty. Other advantages include but not limited to reduced soil loss and improved crop yield.

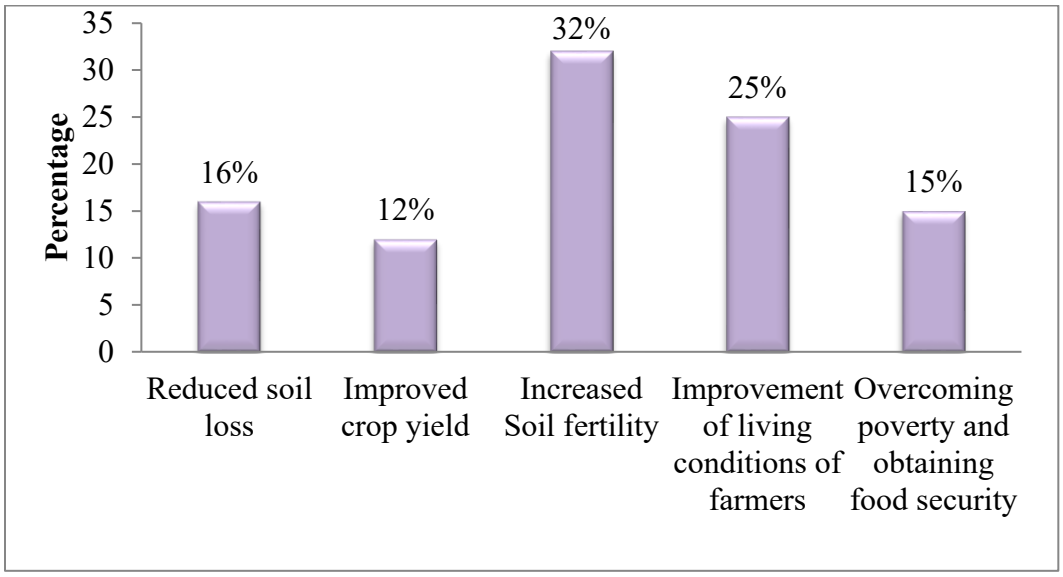

Figure 9: Advantages of adopting land husbandry technologies in farm

3.1.2 Level of production before and after practice of Land Husbandry Technologies

There are three tables: Paired Samples Statistics**,** Paired Samples Correlations**,** and Paired Samples Test**.** Paired Samples Statistics gives univariate descriptive statistics (mean, sample size, standard deviation, and standard error) for each variable entered. Notice that the sample size here is 98; this is because the paired t-test can only use cases that have non-missing values for both variables. Paired Samples Correlations shows the bivariate Pearson correlation coefficient (with a two-tailed test of significance) for each pair of variables

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entered. Paired Samples Test gives the hypothesis test results.

Table 1: Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Level of Production Before	65.4468	98	8.46214	0.42417
Level of Production After	82.74468	98	6.84480	0.34310

The Table 1 indicated that the mean for both levels of production where they mathematically operationalize to 17.30 as mean difference.

Table 2: Paired Sample Correlations

	N	Correlation	Sig.
Pair 1 Production before & After	98	.243	0.000

The Paired Samples Statistics output repeats what we examined before we ran the test. The Paired Samples Correlation table adds the information that level of production before and after scores are significantly positively correlated (r = .243).

Table3: Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
After - Before	17.30	9.50303	.4763	16.3608	18.2337	36.313	97	0.000

In our case this would be: t (98) = 36.313, p < 0.000. Due to the means of the two levels of production (before and after) of the t-value, it is concluded that there was a statistically significant improvement after adoption of land husbandry technologies in farming. So, these findings are closely related to those of Rie (2015) who conducted a

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research on Land husbandry and an Intensive Farming System in Sub-saharan Africa, Kenya; and he found positive and significant impacts of land productivity due to the use of land husbandry technologies. For him this technology increases the chance of being out of poverty specifically for farmers in rural areas.

3.2 Indicators of land productivity increase in Rwamagana LWH terraced Site (RW 34)

Figure 10 indicates that 36% confirmed improvement of living conditions of farmers followed by overcoming poverty and obtaining food security (33%); and increased production (29%). From the findings, through terracing, soil erosion that would wash away soil nutrients was reduced which resulted in a high production that improved the living conditions of the farmers because they managed to have much harvest for the family and the surplus was taken to the market.

Furthermore, through terracing with agroforestry that was confirmed by 70% of the respondents (Figure 8) that impacted the beneficiaries of the site, farmers have managed to save the money which they used to buy inputs (fertilizers) every cropping season that would end up being wash away to the downstream by soil erosion. Also, to add, 29% confirmed increased production (Figure 10) which can be completed by the findings confirmed by 32% who declared increased soil fertility (Figure 9).

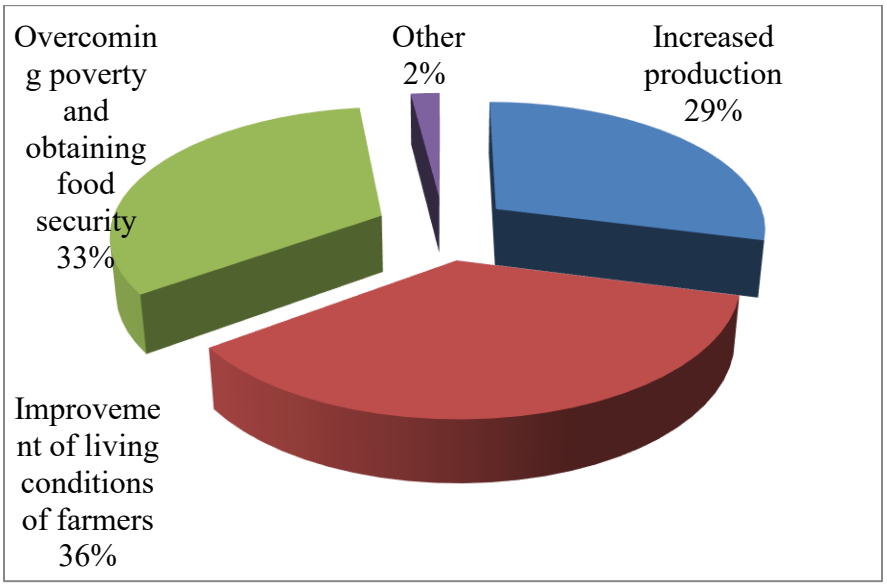

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Figure 10: Indicators of good land productivity

3.2.1 **Suggestion to improve land productivity in farm**

The research wished to know the views and the level of appreciation to the new technologies (CLT) to land productivity increase, from the beneficiaries of Rwamagana terraced area(RW-34.The analysis revealed that 37% of the respondents emphasized on farmers sensitization until the new technology is adopted, 23% might have heard the importance of land husbandry technologies but lack technical support,15%suggested that with farmer trainings and experience sharing one's mind changes while 15% suggested provisions of incentives to farmers to adopt Land husbandry technologies and 10% declared availing selected seeds to farmers.

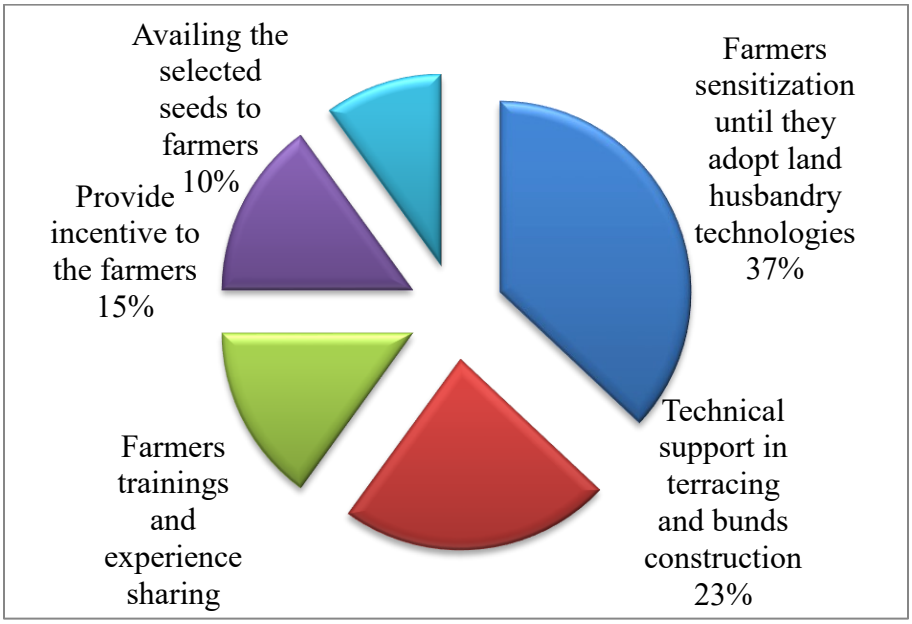

Figure 11: Suggestion to improve land productivity in farm

3.3 Relationship between Land-husbandry technologies and Land productivity

The determination of relationship on the other hand put us in a situation of checking the effects of independent variables (land husbandry technologies) on dependent variables (land productivity. Account held on the conceptual framework of this study, dependent variable is made up of the following sub variables: Increased production, Improvement of living conditions of farmers and Overcoming poverty and obtaining food security while independent variable is made up of:

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Forestation and reforestation, Water ways, Cut off drains, Terracing and Soil Bunds. The use of linear regression model helped to find out both relationship and effects.

Table 4 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.996[a]	0.992	0.992	0.46903

a. Predictors: (Constant), Forestation and reforestation, Water ways, cut off drains, Terracing and Soil Bunds,

Table 4. Provides the R and R^2 values. The R value represents the simple correlation and is 0.996 (the "**R**" Column), which indicates a high degree of correlation. The R^2 value (the "**R Square**" column) indicates how much of the total variation in the dependent variable, Land productivity, can be explained by the independent variable whereas Land husbandry technologies are independents variables. In this case, 99.2% can be explained, which is very large.

Table 5. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2422.999	6	403.833	1835.695	.000
	Residual	19.359	88	0.220		
	Total	2442.358	94			

a. Dependent Variable: Land productivity

Table 5 indicates that the regression model predicts the dependent variable significantly well. Looking at the "**Regression**" row and the "**Sig.**" column. This indicates the statistical significance of the regression model that was ran. Here, $p< 0.0005$, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).

Table 6: Regression coefficients

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	Unstandardized Coefficients		Standardized Coefficients	t	P-value
	B	Std. Error	Beta		
(Constant)	21.102	0.310		68.105	0.000
Forestation and reforestation	.288	0.023	0.196	12.618	0.000
Water ways	1.687	0.029	0.776	57.497	0.000
Cut off drains	0.003	0.003	0.014	0.906	0.0365
Terracing	1.932	0.026	0.019	1.416	0.000
Soil Bunds	0.030	0.063	0.007	0.472	0.0507

a. Dependent Variable: **Land productivity**

The estimates of the regression coefficients, t-statistics, standard errors of the estimates and p values are shown in table 6. By taking mainly the factors into account: Forestation and reforestation, water ways, cut off drains, terracing and soil bunds were all significantly contributing to the level of land productivity as far as their levels of significance were less than the standard level (5%).

The analysis of each factor indicates that forestation and reforestation, water ways and cut off drains are the most contributing factors. Similarly, Downes (2005) pointed out those Land husbandry technologies concerns the active management primarily of rainwater, vegetation, slopes and soils leading to the improvement of the yields.

To add, the relationship between Land-husbandry technologies and Land productivity is confirmed by the research findings presented by Figure 11 where 37 % of respondents declared that farmers should be mobilized until they adopt land husbandry technologies, 23% confirmed technical support in terracing and bund construction, 15% said farmer training and experience sharing in land husbandry respectively.

The shown percentages of respondents(37%,23%and 15% of Figure 11)imply that land husbandry can have an impact on land productivity through farmer mobilization on adoption of new technology and its advantages in a participatory approach, giving them(farmers)technical back stopping and also training them and sharing the experiences where the technology have been applied.15% of respondents find it interesting to provide some incentives to the farmers who might

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hold adoption of land husbandry technologies because of fear of soil structure disturbance.

Also, some respondents confirmed that land husbandry technologies can impact land productivity if accompanied by improved germplasm, and other agricultural inputs like lime, organic and inorganic fertilizers which replenishes soil fertility (Figure.11).

4. Conclusions and recommendations

- ✓ The results of the survey indicated that all beneficiaries practiced land husbandry technologies. However, the study highlighted that terracing was the most practice among the land husbandry technologies like cut off drains, creation of water ways, agroforestry, soil bunds, ditches and other.
- ✓ After the adoption of land husbandry technologies; overcoming poverty and obtaining food security, was highlighted as main indicators of good productivity. This was followed by improvement of living conditions of farmers and increased production.
- ✓ The analysis through linear regression model showed that all factors were significantly contributing to the level of land productivity as far as their levels of significance were less than the standard level.
- ✓ Considering the contribution of each factor to (forestation and reforestation, water ways and cut off drains), there is a significant correlation between land husbandry technologies and land productivity.

Recommendations

a-Because of their positive correlation on land productivity local authorities should encourage the adoption of land husbandry technologies in areas where they have not yet been introduced.

b-Local authorities and the Project should continue the coaching and training offered to the community to avoid damages or destruction of LHTs in place.

c-As the study was conducted in Musha Sector, Rwamagana district of Eastern Province of Rwanda, it would be very interesting to conduct a thoroughly study in all study area with focus on farmers capacity to invest in adoption and maintenance of Land husbandry Technologies, therefore based on the results, the Land Husbandry

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Technologies can be extended to other regions of the country.

d-The project should put continuous effort in sensitizing farmers to adopt and maintain the Land Husbandry Technologies because they are effective against soil erosion.

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