

**EFFECT OF LAND FRAGMENTATION ON SMALLHOLDER FOOD PRODUCTION
IN IBANDA DISTRICT'**

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ABSTRACT

Innovative and sustainable use of land for agricultural production is one of the strongest contributors to food systems across the globe. Access to enough land is of paramount importance to enhancing the welfare and household food security. Land fragmentation is a universal trait of all agricultural systems which affects agricultural productivity and no one has documented a rural society where there is no land fragmentation. This study of the effects of land fragmentation on smallholder food production in Rukiri Sub-County Ibanda District. The specific objectives were to; determine the land size, nature of fragmentation and production status of households, assess the causes and effect of land fragmentation on household food production and explore the current household adaptive mechanisms to fragmented parcels and propose innovative measures of enhancing production on small sized parcels. The study was a cross sectional survey employing both qualitative and quantitative approaches for data collection and analysis. Information was collected from a sample of 288 farming households and other key informants using questionnaire and interviews. Data was analyzed using Microsoft EXCEL and SPSS Version 21.0 to generate both descriptive and inferential statistics. The study established 2.3 acres as the average household land holding size. Land fragmentation in Rukiri Sub-County was as a result of population increase, poverty, family wrangles, communal land conflicts and legal provision based on inheritance divisions. The study established that land fragmentation had effects on over all farm productivity by escalating soil exhaustion, wetland and forest degradation, limiting agricultural mechanization, production of large space profitable crops like banana and coffee, reducing per unit area of production and increasing travelling time and cost of traveling between plots. Farmers had adapted and enhanced food production on small sized parcels by improving soil fertility with organic and inorganic fertilizers, crop diversification, practicing agrosilvipastoral, integrating soil and land management approaches, growing shorter cycle crops and hiring land from neighbors. The study concluded that land fragmentation had a significant effect on smallholder food production in the area. It therefore recommends that Government through relevant Ministries, Ibanda District Local Government and community leadership should come up with mechanisms to address house hold land conflicts, review the land use decree to grant genuine access to contagious land holdings, strengthen population growth control programs and mechanisms of improving productivity on small sized plots like, growing of low space requiring crops, improved high yielding crop varieties, agrosilvipastoral, integrated soil and land management approaches.

Keywords: land fragmentation, smallholder food production, Ibanda, Uganda.

1. INTRODUCTION

Land fragmentation, known as pulverization, parcellization or scattering (Apata et al., 2014), refers to a situation in which a single farm consists of numerous spatially separated parcels (Kuwornu et al., 2012; Veljanoska, 2016). On the other hand, food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life (FAO, IFAD and WFP, 2015).

Achieving sustainable food in a world of a growing human population and large-scale changes in economic development is increasingly becoming a challenge (Sklenicka, 2016). The way land is used plays a significant role in the changing global food economy, and determines food availability at both macro and micro levels. The existence of divided landholdings is one of the important features of less developed agricultural systems as hinders agricultural mechanization, causing inefficiencies in production (Hristov, 2016; Vijulie et al., (2012) land division has had a significant detrimental effect on farm efficiency resulting into low production.

In Africa and Sub-Saharan Africa in particular, is characterized with fragmented land holdings which has greatly burdened the agricultural systems (Austin et al., 2012). The main factors escalating fragmentation are inheritance; population growth; land markets; and historical/cultural backgrounds. Rampant fragmentation has directly affected farm efficiency leading to low production and escalating food insecurity in region. Whereas numerous land consolidation and land reform policies have been implemented to address the problem in some countries like Kenya, Tanzania and Rwanda (Demetriou, and See, 2013), fragmentation still persist.

Agriculture is the largest sector of Uganda's' economy. About 80 percent of the population depend of the sector for income and livelihood. The agriculture resource base has been both shrinking and degrading with the increasing population pressure that has led to intense land fragmentation (Hristov, 2016). The rational use of agricultural land is influenced by land use limitations. One of the obstacles for agricultural development is land fragmentation (Nasinyama et al., 2010).

Dominant problem associated with land fragmentation is the small size, irregular shape, and dispersion of parcels. With this statement, in Uganda, about 92.26% of rural households operate on average holdings 2.5 hectares which constitutes 72% of total crop area. Agricultural land fragmentation is a widespread phenomenon across the country (Nyapendi et al., 2010). The major causes are increase in household size (population), land distribution and redistribution, inheritance rules, and risky peasant agriculture. Land fragmentation has remained the main source of inefficiencies in crop productivity which is associated with production costs due to inefficient resource allocation; suboptimal usage of factor inputs that lowers overall returns to land due to losses on extra travel time, wasted space along borders, inadequate monitoring, and the inability to use certain types of machinery; hindering agricultural modernization and making it costly to modify adverse effects by consolidation schemes (Boliari, 2013).

Empirically, it has been estimated that land division constitutes 60% of the total cash cost of production (Mugabi, 2013). On the other hand, however fragmented land with different biophysical conditions allows farmers to reduce risks such as drought, flood, and fire, diversify crop mixtures, and ease seasonal labor bottleneck. It also allows farmers to grow a wide range of

crops with different ripening time so that they may concentrate their labor at different plots at different time, thereby avoiding the period of labor intension and household labor bottlenecks (Nasinyama and Lee-Smith, 2010).

2. STATEMENT OF THE PROBLEM

Despite the concerted global and national efforts to fight food insecurity, undernourishment is still rampant in the Sub-Saharan Africa in general and Uganda in particular (Mugabi, 2013). Food insecurity in Uganda is estimated at over 17% of the total population, with about 4.5 million people requiring emergency food assistance annually (Nasinyama et al., 2010). Land fragmentation and declining farm efficiency are among the major causes of food insecurity as cited by available literature (Hristov, 2016). Land fragmentation is rampant in most agricultural potential areas of the country, mainly due to increasing population pressure, land distribution and redistribution, inheritance rules, and risky peasant agriculture (FAO, IFAD and WFP, 2015). There is limited evidence from empirical studies in Ibanda District specifically Rukiri Sub-County indicating that the demand for land has been increasing significantly in the last two decades (MAAIF, 2010). Available evidence shows that, over the years, the total land holding per household is becoming smaller and smaller due to rapidly growing population, land distribution and redistribution and inheritance rules. The opportunity to increase smallholders' farmland productivity through land area expansion is limited. Though there are a number of institutional and policy measures being undertaken by government of Uganda to address the negative impacts of land fragmentation on food production, such measures have only focused on providing extension services and formulation of policies that guide the process of curbing the menace of land fragmentation.

Therefore, this study was conducted to determine the effect of land fragmentation on household food production in Rukiri Sub-County, Ibanda District. It carried out to specifically determine the land size, nature of fragmentation and production status of households, assess the causes and effect of land fragmentation on household food production and explore the current household adaptive mechanisms to fragmented parcels and propose innovative measures of enhancing production on small sized parcels.

3. MATERIALS AND METHODS

The study covered Rukiri Sub-County in Ibanda District. The area is predominantly rural with the majority of inhabitants engaged in agriculture. Agriculture is the mainstay of the area's economy and it involves growing crops and rearing of animals on average landholding of 2.5acres. Agriculture is the main source of food and income for most households. The Sub-County was selected because it is among the areas having fastest growing populations in the district. Land fragmentation was rampant in the area mainly due to family expansions and inheritance laws and the nature of the land scape being characterized by undulating hills. As a result of fragmented small sized plots, producing enough food to meet the food needs was increasingly becoming a great challenge for most households.

A cross sectional descriptive survey engaging both qualitative and quantitative approaches was used to gather and analyze responses from farming households and other key informants such as (agricultural service providers). The qualitative approach was used to gather respondent's views,

feelings, knowledge and opinions using interviews while quantitative approach was used to capture quantifiable responses using questionnaire. Data was gathered from 288 respondents.

A combination of proportionate stratified sampling and random sampling techniques were used to choose the households from different villages in the area. Parishes were divided into strata's and respondents selected from them using simple random sampling technique. This technique was used to select the respondents from a list of farmers at village level to come up with the required number of respondents. The researcher applied random numbers to pick farmers from each village and consider them as respondents. On the other hand, purposive sampling involved the selection of key informants who were interviewed from their places of work using face to face interviews.

A semi-structured questionnaire comprising of both open and closed questions to gather primary data from the farmers. The questionnaire designed in English language was translated in local languages and then administered to the farmers for the purpose of extracting information from respondents. Direct observation was used to acquire nonverbal information that was important in justifying the controversial circumstances. The questionnaire was checked for completeness, coded and entered into in Microsoft EXCEL and then exported to SPSS Version 21.0 software for cleaning and analysis.

Both descriptive and inferential statistics were generated and used in interpreting results. Continuous variables were analyzed using mean, variance and standard deviation while frequencies and percentages were applied on categorical variables. Multivariate analysis using correlations and regression statistics was performed to assess the possible associations between the dependent and independent variables and significant relations with the dependent variables. Data outputs were presented in tables.

4. RESULTS

Table 1: Socio-economic characteristics of farmers

Characteristics	Classification	n=288
Gender of respondents (Freq. %)	Male	132 (46%)
	Female	156 (54%)
Age	Age in years (mean ± Std. D)	35.08 ± 8.671
Education level	In years (mean ± Std. D)	11.21 ± 5.341
Marital status (Freq. %)	Never married	88 (30.6%)
	Married	162 (56.3%)
	Others	38 (13.1%)
Household size	Members at household (mean ± Std. D)	5.69 ± 2.135
Source of livelihood (Freq. %)	Agriculture/farming	207 (71.9%)
	Employment	38 (13.2%)
	Business	25 (8.7%)

	Others	18 (6.2%)
Type of agriculture practiced	Crop	83 (29%)
	Animal	4 (2%)
	Both crop and animal	196 (69%)

As shown in figure 1, more than a half (54%) of the respondents were female and 46% male. Mean age and education of the respondents were 35 years and 11 years in school respectively. 56.3% of the respondents were married, 30.6% never married and 13.1% separated/divorced. An average household comprised of five (5) members with the smallest having four (4) members and the largest 10. Majority (71.9%) of the respondents depended on agriculture as a livelihood source, 13.2% employment, 8.7% petty businesses while 6.2% other ventures. 69% of the respondents practiced both crop and animal farming, 29% crop while 2% grazed animals only.

Table 2: Land size and mode of acquisition

Land ownership information		n=288
Total land owned	in acres (mean ± Std. D)	2.5 ± 1.123
Sole owner of land at the household (Freq. %)	Father	134 (46.5%)
	Mother	41 (14.2%)
	Children	89 (30.9%)
	Guardian	24 (8.5%)
Mode of land acquisition (Freq. %)	inherited	115 (39.9%)
	purchase	96 (33.3%)
	Rented	56 (19.4%)
	Government allocated	21 (7.3%)
Mode of inheritance (Freq. %)	Grandparents	20 (20.8%)
	Parents	67 (69.8%)
	Relative	9 (9.4%)

As shown in table 2, most households owned an average of 2.5 acres. Land was owned by fathers at (46.5%), followed by children (30.9%), mothers (14.2%) and guardians (8.5%). 39.9% acquired land through inheritance, 33.3% purchase, 19.4% were renting while 7.3% got it through government allocations. 69.8% of those that inherited, got land from parents, 20.8% from grandparents and only 9.4% from relatives.

Table 3: Nature of fragmentation among households

Land fragmentation information		n=288
Total land area used for;	in acres (mean ± Std. D)	0.65 ± 0.168
Residential area	in acres (mean ± Std. D)	1.55 ± 1.104
Crop production	in acres (mean ± Std. D)	3.42 ± 1.162
Animal rearing	in acres (mean ± Std. D)	2.24 ± 2.331
Number of cultivated parcels	in parcels (mean ± Std. D)	2.13 ± 0.691
No. of people owning parcels at HH	parcels (mean ± Std. D)	

Nearness of parcels to each other	in meters (mean ± Std. D)	7.33 ± 3.626
Average size of divided parcels	In square meters (mean ± Std. D)	4047.00 ± 1.633

Results in table 3 indicate that average land for residential area were 0.65 acres, cop production 1.55 acres, animal rearing 3.42 acres and cultivated area 2.24 parcels. Average number of people owning parcels at household were 2, average closeness of to each other 7.33 meters and average size of divided parcels 4047.00 square meters.

Table 4: Household crop production status from fragmentation

Crop production per season		n=288
Beans	Kgs per parcel (mean ± Std. D)	150.65 ± 12.168
Banana	bunches per parcel (mean ± Std. D)	19.55 ± 6.645
Maize	Kgs per parcel (Mean yield ± Std. D)	227.75 ± 16.133
Vegetables	Sacks per parcel (mean ± Std. D)	10.24 ± 3.299
Potatoes	Sacks per parcel (mean ± Std. D)	7.24 ± 2.867
Millet	Kgs per parcel (Mean yield ± Std. D)	155.41 ± 10.913
Cassava	Kgs per parcel (Mean yield ± Std. D)	215.33 ± 22.226

Results for household food production status from a parcel of land per season as a result of land fragmentation were presented in table 7. Average production was 150.65 kilograms of beans per parcel in a season, 19.55 bunches of banana per parcel, 227.75 kilograms of maize per parcel, 10.24 sacks of vegetable per parcel, 7.24 sacks of potatoes per parcel, 155.41 kilograms of millet per parcel and 215.33 kilograms of cassava per parcel.

Table 5: Results of the logistic regression model of the causes of land fragmentation

Variable	Value	AOR (95% CI)	p-value
Increasing population	Yes	2.060 (1.021 – 4.154)	0.044
	No	1	
Poverty levels	Yes	2.685 (1.507 – 4.782)	0.001
	No	1	
Culture and traditional beliefs	Yes	0.736 (0.468 – 1.158)	0.185
	No	1	
Family wrangles and disagreements	Yes	2.569 (1.239 – 5.327)	0.011
	No	1	
Traditional system of inheritance	Yes	0.364 (0.863 – 2.153)	0.183
	No	1	
Land conflicts	Yes	1.603 (0.390 – 4.933)	0.023

	No		
Immigration	Yes	1.441 (0.656 – 3.164)	0.363
	No	1	

Dependent variable: land fragmentation

- OR → Odds Ratio
- CI → Confidence Interval

Results of the logistic regression model of land fragmentation with its causes were presented in table 5. Seven variables were hypothesized and only four were found to be statistically significant including; population increased [AOR = 2.060; (95% CI: 1.021 – 4.154); p = 0.044], high poverty levels [AOR = 2.685; (95% CI: 1.507 – 4.782); p = 0.001], family wrangles and disagreements [AOR = 2.569; (95% CI: 1.239 – 5.327); p = 0.011] and communal land conflicts [AOR = 1.603; (95% CI: 4.390 - .933); p = 0.023].

Table 6: Regression estimates for land fragmentation effects on household food production

Model		Unstandardized Coefficients		Standardized Coefficients		Sig.
		B	Std. Error	Beta	t	
1	(Constant)	18.057	6.774		2.666	.000
	Growing wide mix of crops	4.083	1.545	.206	2.642	.000**
	Use of mechanization	-1.068	1.038	-.139	-1.792	.004*
	Affects travel time between plots	.261	.146	.127	1.792	.075
	Hinders of economies of scale	-.161	.298	-.038	-.540	.590
	Production per unit area	-1.871	1.451	-.096	-1.289	.003*
	Reduced production space	-2.935	1.531	-.202	-2.570	.001*
	Production costs	2.657	1.584	.131	1.677	.002**
	Production of certain crops	-3.531	1.565	.207	2.979	.000**
	Use of SWC measures	.399	1.526	.117	.516	.234
	Use of production inputs	1.865	1.748	.096	1.067	.287

*, **, *** statistically significant at 10%, 5% and 1% significance level

Results of the regression model assessing the effect of land fragmentation on household food production were presented in table 6.

Land fragmentation presented a positive and significant effect on growing a wide mix of crops among households at 5% level of significance. The coefficient (4.083) revealed that a unit increase in the number of parcels divided increased the probability of growing a wide mix of crops by 4.083. This is because splitting of land gives household members a chance to gain full ownership which results in growing of different crops hence boosting food production.

Land fragmentation presented a negative but significant effect on use of agricultural mechanization at 10% level of significance. A unit increase in the number of parcels divided was found to negatively affect the use of agricultural mechanization by -1.068. This is because small sized plots affect the use of agricultural machines like tractors hence affecting production.

Land fragmentation presented a negative but significant effect on per unit area land for production at 10% level of significance. A unit increase in the number of parcels divided was found to reduce land for production by -1.871 acres. This affects the overall food production given that small sized land discourages the use of agricultural technologies like irrigation and mechanization which are key in agricultural production.

Land fragmentation presented an inverse relationship with production space at 10% level of significance. A unit increase in the number of plots as a result of fragmentation to reduced food production space by -2.935 units hence affecting the overall food production at household.

As predicated land fragmentation presented a positive significant effect in production costs at 5% level of significance. A coefficient of 2.657 indicated that a unit increase in the number of divided plots, increased food production costs by 2.7 units. The increased costs are as a result of hiring labour and applying agricultural technologies on different plots.

Land fragmentation presented an inverse relationship with production of certain large space requiring crops at 10% level of significance. A coefficient of -3.531 indicated that a unit increase in the number of divided plots limited the production of big space requiring crops like banana by -3.5 units hence affecting the food production at household.

Table 7: Current household adaptive mechanisms to fragmented parcels (multiple responses generated)

Adaptive mechanisms	Frequency	Percentage
Growing low space requiring and shorter cycle crops	67	20.8
Crop diversification	127	39.4
Backyard gardening	25	7.8
Agrisilviculture	69	21.4
Hiring of land for production	34	10.6
Total	322	100

As shown in table 7, there were different household adaptive mechanisms to fragmented parcels reported. As a way of utilizing the limited spaces, majority (39.4%) adopted to crop diversification, 21.4 % agrisilviculture 20.8% grew low space requiring seasonal crops like, vegetables, cereals and legumes ,7.8% did backyard gardening and 10.6% hired land from neighbors to increase on food production.

Table 8: Innovative measures of enhancing production on small sized parcels (multiple responses generated)

Innovative measures	Frequency	Percentage
High yielding improved varieties	67	20.9
Integrated pest and disease management	45	14
Intensifying input use	63	19.7
Integrating crop with livestock	56	17.5
Crop diversification	29	9
Small scale irrigation	15	4.7
Soil and water conservation	27	8.4
Growing low space requiring crops	18	5.6
Total	320	100

The results on the key innovative measures of enhancing production on small sized parcels were generated through multiple responses as presented in table 8. Majority 20.9% proposed increasing production and productivity through embracing growing of high yielding improved varieties 19.7%, fronted intensifying input use, 17.5, suggested integrating crops with livestock 14% recommended use of integrated pest and disease management, 9% put forward mixed cropping/intercropping to maximize productivity, 8.4% suggested soil and water conservation 5.6% adopting growing of low space quick maturing crops whereas 4.7% recommended small scale irrigation.

5.DISCUSSIONS

According to the most households in the area owned an average of 2.5 acres. Household land was mainly owned by male parents, followed by children who happened to be heirs and finally female parents especially those from female headed households. Most of the respondents acquired land through inheritance from parents and other relatives, others purchase, whereas a few hired from neighbors with relatively big land. The smaller sized landholdings in the area as a result of the increasing members at household causing land division among household members especially children. This study finding is in line with Iriama, (2010) who asserted that some countries have an even smaller average land holding size which indicates serious land fragmentation; Asian and African countries have an average land holding size of less than 1 ha (Latruffe and Piet, 2014). The Asian countries and the corresponding values are: Bangladesh (0.35 ha), Sri Lanka (0.5 ha), China (0.67 ha), Vietnam (0.71 ha), Nepal (0.79 ha) and Indonesia

(0.79 ha). Not only are these land holdings extremely small, but each land holding consists of about 1.8 parcels, a fact that exaggerates the problem.

Study results showed that on average, at least 2 members of the household owned a parcel of land with an average size of 4047.00 square meters. The size of parcels however kept on decreasing as household size increased due to inheritance division. Regarding the nature of fragmentation, an average of 0.65 acres of land is dedicated for residential areas, 1.55 acres for cop production, 3.42 acres for animal rearing, 2.24 parcels for crop cultivation. On average 2 members owned a parcel of land at household with average size of divided parcels standing at 4047.00 square meters. This division of holdings into discrete parcels that are dispersed over a wide area but operated by a single household members affected farm productivity hence affecting household food production status per parcel of land in season. This study finding is in line with findings by Kakwagh et al., (2011) who asserted that the smallest average holding size found in African countries is less than 5 ha and this figure is due to lack of adoption to appropriate policies to control land fragmentation and particularly the implementation of land consolidation schemes. This nature of fragmentation reduces per unit area farm production.

The study identified the different causes of land fragmentation in Ibanda District. Population growth increased the probability of dividing land at both household and community level. Increase in population was mainly as a result of area development that triggered immigration, and household expansion resulting from inadequate use of birth control methods. These factors together with weak inheritance land policies have promoted fragmentation of land holdings which is a key feature of less developed agricultural system. This finding is comparable to findings by McMichael, (2012) who stated that the main factors triggering land fragmentation are inheritance; population growth; land markets; and historical/ cultural background. Land fragmentation has become a common feature of agriculture across the country Uganda leading to inefficient farm management.

Household poverty levels are presented as a significant cause of land fragmentation. Households struggling with poverty were 2.7 times more likely to have their land fragmented compared to well off households. Due to limited resources to support their livelihoods, members from poor households are left with no choice than to divide the little land they have amongst themselves or even sell off their acquired parcels to start up petty businesses, like shops to meet their daily income needs. This study finding is comparable to Letai, (2011) who asserted that in Uganda, various factors are responsible for farm fragmentation. Among the main factors that have directly or indirectly contributed to subdivision and fragmentation is the traditional system of inheritance of land (inheritance laws), which divide a family's land amongst the sons. As the population increases, not only does the size of holdings fall, but it is also increasingly fragmented into small plots and scattered over a wide area. The most common problems of fragmentation include the fact that fragmentation makes supervision and protection of the land difficult.

Family wrangles and disagreements presented as a significant cause of land fragmentation. Households with wrangles and disagreements were 2.6 times more likely to have their land fragmented than families free from wrangles and disagreements. It is reported that the rate of land fragmentation in the area has been increasing due to family wrangles and disagreements which forces the affected parties to split land or sell it off. This finding is comparable to findings

by Nyapendi et al., (2010) who revealed that the division of holdings into discrete parcels that are dispersed over a wide area but operated by a single farmer and his or her household - have a long history in agricultural economics and related disciplines.

Land fragmentation presented a significant effect on household food diversity by encouraging the growth of a mix of crops among households. Respondents reported that land fragmentation had advantages on agriculture production. It was reported that as a result of fragmented parcels, farmers have an opportunity to grow different type of crops in different plots in the same season which helps in diversifying product hence minimizing the risks of food insecurity. Another benefit associated with land fragmentation is the variety of soil and growing conditions that reduces the risk of total crop failure by giving the farmer a variety of soil and crop growing conditions. Many different plots allow farmers access to land of different qualities when it comes to soil, slope, micro-climatic variations. This study finding is in line with Veljanoska, (2016) who stated that spatially separated farmland lowers the risk that the entire crop is affected by the disaster and disease in the same growing season. Land fragmentation enhances the production risk by increasing the product diversity. In the fragmentation situation, the agriculture product diversity may be increased. Because when the households have several plots which differ in micro-climatic and environmental conditions, there is possibility of growing more type of crops.

Land fragmentation had a negative but significant effect on use of agricultural mechanization. A unit increase in the number of parcels divided was found to negatively affect the use of agricultural mechanization. It was reported that small and scattered plots hampered the use of machinery and other large scale agricultural practices. In these small fields operating machines and moving them from one field to another was found to cause problems. Use of modern machinery was impossible in tiny parcels and irregular parcel shapes had prevented proper cultivation of land. As a result of these problems, productivity was decreasing and hence the decline in farmer's income. This study finding is in line with Hristov (2016) who stated that land fragmentation phenomenon in sub-Saharan Africa has reduced the mechanical management of agricultural leading to the abandonment of agricultural practices in harsh environments. Land fragmentation problem has resulted in a shift from mechanized to non-mechanized crop production; statistically, minimal mechanization is recorded in rural households. The direct consequence of this is low productivity; the shift from commercial to traditional crop production; and a rise in transaction costs.

Land fragmentation presented a negative but significant effect on per unit area land for production. A unit increase in the number of parcels divided was found to reduce land for production by -1.871 acres. Land fragmentation involves a complicated boundary network among parcels (hedges, stone walls, ditches, etc.) which cause land wastage because a part of a holding (especially in small parcels) remains uncultivated at the margins of the parcels. This affects the overall food production given that small sized land may discourage the use of agricultural technologies like irrigation and mechanization which are key in agricultural production. This study finding however contradicts findings by Meyfroidt, (2017) who observed inverse relationship between farm size and output per hectare in Indian agriculture, suggesting that small farms are more productive compared to large ones. This relationship is explained by the relative advantage of using more family labor by small farms that may reduce the monitoring

and supervision costs of hired labor. These findings show that equity does matter for efficiency in the agricultural sector and raise the question of redistributive land reform in most agrarian countries.

Land fragmentation presented an inverse relationship with production space. A unit increase in the number of plots as a result of fragmentation was found to reduce food production space by - 2.935 units hence affecting the overall food production at household. This is because the more plots reduces per unit area of production space hence affecting production large space requiring crops like banana. More so, smaller sized parcels discourage the application of production enhancing technologies like mechanization. This finding is comparable to findings by Letai, (2011) who found out that land fragmentation is associated with lower agricultural output and reduced productivity in settings as diverse as rural China, India, Vietnam and, while others find no significant effect on yields. Land fragmentation is associated with higher production costs, particularly in terms of labor, because of the lost time spent getting to spatially separated parcels.

Land fragmentation presented a positive significant effect in production costs. A unit increase in the number of divided plots, increased food production costs by 2.7 units. The increased costs are as a result of hiring labour and applying agricultural technologies on different plots. In some cases, where plots are located far from the home, and far from each other, there is a waste of time for the workers spent on travelling in-between the plots and the home. Management, supervision and securing of scattered plots can also be more difficult, time consuming, and costly. Small and scattered plots and waste land area require more land for fencing, border constructions, and paths and roads. This finding is in line with Laney and Turner, (2015) argued that land fragmentation had various implications on agricultural practices with some studies indicating a positive outcome while others indicating a negative outcome. In some areas land sub division had always revealed negative outcomes i.e., excessive land subdivisions are commonly cited as an impediment to agricultural development because of the inefficiencies involved in owning several non-contiguous parcels in terms of travels and costs hence lowering crop and animal production. In some cases, severe sub-division made it difficult to apply new agriculture techniques obstructing agricultural production

Land fragmentation presented an inverse relationship with production of certain large space requiring crops. It was reported that small fragmented land holdings cause difficulties growing certain crops, and prevent farmers from changing to high profit crops. More profitable crops, like for example fruit crops, require larger plot areas, so if the farmers only possess small and fragmented plots, they may be forced to grow only less profitable crops. This study finding is in line with findings Kobusingye, (2014) who asserted that small fragmented land holdings cause difficulties to grow certain crops, and prevent farmers from changing to high profit crops.

Household used different adaptive mechanisms to fragmented parcels in the area. Small plot owners applied mechanisms like growing of seasonal low space requiring crops such as vegetables and legumes, mixed cropping /crop diversification to increase productivity, backyard gardening, mixed farming/integrating crops with livestock and hiring land to increase on food production. This finding is comparable to findings by Mugabi, (2013) who in his study revealed that farmers had adapted to the limited spaces in different ways. For crop farmers had utilized space by allocating a relatively bigger portion of land to banana enterprises, followed by

maize, vegetables, beans, fruits, and Irish potato. Similarly, animal farmers were utilizing space by allocating a bigger part of land cattle rearing, followed goat rearing, piggery, poultry, rabbiting keeping and bee keeping. Given the tremendous pressures from industries and peri-urban encroachment, limited space was ranked the most critical challenges facing agriculture.

The key innovative measures of enhancing production on small sized parcels included soil enrichment through continuous organic manure application, adopting home gardens to supplement the small sized parcels, integrated pest and disease control, adopting low space requiring crops like mushrooms and vegetables, crop rotation to control soil depletion, backyard farming using sacks and polythene bags, soil and water conservation as well as small scale irrigation using rain water harvesting. This finding is in line with Demetriou and See, (2013) who revealed that the farmers coped with space constraints by carrying out intensive vegetable and other crops production in backyards (compound gardens), along roadsides and swamps, and in tins, pots, sacks and polythene bags or by renting and borrowing land anywhere they can find it. Use of sacks is a common practice among vegetable growers: they mix small stones, to ensure good aeration, and manure or compost are added to the soil to improve its fertility.

6.CONCLUSIONS

The study confirmed that most households owned an average land of 2.5 acres. There is a high degree of land fragmentation in the study area where at least 2 household members own a parcel of land, which has a negative effect on food productivity by reducing per unit area production. Land fragmentation in Rukiri sub-county is caused by population increase, high levels of poverty, family wrangles and disagreements, communal land conflicts and legal provision based on inheritance division. Land fragmentation has affected food production by limiting agricultural mechanization and production of large space profitable crops like banana, reducing per unit production area, increasing both travelling time and cost of traveling between plots, hence lowering labour productivity and raising the transport cost for inputs and outputs. This reduces the overall productivity of the farm. Farmers have adapted and enhanced food production on fragmented parcels by enriching the soils with manure application, growing low space requiring crops like mushrooms and vegetables, utilizing backyard gardens, growing crops in ports, sacks and tins, seasonal crop rotation, land renting as well as small scale irrigation.

7.RECOMMENDATIONS

Government through District and community leadership should come up with mechanisms of addressing household and communal land conflicts as this would help minimize the continuous division of land in the area resulting from wrangles and disagreements.

There is need for urgent land reform policies and programs that would give farmers access to more contiguous land holdings for increased agricultural production. In particular, there is the need for review of the land use decree to grant genuine farmers access to contiguous land holdings.

Productivity enhancing support services such as fertilizers and other agrochemicals, improved varieties, and extension services should be made available to farmers at affordable prices so as to achieve self-sufficiency in food production.

Population growth controlling programs through appropriate family planning services should be introduced in advance.

General recommendation on family planning to reduce population pressure on the available land. Residence of Ibanda District needs to be sensitized to encourage population movement or migration to purchase land elsewhere where there is space to reduce the burden of land subdivision.

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