Farmland Fragmentation and Its Impact onFood Production in Highland Villages of Seru District, Oromia Regional State, South Eastern Ethiopia

By

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Abstract

Land farmland fragmentation has been a continuous phenomenon and could be a major cause for total natural resources loss within short period unless the government makes change in agricultural policy .The Ethiopian Rural Development Policy which focuses on land tenure and assumes that achieving rapid development in other sectors serves as a remedy to the problem of land fragmentation. However, available empirical evidence shows that the Strategy has brought no measurable and acceptable changes in solving the problem of fragmentation. The existence of ever growing difficulty in managing scattered parcel of plots and its impacts on the households' food crop production and the quality of the life of the smallholders. This paper thus discussed the findings of the study on the impacts of farmland fragmentation on productivity of crops in four villages of Seru District in Southeast Ethiopia. The study revealed that the social and economic problems induced by farmland fragmentation are diverse and significant in income reduction of the cereal crop producers. The mean adult labors are 4.22 and mean landholding is 2.30 hectares and the ratio of land to adult labor is 0.46 hectare. Nevertheless, trend analysis and forecast based on the number of heirs to the present landholders showed that fragmentation due to inheritance had reduced the current labor to land ratio down to 0.13 for hectare in the next generation, assuming that the level of the efforts needed to detaching the surplus rural labor force from direct farming business are continued at the present level. The output elasticity estimates showed that farm fragmentation had influenced the productivity of crops and croplands negatively. For example, a 10% increase in farm size, cash capital used, expenses for all inputs, labor inputs, average parcel size and in application of manure was found to increase income of the households by 1.05%, 0.69%, 0.35%, 0.32%, 0.12%, and by 0.012% respectively. In addition, a 10% increase in the distance of plots and a 10% increase in the level of fragmentation are found to decrease farm income by 0.05% and 0.14% respectively. Border conflict is also found to be rampant;

land lose due to border marking is observable, transportation of inputs and outputs and provision of care and supervision affect yield; and damage by domestic and wild animals and theft by human were found to be the major problems in the management of spatially fragmented plots.

Key words: Farmland fragmentation; land-use-land cover; demographic variables; hectare

Background of the Study

Agriculture is the foundation of economy of the country generating employment, about 90% of exported commodities, and contributes 46% to the Gross Domestic Production. The livelihoods of 83 percent of the population (73.9 million) depend on agriculture, according to the 2007 Population and Hosing Census of Ethiopia (CSA, 2008).

Ethiopia has a total area of 112 million hectares; out of which about 45% is arable (Demese et al., 2009). Out of the available arable land, about 11 million hectares were put under cultivation during the 2007/08 cropping season where annual crops, perennial crops, pasture land, fallow land, woodlands, and others accounts for 74.2%, 6.0%, 8.7% , 7.6%, 0.8% and 2.7% respectively. The country has 11,047,249 ha (10,758,597 plots) of cultivable land (CSA, 2000); of which only 3.7 million hectares were potential irrigable land. Until 2008, 3% of the total potential was utilized and 13.2 million farmers, each owning about 0.9 ha of land, on average, were practising irrigated farming (Getent et al., 2009). However, the average farm size holding was about 1.02 ha in 2000, and reduced to 0.9 ha by 2008 (CSA, 2000). Thus, it is possible to clearly see that land fragmentation has been a continuous phenomenon and could be a major cause for total natural resources loss within short period unless government makes change in agricultural policy.

In Ethiopia, there is an annual 2.6% increase of population, which is one of the causes of fragmentation, seems to be no more possible (Melkamu et al., 2010; Demese et al., 2009). If land redistribution is allowed to continue at its current trend, the impact will be clearly reflected on the agricultural productivity and may intensify the existing problem.

In the presence of land fragmentation problem, the priority of the Ethiopian Rural Development Strategy focuses on land tenure. The Strategy sets an assumption that achieving rapid development in other sectors serves as a remedy to the problem of farmland fragmentation. Therefore, results show that an imperative to engage in actions aiming at solving the problem through securing tenure.

In Ethiopia, the responsibility for land administration has been delegated to regional states. Four regional states have formulated policies on land and environment, which can manage the specific needs of each region, suits to social conditions and conserve land based resources. Nevertheless, the formulation of this policy has brought no vivid change in terms of solving farmland fragmentation problem.

Statement of the Problem

The Ethiopian Agricultural Census of 2001/02 shows that 11,047,249 ha of land has been cultivated in 10,758,597 holdings and fragmented into 35,340,605 parcels, making the average size of plots 0.31 ha with a severe problem of economies of scale (CSA, 2001).

The National Rural Development Policy asserts that rapid development of non-agricultural and industrial sectors has detached the young from the agricultural sector which, in turn, bring in solutions to land related problems, including farmland fragmentation (FDRE, 1997). A study on land policy and smallholder agriculture in Ethiopia indicated that farmland fragmentation had increasingly emerged as one of the key problems of subsistence farming of Ethiopia where the average farm size in the highlands was 0.35 hectares each fragmented into 2.3 plots (CAADP, 2009). The size of family labour in

the Ethiopian smallholder sector increased from 38% in 1984 to 55% in 1994. Thus, this shows that redistribution and fragmentation of smallholders' land has reached a point of impossibility (CAADP, 2009). Inappropriate land policy has increased farmland fragmentations that preclude scale of economies in agricultural production, increased levels of environmental degradation and poor agricultural performance. This assertion considers the lack of market-led policy orientation as a major cause for farmland fragmentation. The ever growing difficulty in managing scattered plots and its impacts on household food crop production are the issues calling for an urgent intervention in order to improve the quality of life of smallholders.

Justification and Significance of the Study

Farmland fragmentation seems more rampant in the study area than it is elsewhere in the zone. It is regarded as a top problem and, thus, its impact was seen from the perspectives of farm efficiency and economies of scale. Moreover, the problem has increased operation costs since most holdings are characterized by long distance between parcels. The long distance between parcels has prompted many owners to lease out family lands and not to invest in the land. Owners lacking farmlands close to their village would opt for unfair informal land transactions.

In order to describe the extent of farmland fragmentation and its impacts on food crop production in the area the study, the study therefore assessed the size, number, and the distance between farmers' parcels under operation. Farmland fragmentation, being a major problem in Ethiopia, has never been the focus of planners, whereas its outcomes are bitterly felt by smallholders in the study area. The extent of fragmentation is increasing every year and has apparently increased the severity of food insecurity. The problem is less

recognized and significant effort is not underway in the country to avert the condition. The result of this study is expected to motivate others to make an in-depth study on the fragmentation of farmland and its impact on national economy growth and environmental sustainability.

Research Hypothesis

The hypotheses of this study are:

. Crop output per unit area decreases significantly with the increasing level of farmland fragmentation and the distance of the plots from residential locations; and

. The level of soil fertility maintenance by households decreases as the distance of the plot increases from residence.

Description of the Study Area

Seru district, the remotest of all the 19 districts in Arsi Zone of Oromia National Regional State, is located 290 km southeast of Addis Ababa and the most underdeveloped Zone in terms of basic infrastructures. The study area is located between 7^0 30' N - 70 40' N and 40^0:00' E - 40^0:05' E. The District has a total area of 1689.7 sq. km and the altitude ranges from 1500 to 2450 meters a.s.l. However, the part of the District where this study was undertaken lies between 2350 and 2450 meters above the sea level and topographically dominated by moderate flat plains dissected by seasonal waterways. The land use or land cover is characterized by an overwhelmingly uncultivable land (49.05%) and the rest, 36.75, 10.75, 3.38 and, 00.7% are arable, cultivated, pasture/ bush land, rocky and marshy areas respectively. The Seru district is characterized by bimodal rainfall

distribution pattern (March to May is short and June to September is long rainy season) receiving l 800-1400 mm rainfall per annum. The population of Seru district is 73591 from which female population is 37,142 accounting for 50.5% of the total population. A total of 12,265 households, each, on average, inhabits 6 persons per a household (CSA, 2008). The study covered an area of approximately 337.94 sq. km with a total population of 7224 (1068 male- and 146 female-headed households).

Research Methods and Data

In this study, both quantitative and qualitative research methods were employed by the researcher to collect pertinent primary and secondary data from respective sources in cross-sectional manner. Quantitatively, descriptive survey was used based on structure questionnaire or interview schedule. Qualitatively, the study depended on the use of interview protocol/guide.

Data Collection and Analysis

The data required for the study were generated through a structured questionnaire or interview schedule, semi-structured interview, focus group discussion and documentary analysis methods which were conducted in 2011. A total of 92 randomly selected sampled households were interviewed. The questionnaire or interview schedule generated household level data on farm size, number of plots, average parcel size, average plot distance, use of inputs mainly improved seeds, type of farm power, manure and commercial fertilizers, total land productivity and net annual income. In addition, semi-

structured interviews with key-informants from different sections of the local community (such as grassroots community, institutions, and government departments to collect data on insights into the status of existing land management practices and to see how land transactions relate to the provisions of existing land policy and fragmentation) were held using semi-structured checklists and focus group discussions (four sessions of focus groups to gain more insights into the dimensions of the problems associated with farmland fragmentation) to generated additional in-depth qualitative information. Moreover, relevant published and unpublished materials on the issues under investigation were located at different resource centres, and analyzed to draw complementary qualitative and quantitative data for the study.

Descriptive statistics were used to summarize the quantitative data, while Jan Januszewski Index, Kolmogotov- Smimov statistics, GLM model, Pearson's moment correlation coefficient, regression analysis and Cobb-Douglas Productivity Function Model were employed on the Statistical Package for Social Sciences (SPSS) to test statistical significance of variations across the sampled household in the study area. Qualitative data were analyzed using thematic data analysis and then the results used to augment and substantiate the findings of the quantitative research methods.

Model Specification

This study tried to assess land fragmentation using number of plots, average size of plots and distances of plots from homestead as important indicators of farmland fragmentation. The number and average sizes of plots and the distances of plots are important parameters to suggest how land

fragmentation influences productivity and the efficiency of production (Rahmana, 2006; Tan, 2005).

The choice of appropriate model deserves much attention due to its importance in quantitative analysis of land fragmentation. Theoretically, as a system farm size, number of non-contiguous plots, area of each plot, distance of each plot to the homestead and plot shape can provide a full picture of land fragmentation at the farm level (Shuhao, 2005) After many similar studies had been assessed, three useful models all which could be grouped in two broad categories were identified. These are: (1) the Januszewki Index for measuring the degree of fragmentation, and (2) the General Linear Model, and the Cobb Douglas Production Function (CD) for measuring net cropping income and estimate productivity of plots.

Measuring the Degree of Fragmentation

Bentley (1987) and Simmons (1988) have used farm size, shape of plots, number of plots, average size of plots, size distribution and spatial distribution of plots to study land fragmentation regardless of their importance shape and spatial distribution were not assessed as it is difficult to gather data on these parameters for the purpose of this research.

The two frequently used indexes for measuring farmland fragmentation are the Januszewki index and the Simpson index and both these indexes were used in this study.

The Januszewki Index (JI) is an index that divides the square root of the total farm area by the sum of the square roots of the plot sizes:

$$K = \frac{\sqrt{\sum_{i=1}^{\eta} \alpha}}{\sum_{i=1}^{n} \sqrt{\alpha}}$$

Where:

n = the number of plots, a = the area of each plot,

According to Melmed-Sanjak (1998), "This index has three properties - fragmentation increases (the value of the index decreases) as the number of plots increases, fragmentation increases when the range of plot sizes is small, and fragmentation decreases when the area of large plots increases and that of small plots decreases". Awotide et al. (2010) presented that the value of *Januszewski Index* combines information on the number of plots, the average plot size and the size distribution of the plots.

Measuring productivity of plots

The model selected for this study was the General Linear Model (GLM). It is a useful econometric model that expresses better the relationship between inputs and outputs mathematically and gives the picture of production function. The function uses an Ordinary Least Square (OLS) method in estimating the values. This model is specified as:

$$Y_i = ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5X_5$$

Where:

y_1 = Net income from crop production,

X_1 = Number of plots operated,

X_2 = Average size of parcel,

X_3 = Expense for all inputs,

X_4 = Labor inputs (Human and oxen power converted to Eth. Birr),

X_5 = Application of manure (dummy value is 1 if applied and 0 otherwise), and

- $\beta_0, \beta_1 \cdots \beta_n$ = the parameters to be estimated.
- The expected residual error is not included in the model assuming that it is zero, on average.

The determination of the minimum farm size and the analysis of the impact of land fragmentation on returns of households were done by using Cobb-Douglass production function.

Results and Discussion

Change in the Landholding Trend and Land Fragmentation

To understand the trend of farmland fragmentation, the study identified the size of land available to the past one-generation and the present one. An attempt to capture the trend of past land fragmentation in the study area it is worth considering that as it would give an insight into the current state and be a basis for the analysis of the effects of land fragmentation at present. Hence, the number of present land holders who had inherited land from their parents and the number of each holder that would inherit his/her current holding were analyzed. The major modes of land acquisition identified in the study area were found to be inheritance, land development exclusively by clearing natural forest areas, allocation of land by the state, and by leasing plots of land from individual land holders.

Table 1 - Mode of Land Acquisition/Responses

Mode of land acquisition /responses	Observation	Percent (%)	Age		
			Mean	Max	Min
Inherited from parents	42	45.66	38.79	63	19
Given by State/land reform	30	32.61	41.59	56	25
Sharecropped or Rented land	15	16.30	28.40	37	22
Cleared forest land /land development	5	5.43	64.30	75	60
N=92		**100.00**			

Source: Outputs of own survey data analysis, 2011.

Table 1 illustrates 45.66%, 32.61%, 16.30% and 5.43% of the sample households acquired their current holdings through inheritance, land reform given by the state, rental/sharecropper arrangement and through land development respectively. From the mean age of the category responded to have gotten land through clearing forest (mean=64.3 years), it is clear that accessing unoccupied land has faded out. The mean age of farmers in the category of rental and sharecropper mode of acquisition were found to be 28.4 years where the maximum and minimum age of the household in the group were 37 and 22 years respectively. The result also shows that sharecropping or renting is a common phenomenon among the young age group in the study area.

Nevertheless, inheritance is the most important mode of land transaction at present and would remain the same for majority since almost all the current direct land holders in whatever way they might have acquired earlier, and expect to pass their holding to their children.

Table 2 - Intergenerational Landholding Size and Inheritance Pattern

Variables	Min	Max	Mean	Std. Dev
Age of Head Household/AGHH	19	75	39.21	11.76
Size of land operated/TFSZ	0.25	6	2.3	1.31
Land Size Per household in the next generation/ LDSNG	0.13	3	0.90	0.56
Number of siblings with whom the current land holders inherited	0	6	3.13	1.57
Expected heirs to the current land holders	1	6	2.92	1.14
Valid N (list wise) =92				

Source: Own survey, 2011.

Each of the farmers who inherited land from their parents were asked to indicate the number siblings among whom parent's land was shared, and again, responded for how many children they would inherit next. Accordingly, the current holders divided a unit of land of their parents into mean of 3.2 units. In other words, each of the immediate past generation of farmers had inherited the unit of land they owned to mean 3.13 children. Through inheritance, each of the current holders would again expect to divide their current holdings to a mean of number of 2.92 children, which means they would divide their current landholdings almost to 3 children on average.

The mean of the current landholdings of the sample population was found to be 2.3 ha with standard deviation of 1.31, while the mean current household's landholdings would fall to be 0.9 hectare in the next generation, suggesting that household's land in the study area would reach the national average, i.e. 0.9 ha during the coming farmers' generation.

If we assume that a farmer and the current holders will remain active for 39 years on average and then would their land to next generation through inheritance, per head-household holding would completely fall from the current mean 2.3 ha to 0.9 ha (fall by about 43%) by the end of the next 39 years. This finding conforms to the result of the ECA assessment conducted in 2009. The findings of the assessment reflected that the phenomenon representing a peculiar vertical subdivision of land across the generations. According to this ECA study, the phenomenon tends to bring horizontal distribution of parcels, and because of this phenomenon, the ratio of land under crop cultivation to agricultural population has been cut to half in Ethiopia and Kenya over the period of 42 years.

Labour Force and Available Farmland

Farming makes the sole source of revenue for the people of the study area. Due to the poor availability of social and economic infrastructures, the emerging labour force will be enforced to go into the farming business. Thus, farms are mainly operated by family labour in the study area.

The factors used to convert household members into adult equivalent were adopted from what Maxwell (1999) has used as cited in CARE-Ethiopia (2004). The relationship between labour force and available farmland was assessed to see the corresponding impacts of fragmentation.

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Table 3- Labor Force and Farmland Size (n=92)

Variables	Min	Max	Mean	Std. Deviation
Size of land operated per sample household/ currently	0.25	6	2.30	1.31
Adult Equivalent labour Force in the family for the sample households	0.88	5.06	4.22	1.44
Current Ratio of Land to Adult equivalent	0.09	2.27	0.46	0.30
Expected heirs to the current land holders	1	6	2.92	1.14
Predicted Size of Land Per household for the next generation	0.13	3.00	4.22*	0.56
Predicted Ratio of Land to adult equivalent for the next generation	0.03	1.22	0.19	0.18

**The adult equivalent labor per a household assumed to remain constant.*

Source: Own data analysis results, 2011.

The ratio of land size to adult equivalent of the sample households is 0.46 ha and this is statistically significant to show that a large size of labor force is available and land is highly scarce. On other hand the correlation coefficient of labor and number of plots operated is 0.444, (significant at 0.01% probability level) and that of labor & total household's farm size is 0.866 (significant at 0.05% level of probability). These indicated the positive relationship between the two parameters and labor intensity, of course labor cost, becomes high as the size of land and the number of spatially distributed plots increases. For the sample population, land available per adult equivalent is 0.46 hectare. The mean of the number of children expected to receive land from 1 parents is about 3 children (mean =2.97). This shows that the land currently held by one farmer would be shared among 3 young farmers during the next generation if all other factors remain unchanged.

From this, assuming all other factors remain constant, the analysis of the data indicated that farmland diminution is largely caused by inheritance. From analysis of the trend of inheritance, the current ratio (0.46) of land to adult equivalent of the next generation will fall down to 0.19 hectare to make the holding sizes far more uneconomic.

The analysis of the age of farmers and land size showed that the age of the a single who owns 0.25 hectare of land is 25, where as the mean age of the only 3 farmers owning 6 hectare is between 52 and 68 years. This result is thus, substantiating the fact that age has direct relationship with landholding size.

Landholding Size and Number of plots

The assessment of the landholding size indicated the highly variable nature of landholding among the sample households. Among other factors, landholding size varies with the age of the households. The young farmers have small sizes landholdings, whereas the older farmers have big fields. Age of household head is negatively correlated with distance of the plots ($r = -0.337$ at 0.05% level of significance). This relationship proves the fact that older farmers are large holders and, hence, are at a better position in terms of facing the financial difficulties which others smallholders faced. In addition, the landholding size, the average parcel size, productivity per unit area, labour inputs, expenses for all other inputs and net annual income from crop production are all positively correlated with age of the households. Furthermore, landholding size, the average parcel size, productivity per unit area, labour inputs, expenses for all other inputs and net annual income from crop production are all positively correlated with age of the household.

A comprehensive assessment of the important aspects of farmland fragmentation such as the farm size, number of plots, sizes of parcels, and the distances of plots from homesteads. These are closely interrelated and interacting factors, which cannot be seen in isolation from each other in the analysis of farmland fragmentation.

The number of plots and landholding sizes, walking distance from homestead to plots in minutes, and number and types of crops grown by the sample households were analyzed. However, an assessment of the numbers and types of crops by sample household is beyond the scope of this study. On the other hand, it was included in this research because the need for diversification of harvest is found to be a factor to intensify the level of fragmentation of holding.

The size of land held by a farmer differs based on the age of the household. Only 5% of the total households owned 20.25% of the available arable land households. Operational holding, however, does not imply ownership since some of the old households lease out a part of their lands to one or more cultivators on sharecropping arrangements as they have become older. This means that far more acreage of land is held by the less inactive old households than estimated by this analysis. From this observation, it is clear that land ownership has been highly skewed; such a distribution could lead to fragmentation when leasing it out for other farmers. Thus, this arrangement is involved because of the owner's inability to manage large farm sizes is evident as a result of old age.

According to the analysis, the mean fragmentation index for the sample household was found to be 0.587; whereas others were found to deviate from the mean by 0.141. The closer the index towards the value of 1 means

decrease in the level of fragmentation. The value of 1 indicates that the farmer has been operated all his/her land in one single unit. High level of fragmentation was observed among farmers operating in the range from 1 to 1.5 ha, and above 2.5 hectares.

The sample households (31.52%) operated on land sizes ranging from 1.5 to 2.5 hectares with mean walking distance of 32 minutes from the homesteads to farmlands. The mean plot size for the four categories tended to increase with the size of holding as it was expected. The mean number of the types of crops grown by farmers was found to increase as mean holding size increases. The mean parcel size for more than 2.5 hectares of landholding category was 1.2 hectares which was about 3 times that of the least land holding category (0.37 ha). This finding indicates that neither the number of plots nor the small nature of plot size is indicating fragmentation. It shows that land fragmentation has been the result of the cumulative effects of number and size of plots.

Fragmentation index was calculated using the observed number of plots and the mean plot sizes as indicated in the model. The corresponding mean value of Januszewki Index and the total number of observations in each category show the degree of land fragmentation.

Table 4 - The Extents of Fragmentation by Number of Plots Operated (NPO) and Jan Januszewski Index

Number of plots	Frequency /households/	Percent (%)	Januszewski Index (fragmentation index)
1	4	4.3	0.41
2	13	14.1	0.45
3	36	39.1	0.50
4	27	29.3	0.58

Number of plots	Frequency /households/	Percent (%)	Januszewski Index (fragmentation index)
5	11	12	0.71
6	1	1.1	1.00
Total	**92**	**100**	

Source: Own survey, 2011.

As it is depicted in Table 4, the level of fragmentation found to increase as the number plot increases. The higher fragmentation index among 1-2 plot holders and this is mainly because of the smallness of the sizes of land operated by the farmers in the category. The other observation that substantiates this finding is that the increased number of plots does not affect productivity because of the corresponding increase in sizes.

The above analyses suggested that the households had tended to operate on more fragment of lands to minimize the risks involved in growing a single crop at the same time and to fulfill family's need for diverse food crops. The positive correlation value between number of plots and farm size (r=0.316, significant at the 0.01% level) is attributable to the need for diversification. The mean number of plots under operation by each category is found to depend on the household's total farm size. Large owners, in general, are operating large number of plots and represented 2.2% of the total sample population.

Based on the findings, the mean number and size of parcels increased with corresponding increase in the mean farm size; and the yield per hectare is also found to increase with increasing mean landholding size. However, the mean number of plot cannot show the degree of fragmentation in isolation from the mean size of parcel and holding sizes. Thus, the degree of

fragmentation is clearly seen with reference to the combined effects of the two variables, plot and farm size.

The number of types of crops grown increases tended to increase with increasing farm size and the level of fragmentation is also positively correlated with land size available to households. These findings are consistent with that of previous research undertakings (Salvatore et al., 2004) which show that different crop varieties have been performed better and farmland fragmentation is positively correlated with number of crops.

It was hypothesized that the number of plots indicates the level of fragmentation and the higher the yield if proper crop management is applied. However, the result was the opposite. the unexpected result was mainly due to the large plot size of few large farm size holder (mean =1.2 ha) and they were comfortable with putting the lands into many plots than smallholders in order to increase the diversity of crop and avoid the risks involved in crop failure. The finding, therefore, indicated that the mean size of plots is an indispensable in showing the state of fragmentation and its impacts on productivity.

The Effects of Plot Distance on Productivity

The analysis showed that 6 minutes walking distance on average between two plots caused about 340 kg reduction, which is about 10.6% of the yield. Moreover, the analysis of distance and net income showed negative correlation (r= -0.352 at p-vale=0.01% level of significance). Distance of plots is found to influence productivity negatively. Thus, the distance between the plots can be seen as a main reason for inefficiency based on this finding. Likewise, the findings of the studies on the effect of distance of

farms (Awotide et al., 2010; Tan et al., 2007) showed that the distance of plots to the homestead has a significant positive impact on production cost.

This analysis showed that comparatively low amount of improved seed was used for distant fields and 69.6%, 11.9 %, 16.3% and 2.17% of the total sample households have used improved seeds on nearby, far away, both far and nearby plots and not used seed on both far and nearby plots respectively. Thus, distance is found to be a factor influencing the utilization of inputs, similarly, the analysis of the preferences of the sample households with respect of applying soil management practices showed that long distances of plots is a disincentive.

It was found that the average distance traveled varies significantly and travel time of each household deviated from the mean by 15.96 minutes, whereas the mean walking distance for all the sample population is 32.17 minutes walk from homestead to the farm. The level of fragmentation among the sample population was easily reflected by the value of mean plot size, which was found to be 0.74 ha, and the minimum size of plot of land was found to be 0.3 hectare and the maximum was 2 hectares.

On the large size plot, situated far away productivity is increasing because cultivators have given the high level of care or adequate land management practices. Here too, the average distance of plots is negatively correlated with manure application (r= -0.474 significant at 0.05% level). This finding indicates that farmers refrained from investing on distant plots due to transportation and labour as well as other difficulties has involved in the management of distant plots. Thus, soil management efforts become negligible as plot distances increases and the size of plots decrease. The increase in labour input will increase production cost or reduce net income

keeping all other factors constant. This finding confirmed that the productivity decreases with increasing distance due to reduction in working hour.

The analysis of land renting showed that 35 households (38.04%) of the total sample households had been using one of these informal land transaction options to overcome problems associated mainly to distant plot. Out of 35 households, however, 20 households exchanged their plots and got better plots with respect to fertility, terrain, soil workability, etc. However, these informal arrangements are frequently ended up in conflict, but the practices are sustained as the informal local leaders are mediators whenever such conflicts occur following informal transactions.

The ranking analysis of the top three problems results, namely, **transporting manure, harvest and straw,** control **of theft by thief/ wild animal, and** border **conflict.** More specifically, study results showed that 67.4% of the households had mentioned problems associated with transportation of inputs, outputs, care of plots and supervision; while 23.9% suffered most from theft and/or crop damage, and the remaining, 8.7% indicated that border conflict was found to be the most important problem on the top of other problem.

The Effect of Number of Plots on Crop Types Grown

The analyses of data on the effects of number of plots on crop diversity grown suggest that households which had been operating above 2.5 hectares with mean parcel size of 1.2 hectares were growing larger numbers and types of crops. The increase in the level of fragmentation by increase in the numbers and types of crops is attributed to farm size. In addition, the direct relationship between farm size and numbers and types of crops grown by

households reaffirm that large landholders have been at a better position of growing more diverse crops while keeping the plots size well above the mean size.

However, a mere increase in the number of plots cannot increase productivity since the size of plots can offset the effects. For example, households who had been operating in a single unit with average parcel size of 0.37 hectare gained 2820 kg per hectare, whereas households with mean parcel size of 1.2 ha harvested 3158 kg of grain per hectare.

The Cobb-Douglas (CD) Model showed that land fragmentation does not significantly affect crop production and is also a common model for estimating production functions and the relationships between the dependent and descriptive variables which are complex in the presence of land fragmentation (Hristov, 2009), GLM Model is also used as an alternative model to capture the level of fragmentation and its impacts on food crop production.

First, the Kolmogorov-Smirnov statistics was used to check whether the variables are linear and normally distributed or not. Thus, based on the outcome, the null hypothesis was accepted or rejected/failed to accept. The Levene's Test of Equality of Error Variances was applied to test the fact that the error variance of the dependent variable is equal across groups or otherwise. Then, in this test, the normality of for all variables is greater than 0.05. The variables are normally distributed and the relationships between variables are linear to make Linear Regression Model the best for the prediction of dependent variable value.

The error variance of the dependent variable is equal across groups. The test proved that the variance of the error is constant across the cells defined by

the combination of factor levels and the significance value of the test, 0.160, is greater than 0.05; there is no reason to believe that the equal variances assumption is violated.

Net Income from Crop Production and Farmland Fragmentation

The regression result of the Net Annual Income from Crop Production (NAICP) over Total Farm Size is shown in Figure 1. From this table, it is clear that the net annual income is increasing with an increase in land size, and the majority of the households are concentrated around small land holding groups which are also the low income earners. The distribution income by landholding size which is supporting the regression analysis indicated in the following figure. Figure 1 presented below illustrates the regression of landholding size by households.

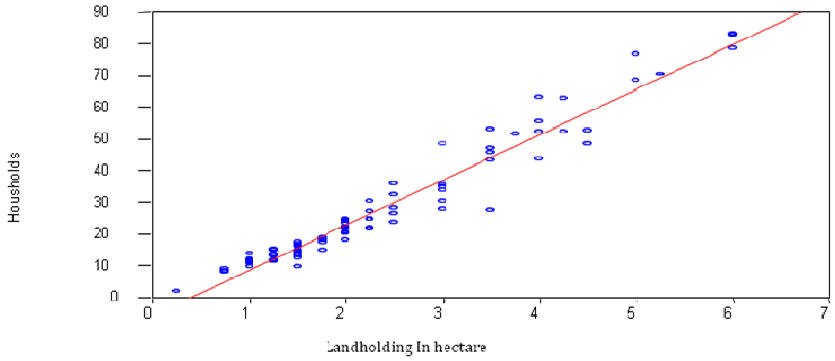

Figure 1 -- Distribution of Households Income by Landholding Size

The analysis of data on income of households in the study shows a significant increase in the level of fragmentation with increasing landholding

size. However, CD regression function proved that fragmentation had reduced productivity. A farmer can grow more diverse crops depending on the size of land, and that is why farmers in the extreme smallholder category (0.25 - 0.75 hectare) were restricted from using the opportunity of crop diversification.

Table 5 - Description of Income Categories by Landholding Size and Level of Fragmentation

Income Categories (Eth birr)	Observation		Land holding size in (ha)		Level of Fragmentation				Income in Eth Birr	
	(n)	(%)	Mean	STDEV	Low	Medium	High	Mean (JI)	Mean	STDEV
<19999	42	45.7	1.28	0.35	0.45	0.58	1.00	0.60	13160.8	3300.5
20000-39999	30	32.6	2.35	0.42	0.50	0.58	1.00	0.61	25957.7	4812.6
40000-59999	12	13.0	3.83	0.46	0.50	0.58	0.71	0.54	49622.8	4016.8
60000-79999	6	6.5	4.92	0.72	0.41	0.54	0.71	0.54	70039.7	6693.7
>80000	2	2.2	6	0	0.45	0.48	0.50	0.48	83050.0	424.3

Source: Outputs of own data analysis, 2011.

The highest income category is found to have the high fragmentation level and was reflected by JI value (mean JI= 0.48). No significant difference in the mean fragmentation index (JI) is observed between the second income category (20000-39999 birr, JI= 0.61), and the third income group (40000-59999, JI=0.54 and 60000-79999, JI= 0.54). These findings indicate that the level of fragmentation has increased with net annual income in the sample population. This is not against the hypothesis of this study, for the group with 2.5 ha of landholding the average parcel is 1.2 ha, which is about three times as vast as that of the single plot operators (0.37 ha). The net annual

income and fragmentation index showed negative correlation (r= -0.188 significant at the p-value=0.05% level).

Crop output per unit area decreases significantly with the increasing level of farmland fragmentation and when the distance of the plots from residential locations increases; and the level of soil fertility maintenance decreases as the distance of the plot increases.

Table 6 - Description of Sample Households-Based on Income

Observation		Mean Income	Mean Landholding Size in ha	Mean Number of parcels	Mean Parcel Size	Mean Yield/ha in quintals	Fragmentation Index/JI
Count	%						
31	33.7	48900.13	3.79	3.65	1.13	31.43	0.56
61	66.3	16182.66	1.54	3.21	0.50	27.26	0.60

Source: Results of own data analysis, 2011.

The analysis showed that the income of 31 households (33.7% of sample) was found to be Eth. Birr 48900.13, which was above mean (Eth. Birr 27138); and that of the reaming 61 households (66.7%) was Eth. Birr 16182.66). The GLM regression analysis and the analysis of variance for Net Annual Income for Crop Production (NAICP) with reference to the total farm size, number of plots, plot distance, labor, inputs expense, and fragmentation index did not show significant variation between the predicted and observed values.

Conclusion and Recommendation

Conclusion

The objective of this study was to study the extent of farmland fragmentation and to describe its impacts on the food crop production in Seru District in South east of Ethiopia and to add knowledge gained from this context and to adopt it for developing comprehensive policy at the regional level.

Important aspects of farmland fragmentation and crop production, including the number of parcels, average parcel sizes, total farm size and land availability for households, the degree of farm fragmentation, level of inputs availability and associated soil fertility management practice. The income gained from crop production was used as independent variable in assessing the influence of land fragmentation on crop production. The land size available per adult equivalent was low for the farmers in the study area (mean=0.47 ha) and expected to show an awful reduction in the next generation (mean = 0.19) if the current trend of farmland fragmentation through inheritance is allowed to continue.

This study shows that the mean size of land operated per farming household is 2.31 hectare, the mean number of plot is 2.34, and the average parcel size is 0.47 ha. The distribution of land among the sample households is highly skewed since the minimum and the maximum holding sizes are 0.25 and 6 hectares respectively. The current ratio of the land size to adult equivalent is 0.46 indicating that the available labor force is high whereas land is highly scarce. The per household holding which is estimated to be 5.8 ha during the parents of the current holders, has fallen to 2.31 hectares at present and will again fall to 0.9 hectares in the next generation if the current population

growth is unchecked and all other factors that reduce the available arable land is kept constant.

The reduction of mean plot sizes and the increase in types of crops grown tended to increase with increase in the size of holding. The mean parcel size decreases as the number of plots increase with farm size for purpose of crop diversification. On average, a household operates 3.4 plots with mean parcel size of 0.47 ha. The number of plots changes proportionally with total farm size, and is found to influence productivity. Therefore, increase in number of plots, which partly explains fragmentation alone has no significant influence on productivity. Large holders tended to operate larger number of plot to meet family's need for diverse crop types and smallholder has to fragment their land to meet this need. Farms of the large holder households were found to be more fragmented than that of the extreme smallholders, but the negative effect of farmland fragmentation on productivity is more pronounced on smaller farm size.

The state of farmland fragmentation is found to depend on the combined effects of land size and number plots. Therefore, it is possible to conclude that in isolation from each other the number of plots, the size of plots alone cannot indicate the level of fragmentation. However, the negative effects of farm fragmentation on productivity are more significant mainly when the number of plots increase while decreasing mean size of each plot.

The increase in number of plots found to reduce annual income since it requires more labour input per a unit area. Reduction in unit area yield because of increased number of plot is higher when the effect is compounded by distance and fall of the size of the plots. The present landholders have a very few options at hand to confront the problem involved in the

management of spatial distribution of plots, which has mainly happened during the previous land reforms in 1974.

Few households have begun putting their lands together with intention of operating in a single unit anticipating that income and crop diversity increases as the land size increases. Even if farmers' efforts to diversify crop type are worthwhile, they are still prone to adverse effects of informal transaction. Productivity per unit area is found to be lower as parcel size falls. Hence, fragmentation has a significant negative impact on diversification and productivity.

Although distance is found to have no correlation with labour input (r= 0.058, significant at p-value= 0.01, 2-tailed), households ranked plot distance as one of the top problems. Accordingly, transporting of manure, harvested grain and straw, control of theft/wild animal and border conflicts were ranked as the first, second, and third important problems respectively. The adverse effect of the distance of plots over soil management practices mainly with reference to application of manure was found to be significant. A 10% increase in the utilization of manure has increased productivity and the net income by 0.8% and failure to apply reduced income by 0.02%. Regardless of the extension support, none of the households was found to apply physical and biological soil conservation measures. The level of application of manure was also limited by distance, and, therefore, 34.7% of the total population applied manure to nearby plots.

Generally, based on the result of the Cobb Douglas Model analysis land size was the dominant factor (coefficient =1.049153, at 0.05% significance level) followed by cash capital used (coefficient =0.68603 at 0.05% significance

level) and inputs expense excluding labor costs (coefficient = 0.319868 at 0.05% significance level).

Output elasticity of farmland fragmentation of the variables was estimated based on Cobb-Douglas productivity function and it has confirmed that an increase by 10 % in farm size, cash capital, expenses for inputs, and the magnitude of labour has increased the income from crop production by 1.05%, 0.69% and 0.32 % respectively.

On other hand, the correlation coefficients of labour and number of plot (r=0.444, significant at p-value=0.01 for 2-tailed) and labour and total household's farm size (r=0.866, significant at p-value=0.05 for 2-tailed) implied positive relationships and confirmed that the labour intensity had become high as the size of land and the number of spatially distributed plots increase.

From the findings of the study, it is, therefore, possible to conclude that crop output per unit area decreases significantly with the increasing level of farmland fragmentation and the distance of the plots from residential location; and the level of application of sustainable soil fertility management practice also decreases as the distance of the plot increases.

Recommendation

Given the current national and regional land policy continued to be unchanged, land consolidation through private ownership will remain impossible. Therefore, problems due to fragmentation can be solved by implementing a policy that supports formalization non-monetary exchanges /in-kind/ and the accommodation of the practice of voluntary land exchange

between households. In this way, the farmer could mitigate the productivity constraints imposed by a wide scatter of plots.

The continually declining of labour equivalent ratio over time shows the importance of unchecked demographic pressure which aggravated land shortage because of the distribution of land through the process of inheritance. The land holding is on the verge of failing to support subsistence and demands a strong coordination among government sectors to scale up efforts being made in line of family planning, education provision and the adoption viable income generation off-farm activities focusing on subsidiary to detach the growing rural labour force from agricultural activities. This would contribute to the efforts of minimize farmland fragmentation and mitigate its negative impacts on productivity.

Government of Ethiopia as well as local government to consider the following policy researches that accommodated local and regional specific problems to combat the occurrence and impacts of farmland fragmentation.

1. The concerned government office(s) should put in place a rule that fixes the minimum permissible land size/ ceiling law/ to discourage further diminution.
2. They should review the laws pertaining to rural land inheritance to address the structural causes of land fragmentation.
3. They should develop rural infrastructural amnesties which are preconditions for creation and diversification of non-farm income sources, value adding activities based on local products and employment opportunities to prevent further land fragmentation.
4. They should incorporate actions in the future rural development programs that encourages voluntary land exchange between farmers.

5. They should create a system of targeted incentives to encourage the farmers to seek ways of consolidation, by entering into agreements with the adjacent holders to exchange plots to increase their farm size.
6. They should consider the formalization of land for land exchanges and contract agreements between rural farmers to counter the present informally applied fixed rentals in the form of sharecropping arrangements or in cash.
7. They should employ research on the ways of the promotion a household based cooperatives to counter the possibility of further land diminution by combining parcel.
8. They should strengthen extension support and its links to research, mainly on the areas of soil and water conservation, watershed management, etc.
9. They should expedite the process of introduction, dissemination and adoption of farm technologies.
10. They should accommodate short-term and long-term livelihood needs of the small holders and develop a means for commercialization of agriculture through crop specific specialization at district, village or household level pursuant to land capability and agro-ecological potentials.
11. Overall, this research, as ways of countering and minimizing the impacts of farmland fragmentation, would suggest issues related on the sustainable natural resources management, comprehensive land-use plan development, adoption of improved technologies to increase agricultural productivity, scaling up of and incorporation of rules prescribing disincentives for the present landholding situations, voluntary consolidation of land, and increasing decentralization of land administration are the issues.

REFERENCES

Awotide, D. O., & Agbola, P.O (2010). *Relationship between land fragmentation and maize farmers' productivity in northern Nigeria*. Ogun State, Nigeria: Department of Agricultural Economics and Extension, Osun State University (pp-1-9).

Bentley, J.W. (1987). Economic and ecological approaches to land fragmentation. In defense of a much-maligned phenomenon. Ann. Rev. Anthropology, 16, 31-67.

Comprehensive Africa Agriculture Development Programme (CAADP). (2009). *Annual report of 2008.* Midrand, South Africa: Agriculture Unit, the New Partnership for Africa's Development (NEPAD) Planning and Coordinating Agency.

CARE-Ethiopia. (2004). *Towards promoting food security among the poor in Ethiopia.* Addis Ababa, Ethiopia: CARE-Ethiopia.

Central Statistical Authority (CSA). (2000). National census 1999/2000. Addis Ababa, Ethiopia: CSA.

____. (2001). *Report on the 1999/2000 household income, consumption and expenditure survey.* Addis Ababa, Ethiopia: CSA.

____. (2008). *Agriculture sample survey, 2000 -2008*. Addis Ababa, Ethiopia: CSA.

Demese, C. Getenet Gebeyehu, Goshu Mekonen, & Yaddesa Dinssa. (2009). *CAADP. Comprehensive Africa Agriculture Development Programme, Volume I, (Final report)* Addis Ababa, Ethiopia: Planning and Coordinating, NEPAD.

Economic Commission for Africa (ECA). (2004). Economic Commission for Africa: Land tenure systems and their impacts on food security and sustainable development in Africa. Addis Ababa, Ethiopia: ECA. pp 1-15.

Ellis, F. (1988). *Peasant economics: Farm households and agrarian development*. Cambridge, UK: Cambridge University Press.

Federal Democratic Republic of Ethiopia (FDRE). (1997). The *national rural development policy 1997*. Addis Ababa, Ethiopia: Berhanena Selam Printing Enterprise.

Getenet G., Demese, C., Goshu Mekonen, & Yaddesa Dinssa. (2009). *Comprehensive Africa agriculture development programme (Final report).* Addis Ababa, Ethiopia: CAADP.

Hristov, J. (2009). *Assessment of the impact of high fragmented land upon the productivity of the farms – The case of the Macedonian vegetable growers* (Master's thesis). Uppsala, Sweden: Department of Economics, Swedish University of Agricultural Sciences (SLU).

Maxwell, D. (1999). Urban food security in sub-Saharan Africa. In M. Koc, R. MacRae, L.J.A.Mougeot, & J. Welsh (Eds.), *For hunger-proof cities: Sustainable urban food systems* (pp. 26-29). Ottawa, Canada: International Development Research Centre (IDRC).

Melkamu Belachew, & Shewakena Aytenfisu. (2010). Facing the challenges in building sustainable land administration capacity in Ethiopia. Sydney, Australia: FIG Congress. pp-3-21.

Melmed-Sanjak, J., Bloch, P., & Hanson R. (1998). *Project for the analysis of land tenure and agricultural productivity in the republic of Macedonia. Working Paper, No. 19*. Macedonia: Land Tenure Center, University of Wisconsin–Madison.

Rahmana, S., & Mizanur, R. (2006). *Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh* (Master's thesis). Drake Circus, Plymouth, United Kingdom: School of Geography, Faculty of Social Science and Business, The University of Plymouth.

Salvatore, D. F., Ivan, P., Aleksi, A., & Tom, M. van R. (2004) Agricultural biodiversity and land fragmentation: The case of Bulgaria. *African Journal of Business Management, 4*(8), 1614-1618.

Shuhao, T. (2005). *Land fragmentation and rice production: A case study of small farms in Jiangxi Province*. Jiangxi, China: P. R. China.

Simmons, C. S. (1988). The local articulation of policy conflict: Land use, environment, and Amerindian rights in eastern Amazonia. *Professional Geographer 54*, 241-58.

Tan, S., Kruseman, G., & Heerink, N. (2007). Land fragmentation and smallholder rice farm's production costs in Jiangxi Province, China. In Max Spoor, Nico Heerink, & Futian Qu (Eds.), *Dragons with clay feet? Transition sustainable land use, and rural environment in China and Vietnam.* (pp. 211-228). Plymouth, United Kingdom: Lexington Books.