Journal of Development and Agricultural Economics

Volume 9 Number 2 February 2017
ISSN 2006-9774

Academic Journals

ABOUT JDAE

The Journal of Development and Agricultural Economics (JDAE) (ISSN:2006-9774) is an open access journal that provides rapid publication (monthly) of articles in all areas of the subject such as The determinants of cassava productivity and price under the farmers' collaboration with the emerging cassava processors, Economics of wetland rice production technology in the savannah region, Programming, efficiency and management of tobacco farms, review of the declining role of agriculture for economic diversity etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in JDAE are peer- reviewed.

Contact Us

Editorial Office: jdae@academicjournals.org

Help Desk: helpdesk@academicjournals.org

Website: http://www.academicjournals.org/journal/JDAE

Submit manuscript online http://ms.academicjournals.me/

Editors

Editorial Board

Journal of Development and Agricultural Economics

Table of Contents: Volume 9 Number 2 February, 2017

ARTICLES

academicJournals

Vol. 9(2), pp. 16-25, February, 2017
DOI: 10.5897/JDAE2016.0757
Article Number: D786E3F62551
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

Off-farm participation decision and its impact on crop yield in Northern Ethiopia

Berihun Kassa[1]*, Bihon Kassa[2] and Kibrom Aregawi[2]

[1]College of Social Sciences and Humanities, Samara University, P. O. Box 132, Samara, Ethiopia.
[2]College of Business and Economics, Mekelle University, P. O. Box 450, Mekelle, Ethiopia.

Received 13 July, 2016; Accepted 15 November, 2016

One of the most important facets of off-farm activities is providing employment opportunities and additional income for rural households and thereby accommodates the seasonal and fluctuating agricultural production. Given this, identifying the underlying determinants of off-farm participation and its impact on crop yield was found to be of the essence. Cross sectional data was collected through structured questionnaire administered on 384 randomly selected farmers. Descriptive statistics, probit and Ordinary Least Square (OLS) models as well as t and chi-square tests were used to analyze the data. The regression result revealed that off-farm participation was positively influenced by gender, education, working people, number of pack animals and credit access; while age and land size carried a negative sign. Off-farm participation was also found to have a negative and statistically significant impact on crop yield where non-participants were better producers; since majority of off-farm participants participate only on food-for-work which has nothing to add for crop yield rather than compromising farm activities. Hence, training on non-farm activities need to be given; the current adult education, being propagating, need to be strengthened; and there is a need to solve liquidity problem through credit access that could serve as startup capital.

Key words: Off-farm, participation, smallholder farmers, probit, Ordinary Least Square (OLS).

INTRODUCTION

As engine of economic growth and poverty reduction, in developing countries, agriculture should be integrated with sectors that have direct or indirect linkages. According to Babatunde et al. (2010) financial capital appears to be the most limiting factor for farming, so that cash income from off-farm activities helps to expand farm production; increase household income and reduce risk of crop failure. Hence, off-farm is one among the activities whereby agriculture is believed to be integrated with. World Bank (2008) has reported that, in most developing countries, the importance of off-farm activities is increasing and estimated to account for 30 to 50% of rural incomes. According to Rios et al. (2008), the higher the off-farm income is, the larger capital endowments will be; and having higher capital endowments will in turn help to produce more and more and even to be

*Corresponding author. E-mail: berihun2@gmail.com. Tel: +251 913 28 55 45.

productive. According to Asenso-Okyere and Samson (2012), Haggblade et al. (2010) and Diao and Nin Pratt (2007), modern agricultural inputs can result with ample production and productivity of marketable commodities that results with trade linkage; the requirement of agricultural inputs and marketing facilities by itself, then, induces off-farm activities.

As per the view of Haggblade et al. (2010), those who live in arid areas where production is sluggish tend to participate in off-farm activities and diversify their income sources. Similarly, in Burkina Faso, Zahonogo (2011) purport that a decline in farm income and farm production let farmers to participate in off-farm activities; and increment in farm production and income do the opposite. Furthermore, in areas where agriculture is grown, the rural off-farm economy was also been founded to be grown (Haggblade et al., 2009). While quantifying this direct linkage between agricultural growth and off-farm economy, Haggblade et al. (2009) reported that a one dollar value invested on to agriculture generates 0.3 and 0.5 additional dollar on to rural off-farm income in Africa and Latin America, respectively.

In Africa, off-farm economic activities, as a means of income diversification, are very much indispensable for improving the livelihood of rural poor (Asenso-Okyere and Samson, 2012; Diao and Nin Pratt, 2007). Besides, it can serve as source of input supply for agricultural production and employment opportunity for those who do not have arable land and do not further want to rely on agriculture. Despite its vitality, in Africa, off-farm activities participation is low; and according to Haggblade et al. (2007), 37% of the rural households' income is really extracted from off-farm activities where surprisingly not more than 20% of the labor force is being participated. Likewise, in Nigeria, a study by Adewunmi et al. (2011) revealed that participation in off-farm activities more particularly wage employments of skilled and unskilled had resulted in a reduction of rural poverty by 11.02 and 10.68%, respectively; participants lessen poverty better than non-participants (Alaba and Kayode, 2011).

In Ethiopia, being part of developing regions in general and sub-Saharan Africa in particular, agriculture is the real backbone that enables 85% of Ethiopian people to walk upright and be able to feed the remaining 15% of the fortune coincidence urban residents. In line with this, Ministry of Agriculture and Rural Development (2010) acclaimed smallholder farmers in producing majority of the country's total production. Furthermore, World Bank (2010) inferred that 90% of the foreign earnings and 70% of the raw materials for industry are being sourced from agriculture. Hence, 85% of the Ethiopian people believe that agriculture is the way out to be food secured and even be luxuriant in the long run. Given this deep rooted belief, starting from recent past, arable land size and agricultural production are dwindling and thereby the society is being forced either switching to off-farm activities or stretch their hand for food aid basically for clothing the food longing mouths at home.

According to Merima and Peerlings (2012) and Abebe (2008), in Ethiopia, farmers tend to participate in off-farm activities to satisfy consumption needs by supplementing the sluggish agricultural income caused by erratic and seasonal rain fall; and due to crop failure and the resultant abundant labor force. Besides, farmers are vulnerable both for natural and manmade disasters and shocks that could be weather related, pests, death of livestock and others. As a means of relief, rural farm households prefer to participate in off-farm activities and diversify their income thereby (Berg and Kumbi, 2006; Dercon and Woldehanna, 2005). Hence, a certain farm household is tempted to participate in off-farm activities due largely to push factors, like drought. They further inferred that, Ethiopian rural poor prefer to participate in off-farm activities that require less entry costs like fire wood collection and charcoal production, while the most lucrative off-farm activities are left for the haves. Contrary to this, some rural farm households tend to participate in off-farm activities basically to widen their income sources given their ample agricultural production and the resultant accumulated wealth, as a pull factor.

In line with the above inclination, Rijkers et al. (2002) as cited in Woinshet (2010) purported that 25% of Ethiopian rural households own more than one labor intensive off-farm activities, although 23% of these rural households did their off-farm activities parallel with their agricultural practices. Hence, only 2% of Ethiopian rural households were those who exclusively rely on off-farm activities. Besides, according to Merima and Peerlings (2012) for the past eight years, back from 2012, not more than 25% of the rural households had engaged in off-farm activities which are minimal compared with 42% of the sub-Saharan Africa average; and its contribution for employment creation in Ethiopia is 1.14%. From this one can deduce that Ethiopian rural households' off-farm participation is insignificant and its effect onto crop production as well as its overall benefit has not yet been exploited. Hence, identifying determinants of off-farm participation decision and examining the impact of participation on crop yield is found to be imperative for a clear and sound policy indication whereby farm households would participate and diversify their income and cope up food security challenges.

MATERIALS AND METHODS

Site selection, sampling method and data collection

As far as the study area selection was concerned, compared with the rest districts of Southern zone, Raya-Azobo and Raya-Alamata are more of promising and lucrative with plenty resource reservations basically fertile land resource, ground water, flat plain land supported by runoff rain water from the surrounding hilly parts. Despite these endowments, since production is decreasing, these districts were reported to face recurrent drought and food insecurity; and the society is been engaged in off-farm activities basically to

Table 1. Targeted sub-districts and villages with their total population and sample size taken (CSA, 2007; Own Computation, 2016).

S/N	Name of sub-district	Population size (N)	Sample size (n)
1	Bala-Ulaga	2164	89
2	Kukufito	3784	155
3	Lemeat	1697	70
4	Tao	1697	70
-	Total	9342	384

curtail the food shortage. As a result of this researchers were intended to have a look on the impact of off-farm activities participation on crop yield.

Multi-stage sampling procedure was followed to reach on to final respondents. Firstly, Raya-Azebo and Raya-Alamata districts were selected from Southern Tigray; followed by the randomly selected four sub-districts, Bala-Ulaga, Kukufito, Lemeat and Tao. Thirdly, on the basis of Yamanes' sample size determination formula, as cited in Israel (1992), 384 sample respondents were calculated. Finally, 384 respondents were randomly selected from the list provided from each sub-district, as its proportion is shown in Table 1 and these people were considered to collect primary data mainly through structured questionnaire in 2014 cropping year. In-depth interview with crop production personnel and farmers who were on the verge to leave agriculture were interviewed. Besides, four focus group discussions with off-farm participants and non-participants, including female participants, were held to support the questionnaire based data. Interviewees and focus group discussants were selected purposively with the assumption that these people could provide us with tangible and pertinent information in the ground.

Method of data analysis and econometric model specification

To analyze the data, descriptive statistics like mean, percentage and standard deviations were used to assess socio-economic and demographic characteristics of sample respondents; while probit model was used to examine determinants of participation, Ordinary Least Square (OLS) model was employed to examine the impact of participation on crop yield. Besides, to test the relationship between dependent and independent variables vis-à-vis the two groups of individuals, t-test and Chi-square tests were used, respectively, for continuous and dummy variables. Data collected through interview and focus group discussion was basically analyzed qualitatively.

Regardless of the amount of money earned and the duration farmers relied on off-farm activity, in this article, a farmer was taken as off-farm participant if he/she did out of his/her farm land; while those who solely dependent on their farm land were considered as non-participants. Due to this dichotomous classification, the dependent variable (off-farm participation) has a binary nature taking the value of "1" for participants and "0" for non-participants that paved the way to employ binary outcome models particularly probit model. The reason behind employing probit model was due to its normal distribution assumption of error terms and farmers' unobserved or latent behavior by which households are assumed to make decisions pertaining to utility maximization; and hence in this model there is a latent or unobservable variable that takes all the values in (-∞, +∞). As a result, probit model can be expressed by the following general formula:

$$Pr\ (Y=1/X_i) = \Phi\ (\beta_1\ X_1 + \varepsilon_{i1}) \quad (1)$$

The latent variable Y_i^* is not observable and is represented by its proxy Y_i taking a value one (1) for participants and zero (0) for non-participants.

$$Y_i = \begin{cases} 1, & Y^*_i > 0 \\ 0, & Y^*_i \leq 0 \end{cases}$$

$$Y^*_i = X_i' \beta + \varepsilon_i \quad (2)$$

where ε | *x* is a normally distributed error term.

Thus, for the household *i*, probability of participation is given by:

$$P(1) = \Phi\ (\beta X_i) \quad (3)$$

where P (1) is the probability of participation, Φ is the cumulative distribution function of the standard normal distribution, β is the parameters that are estimated by maximum likelihood, *x'* is a vector of exogenous variables which explains off-farm participation. Therefore,

$$OFP=\Phi(\beta_1 GENDER+\beta_2 AGE+\beta_3 EDUC+\beta_4 WORKING+\beta_5 DEPENDENT+\beta_6 LANDSZ+\beta_7 MRKTDIS+\beta_8 LOCATION+\beta_9 TLU+\beta_{10} PACKANIM+\beta_{11} CREDIT \quad (4)$$

Besides, to estimate magnitude of parameters or variables mainly to clearly put the percentage likelihood of participation, marginal effect of variables was calculated. Marginal effect of a variable is the effect of unit change of that variable on the likelihood of participation and it can be seen as *P(Y = 1|X = x)*, given that all other variables are constant. Hence, it is expressed as:

$$\frac{\partial P(Yi=1/Xi}{\partial Xi} = \frac{\partial E(Yi/Xi)}{\partial Xi} = \varphi(X_i'\beta)\beta \quad (5)$$

As far as examining the impact of participation on crop yield was concerned, Ordinary Least Square (OLS) regression model was employed due to the continuous nature of the dependent variable, crop yield measured in quintal. Furthermore, according to Gujarati (2006), with the assumption of classical linear model, OLS estimators are with unbiased linear estimators with minimum variance and hence they are Best Linear Unbiased Estimators. Hence, its specification is given as follows using the same independent variables used in probit model earlier.

$$Y = \beta_0 + \beta i\ Xi + U$$

where *Y* is the dependent variable (crop yield), *X*i is a vector of explanatory variables, β*i* is a vector of estimated coefficient of the explanatory variables (parameters) and u_i indicates disturbance term which is assumed to satisfy all OLS assumptions (Gujarati, 2006).

$$CropyId=\beta_0+\beta_1 GENDER+\beta_2 AGE+\beta_3 EDUC+\beta_4 WORKING+\beta_5 DEPENDENT+\beta_6 LANDSZ+\beta_7 MRKTDIS+\beta_8 LOCATION+\beta_9 TLU+\beta_{10} PACKANIM+\beta_{11} CREDIT \quad (6)$$

Table 2. Variables and expected signs (Hypothesis).

Variable type	Character	Unit of measure	Expected sign
Sex of household head (GENDER)	Dummy	1 if Male, 0 if Female	+
Age of household head (AGE)	Continuous	Years	+/-
Education of household head (EDUC)	Dummy	1 if literate, 0 otherwise	+
Number of Working people (WORKING)	Continuous	Numbers	+/-
Number of Dependents (DEPENDENT)	Continuous	Number	+
Cultivated land size (LANDSZ)	Continuous	*Tsimad*[1]	+
Tropical Livestock Unit (TLU[2])	Continuous	Number	+/-
Number of pack animals (PACKANIM)	Continuous	Number	+
Distance to the nearest market (DISMRKT)	Continuous	Kilometers	-
Location effect (LOCATION)	Dummy	Across locations	+/-
Access to Credit (CREDIT)	Dummy	1 if Yes, 0 otherwise	+
Non-farm Trainings (NFTGS)	Dummy	1 if trained, 0 otherwise	+

[1]One *Tsimad* is equivalent with 0.25 hectare or one hectare is equivalent with 4 *Tsimad*; [2]TLU was calculated excluding pack animals basically to solve problem of multicollinearity. +, Positive; _, Negative.

where Cropyld=Continuous dependent variable indicating crop yield measured in quintal.

Therefore, description of variables indicated earlier and their expected sign or hypothesis has shortly been summarized in Table 2.

RESULTS AND DISCUSSION

Socio-economic and demographic characteristics of sample households

Examining farm households' socio-economic and demographic characteristics is believed to be an important indicator for probability of off-farm participation in such a way that farm households can be determined with. As a result of this, an attempt has been made to describe some socio-economic and demographic characteristics where differences between participants and non-participants were tested using t and Chi-square tests.

Table 3 clearly purports that majority of the sample respondents (73.44%) were off-farm participants. In line with this rate of participation, majority of participants (78%) were male headed households supported with a significant Chi-square test result. Compared with non-participants, participants were male headed households, younger in age, educationally better, large in number of working people, wealthier in pack animals possessed and farm income and then with better credit access. On the other hand, non-participants were owners of large arable land size and better crop producers. These all differences were supported with significant t and Chi-square tests for continuous and dummy variables, respectively.

Types of off-farm activities vis-à-vis place of work

Types of off-farm activities along with place of work were discussed in Table 4.

As it can be seen in Table 4, 65.6% of the total off-farm participants were engaged in food-for-work under the umbrella of Productive Safety Net Program (PSNP). These people were paid employees where one person was expected to do five days per month and will be awarded birr 19 in cash and 3 kg (0.03 quintal) in food/kind. As far as place of work was concerned, 76.95% of off-farm participants have been doing with in their respective sub-districts. To engage in food-for-work and transacting goat, sheep and cereals by buying and selling on market day time mainly on weekly and monthly basis, farmers were not forced to go out of their residence and thereby lose their social tie and family kinship.

Table 4 further reveal that, 67.02% of the total participants were instigated to participate due to the advent of and access to PSNP; followed by their residences' proximity to urban area that is believed to expose them to new and updated information as well as market identification mainly for petty trading activities like trading egg, coffee, honey, selling local beer (ale) and using cart.

Table 4 also indicated that, more than 57.84% of non-participants were seriously inhibited by absence and the resultant farness of off-farm opportunities coupled with shortage of startup capital. Had there been off-farm opportunities, they would not have been exploited opportunities due largely to shortage of startup capital. From this one can infer that, farm respondents were highly intended to do activities that requires startup capital like trading camel-the then costly animal being transacted and trading cereals across different regions. On the other hand, opportunities' farness highlights that, respondents were intended to do off-farm activities without compromising their farm activities, their family's love, affection and social ties.

Table 3. Descriptive statistics of variables used in regression analysis and important ones (Own Survey Result, 2016).

Variable	Average statistics (N=384)	Off-farm non-participants (N= 102)	Off-farm participants (N= 282)	t & chi-square tests (P-Value)
	Mean (Std.dev)	Mean (Std.dev)	Mean (Std.dev)	
Gender (1=Male)	0.786 (0.410)	0.706 (0.458)	0.816(0.388)	0.016**
Age	44.421 (11.481)	46.716 (12.846)	43.592 (10.851)	0.009***
Education (1=Literate)	0.349 (0.477)	0.245 (0.432)	0.386 (0.488)	0.030**
Number of Working people	3.086 (1.301)	2.931 (1.299)	3.142 (1.299)	0.038**
Number of Dependents	3.102 (1.462)	3.088 (1.695)	3.106 (1.372)	0.542
Cultivated Land Size	1.474 (0.693)	1.649 (0.884)	1.410 (0.599)	0.001***
Tropical Livestock Unit	4.853 (3.574)	4.779 (3.239)	4.879 (3.692)	0.596
Number of pack animals	0.602 (0.919)	0.324 (0.616)	0.702 (0.989)	0.074**
Distance to the nearest market	24.395 (13.023)	23.088 (9.057)	24.869 (14.172)	0.881
Access to credit (1=Yes)	0.365 (0.482)	0.127 (0.335)	0.450 (0.498)	0.000***
Non-farm Training (1= Trained)	0.099 (0 .298)	0.098 (0.297)	0.166 (0.408)	0.576
Farm income in Birr	39286.2 (29614.8)	32538.2 (29009.9)	46034.3 (29880.4)	0.041**
Crop yield in Quintal	8.522 (6.145)	9.946 (7.337)	8.369 (5.659)	0.024**

Std.dev; Standard deviations; ***, ** and * is significant at 1, 5 and 10% significance level.

Table 4. Off-farm activities and place of work (Own Survey Result, 2016).

Variable	Labels	Freq.	%
Off-farm activities being done	Trading goat, sheep and cereal crops	37	13.12
	Trading cereal crops	24	8.51
	Trading egg, coffee, honey and shopping	5	1.78
	Cart and Daily work	28	9.93
	Hair dressing and selling local beer (ale)	3	1.06
	Food for work	185	65.60
	Total	282	100
Location of employment	Within village	15	5.32
	Within sub-district	217	76.95
	Within district	22	7.8
	Neighboring region (Afar)	28	9.93
	Total	282	100
Off-farm motivating factors	Proximity to urban area	51	18.09
	Education level and Excess labor at home	12	4.25
	Small land size possessed	30	10.64
	Access to Productive Safety Net Program	189	67.02
	Total	282	100
Inhibiting factors	Needed on farm	5	4.9
	Retired	12	11.77
	Shortage of startup capital	26	25.49
	No opportunity and far away to find work	59	57.84
	Total	102	100

Estimation results of probit regression model

Before rushing to regression result display, pair-wise correlation matrix and the Brush Pagan test were used to test the problem of multicollinearity and hetroscedasticity, respectively (Table 5).

Table 5. Determinants of off-farm participation (Probit Estimates) and marginal effect (Own Estimation Result, 2016).

Explanatory variable	Coef.	Std. Err.	z	P>|z|	Marginal Effect (dy/dx)
-Cons	0.1731	0.4400	0.39	0.694	-
GENDER	0.5874	0.2034	2.89	0.004***	0.1790
AGE	-0.0169	0.0074	-2.31	0.021**	-0.0461
EDUC	0.5120	0.2085	2.46	0.014**	0.1275
WORKING	0.2508	0.0716	3.50	0.000***	0.2672
NUMBDEPEN	-0.1184	0.0850	-1.39	0.164	-0.0317
LANDSZ	-0.3050	0.1514	-2.01	0.044**	-0.0817
TLU	-0.0278	0.0320	-0.87	0.385	-0.0074
PACKANIM	0.2942	0.1469	2.00	0.045**	0.0788
DISTMRKT	-0.0028	0.0252	-0.11	0.910	-0.0010
Dummylocation1(Bala-Ulaga)	0.7205	0.3988	1.81	0.071*	0.1599
Dummylocation2 (Kukufito)	-0.7449	0.2419	-3.08	0.002***	-0.2105
Dummylocation3 (Lemeat)	-0.2008	0.3242	-0.62	0.536	-0.0568
CREDIT	0.5857	0.2130	2.75	0.006***	0.1455
NFTGS	0.0302	0.3784	0.08	0.936	0.0082
Log likelihood = -163.49267					
Number of obs = 384					
LR chi^2 (13) = 117.58					
Prob > chi^2 = 0.0000					
Pseudo R^2 = 0.2645					

*,**,***Significant at 10, 5 and 1 %, respectively.

Implication of gender on participation decision is positive and statistically significant at 1% level. Male headed households, citrus paribus, have 17.9% higher probability of participation than female headed households who are more probable to be sandwiched with child rearing practices. In fact, in the study districts, letting females to be a household head is not yet well developed and recognized. Consequently, female headed households mostly are those who are widowed and divorced; and hence, challenged by districts' labor division culture. In line with this, the prior proposed hypothesis is not rejected at 1% significance level. The finding corroborates with the findings of Haggblade et al. (2010) in North Africa, Latin America and West Asia; Babatunde and Qaim (2009) in Kwara State of Nigeria and Abebe (2008) in Ethiopia where by female-headed households are less probable to participate and influenced by cultural influences. However, it strongly disagrees with the findings of Merima and Peerlings (2012) in Tigray, Amhara, Oromia and Southern Nations Nationalities and Peoples regions of Ethiopia; Alaba and Kayode (2011) in South West Zone of Nigeria; and Kaija (2007) in rural parts of Uganda where female-headed households were better off-farm participants unlike male headed households.

Effect of age on participation is negative and statistically significant at 5% level that lets not to reject the prior proposed hypothesis. By its very nature, off-farm participation does require physical strength and fitness whereby younger farmers are better than older ones. Keeping other things constant, as age increases by a year, probability of participation would decrease by 4.61%. Old aged farmers really have an accumulated farm experience like plot preparation and in clearly identifying what and when to sow crops. Besides, they are too stable and mostly could not think some other off-farm activities and migration. Due to this, they are more probable to invest their time on farm activities that participating in off-farm activities.

Contrary to old aged farmers, younger farmers are improbable to be stable and be motivated to do their farm activities. They really wonder here and there in search of some lucrative off-farm activities. Typically, inter and intra migrations were their features and hence they engage in farm activities consciously to buy time. The finding is consistent with the findings of Babatunde and Qaim (2009) in Kwara State of Nigeria and Abebe (2008) in Ethiopia; and Kaija (2007) in Uganda in such a way that probability of participation decreases as age increases. Nevertheless, the finding contradicts with the finding of Zahonogo (2011) in Burkina Faso and Berg and Kumbi (2006) in Ethiopia where older farmers tend to participate better than middle or younger farmers.

The probit estimation result also reveals that, the effect of education (literate and illiterate) is positive and statistically significant at 1% level. In fact, majority of the

sample households have engaged in food-for-work, as their typical and best off-farm activity. Food-for-work, therefore, did not require education and for that pointing finger signature is enough basically to take the salary either in cash or in food. Despite this, the implication here is that, the more farmers become literate the higher will be their probability of searching off-farm work in non-agricultural sectors. Magnitude of the positive sign suggests that literate households, keeping other things constant, have 12.75% higher probability of participation unlike their counter parts. The finding confirms the findings of Zhu and Luo (2006) cited in Babatunde and Qaim (2009) in such a way that the more literate the household is, the more probable to search and participate in profitable off-farm activities. Hence, the prior hypothesized positive coefficient is accepted at 1% level of significance.

Off-farm participation decision is positively related with number of working people or active labor force at home; and statistically significant at 1% level. Presence of larger number of working people in a certain house can really do and manage both farm and off-farm activities without compromising each of the activities. A unit increase in number of working people, citrus paribus, would raise the probability of off-farm participation decision by 26.7%. From this inference can be made that households with large active labor force would more be probable to participate in such a way that labor division would prevail more; and besides, enough labor force at home would let family members to participate in off-farm activities. The finding is consistent with the findings of Zahonogo (2011) in Burkina Faso. As a result of this, the prior indeterminate hypothesis is liable to be positive and statistically significant at 1% level.

The regression result indicated that, the effect of land size on off-farm participation decision is negative and statistically significant at 5% level of significance. As land size increases by one *Tsimad*, keeping other things constant, the probability of participation would decrease by 8.17%. In the study districts, households who owned an arable land size ranged in between 1 and 2 *Tsimad* are young farmers while the larger land share was positioned on modal age group interval of 40 to 56 years and the preceding age group interval of 57 to 73 since they have had a great share from the last regional land redistribution held twenty five years back.

Young age groups, therefore, are more liable to meager land size transfer from their fathers' and mothers' lottery, a single dead bodies and if possible, expanding to the frontier. In the study region, Tigray, for instance, 4,005 hectare was given for 15,198 youngsters through inheritance; and 27,924 hectare was divided among 23.6 thousand youngsters in the frontiers (Bureau of Agriculture and Rural Development (BoARD), 2011). It is possible, therefore, to deduce that when we come across higher age groups, it is fortunate to find higher land holding size. This large land holding size is found to be imperative for producing a relatively higher crop production that would retain them to do farm activities and not to participate in off-farm activities. Hence, it is possible to infer that, participation in off-farm activities was in response to farm land constraints. The finding is in line with the findings of Asenso-Okyere and Samson (2012) in Africa at large; Alaba and Kayode (2011) in South West Zone of Nigeria; Babatunde and Qaim (2009) in Kwara State of Nigeria and Abebe (2008) in Ethiopia. The prior hypothesized positive coefficient is rejected at 5% level of significance.

Presence of pack animals has positive relationship with participation and statistically significant at 5% significance level. The finding reveals that a unit increase in draft animals would raise the probability of participation by 7.88%. Farm households who possess pack animals are more probable to participate in activities like trading cereals, doing with cart, transporting sand and stone for construction purpose, charcoal production, fire wood selling and the like. This finding is similar with the findings of Abebe (2008) and Berg and Kumbi (2006) in Ethiopia as if households who possess pack animals would participate better than those who did not possess. Nonetheless, the finding strongly contradicts with the finding of Rios et al. (2008) whereby pack animals would transport manure from home to farm land and thereby increase crop production that finally decreases the probability of off-farm participation decision. The prior hypothesized positive coefficient is accepted at 5% significance level.

As a liquidity factor, access to credit is one best option whereby smallholder farmers could be instigated in diversifying their economic base. Access to credit has a positive effect on participation and statistically significant at 5% level of significance. In line with this, credit non-rationed farm households, keeping other things constant, have 14.55% higher probability of participation unlike credit rationed farmers. Hence, access to credit and taking credit influences participation, indicating that the more farmers have access to source of finance, the more likely to decide and participate in off-farm activities. The finding agrees with the findings of Adebiyi and Okunlola (2013) in Oyo State of Nigeria and Abebe (2008) in Ethiopia; as if taking credit is imperative for solving liquidity problem and thereby increases the probability of participation. On the other hand, the finding contradicts with the findings of Babatunde and Qaim (2009) in Kwara State of Nigeria where liquidity problems, while intending to participate in off-farm activities, could not be solved by accessing and taking credit. The prior proposed positive coefficient is not rejected at 5% level of significance.

Location can serve as a proxy of rain fall availability, productive potential of districts, sub-districts and villages; and it is worth to note discrepancy of participation among sub-districts. Consequently, sub-district dummies have been created; *Tao* was taken as a reference group due to its middle crop production position. Relative to *Tao*, the

Table 6. Impact of off-farm participation on crop yield: OLS estimation result (Own Estimation Result, 2016).

Explanatory variable	Coef.	Std. Err.	t	P>|t|
-Cons	2.74336	2.02551	1.35	0.176
OFFPARTICI	-1.9905	0.708387	-2.81	0.005***
GENDER	1.873583	0.6550402	12.86	0.004***
AGE	-0.0724498	0.0308629	-2.35	0.019**
EDUC	0.3936218	0.1460205	. 2.70	0.007***
WORKING	0.4806521	0.2401594	2.00	0.046**
NUMBDEPEN	-0.8965219	0.2908585	-3.08	0.002***
LANDSZ	3.224635	0.4980494	6.47	0.000***
TLU	0.3633074	0.1102191	3.30	0.001***
PACKANIM	0.5429241	0.442973	1.23	0.221
DISTMRKT	0.6491295	0.4892841	1.33	0.185
Dummylocation1(Bala-Ulaga)	-3.62553	2.151253	1.69	0.093*
Dummylocation2 (Kukufito)	-3.077394	1.014261	-3.03	0.003***
Dummylocation3 (Lemeat)	0.238694	1.141905	0.21	0.835
CREDIT	0.00045	0.0001032	4.36	0.000***
NFTGS	0.0302	0.3784	0.08	0.936
Number of obs = 384				
R-squared = 0.3647				
F (14, 369) = 15.13				
Adj R-squared = 0.3406				
Prob > F = 0.0000				
Root MSE = 5.14				

*,**,***Significant at 10, 5 and 1%, respectively.

probability of participation is higher in *Balla-Ulaga* sub-district by 15.99%; a sub-district basically with higher crop yield and total farm income and it is statistically significant at 10% level of significance. Compared with *Tao*, the probability of participation is much lesser in *Kukufito* sub-district by 21.05% that relatively is food-deficit and a sub-district typically credit rationed due to rules of their holly Qur'an and it is statistically significant at 1% level. Farmers with relatively better crop yield and total farm income, therefore, tend to participate in lucrative off-farm activities unlike farmers with low crop yield and farm income. Due to this, the finding completely disagrees with the findings of Zahonogo (2011) in Sudanese, Sahelian, North and South-Guinean zones of Burkina Faso and Abebe (2008) who found as participation is higher and lower in food-deficit and surplus regions, respectively.

It is believed that providing non-farm training is imperative for instigating farmers to participate and thereby diversifying their economic and income base. Although, the probit estimation result is not statistically significant, non-farm training has a positive linkage with off-farm participation decision where it gives an insight to provide and strengthen trainings pertaining to off-farm activities. In the study districts, there is a cross generational task of preparing cultural manifestation using animal skin as well as a culture of weaving (to prepare cultural dresses). Hence, there is a need to invigorate this cross generational endowment via providing an inclusive training pertaining to the aforementioned focus areas.

Impact of off-farm participation on crop yield

Table 6 depicts the impact of off-farm participation on crop yield considering Ordinary Least Square (OLS) regression model as a measuring instrument.

As it has already been discussed earlier, the t-test statistics result inferred that yield difference between off-farm participant and non-participant is significant where non-participants produce better than participants. Consistent with the descriptive statistics, regression result revealed that off-farm participation has a negative and statistically significant impact on crop yield, at 1% level of significance. Hence, both descriptive and econometric statistics results purport the negative impact of off-farm participation on crop yield. The regression result shows that, keeping other things constant, off-farm non-participants were much better to get 1.99 quintal than their non-participant counterparts. Hence, off-farm participants produce lesser than non-participants. This

could basically be due to their participation in non-lucrative off-farm activities that could add nothing to their total production. In this case food-for-work was the most important off-farm activity on which majority of the participants engaged on. Having this activity does not mean that they could be productive rather they spent half of their time by compromising their farm activities; and at the end of a month they will be given only birr 19 in cash or 3 kg(0.03 quintal) in kind which is very negligible. On the contrary, off-farm non-participants are believed to spend their time on farm activities and thereby produce better.

CONCLUSION AND POLICY IMPLICATION

One of the most important facets of off-farm activities is providing employment opportunities and additional income for rural households more particularly during the slack time. Besides, off-farm participation has a multifaceted effect on agricultural production in such a way that it paves the way for ease access of inputs and on the other hand it negatively shares the time to be allocated for farm activities. By and large, it is one of the best means of risk minimization. This research paper has tried to examine the underlying determinants of off-farm participation and the impact of participation on crop yield in Tigray region, Ethiopia. The probit regression result revealed that off-farm participation was positively influenced by gender, education, working people, number of pack animals, credit access and dummy location one, while age, land size and dummy location two influenced off-farm participation negatively. In a nut shell, even though some people do participate in off-farm activities on the basis of their internal motivation or demand driven, majorly a push driven participation has been investigated. Ordinary Least Square (OLS) regression result revealed that off-farm participation has a negative and statistically significant impact on crop yield where off-farm non-participants were found to be better producers unlike their counter parts.

Without the shadow of doubt, instigating off-farm participation is the only way-out and the sole alternative that smallholder farmers need to follow basically to accommodate their seasonal and fluctuating agricultural production. In doing so, an inclusive non-farm activities training need to be given for the community like on weaving, leather and leather products training like shoe and mat making, leather strap; carpentry and some other activities. Hence, investment on human resource actually on to education is highly required (both short-term and long-term trainings). The current adult education, being propagating, need to be strengthened since literate households (those who simply can read and write) were found to be better participants unlike illiterate farmers. On the other hand, access to credit need to be propagated basically to solve liquidity problems and thereby serve as off-farm startup capital.

Conflict of Interests

The authors have not declared any conflict of interest.

REFERENCES

Abebe DB (2008). Determinants of off-farm participation decision of farm households in Ethiopia. Agrekon 47:1.

Adebiyi S, Okunlola JO (2013). Factors Affecting Adoption of Cocoa Farm Rehabilitation Techniques in Oyo State of Nigeria. World J. Agric. Sci. 9(3):258-265.

Adewunmi IO, Awoyemi TT, Omonona BT, Falusi AO (2011). Non-farm income diversification and poverty among rural farm households in Southwest Nigeria. Eur. J. Soc. Sci. 21:1.

Alaba AO, Kayode SK (2011). Non-farm income diversification and welfare status of rural households in South West Zone of Nigeria. Conference paper presented for IFPRI.

Asenso-Okyere K, Jemaneh S (2012). Increasing Agricultural Productivity & Enhancing Food Security in Africa: New Challenges & Opportunities. Synopsis of an International Conference, International Food Policy Research Institute Washington, Dc.

Babatunde RO, Olagunju FI, Fakayode SB, Adejobi AO (2010). Determinants of Participation in Off-farm Employment among Small-holder Farming Households in Kwara State, Nigeria; PAT December. 6(2):1-14.

Babatunde RO, Qaim M (2009). The role of off-farm income diversification in rural Nigeria: Driving forces and household access. Paper Presented at the center for the study of African Economies (CSAE) conference, Economic Development in Africa, March 22-24, University of Oxford, United Kingdom.

Berg M, Kumbi G (2006). Poverty and the Rural Non-Farm Economy in Oromia, Ethiopia', International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18. Int. Assoc. Agric. Econ. pp. 1-17.

BoARD (2011). Government of National Regional State of Tigray Five Years (2010/11 - 2014/15) Growth & Transformation Plan, Mekelle, Tigray, government printer.

CSA (2007). The Population and Housing Census of Ethiopia. Addis Ababa, Ethiopia government printer.

Dercon S, Woldehanna T (2005). Shocks and Consumption in 15 Ethiopian Villages, 1999-2004'. Afr. Econ. 14:559-585.

Diao X, Nin Pratt A (2007). Growth options and poverty reduction in Ethiopia –An economy-wide model analysis. International Food Policy Research Institute, Development Strategy and Governance Division, 2033 K St., NW, Washington, DC 20006, USA; Food Policy 32 (2007) 205–228 available online at www- siencedirect.com

Haggblade S, Hazell PBR, Reardon T (2007). Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World. (1st edn). Baltimore: International Food Policy Research Institute.

Haggblade S, Hazell PBR, Reardon T (2009). Transforming the Rural Non- Farm Economy: Opportunity and Threats in the Developing World', IFPRI Issue Brief No. 58. Washington DC. International Food Policy Research Institute.

Haggblade S, Hazell PBR, Reardon T (2010). The Rural Nonfarm Economy: Prospects for Growth and Poverty Reduction. World Dev. 38(10):1429-1441.

Israel GD (1992). Determining Sample Size. Program Evaluation and Organizational Development, IFAS PEOD-6, Series of Agricultural Education and Communication Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida; available at EIDS web site at http://edis.ifas.ufl.edu.

Kaija D (2007). Income Diversification and Inequality in Rural Uganda: The Role of Non-Farm Activities. A paper prepared for the Poverty reduction, Equity and Growth Network (PEGNeT) Conference, Berlin, September 6-7, 2007.

Merima A, Peerlings J (2012). Farm households and nonfarm activities in Ethiopia: does clustering influence entry and exit? Agric. Econ. 43:253-266.

MoARD (Ministry of Agriculture and Rural Development) (2010). Federal Democratic Republic of Ethiopia, Ethiopia's agriculture sector policy and investment framework: Ten year road map (2010-2020). Final Report

Rios AR, Masters WA, Shively GE (2008). Linkages between Market Participation and Productivity: Results from a Multi-Country Farm Household Sample. Prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, Florida, July 27-29, 2008.

Shumet A (2011). Analysis of technical efficiency of crop producing smallholder farmers in Tigray, Ethiopia. MPRA Paper No. 40461, posted 6. August 2012 13:41 UTC Available online at http://mpra.ub.uni-muenchen.de/40461/

Shumet A (2011). Analysis of technical efficiency of crop producing smallholder farmers in Tigray, Ethiopia. MPRA Paper No. 40461, posted 6. August 2012 13:41 UTC Available online at http://mpra.ub.uni-muenchen.de/40461/

World Bank (2008). The Growth Report: Strategies for Sustained Growth and Inclusive Development. Washington D.C., Commission on Growth and Development, World Bank or The International Bank for Reconstruction and Development / The World Bank

World Bank (2010). Ethiopian agricultural growth project. Project appraisal document. Addis Ababa, Ethiopia. Report No.: AB5416.

Woinshet A (2010). Participation into off-farm activities in rural Ethiopia: who earns more? MA Thesis, Graduate School of Development Studies, The Hague, The Netherlands.

Woldehanna T (2002). Rural farm/non-Farm Income Linkages in Northern Ethiopia', in B. Davis, T. Reardon, K. Stamoulis and P. Winters (eds) Rome: FAO. pp. 121-144.

Zahonogo P (2011). Determinants of non-farm activities participation decisions of farm households in Burkina Faso. J. Dev. Agric. Econ. 3(4):174-182.

academicJournals

Vol. 9(2), pp. 26-36, February, 2017
DOI: 10.5897/JDAE2016.0797
Article Number: E25274D62552
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

Land fragmentation, agricultural productivity and implications for agricultural investments in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) region, Tanzania

Reuben M. J. Kadigi[1]*, Japhet J. Kashaigili[2], Agnes Sirima[3], Felix Kamau[4], Anna Sikira[5] and Winfred Mbungu[6]

[1]Department of Food and Resource Economics, School of Agricultural Economics and Agribusiness, Sokoine University of Agriculture, Morogoro, Tanzania.
[2]Department of Forest Resources Assessment and Management, College of Forestry, Wildlife and Tourism, Sokoine University of Agriculture, Morogoro, Tanzania.
[3]Department of Wildlife Management, College of Forestry, Wildlife and Tourism, Sokoine University of Agriculture, P.O Box 3000, Morogoro, Tanzania.
[4]The Nature Conservancy, Africa Regional Office, 31 El Molo Drive, Off MajiMazuri Road, Lavington, Nairobi, Kenya.
[5]Department of Development Studies, Sokoine University of Agriculture, Morogoro, Tanzania.
[6]Department of Agricultural Engineering and Technologies, Sokoine University of Agriculture, Morogoro, Tanzania.

Received 22 November, 2016; Accepted 17 January, 2017

There are polarized evidences of the impact of agricultural land fragmentation on land productivity. On the one hand there viewpoints which consider land fragmentation to harm agricultural productivity. On the other hand there are counter thoughts which view land fragmentation as a positive situation which allows farmers to cultivate many environmental zones, minimise production risk and optimise the schedule for cropping activities. We use the case of Ihemi cluster in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) to investigate the impact of land fragmentation on crop productivity. We furthermore discuss the nature and causes of land fragmentation in the SAGCOT region and its implication on the future structure of agricultural landholdings and welfare of smallholder farmers in the region. The results showed that the nature and level of fragmentation in the study area were the outcome of combined, rather than isolated influences of supply and demand driven factors. Overall, the results did not support the claim that fragmentation reduces land productivity. This then implies that land fragmentation should not always be considered as defective. There were evidences of increasing chunks of land owned by rich farmers and investors which increased the possibility for increased consolidation of agricultural land under large scale farming. However, the landholdings for smallholder farmers might become increasingly more fragmented as poor smallholder farmers continue selling their land holdings to rich farmers and investors. Releasing the SAGCOT region's potential for agricultural development will require that smallholder farmers are helped to secure adequate and suitable land for farming, raise agricultural productivity, diversify their sources of income, and adopt good production practices. This requires setting up a strong base of investor - farmer synergies for inclusive agricultural growth.

Key words: Ihemi cluster, land fragmentation, land consolidation, agricultural productivity; agricultural investment.

INTRODUCTION

Land fragmentation, also known as pulverization, parcellization or scattering (Bentley, 1987), is defined in the literature as the situation in which a single farm consists of numerous spatially separated parcels (Binns, 1950; King and Burton, 1982; McPherson, 1982; Van Dijk, 2003). It is characterised as a fundamental rural spatial problem concerned with farms which are poorly organised at locations across space (King and Burton, 1982).

Four types of land fragmentation are distinguished in the literature: fragmentation of land ownership; land use; within a farm (or internal fragmentation); and separation of ownership and use (Van Dijk 2003; Van Dijk, 2004). Fragmentation of land ownership refers to the number of landowners who use a given piece of land. Fragmentation of land use refers to the number of users that are also tenants of the land. Internal fragmentation emphasizes the number of parcels exploited by each user and considers parcel size, shape and distance as the main issues. Separation of ownership and use involves the situation where there is a discrepancy between ownership and use.

Past studies and substantial literature have examined the relationship between land fragmentation, on the one hand, and land productivity, or efficiency at farm level, on the other (Blarel et al., 1992; Bizimana et al., 2004; Wu et al., 2005; Van Hung et al., 2007; Thomas, 2007; Rahman and Rahman, 2008; Chen et al., 2009; Corral et al., 2011, Austin et al., 2012; Sauer et al., 2012).

There are contradictory considerations regarding whether land fragmentation is a problem or not (Sklenicka, 2016; Sklenicka et al., 2014; Wu et al., 2005; Nguyen et al., 1996). Firstly, there is a viewpoint that sees land fragmentation as the source of ineffective agriculture (Sklenicka et al., 2014; Apata et al., 2014; Latruffe and Piet, 2014; Corral et al., 2011; Di Falco et al., 2010; Rahman and Rahman, 2008; Van Hung et al., 2007; Bentley, 1987). This viewpoint considers land fragmentation as a major threat to efficient production system due to the fact that continuous subdivision of farms would lead to small sized land holdings that may be hard to economically operates. According to this viewpoint, land fragmentation is said to harm productivity in a number of ways: fragmented land holdings can increase transport costs. If the plots are located far from home, and far from each other, there is a waste of time for the workers spent on travelling in-between the plots and home. Management, supervision and securing of scattered plots can also be more difficult, time consuming, and costly. Small and scattered plots waste land area and require more land for fencing, border constructions, and paths and roads. Land fragmentation might also increase the risk of disputes between neighbours (Mwebaza and Gaynor, 2002).

Small fragmented land holdings might also cause difficulties to grow 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 (The World Bank, 2005).

Other costs associated with land fragmentation include the hindering of economies of scale and farm mechanization. Small and scattered plots hamper the use of machinery and other large scale agricultural practices. In small fields operating machines and moving them from one field to another can cause problems. Small land holdings might also discourage the development of infrastructure like transportation, communication, irrigation, and drainage (Mwebaza and Gaynor, 2002). Finally it is noticed that banks are sometimes unwilling to take small, scattered land holdings as collateral, which prevents farmers from obtaining credit to make investments (ibid). In view of these disadvantages, land fragmentation is thus considered as defective and this has in turn caused several countries to implement land consolidation programs (Sundqvist and Andersson, 2006; Van Hung et al., 2006; The World Bank, 2005). Along the same line Sklenicka (2016) recommends corrective policies in countries with high fragmentation to focus on three different levels: identifying the causes of fragmentation (slowing the process), decreasing current fragmentation (defragmenting ownership), and remedying the effects.

The counter viewpoint sees land fragmentation as a positive situation under which farmers can cultivate many environmental zones, minimise production risk and optimise the schedule for cropping activities (Bentley, 1987). The recognized advantages of land fragmentation in this perspective are closely related to the demand-side causes of fragmentation. One of the benefits associated with land fragmentation is the variety of soil and growing conditions that reduce the risk of total crop failure by giving the farmer a variety of soil and growing conditions. Many different plots allow farmers access to land of different qualities when it comes to soil, slope, micro-climatic variations etc. Fields with high yields one year may the following year generate much lower yields, thus several plots of the same crop also spreads out the risk. In addition, a holding with several plots facilitates crop

*Corresponding author. E-mail: rmjkadigi@yahoo.co.uk.

rotation and the ability to leave some land fallow (*ibid*).

Another benefit of land fragmentation is the use of multiple eco zones. Different plots enable farmers to grow a wider mix of crops. Since crops ripe at different times when the plots are in different altitudes, spreading out the agriculture work like harvest and sawing during a longer period of time helps farmers to avoid household labour bottlenecks. This is especially important when the growing season of the crop is short and easily creates seasons of peak labour demand (*ibid*).

Farmers may also prefer fragmented land holdings when there are diseconomies of scale with respect to the size of the parcels. This phenomenon might be a result of labour market failure. The farmers might be unable to gather enough labour to meet seasonal peaks on large parcels (*ibid*). Labour market failure, that is, the lack of off-farm job opportunities, can also result in a large amount of unproductive family members working on the farm due to their low opportunity cost. The resulting high ratio in labour to land makes the productivity per acre of land high. This could be an explanation of the existence of diseconomies of scale (Heltberg, 1998).

This paper evaluates the impact of land fragmentation on crop productivity in Ihemi cluster of the SAGCOT area in Tanzania using data which were collected during the baseline survey conducted by the LiFELand (Laying the Foundations for Effective Landscape-level Planning for Sustainable Development in the SAGCOT Corridor) project, which runs from April 2015 to December 2017. Funded by the CGIAR/International Water Management Institute (IWMI) Research Program on Water, Land and Ecosystem, the project promotes and facilitates the adoption of sustainable intensification in the Ihemi cluster through provision of robust, evidence-driven processes and strategies.

The study area

The study was conducted in Ihemi Cluster which is located in the eastern-most part of the Southern Highlands of Tanzania. This together with other six clusters (that is, Ihemi, Kilombero, Sumbawanga, Mbarali, Rufiji, and Ludewa clusters), were identified under the SAGCOT initiative as especially ripe for agricultural investment. The initiative was launched by the Government of Tanzania (GoT) in 2010 as a Public Private Partnership (PPP) dedicated to ensuring food security, reducing poverty, and spurring economic development in the southern part of the country. The corridor stretches from the Indian Ocean to the Zambian border covering a total area of about 300,000 km^2 (approximately one third of total area of Tanzania Mainland) (AGG Team, 2012). The region has considerable agricultural potential which is underutilized and characterized by low productivity, low levels of investment, and high rates of poverty. To release the region‘s potential, the SAGCOT initiative seeks to attract more than US $3 billion of investment to dramatically increase food production, increase annual farming revenues by more than US $1.2 billion, benefit small-scale farmers and the rural poor, and establish the southern part of Tanzania as a regional food exporter. It will do so by concentrating and linking agricultural investment from the public sector, development partners, and Tanzanian and international investors to kick start the region‘s latent potential for highly productive agriculture and efficient value chains.

In particular, the Ihemi cluster falls in two regions namely Iringa and Njombe [located between latitudes 6°30’ and 11°0’ south of the Equator and longitudes 33°30’ and 37°0’ east of the Greenwich (Figure 1)]. The Iringa region shares borders with Singida and Dodoma regions (towards the north); Morogoro region (eastwards), Mbeya region (westwards) and Njombe region (southwards). Iringa region covers a total area of 35,743 km^2 out of which 2,704.2 km^2 (7.6%) is covered by water bodies of Mtera Dam, the Little and Great Ruaha Rivers. The remaining area (33,038.8 km^2) is land area (Iringa Regional Commissioner’s Office, 2013).

The Njombe Region borders Iringa Region in the North, Morogoro Region in the East and Ruvuma region in the South. It also shares borders with the Republic of Malawi via Lake Nyasa and part of Mbeya Region in the North-West and West. The Region has the total surface area of 24,994 km^2 out of which 21,172 km^2 is covered by land (84.7%) and 3,822 km^2 is covered by water (15.3%) (*ibid*).

STUDY APPROACH AND METHODOLOGY

Sampling procedure and data collection

The study districts, wards and villages were purposefully selected based on their location along the cluster landscape, suitability as an average unit for socioeconomic analysis and potential for agricultural investment**.** A total of five districts were selected, two from Njombe and three from Iringa Region. The sample villages in each of the five sample districts and the respective sample sizes are presented in Table 1.

Prior to the selection of sample households and commencement of questionnaire survey, a range of Participatory Rural Appraisal (PRA) methods, including Focus Group Discussions (FGDs), Key Informants Interviews and Wealth ranking were conducted as a footing step to the study. These helped to identify wealth groups and socio-economic landscapes that acted as the sampling frame for a stratified random sample.

The wealth ranking exercise was conducted in all the twenty sample villages and at least 10% of the total households were chosen in each village (from the village registers) in order to provide a logistically feasible sampling frame. The wealth ranking exercise eventually resulted in identification of three wealth groups (“rich” “medium”, and “poor”). Prior to the wealth ranking exercise the participants were asked to list the indicators of wealth which were then used to rank every household in the sample villages.

The “rich” households were relatively a small group, covering only about 11% of the total households. They were food secure all year round and had a fairly secure livelihood base. The “medium” wealth class constituted about 40% of the households, with a

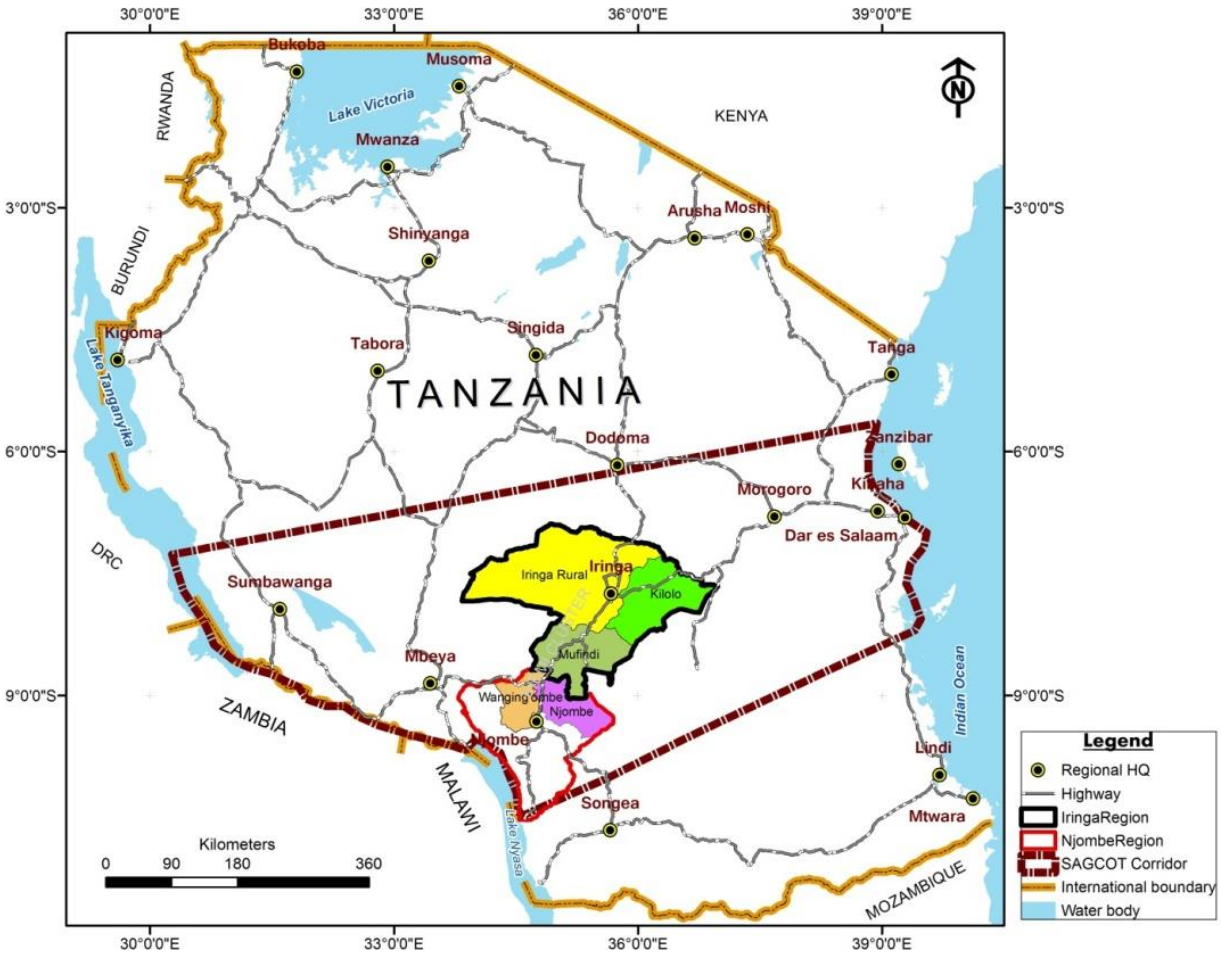

Figure 1. Map of Tanzania showing the location of Ihemi cluster and SAGCOT region.

Table 1. Levels of fragmentation of operated land in the two regions of Ihemi cluster, 2014/15 (%).

Measure of dispersion	Region		Total
	Iringa	Njombe	
Simpson index			
0.0 - 0.5	35.6	11.1	23.3
0.5 - 0.7	64.4	77.8	71.1
Over 0.7	0.0	11.1	5.6
Mean*	0.6	0.7	0.6
Median*	0.6	0.7	0.6
Number of parcels			
0	6.3	3	4.7
1	19	20	19.5
2	32.7	34	33.3
3	28	26.5	27.3
4	8.3	10.5	9.4
5	3.7	4.5	4.1
6 and above	2	1.5	1.8
Mean*	2.9	3.5	3.2
Median*	3.0	3.0	3.0

smaller base of assets to draw on, but the majority of the households in this class were still food secure all year round. The "poor" households constituted about half of the total households (49%). In total, 607 households were interviewed in twenty villages from five study districts namely Iringa, Kilolo and Mufindi district councils (in Iringa region) as well as Njombe and Wanging'ombe district councils (in Njombe region).

Data analysis

Data gathered using FGDs, key informants and audio recorded interviews were transcribed and organised into discussion topics. A content analysis of transcribed data was then carried out using Excel spreadsheet. The data were first sorted into themes and later patterns were generated across themes to show the relationships across key issues such as farm/parcel sizes, soil and water conservation practices, and income sources just to mention few.

The questionnaire for household survey was pre-coded prior to actual data collection. The open ended questions were coded and generated during the compilation of responses to ensure consistence in the use of codes for open ended questions. A coded template was designed in SPSS and the information contained in the questionnaire was transferred into the software for data analysis. Data cleaning was performed to ensure that data values are complete, accurate correct and free from outliers.

The analysis of data entailed mainly the production of descriptive statistics such as means, standard deviation, analysis of variance, and t-tests. In addition, a linear regression analysis was used to assess the effects of land fragmentation on productivity. The study assumed a linear relationship between dependent and independent variables. Land fragmentation was analysed using a combination of measures including the size and number of parcels, average distance to parcels and the Simpson index. These measures and the alternative approaches to assess farm fragmentation are presented in the next section.

Measures of land fragmentation

Land fragmentation is a spatial phenomenon which depends on many parameters. King and Burton (1982) cite the following six relevant factors: Holding size; number of parcels belonging to the holding; size of each parcel; shape of each parcel; the spatial distribution of parcels; and the size distribution of parcels.

Most authors who tried to measure fragmentation have used a simple average of the number of parcels per holding (either regional or national), an average of holding size and an average of parcel size. Some other authors developed more complicated descriptors. In particular, Edwards (1961) calculated a fragmentation index as the percentage of a holding's land which is not adjacent to the farmstead. In addition, Simmons (1964) proposed a land fragmentation index which took into account the number of parcels in a holding and the relative size of each parcel. The formula for Simmons's land fragmentation index is as follows:

$$FI = \frac{\sum_{i=1}^{n} a_i^2}{A^2} \quad (1)$$

Where *FI* is the fragmentation index, *n* is the number of parcels belonging to a holding, *a* is the size of a parcel and *A* is the total holding size. An *FI* value of 1 means that a holding consists of only one parcel and values closer to zero mean higher fragmentation. The Simmons index becomes the Simpson index if it is subtracted from 1 (Shuhao, 2005).

Furthermore, Dovring (1965) computed fragmentation by measuring the distance which a farmer would have to travel to reach each of his parcels, returning back to his farmstead after each visit although it ignores the number of actual visits per year and the potential that any parcel could be visited without returning back to the farmstead. Moreover, Januszewski (1968) developed a similar fragmentation index to Simmons, combining the number of parcels per holding and their size distribution into a *K* index as follows:

$$K = \frac{\sqrt{\sum_{i=1}^{n} a_i}}{\sum_{i=1}^{n} \sqrt{a_i}} \quad (2)$$

Where *n* is the number of parcels and *a* is the parcel size. The *K* values range from 0 to 1. As values tend to zero, *K* indicates a high degree of fragmentation. This index has three main properties: the degree of fragmentation increases proportionally with the number of parcels; fragmentation increases when the range of parcel sizes is small and fragmentation decreases as the area of large parcels increases and that of small parcels decreases. Blarel et al. (1992) note that Januszewski and Simmons indices are the most popular. Igozurike (1974) suggested a 'relative index of land parcellization'. In contrast to the above indexes, this measure is based on the average size of the parcels and the distance travelled by a farmer to visit all his parcels sequentially (that is, in one round trip). This index is given by the following equation:

$$P_i = \frac{1}{\frac{S_i}{100}} Dt \quad (3)$$

Where P_i is the fragmentation (or parcellization) index of holding *i*, S_i is the size of each parcel and *Dt* is the total round-trip distance covering all parcels. King and Burton (1982) criticized this index because distance has not been clearly defined by the researcher and is overemphasized, without taking into account the number of parcels. An example is quoted based on a holding with two parcels with size S_i and a distance of 10 km apart, which would give a P_i twice as high as a holding with 10 parcels of size *S*, each 1 km from its neighbours. Schmook (1976) defined a fragmentation index called P_0, which is the ratio between the area of a polygon which circumscribes all the parcels of a holding, to the area of that holding. Values of this index are always above 1; a high P_0 value indicates intense fragmentation. Schmook (1976) also suggested another fragmentation coefficient which is calculated by dividing the average distance to parcels by the mean parcel size.

This study employed a mixture of measures of fragmentation including the size and number of parcels, average distance to parcels and the Simpson index. The latter is widely used because it is sensitive to both size of parcels and number of parcels. The Simpson index can arithmetically be defined as (Equation 4):

$$SI = \frac{\sum_{j=1}^{J} A_i^2}{A^2} \quad (4)$$

Where, SI = the Simpson index; A_i = the area of the *i*th plot; A = $\sum_{j=1}^{J} A_i$ = the total farm area.

A value of zero indicates complete land consolidation (one parcel only), while the value of one is approached by holdings of numerous parcels of equal size.

To examine the impact of land fragmentation on productivity a two stage least squares (2SLS) analysis was used. The 2SLS procedure was purposefully used in order to tackle the problem of "misspecification" of variables. Three models were formulated (Equations 5 to 7). These were basically of the same nature but differentiated by either excluding both the observed and predicted values for average distance to parcels (T and T_p), or including only one of them. In other words, equation 5 served as a control model by which the evaluation of explanatory powers in Equations 6 and 7 was facilitated.

$$Y_a = f(E_p, X_6, D). \quad (5)$$

$$Y_a = f(E_p, T, X_6, D). \quad (6)$$

$$Y_a = f(E_p, T_p, X_6, D). \quad (7)$$

$$X_6 = f(G, C, L_a, S)$$

Where: Y_a = crop productivity; T = average distance from homestead to parcels; E = number of parcels; L = household labour equivalent; G = age of head of household; S = sex of head of household; C = education level of head of household; D = regional dummy; E_p = predicted values for number of parcels; T_p = predicted values for average distance to parcels

The implicit assumption underlying the formulation was that the models were correctly specified in the first place. A number of OLS formulations were tried before adopting the 2SLS model.

RESULTS AND DISCUSSION

Parcel sizes and land fragmentation

Generally, crop parcels are very small - 60% to about 86% had sizes ranging from 0.25 to 2 acres (Figure 2) compared to average farm size in Africa of 2.5 ha; North America (121 ha), Latin America (67 ha) and Europe (27 ha) (Kanu et al., 2014).

The results of analysis of land dispersion using the Simpsom Index (SI) and number of parcels (Table 2 and Figure 3) as well as the average time spent by farmers to walk from their homesteads to parcels (Figure 4) suggest high levels of land fragmentation for both the two regions and districts of Ihemi cluster. Relatively however, the land holdings were more fragmented in Njombe region than in Iringa region. This can partly be explained by the difference in relative per capita land size between the two regions, which supports the argument that fragmentation is a supply driven factor. On average our results showed relatively smaller per capita cropland for Njombe region (0.16 acres/person) than Iringa region (0.21 acres per person).

Although the median number of parcels (Table 1) was the same for both regions (3.0), the median value of the Simpson Index was greater for Njombe region (0.7) compared to that of Iringa (0.6) and the difference was significant at $P < 0.01$. In Njombe region, about 20% of farmers operated four or more parcels, whereas for Iringa it was only 16.9%.

Most parcels were located at distances of 1 km^2 and more from homestead (Figure 4). The correlation between Simpson Index and the average distance to parcels was -0.281, and this relation was significant at 0.01 level. The t-test results on both the mean number of parcels and the Simpson Index supported the assertion that land consolidation increased with land scarcity and market access. Land consolidation was relatively higher in Iringa than Njombe district at $P < 0.01$ with t-values equal to 3.08 and 3.28 respectively. In this test, fragmentation (Simpson Index or number of parcels) was used as the inverse measure of consolidation.

It is important to note that the disparity in land fragmentation between farmers in the two regions of Ihemi cluster (Iringa and Njombe) was not necessarily an outcome of only supply driven factors (higher population density in this case) or demand drive factors. The disparity seemed not to originate purely from constraints in land acquisition or from limited choice of parcel location. A number of both side supply - and demand driven factors seemed to interact together to define the prevailing levels of fragmentation. We evaluate and discuss some of these factors in our analysis of the effects of land fragmentation on productivity in the next subsection.

Land fragmentation and productivity

The regression results for the three models specified in the analysis (Equations 5 to 7) are summarized in Tables 2 to 4, respectively. In Tables 2 and 3, only age of the head of household, labour equivalents per hectare, and regional dummies were statistically strongly significant. The rest of predictors were non-significant. In Table 4 however, only two predictors remained consistently non-significant (education level and sex of head of household). The predicted values for the number of parcels were significant at $P < 0.05$, and the rest were all significant at $P < 0.01$ level, as expected.

The regression results for Equation 7 (Table 4) show that fragmentation has a positive impact on land productivity (crop yield) when predicted values (T_p) are used instead of observed values of average distance to parcels (T). When both these values are excluded (Table 2), and when only observed values of average

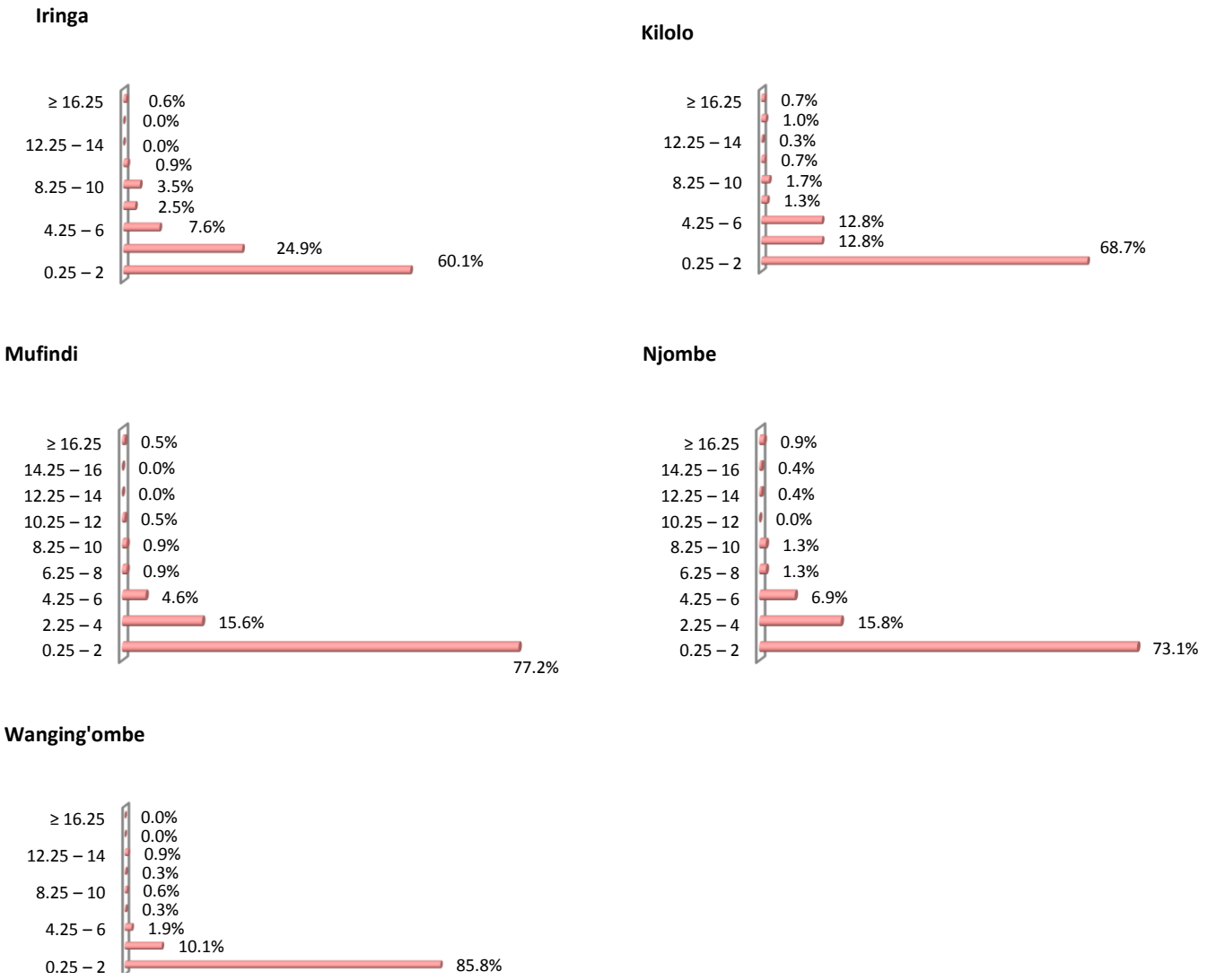

Figure 2. Parcel sizes (acres).

Table 2. Regression results of second stage – 2SLS for the control fragmentation-productivity model.

Term	Coef.	StDev	T	P
Constant	88717.0	53926.0	1.65	0.104
E_p	-10660.0	8500.0	-1.25	0.213
Age of head of household	2792.5	732.2	3.81	0.000***
Education level of head of household	2262.0	2031.0	1.11	0.269
Labour equivalent/Ha	-71725.0	15127.0	-4.74	0.000***
Sex: 1	-3508.0	10057.0	-0.35	0.728
Region: 0	29744.0	7575.0	3.93	0.000***
S	64667			
R^2	43.3%			
Adj R^2	39.2%			
F	10.56			
P	0.000***			

E_p = predicted values of number of parcels; ***significant at 0.01% level.

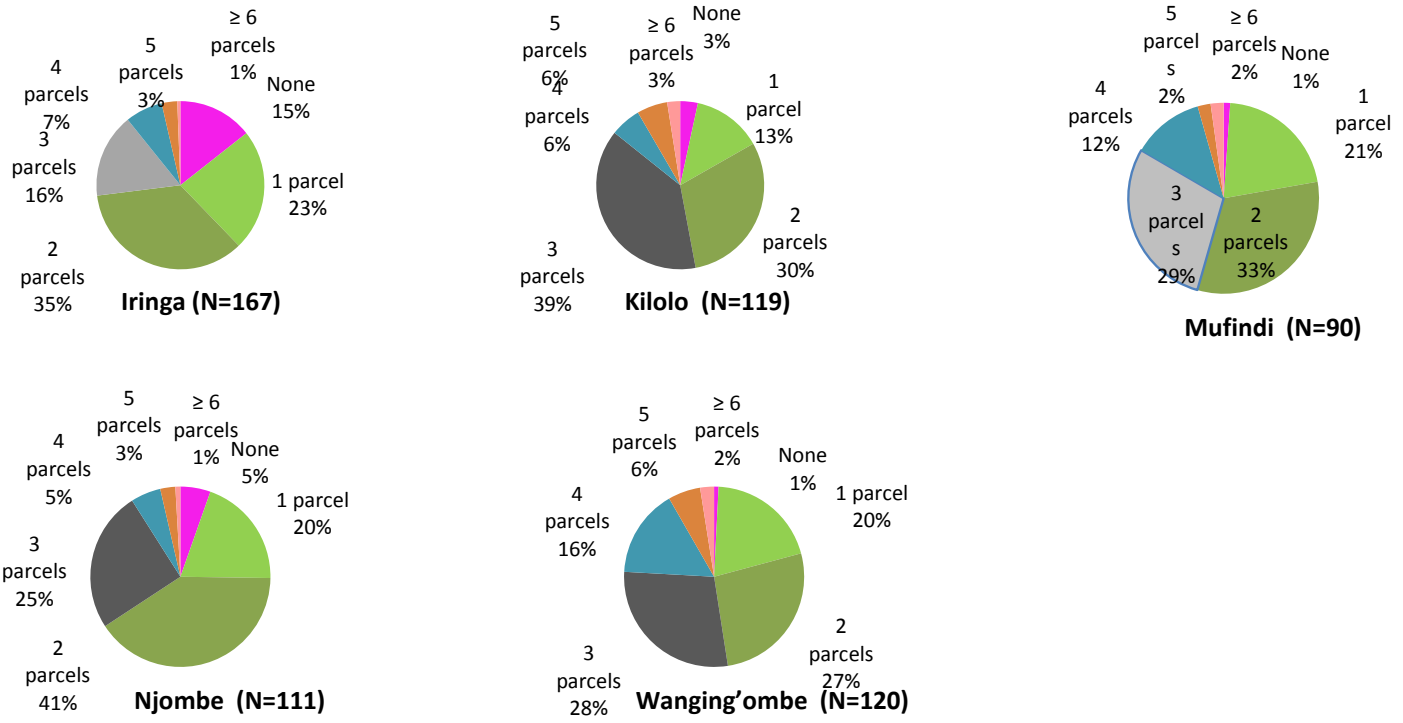

Figure 3. Land ownership by number of parcels.

distances to parcels are included – an approach which is considered to ignore the effects of variables specified as exogenous (Table 3), the results support a contrary explanation: that is, fragmentation has a negative impact on land productivity. When subjected to correlation coefficient test (in isolation) the observed values of number of parcels correlated negatively with observed values of land productivity (r = -0.269) at 0.05 significant level. The correlation coefficient between predicted values of number of parcels and observed values of land productivity was also negative (-0.269) and significant at 0.01 level. In addition, many smaller parcels were generally close to homesteads in Njombe region (Figure 4), whereas, only few, larger parcels were far away from houses in Iringa region (Iringa, Kilolo and Mufindi district councils in the same figure). This would support Fenoaltea (1976)'s and Blarel et al. (1992)'s argument that, greater fragmentation does not necessarily result in greater average distances for farmers.

It is important to note that these results make a deceptive but interesting point which tends to be overlooked frequently in the analysis. The point is that analyzing the factors hypothesized as affecting land productivity in isolation rather than in an integrated or comprehensive manner may be too hypocritical to draw any tangible conclusion. The opposite appears to be an appropriate approach, particularly when one evaluates the causes and persistence of land fragmentation prevailing in most smallholder production systems in developing countries. Several socioeconomic factors are interlinked together and are more likely to have a combined, rather than separable, effect on land productivity.

The positive impact that the average distance to parcels has revealed on land productivity can partly be explained by the fact that distant parcels are comparatively the more currently cleared or developed ones. It therefore becomes logical when one considers them as less suffered from continuous cultivation and hence less degraded.

Implication for agricultural investment in the SAGCOT

The findings presented and discussed in the foregoing subsection raise particular questions regarding the future of smallholder landholdings as agricultural investments expand in the SAGCOT region. These include among others the following two key questions: (a) Will the agricultural landholdings become more fragmented or more consolidated? (b) What will be the likely impact on access to land and productivity as well as welfare of smallholder farmers at large?

Obviously, we expect several chunks of land owned by rich farmers and investors to sprout which is more likely to result in increased consolidation of the agricultural land in the cluster. However, the landholdings for smallholder farmers will become more fragmented as poor smallholder farmers are increasingly selling their small

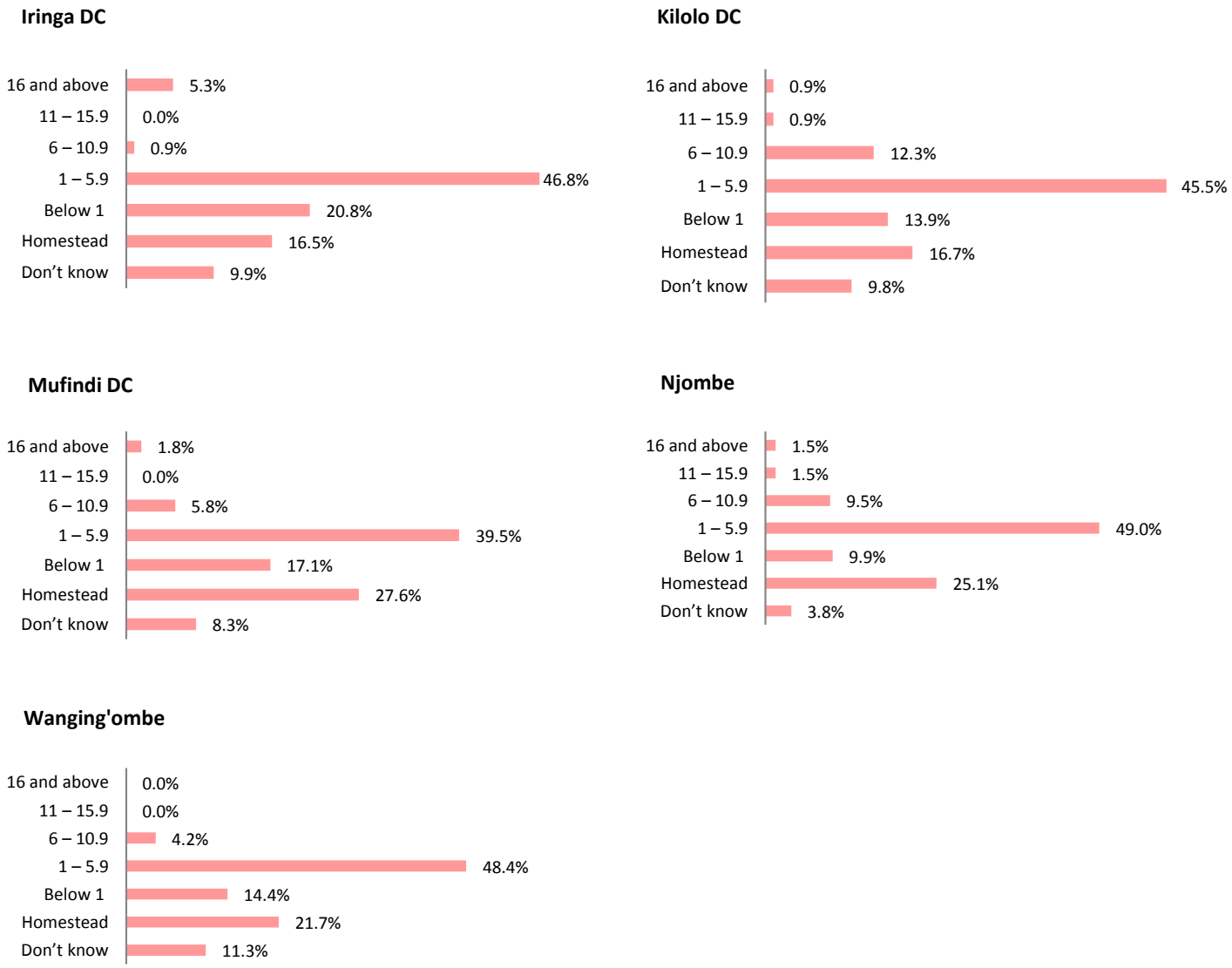

Figure 4. Distance to crop parcels (km).

Table 3. Regression results of second stage - 2SLS with *T* variable included in the fragmentation-productivity model.

Term	Coef.	StDev	T	P
Constant	64574.0	67751.0	0.95	0.343
E_p	-8257.0	9448.0	-0.87	0.385
T	1277.0	2154.0	0.59	0.555
Age of head of household	2776.1	735.6	3.77	0.000***
Education level of head of household	2186.0	2043.0	1.07	0.288
Labour equivalent/Ha	-70769.0	15272.0	-4.63	0.000***
Sex: 1	-3610.0	10098.0	-0.36	0.722
Region: 0	29645.0	7607.0	3.90	0.000***
S	64921			
R^2	43.5%			
Adj R^2	38.7%			
F	9.03			
P	0.000***			

E_p = predicted values of number of parcels; *T* = average distance to parcels; ***significant at 0.01 per cent level.

Table 4. Regression results of second stage - 2SLS with T_p variable included in the fragmentation-productivity model.

Term	Coef.	StDev	T	P
Constant	-797431	297087	-2.68	0.009***
E_p	79580	30881	2.58	0.012**
T_p	47404	15653	3.03	0.003***
Age of head of household	2666.1	699.8	3.81	0.000***
Education level of head of household	-826	2189	-0.38	0.707
Labour Equivalent/Ha	-75835	14497	-5.23	0.000***
Sex: 1	-5658	9622	-0.59	0.558
Region: 0	26542	7304	3.63	0.000***
S	61701			
R^2	49.0%			
Adj R^2	44.6%			
F	11.25			
P	0.000***			

E_p = predicted values of number of parcels; T_p = predicted values of distance to parcels; *** = significant at 0.01 per cent level;** = significant at 0.05% level

parcels to rich farmers and investors. This trend is likely to continue and may result in increased number of landless farmers.

Climate change and lack of funds to purchase inputs will also continue to impact negatively the agricultural productivity of smallholder farmers. Frequent droughts and crop losses resulting in unreliable rainfall rainfall increasingly force smallholder farmers to cultivate crops on fragile lands like the bottom valleys (*vinyungu* farming) leading to degradation of existing water sources in the SAGCOT region. Releasing the region's potential will require that these issues are appropriately addressed and smallholder farmers are helped to secure adequate and suitable landholdings for farming, raise agricultural productivity, diversify their sources of income to reduce overreliance on crop production, and adopt good agricultural practices. This has to be achieved by promoting strong investor - farmer synergies for inclusive agricultural growth.

There are already some good examples of investor - farmer engagement emerging in the region. The Rutuba farm for example undertakes training of farmers in good agricultural practices through the Clinton Foundation Program at Gongwa area. Early lessons from this model suggest that small farmers can triple their yields if helped to intensify their agricultural practices (personal conversation with the management of the farm). Smallholder farmers in the SAGCOT region can harvest more crops per unit area provided that they are helped to access right seeds at the right time, own good storage facilities, given the right education and assisted to access competitive markets.

Another example in the region is the Silverlands' model of agri-intensification. Silverlands is a private company which has invested in a big poultry project at Ihemi village that produces three poultry breeds namely the Highland brown, Cobb 500, Sasso - French bird breeds. The company has a hatchery unit and produces vegetarian and high quality; scientifically formulated poultry feeds and buys crops (maize, soybeans and sunflower) from smallholder farmers in the cluster and in other areas outside Iringa and Njombe regions.

The company normally buys the produce through NGOs who work for the interest of small-scale farmers by so doing bypassing the middlemen node and shortening the value chain or marketing channels of these crops. The company was also piloting a selling mall for poultry products and had selling points in different parts of the country notably the Southern Highlands, Morogoro, Dodoma, and Dar es Salaam regions. In addition the company has established a poultry training college for farmers and other entrepreneurs.

Conclusions

Land holdings in Ihemi cluster were generally highly fragmented. The pattern of dispersion is however contrary to the explanation given by many analysts of the causes of land fragmentation attributing it to supply driven factors. The population density in Iringa region was relatively higher (174 people per ha) than in Njombe (145 people per ha) yet the land holdings in the latter region were more fragmented than in the former.

In addition, land fragmentation was declining with farm size, and parcels located closer to homestead were more fragmented than the ones located far. It was increasing with land scarcity. The results in this study show a positive relation between land fragmentation and productivity.

We draw the following key lessons from the study of land fragmentation in the Ihemi cluster of SAGCOT: (a)

Land fragmentation should not be considered as undesirable; b) it should also not be viewed as purely originating from, and/or made persistent by the influences of only a single type of factor (e.g. population density – a supply side factor) but a result of interaction between both the supply – and demand – driven factors. Which type dominates the other will depend on the farming environment prevailing in a specific area.

Conflicts of Interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors highly acknowledge the financial support from a research program on Water Land and Ecosystem (WLE), an ambitious 12 years CGIAR's Research Program led by the International Water Management Institute (IWMI) as well as all the individuals who were consulted during the study.

REFERENCES

Apata T, Sanusi A, Olajorin V (2014). Small Farms and Agricultural productivity in Nigeria: Empirical analysis of the effects of land tenure, fragmentation and property rights. Paper prepared for presentation at the 2016 World Bank Conference on Land and Poverty, March 14-18, 2016. The World Bank - Washington DC.

Austin OC, Ulunma AC, Sulaiman J (2012). Exploring the Link between Land Fragmentation and Agricultural Productivity, Int. J. Agric. For. 2(1):30-34.

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

Binns O (1950). The Consolidation of Fragmented Agricultural Holdings. Washington DC: FAO Agricultural Studies P 11.

Bizimana C, Nieuwoudt WL, Ferrer S (2004). Farm size, land fragmentation and economic efficiency in southern Rwanda. Agrekon 43(2):244-262.

Blarel B, Hazell P, Place F, Guiggin J (1992). The economics of farm fragmentation—evidence from Ghana and Rwanda. World Bank Econ. Rev. 6(2):233-254.

Chen Z, Huffman W, Rozelle S (2009). Farm technology and technical efficiency: Evidence from four regions in China. China Econ. Rev. 20:153-161.

Corral J, Perez J, Roibas D (2011). The impact of land fragmentation on milk production. J. Dairy Sci. 94:517-525.

Di Falco S, Penov I, Aleksiev A, van Rensburg T (2010). Agrobiodiversity, farm profits and land fragmentation: Evidence from Bulgaria. Land Use Policy 27:763-771.

Dovring F (1965). Land and labour in Europe in the twentieth century (3rd ed.). Hague: The Nijhoff.

Edwards D (1961). An economic study of small farming in Jamaica. University College, West Indices.

Fenoaltea S (1976). Risk, transaction costs, and the origin of medieval agriculture. Expl. Econ. Hist. P 13.

Heltberg R (1998). Rural Market Imperfections and the Farm Size-Productivity Relationship: Evidence from Pakistan. World Dev. 26:10.

Igozurike MU (1974). Land tenure, social relations and the analysis of spatial discontinuity. Area 6:132-135.

Iringa Regional Commissioner's Office (2013). Iringa Region Investment Profile. Available online at: www.iringa.go.tz/en/information-centre/documents.html?

Januszewski J (1968). Index of land consolidation as a criterion of the degree of concentration. Geogr. Polon. 14:291-296.

Kanu BS, Salami AO, Numasawa K (2014). Inclusive Growth: An imperative for African agriculture. Agriculture and Agro-Industry Department (OSAN). Development Research Department (EDRE). African Development Bank Group. Available at: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Inclusive_Growth_-_An_imperative_for_African_Agriculture.pdf

King R, Burton S. (1982). Land fragmentation: Notes on a fundamental rural spatial problem. Progr. Hum. Geogr. 6(4):475-494.

Latruffe L, Piet L (2014). Does land fragmentation affect farm performance? A case study from Brittany, France. Agric.Syst. 129:68-80

McPherson MF (1982). Land fragmentation: a selected literature review. Development Discussion Paper No. 141. Harvard Institute for International Development, Harvard University.

Mwebaza R, Gaynor R (2002). Land sector analysis; land market, land consolidation, and land re-adjustment component, Rural Development Institute, The Government of the Republic of Uganda.

Nguyen T, Cheng E, Findlay C (1996). Land fragmentation and farm productivity in China in the 1990s. China Econ. Rev. 7(2):169-180.

Rahman S, Rahman R (2008). Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh. Land Use Policy 26:95-103.

Sauer J. Davidova S, Gorton M (2012). Land fragmentation, market integration and farm efficiency: empirical evidence from Kosovo. Contributed Paper prepared for presentation at the 86th Annual Conference of the Agricultural Economics Society, University of Warwick, United Kingdom. 16 - 18 April 2012.

Schmook G (1976). The spontaneous evolution from farming on scattered strips to farming in severalty in Flanders between the sixteenth and twentieth centuries: A quantitative approach to the study of farm fragmentation. In R. H. Buchanan, R. A. Butlin, & D. McCourt (Eds.), Fields. Belfast: Ulster Folk and Transport Museum. Farms Settle. Eur. pp. 107-117.

Shuhao T (2005). Land fragmentation and rice production: a case study of small farms in Jiangxi Province, P.R. China. PhD Thesis, Wageningen University.

Simmons AJ (1964). An Index of Farm Structure, with a Nottinghamshire Example. East Midlands Geogr. 3:255-261.

Sklenicka P (2016). Classification of farmland ownership fragmentation as a cause of land degradation: A review on typology, consequences, and remedies, Land Use Policy 57:694-701.

Sklenicka P, Janovska V, Salek M, Vlasak J, Molnarova K (2014). The farmland rental paradox: extreme land ownership fragmentation as a new form of land degradation. Land Use Policy 38:587-593.

Sundqvist P, Andersson L (2006). A study of the impacts of land fragmentation on agricultural productivity in Northern Vietnam. Bachelor Thesis. Department of Economics. Uppsala University.

The World Bank (2005). Land Consolidation Issues in Northern Vietnam – Institutions, Implementation, Impacts. Working Paper, The World Bank.

Thomas J (2007). Property rights, land fragmentation and the emerging structure of agriculture in Central and Eastern European countries. Elect. J. Agric. Dev. Econ. 3(2):225-275.

Van Dijk T (2003). Dealing with Central European Land Fragmentation. Delft: Eburon.

Van Dijk T (2004). Land consolidation as Central Europe's Panacea reassessed. In: Proceedings of Symposium on Modern Land Consolidation, September 10–11, Volvic (Clermont-Ferrand), France. Available from URL: http://www.fig.net/commission7/france_2004/papers_symp/ts_01_van dijk.pdf

Van Hung P, MacAulay TG, Marsh S (2007). The economics of land fragmentation in the North of Vietnam, Austr. J. Agric. Resour. Econ. 5:195-211.

Van Hung P, MacAulay TG, Marsh S (2006). The Economics of Land Fragmentation in the north of Vietnam, The University of Sydney.

Wu Z, Liu M, Davis J (2005). Land consolidation and productivity in Chinese household crop production. China Econ. Rev. 16:28-49.

Journal of Development and Agricultural Economics

Related Journals Published by Academic Journals

- ***Journal of Plant Breeding and Crop Science***
- ***African Journal of Agricultural Research***
- ***Journal of Horticulture and Forestry***
- ***International Journal of Livestock Production***
- ***International Journal of Fisheries and Aquaculture***
- ***Journal of Cereals and Oilseeds***
- ***Journal of Soil Science and Environmental Management***
- ***Journal of Stored Products and Postharvest*** *Research*

academicJournals