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Determinants of Agricultural Intensification: The Case of Kembata Tambaro Zone, Southern Ethiopia

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Abstract
Increases in population density lead to lower farm sizes which have major implications for agricultural intensification. Farmers in the Kembata Tambaro Zone are widely practicing crop intensification through intensive use of improved seed and chemical fertilizer. However, crop intensification is determined by different factors in the study area. Thus, the aim of this study is to identify the potential determinants of cereal intensification in KTZ. The data were collected from both primary and secondary sources through personal interview using structured questionnaire. The data were obtained from 252 sample household heads that were selected through a combination of purposive and stratified random sampling techniques. The descriptive e statistics were used to examine the existing utilization of farm inputs and the yield obtained per hectare among three farm size categories. The finding of the study indicates that small farms use higher per hectare improved seed and fertilizer and earn more crop yield followed by medium farms while large farms utilize lower farm inputs and obtained the lowest yield implying that small farmers are the most efficient with highest yield per hectare. Multiple linear regression function (The linear form of Cobb-Douglas Production Function) was used to find out the determinants of major crops yield. The econometric analysis demonstrated that out of the total 20 variables included in the model, 10 variables including crop area, crop price, hired labor, quantity of fertilizer used, farming experience, age, education, market distance, non-farm income and development agent's visit are the significant variables affecting major crops yield. The results of this study suggested that there is the need for strengthening a policy option that expands the agricultural extension services more efficiently and farming households' access to market in the study area. In addition, improving the application and supply of agricultural inputs and enhancing non-farm income sources is extremely imperative.
Keywords: Agricultural intensification, CDPF, land scarcity, farming households, determinants of major crops yield, Ethiopia.

1. Introduction

Ethiopia's economy is predominantly an agricultural economy. Agricultural growth provides important basis for general economic growth as well as employment creation in the country. The agricultural Gross Domestic Product (GDP) of Ethiopia is 41 percent, export is 90 percent, employment is 85 percent and food security is high (World Factbook, 2012). The small-scale farming dominates the agricultural sector and accounts for 95 percent of the total area under crop and more than 90 percent of crop output. The livelihoods of 84% of the citizens depend on various agricultural productions (Fikremarkos, 2012).

The agricultural sector in Ethiopia is composed of different farming systems. Crop sector is the major subsector and it is dominated by cereal production. In 2009/10, *Meher* (main cropping season) *teff*, wheat, maize, sorghum and barley accounted for 95.74% of the cereal production (155.3 million quintals) and covered 95.23% of the land (9.23 million hectare) under small households (CSA, 2003-2009/2010). Maize, *teff*, wheat, sorghum and barley accounted for 25.09%, 20.46%, 19.80%, 11.27% and 19.13% of the volume of cereal production, respectively (CSA, 2010). *Teff* is the most favorable staple crop for different income levels of rural and urban consumers. Of the total cultivated land in 2009/10, *teff* accounted for 28.04%, followed by maize (19.19%), wheat (18.23%), barley (17.53%) and sorghum (12.23%). The farming of cereal production gradually increased the coverage of the land. For example, land covered by *teff* increased from 1.9 to 2.6, wheat from 1 to 1.7 and maize from 1.19 to 1.8 million meter hectare since 2003/04 (CSA, 2010). This entails that to increase crop production further, the focus should be on increasing smallholders' productivity rather than on area expansion.

There has been a strong policy focus by the Ethiopia government on encouraging productivity growth in small holder cereal farming during this period in the ADLI and its later formulation in the PASDEP. In addition, attainment of food self -sufficiency is a prominent developmental agenda facing most nations of Sub-Sahara Africa. To stem the tide of the food problem through crop production intensification, the Federal government in 2010 initiated the GTP emphasized on basic direction of agricultural development such as extensive utilization of human labor, proper use of agricultural land, combining diversification and specialization with four priority areas for development: irrigation, fertilizer, technology and infrastructure (MoFED and MoARD, 2010). As part of this strategy the government has spent considerable resources supporting cereal intensification of small holder farmers, for example through investments in agricultural extension and supporting fertilizer distribution (Ruth and Eyasu, 2014).

In relation to the productivity of cereal crops, the average productivity achieved in the first three years of the GTP period is encouraging (Table 1). The production of smallholder farmers in the *meher* season contributes above 92 percent of the total production and the strategic direction thus focuses on increasing the productivity of smallholders during the *meher* season. In 2012/13, the average productivity of smallholder farmers registered by cereals during *meher* season was 20.46 quintals/hectare which is 0.85 quintals/hectare and 2.14 quintals/hectare higher than the productivity in 2011/12 and 2010/11 respectively. Major cereal crops which have registered relatively significant improvements in productivity during the *meher* season include maize 30.59 quintals/hectare, wheat 21.1 quintals/hectare, sorghum 21.05 quintals/hectare, barely 17.48 quintals/hectare and *teff* 13.79 quintals/hectare. Comparing the productivity of cereals in this fiscal year with 2010/11 fiscal year, maize, wheat, barley, *teff* and sorghum witnessed an increase in productivity of 5.2 quintals/hectare, 2.72 quintals/hectare, 1.21 quintals/hectare, 1.19 quintals/hectare and 0.2 quintals/hectare respectively. The average productivity of major cereal crops particularly the productivity of maize and wheat is encouragingly improving.

Table 1. The productivity of cereal crops for the first three years of the GTP (2010/11-2012/13)

Crop type	Productivity in 2010/11 (q/h)		Productivity in 2011/12 (q/h)		Productivity in 2012/13 (q/h)	
	meher	belg	meher	belg	meher	belg
Cereals	18.32	8.64	19.61	6.51	20.46	8.76
Teff	12.60	5.55	12.80	4.18	13.79	6.43
Barely	16.27	6.94	16.72	5.77	17.48	7.07
Wheat	18.38	9.85	20.28	8.91	21.10	-
Maize	25.39	9.50	29.53	7.15	30.59	9.49
sorghum	20.85	7.0	20.53	2.99	21.05	5.36

Source: GTP annual progress report for F.Y 2012/13; computed from the CSA annual production estimates, 2013.

In spite of the fact that the performance achieved in the last three years of the GTP period in relation to increasing production is encouraging and the productivity of cereals is improving gradually, the productivity currently achieved is below the planned target. Moreover, marginal increase had been brought about on the yield of most cereal crops (especially *teff*, maize, wheat and barley) and even when such is achieved, identifying the determinants of crop production intensification is also crucial to help in policy formulation and decision making concerning the sustainability of future agriculture production. Furthermore, with an annual population growth rate of 2.9%, the restricted potentially favorable share of the land area is increasingly put under pressure to meet the growing demand for food, feed, fuel and industrial products. Due to demographic growth combined with closed land frontiers, the same land area has to support an ever increasing number of people (Josephson, 2013). Farm sizes are generally very small in the Ethiopian highlands and declining overtime, with young rural households facing particularly severe land constraints which are inducing agricultural intensification (Derek *et al.*, 2013).

Farmers in Kembata Tambaro Zone are already applying agricultural intensification that suit their respective household needs and available resource endowments. The majority of the farmers in the KTZ had less than 0.50 ha due to the population pressure. In 2003/04, 1990 holders had above 2.00 ha land each which totals 5728 ha. This figure became 0 in 2011/12 (CSA, 2003-2011/12). The reduction in fallow land from 8332 ha in 2003/04 to 1200 ha in 2011/12 and increment of wood land and other land use from 3483 ha and 2602 ha in 2003/04 to 6910 ha and 7858 ha in 2011/12 reveals that there is land intensification and population explosion (CSA, 2012). On the other hand the increment of grazing land from 2889 ha in 2003/04 to 19055 ha in 2011/12 shows the livestock intensification where as the increment of number of households, holders and all crop area from 107517, 113238 and 49,007 ha in 2003/04 to 249385, 255354 and 114 677 ha respectively in 2011/12 signifies crop intensification and population density with average household size 5.9 (CSA, 2003-2011/12).

Yet despite the impressive improvements in yield and the effectiveness of government's focus on different poverty reduction strategies, the existing literature on Ethiopian agricultural development has focused mostly on the impact of these strategies on the spatial nature of poverty in Ethiopia. Furthermore, Darek *et al.* (2013) examined land constraints and agricultural intensification; Josephson (2013) estimated how does population density influence agricultural intensification and productivity and Ephrem and Bekele (2012) explained the determinants of the decisions of smallholder farmers to intensify their subsistence agriculture in North Eastern Ethiopia. What remains to be researched are potential determinants of crops yield intensification to improve household income. This study, thus, aims to fill this knowledge gap and provide quantitative information to be used by all the stakeholders involved in policy, land use planning and agricultural intensification. Given the prime position of agriculture in the Ethiopian economy, the objective of this study, therefore, is to examine the existing utilization of farm inputs and the yield obtained and to identify the determinant factors influencing the intensification of agricultural production in terms of yield of major crops at household level in the KTZ.

2. Methodology

2.1. Descriptions of the study area

The study is conducted in Kembata Tambaro Zone which is found in SNNPR, Southern Ethiopia. The zone is located around 306 km south from the capital city of Ethiopia, Addis Ababa. Astronomically it is located or extends from $7^0$10'N to $7^0$50'N latitude and from $37^0$34'E to $38^0$08'E longitude. KTZ has an area of 1,356 km^2 with elevations ranging from 501 meter at Gibe River to about 3000 meter in the Ambaricho Mountain (SNNPR, BoFED, 2013). The zone experiences three agro-climatic zones namely Dega, Woinadega and Kola[1]. 22.25 percent or 33,880.52 ha of the zonal surface area fall in the Dega climatic zone. Area covered by Woinadega zone is 70.75 percent or 107,732.44 ha. Kola zone covers an area of 10,659.04 ha. The rainfall is erratic. The weighted mean annual rainfall ranges from 1001-1400 mm. The spatial variation of mean annual temperature ranges from 12.6$^{\circ}C$ to 27.5$^{\circ}C$ (KTZ, DoARD, 2012). Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia, Kembata Tambaro Zone had a total population of 792,999, of whom 392434 were males and 400565 were females with 84.4% (669291) rural and 15.6% (123708) urban. The crude population density of the zone is 585 persons/km^2 (CSA, 2007). Small scale mixed farming is the dominant source of livelihood to the farmers. Wheat, *teff,* maize, sorghum and barely are the major crops of study area while coffee and ginger are the sole major cash crops. The zone is endowed majorly with cattle, sheep, goats and poultry production (Fig 1).

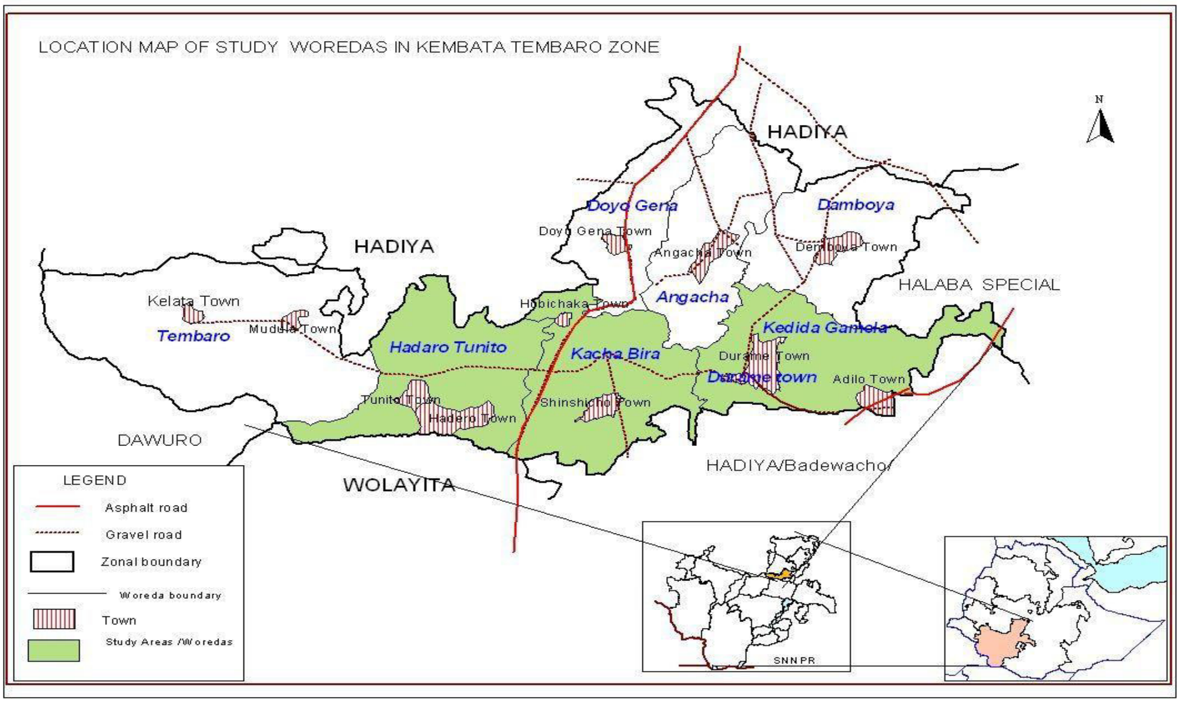

Fig.1 Location Map of Ethiopia, SNNPR, and Kembata Tambaro Zone

2.2. Data types, Methods of Data Collection and Sampling Procedure

Primary and secondary data were collected for the study. A huge amount of farm level primary data was collected from the study area individual farmers through personal interview using a well defined- structured questionnaire with close ended questions. Secondary data were obtained from different published research journals, books and unpublished theses, CSA Agricultural sample survey, various reports of FAO and World Bank publications and assessing different records and reports of agriculture and rural development department on input and output prices, farm size, crops area production and yield. The sampling procedures employed were the purposive and stratified random sampling techniques to select the sample farmers. At the first stage, out of seven districts, Kachabira, Kadida Gamela and Hadero tunto Zuriya were selected for the study purposes. At the second stage, three villages were selected randomly from each district. Finally, at the third stage with in these three villages, 28 farm households from each village were selected randomly for interview by chance meeting with them at the time of field survey. Overall 84 respondents from each of three districts and totally 252 farmers were interviewed to collect the farm level primary data.

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[1] Dega = cool; woinadega = temperate; kolla = lowland or warm climate

2.3. Methods of Data Analysis

Two types of data analysis namely descriptive statistics and econometric analysis were used. To examine the existing utilization of capital inputs by the farming rural households in the study area, the farm level data concerning the total land size cultivated and the farm inputs used including the yield obtained were analyzed through descriptive statistics like mean, percentage and standard deviation. These were analyzed in the three farm size structures. To analyze the determinants of major crops yield, multiple linear regression function (The Linear form of Cobb Douglas Production Function) was used. The descriptive and econometric analyses were conducted using SPSS version 16.

There are many different approaches in measuring agricultural intensification. The measures included: area under irrigation, number of harvests per year, input and output per hectare and per person, capitalization per hectare and per person, population density per hectare, and energy consumption per hectare (Leaf, 1987). But for the purpose of this analysis, the study used the amount of yield of major crops (in kilogram) produced per hectare, which symbolizes overall efficiency as our response variable.

The Cobb-Douglas production function is an economic mathematics model that describes production input and output under certain assumptions. It indicates functional relationship between a certain combination of whole production factors input and the possible maximum output with same technology. The Cobb-Douglas Function is among the best known production functions utilized in applied production function (Enaami *et al.,* 2011).

In economics, this form of production functions is widely used to represent the relationship of an output to inputs. Charles Cobb and Paul Douglas considered a simplified view of economy in which production output is determined by the amount of labor involved and the amount of capital invested (Cobb and Douglas, 1928). The function they used to model production was of form:

$$P\ (LK) = b\ L^{\alpha}\ k^{\beta} \qquad (1)$$

where, P = Total production (the monetary value of all goods produced in a year), L = Labor input (the total number of person-hours worked in a year), K = Capital input (the monetary worth of all machinery, equipment, and buildings), b = total factor productivity, α and β are the output elasticity's of labor and capital, respectively.

Linear regression based on Ordinary Least Squares (OLS) is a feasible method to analyze linear relationships but is worthless when relationships are non-linear. However, a non-linear relationship between an independent variable and the dependent variable can be converted into a linear relationship by a logarithmic transformation of variables (D'Ambra and Sarnacchiaro, 2010). Cobb-Douglas Production Function having exponential relationships which is quite common in the rational theories of economics can be turned into linear relationships by taking the natural logarithm of separate variables (Pennings *et al*., 2006).

The Cobb-Douglas production function, in its stochastic form may be expressed as

$$Y_i = \beta_1 X_{2_i}^{\beta 2}\ X_{3_i}^{\beta 3}\ e^{\mu_i} \qquad (2)$$

where, Y = Total output, x_{2_i} = Labor input, x_{3_i} = Capital input, μ = Stochastic disturbance term, β_2 and β_3 = Output elasticity's of labor and capital

This equation shows the non-linear relationship between output and two inputs. The following equation can be obtained by the log-transformation of equation 2:

$$LnY_i = \ln \beta_1 + \beta_2 \ln x_{2_i} + \beta_3 \ln x_{3_i} + \mu_i$$

$$= \beta_0 + \beta_2 \ln x_{2_i} + \beta_3 \ln x_{3_i} + \mu_i \qquad (3)$$

The model is linear in the parameters β_0 , β_2 and β_3 and is therefore a linear regression model. This model is a ln-ln/double ln or ln-linear model.

Whenever there is ln-linear regression model involving the number of variables, the coefficient of each of X variables measures the partial elasticity, the output with respect to that variable. If there is K number of independent variables, the ln-linear model would be as follows:

$$LnY_i = \ln\beta_0 + \beta_2 \ln x_{2i} + \beta_3 \ln x_{3i} + \text{---} + \beta_k \ln x_{ki} + \mu_i \qquad (4)$$

Each of regression coefficient, $\beta 2$ through βk is the partial elasticity of Y with respect to variables X2 through Xk (Gujarati 2003).

Empirical Model Specification: The econometric tools were employed to find out the determinants of yield of major crops of farmers in the study area. A double natural log function was used by employing Ordinary Least Square (OLS) method to investigate the relationships between different explanatory variables and major crops yield (dependent variable). The following general farm model equation was used to test the hypothesis regarding determinants of yield of major crops:

$$LnY = \alpha + \beta_i \sum_{i=1}^{n} LnXi + Yi \sum_{k=1}^{n} Di + ei \qquad (5)$$

where, LnY= Yield of major crops (dependent variable), Xi = List of independent continuous variables, Di = List of independent dummy variables, α, β_i and Y_i = production function parameters to be estimated, e_i = Disturbance term

Major Crops yield Ln-Ln Production Function:

LnYLD = β_0 + β_2 LnARSOWN + β_3 LnPRODPR + β_4 LnPLOW + β_5 LnSEDRAT + β_6 LnFAMLAB+ β_7 LnHRLAB + β_8 LnDIVERINC + β_9 LnVARCOST + β_{10} LnEXPR + β_{11} *Ln*FERT + β_{12} LnAGHH + β_{13} LnEDUHH + β_{14} LnHHSIZE + β_{15} LnAGCRED + β_{16} LnMKTDIS+ β_{17} DAVISIT (D) + β_{18} OXEN (D) + β_{19} SMLFRMS (D) β_{20} MEDFRMS (D) + β_{21} LARFRMS (D) + e_i (6)

Where, β_0 = Ln β_1 each of the (partial) regression coefficients, β_2 through β_{16} is the (partial) elasticity of crops yield with respect to ARSOWN through MKTDIS.

Definition of variables:

Dependent variable: YLD = Yield of major crops (*teff*, wheat, maize, barely) (Kg/ha)

Table1 Definition of explanatory variables and their expected sign in Ln-Ln Production Function

Variable name	Definition of variables	Hypothesized relationship
ARSOWN	Area sown (in ha)	positive
PRODPR	Product (crop) price (in ETB)	positive
NOPLOW	Frequency of plowing (in number)	positive
EXPR	Farming experience (in years)	positive
SEDRAT	Seed rate (in kg/ha)	positive
FERT	Quantity of fertilizer applied (in kg/ha)	positive
VARCO	Variable cost (in ETB/ha)	positive
DAVISIT	a dummy variable, contact with extension agent 1 is yes, 0 otherwise	positive
AGHH	Age of the household head (in years)	positive
EDUHH	Household head's education (in years)	positive
HHSIZE	The size of family members in the household (in number)	positive
FAMLAB	Number of labor (between age of 15 and 65) in a farm household (Hrs/ha)	positive
HRLAB	The availability of hired labor for agriculture (Hrs/ha)	Positive
DIVERINC	It is a continuous variable that is ETB received from non-farm and off-farm activities (ETB/annum)	Positive
MKTDIST	Market distance (in km)	positive
AGCRED	Agricultural credit (ETB)	Positive
OXEN	A dummy variable, oxen ownership for traction =1, otherwise 0	Positive
SMLFRMS	Small farms (dummy)	negative
MEDFRMS	Medium farms (dummy)	negative
LARFRMS	Large farms (dummy)	negative

3. Results and Discussion

3.1. Descriptive results

For descriptive data analysis, the sample farms were classified into three distinct size categories on the basis of operational landholdings as small farms having less than 1ha, medium farms with 1ha to 1.5 ha and large farms with more than 1.5 ha. Overall 51.6 percent of farms belong to the small farm size category while 33.3 percent were included in the medium and 15.1 percent are included in large farm size category. Average farm size for small farms category is 0.58 ha, for medium 1.2 ha and for large farm size category it is 1.88 ha. As farm size structure increases from small to large, the percentage of farm size decreases with similar pattern (Table 2).

Land and labor are the most important factors in agricultural production while the effect on average yield per hectare is different across farm size categories. The total land cultivated and labor used in the study area is 247 hectares and 1613 hours per hectare respectively. The labor demand for farming is met by family labor and hired labor. Most farm labor comes from family labor which accounts for 62.7 percent of the farm labor, while the share of hired labor is 37.3 percent. Overall, 1010 family labor hours per hectare are involved in farming activities annually. Large farms have only about one fifth family labor per hectare (423 hrs) as compared to that of small farms (2240 hrs). Family labor involved in farming is high in small farm households as compared to that of medium and large farm households. Per hectare hired labor constitutes small portion compared to total labor involved in farming.

The farming technology in the study area is traditional, simple hand tools and oxen driven implements. However, most of the farm households use capital input such as fertilizer and improved seed. The overall improved seed used for sowing maize, wheat, barley and teff is 33kg/ha which decreases with the increase in the farm size category. Small farms use highest per hectare improved seed (36 kg/ha) than medium (31kg/ha) and large farms (29 kg/ha). Similarly, the overall quantity of fertilizer applied in their farm land for the production of all major crops per hectare is 229 kilogram. Small farms applied highest percentage fertilizer (247 kg/ha) followed by large farms (221 kg/ha) while medium farms (204 kg/ha) used the lowest amount of fertilizer. The total purchased inputs cost per hectare also decreases with the increase in the farm size category. The overall expenditure of farm household on improved seed, fertilizer and pesticide per hectare is 2219 Ethiopian Birr. The input cost at small farms is higher (ETB 2345 per hectare) than that of medium (ETB 2096 per hectare) and large farms (ETB 2058 per hectare).

Table 2. Description of farm inputs and major crops yield

Farm category	Small	Medium	Large	Total
Total cultivated land size (ha)	75.05	100.65	71.38	247.08
Mean	0.58	1.20	1.88	0.98
Std.Dev	0.19	0.17	0.28	0.51
% age of farms	51.6	33.3	15.1	100.0
Family labor (hrs/ha)	2240.37 (1326.66)	896.29 (530.75)	422.98 (250.47)	1010.4 (74.79)
Hired labor (hrs/ha)	673.50 (1039.23)	576.55 (889.63)	589.47 (909.57)	602.4 (929.52)
Total labor (hrs/ha)	2913.87 (2405.39)	1472.84 (1215.82)	1012.45 (835.77)	1612.8 (1331.36)
Improved seed (kg/ha)	35.51 (21.76)	31.06 (20.32)	29.30 (22.43)	33.09 (21.46)
Fertilizer used (kg/ha)	246.99 (273.24)	204.19 (154.39)	221.24 (177.70)	228.84 (226.48)
Total purchased inputs cost (ETB/ha)	2345.16 (916.96)	2096.13 (503.70)	2057.83 (456.24)	2218.82 (750.96)
Maize yield (kg/ha)	2577.50 (3732.45)	1067.76 (1299.55)	564.78 (495.53)	1770.75 (2911.56)
Wheat yield (kg/ha)	2166.80 (3132.36)	988.55 (1154.03)	419.59 (694.31)	1510.58 (2459.38)
Barely yield (kg/ha)	1213.49 (2176.96)	667.69 (969.91)	347.53 (564.93)	900.98 (1705.57)
Teff yield (kg/ha)	1087.40 (1315.99)	463.95 (438.88)	271.02 (227.88)	756.48 (1040.41)

Source: Computed from survey data 2015. Figures in parentheses are standard deviation.

The overall maize yield of study area is 1771 kilogram per hectare which is below national average. The maize yield of small farms is the highest (2578 kg/ha) followed by medium farms (1068kg/ha) while large farms (565kg/ha) have the lowest maize yield. The overall wheat yield of study area is 1511 kilograms per hectare. This yield of study area is also lower than the national average. The wheat yield of small farms is highest (2167kg/ha) followed by medium farms (989 kg/ha) while large farms (420kg/ha) have lowest yield. Similarly, the overall barely and *teff* yield of study area is 901 kg/ha and 757kg/ha respectively. The yield of barely and *teff* crops is highest in small farms (1214 kg/ha and 1087 kg/ha) followed by medium farms (668 kg/ha and 464 kg/ha) while large farms have lowest yield (348kg/ha and 271 kg/ha) respectively. The main reason for lower yield of the major crops in the study area as compared to the nationally reported average yields is the low rainfall during summer season in 2014 as compared to the same duration of previous years. The comparison of small, medium and large farms of each crop production system highlights the fact that small farmers are the most efficient with highest yield per hectare.

3.2. Regression results

Multiple linear regression function (The linear form of Cobb-Douglas Production Function) was used to find out the determinants of major crops yield. For this purpose the natural logarithm of dependent variable and all independent variables was taken. The usual problem in the cross sectional farm level data is multicollinearity. The Variance Inflation Factor (VIF) was used for testing multicollinearity. Generally, when VIF > 10, it is assumed that high multicollinearity exists between the exogenous variables (Gujarati, 2003).

Table 5 displays the results of major crops yield Ln-Ln production model. Overall 20 independent variables are used in the production function to determine their relationship with four major crops yield. Linear regression models for four major crops are overall highly significant at 1 percent significance level. Out of 20 independent variables 10 have significant affect on four major crops yield (kg/ha). The coefficient of variance ranges from 0.81 to 0.99 which shows that variables included in the models describe the sufficient variance in the dependent variable. The mean value of VIF for all crops shows that the model does not have serious problem of multicollinearity.

There is an inverse relationship between area sown and teff, maize and wheat yield which are statistically highly significant with strong coefficients (-0.068, -0.309 and -0.674) respectively. This elasticity shows that with 1 percent increase in sown area in the study area, on average per hectare yield would reduce by 0.07, 0.31 and 0.67 percent. The area sown is not significant variable to affect barley yield. Product price has significant positive affect on all major crops per hectare yield with high coefficient of 0.063, 0.135, 0.912 and 0.231 for teff, maize, wheat and barley yields respectively. This means that a unit increase in product price will raise the crops yield by 0.063, 0.135, 0.912 and 0.231 respectively. The implication is that the yield of major crops is responsive towards financial incentive to farm households.

The result of the study indicated that hired labor and quantity of fertilizer used are important to increase the yield of major crops. Hired labor has negative relationship with *teff* yield (highly significant at 1%) with the coefficient of -0.123 while for maize and barely it has positive relationship with the coefficient of 0.445 and 0.138 respectively at 10 percent level of significance but it has no significant effect on wheat yield. The amount of fertilizer used has significant positive affect on wheat and barley yields (significant at 5%) with the coefficient of 0.100 and 0.188 respectively while it has no effect on *teff* and maize yield. The frequency of plowing, seed rate, family size, family labor and variable cost has no significant affect on commodities yield.

Table 5. Comparative results of determinants of major crops yield
Dependent variable: Yield (kg/ha)

Variables	*Teff*	Maize	Wheat	Barely
R²	99.9	98.5	97.8	81.2
F	8.623***	38.490***	94.625***	4.550***
Mean VIF	2.848	5.623	5.518	6.379
(Constant)	-.399**	4.837***	-1.540***	6.473***
Crop area (ha)	-.068***	-.309***(3.885)	-.674***(-3.212)	-
Product price (ETB)	.063***(3.632)	.135***(5.253)	.912***(22.90)	.231**(2.737)
No of plowing	-.060(-1.240)	-	-.145 (-0.857)	-.220(-0.779)
Seed rate (kg/ha)	-.028(-1.239)	-	-	-
Hired labor (hrs/ha)	-.123***(-4.00)	.445*(2.136)	.004 (0.141)	.138*(1.956)
Family labor (hrs/ha)	.006(0.313)	.031(0.960)	-.006(-0.173)	.016(0.165)
Quantity of fertilizer used (kg/ha)	-.102(-1.603)	-	.100**(2.353)	.188**(2.131)
Variable cost (ETB)	-	-.306 (-1.835)	-	-.079(-0.778)
Farming experience (yrs)	-.040(-1.375)	.104**(1.895)	-	.012(0.145)
Age of the household head (yrs)	-.083(-1.439)	.003 (0.267)	- .133**(-2.106)	-.079(-0.413)
Family size (no)	-	-	.035 (0.447)	-.044(-0.263)
Education of head (yrs)	-.006(-0.225)	-.122(-1.863)	.052**(2.447)	.049(0.965)
Agricultural credit (ETB)	-	.080	.023 (1.308)	.021(0.693)
Market distance (km)	.090**(3.384)	.075**(2.237)	.015 (0.666)	.060*(1.826)
Non-farm income (ETB)	.018**(2.062)	.163***(3.406)	.031**(2.572)	.065**(2.348)
Oxen ownership (D)	.021(1.273)	-	-.002 (-0.096)	-.012(0.278)
DA's farm visit (D)	.044**(2.238)	.342**(2.856)	.011 (0.487)	.020***(2.250)
Small farms (D)	-	.117 (0.837)	.560**(2.721)	.281***(3.577)
Medium farms (D)	.033**(2.418)	-	.026 (-0.358)	-
Large farms (D)	.009(0.220)	.075**(2.237)	-	-.018(-0.384)

*Significant at 10% level, **Significant at 5% level, ***Significant at 1% level. Source: Based on Author's survey data 2015. Figures in bracket are t-values

The study implied that most of the farming households have been practicing farming for long and this accumulated years of experience is expected to have a considerable effect on their productivity efficiency. Therefore, farming experience positively affected the maize yield of the households at 5 percent level of significance with the elasticity of 0.10 percent while it has no affect on other crops yield. The age and education of the household head have strong negative and positive relationship with wheat yield respectively. Both are significant at 5 percent level of significance with the coefficient of -0.133 and 0.052 respectively while they didn't affect *teff*, maize and barely yields. Agricultural credit and oxen ownership have no significant relationship with the yield of commodities.

Market distance has significant positive affect on *teff*, maize and barely yields (highly significant at 5% and 10% level) with an elasticity of 0.090, 0.075 and 0.060 percent respectively while it is not significant variable to affect wheat yield. Unless the markets develop, farmers will have no incentives to raise their agricultural productivity through investing in external inputs like improved variety seeds, inorganic fertilizer and hired labor. Nearest farm households from their farmland intensified more than the distant farm households.

Farmers with more contact to the development agents had higher probability to use inorganic fertilizers. The results show that the development agent's visit to farmers has significant and positive affect on major crops yield except wheat production. Teff yield and maize yield are significant at 5 percent level of significance with the coefficient of 0.044 and 0.342 respectively while barely yield is significant at 1 percent significance level with the coefficient of 0.020. Thus, household heads who received frequent visit from the development agents had much higher crops yield than those without frequent visit from the development agents.

The purpose of agricultural intensification is to increase the land productivity and yield of crops per hectare through increased use of inputs or better quality inputs. Farm households with more diversified sources of income have a higher agricultural productivity, since expenditure on farm input is dependent not only on agricultural production, but also on off/non-farm income because of capital market imperfections. Therefore, the finding of this study shows that off/non-farm income positively affected the yield of maize, teff, wheat and barley at 1 percent and 5 percent significance level with an elasticity of 0.163, 0.018, 0.031 and 0.065 percent respectively. This result is in agreement with the study conducted by Babatunde and Matin (2010) and Babatunde R.O (2013) in Nigeria and Wang ye *et al.* (2011) in Rural China. Similarly, the results of Mathenge and Tschiery (2009) study suggest that off-farm income has a high and significant effect on fertilizer use and relieves credit constraints to agricultural intensification among households that are not a member of credit groups.

On the contrary, Mezid and Bekele (2014) argued that household's engagement in off-farm activities is inversely related to crop production implying that the rural non-farm economy competes with agriculture for labor. This does not hold true for the study area of current investigation. The reasons may be labor intensive type of agriculture of area and the abundant family labor force. The average household consists of about six family members. The overall operational land holding of area is small while family labor is more than the farm operation's requirement of majority of small and medium farms. The household head is usually the eldest male of family. Hence the involvement of some of the farm household members in off-farm activities doesn't affect the farm operations.

Small farms are good in producing wheat and barley crops while medium and large farms are favorable for only *teff* and maize production respectively. The results are significant and consistent with the models of output per hectare, reflecting that small farms use more input and labor unit per hectare than do large farms. The possible reason may be due to differences in soil quality and differences in soil productivity which affect output, with the assumption that the small farms are more productive because of having plots of better quality.

4. Conclusions and Policy Recommendations

Rural farm households in the study area are smallholders and cultivated less than one hectare land. Most farm labor comes from family labor which accounts for 62.7% of the farm labor. Family labor involved in farming is high in small farm households as compared to that of medium and large farm households. Most of the farm households use capital inputs such as fertilizer and improved seed. The overall improved seed, fertilizer used and cost incurred to purchase these farm inputs decreases with the increase in the farm size category. Small farms use higher per hectare improved seed and fertilizer and incur more cost on inputs than medium and large farms. As a result of this intensive use of capital inputs, there is an impressive and significant increase in major crops yield. The yield of all targeted crops is highest in small farms followed by medium farms while large farms have the lowest yield. The comparison of small, medium and large farms of each farming system highlights the fact that small farmers are the most efficient with highest yield per hectare.

The econometric analysis demonstrated that the rural households in this study area intensify their agricultural production when they have higher educational level and long farming experience. The scope for agricultural intensification also gets boosted when the farmers have more number of non-farm income sources to purchase farm inputs and hire labor and applied the recommended rate of fertilizer. Finally, market distance and development agent's regular visit to the farmers have a significant influence on the smallholders' agricultural intensification. So, the concerned bodies should give due attention to the significant variables. Thus, it is recommended that the government should strengthen a policy framework through training on modern agriculture technologies and modernization of indigenous farming techniques for both farm households and development agents in addition to identifying appropriate technologies for households' intensive farming practices which may attract the younger more. In addition, when farmers sell their agricultural produce competitively they are able to reduce the income constraint hence are able to purchase the external inputs that are required to increase agriculture productivity. Therefore, infrastructure (rural road constructions and feeder roads) for market development needs due attention. Moreover, access to alternative non-farm income leads to higher use of capital-intensive agricultural strategies. Due to this, policy has to be strengthened on an integrated agriculture system for sustainable agricultural intensification through livelihood diversification to supplement agricultural intensification.

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