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Factors Affecting Productivity of Smallholder Potato Growers in Bore District, Guji Zone, Oromia Regional State, Ethiopia

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Abstract
Agricultural production of the Ethiopia is mostly dominated by smallholders. But due to various chronic constraints the productivity of smallholders are low. Seven kebeles were randomly selected. Based on proportion to the number of potato producers in the selected kebeles, 192 sample size was used. Questionnaire and Focus Group Discussion were employed to collect primary data while secondary data were collected from different sources including reports and internet. The collected data were analyzed by frequency, percentage, mean and standard deviation. The mean of productivity of potato was 109.95 qt/ha. The results of Ordinary Least Square showed that sex, improved variety, fertilizer, education level, experience, access to extension, harvesting time, soil conservation, nature of access to land, access to market and access to irrigation schemes affect productivity of smallholder potato growers. To improve the productivity of smallholder potato growers' provision of improved seed, use of fertilizers and chemicals as recommendation should be used by the smallholders. In addition, the smallholders should conserve their soil and harvest potato as soon as it matured. Furthermore, legal rules that sustain agreement on share and contract land use, developing market access by agricultural cooperatives and mobilizing smallholders to form groups should be encouraged to bring reliable market access for smallholders' product.
Keywords: Potato, Bore, Smallholder, Productivity, Ordinary Least Square.

1. Introduction

In Ethiopia, agriculture plays an important role as the primary source of food and income for the poorer sections of the population (Tassew, 2014). In Ethiopia, agriculture is the most important sector which accounts 46% of GDP, 80% of export value and about 73% of employment (Aklilu, 2015). In addition, agriculture of the country supports 98% of the total calorie supply and 70% of industrial raw material supplies (Assefa, 2014). The sector still remains largely dominated by rain-fed subsistence farming by smallholders (Aklilu, 2015). Having all these importance, however, Ethiopian agriculture is characterized by subsistence based farming, poor management practices, low productivity, low level of inputs, lack of post- harvest management, market failure, poor linkage between research and extension, diseases and adverse climate conditions.

There are about 13 million smallholder farmers accounting for 95% of total production in Ethiopia (Dawit, 2012). However, smallholder productivity is still well below its potential (Dube and Guveya, 2014). Even though smallholder farmers are increasingly being recognized as important contributors to enabling global food security, smallholder's production is fraught with a multitude of challenges, including low yields, low quality of crops, lack of access to markets and credit. In addition, most smallholder and emerging farmers faced with a range of technical and institutional factors influencing marketing access for their product.

Potato (*Solanum tuberosum* L.) is the fourth most important food crop in production after maize, wheat and rice (Ayalew, 2014). It produces considerably more energy and protein than cereals (Haverkort *et al*., 2012). Potato is also the fastest growing staple food crop and source of cash income for smallholder farmers in Ethiopia (Beliyu and Tederose, 2014; Berhanu and Getachew, 2014). In the main production season, average potato productivity on research based and farmers level is 29-45 t/h and 22 t/ha respectively (Ali *et al*., 2014). This productivity gap between research based and smallholder farmers could be due to mismanagement practices done by the smallholder farmers, lack of improved seed and adverse climate conditions.

The government of Ethiopia and its research institutions have invested a lot of money and time improving the technology and quality of potatoes to increase smallholder production systems. Despite the presence of good research and extension system, Bore smallholder potato growers are still having low productivity. Up to date, there is no study on stallholders' productivity from the disseminated potato in the study area. Thus, this study was intended to analyze the factors affecting productivity of smallholder potato growers in Bore district, Guji Zone, Ethiopia.

2. Description of study area

Bore is 385 km away from Addis Ababa to the South. The district is bordered by Hula district of SNNPR in the North, Ana Sora district in the South, Bona district of SNNPR in the East and Dama district in the West. Bore is divided into 33 rural kebeles and 3 town kebeles (BoARDO, 2015). The total population of the district is 158359. About 92% of population lives in rural area. The major agro-ecology of the district was highland (90%) and

midland (10%). Annual average of temperature of the district is 16.05 ^{0}C. The mean annual rainfall is 1300mm while its altitude ranges from 1400 up to 2910 meter above sea level allowing a favorable opportunity for wider crop production and better livestock rearing. From the total land area (64395 ha) of Bore district, 37375 ha was allocated for annual crops where 57.7% covered by cereals, 21.5% pulses, 10.3% root crops, 8.7% vegetables and 1.8% covered by cash crop namely coffee.

Root crops such as carrot and onion and vegetable crop like cabbage could be grown throughout the year but majority of smallholders commonly produce these crops during *belg* season. Potato is also one of the root crop mostly grown in the study area. In Bore district potato is used as cash crop and household consumption. Wheat, barley, field bean, faba bean, *teff*, haricot bean and others crops were also produced in the district. At Bore district, cattle, horses, sheep and bee keeping are the dominant livestock. Selling of milk is one of income generating activity for rural women. Bore is also well known by its 'white honey' which is produced from different vegetation distributions found in the district. Most rural youth and male farmers of Bore district are migrant to extract minerals namely gold to maintain their income during off season.

3. Sampling procedures

Bore district was purposively selected as the district has potential for potato production. The district has 33 *kebeles* out of which 14 *kebeles* are major growers of potato. In the first stage, seven *kebeles* were selected randomly from 14 *kebeles* of major growers of potato and the number of respondents were determined by using probability proportional to size. Simple random sampling technique was employed to select the size of the sample smallholders from each kebele. From 3428 household heads producing potato in the district a total of 192 household heads were selected by simple random sampling method. To determine the required sample size, this study employed a simplified formula developed by Yamane (1967) at 93% confidence level and 10% non-response rate as provided below:

$$n = \frac{N}{1+N(e)^2} = \frac{3428}{1+3428(0.07)^2} = \frac{3428}{17.7972} = 192.$$

Where, n= sample size for the study, N= total number of household head producing potato
e= margin of errors at 7% and 10% non-response rate.

4. Data collection Methods

For this study, primary data was collected by using structured and non-structured questionnaire interview. The questionnaire was reviewed by Development Agents and different researchers for a sake of relevancy of questionnaire to respondents' characteristics like their languages. After translation to local language (Afaan Oromo), questionnaires were pretested on ten (10) farmers outside the sample size and the final questionnaire was prepared using responses obtained from the pre testers. This is done in order to ensure the content validity of questionnaires. Primary data was collected by trained enumerators and collected from smallholders who were growing potato in 2015 *belg* season. Three Focus Group Discussions (FGDs) having 5-8 members were conducted in order to generate information and elaborate factors affecting productivity of potato. Secondary data such as literature review, district report on potato work and number of smallholders participating on potato farming was collected from reports of the district.

5. Data Analysis

Descriptive statistics like means, percentages, standard deviation and frequencies were used in analyzing socio-economic characteristic of respondents. Multiple regression model (Ordinary Least Square) was employed to analyse factors affecting productivity of potato in Bore district. There are various functional forms for expressing production relationships such as: Polynomial, Linear, Cobb-Douglas, quadratic, semi log and square roots. In this study ordinary least square (OLS) was used to analyze factors affecting productivity because the OLS estimator is known as best, linear, unbiased estimator (BLUE) under the validity of a particular set of assumptions. The underlying OLS assumptions are as follows: (1) the variance of independent variables is the same all over the ranges; (2) the variance of error term value is approximately the same over all ranges of independent variables; (3) the expected value of each disturbance (error term) is equal to zero. However, when these assumptions are violated, this would weaken the validity of the results obtained from the regression (Fred *et al.*, 2012). The result of multicollinearity test, contingency coefficient, Shapiro test and specification error test showed that the assumption of OLS fulfilled, hence the result was unbiased for conclusion (Appendix Table 1-4).

Following Obasi *et al*. (2013) and Osondu and Ijioma (2014), four (4) functional forms of production namely linear, semi-log, double-log and exponential were fitted using OLS technique under the assumption that the data fulfilled the assumptions of the multiple regression models. The lead equation was chosen based on a prior theoretical expectations, magnitude of the coefficient of multiple determinations (R^2) and statistical significance of the coefficient. The explicit forms of productivity analysis model were as follows:-

$Y= \beta0+ \beta1X1 + 2\beta X2 + \beta3X3 + \beta4X4 + \ldots\ldots\ldots\ldots + \beta16X16+ et$ (Linear) ……..1
$lnY= \beta0 + \beta1lnX1 + \beta2lnX2 + \beta3lnX3 + \beta4lnX4 + \ldots + \beta16X16+et$ (Double-Log)……..2
$Y= \beta0 + \beta1lnX1 + \beta2lnX2 + \beta3lnX3 + \beta4lnX4 + \ldots.. + \beta16X16+et$ (Semi-Log)…….….3
$lnY = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \ldots\ldots\ldots...+ \beta16X16+ et$ (Exponential)……..4

Where, Y= represents the yield per hectare of potato produced, β0 = constant, βi = estimated coefficients of the explanatory variables, X1-16 = independent variables: age of household head, sex of household head, education level of household head, potato farming experience of farming household head, household size, seed variety, fertilizer, farm size, soil conservation, harvesting time, access to extension, credit, market, irrigation, nature of access to land and seed cost, et = error term.

6. Results and Discussion

6.1. Continues variables characteristic of respondents

General information of the potato growers in the study area was presented in Table 1. The result showed that the mean age of smallholder farmers was 39 years indicating that most of the households were in the active age group engaged on production of potato. The study area seems highly populated since the mean household size was 8.46 persons per household. Culturally, in the study area, it is common that the male households were married to many women resulting high household size. This high household size could influence productivity since greater family labour being available to the household for the timely operation of farm activities could increase yield. The mean of experience household head was 3.56 years. Land size is key resource for production of potato. In the study area, the average land holding of household was 2.1 hectare while 1.44 hectare and 0.69 hectare was allocated for crop and livestock rearing.

Major animals owned by the sampled smallholder are cows, oxen, horse, sheep and bee keeping. This could imply that livestock ownership has impact on potato production, for instant, oxen used for ploughing while horses used as transporting potato to the market. In terms of land allocation, Table 1 shows that, on average, 0.38 hectares of land per household is allocated for potato farming as compared to 0.42 and 0.34 hectares for wheat and maize, respectively. Potato has higher productivity (109.95 qt/ha) than other crops produced in the study area but less than the country's average which was 137 qt/ha (CSA, 2015). In the study area potato is consumed either when cooked alone or with *wot.* In study area, *enset* was used for household consumption though it is very difficult to know its productivity due to its measurement was in unstandard bags and intermittently extracted when it was needed by smallholder.

Table 1. Household and farm characteristics of selected respondents

Characteristics		N	Mean	Std. Dev
Age of household head in years		192	38.83	8.352
Household size in numbers		192	8.46	3.042
Experience of household head		192	3.56	1.832
Farm size	Farm size allocate for crop production	192	1.44	0.712
	Farm size allocate for livestock rearing	192	0.69	0.578
	Farm size allocate for potato per crop	192	0.38	0.189
Number of animals owned	Cows	192	5.60	5.063
	Oxen	192	2.29	2.368
	Sheep	192	5.27	3.603
	Horses	192	2.14	1.717
	Goats	192	0.19	0.752
	Beehives	192	2.90	6.041
	Hens	192	6.66	4.296
	Others	192	0.18	0.446
The farm size of major crop produced in the study area	Potato	192	0.38	0.189
	Wheat	151	0.42	0.508
	Barley	158	0.31	0.122
	Maize	129	0.34	0.317
	Enset	189	0.28	0.183
Inputs used per hectare	Potato seed in Quintals (1quintal= 100kg)	192	12.67	3.390
	Fertilizers in Quintals	192	93.70	37.570
Seed cost	Potato seed cost per hectare	192	4300.52	1448.51
Productivity of major crop during survey period	Potato	192	109.95	19.20
	Wheat	151	22.60	3.838
	Barley	158	13.62	3.170
	Maize	129	20.71	4.853
	Enset	189	-------	--------

6.2. Dummy and categorical related respondent characteristic

Out of 192 sampled respondents, 79% were male headed and 21% was female headed household. More educated persons have good and confident relationship with Development Agents thus they can maximize their yield of potato. Seed varieties could affects the productivity of smallholders. In the study area, most smallholder were using the improved seed (77.6%) purchasing from agricultural office and Community Based Organizations of potato producers. They also used their own seed and purchased from market and other sources for their production. The use of above and below the recommended amount of fertilizer can influence the production. The recommended DAP and Urea for potato in the study area is 100kg and 165kg respectively (BoARC, 2013). However, the amount of fertilizer used by respondents were below the recommended. Majority of the respondents were not using pesticide in case of Late Blight disease. Rather they prefer to use the traditional mechanism like removing the infected tubers and adding ash to minimize late blight severity. Despite of these local methods prevention by the respondents, Late Blight has been highly affecting the production of potato in Bore district.

Soil conservation play a great important role in production of the crop. Majority (96%) of the respondents were conserving their soil land. Potato could stay under the ground without harvesting at its maturity time. This could help poor smallholders who have no storage facilities. But being in the ground, potatoes are susceptible for insects, animals or even they may sprought under the ground which affects the production of potato. A visible concern of many smallholder is land insecurity with impacted for low yield of the crop. But in the study area, majority of the respondents produce potato on their own land (77.6%). Other form of land acquisition in production of potato was share (9.4%) in which land user contribute all costs, inputs and provide necessary managements while land owner provide land and share potato yields at harvesting time based on their agreements. There are many agricultural extension services conducted in Ethiopia but major extension services given at farm level are expert advice, training, exchange visit and field days. For this study, respondents assessed these services obtained during potato production seasons. Out of 192 respondents, majority of households (111) have access to extension services like expert advice, training and field days. Access to credit is important for smallholder since loan derived from credit institution would help smallholder to purchase inputs for farm production. Most rural smallholders were characterized by the absence of market for their produce. But in the study area, 53% had access to market information. But during harvesting time, market price would spectacularly fail which tell us smallholder have no access to the market throughout their production seasons. Since smallholder farmers were scattered with no formal farmer associations, they practically had no say on prices. Quite often they have remained price takers. On the other hand poor price has negative consequences to farmers because it results into low or non-use of inputs and poor crop management practices that resulted into poor yields. Being question that quality of information obtained from different sources, smallholder farmers themselves share price information and the supply of inputs among each other.

Table 2. Dummy and categorical variables

Demographic Characteristics of dummy and categorical variables		Frequency	Percent
Sex of household head	Male	152	79
	Female	40	21
Educational level of household head	Non formal	44	23
	Primary education /grade one -four/	49	25
	Primary education /grade five-eight/	39	20
	Secondary education /grade nine-twelve	28	15
	Beyond secondary	32	17
Seed variety used	Improved variety	149	77.6
	Local variety	43	22.4
Soil conservation by respondents	Yes	184	95.8
	No	8	4.2
Harvesting time	As soon as potato matured	102	53.1
	Postponed harvesting	90	46.9
Nature of access to land	Own	149	77.6
	Contract	25	13
	Share	18	9.4
Access to extension services	Access	111	57.8
	No access	81	42.2
Access to credit	Access	119	62
	No access	73	38
Access to market	Access	102	53.1
	No access	90	46.9
Access to irrigation schemes	Access	42	21.9
	No access	150	78.1

The OLS results of the variables that are expected to affect productivity of potato are presented in Table 3.

Even though the R^2 of linear function of productivity measurement was lower than double log function but higher than the other functions, it was chosen based on theoretical, prior hypothesis and fulfilling assumption of OLS model. The R^2 of the model was 85.72%. The R^2 (85.72%) denotes that 85.72% of the total variation of the dependent variable (productivity) is explained by the independent variables included in the multiple regressions. The remaining 14.28% due to random error in the model. The test of significance of the R^2 produced an F-value of 73.65 which was significant at 1%, implying linear function gave a good fit to the data and the joint effects of all the independent variables on the productivity variation of smallholder potato growers was significantly above zero. The critical F-value has an n and n-k-1 degrees of freedom, where n is the number of respondents and k is the number of independent variables inter into the model. The standard error of regression coefficients is the measure of error about the regression coefficients. The linear function was therefore chosen as the lead equation and used for discussion.

Out of 16 variables, 12 were found to significantly influence the productivity of smallholder potato growers at different level of significances. The result of the study also confirmed that sex of household head affect productivity of potato at 1% level of significance. This result also similar to the study of Okoli *et al*. (2015). Female households were higher productivity than male household head in the study area. The implication could be male household head most of the time migrate during off season which is also potato's farming calendar in the study area. While women were stayed at home and could provide on right management practices for their farm thus could obtained higher yield than male household heads.

Education affect the productivity of smallholder potato growers at 1% level of significance. Despite the importance of education in increasing farm productivity (Okoli *et al.,* 2015), surprisingly, its effect was negatively significant in this study. More educated smallholder obtain less yield than non-educated in the study area like the study of Nahusenay *et al*. (2015) and contradict studies of Aklilu *et al.* (2015) who stated that more educated get higher yield than non-educate of onion producers. The higher education they reach the more they move away from agricultural activities to non-agricultural enterprises including salaried work and therefore produce only small amount for home consumption and had other enterprises which reduced their time for potato management practices that could influence crop productivity. Experience of potato production was highly affecting the productivity of potato at 1% of level of significance and similar to studies of Okoli *et al*. (2015) and Lawal *et al*. (2013). There is positive relationship between experience and productivity since more experienced could learn production of potato gradually from their practices than their counterparts.

The result of this study showed that seed variety affect the productivity of smallholder potato growers. This result is also similar to study of Asres *et al.* (2013) and contrast to the study of Mugula (2013). Wondwesen *et al.* (2015) also stated that dissemination of improved variety to the farmer is vital to increase the productivity of Irish potato. Amount of fertilizer applied by smallholder was expected to influence productivity of smallholder potato growers. The variable was highly significant and affect positively the productivity of smallholders. The study is similar to the findings of Aklilu *et al.* (2015) and Okoli *et al*. (2015) and contrast with Ogisi *et al*. (2013). Where other variables held constant, additional increase of fertilizer by 1kg led to increase the productivity of smallholder potato growers by 0.17 quintals per hectare. Thus, applying amount of fertilizer based on the recommended in the study area had impact on productivity.

Soil conservation methods while producing potato was expected to affect the productivity of smallholder potato growers. Soil conservation methods can positively determine the productivity of smallholder. Other factors being constant, increase in soil conservation by smallholders increases potato productivity by 1.54 qt/ha. Thus, conserving soil could increase fertility of soil which could increase productivity of crop. Potato yield is a bulky nature. Some smallholder harvest as soon as it matured to use their land for other purpose while others postponed the harvesting time. Harvesting time affect the productivity of potato in the study area. Unseasonable rainfalls affecting potato production. Harvesting during the rain cause rotting resulted to loss of potato. Traders also force farmers to harvest potato early in order to purchase at lower price reducing production of farmers (Kaguongo *et al*., 2015). Harvesting potato as soon as its maturity date increases the productivity. This could be due to no yield loss by insects and by others in the ground. Reuse of the land of potato for the other crops also could increase the productivity of smallholders.

The major role of extension service in agriculture is dissemination of technologies such as agricultural inputs, management practices and advising services to increase productivity of smallholder farmers. The result of this study also confirmed that access to extension services positively affect the productivity of smallholder potato producers. This result also similar to the finding of Lawal *et al*. (2013) and oppose Ali *et al*. (2012) who reported that extension contacts made no difference in the achievement of farmers regarding their productivity. The coefficient of extension service was significant at 1% level of significance. Additional increase of access to extension services on potato increases productivity of smallholder by 20.9 quintals per hectare. This suggests that access to extension services has a great role in increasing productivity of smallholder.

Market access is determined by factors such as, product availability, attributes, prices, costs of these processes and market information (Anim and Mukwevho, 2014). The result of this study showed that access to

the market is also another factor, which positively affects productivity of smallholder. Market access is a critical determinant of farmers' production habits: those who live close to better roads and have more frequent and direct contacts with the market appeared more willing to produce more systematically for the market, while those with poor market access have little incentive to produce crops other than those required for domestic consumption (Onoja *et al*., 2012b). Having market access increases the productivity of smallholders by 0.86 quintals per hectare. The implication is that obtaining and verifying information helps to produce more.

The result of the study also showed that nature of access to land affect productivity of smallholders. This study support study of Asres *et al*. (2013). Contract farm has positive impact on productivity of farming but has smaller impact on total household income (Otsuka *et al.,* 2015). However, Key (2013) argues that contract farm enhance the expansion farm of size especially for small-scale farmers resulted in improvement of productivity from scale effects. Idoma and Isma'il (2014) also indicated that there is relationship between land tenure mode and farmers' level of agricultural output. According to authors, farmers who rent land had higher output of agricultural production than freeholders and communal land owners by justifying renters of the lands who usually have small parcel of land go on intensive agricultural resulting into higher yield. Smallholders produce potato based on different arrangement of land use like own, contract and share in order to increase their productivity.

The result of the study confirmed that irrigation scheme affect productivity of potato at 5% level of significance. This result also similar to the study of Aklilu *et al*. (2015) who reported number of irrigation applied affect yield of onion and Nahusenay *et al*. (2015) studied that small-scale irrigation schemes could improve agricultural. However, in this study there is a reverse relationship between irrigation and potato productivity similar to the study of Singh (2016). This could be due to the amount of water applied to the crop is above the crop's requirement. After tubers were planted some potato tubers have long dormancy period while others early germinate. Frequent usage of irrigation schemes on dormant and late seedling affect the growth of crop. Thus usage of irrigation request the knowledge of when to apply and what amount of water to apply. Seed cost vary across seasons. At harvesting time seed cost is low since there is a surplus production. But at planting time seed cost is high since tubers are highly demanded for planting purpose. Most smallholder farmers expect more yield when they purchased the seed at high cost. This high cost push the smallholder farmers to do necessary management practices that bring high productivity so as to regain the cost they incurred for seed.

Table 3. Factors affecting the productivity of smallholder potato growers in Bore district

	Functional forms											
	Linear (**L**)			Double log			Semi log			Exponential		
Independent Variables	B	Robust Std.err.	T	B	Robust Std.err.	T	B	Std.err	T	B	Std.err	T
Sex	-2.37***	0.41	-5.72	0.02	0.02	1.07	-6.12***	1.14	-5.37	-0.02***	0.004	-6.06
Age	0.001	0.07	0.01	0.01	0.06	0.24	0.77	3.34	0.23	-0.001	0.0007	-0.19
Hhsize	-0.05	0.19	-0.27	0.05**	0.03	1.97	-1.53	1.6	-0.99	0.001	0.002	0.11
Educ	-1.77***	0.43	-4.09	0.01	0.02	0.66	-2.4**	1.08	-2.22	-0.021***	0.004	-5.54
Seedvarity	1.03***	0.36	2.87	-0.02**	0.02	-1.15	2.6**	1.04	2.51	0.01***	0.004	2.92
Farmsize	5.91	3.71	1.59	0.83***	0.03	28.84	3.45**	1.64	2.11	0.04	0.032	1.25
Experience	3.36***	0.52	6.48	0.01	0.03	0.51	10.34***	1.53	6.78	0.03***	0.004	7.2
Fertilizer	0.17***	0.03	6.88	-0.05	0.03	-1.62	13.42***	1.88	7.13	0.006***	0.001	7.49
Conservsoil	1.54*	0.84	1.84	-0.05	0.04	-1.51	4.22**	2	2.11	0.013*	0.007	1.84
Harvestime	3.84***	1.19	3.24	0.01	0.04	0.33	6.89***	2.06	3.35	0.037***	0.012	3
Accesextser	20.9***	0.31	2.93	0.01	0.01	0.67	2.6***	0.81	3.19	0.008***	0.003	2.69
Accesscredit	0.13	0.29	0.43	0.001	0.01	0.1	0.1	0.8	1.12	0.001	0.003	0.39
Accessmrkt	0.86***	0.3	2.93	-0.01	0.01	-0.89	2.33***	0.79	2.93	0.007***	0.003	2.58
Nausela	1.18**	0.48	2.46	-0.004	0.02	-0.18	2.6**	1.25	2.07	0.012**	0.005	2.24
Accessirrig	-0.85**	0.38	-2.25	-0.003	0.02	-0.17	-3.05***	1.03	-2.95	-0.008**	0.004	-2.06
Seedcost	0.003***	6.1E-04	5.35	0.09	0.04	2.16	16.16***	2.38	6.8	3.14E-05***	4.75E-06	6.61
cons	62.36***	5.72	10.9	-0.87**	0.42	-2.08	-92.01	23.9	-3.85	4.3***	0.05	89.95
	R^2 = 85.72,F= 73.65***			R^2= 86.50,F =70.10***			R^2=82.88 F= 52.95***			R^2=85.06, F= 62.27***		
				Adj. R^2 = 85.27			Adj. R^2= 81.32			Adj. R^2= 83.69		

Source: Own Data, 2015. **L**= Lead equation, symbol ***, ** and * shows significant level at 1%, 5% and 10% respectively.

7. Conclusion

The Ethiopian economy is characterized by the persistence of low technology intensive, poor management practices and other interrelated problems resulted into low yield. The major agricultural production is dominated by smallholder farm households with less productivity. Better agricultural productivity of smallholder potato producers can be achieved through improvement of household situations, improvement of technological and management related factors. Moreover, the availability of institutional and organization services and their well-functioning accordingly are the most important in improvement of smallholders production system.

The factors affecting productivity of smallholder potato growers was conducted at Bore District, Guji Zone, Oromia Regional State, Ethiopia. In the district, potato is a currently crop used for both cash and household

consumption. The requirement of labour for the potato crop production compared to other crop in the area was less and can be managed as a sole crop because potato farm calendar is different from other crops so that there is no over load of other farm activities of smallholder households. Thus, potato is an interesting crop for smallholder farmers. Productivity of smallholder potato growers was affects by different factors. The result of Ordinary Least Square confirm that sex of household head, education level of household head, seed variety, farm experience of household head, fertilizer, harvesting time, soil conservation, access to extension services, access to market, nature of access to land, access to irrigation scheme and seed cost affect productivity of smallholder potato growers in Bore district.

8. Recommendations

Based on the outcome of the study, the following recommendations were made:
Extension services (training and field visit) have to widely reach the smallholders to increase the capacity of smallholders in usage of fertilizers and other recommended packages of potato productions. Soil conservation should be encouraged by smallholder farmers. Smallholder should harvest their potato as it matured. Postponed harvesting led to loss of yield. Smallholders should develop legal rules that can sustain their responsibilities on share and contract arrangement of land use on their potato production. Market access could be developed by establishing agricultural cooperatives that help smallholders jointly negotiate better prices for seeds and fertilizers. Smallholder potato growers should be mobilized to form groups so that together they could form their own produce markets and collectively establish organized market networks which enable them to access reliable markets.

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11. Appendix

Appendix Table 1. The result of multicollinearity test

Continues Variables	**VIF $(1-R^2)^{-1}$**	**Tolerance(1/VIF)**
Fertilizer	2.24	0.447212
Experience	2.08	0.481103
Seed cost	1.8	0.556981
Age	1.47	0.67827
Farm size	1.35	0.741998
Hhsize	1.23	0.810397
Mean VIF	1.70	

The larger the value of VIF, the more collinear is the variable Xi. As a rule of thumb if the VIF greater than 10 the variable is said to be highly collinear (Gujarati, 2003). Multicollinearity of continuous variables can also be tested through Tolerance. Tolerance is 1 if Xi is not correlated with the other explanatory variable, whereas it is zero if it is perfectly related to other explanatory variables. There is no problem of multicollinearity in this model because the VIF is less than 3 in all cases.

Appendix Table 2. Contingency coefficients for dummy variables

	Gender	Educ	Varity	Soil	Hartime	Exten	Credit	Mrkt	Nausela	Irrig
Gender	1									
Educ	0.216	1								
Varity	0.340	0.147	1							
Soil	0.086	0.064	-0.050	1						
Hartime	-0.200	0.062	-0.254	-0.196	1					
Exten	0.081	0.161	0.123	-0.073	-0.021	1				
Credit	0.047	0.025	-0.060	0.051	-0.133	0.026	1			
Mrkt	0.109	0.089	0.071	0.118	-0.046	0.170	0.038	1		
Nausela	-0.070	0.057	0.105	-0.109	0.003	-0.050	-0.099	0.093	1	
Irrig	0.054	-0.139	0.103	-0.016	-0.084	-0.186	-0.0008	-0.008	-0.125	1

Contingency coefficient was used to check multicollinearity of dummy variables. It measures the relationship between the raw and column variables of a cross tabulation. The value ranges between 0-1, with 0 indicating no association between the raw and column variables and value close to 1 indicating a high degree of association between variables. Thus, there is no serious problem of multicollinearity.

Appendix Table 3. Shapiro-Wilk W test for normality of residuals
Ho: There is normality of residuals
Ha: There is no normality of residuals

Model		Obs.	W	V	Z	Prob>z	Decision
Productivity	Residual	192	0.99123	1.263	0.536	0.29603^{NS}	Accept Ho

NS = Not Significant at 5%. The null hypothesis residuals variance is homogenous. Therefore, if the p-value is less than 5% probability, we would have to reject the hypothesis and accept the alternative hypothesis that the variance is not homogenous. Based on the rule we can conclude that there is no problem of heteroskedasticity in the model.

Appendix Table 4. Linktest of specification error in dependent variables
Ho: No specification error
Ha: There is specification error

Productivity	Coef.	Std. Err.	T	P>t	Decision
_hat	1.14087	0.289441	3.94	0.001	Since -hatsq is not significant at 5% there is no specification error
_hatsq	-0.00062	0.001275	-0.49	0.625	
_cons	-7.74831	16.17741	-0.48	0.633	

Linktest creates two new variables, the variable of prediction, _hat, and the variable of squared prediction, _hatsq. The model is then refitting using these two variables as predictors. _hat should be significant since it is the predicted value. However, _hatsq should not, because if our model is specified correctly, the squared predictions should not have much explanatory power. That is we wouldn't expect _hatsq to be a significant predictor if our model is specified correctly. So we checked at the p-value for _hatsq.