Impact of Teff Row Planting Technology Adoption on Smallholder Farmers' Yield: The Case of Banja District, Awi Zone, Amhara Region Ethiopia

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Abstract
Agricultural intensification is presumed to be a necessary pre-condition for the development of the agricultural sector in Ethiopia in general and in Awi zone particularly. In this regard, various governmental and non-governmental organizations (NGOs) initiated agricultural technology schemes specifically row planting throughout the country including the Amhara region. Despite these efforts, however, smallholder farmers in the study area are found to be reluctant to adopt or practice row planting methods of sowing. Therefore, this study assesses the impact of teff row planting technology adoption on smallholder farmers' yield: the case of Banja District, Awi Zone, Ethiopia. Three stage sampling procedure was employed in the selection of sample respondents. Results are based on data collected from a sample of 120 selected rural farm households. Descriptive statistics, binary logistic regression and PSM were used to estimate the determinants of row planting technology adoption and to estimate impact on teff yield. The logit result revealed that out of eleven explanatory variables used in the model four variables are statistically significant. These variables are age of household head, education level of household head, access to credit usage and participation in the off- farm activity. Of which significant variables only age of household head has negatively affects technology adoption the rest three have positively influences row planting technology adoption. Finally, the average treatment effect on the treated (ATT) estimated result obtained using PSM method has proven that technology adopters (treated) get 5.25 quintal of teff yield per hectare in a single production year than non-adopters (controls) but labor cost is the same in both cases. Therefore, both governmental and non-governmental organization interventions should include strategies on how to enhance the participation of households to row planting activity to meet the high demand of teff for this rapidly increased population in the country.
Keywords: Adoption, Banja, Impact, Row planting, Smallholder farmer, Technology
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INTRODUCTION

Background of the Study

Agriculture is the main income source of many farm households in sub-Saharan Africa (SSA). However, productivity levels are low and growth rates have recently stagnated (Pardey et al., 2014). The majority of Ethiopia's population earns its livelihood primarily from agriculture. The agricultural sector, which is stunned by subsistence smallholder farmers, is the primary source of livelihood for the majority of the population and the basis of the national economy. Agriculture accounts for 42.9% of GDP (MoFED, 2014), it contributes to nearly 80% of export earnings, provides employment to 73% of the population (EATA, 2014).

According to (MoFED, 2014) In Ethiopia, smallholder agriculture is the main source of food. In 2012/13 production season this sector was sharing about 96% of total crop production. Thus, smallholder agriculture is the base for family livelihood and food security of the country (Adenew, 2006). However, the productivity of this sector is very low in quantity and poor in quality. On the other hand smallholder, agriculture is the main and the only supplier of staple food crops like teff in this country.

Teff is Ethiopia's most valuable staple food crop. It is cultivated over approximately 2.8 million hectares; teff accounts for 28.5 percent of land area under cereal cultivation, the largest share of all staple grains in Ethiopia. *Teff* is indigenous to Ethiopia and is a fundamental part of the culture, tradition and food of its people (MoARD, 2010). *Teff* bread, locally known as *Injera*, is a major staple food for many Ethiopians. It is the most preferred crop than other grains but in general more widely consumed by the economically better urban residents than by rural households. *Teff* contributes up to 600 kcal/day in urban area compared to only 200 kcal/day in rural area (CSA, 2015).

In Ethiopia, *teff* is mainly produced in Amhara and Oromia, with smaller quantities in the Tigray and SNNP regions. There are major teff producing areas in the country. In the Amhara region, Awi zone (on which *Banja woreda* found), East and West Gojjam and, North and South Gonder, North and South Wollo, North Showa are the major producers of teff. In Oromia region the major *teff* producing zones includes the East Shoa, West Shoa, South-West Shoa, North Shoa, East Wallaga, Horo Guduroo Wallaga, Jimma, Illubabor and Arsi zones. The Central and Southern and in some part of North-Western are the teff producing zones of Tigray region (CSA, 2011).

Teff production system used by the majority of farmers is very backward and traditional, most of the farmers in the country broadcast (scattering seed by hand, at high seed rates) *teff* seeds. In recent years much of Ethiopian farmers have begun planting many of their grains in rows, which includes wheat, maize, barely and sorghum and they also started to realize this technique yields better results, reducing the competition among individual plant, however on teff which is the national grain of the country farmer are still following the traditional way of planting *teff* seedling therefore it resulted in *teff* grain yield reduction (ATA, 2012); Specifically in the study area still practiced by limited farmer.

Objectives of the Study

The general objective of the study was to assess the impact of teff row planting technology adoption on smallholder farmers' yield in Banja District.

Specific objectives were

- ✓ To identify the major challenges of row planting application in the study area.
- ✓ To identify the major determinant of row planting technology of *teff* in the study area.
- ✓ To examine the impact of row planting technology adoption on *teff* yield

Methodology

Description of the Study Area

The research area, Banja district, is one of the 11 districts of Awi Zone in Ethiopia. The district is subdivided into 14 kebeles (small administrative units). Agriculture is the mainstay of people in the district. Agro ecologically; the Woreda (district) categorized into middle altitude (*Woinadega*) 75%, high altitude (*Dega)* 17% and 11% (*Kola*), it is suitable for diverse agricultural production. Crop and livestock production are the major sources of income in the district. The total area of the district is 21565 hectares and out of which the total 11219 hectare land is used for annual crop production, 1453 hectares are covered by permanent crops, 5193 hectare is covered by forest, and 3710 hectares are used for other purposes such as grazing.

The area receives an average of 1750 mm rainfall annually and the temperature ranges from 15 c^0 (min) to 24 c^0 (max). The area is characterized by a mixed farming system where the major livestock raised are cattle, sheep, goat, and poultry. *Teff* and potato are the dominant crops grown in the area. Besides this, crops grown in the area are barley, wheat, mango, banana, sugarcane and others. The average elevation of the area is 1810 meter above sea level. In the area 54.25% of land is arable or cultivable, 23.98% is for pastures, and 5.12% of land is covered by forest and 16.65% the land is for infrastructure or other uses.

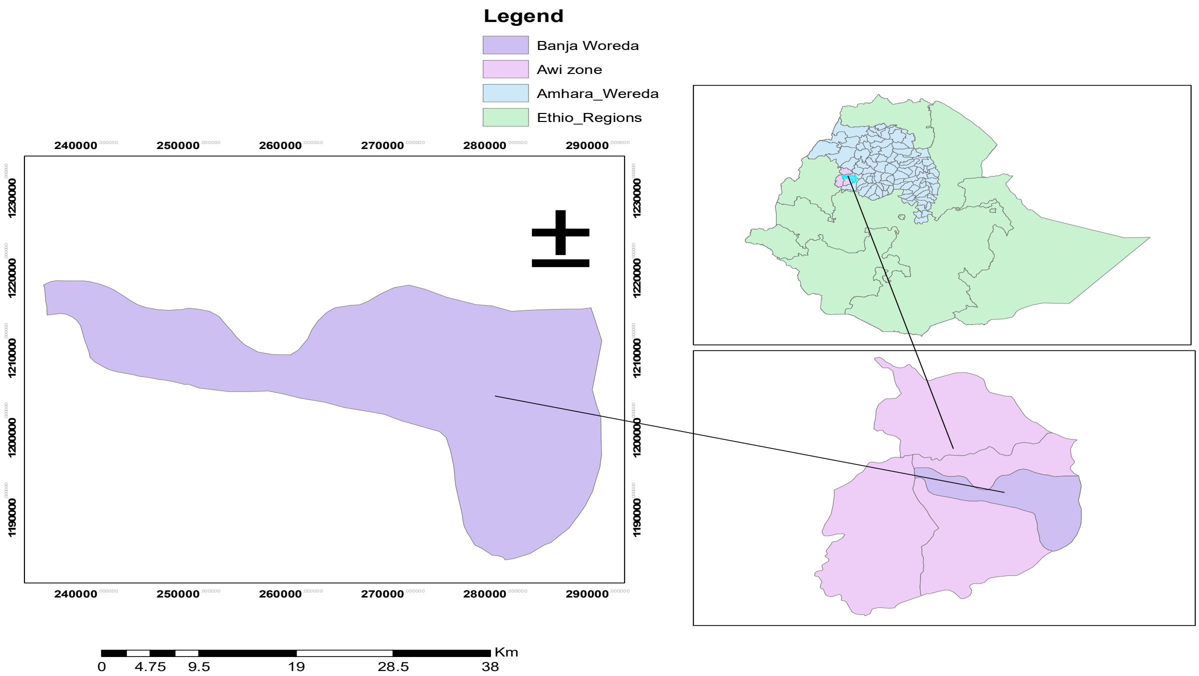

Figure 1: Map of the study area

Sources and Methods of Data Collection

The data for this study was collected from both primary and secondary sources. The primary data was collected from the sample respondent household heads, which have the dominant share in the decision on the selection and application of teff row planting technology and non-applicants as well. On the other hand, the secondary data was collected from various secondary sources like *Kebele, Woreda* and Zonal Agricultural coordination offices. Primary data was collected with the help semi-structured questionnaire. Moreover, personal interview was conducted with the *Woreda* and Zonal agricultural extension communication experts.

Sample Size and Sampling Method

In this study, three stage sampling procedure was employed for the selection of sample households. In the first stage, out of 11 Woredas under the current administrative structure in Awi Zone, *Banja woreda* was selected purposively because of its adoption and production potential. In the second stage, out of 14 kebeles that are found in *Banja woreda*, three rural *kebeles* were randomly selected. In the third stage households in the sample kebeles were stratified into adopters and non-adopters and then a total of 66 adopters and 54 non-adopters were sampled from each stratum randomly and proportionally to obtain a total of 120 samples. The number of sample household ware determined based on the formula developed by Yamane (1969). By considering the homogeneity of the respondents and to reduce the sample size the researcher was applied 9% precision level in the formula.

$$n = \frac{N}{1+N(e)^2}$$

Methods Data Analysis

In order to address the objectives of this study, both descriptive statistics and econometric approaches were employed.

Descriptive Data Analysis

The descriptive analysis was performed by using averages, standard deviation, frequency percentage and also chi-square, and t-tests. The objective of the descriptive analysis is to compare both the treated and control group's different characteristics.

Model specification

One of the purposes of this study is to assess the factors that affect the adoption of row planting technology and its impacts on *teff* yield. The dependent variable in this case takes a dichotomous variable, which take a value of zero for non-adopter households and one for the adopter once. When one or more of the independent variables in a regression model are binary, we can represent them as dummy variables and proceed to analyze.

Binary models assume that households belong to either of the two alternatives and that depends on their characteristics. The Probit and Logit models are commonly used models in adoption studies. However, the probit probability model is associated with the cumulative normal probability function, whereas the Logit model assumes cumulative logistic probability distribution. The advantage of these models over the linear probability model is that the probabilities are bound between 0 and 1. Moreover, they best fit to the non-linear relationship between the probabilities and the independent variables; that is, one which approaches zero at slower and slower rates as an independent variable (Xi) gets smaller and approaches one at slower and slower rates as Xi gets large (Train, 1986). Usually a choice has to be made between Logit and Probit models, but the statistical similarities between the two models make such a choice difficult. Gujarati (1988) illustrated that the logistic and probit formulation are quite comparable. The choice becomes a matter of preference (Gujarati, 2004). Therefore, the logit model was employed for this study because of its computational and mathematical conveniences and mathematically it can be illustrated below in step one of PSM approach.

Propensity score matching method

PSM initially coined by Rosenbaum and Rubin (1983) and has been applied in many program evaluations. PSM matches groups based on their conditional probability of receiving a treatment given pre-treatment characteristics. As far as this impact of agricultural technologies is concerned the impact of row-planting technology was founded by comparing the average *teff* yield of adopter and non-adopter households. The correct evaluation of the impact of technology requires identifying the "average treatment effect on the treated". ATT is the difference between the outcome variables of being treated and its counter factual (outcome of a beneficiary if s/he was not been part of both row-planting technology). The average treatment effect on the treated (ATT) is given as;

$$ATT = E(Y1/D=1) - E(Y0/D=0) \quad (2)$$

Where; E (Y1/D=1) = the production levels of the adopters

E (Yo/D=0) = is a counter factual and is not observed.

E= mathematical expectation operator

D= dummy variable that takes the value 1 if the individual is treated 0 otherwise

Variables and Hypothesis

Table 1: Summery of hypostasis independent variable and there expected sign

Variable	Description	Type	Expected sign
Dependent variable			
TA	Technology adoption	Dummy	
Explanatory variables			
AHH	Age of household head	Continuous	-
SHH	Sex of the household head	Dummy	+/-
HFS	Family size	Continuous	+
FS	Farm size	Continuous	+
FCE	Frequency of DA visit	Categorical	+
ACS	Access to credit services	Dummy	+
ELHH	Education level of household head	Categorical	+
ROSE	Availability of row seeder	Dummy	+
OXEN	Number of oxen owned	Continuous	+
OFF –FARM	Off -farm participation	Dummy	+
LACO	Labour cost	Continuous	-
Outcome variable			
TGY	*Teff* grain yield	Continuous	

Source: own definition, 2018

Results and Discussion

Econometric Result

This section presents the result of the logistic regression model and propensity score matching technique. It explains the estimation of propensity scores, matching algorithm, common support region, balancing test of covariates, and sensitivity analysis. It also explains the treatment effect of the intervention across the adopter households.

The Logit model

Table (8) shows the econometric estimation results of the logit model. The estimated model appears to perform well for our intended matching exercise. The pseudo-R^2 value is 0.2886. A low R^2 value shows that the allocation of the program has been de facto random (Pradhan and Rawlings, 2002). In other words, a low R^2 value means that program households do not have many distinct characteristics overall and as such finding a good match between program participant and non-participant households becomes easier. After matching there should be no systematic differences in the distribution of covariates between both groups and therefore, the pseudo-R^2 should be fairly low (Caliendo and Kopeinig, 2005).

The result of logistic regression model indicated that row planting participation was significantly influenced by four of eleven explanatory variables used in propensity score estimation model. These include age of household head, access to credit usage, education level of household head and off farm participation. Of these four variables only one had a negative sign and the rest three had a positive sign. The significant explanatory variables, which have effect on participation in row planting technology, are discussed below.

Age of household head (AHH): The binary logit result revealed that this variable was negatively and statistically significant at 1 percent probability level and the result is consistent with the prior expectation. (Sulo, *et al*, 2012) assumed that as a farmer's age increases the probability of adoption is expected to decrease because as the farmer's age increases the farmer becomes conservative, but to the contrast, it's assumed that younger farmers are more innovative and hence more willing to adopt new agricultural technologies than older farmers. Besides, the marginal effect of this variable indicated that as the age of the household head increases from 45 to 46 the probability of participation in row planting activity decrease by 1.5 percentage points, ceteris paribus (Table 2).

Education level of the household head (ELHH): Education level of household head is statistically significant at 1% significant level which is consistent with expected positive sign and the result is similar to Yonas 2014. The positive sign of the coefficient assures that more educated households may have more knowledge and awareness about the advantages of row planting on farm. Moreover educational attainment by the household head could lead to awareness which, in turn, would enhance agricultural production and productivity as well. Thus, as the household head level of education increases by one grade, the probability of adoption of row-planting use would increases by 22.87%, holding other variables constant (Table 2).

Access to credit usage: this variable positively influences row planting technology adoption decision of households. It was positively and statistically significant at 1 percent significance level. The positive relationship could be because those households who use access to credit have a better possibility of getting farm inputs. Credit helps farmers to purchase technological farm input such as sowing machine and it helps to increase their confidence in risk taking behavior. The marginal effect of this variable revealed that those households who use credit access have 35.83 percentage points more chance for adoption than those households who do not use credit access, while keeping all other variables constant at their mean value (Table 2).

Off-farm participation: The binary logit result showed that participation in off-farm activity also positively and significantly affect row planting technology adoption at 5 percent level of probability. The positive sign shows that households participate in off-farm activities have a large probability to adopt row planting than non-participants. Off-farm activities play a great role by generating additional income and commonly practiced by most of the rural households in the study area. The marginal effect of this variable indicated that if the household participate in off-farm activity, the probability of row plating technology adoption increased by 28.97 percentage points, ceteris paribus (Table 2).

Table 2: Factors affecting households' adoption of row planting technology

Variables	Coef.	Std. Err.	Z	dy/dx
AHH	-.0617223	.0218154	-2.83***	-.0148742
SHH	-.2356299	.6460472	-0.36	-.055781
ELHH	.9490231	.3435668	2.76***	.2287019
HFS	-.3160703	.2206915	-1.43	-.0761687
FS	.4875431	.4478466	1.09	.1174914
OXEN	-.5325046	.4120264	-1.29	-.1283265
TLACO	.0004779	.0004941	0.97	.0001152
ROSE	-.0935096	.4653785	-0.20	-.0225175
ACS	1.521359	.545928	2.79***	.3583123
FEC	-.1548118	.2021563	-0.77	-.0373076
OFFFARM	1.313246	.5687911	2.31**	.2897363
_cons	-.7284424	3.509434	-0.21	

Number of obs = 120
LR chi2 (11) = 47.67
Prob > chi2 = 0.0000
Pseudo R2 = 0.28
Log likelihood = -58.74

Source: model result, 2018
***, and ** indicates significant at 1% and 5% probability level respectively

Estimating treatment effect on the treated

In order to attain the second main stated objectives of this study, this section evaluated the impact of row planting technology on the outcome variables for treated households, after the pre-intervention differences were controlled. The estimation result presented in Table (11) provides a supportive evidence of statistically significant effect of the row planting technology adoption on teff grain yield, households food expendicture per adult equivalent.

Table3: The ATT for outcome variable due to intervention

Outcome Variable	Mean		Difference	SE	t-stat
	Adopters	Non-adopters			
Teff grain yield	17.19	11.94	5.25	1.97	2.66***

Suorce : own survey result,2018
*** indicates significant at 1% probablity level.

Table 11 presents that the estimation result and a supportive evidence of statistically significant effect of adopting row planting on the above outcome variable based on the already chosen matching algorism. Accordingly the row planting technology intervention has resulted in a positive and statistically significant mean difference between adopter (treated) and non-adopters (control) of technology in terms teff grain yield. A positive value of ATT confirmed that households teff yield produc has been improved due to row planting technology intervention in the study area.

After passing different steps of matching technique, it has been found out that the technology intervention has increased the adopter (treated) households yield of teff by 5.25 quintal and this difference was significant at 1%. Propbablity level..

Reference

Adesina, A. A. and Chianu, J. (2002): Determinants of farmers' adoption and adaptation of alley, farming technology in Nigeria. Agroforestry Systems, 55: 99-103.

ATA, (2013): “Results of 2012 New Teff Technologies Demonstration Trials Draft Report VF”. Addis Ababa, Ethiopia.

Behailu, G., (2014): assessment of farmers’ adoption level of teff row planting technology on teff production in Minjar Shenkora district, North showa zone, Amhara region.

Berhe, T., Z. Gebretsadik, S. Edwards, and H. Araya, (2011): “Boosting Tef Productivity Using Improved Agronomic Practices and Appropriate Fertilizer.” In Achievements and Prospects of Tef Improvement: Proceedings of the Second International Workshop, November 7-9, 2011, Debre Zeit, Ethiopia, edited by K. Assefa, T. Solomon, and Z. Chanyalew, 133–140.

Bryson, A., Dorsett, R. and Purdon, S. (2002). The use of propensity score matching in the evaluation of labor market policies. Working Paper No. 4: Department for Work and Pensions.

Bryson, A., R. Dorsett, and S. Purdon, (2002).The Use of Propensity Score Matching in the Evaluation of Labour Market Policies, Working Paper No. 4, Department for Work and Pensions.

Caliendo, M. and Kopeinig, S. (2005).Some Practical Guidance for the Implementation of Propensity Score Matching, Discussion Paper No. 1588, University of Cologne.Li, H., Rozelle, S. and Zhang, L. 2004. Micro-Credit Program and Off-Farm Migration in China: Pacific Economic Review, 9(3): 209–223.

Caliendo, M., and Kopeinig, S. (2008): Some practical guidance for the implementation of propensity score matching. IZA, Discussion Paper No. 1588: University of Cologne.

Chambers, R., Karlan, D., Ravallion, M. and Rogers, P. (2009): Designing impact evaluations: Different perspectives. International Initiative for Impact Evaluation Working Paper 4: New Delhi: 3ie.

CSA (Central Statistical Agency), (2015): Agricultural sample survey report on Area and production of major Crops (private peasant holdings, Meher season 2014 / 2015; Addis Ababa Ethiopia, the FDRE statistical bulletin, Volume I.

CSA (Central Statistical Agency).(2012):The Federal Democratic Republic of Ethiopia, Central Statistical Agency, Agricultural sample survey report on crop and livestock product utilization; vol VII

CSA.2011. Agricultural Sample Survey: Area planed and production of major crops, Meher Season. Volume I. Addis Ababa, Ethiopia

Central Statistics Agency, (2007/08): Agricultural Sample Survey 2007/08, Addis Ababa, Ethiopia.

Chamberlin, J., (2008). It’s a Small World After All: Defining Smallholder Agriculture in Ghana. IFPRI Discussion Paper No. 00823, November 2008. Available on: http://www.ifpri.org/pubs/dp/ifpridp00823.asp.

Dehejia, R., H., and S. Wahba, (2002): Propensity Score Matching Methods for Non-Experimental Causal Studies: The Review of Economics and Statistics, 84(1), pp.151–16.

Debelo, (2015): on the impact of adoption of Quncho tef on crops income in the case of Wayu Tuqa District in oromia, Ethiopia.

Ethiopian Economic Association, (EEA). (2013): Annual Report on the Ethiopian Economy. Addis Ababa.

Ezemenari K., A., Rudqvist and K., Subbarao, (1999). Impact Evaluation: A Note on Concepts and Methods, Poverty Reduction and Economic Management Network, World Bank.

Feder, L., R.E., Just and O.Zilberman. (1985). Adoption of Agricultural Innovation in Developing Countries: A survey.

Fufa Bekabil, Behute, B., Simons, R., and Tareke Berhe (2011): “Strengthening the teff value chain in Ethiopia.” Mimeo Agricultural Transformation Agency (ATA), Addis Ababa, Ethiopia.

Geremew in (2016) on Analysis of Smallholder Farmer’s Adoption and Continued Application of Teff Row Planting Technique in Wolaita Zone, Southern Ethiopia.

Gujarati, D.N. (2004): Basic Econometrics, 4th edition. McGraw-Hill, Inc.: New York.

Gujarati, D.N. (1995): Basic Econometrics, 3rd edition. McGraw-Hill, Inc: New York.

Healy, F.J. (1984). Statistic: A Tool for Social Research. Wadsworth Publishing Company, California.

Jalan, J. and Ravallion, M. (2003): Estimating the Benefit Incidence of an Antipoverty Program by Propensity-Score Matching: Journal of Business and Economics Statistics, 21(1), pp. 19-30.

Lee, W. S. (2006). Propensity Score Matching and Variations on the Balancing Test: Melbourne Institute of Applied Economic and Social Research, the University of Melbourne

MAFAP:"Analysis of Incentives and Disincentives for Tef in Ethiopia." 2013.

Meinzen-Dick, R. Adato, M. Haddad, L. & Hazell, P. (2004) Science and Poverty: An Interdisciplinary Assessment of the Impact of Agricultural Research.

MoARD (Ministry of Agriculture and Rural Development), (2010) Ethiopia’s Agriculture Sector Policy and Investment Framework: Ten-year Road Map (2010-2020).

MOFED 2010).The Federal Democratic Republic of Ethiopia, Growth and Transformation Plan (GTP) 2010/11-2014/15: Draft. (2010): September, Addis Ababa.

Mulugeta, (2002): Rural Development Options, Zed Books Ltd., London and USA.
Okuthe, I.K., Ngesa, F.U. and Ochola, W.W.(2013) The influence of institutional factors on the adoption of improved sorghum varieties and technologies by smallholder farmers in Western Kenya: International Journal of Humanities and Social Science.
Ray, H. (2001). Agricultural Policy Analysis, McGraw Hill Inc., USA
Rogers E.M., (1995): Diffusion of innovations. New York: Free Press
Rose J. (2011). Teff Accessed on May 24, 2013: Retrieved from http://www.traditional- foods.com/profiles/teff/
Rosenbaum, P.R. and Rubin, D.B, (1983). The central role of the propensity score in observational studies for causal effects. Biometrika, 70(1): 41-55
Rosenbaum, P. R. and Rubin, D. B. (1985).Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. The American Statistician Rosenbaum, P. R, (2002). Observational Study: 2nd Ed. New York: Springer.
Stern, E., Stame, E., Mayne, J., Forss, K., Davies, R. and Befani, B. (2012), Broadening the range of designs and methods for impact evaluations. Report of a study commissioned by the Department for International Development (DFID) Working Paper 38
Sulo T., Koech, P., Chumo, C. and Chepng"eno, W. (2012): Socio-economic factors affecting the adoption of improved agricultural technologies among women in Marakwet County Kenya: Journal of Emerging Trends in Economics and Management Sciences.
UK Department for International Development (2011) Guidance on using the revised Logical Framework a DFID Practice Paper.
USAID, (2012): Improved Grain Varieties: Impact through Research and Development, tool for transformation, capacity to improve agriculture and food security.
Yamane Taro, (1969): Statistics, an Introductory Analysis 2nd edition. New York: Harper and Row: 886.
Yonas (2014), the impact of row planting of teff crop on rural Household income: A case of Tahtay Maychew woreda, Tigrai, Ethiopia