Ethiopian Economics Association (EEA)
and
Ethiopian Strategy Support Program (ESSP) of IFPRI

PROCEEDINGS OF THE FIFTEENTH INTERNATIONAL CONFERENCE ON THE ETHIOPIAN ECONOMY

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Volume II

Published: June 2018

ISBN – 978-99944-54-65-5

- Partners of all activities of EEA are the African Capacity Building Foundation (ACBF), the Friedrich Ebert Stiftung of Germany (FES), Think Tank Initiative of the International Development Research Center (IDRC) of Canada, and Civil Society Support Program (CSSP).

- The 15th International Conference was Co-organized by the Ethiopian Strategy Support Program (ESSP) of the International Food Policy Research Institute (IFPRI).

- The 15th International Conference Sponsored by Sponsored by IFPRI, EDRI, Friedrich Ebert Stiftung of Germany, UNECA, UNDP, International Growth Center (IGC), USAID, AKLDP Ethiopia, The World Bank, European Union, PRB, ILRI, CGIAR UF/IFAS.

FOREWORD

The Ethiopian Economics Association (EEA) is happy to issue two volumes of the proceedings of the 15th International Conference (the 26th Annual Conference) on the Ethiopian Economy that was held from July 20 – 22, 2017 at EEA Multi-purpose Building Conference Hall. EEA has been organizing annual conferences on the Ethiopian Economy every year as part of its overall objectives of promoting the development of economics profession in Ethiopia and contributing to the policy formulation and implementation process of our country through research, training, public dialogue forums and publications and dissemination activities.

EEA had launched its international conference series in June 2003, after organizing 11 annual national conferences. This series has proved to be an excellent forum at which not only resident Ethiopian researchers, but also Ethiopian researchers based abroad as well as non-Ethiopian researchers throughout the world conducting research on Ethiopia, or more widely, present and discuss research findings.

This year's conference, as was last seven years, is co-organized by the Ethiopian Strategy Support Program (ESSP) – the collaborative program of the International food Policy Research Institute (IFPRI) and the Ethiopian Development Research Institute (EDRI). It was also co-sponsored by IFPRI, EDRI, Friedrich Ebert Stiftung of Germany, UNECA, UNDP, International Growth Center (IGC), USAID, AKLDP Ethiopia, the World Bank, Population Reference Bureau (PRB), and European Union (EU). The contribution of EEA's partners that includes the African Capacity Building Foundation (ACBF), Think Tank Initiative of the International Development Research Center (IDRC) of Canada and the Friedrich Ebert Stiftung of Germany is also critical for the organization of this important conference and other activities of the Association.

At the conference about 80 presentations were made in five plenary and five parallel sessions with the attendance of about 956 persons in three days. That is the conference attracted about 486, 250 and 220 participants during the first, second and third days of the conference, respectively. Out of the total 80

presentations, about 44 were presented by partner institutions like (IFPRI-ESSP), International Growth Centre (IGC), United Nation Economic Commotion for Africa (UNECA), the World Bank, EDRI, AKLDP Ethiopia/Tufts University, UNDP, Young Live Ethiopia, Addis Ababa University and Population Reference Bureau (PRP) and etc. The rest 36 papers were presented by individual researchers.

The conference was opened by H.E. Ato Hailemariam Desalegn, X/Prime Minster of the Federal Democratic Republic of Ethiopia at the presence of higher dignitaries and invited guests. The presence of H.E. Ato Hailemariam Desalegn, demonstrates the value of the conference to the economic policy making process of the country. The year also marked as Silver Jubilee of the Ethiopian Economics Association.

The editorial committee reviewed papers that were presented for the publication of the proceedings of the conference and communicated its comments and suggestions including editorial comments to authors. After passing all these process and language editing, the editorial committed selected 18 papers to be included in the proceedings. All these papers are organized into two volumes. Volume I consists of Macroeconomics, Industry and social Sectors issues while Volume II consists of Agricultural and Natural Resources related topics.

At this juncture, on behalf of the Ethiopian Economics Association, I would like to thank the Ethiopian Strategic Support Program (ESSP) of the International Food Policy Research Institute (IFPRI), for being a regular co-organizer of the EEA's International conferences since 2010. My appreciation also goes to the authors of the papers and the conference participants whose active participations made the conference meaningful and dynamic. The many professionals who dedicated their time to the conference and served as chairpersons deserve due thanks for their special contributions.

I would like also to thank IFPRI, EDRI, Friedrich Ebert Stiftung of Germany, UNECA, UNDP, International Growth Center (IGC), USAID, AKLDP Ethiopia, the World Bank, Population Reference Bureau (PRB), and European Union (EU). The contribution of EEA's partners that includes the African

Capacity Building Foundation (ACBF), Think Tank Initiative of the International Development Research Center (IDRC) of Canada.

The organizing committee and staffs of the EEA deserve a special recognition for their enthusiasm and perseverance in managing the conference from inception to completion. I also want to extend my personal gratitude to the members of the Executive Committee of the Ethiopian Economics Association for the dedicated services and the leadership they provided to the Association.

Our special thanks go to our partners who have shared our vision and provided us with generous financial support to operationalize the activities of EEA. These include; the African Capacity Building Foundation (ACBF), Think Tank Initiative of the International Development Research Center (IDRC) of Canada and the Friedrich Ebert Stiftung of Germany.

I would like also to extend my sincere gratitude to H.E. Ato Hailemariam Desalegn, former Prime Minster of the Federal Democratic Republic of Ethiopia for his an insightful opening address; and other senior government officials who spared their busy schedule and participated in the conference.

Finally, I would like to convey the message that our Association is willing to seek new ways of addressing the economic problems and to be of better service and to meet the expectations of its members and the public at large.

Tadele Ferede (PhD)
President
Ethiopian Economics Association

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Governance Structures and Incentives in the Wheat Industry of Ethiopia

Zewdie Habte[1]*, Belaineh Legesse[2], Jema Haji[3], and Moti Jaleta[4]

Abstract

The purpose of this paper is to investigate the effects of governance structures on incentives in different functional nodes of the wheat value chain (WVC). This study used personal interview surveys to collect primary data from relevant actors. The data used in the analysis came from input suppliers, wheat producers, wholesalers, wheat processors and support institutions. Mixed sampling techniques (random, census and purposive) were applied to select sampling units. Descriptive statistics and regression models were used to analyze the data. This paper found that the governance structure, transaction risks, asymmetric information and trust influence actors' incentives in each functional node of the wheat value chain. Specifically, wheat producers' incentives significantly increase with extension service, governance structure, power relation and price information. The study provides pioneering evidence on the effects of the governance structures on incentives in each functional node of the value chain. The study adds new knowledge to the existing empirical knowledge. It shows the effects of coordination failures on actor's incentives. Coordination failures in the first node decrease incentives of actors which subsequently trigger unattractive incentives in subsequent nodes.

Keywords: Incentives, Spot market, Hybrid governance structures, Opportunistic behavior, Coordination failures, Wheat value chain

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1. Introduction

For many economists, economics is to a large extent a consequence of incentives in order to supply more volume and quality products and invest in technology (Laffont and Martimort, 2002). In economics, an incentive is defined as a reward or cost that motivates an economic action. For example, possible incentive mechanisms in agricultural markets are supervision of farmers during the production period, quality measurement before purchase (Hueth et al., 1999; Wolf et al., 2001), and payment of price premiums in certification schemes (Dörr and Grote, 2009).

Incentives in value chains are highly associated with governance structures (Wolf et al., 2001; Dekker, 2003). The level of incentives varies across governance structures which range from the spot market to hierarchy (Williamson, 1985, 1999); hybrid governance structures lie between the two extremes of the continuum.

Economic incentives such as prices and costs link with spot markets (Gereffi et.al., 2005). Spot market transactions have many buyers and sellers that are characterized byseries of short-term, one-off, self-preservation, little information exchangeand adversarial and distrusting relationships. The spot market transactions in less industrialized countries tend to reduce price incentives and/or increase producer's risks because it is characterized by high physical marketing cost per unit, the high uncertainties of prices, poor quality grades and standards specification and the lack of means of quality control which may constrain value addition (DIIDRC, 2011).

Incentive systems associate with transaction attributes and behavioral attributes (Williamson, 1999). The high uncertainties of the transactions increase the level of transaction costs which adversely influence incentives (Williamson, 1996). The source of uncertainties of the transactionsis opportunistic behavior of value chain actors andinformation asymmetries. Opportunistic behavior refers to the possibility of agents to act out of self-interest. Actors can face the risk of adverse selection due to ex-ante opportunism which arises from hidden information or face the risk of moral hazard due to ex post opportunism arising from the hidden actions of agents.

Frequent transactions between upstream and downstream actors decrease the incentives to behave opportunistically and take advantage of information asymmetries (Hobbs, 1996;Williamson, 1999). Trust reduces opportunistic behavior and asymmetric information (Gereffi, 2005; Ruben et al., 2007) by increasing information access and knowledge transfer between suppliers and buyers (Coleman, 1990; Burt, 1997; Humphrey & Schmitz, 2002).

The non-spot markets like hybrid governance structures provide more actors' incentive than those of spot markets(Wolf et al., 2001; Gumataw, 2013; Getaneh and Bekabil, 2007) since it reduces the costs of the transaction, boosts bargaining power and mitigates individual risks (DIIDRC, 2011). Cooperatives are one of the hybrid governance structures (Ménard, 2007) and borrowed some attributes from spot market and some attributes from vertical integration (Chaddad, 2012). The cooperatives are viewed as a form of vertical integration that addresses asymmetric information problems about input and product quality between producers and buyers (Hennessy, 1996; Hueth et al., 1999). The cooperatives rewards incentive to members and give solutions for adverse selection problems (i.e., higher prices for the lower the inputs quality and lower prices for higher quality product) because it enables them to have forward vertical integration which allows them to control over the distribution system. It allows members to have incentives from backward vertical integration into the manufacturing of inputs (Van Stuijvenberg, 1977).

Producers with higher quality wheat are provided better incentive in the market (Dahl and William, 1997). Value chain governance structures associate more with incentives (Wolf et al., 2001; Dekker, 2003; FAO, 2013; Kifle, 2013). The serious problem in the Ethiopian WVC is low economic incentives such as prices (Mohammed, 2009; Dendena, 2009). The Ethiopian agricultural food value chains encountered with poor information flow (Kaleb, 2008), coordination failures (Bezabih, 2008), the absence of quality-based pricing system (Mohammed, 2009). The WVC is subjected to low incentives which result in the poor functioning of theWVC in Ethiopia (Mohammed, 2009). Producers' incentives in the WVC are associated with low farm gate prices and unbalanced bargaining power (FAO, 2013). There are no empirical studies on the relationship between the WVC governance structures and WVC actors' incentives in Ethiopia. The paper assesses effects of transaction and behavioral

attributes and coordination on actors' incentives in the WVC. The paper investigates the effects of governance structures on producers' price incentives in wheat markets.

The examination of determinants of price incentive is a significant academic exercise for many reasons. The study adds a new dimension to the existing empirical evidence with regards to incentives. As prime beneficiaries, the WVC actors may benefit to a great extent from improved coordination, reduction of input quality uncertainty and information asymmetry. Accordingly, it is supposed that results will be used to increase actors' wheat productivity and incentives, and enhance their income which, in turn, greatly improves household food security. These findings can yield a positive impact in wheat value chain-linked livelihood dimensions.

2. Conceptual Framework

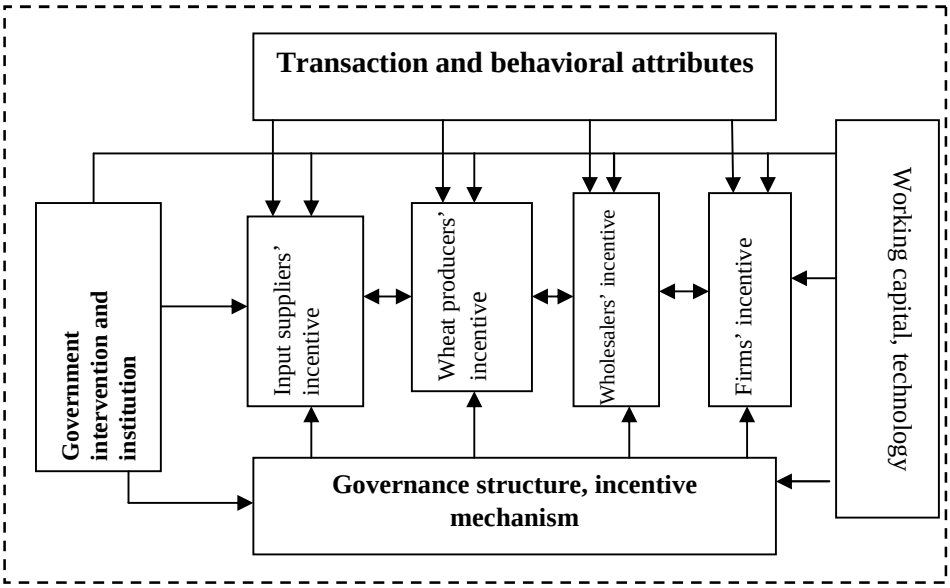
Incentives increase from spot market transactions to hybrid governance structures (Wolf et al., 2001; Gumataw, 2013). The hybrid governance structures increase actors' incentives in each functional node of the value chain (Williamson, 1999) by minimizing transaction costs, and transaction risks (Williamson, 1979). Incentives associated with the relational based transactions are higher than those of the spot markets(DIIDRC, 2011). The governance mechanisms such as the quality-based pricing system, regulatory mechanisms, laboratory tests and/or third party verifications have tighter links with the costs of transactions and input quality and price uncertainty in different functional nodes of the value chain (Krueger, 1988). So, these governance mechanisms reduce asymmetric information, which, in turn, leads to lower risks of opportunism. Coordination increases incentives across chain by reducing transaction costs and increasing efficient information flows and outputs (Lee et al, 1997). Social networks and trust increase actors' incentives by increasing access of information and financial support (Coleman, 1990 and Burt, 1997) and by increasing information transfer between the actors (Humphrey and Schmitz, 2002). Technologies are associated with incentives by influencing production costs and outputs (Laffont and Martimort, 2002). This study describes conceptual relationships between governance structures

and incentives which are constructed as a tool to conceptualize relationships which are clearly depicted in Figure1.

Hence, the following hypotheses are derived from the conceptual framework:

1) Incentives such as price and costs at the spot input markets associate more with coordination, uncertainty and opportunistic behavior.
2) Incentives such as costs and productivity associate more with information asymmetry.
3) Non-spot market governance structures associate more with producers' price incentive.

Figure 1: Conceptual relationships between governance structure and incentives



Source: Own construction (2015/16)

3. Data

3.1 Data collection

This study used personal interviews to collect the research data by using surveys. Prior to final data collection, the preliminary surveys were carried out to make appropriate modifications tothe interview schedules. Separate

interview schedules consisting of detailed questions were administered to collect data from each actor. This study targeted input suppliers, wheat producers, wheat wholesalers, firms or wheat processors and cooperatives. The data were collected over a period of 13 months, from August 2015 to September 2016.

Data were gathered from wheat producers with the help of interview schedules at both spot and non-spot markets. We visited wholesalers at the spot and non-spot markets and input suppliers at small retail shops and the spot markets at different times of the day to interview all present in three districts such as Gimbichu, Hetosa and Tiyo. Wholesale input suppliers were interviewed in Addis Ababa. Bakeries, wheat processing factories were visited in each district. In addition, we visited wholesalers and wheat processing factories in Adama, Assela and Bishoftu towns as well as Addis Ababa. At last, we also visited most of indirect actors to collect research data.

3.2 Sampling techniques

This study used a multi-stage sampling technique to select sampling units. The 2 major wheat producing zones were purposely selected and further streamlined into major and minor wheat producing districts. From the major wheat producing districts, we randomly chose 3 districts such as Gimbichu district from East Shewa zone and Hetosa and Tiyo districts from Arsi zone. Again, we demarcated these 3 randomly selected districts into major and minor wheat producing villages (‘kebeles’). From the major wheat producing villages of the 3 districts, we selected 2 villages at random from each district (i.e., a total of 6 villages). Finally, data used in this paper were randomly collected from 220 wheat producers from 6 villages based on probability proportional to their size. The total sample size was determined on the basis of 10 or more times a number of relevant independent variables in the given model which is recommended by most statisticians and econometricians (Edriss, 2013).

The spot and non-spot markets were purposively selected from 3 randomly selected major wheat producing districts. Criteria for selection of these targeted markets included the physical proximity of wheat producers to these

markets in these districts. Census surveys were conducted to collect research data from wholesalers from purposively selected 4 markets. The sample size of the WVC actors in the 3 randomly selected major wheat producing districts was 20 retail input suppliers and 21 wheat wholesalers at spot markets and 29 wheat wholesalers at non-spot markets. The wheat wholesalers were purposively selected to collect data in Adama, Assela, Bishoftu and Addis Ababa towns. The sample size of the WVC actors in these mentioned big towns was 5 wholesale input suppliers and 20 wheat wholesalers.

Census surveys were conducted to collect research data from wheat processors in the major wheat producing districts. The total sample size was 30 wheat processors in these major wheat producing districts. The wheat processors were purposively selected to collect data in Adama, Assela, Bishoftu and Addis Ababa towns. The sample size of the WVC actors in these big towns was 15 wheat processors. This study chose purposively 13 cooperatives to collect data.

3.3 Data analysis

Data reduction and display, percentage, mean and ordered logit were employed to analyze the data. The ordered probit and logit models are found to be more appropriate to analyze the effect of explanatory variables on than those of unordered multinomial logit or probit models (Greene, 2000). In practice, ordered probit and logit models yield similar results, but their coefficients differ by a scale factor. An ordered probit models' error term requires normal distribution whereas error term of ordered logit model requires logistic distribution. The ordered logit model was used to examine the causal relationship between governance structure and wheat producers' price incentive due to its extremely flexible and easily practical nature from the mathematical point of view. Average wheat price, which was received by wheat producers, was taken as a proxy variable for wheat producers' incentive. Maximum likelihood is the most efficient means to estimate the parameters of specifications that involve limited dependent

variables (Davidson and MacKinnon, 1993). A parallel regression assumption test was conducted to ensure the appropriateness of the model. The result indicates that ordered logit was the appropriate choice for analysis of determinants of wheat producer's price incentive (Brant test Chi2= P>Chi2=0.127). The assumption of equality of the parameters across different categories or cut-off points was held true. The likelihood ratio test was conducted to test the validity of the proportional odd model and found to be statistically significant (P>Chi2=0.000) at 1 per cent level of significance. Following Liao (1994), the functional form of the ordered logit model is presented as follows:

$$y^* = \sum_{k=1}^{k} \beta_k X_k + \varepsilon \qquad \textbf{(1)}$$

Where y* is an unobserved variable, β_k are parameters to be estimated, X_k are explanatory variables, ε is the error term.

It is assumed to have a definite symmetric distribution with zero mean, such as normal or logistic distribution. It is explained here under:

$$y = 1 \text{ if } y^* \leq \mu_1 \ (=0)$$
$$y = 2 \text{ if } \mu_1 < y^* \leq \mu_2$$
$$y = j \text{ if } \mu_{i-1} < y^* \qquad \textbf{(2)}$$

Where y is an observed dependent variable in j ordered categories; μi are unknown threshold parameters separating the adjacent categories to be estimated with βk. The ordered logit model is described as follows:

$$\text{Prob}(y = j) = 1 - L\left(\mu_{j-1} - \sum_{k=1}^{k} \beta_k X_k\right) \qquad \textbf{(3)}$$

Where L (·) is cumulative logistic distribution.

Marginal effects on the probabilities of each wheat producer's price incentive are calculated by:

$$\frac{\partial \text{Prob}(y = j)}{\partial X_k} = \left[f\left(\mu_{j-1} - \sum_{k=1}^{k} \beta_k X_k \right) - f\left(\mu_k - \sum_{k=1}^{k} \beta_k X_k \right) \right] \beta_k \quad \textbf{(4)}$$

Where f (·) represents the probability density function.

4. Results

4.1 Transaction Attributes and Incentives

Transaction attributes such as frequency and uncertainty influence actors' incentives across wheat value chain by influencing information flows, transaction risks and informationasymmetry as argued by (Williamson, 1979). The level of transaction costs increases with uncertainty (increase) and frequency (decrease) (Williamson, 1979).The uncertainty onthe quality of inputsdue to information asymmetryare not known in advance which increases transaction risks and adversely affect actors' incentives across wheat value chain.

Frequency: Although wheat is a one season crop, wheat producers and wholesalers transact wheat, on average, 4 times throughout the year at non-spot markets. They meet once in a year if the wheat transaction is carried out at the farm gate. The mobile phone has a positive effect on the frequency of wheat selling (Getaw and Gahiigwa, 2015). About 95 per cent of wheat producers had mobile phones in the study districts. Particularly, in the Gimbichu district, about 95 per cent of wheat producers did not use their mobile phones to search for wholesalers and other market wheat price information because they obtain it from friends and neighbors, and have, therefore, the weakest relationship with wholesalers in district. About 77 per cent of wheat producers used their mobile phones all the time to check wholesalers' wheat price information in Tiyo district. About 22 per cent of them did not use their mobile phones to search for wholesalers' wheat price information because they ask their friends and/or neighbors for the wheat price information (Table 1). The wheat transaction at warehouses operates on a daily basis and enables wheat producers to access price information using their mobile phones.

Wholesalers supply wheat 4 times per month at least to 3 wheat processing factories. More frequent transactions could build a trustworthy relationship between the actors. Transactions become less frequent; the incentive to act opportunistically and exploit information asymmetries tends to increase (Hobbs, 1996). The level of these transaction costs are determined by uncertainty (increase) and frequency (decrease) of the transactions and the amount of specific investments involved (increase) (Williamson in Ménard, 2005).

Uncertainty: According to the survey, sources of uncertainty are opportunistic behavior of actors and information asymmetry.Theuncertainty of input quality and price isextensive in the spot input markets which are characterized by high information asymmetry, lack of means of quality controland with no other bonds existing between the actors before or after the transaction as observed by Dwyer et al. (1987). Wheat producers faced high uncertainty regarding the quality and the price of seeds, pesticides and herbicides which increase transaction risks and associated costs, which in turn decline the productivity and incentives. Farming transactions seriously suffer from unsecured quality of inputs (Wolf et al., 2001). Information asymmetry regarding herbicide and pesticide quality is rampant among wheat producers which lead to high transaction risks in the study area as evidenced by Hueth et al. (1999) and Kherallah and Kirsten (2002). The information asymmetry is widespread in the WVC in which input retailers conceal information about input quality to the wheat producer at small shops and spot markets in the villages and towns. The information asymmetry among suppliers and buyers makes it difficult to knowthe quality of the product transacted (Akerlof, 1970).

For instance, the input suppliers at the spot markets highly manifested their opportunistic behaviors, exploited asymmetric information and sold adulterated or low input quality to the wheat producers at the spot markets.Because of the absence of information about the quality of input, about 30 percent of wheat producers in the study area obtained the lower wheat yield. As result, they harvested the lower wheat yield. As a result, about 30 per cent of wheat producers used low quality pesticides and herbicides and then harvested, on average, 17 quintals per ha, which was lower than those of total sample producers' wheat output (i.e., on average, 39.64 quintals per ha). It subsequently caused group's wheat yield to decrease by about 57 per cent.

In agreement with the claim of North (1990), a weak institution allows the existence of low-quality of inputs in the markets which, therefore, results in low wheat productivity and the high production cost per unit.

4.2 Incentive Mechanisms and Price Incentives

There is no policy environment that facilitates the implementation of wheat and wheat product quality standards and measurements. It led to a weak quality-based pricing system which influences the quality of agricultural commodities, input control and quality measurements (Hueth et al., 1999). In the study areas, about 90 per cent of wholesalers paid an equal price to wheat producers with higher and lower quality wheat, which caused an adverse selection problem. Wholesalers mix high and low quality wheat and supply mixed wheat to the processors, because they do not pay the highest price for the highest quality of wheat. Opportunistic behaviors such as these ones discourage wheat producers to put forth their efforts to improve wheat quality. In general, the present study implies that incentive mechanisms are absent in both input and output markets in the study areas. Specifically, the wheat transaction is devoid of incentive mechanisms that encourage wheat producers to supply higher wheat quality.In general, about 1 per cent, 27 per cent and 72 per cent of wheat producers understood that the quality of wheat they sold was of low, medium and high quality, respectively (Table 1). In particular, about 14 per cent and 86 per cent of wheat producers in Gimbichu district perceived that the quality of wheat they sold was of medium and high, respectively. Almost 39 per cent and 61 per cent of wheat producers in Hetosa district perceived the quality of wheat they sold as medium and high, respectively. Wheat producers in Gimbichu district perceived that the quality of wheat they sold was of the highest quality. Approximately 81 per centof wheat producers in Hetosa district checked wholesalers' wheat price information with their mobile phones (Table 1).

For instance, the weighing instrument was absent at the spot market which made the wholesalers to gain and wheat producers to lose about0.05 quintals of wheat per sack. Wheat producers are accustomed to using a sack as a weighing scale which often contains 0.75-0.80 quintals of wheat depending on the compactness and grain size of wheat. The spot markets provided higher

incentives to be opportunistic for wholesalers. This is because they take advantage of the absence of the weighing scale. An aspect of the inputs, the quality of pesticides and herbicides could not easily be checked because laboratory tests and/or third party verifications were absent in the study areas. This has to do with the absence of a regulatory mechanism on the part of federal and regional governments. Subsequently, input retailers gained more incentives at the cost of wheat producers due to an absence of laboratory tests or third parties in the market. Some authors propose a third-party certification to tackle the information asymmetry problems more efficiently and effectively in agricultural markets (Wimmer and Chezum, 2003). The spot market is more reasonable for value chain actors when the uncertainty regarding quality is a serious challenge and a formal quality control instrument like third party certification is accessible (Raynaud et al., 2005). General price increment is one of the best institutional mechanisms that coordinates the interaction between actors to ensure quality (Holmstrom and Milgrom, 1994; Laffont and Martimort, 2002).

Table 1: Frequency distribution of important attributes in wheat markets

Characteristics	Study districts			
	Gimbichu	Hetosa	Tiyo	Total
	%	%	%	%
Governance structures				
Spot market	96.88	0.00	2.33	29.09
Warehouse transaction	1.56	60.00	63.95	44.55
Farm gate transaction	1.56	40.00	33.72	26.36
Producers' perception about wheat quality				
Low wheat quality	0.00	0.00	1.16	0.90
Medium wheat quality	14.06	38.57	27.91	26.82
High wheat quality	85.94	61.43	70.93	72.27
Producers' price information searching				
No	95.31	18.57	22.09	42.27
Sometimes	0.00	0.00	1.16	0.45
Always	4.69	81.43	76.74	57.27
Producers' bargaining power over buyers				
Low bargaining power	31.25	2.86	6.98	12.73
Medium bargaining power	53.13	42.86	52.33	49.55
High bargaining power	15.63	54.29	40.70	37.73

Source: Own computation based on survey data (2015/16).

About 80 per cent of wholesalers did pay a price premium for wheat quality on the basis of physical parameters, such as weight, grain filling and the admixtures in large towns including Assela, Adama and Bishoftu. This is because they sold to end consumers who could pay high price for high quality of wheat. This result contradicts with the above conclusion that there is no incentive mechanism for higher quality wheat in the 3 districts. Information economics theories suggest that buyers may design incentive mechanisms such as price which motivate farmers to enhance the quality of their produce (Stiglitz, 1987; Maskin, 2008).

Table 2: Frequency distribution of some dummy variables

Dummy variables	Gimbichu		Hetosa		Tiyo		Total	
	Yes	No	Yes	No	Yes	No	Yes	No
	%	%	%	%	%	%	%	%
Mobile phone ownership	95.31	4.69	92.86	7.14	97.67	2.33	95.45	4.55
Cooperative membership	79.69	20.31	71.43	28.57	63.95	36.05	70.91	29.09
Wheat producer's trust	15.62	84.38	11.43	88.57	5.81	94.19	10.45	89.55

Source: Own computation based on (2015/16) survey data.

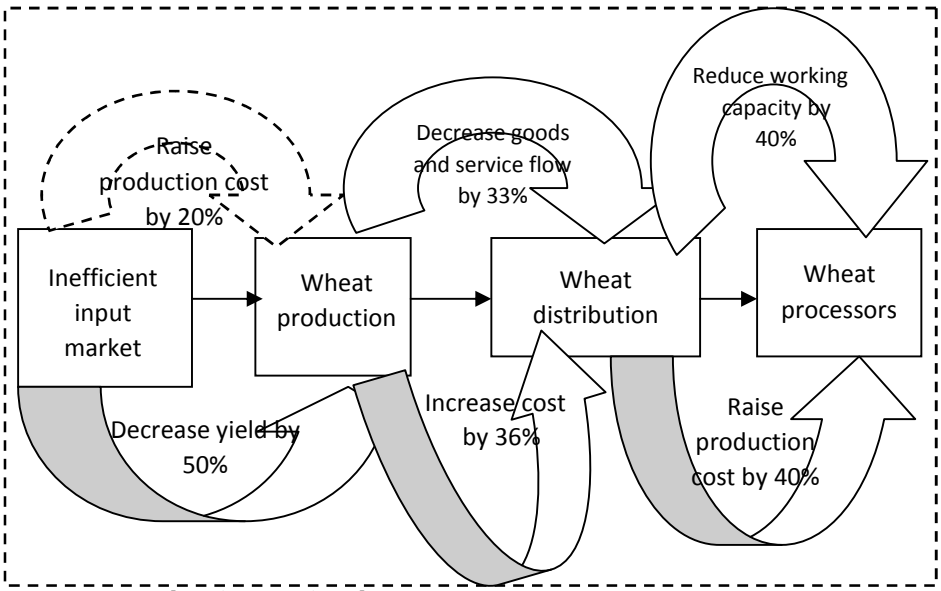
About 10.45 percent of the wheat producers trusted wholesalers and 89.55 per cent of them distrusted wholesalers in the study districts (Table 2). Particularly, about 15.62 per cent, 11.43 per cent and 5.81 per cent of wheat producers trusted wholesalers in Gimbichu, Hetosa and Tiyo districts, respectively. According to the survey result, around 90 per cent of the wheat transaction was carried out between wheat wholesalers and wheat processors, built on the basis of trust. It maintained a more significant mutual cooperation, coordination and short-term credit. It also extended the length of their relationships and wheat transactions and maintained a more frequent wheat price information flow between them. It reduced the costs of searching for wheat price information and partners. Both actors do not want to damage their long-term business relations and reputation because it affects their future incentives and quantity of wheat supply. In the case when wholesalers sell the lowest wheat quality to wheat processors, they break their long-term business relation with wholesalers. Observations show that 2 in 10 customers (wheat producers) receive credit from wholesalers in Hetosa and Tiyo district. Wholesalers also purchase wheat from their customers without checking the quality of wheat and pay visit to their customers during wedding and funeral

ceremonies to maintain their business relationship with their customers. Most wheat producers and wholesalers transact wheat with more than one customer; actors' satisfaction with the exchange of wheat builds trust and extends their wheat transactions in the future. The transaction risks emanate from coordination failure (Masten, 2000, Williamson, et al., 2004).

4.3 Coordination Failures and Incentives

The survey result indicates that coordination failures are caused due to market failure including asymmetric information, incomplete information and opportunistic behavior. It has a great successive effect on the quantity of commodity supply in each functional node of the WVC as approved by (Bryceson and Kandampully, 2004). The finding indicates that coordination failures in the first node cause the costs of wheat production to increase by 20 per cent and decrease wheat yield by 50 per cent in the next node. The second node decreases the flow of goods and services by 33 per cent and raises the costs of services by 36 per cent in the third node. The effects are extended further to the wheat processing factories and final consumers (Figure 2).

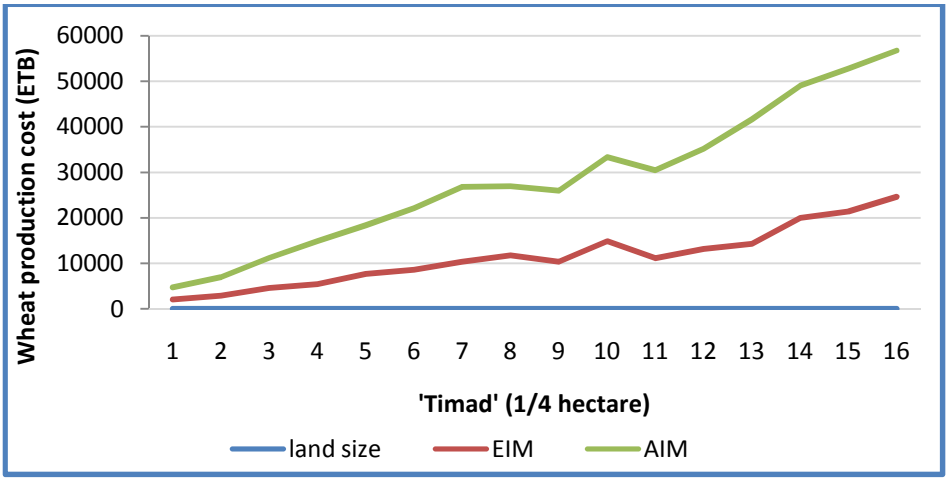
Figure 2: Coordination failures in the first node lead to a failure in the next three nodes.



Source: Survey data (2015/16) and CSA

According to the survey result, inefficient input market leads to a high cost of wheat production which reduces wheat producers' incentive and profitability. The effect of input market on the cost of wheat production is presented in Figure 3.

Figure 3: The effect of improved technology use on the costs of wheat production.



Source: Survey data (2015/16).

Note: EIM= Existence of tractor and combine harvester in the input market, AIM=Absence of tractor and combine harvester in the input market.

The average cost was 10,559.00 ETB per hectare (ha) for rented tractor users and 10,907.00 ETB per ha for non-users, but mean difference was found to be insignificant. Utilization of combine harvesters made significant difference in the costs of wheat production at a 1 per cent probability level between two group mean scores (t-value= 2.86, p-value= 0.000).The combine harvesters and tractors in the input markets deliver a better harvesting and tilling services to wheat producers, respectively. Utilization of combine harvesters decreased the costs of wheat production by 30 percent.

4.4 Governance Structures and Price Incentives

Two types of governance structures are distinguished in the WVC namely spot market and hybrid governance structures. The spot market refers to a large

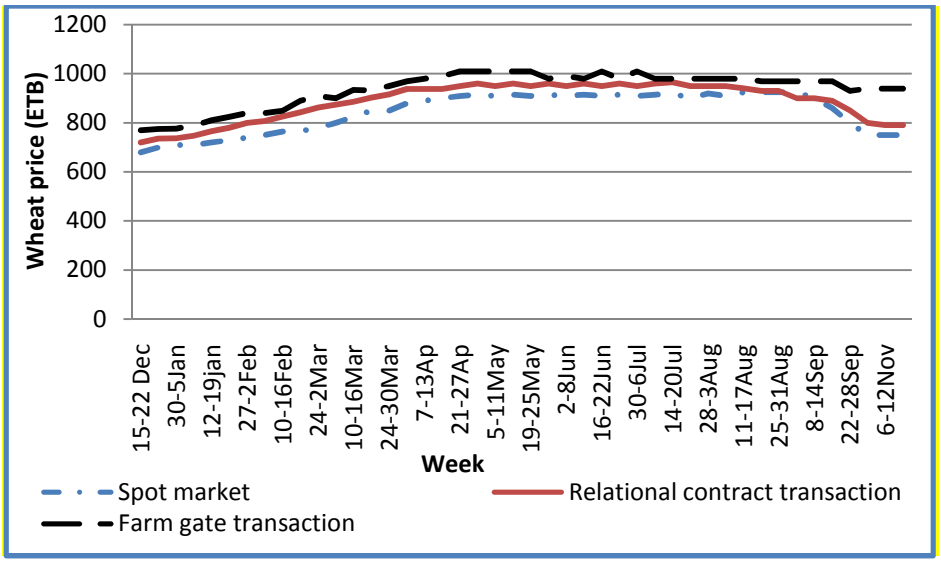
number of buyers and sellers who do not make the wheat transaction frequently and do not have a close relationship with each other which results in opportunistic behavior. Value chain actors at the spot markets transact wheat with each other at a certain place, day and time. The hybrid governance structures are further divided into three forms of contractual relationships. These are: 1) relational contracts, 2) relational farm gate transactions and 3) cooperative governance structures.

Nearly, all wheat producers in the Gimbichu district sold wheat at a spot market. A wheat transaction in Gimbichu district takes place three days per week: Saturday, Monday and Thursday. About 97 per cent of wheat producers in the Gimbichu district sold wheat to the wholesalers at the spot market. On the other hands, almost all wheat producers sold wheat at non-spot markets on a daily basis in Hetosa and Tiyo districts. About 60 percent of wheat producers in Hetosa district sold wheat to wholesalers at warehouses. The remaining 40 per cent of them sold wheat to the wholesalers at the farm gate transaction in Hetosa district which invited only wheat producers who could supply a minimum of 50 quintals of wheat at a time. Approximately, 64 percent of wheat producers sold wheat to wholesalers at the warehouses, 34 per cent of them sold wheat to wholesalers at the farm gate in Tiyo district (Table 1). Around 2 percent of wheat producers in Tiyo district sold wheat to the ultimate consumers at the spot market. Those wheat producers or their family engaged in selling wheat at the retail spot market because selling wheat to end consumers at the retail spot market provides higher price incentive as compared with selling wheat to wholesalers.

The average wheat price received by wheat producers at the spot market was 844.50 ETB per quintal and was the lowest of three wheat markets. Wheat price at the spot market ranged from 680.00 to 925.00 ETB per quintal. The average wheat price received by wheat producers at the farm gate transactions was 937.00 ETB per quintal, and it was the highest of three wheat markets. Wheat producers' price ranged from 770.00 to 1,100.00 ETB per quintal. The average wheat price was887.00ETBper quintal at the warehouse and ranged from 720.00 to 965.00 ETB per quintal. Nearly, all wheat producers in the Gimbichu district sold their wheat at a spot market. Moreover, the result in Figure 4 indicates that an upward trend of wheat price benefits wheat

producers who can then speculatively withhold their product and wait for higher prices during the peak season. This situation puts wheat producers with 0.5 or less hectare of land at a disadvantage who sell their product at harvesting season. That is, the wheat producers receive a lower price for their product when they sell it immediately after harvest because the quantity of wheat supplied exceeds the quantity of wheat demanded in the wheat market.

Figure 4: The effects of governance structure and selling time on wheat price



Source: Survey data and district municipal (2015/16)

4.5 Hybrid Governance Structures and Incentives

A. Relational contracts

The relational contract is an informal contract that exists between the WVC actors. Verbal agreements are made between the WVC actors regarding wheat supply. Wheat producers supply wheat to wholesalers, regardless of delivery time, frequency and wheat quality per transaction. Similarly, when wheat processors demand wheat and communicate wholesalers with mobile phone wholesalers supply wheat to them as per their quantity demanded. Macaulay (1963) argues that formal contracts are unnecessary because such relationships show an absence of trust between actors. This verbal binding agreement between the wholesalers and wheat processors is built on the basis of trust and

long-term business relations. About 70 per cent of wholesalers had strong long-term relationships with the wheat processors. Relational contracts with a price premium for wheat were commonly practiced by 63 per cent of wheat processors in order to ensure reliable wheat supply. About 75 per cent of wholesalers had two or more wheat processors as a customer. The wheat producers made negotiations with two or more wholesalers on the price of wheat through their mobile phones or face to face communication at non-spot markets before the wheat transaction. But, relational contracts between actors did not exist in input markets which were highly characterized by opportunistic behavior. As a consequence, input suppliers exploited this information asymmetry and requested wheat producers to pay a higher price for an inferior input quality.

B. Farm gate transactions

The result indicates that about 26 per cent of wheat producers carried out their wheat transaction at the farm gate in the study areas (Table 1). They could also manage the opportunistic behavior of the wholesalers since most of them had their own weighing scale with knowledge and skills to use. Wheat wholesalers covered the costs of physical marketing such as transport, loading and unloading costs, while they bought wheat from wheat producers at the farm gate. They also pay a price premium for a higher quality of wheat per quintal as compared to other markets. The study indicates that the wheat producers' bargaining power associated with the wheat price was the highest under the farm gate transaction and the lowest under spot market transaction. A bulk volume (i.e. above 50 quintals) of wheat supply enabled wheat producers to exert influence over wholesalers. Bulk wheat purchased by wholesalers retained the higher wheat quality and reduced physical marketing costs as evidenced by DIIDRC (2011). About 13 per cent of the wheat producers perceived that they had low bargaining power regarding the price of wheat, and approximately 50 per cent and 38 per cent of wheat producers recognized their bargaining power regarding wheat price over buyer as medium and high respectively in the study areas. The highest wheat producers' bargaining power was observed in Hetosa district and the lowest was observed in Gimbichu district.

C. Cooperative governance structures

Primary cooperatives purchase wheat from wheat producers at spot market and cooperative office at a yearly average wheat price during trough season for two months. It provides a relatively moderate price incentive to wheat producers as compared with the highest wheat price incentive during peak season. Following this, only a few number of wheat producers sell wheat to the primary cooperative. Unions provided a limited amount of money to primary cooperatives in the form of credit. The primary cooperatives fail to purchase wheat from wheat producers throughout the year because they do not have the self-governing authority to rotate money, resell wheat to any actors and purchase inputs directly from companies. They stick to a blue print approach which takes away their input and output market decision power. They purchase wheat with help of this credit from wheat producers at spot market and cooperative office for only two months because they cannot rotate the limited amount of capital and, therefore, resell it to the union for profit, on average, 35 ETB per quintal and then the unions sell it to potential actors during peak period through auction. They were able to purchase only 25,074.2 quintals of wheat per annum from wheat producers at spot markets and cooperative offices in Gimbichu district, 13,792.4 quintals of wheat in Hetosa district and 782.3 quintals of wheat in Tiyo district.

About 65 percent members of the cooperatives claimed that cooperatives did not supply adequately lately introduced chemical inputs on time and over supply old and unwanted chemical inputs. This creates an opportunity for private chemical input retailers to increase prices of the chemical inputs by 50-200 ETB per liter when the inputs are not found in the stores of the cooperatives. On the contrary, when the chemical inputs are found in the primary cooperatives input retailers decrease the price of input by 50-100 ETB per liter which creates unsold or surplus input inventory in the stores of cooperatives. These situations result in high transaction risks, costs and existence of expired or adulterated pesticide and herbicide in the input market. It is possible to conclude that existing weak institutions provide the strong incentive to chemical input suppliers at the cost of wheat producer's wheat yield. About 71 per cent of the wheat producers were the primary cooperative membership. Particularly, about 80 per cent, 71 percent and 64 per cent of

wheat producers were cooperative membership in Gimbichu, Hetosa and Tiyo districts, respectively (Table 2).

4.6 Determinants of Wheat Producers' Price Incentive

Price incentive is an important instrument to motivate farmers to adopt technology and enhance productivity and production. The price of wheat plays a significant role in wheat productivity and adoption of improved wheat varieties. In this study, the average price is equal to wheat producers' total price being received over a year divided by the number of prices received within the year. The average wheat price is expected to be dependent on governance structures, selling time, price information, economies of scales and other explanatory variables.

The results on the determinants of price incentive are provided in Table 3. Out of 3 variables, 4 variables are found to be significant at a 1 per cent level of significance. The governance structures are found to be significantly and positively related to wheat producers' price incentive at the1 per cent level of significance. The result implies that the price incentive increases from the spot market to the non-spot market. Governance structures (i.e., selling wheat at the non-spot market) increase the probability of wheat producer's price incentive by 2.23 ETB per quintal. Price information and price incentive are found to be positively and significantly related to each other at the 1 per cent level of significance. This is because adequate wheat price information increases the bargaining power of wheat producers as well as enables them to exploit wheat price differences across the wholesalers. This result corroborated the finding of Getaw and Gahiigwa (2015). Utilization of price information with mobile phone increases the probability of price incentive by 0.66 ETB per quintal. Wheat producers' participation in extension service is significantly related to price incentive at the 5 per cent level of significance. A 1 frequency increase in extension service increases the probability of wheat producers' price incentive by 0.13 ETB per quintal. The model result shows that economies of scale are significantly and positively associated with wheat producers' price incentive. Selling bulk volume at a time could lower physical marketing costs; could enable wheat producers to exert influence over buyers during price negotiation and influence the opportunistic behavior of the buyers (DIIDRC,

2011). The result indicates that an increase in wheat output by a quintal increases the probability of wheat producer's price incentive by 0.04 ETB per quintal. Trust, producer's power relations, producer's perception on wheat quality and co-operative membership affect wheat producer's price incentive positively, but not significant at the 10 per cent level of significance. Distance to flour factory influences wheat producer's price incentive negatively, but not significant at 10 per cent level of significance.

Table 3: Determinants of wheat producers' price incentive

Independent variables	**Ordered logit, number of observations (220)**	
	dy/dx	**Std. Err.**
Governance structure (Likert scale)	2.31***	0.36
Trust (binary)	0.29^{ns}	0.39
Producer's price information (Likert scale)	0.66***	0.19
Producer's power relations (Likert scale)	0.05^{ns}	0.33
Producer's perception on wheat quality (Likert scale)	0.04^{ns}	0.29
Co-operative membership (binary)	0.27^{ns}	0.36
Extension service (frequency in a year)	0.13**	0.05
Distance to flour factory (km)	-0.01^{ns}	0.01
Combine harvester use (binary)	0.87^{ns}	0.56
Landholding size (hectare)	0.06^{ns}	0.05
Economies of scale (quintal)	0.04***	0.01
Cut1	3.78	1.76
Cut2	6.34	1.81
Log likelihood=-161.60		
LR chi2(11)= 157.99, Prob> chi2 = 0.00		

Source: Own computation result based on (2015/16) survey data;
Note: *** and ** and * imply statistical significance at 1 per cent level, 5 per cent level and 10 per cent level, respectively, ns=non significant at 10 per cent level.

Dependent variable is the price incentive of wheat producers which is captured through average wheat price as a proxy variable. Average wheat prices of wheat producers are equally divided into three categories since average wheat producers' prices are not normally distributed. For instance, the average price of wheat producers has been classified into three levels: low (<785 ETB), medium (785-900 ETB) and high (900-1,100 ETB). Governance structure is

defined as 0 if wheat producers sell wheat at spot market, 1 if wheat producers sell at warehouse, 2 if wheat producers sell at farm gate.

5. Conclusion

The result of the study shows that level of incentives increase from the spot market to hybrid governance structure. Input spot markets at the beginning node of the WVC suffer from opportunistic behavior, and high transaction risks which remarkably increase costs of production and decrease productivity. As result, coordination failures in the first node decrease incentives of actors in next node which subsequently trigger lower incentives in subsequent nodes. Network and trust provide a high price incentive for both wheat processors and wholesalers. This paper found that the governance structure, transaction risks, asymmetric information and trust influence actors' incentives in each functional node of the WVC. The governance structures, extension services and price information had a significant effect on wheat producers' price incentive.

NGOs and GOs should work intensively for the betterment of input markets by encouraging introducing hybrid governance market transactions and governance mechanisms such as the quality-based pricing system, regulatory mechanisms, laboratory tests and/or third party verifications. NGOs should encourage private sectors and jointly work with GOs to provide services such as third-party certification to tackle the information asymmetry problems in input markets, weak pricing system, and risk and uncertainty regarding the quality of inputs. These strategies would provide fair incentives to all WVC actors, and influence wheat productivity and profitability which also have a positive impact on the welfare of upstream suppliers.

Conflict of interest The authors declare that they have no potential conflict of interest.

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Credit Access and Adoption of Small Scale Irrigation Technologies: Case of ILSSI Sites in Ethiopia

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Abstract

Whether access to credit is critical for adoption of irrigation technologies, and identifying factors that influence participation and level of loan are important research questions. Identifying factors that influence adoption of water lifting (WL) technologies is also another important research question. This study addresses these questions by using 193 irrigation households and 207 control households from selected sites in three regional states in Ethiopia. The availability of private water sources, years of irrigation experience,and plot distance are important determinants of adoption of WL technologies, both manual or motorized pumps. The mean difference in cost of technologies was significantly different between the treatment and control households indicating the importance of access to credit, including involvement in revolving fund, for adoption of irrigation technologies. Asset holding, mainly land and livestock ownership, credit service provision variables, perceptions of weather risk and climate change influenced participation and level of loan demand. Some village variables like distance to major markets and to microfinance office had important influence on participation and size of the loan received. Conclusions and policy implications were drawn.

Key words: credit service, loan demand, irrigation technology adoption, propensity score matching, triple-hurdle model, Ethiopia, Africa

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Acknowledgement

The data collection and analysis was supported by Feed the Future (FtF) Innovation Lab on Small Scale Irrigation (ILSSI). We are grateful to the survey respondents for sharing their time to respond to our long questionnaire. The authors are responsible for errors in analysis, if any. The results of this study do not reflect views of the project or funding agency.

1. Background

Smallholder farmers are investing in different water lifting (WL) technologies directly (de Fraiture and Giordano 2014; Namara et al. 2014; Burney et al. 2013), such as manual and motorized pumps. These technologies require access to shallow wells or perennial streams (rivers), not requiring costly infrastructure investmentsin infrastructure development for storage (e.g. dams and reservoirs) and conveyance structures (e.g. canal systems).

The government of Ethiopia (GoE) envisages that about 80 percent of the households will have access to water (NPC, 2016), indicating the scale of expansion of small scale irrigation in Ethiopia the coming years. The potential for small scale irrigation in Sub-Saharan Africa (SSA) is estimated at tens of million ha (detail see Xie et al. 2014).

Many studies suggest a positive link between irrigation development and poverty reduction (Namara et al. 2010; Hagos et al. 2012; Burney and Naylor, 2012; de Fraiture and Giordano, 2014; Giordano and de Fraiture, 2014). Evidence is emerging that small scale irrigation technologies is financially feasible (Gebregziabher et al. 2017), even if access to credit is not necessarily guaranteed. There are studies that indicate that micro-credit is notwidely available to smallholder farmers and credit products are limited to respond to specially to demands of smallholder commercial farmers[3](Chanyalew, 2017).
Smallholder farmers face a range of constraints to adopt WL technologies. A key limitation to smallholder farmers is the lack of cashfor outright purchase from local markets.Many studies confirm working capital requirements as a main limitation to irrigated agriculture (Grimm and Richter 2006; Kereta 2007; Burney et al. 2013; Namara et al. 2014).Stiglitz (1990) and Godquin (2004) highlighted lack of access to credit and high cost of technologies are important impediments to adoption of irrigation technologies. Namara et al. (2011) noted the upper quintile of farmers tend to adopt small scale irrigation (SSI) technologies, because poorer households are unable to afford them outright and lack access to finance. Other studies suggest that credit access

[3] Chanyalew (2017) defined smallholder commercial farmers (SCF) as farmers that are market-oriented and their loan demand is higher compared to the traditional semi-subsistence farmers.

among other factors is an important determinant in adoption of irrigation technologies, treadle and motor pumps, and other agricultural technologies (Adeoti 2009; Gebregziabher et al. 2014; Getacher, et al. 2013; Hailu et al. 2014). Evidence by Liverpool and Winter-Nelson (2010) indicate that microfinance can play positive effects on the use of improved technology, asset growth and consumption. Abate, et al. (2016) report that access to institutional finance (loans from cooperatives) has a significant positive impact on both the adoption and extent of use of agricultural technology in Ethiopia. In summary, the technology adoption literature identifies access to credit as one of the general determinants of adoption.Various consultations with agricultural sector stakeholders over the past several years in Africa confirmed this as a critical issue.

Exploring the effect of microfinance access in adoptions of irrigation technologies, identifying factors for participation and loan size (intensity) are important research questions. It is important to identify factors for credit participation including the role of perception of risks - crop failure risk (due to bad weather), climate risk, etc. and factors affecting farmer's demand for credit (loan size).

Evans et al. (1999) while indicating that rates of participation in microcredit are higher among poorer households in Bangladesh, lack of female education, small household size and landlessness are factors for nonparticipation. Amin et al. (2003) indicate that microcredit is successful at reaching the poor but it is less successful at reaching the vulnerable suggesting evaluation of their targetingstrategy.

This study seeks to fill a gap in the adoption literature through a case study that looks specifically of credit access and SSItechnology adoption in Ethiopia. The main objectives of this study are, hence, to explore the following:

1. To explore whether access to credit have a significant impact on the extent of adoption (measured by cost of irrigation technology),
2. To identify factors that determine households' decision to adopt WL technologies? and

3. Conditional of adopting WL technologies,to identify factors that affect households' decision to participate in credit market and households' decision on the amount of loan demanded.

The novelty of this study is estimating average treatment of access to credit service on adoption of irrigation technologies (measured by the cost of irrigation technology) and simultaneously estimating the three decisions – adoption of WL technologies, the decision to participate in credit market and decision on the loan size- using an advanced econometric approach. This study used a unique dataset on smallholder farmers, 193 treatments and 207 control households, collected in 2016 in Ethiopia.

The paper is organized as follows. Section twointroduces the study area, surveyand empirical approaches followed by description of econometric methodologies used. Section 3 presents results and discussions and the final part concludes and draws policy implications.

2. Site description, survey and empirical approaches

2.1 Study site and survey approach

The case study included five target kebeles[4] in four field research intervention sites, from the Feed the Future Innovation Laboratory for Small Scale Irrigation (ILSSI) project in Ethiopia including Robit-Bata and Dangila in the Amhara regional state, Lemo in Southern Nations, Nationalities and peoples (SNNP)regional state, and AdamiTulu in Oromia regional state, (see Figure 1). ILSSI projectpilot tested four WL irrigation technologies,pulley, rope and washer pump, motor pump and solar pump,for small scale farmers. The project worked with local microfinance institutions and cooperatives to transfer the technologies on credit to farmers.

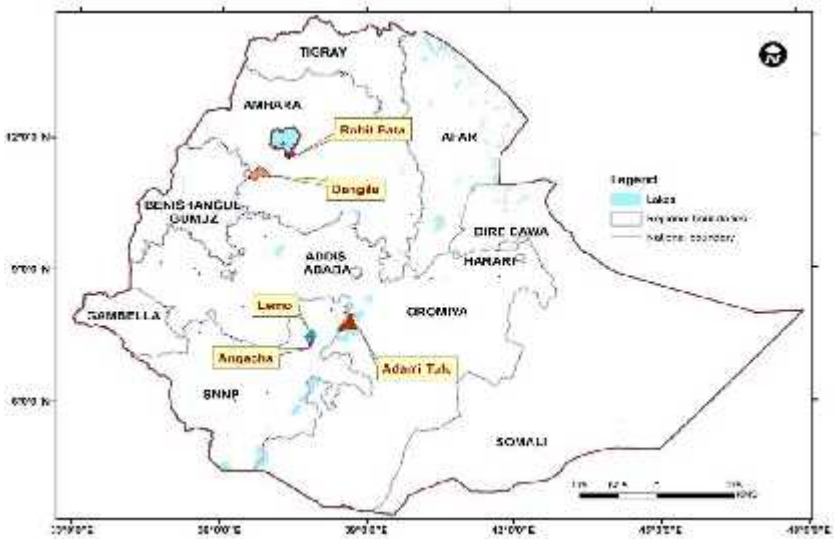
The five target kebeles in corresponding werdas (districts) were purposively selected. For this study. Data was collected from 400 households, 193 irrigating (treatment) and 207 control households,the later randomly selected

[4] Kebele or peasant association is the lowest administrative unit in Ethiopia. It covers an area which inhabits about 1000 households.

from these sites.Data from treatment and control households were collected so the study can statistically assess the impact of the intervention (i.e. credit access not only those targeted) using an innovative approach such as propensity score matching. The results could be applicable to the corresponding districts although it would be difficult to extrapolate the results to the whole country. Moreover, the randomly households were asked for their consent, i.e. if they are willing to be involved in the survey, before starting interviewing using structured questionnaire.

The questionnaire developed for this purpose had different modules: identification information, household and demographic characteristics, access to infrastructure and services, current asset holdings, characteristics of land owned/used, rainfed and irrigated crop production and input use, post-harvesting and marketing, credit services including burrowing history and risk and insurance. The survey was implemented during May to June 2016 and targeted 2015/2016 production year. 10 enumerators were trained on survey methodology and the questionnaire so that enumerator could ask the interviewees in clearer manner and record their responses accurately. The survey was paper based and involved face-to-face interview.

Figure 1: Location of study sites



In addition to this formal survey, the study includes semi-structured interviews targeting all relevant stakeholders in all the sites though Key Informant Interviews (KIIs). This information was used to contextualize the results of the formal survey and the results also enabled better understanding of the lending institutions and their products and lending practices, which in turn may influence likelihood of farmers to seek out loans.

2.3 Description of empirical approaches

Assessing the impact of certain policy intervention, in this case access to credit, requires creating comparable groups of treatment and non-treatment households (details presented in the methodology section). This is important in estimating the average treatment effects on the treated (ATT) because of this intervention. Since this paper wanted to assess whether being a target household and/or havingaccess to credit (taking the whole sample households) had a statistically significant impact on adoption, (ATT).In the two empirical models, target(1) and non-target households (0) and application for loan (yes/no) were used as dependent variable and cost of the technologies was used as an outcome variable. This is to address objective one.

In addressing objectives 2 and 3, the three decisions– households' decision to use WL technologies, the decision to participate in loan for WL technologies and decision on the amount of loan for WL technologies could be linked; they can be estimated simultaneously. Estimating these as joint decisions, will enable us to test whether these decisions are separate or joint. Estimating these decisions separately while they are joint decisions, yield results which are statically biasedGebremedhin et al. (2017).

Households' decision to use WL technologies is captured by binary variable (yes/no) and the decision to participate for loan for WL technologies is also captured by binary variable (yes/no) and the amount of loan is measured by maximum amount of loan taken last year for WL technologies. Various variables like household characteristics (like head's sex, age, educational status of the head)(hhc), labor endowment (in terms of adult equivalent), plot size, both rain fed and irrigated, livestock holding (expressed in terms of Tropical livestock unit (TLU))(Asset), variable related to water source(hyd),

village level variables related to access to services and infrastructure(vc), credit service related variables(credit), and weather risk and crop price risk perception variables(risk) were used, according to their specification, in the different models, which are outlined below.

2.4 Econometric models

When assessing the impact of a given intervention on technology adoption, propensity score matching (PSM)provides a promising tool to find comparable groups of treatment and control groups. In this case, applicants of loan will be treated as treatment group while and non-applicants of loans are considered as control group. PSM aims to create comparable groups of treatment and control group based on their observed characteristics, as explained above. Various works have been explainedthe structure of the model (Wooldridge, 2010; Khandker et al. 2010), why it is preferred (Ravallion, 2003; De Janvry et al. 2010), its application (Abebaw et al. 2010; Hagos et al. 2012), including Statauser-written commands (Becker and Ichino, 2002).

For matching to be valid certain assumptions must hold. The primary assumption underlying matching estimators is the Conditional Independence Assumption (CIA). CIA stated that the decision to adopt is random conditional on observed covariates X_i. This assumption implies that the counterfactual outcome in thenon-treatment group is the same as the observed outcomes for treatment group. This assumption rules out selection into the program because of unobservables gains from access (DiPrete and Gangle, 2004). The intuition is that two households with the same probability of adoption will show up in the treated and untreated samples. Once the propensity score (pscore) is estimated, the data is split into equally spaced intervals (also called common support). Within each of these intervals the mean pscore and of each covariate do not differ between treated and control households. This is called the balancing property.

The second econometric toolused is triple-hurdle model, which has attractive features (Roodman, 2011; Bruke et al. 2015) compared to double-hurdleapproach (Cragg, 1971). This study was inspired by the works

Gebremedhin et al. (2017) and Shiferaw et al. 2017). A farmer passes through three hurdles: using WL technologies or not - first hurdle, conditional on using WL technologies decide to participate in the credit market - second hurdle, and once the decision is made to participate then the farmer decides the amount of loan – third hurdle, i.e. going for more expensive WL technologies. In other words, all households who have access to irrigation do not use WL technologies. The first hurdle is identifying factors for using WL technologies. The second hurdle is identifying factors that determined participation in credit market for WL technologies. And the third hurdle is identifying factors that determine the amount of loan acquired for WL technologies.

The full triple-hurdle model is represented as follows:

1. W_1=W_1 **(hhs, asset, hyd, villageccredit access)**, decision to use WL technologies
2. W_2=W_2 **(hhs, asset, credit, risk, villagec)**, decision to participate in credit market for WL technologies
3. W_3=W_3 **(hhs, asset, credit, risk, villagec)**, decision on the amount of loan received for WL technologies

Where W_1 is a binary indicator of whether the household uses WL technology, W_2 is a binary indicator on whether the household applied for loan for WL technology and W_3 is the amount of loan received last year demanded conditional on the household positively decides on loan participation, which is a censored variable.The covariates for each equation are indicated (as was explained earlier above). Triple-hurdle model is an extension of Heckman (1979). The first and second stages are estimated using a probit models. Since the dependent variable in the third stage is strictly positive, using lognormal model is advisable (Wooldridge, 2010).The loglikelihood function (not indicated here) incorporates two probabilities of two possible outcomes; namely, household applying WL technology or not and, a household taking loan, deciding to allocate to WL technologies or other purposes, and log normal model estimating the marginal effect of a variable of the amount of loan. Combing the indicated possible outcomes gives the likelihood function.The model integrates and simultaneously estimates these three decisions. the three equations(Equations 1-3)by including Inverse Mill's Ratio

(IMR) estimates from Equation 1 to 2 and 2 to 3. Inclusion of appropriate exclusion restrictions (to enable identification) could be necessary. The specification of the three equations isdifferent (see the Stata outputs below).The triple-hurdle model is estimated as suggested by Roodman(2011) and Burke et al.(2015) in Stata 13.0.

The variables entered equations 1- 3, together with their description and their expected effect on the three dependent variables is summarized in Table 1.

Table 1: Variables and their expected sign

Loan demand Variables	**Description**	**Expected sign**		
		W_1	W_2	W_3
Access to irrigation	Accessing irrigation through water lifting (WL) technologies or otherwise	+	+	+
Irrigated land	land holdings, both own-operated and rented-in/sharecropped-in (in timad)	+	+	+
Total farm size	Total land holdings, both own-operated and rented-in/sharecropped-in (in timad)	?	+	+
Distance from home	Plot distance (in mts)	-	-	-
Source of water	1= private, 2= publics	+	n.a.	n.a.*
Livestock holding	Number of livestock (in TLU)	+?	+	+
Wealth	Value of farm assets (in ETB)	+	+	+
Weather shocks/crop failure	Was last year good year (reference bad)	n.a.	+	+
Group lending	Group liability in lending	n.a.	_	_
Individual lending	Private loan service	n.a.	+	+
Interest rate	Annual interest rate	n.a.	-	-
Loan duration	Length of loan duration (in yrs)	n.a.	-	-
Rescheduling	Repayment rescheduling	n.a.	+	+
Access to irrigation	Accessing irrigation through water lifting (WL) technologies or otherwise	+	+	+
Irrigated land	land holdings, both own-operated and rented-in/sharecropped-in (in timad)	+	+	+
Total farm size	Total land holdings, both own-operated and rented-in/sharecropped-in (in timad)	?	+	+
Distance from home	Plot distance (in mts)	-	-	-
Source of water	1= private, 2= publics	+	n.a.	n.a.*

Source: authors, * n.a.= not applicable.

3. Results and discussions

3.1 Situational analysis

The National Bank Ethiopia (NBE) developed a legal framework in 2009 to govern the development and soundness of microfinance in Ethiopia (FDRE, 2009). The Microfinancing Business Proclamation No. 626/2009 states the main purpose of a microfinancing institution as collecting deposits and extending credit to rural and urban farmers, and people engaged in other similar activities, as well as micro- and small-scale rural and urban entrepreneurs. It mandates theNBE to set the maximum amount of a credit product that a microfinance institute can provide (FDRE, 2009). According to the same proclamation, loans may be made without collateral, secured by collateral or secured by group or individual guarantees as appropriate and at the discretion of the institution. The NBE issued directives on licensing and supervision of MFIs following the proclamation (NBE, 2013).

The potential reach of MFIs appears substantial. in Ethiopia. Thirty-fourMFIs had obtained a license from National Bank of Ethiopia to operate in the country (Chanyalew, 2017). Wiedmaier-Pfister et al. (2008) show the regional distribution of MFIs in Ethiopia. Currently the Association of Ethiopian Microfinance Institutions (AEMFI), an umbrella organization of MFIs, has 34 members, suggesting growth in the number of MFIs. The total number of organizations operating in the microfinance sector is larger than the number of registered members of AEMFI. Savings and credit cooperatives, which are not members of AEMFI, are growing in number and size in the country (Wiedmaier-Pfister et al. 2008).

The NBE removed all interest rate ceilings in the financial sector in 1998, presumably to encourage financial service providers to increase lending operations. However, this has not led to free market-based determination of interest rates in all cases. Lending interest rates of Ethiopian MFIs range between 9% and 24% flat rate5, and are thereby relatively lower than other sub-Saharan countries (Wiedmaier-Pfister et al.2008).

[5] A group loan from the ACSI costs 18% a year and for DECSI 15%. In both MFIs, an individual MSE loan costs 9% to 12.5%. MFIs affiliated to international NGOs or the privately owned Aggar charge a flat rate of 15% to 24% respectively.

The number MFIs appears promising, with almost all MFIs offering micro-lending and saving to smallholder farmers. However, the lending and saving products are limited.Larger MFIs, such as Amhara Credit and Saving Institute (ACSI), Dedebit Credit and Saving Institute (DECSI), Oromia Microfinance Institution and Omo Microfinance Institute (OMFI), offer a limited range of finance products, micro-insurance, leasing, pension funds and transfers products.

Table 2: MFIs, their products, capacity, management of seed money and repayment conditions

Variables	Microfinance Institutions and Credit and Saving Cooperative			
	WLQO	**OMFI**	**ACSI**	**Albina Cooperative**
Credit system	Cash	Cash	Cash or vouchers	Cash
Loan cap/range in ETB	3000-6000*	2000-10000*	4,360 -14,000	5256
Type of lending	Group	Group	Group and individual	membership (group) and personal loans
Interest rate/range	12	12	18	14.5
Repayment performance	12	10	100	100
Repayment duration	3 months to 1 year**	3 months to 1 year**	1 year	6 months up to 5 years***
Factors affecting repayment	Crop failure, price volatility, Higher interest rate and percept of loan as a gift	Crop failure, price volatility, Higher interest rate and percept of loan as a gift	Poor credit appraisal, inadequate monitoring and diversion of funds	Crop failure, market price volatility, willful default, and inappropriate timing of credit delivery
Training to improve capacity	Twice a year	Once a year	n.a.	n.a.

* The lower range is for ranfed inputs while the later for purchase of irrigation equipment

** The lower margin is for fattening and the later for agricultural inputs (both Rainfed and irrigated)

*** For agricultural loan and non-agricultural loan respectively.

Source: Semi-structured interview 2016

This study sought to understand factors that influence the supply side of microfinance in the study areas, and carried out number of semi-structured interviews inthe 4 sites with MFIs and relevant stakeholders, such as local government. The results of the interviews reflect the situation described above (see Table 2). MFIs and cooperatives operate in the study areas, but offer few products, with a range of interest rates and repayment terms.An overview of the microfinance lending situation for each site is provided below.

The summary of result of the semi-structured interviews is reported in Table 2. The interview results point to the situation in the study areas for credit supply, while also suggesting some factors that may influence both demand for credit and likelihood for loan repayment. Finance products, limited to purchase of agricultural inputs, irrigation technologies and business relate (non-agricultural), are available to farmers through MFIs or local cooperatives with a wide range of rates and payment terms. All the institutions interviewed noted that the number of loans to farmers is increasing and the upper cap of the loan amount is rising. Some MFIs do lend for irrigating farmers, but the size of the loan that the MFIs and cooperatives offer may be too low for farmers to enable them to generate adequate capital to purchase technologies that will most effectively increase farmers' income and reduce drudgery of labor. Nearly all the institutions agree on the risks for non-repayment of loans, and weather features prominently, suggesting that increased supplemental and dry season irrigation could improve loan repayment and reduce the risks both to lenders and farmers. The interviews also described the process for payment collection involving multiple institutions, including government and in some cases security (police). This appears to improve loan collection and decrease default, but raises some questions about institutional mandates and disincentives smallholders have in borrowing. In sum, MFIs and cooperatives do provide a range of credit products however, only some of the financial products are appropriate for irrigation investments, and the terms of repayment and practices for loan collection may discourage smallholders from borrowing. This situation may in turn decrease the impact of nominal credit access on adoption of irrigation technologies by smallholders.

3.2 Summary statistics

The survey results provide a sample summary of socio-economic variables, credit services andother important factors that may affect actual borrowing by smallholder farmers, The average age of the household head is 46 years, butthere is no significant difference in age between those loan applicants and non-borrowers. 87 percent of the head were male- while 13 percent were female-headed. Of all those households surveyed, 72 % applied for loan last year, and of those loan applicants, 84 % could get a loan. 55.7 % of the female-headed households surveyed applied for loans. This compares to the 74 % of the male-headed household that applied for loans. The regional distribution of applicants and non-applicants is given in the table3. The major credit sources in the study sites are microfinance institutions (76.32 %), followed by friends/relatives (4.22 %) and farmers groups (3.73%). Formal banks and private lenders play only a very minimal role in the study sites.

Disaggregated by purpose, survey households stated that loan applications had been made for the following: oxen purchase (32.30%), purchase of farm inputs (24.72 %), such as improved seeds and agro-chemicals, family health expenses (19.45%), small scale irrigation (17.96 %) and other or non-agricultural businesses (3.42 %). From the survey, we found out that no credit service was available to cover expenses for family events and consumption.

The main reasons for not applying for loan, included fear of failure to repay (50.75%), lack of need for loan (31.0 %), outstanding loan (6.40 %), denied loan in previous year (5.44%), lack of awareness of credit service (2.45%) and other (3.94 %). In this case, the fear of failure to repay is the primary reason for not applying for loan. A strategy should be devised to encourage loan taking, in the face of this underlying risk, loan payment collection process and potential consequences for default.

The number of adults (in adult equivalents) in the household, which could be a good measure of labor holding of the household, is significantly associated with loan application.Households that applied forloan in the previous year had about 4 adults, while those who did not haveabout 3.5 adult members. The

consumer-worker ratio is about 0.823for those who applied for loan and 0.825 those which did not and it is not significantly associated with loan application.

Not surprisingly given loan requirements by MFIs, wealth (measured by the value of asset holding) was significantly higher for applicants compared to non-applicants. Livestock holding, in tropical livestock unit (TLU) was 3.5 units for loan applicants and only 2.5 units for non-applicants, which is significant at 1 percent level of significance. When disaggregated, oxen holding, large ruminants and equines are significantly higher for loan applicants. Land holding did not follow this pattern, however. The average land holding is 0.8 timad (~ 0.2 ha)for loan applicants and 0.9 timad (~ 0.225 ha)for non-applicants, which is significantly different. This indicates that households with larger average land holding borrowed less than those households with smaller land holdings.

Table 3: Summary statistics (n= 2903)

Variable name	Description of the variable	Applied for loan	Not applied	t-test/X2 test
age	Age of household head/spouse	46.6	46.4	0.339
sex	Sex of the household-head (reference female)	84.35	78.35	7.648***
Adult equivalent	Male and female adults equivalent (between the age of 14-65 years)	17.60	13.75	-5.57***
c-worker ratio	Consumer-worker ratio	0.823	0.825	0.0775
Land holding	Cultivated land both rainfed and irrigated , in timad[1])	0.84	0.93	2.43**
Irrigland13/14	Irrigated land in 2013/14 (in timad)	0.22	0.25	0.933
Irrigland12/13	Irrigated land in 2012/13 (in timad)	0.21	0.23	0.833
Livestock holding	Household livestock holding (in TLU)	3.51	2.55	-10.30***
Oxen holding	Number of oxen the household owns	1.06	0.80	-9.57***
Large ruminant	Number of large ruminants in TLU the household owns	2.78	2.00	-12.39***
Small ruminants	Number of small ruminants in TLU the household owns	0.119	0.13	1.34
Equines	Number of equines in TLU the household owns	0.61	0.42	-4.77***
Livestock less oxen	Household livestock holding less oxen (in TLU)	2.83	1.88	-9.59***
Wealth	Value of asset holding	100031.4	58965.41	-2.35**
Applied loan	Applied for loan for different purposes (%)	72.35	-	-
Able to obtain	Able to obtain loan (%)	84.06	-	-
Total credit	Total credit for agricultural, non-agricultural, and health purposes received last year (in ETB)	397.4		

[1] A timad is quarter of hectare.

Variable name	Description of the variable	Applied for loan	Not applied	t-test/X2 test
Interest rate	Average annual interest rate (%)	16.93	-	-
Repayment	(%) Households who succeeded to repay their loan last year (reference= no)	0.41	-	-
Irrigation experience	Households with irrigation experience (%)	0.34	0.32	0.23
Year irrigation experience	Number of years of irrigation experience	2.48	2.02	-2.03**
Apply irrigation technology	Use of irrigation technology (% of irrigators)	0.777	0.66	15.69***
Irrigation technology cost	Cost of irrigation technology	1779.54	2574.69	5.10***
Distance major market	Distance to district major market (in km)	24.55	54.90	14.24***
Distance to all weather road	Distance to all weather roads (in km)	19.6	10.86	-1.49
Distance to microfinance institution	Distance to the office microfinance institution (in km)	7.143	16.60	5.63***
Amhara	Households from Amhara region (%)	66.57	29.44	49.03***
Oromia	Households from Oromia (%)	13.45	14.42	11.72***
SNNP	Households from SNNP region (%)	19.98	56.53	11.26***

Source: Survey 2016

Irrigated farming was positively associated with loan application, as 77 % of the loan applicants used irrigation technologies compared to 66 % of non-applicants. Cumulative experience in irrigated agriculturewas also an important factor in likelihood to apply for loan. About 34 % of households surveyed have irrigation experience, and the level of experience increases the likelihood to apply for a loan. Households with more irrigation experiences (close to 3 years) applied for loan compared to households with 2 years of irrigation experiencesthat did not apply.However, irrigated landholding was not significant associated with loan application.

Regarding small scale irrigation technologies, about 46 percent of the households apply various irrigation technologies (not indicated in the table): About 33 % manual pumps (i.e.13.07 % rope and washer pump, 19.22 % pulley and 0.91 % treadle pump),12.96 % motorized pumps, 1.19 % solar pumps, 0.17 % electric pumps, and 6.43 %applymanual practices, using bucket, hose and watering can. The list of technologies of the whole sample differs from those four technologies piloted by the ILSSI project. The dominant water application is manual practices using bucket/hose/watering can (73.5 %), followed by surface flooding (13.87 %), furrow irrigation (7.05 %) and drip technology (3.30 %).

The mean loan applied for was about ETB 397 (USD 18)[1] while the average irrigation technology cost wasETB 2000, being on average ETB 1779.5(USD 92) for applicants and ETB 2574.7 (119 USD)for non-applicants., perhaps indicating that households that depend on their own cash (saving) invest more. However, not surprisingly, the households that were targets of ILSSI projecthad acquired[2] irrigation technologies which costed about ETB 3867 (USD 179) compared to non-participating households whose average cost was ETB 694 (USD 32), which was significantly different at 1 percent level of significance.

Regarding loan repayment, only 41 % of the borrowers stated that they repaid their loan last year. The average repayment ratio is equal to 0.046, which is low, ranging between 0, indicating complete defaulted, in between households that repaid part of the loan and 1 being those who repaid the whole amount. This

[1]1 USD was equivalent to 21.60381 ETB in June 2016 at the time of the survey.

[2] ILSSI piloted pulley, rope and washer pumps, motor pumps and solar pumps and transferred them to smallholder farmer's ownership on credit basis.

contradicts the views of the financial service providers that stated full loan repayment is the normal practice, but the reason for the discrepancy is not known.

The average distance to major district markets for surveyed households was 25 km for applicants and 55 km for non-applicants, suggesting the importance of market proximity to likelihood of loan application. The average distance to a microfinance institution was about 7 km for loans applicant and 16 km for non-applicants, also showing that proximity to lending MFI or cooperative branch or satellite offices influences loan application. Both variables are statistically different implying that access to market and microfinance institution is important for participating in loan services.

In summary, cross tabulation of survey results indicatespossible trends in loan applicant households; households that apply for loans tend tohavemore labor availability (in adult equivalent terms), smaller land holdings, more wealth (asset holding), morelivestock holdings, higher experience in irrigation, closer proximity to major markets and microfinance institutions. The next section explores the validity of these observations using multivariate analysis that controls for the effect of other covariates.

3.3 Impact of credit access on cost of irrigation technology used

We created comparable groups of control and treatment using PSM (psmatch2). The matching variables used weretarget and non-target household and access to loan last year(yes/no), while the outcome variable was cost of irrigation technology. In the first equation,of the total 1695 observations 1009 untreated and 689 treated (95 percent of the total) were on the common support. In the second equation, of the total 1242 observations 604 untreated and 1137 treated(98 percent of the total) were on the common support.The balancing property is, thus, satisfied in both cases.

Table 4: Impact of being target in revolving fund on costs of irrigation technology

Variable	Observations	Treated	Control	t-test
Technology cost	Unmatched	3747.81	736.05	20.03
	ATT	3692.85	2363.12	4.07***

***, significant at 1 percent level of significance

Source: 2016 survey

Several propensity score variables were identified (See Table 1A). Households that apply irrigation technology are more likely to apply for loan services compared to households that did not use irrigation technologies, even if they have access to irrigation. Households with more livestock holding (in TLU) are also more likely to apply for loans. The results indicated that households which are livestock rich are more likely to borrow (but may also be targeted by the credit service providers). Therefore, microfinance service programs in Ethiopia targets the relatively better-off, male-headed and relatively educated household members. This is in line with the results of a case study in Bangladesh that found that microfinance programs have not reached the poorer households (Amin et al., 2003). This result implies that the lending institutions aim to minimize the risk of default, which makes sense from their point of view.

Table 5: Impact of credit access on the cost of irrigation technology

Variable	Observations	Treated	Control	t-test
Technology cost	Unmatched	1916.2	2267.5	-2.02
	ATT	1948.93	1080.27	3.21***

***, significant at 1 percent level of significance
Source: Survey 2016

Moreover, households located further away from Farmer Training Centers (FTCs) and major markets are less likely to apply for loans, which indicates the importance of access to both extension services and markets.

Some household characteristics such as educational attainment, age and sex of the household head were important variables for participation in the credit market. Household heads with higher educational attainment were more likely to apply for loans. Male-headed households are also more likely to apply for loans, compared to female-headed households. Household heads, which on average, are older are more likely to apply for loan however as age increases (age squared) this likelihood decreases. Based on the estimated ATT values (see Table 4 and 5), the mean difference in cost of technologies was significantly different between the treated and control households, indicating the importance of access to credit for adoption of motorized and solar than manual irrigation technologies.

3.4 Factors affecting the household's decision to use WL technologies

The decision to use WL technology is mainly determined by experience in irrigation, availability of private water source and plot distance from homestead. That means that households who have more experience in irrigation and have private water source in the form of seasonal/permanent shallow well, river/stream or lake (compared to public water source like small dams, river diversions) are more likely to apply WL technologies (Table 6). Households apply WL technologies on distant plots given they have more irrigation experience and private source of water. Households with average older heads are less likely to apply WL technology.

Table 6: The decision to use WL technologies - first hurdle decision

Dependent variable: apply to WL technology (yes=1 no=0)		
Variables	**Coef.**	**SE.**
Age of the household head	-0.038	0. 014***
Educational status of household	-0.003	0.006
Male-headed household (reference Female headed)	-0.056	0.416
Consumer-worker ratio	-0.325	0.222
Plot distance from homestead (in minutes)	0.023	0.008***
Land holding (in timad)	0.115	0.021
Experience in irrigation (yrs)	0.125	0.063**
Private water source (reference public)	0.858	0.441**
Access to loan (reference no)	0.642	0.434
Market orientation	0.00002	0.00003
No of crop harvest in a year	0.154	0.137
Cons-	1.402	1.038
Number of obs = 644		
Wald chi2(11) = 24.43		
Prob > chi2 = 0.0111		
Log pseudolikelihood = -206.64681		
Pseudo R2 = 0.2067		

*, **,*** significant at 10, 5, and 1 percent level of significance
Source: survey 2016

Households with larger consumer-worker ratio, credit access, land holding, are market-oriented and practice higher irrigation intensity is positively, as expected, associated with likelihood of application of WL technologies, although they are statistical insignificant.

3.5 Determinants of participation in credit market and level of loan demanded

The factors that important factor for participation and level of loan demanded– second and third hurdle -are reported in Table 7. Asset holding, in terms oflivestock and land holding has significant effects on participation and levelof demand. Households with larger livestock holding (in TLU) do participate in credit programs and demand more loans.Larger plot size increases participationand it increases the amount of loan demanded.

Table 7: Determinants of participation and level credit demanded

	Second hurdle: apply to loan (yes=1 no=0)		Third hurdle: Amount of loan received	
Variables	**Coef.**	**SE.**	**Coef.**	**SE.**
Inverse Mill's ratio	-5.577	2.244**	-	n.s.
Age of the household head	-0.023	0.017	-0.022	0.008**
Educational status of household	-0026	0.051	0.020	0.046
Male-headed household (reference female-headed)	0.335	0.506	0.694	0.469
Consumer-worker ratio	-0.006	0.004	0.079	0.913
Plot distance	-0.016	0.010	0.006	0.004
Livestock holding (in TLU)	0.024	0.060	0.067	0.043
Land holding (in timad)	0.113	0.0350***	-0.017	0.021
Proportion sold (in kg)	0.116	0.331	0.089	0.029***
Credit duration	-0.008	0.014	-0.043	0.0190**
Group loan(reference private loan)	1.265	0.561**	8038.16	3790.66**
Good growing season (reference bad)	1.232 -	0.569**	2.041	0.771***
Failure of WL technology	-	-	-.0558	0.356
Likelihood of drought and flood next year	-0.883	0.515*	-0.433	0.457
Climate change the last 10 year	-0.681	0.857	0.003	0.700
Drought in next five years	0.034	0.163	-0.141	0.153
Log of distance to MFI	-0.103	0.182	-0.374	0.142**
Log of distance to FTC (in km)	-0.031	0.096	-0.073	0.0728
Log of distance to major markets (in km)	-0.194	0.2407	0.885	0.270***
Region1			-0.373	0.187**
Region 2			-0.047	0.253
Cons-	9.907	4.068**	6.948	1.077***

Source: survey 2016, **,*** significant at 10, 5, and 1 percent level of significance, n.s.= not significant and excluded from the specification

Group lending increases the likelihood of participation and loan size compared to private lending.

Perception of risk factors such as whether last year was a 'good year' havepositive influence on participationand on level of credit demand.

Distance to microfinance institutions had a negative effect on participation and level of loan demand for WL technologies. Distance to major market had, unexpectedly, a positive effect of loan demanded, which is unexpected. Finally, age of the household head has on average negative effect on loan demand.

4. Conclusions and recommendations

Accessing water lifting technologies enhances household's access to irrigation water without requiring huge investments on irrigation storage and conveyance structures. There are studies that indicate the economics of some of the water lifting technologies (Gebregziabher et al., 2017). However, acquiring irrigation technologies may require availability of credit service.

The study explores whether targeted households, through revolving fund scheme or having access to microfinancein general is important for the adoption of small scale irrigation technologies. The study also examines the determinants of adoption of WL technologies. Moreover, Moreover, the study assessed determinants of participation and level of loan demandedfor those households that use WL technologies. The study also put a general picture of microfinance services in ILSSI intervention districts through semi-structured interviews.

Loan products served by MFIs and saving and credit cooperatives is limited; the credit instrument is predominantly cash, although voucher is used in some MFIs. In general, there is a lack of innovative, demand-driven financial services and sustainable institutions that can cater for the huge unmet demand of poor households (Wiedmaier-Pfister et al., 2008). The outreach of the existing microcredit services, considering only the magnitude of the household served, is encouraging, reaching about 72 percent of the households mainly for the purchase of farm inputs, livestock purchase and fattening, irrigation technologies and non-agricultural investments. The mean loan was about 18.4

USD. The average irrigation technology cost is about 93 USD, it is 82 and 119 USD for loan applicants and non-applicants respectively.

The econometric results indicate that being target households or loan access in general is an important variable for adoption of small scale technologies. This result shows, in both cases, that the mean difference in cost of technologies was significantly different between the treated and control households, indicating the importance of access to credit for adoption of motorized and solar irrigation technologies.

Households who have more experiences in irrigation and have private source of water compared to public water sources are more likely to apply WL technologies. Households may apply WL technologies on distant plots given they have more irrigation experiences and privatewater source. Households with average older heads are less likely to apply for one of these technologies.

Wealth (in terms land and livestock) are important determinants of participation and loan demand. Group lending increases the likelihood of participation and loan size compared to private lending. Perception of risk factors like whether last year was a good year have positiveinfluence on participation and level of credit demand. Moreover, access to microfinance and distance to major markets have important influence on participation and loan demand.

The evidence that we have from this study is microfinance services target the relatively better off. Policy decisions could take multiple directions: devising products to reach out the very poor and vulnerable sections of society and targeting the emerging smallholder commercial farmers. Targeting the very poor, effectiveness of microfinance and regular repayment is important. to enhance irrigation development in Ethiopia. Designing revolving credit scheme for the relatively poor could be an entry point. Promoting irrigation technology through credit service may also require improvement of the input and output markets and strengthening extension in farmers' training centers. Another entry point, in the light of transformation of agriculture in Ethiopia, expanding the credit products so that they could meet the needs of the emerging smallholder commercial farmers is also crucial.

Furthermore, there is need of linking credit with micro insurancebecause householdsrefrain from taking loans due to perceptions of crop failure and prices risks. Although the evidence in the current study is not strong, the nexus between microfinance and microinsurance is another future area of research in the light of enhancing agricultural transformation in Ethiopia.

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Table 1A: Propensity score variables

Dependent variable: apply to loan (yes=1 no=0)	**Coef.**	**SE.**
Project (ILSSI) target farmer (reference not target)	-0.023	0.152
Age of the head	.062194	.025427**
Age squared	-0.0006	.0002***
Educational status of household	0.008	0.0036**
Male-headed household (reference Female headed)	0.398	0.159**
Adult equivalent	0.001	0.005
Livestock holding (in TLU)	0.111	0.034***
Land holding (in timad)	0.0005	0.0019
Access to irrigation (reference no=0)	0.086	0.152
Irrigation technology use (reference no=0)	0.339	0.174**
Distance to FTC (in km)	-0.008	0.0019***
Distance to major markets (in km)	-0.021	0.002***
Cons-	-0.856	0.644

Number of obs = 1775
LR chi2(12) = 390.96
Prob > chi2 = 0.0000
Pseudo R2 = 0.1717
Log likelihood = -942.68945

*, **,*** significant at 10, 5, and 1 percent level of significance
Source: survey 2016

Effect of Credit Constraints on Intensity of Fertilzer Adoption and Agricluture Crop Productivity in Amhara Region, Ethiopia: An Endogenous Switching Regression Analysis

Mulat Goshu Gebeyehu[1]

Abstract

Access to finance is a powerful intervention to facilitate the adoption of farm inputs and boost agricultural productivity in developing countries like Ethiopia. Credit constraints limit the ability of households to use inputs at optimal level and thereby stifle agricultural productivity. However evaluation of the impact of credit constraints on agricultural technology adoption and productivity have faced methodological problems and most of the existing studies have failed to explicitly measure and analyze the amount of productivity loss and the magnitude increase in intensity of fertilizer adoption if the farm households are found credit unconstrained. This study examines thepoetional impact of credit constraint on the intensity of fertilizer adoption and productivity among households who vary in their credit constraint status. The study used cross sectional farm household level data collected in 2013 from 1165 randomly selected sampled households. An endogenous switching regression model is used for analytical purpose so as to account for selection bias and heterogeneity problem. The result evidence that intensity of fertilizer adoption and agriculture productivity would be higher among farm households who are found to be credit unconstrained. The result revealed that factors that affect the intensity of fertilizer adoption and agriculture productivity among credit constrained farm households are different from their counterparts. Age and age square of the household head, primary cooperative membership, number of Oxen, ownership of TV, hired labor as dummy and use of manure have significant effect on the intensity of fertilizer adoption among credit unconstrained regimes. Whereas, household size, altitude of land, ownership of land, way of land cultivation, and being risk averse household have significant effect on the intensity of fertilizer adoption in the credit constrained regimes. The result shown that size of land has negative and significant impact on the intensity of fertilizer adoption in the constrained regime while it has positive and

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significant impact on the intensity of adoption in the unconstrained regime. Age and age square of the household head, TLU, hired labor as dummy are the factors that significantly affect the productivity in the unconstrained regimes. The number of oxen and distance of farm land from residence also affect the productivity. Land size has found the significant and negative effect on the productivity in the constrained regime, but it has the positive and significant effect in the credit constrained regime. The policy implication is that the policy makers should account the credit constraint heterogeneity among farm households when they design agricultural policy to increase intensity of fertilizer adoption and thereby boost productivity of agriculture.

Key words: Credit constraint, agricultural productivity, intensity of fertilizer application, an endogenous switching regression, Ethiopia

1. Introduction

In Ethiopia, agriculture continues to be main instrument for the country's food security, and the sector contributes the major shares for sustainable development and poverty reduction. The agriculture production remains the main sources of livelihood for rural communities in Ethiopia. Here, agriculture sector currently contributing nearly (43%) of GDP and provides a source of employment for more than 75 percent of the population (MoA, 2010). However, agriculture is predominantly characterized by low productivity growth and limited value additions activity in the sector. The rural people livelihood directly or indirectly relay on agriculture so the reduction of agricultural output can have significant impact on household's food security, nutrition and income. Consequently, the majority of smallholder farmers live in food insecurity and Ethiopia experiences widespread structural food deficits. The study by Bewket (2014) evokes that in 2004-2005, 38.7% of population in Ethiopia lived in extreme poverty, which is reduced to 29.6% in 2010 that lead to chronic dependence on food aid.

Like the rest of the country, agriculture is a leading economy in Amhara regions and it is fundamental instrument for food security, poverty reduction, income diversification and increased national development and sources of

employment. Agriculture in Amhara region is dominated by small-holder and the traditional farming with low productivity on fragmented and highly degraded lands. Smallholders participate on rearing livestock and crop production. Furthermore, agriculture is subjected to a variety of risks arising from erratic rainfall, drought, temperature fluctuations, hailstorms, cyclones, floods, and climate change since almost all smallholder farmers relay on rain-fed agriculture (MoA, 2010).

To address the issue of poverty as clearly stated in Ethiopia's growth and transformation plan (GTP), it is necessary that the constraints to agriculture should be solved. One main constraint identified by different scholars and policy makers and so far not partly addressed is the lack of access to finance. Ethiopia has a very low rural banking density and consequently one of the lowest financial inclusion ratios in Sub-Saharan Africa, with only 14% of adults having access to credit. Bank branches are concentrated in urban areas, while rural areas remain underserved. Only 1% of the rural population has bank accounts (AGRIFIN, 2012). This evidences that the significant portion of the rural people in Ethiopia do not have access to formal financial services.

Inadequate credit supply is a central problem along with which other production factors exert negative influence on farmers' output and efficiency.When liquidity is a binding constraint, the amount and combinations of inputs used by smallholder farmers may deviate from optimal levels that in turn limit the optimum production or consumption choices. Credit constraint is one main source of low adoption and use of modern inputs and modern farming technology in Ethiopia (Yu.et.al, 2011, Zerfu and Larson, 2010). As noted by Ogato et al (2009), limited access to credit service along with poor infrastructure contributed to the low level of agricultural productivity and output growth in Ethiopia.

Nonetheless, there is scanty household level evidence on the issue under investigation, in the study area. For instance, a study by Ali and Feininger (2012) has found that almost half of smallholder farmers in Amhara region are credit constrained. They also identified risk aversion behavior of farmers as the main determinant that hinders smallholders from accessing agricultural credit. In addition, the recent paper by Girma and Abebaw (2015) also stated

that access to credit among the majority of rural farm households' remains limited in the region.

Nevertheless, many of the existing studies have failed to explicitly measure and analyze the amount of productivity loss, the intensity of fertilizer adoption by farm households, and the magnitude increase in intensity of fertilizer adoption if the farm households are found credit unconstrained. The aim of this study is, therefore, to empirically investigate the effect of credit constraints on the intensity of fertilizer adoption and agricultural productivity among households that vary in their respective credit constraint status by using an endogenous switching regression model-accounted the self-selection problem.

2. Objective of the Study

The main objective of the study wastoinvestigatethe impact of credit constraints on the intensity of fertilizer adoption and agriculture productivity inAmhara, Ethiopia. More specifically the study has the following specific objectives

- To identify the determinants of credit constraints
- To examine the determinants of intensity of fertilizer adoption between farm households that vary in the status of credit constraints
- To examine the determinants of agricultural productivity among families that vary in the status of credit constraints
- To measure the impact of credit constraints on the intensity of adoption fertilizers and agricultural productivity

3. Theoretical Model

In developing countries like Ethiopia farmers consumption and production decision are not separable. In most case the household production decision (that the raw materials for production, in which the amounts, activity choices, seasonal periods and the use of inputs) are influenced by its characteristics of consumption (for example, consumer preferences and demographic characteristics). In this case, the agricultural production, expenditure and income profiles are markedly seasonal and thus the liquidity constraints in

financing production and consumption can be particularly acute (de Janvry et al., 1999). This will lead households to adjust their income generating strategies and their expenditure patterns according to the available credit.

Thus, in this study we assumed that credit constraint leads to sub-optimal level of input use but, it is conditional on access to capital, availability of inputand low level of household income. It is assumed that a farm household wants to maximize their consumption in two period times by consuming C_0 in the first period and C_1 amount in the second period as expressed by an intertemporally additive utility function. The household is assumed to be maximizing the following utility:

$$U = F(C_0, C_1, H) \quad \textbf{(1)}$$

Where H is present the demographic characteristics of farm households (such as gender, age variation, education level, household size etc.). Agricultural production requires cash liquidity to finance cost of inputs and to produce Y output in period 0, while harvest occurs in period 1. To meet liquidity requirements for input purchases, the farmer can take a loan of size K in period 0, which has to be repaid in period1.

The production function of the household is depicted by a twice differentiable, quasi-concave production function Y = f (X^k, X^N, Z). The variable input decomposed in to two (i) the variable inputs which requires upfront financing (e.g. fertiliser) and is thus subject to a liquidity constraint which is defined by X^k and (ii) all other types of variable inputs that is presented by $X^{N.}$ From the production function Z is presented all other exogenous and fixed inputs. Suppose that smallholders face budget constraint in two periods and credit constraint in period 0. The total budget in period 0 is the sum of initial endowment (R) and the amount of credit taken (A), assumed to be obtained only in period 0.At equilibrium the sum of all these is equal to the total expenditure embrace variable input which requires upfront financing plus consumption.

Budget constraint in period $0{:}A + R = p^{XK}.X^k + P_c C_0$ **(2)**

The total budget in period 1 is equal to revenues from production $P_Y.Y$ with the price P_Y of the output. In equilibrium, this is equal to repayment of credit taken in period 0, consumption in period 1, and expenditures on variable inputs not subject to upfront financing.

Budget constraint in period 1: $P_Y.Y = P_c.C_1 + P_n.X^N + A(1+r)$. **(3)**

Smallholder credit constraints: $\bar{A}(X^{XK}, H)-A \geq 0$ **(4)**

The smallholder farmer's optimization problem is express as follow

$$\text{Max } U = \max F(C_0, C_1, H) \quad \text{subject to the constraint functions}$$

Budget constraint in period 0: $A + R - p^{XK}.X^k - P_cC_0 = 0$

Budget constraint in period 1: $P_y.Y - P_c.C_1 - P_n.X^N - A(1+r) = 0$

Smallholder credit constraints: $\bar{A}\,(X^{XK}, H) - A \geq 0$

The Lagrangian formulation of the inequality constraints

$$L = F(C_0, C_1 H) + \lambda(A + R - p^{XK}.X^k - P_cC_0) + \mu(P_y.Y - P_c.C_1 - P_n.X^N - A(1+r)) + \varphi(\bar{A}\,(X^{XK}, H) - A) \quad (5)$$

First order Kuhn tucker conditions

$$\frac{\partial L}{\partial C_0} = \frac{\partial f}{\partial C_0} - \lambda P_c = 0 \quad (5.1)$$

$$\frac{\partial L}{\partial C_1} = \frac{\partial f}{\partial C_1} - \lambda P_c = 0 \quad (5.2)$$

$$\frac{\partial L}{\partial X^{xk}} = -\lambda P^{XK} + \eta P^y \frac{\partial y}{\partial X^{Xk}} = 0 \quad (5.3)$$

$$\frac{\partial L}{\partial X^N} = -\eta P_N \left(P^y \frac{\partial y}{\partial X^n} - P_n\right) = 0 \quad (5.4)$$

$$\frac{\partial L}{\partial A} = \lambda - \eta(1+r) - \varphi = 0 \quad (5.5)$$

$$\frac{\partial L}{\partial \lambda} = A + P + R - p^{XK}.X^k - P_cC_0 = 0 \quad (5.6)$$

$$\frac{\partial L}{\partial \eta} = P_y.Y - P_c.C_1 - P_n.X^N - A(1+r) = 0 \qquad (5.7)$$

$$\frac{\partial L}{\partial \varphi} = \bar{A}\,(X^{XK}, \mathrm{H}) - \mathrm{A} \geq 0,\ \varphi \geq 0,\ \varphi\frac{\partial L}{\partial \varphi} = 0 \qquad (5.8)$$

Where equation 5.1& 5.2 characterize optimal consumption, equation 5.3 and 5.4 are optimal production with respect to variable inputs, equation 5.5 optimal credit demand and equation 5.6, 5.7 and 5.8 are other conditions that have to be satisfied by optimal solutions. η, λ *and* φAre the Lagrangianmultipliers which denote the shadow price of constraints in terms of the objective function.

If we solve equation (5.4), it gives the immediate effect of variable input which is not required upfront finance on marginal revenue. The decision of smallholder does not affected by the intertemporally nature of household model, so that η safely be dropped. The optimal output and the input levels are calculate with standard the conditions marginal revenue should equal to marginal cost.

$$\left(P^y \frac{\partial y}{\partial X^n}\right) = P_n \qquad (5.9)$$

With regarding to variable input X^{XK} which require liquidity cash before harvesting, let assume the smallholder is unconstrained in credit market (i.e. φ=0) and if we solve the optimization problems we get the following optimal conditions for production.

$$P^Y \frac{\partial y}{\partial x} = P^{Xk}(1+r) \qquad (5.10)$$

Equation 5.10 similar with equation 5.9 except the price of input is inflated by interest rate(r), since variable inputs are purchased earlier period and farm revenue is obtained latter. If we normalized the input prices into 1, then at optimal level of output marginal revenue is equal to 1+r. Equation (5.9) and (5.10) which demonstrates separate decisions of production and consumption by households as long as the credit constraint is not binding.

Now let consider the optimal credit demand is effectively restricted by credit limit (i.e. $\varphi=0$), if we evaluate equations 5.3 and 5.5 when the household is tied with credit constraint and normalized the input price P^{xk} to 1, the optimal production condition will be

$$P^{Y}\partial f(.)\partial x = (1+r) + \left(\frac{\varphi}{\eta}\right) pXk. \quad \textbf{(5.11)}$$

Let $r^{*} = r + \frac{\varphi}{\eta}$

$$\left(\frac{p^{Y}}{1+r^{*}}\right)\frac{\partial y}{\partial x} = p^{xk} \quad \textbf{(5.12)}$$

As a consequence, the condition for an optimal allocation of the liquidity requiring input formally remains the same under the binding credit constraint except that the marked-up shadow interest rate must be used. Since the production function is concave in variables inputs, the reduction of output prices leads to reduction of input utilization so as to increase the value marginal productivity of inputs. The binding credit constraint is caused for low input utilization and output reduction. Therefore, the credit constrained household will demand lesser input and produce lesser output than the unconstrained one, other things remain constant.

The implication of all above mathematical and theoretical explanation, households under credit constraint made simultaneous decisions on production and consumption. As result input allocation depends on consumer preference and consumption choice depends on production, both via shadow interest rate.

Finally, we can formulate the demand of inputs and output as function of shadow interest rate and other factors as follows.

$$X = X(r, pc, pypx, R, p, A, h, Z) \quad \textbf{(5.13)}$$

$$Y = f(r, pc, pypx, R, p, A, h, Z) \quad \textbf{(5.14)}$$

Finally, we can develop an estimable model as follows with all due respect to our conceptual and behavioral sketches so far.

4. Methodology of the Study

4.1 The Study Area

The study was conducted in four major zones in, Amhara region consisting West Gojjam, North Shewa North Wello, and South WelloAmhara region cover a total land area of 170,752KM^2 With an estimated population of close 19 million. In terms of livelihood, about 87% of the population live in rural areas and depend on agriculture, while the remaining 13% live in urban area (CSA, 2014). The livelihood of rural Amhara is almost entirely dependent on agriculture with smallholder cultivation of cereals, pulses and fruit and vegetable mainly characterized by subsistence farming mixed with livestock rearing. Among our research site, West Gojjam and North Shewa are relatively productive areas and mixed farming system is commonly practiced. While, North Wello and South Wello are less fertile and rainfall these two zones is more irregular. Average farm size is less than one hectare per family in the place of study.

4.2 Data sources, types and sampling techniques

The data come from a cross sectional quantitative survey data collected in 2013. These data were collected in the four major zones in Amhara region including West Gojjam, North Shewa, NorthWello, and South Wello. The data is a part of household survey project titled “The Ethiopian Project on Interlinking Insurance with Credit in Agriculture (EPIICA)"conducted by university of California, San-Diego, University of Athens, University of Greece and FAO, EEA, Dashen Bank and Nyala Insurance Company in 2013 in Amhara region, Ethiopia. The main purpose of the survey was to promote the use of fertilizers by smallholder farmers and thereby boosting productivity.

Regarding the sampling techniques, surveys was based on NISCO's informed opinion based on best potential to purchase WII, zone and then kebelles from selected zones purposively. The survey covers 120 kebelles and households within the selected kebelles were randomly sampled to participate in the study; in each village 18 cooperative member households and 2 households that are not a member of the primary cooperative were selected (McIntosh et.al, 2013).

Using the full-sized questionnaire, the survey collected valuable information on several factors including household composition and characteristics, income and production situations, consumption expenses, savings and loan conditions, indicators of access to infrastructure, household market participation, asset endowments, membership in different rural institutions, household income sources other than farm income, use of technology, information's related to risk and attitude to weather index insurance(WII). After cleaning the data, we used the information collected from 1165 sampled households to estimate the impact of various factors on the intensity of fertilizer adoption and productivity among credit constrained and unconstrained smallholder farmers.

4.3 Empirical model: an Endogenous Switching Regression Model

Timing, spillover effect, and sample selection bias are the most common problems identified by many researchers. Among these samples selection biases, the greatest challenges is in doing high quality impact assessment is identified statistically valid treatment and control groups. To avoid the selection bias problems the researchers uses experimental and quasi-experimental design. Selection bias occurs when control group members systematically differ from treatment group members in terms of either observable or unobservable characteristics. In both experimental and quasi experimental research, the importance of getting group selection right cannot be overemphasized. The cost of not getting it right is introducing selection bias into the sample (USAID, 2008).

In general econometrics estimation models yields the valid inferences only if the units, in our case the smallholder farmers are sampled at random. Selection bias problem arise when the selection depends on unobserved variables correlated with the error terms of econometrics model of interest. In our case, credit constrained and credit unconstrained smallholders may have been heterogeneous demand of credit. In other hand, smallholder who applied low input utilization and operate low productivity may have higher demand for credit as compared to who utilized more inputs and more productive one. This creates the selection bias in our estimators. However, the increased availability of panel data and some recent developments in the literature have alleviated

these challenges. In the case of strictly exogenous covariates, Wooldridge (2010) and Kyriazidou (1997) offer several ways to tackle both the selectivity and unobserved effects that are allowed to be correlated with covariates in the model. All these panel data models largely focused on binary sample selection, but researchers face selection (regime switching) of sequential nature.

We strongly believe that the failure to control selection bias produces systematically biased and potentially unreliable results. Among the many possible mistakes in empirical research, getting the sample wrong may be one of the most serious ones. To void the selection bias and heterogeneity problems, we used an endogenous switching regression. It allows the correlation between unobserved effects and covariate in the model. The endogenous switching regression can predicate the expected outcome for credit constrained farmers who self-selected in to non-credit constrained and vis-versa (Dutoit, 2007; Lokshin and Sajaia, 2004).

In this study, we adopted the definition of credit constrained by Ali and Feininger (2012). In this regard farm households are said to be credit constrained if they demand more loans than was supplied, if they applied loan but was unable to borrow, and they did not apply for a loan because of unfavorable credit conditions includes afraid of risk, required collateral too high, high interest rate, high transaction cost and loan process is much time consuming. An endogenous switching regression model follows two steps. In the first step, it models the credit status of whether or not smallholder farmer being credit constrained. The equation is called selection equation and specified by the binary choice model as follows.

$$D_i = X_i\alpha_i + \Phi_i \ldots \quad \textbf{(1)}$$

Where X_i is vectors of explanatory variable which affect the credit constraints of smallholders 'i' α_i is a vector of parameters to be estimated, and Φ_i is a random error term with mean zero and variance (δ^2). It has been specified based on the succeeding to separate equations defined a dichotomous outcome for the binary choice variable.

$$D_i = 0 \; if X_i\alpha_i + \Phi_i \leq 0 \quad \textbf{(2)}$$

$$D_i = 1 \; if X_i\alpha_i + \Phi_i = 0 \quad \textbf{(3)}$$

In the second step, it models the outcome intensity of fertilizer adoption and outcome of agriculture productivity depending on smallholder farmers are being credit constrained and non-constrained. Following the above argument from equation 2 and 3 a continuous intensity of fertilizer adoption equation for both credit constrained and unconstrained regimes can be explicitly presented as:

Regime 1: $I_{1i} = w_{1i}\beta_i + U_{1i}, if D_i = 0$ **(4)**

Regime 2: $I_{2i} = w_{2i}\beta_i + U_{2i} if D_i = 1$ **(5)**

Where w_i is 1x K vectors of exogenous covariateswith corresponding conformable parameterβ_i the outcome variable $I_i$is observed when the jth regime be selected. Exogenous variables included inw_i should be contained inX_i in equation (2 and 3), implying that $X_i$must have at least one or more instrumental variable that is not in regime equation (4 and 5). In case, membership of MFIs, borrowing interest rate, bank account dummy, bank trust dummy, Muslim headed dummy and Number of installments are used as instrument in selection equation. Assume that Φ_i, $U_{1i}$and U_{1i}in selection equation and regime equations, respectively have trivariate normal distribution with mean vector zero and the following covariance matrix:

$$\Omega = \begin{bmatrix} \sigma_\mu{}^2 & \sigma_{\mu 1} & \sigma_{\mu 2} \\ \sigma_{\mu 1} & \sigma_1{}^2 & . \\ \sigma_{\mu 2} & \sigma_{12}. & \sigma_2{}^2 \end{bmatrix}$$

Where $\sigma_\mu{}^2$ is variance of error term (Φ_i) in the selection equation and assumed to be unity.$\sigma_1{}^2$ and $\sigma_2{}^2$ are the variances error terms in the regime

equation. $\sigma_{\mu 1}$ is the covariance of Φ_i and U_{1i} and $\sigma_{\mu 2}$ is the covariance of Φ_i and U_{2i}. σ_{12} is the covariance of U_{1i} and U_{2i}. However, σ_{12} is not defined as the outcome variable for a given household and is not observed at a given time as described in Maddala (1983). The unobservable characteristics of farm households that determine the credit status also affect the intensity of fertilizer adoption of the households in each regime. For example, if the lender considered land fertility to select the borrower and land fertility is not observed variable, estimation of credit constraint equation and intensity of fertilizer adoption equation separately leads to selection biased. Therefore, full information maximum livelihood (FIML) estimation is applied to simultaneously measure selection and regime equations using the endogenous switching regression model that takes account of sample self-selection problems. The model is identified by construction through nonlinearities. Given the assumption with respect to the distribution of the disturbance terms, the logarithmic likelihood function for the equation (4 and 5) following the procedure by Lokshin and Sajaia, (2004) is:

$$LnL = \sum_{i=1} \left\{ I_i w_i \left[\ln (F(\eta_{1i}) + \ln (f(\tfrac{\epsilon_{1i}}{\delta_1})/\delta_1) \right] + (1 - I_i) w_i \left[\ln \left(1 - F(\eta_{2i}) \right) + \ln (f(\epsilon 2i\delta 2)/\delta 2 \right. \right. \quad (6)$$

Where F (...) represents a cumulative normal distribution function (...) denotes a normal density distribution function W_i is an optional weight for observation i andη_{ij} is defined as,

$$\eta_{ij} = \frac{\gamma Z_i + \frac{\rho_j \epsilon_{ji}}{\delta_j}}{\sqrt{1-\rho_j^2}} \text{ Where } j=1, 2$$

ρ_1 Is the correlation coefficient betweenϵ_{1i}, and U_i which is defined as$\rho_1 = (\frac{\delta_{1u}^2}{\delta_u \delta_1})$, ρ_2 is the correlation between $\epsilon_{2i} and u_i$ which is defined as$\rho_2 = (\delta_{2u}^2/\delta_u \delta_2)$. To make sure that estimated $\rho 1$ and $\rho 2$ are bounded between -1 and 1 and that estimated $\sigma 1$ and $\sigma 2$ are always positive, the maximum likelihood directly estimates lnσ1, lnσ2, and ρ: The estimates of parameters in the endogenous switching regression can be obtained by using the full information maximum likelihood estimation by using the movestay command in Stata. The robust and meaningful standard errors and correlation coefficients will be obtained simultaneously in the FIML estimation procedure (Madalla, 1983, Lokshin and Sajaia, 2004).

Similarly based on the argument from equation 2 and 3 a continuous agricultural productivity equation for both credit constrained and unconstrained regimes can be explicitly represented as:

Regime 1: $Y_{1i} = Z_{1i}\beta_{1i} + E_{1i}, \ if D_i = 0$ **(7)**

Regime 2: $Y_{2i} = Z_{2i}\beta_{2i} + E_{2i}, \ if D_i = 1$ **(8)**

Where Yi is the agricultural productivity for households in regimes 1 and 2and Zi represents a vector of exogenous the households characteristics with conformable parameter the outcome variable Yi is observed only if the jth regime is selected. Φ_i E_{1i} *and* E_{1i} are error terms which are normally distributed with mean zero and covariance matrix. Except the outcome variable changed to productivity, all assumption and mathematical derivation are similar with above intensity of fertilizer adoption.

4.4 Counterfactual analysis

The main purpose of this study is to examine the effect of being credit constrained on intensity of fertilizer adoption and agricultural productivity. To this end, endogenous switching regression is used as described above. Endogenous switching regression can be used to compare the expected outcome for credit constrained farmers who self-selected in to credit unconstrained and vis-versa. Based on the estimated parameters we can calculate the both conditional and unconditional expected value of intensity of fertilizer adoption for being credit constrained and credit unconstrained households.

For this purpose first we need to calculate the counterfactual value by considering credit unconstrained as a treatment. In order to calculate the average treatment of treated (ATT), we differentiate the intensity of fertilizer adoption (observed) and its counterfactual for being credit constrained households. Similarly the average treatment non-treated (ATN), differentiate the intensity of fertilizer adoption (observed) and its counterfactual for being credit unconstrained. It can be compare the expected intensity of fertilizer adoption and agricultural productivity that being credit constrained(A) relative to the non-credit constrained(B), and examine the expected intensity of fertilizer adoption and agricultural productivity in counterfactual hypotheses case(C), that the credit constrained could credit unconstrained and (D) credit unconstrained being credit constrained.

The expected intensity of fertilizer adoption for non- credit constrained:

$$\epsilon(I_{1i}|D_i = 1) = w_{1i}\alpha_i + \sigma_{\mu 1}\rho_{1i} \quad (7)$$

$$\epsilon(I_{2i}|D_i = 0) = w_{2i}\alpha_i + \sigma_{\mu 2}\rho_{2i} \quad (8)$$

$$\epsilon(I_{2i}|D_i = 1) = w_{1i}\alpha_2 + \sigma_{2\mu}\rho_{1i} \quad (9)$$

$$\epsilon(I_{1i}|D_i = 0) = w_{2i}\alpha_1 + \sigma_{\mu 1}\rho_{2i} \quad (10)$$

Using equation 7 and 9 obtained ATT as follows

$$\text{ATT} = \epsilon(I_{1i}|D_i = 1) - \epsilon(I_{2i}|D_i = 1) \quad (11)$$

Similarly using equation 8 and 10 can obtained ATN as follows:

ATN=$\epsilon(I_{2i}|D_i = 0) - (I_{1i}|D_i = 0)$ (12)

5. Results and Discussion

5.1 Descriptive statistics

5.1.1 Credit Rationing and Causes of Credit Rationing

Table 1 below presents the credit constraint status of the households and main causes of credit constraints on the study area. To detect the credit constraint status of the households, the survey applied “direct elicitation" approach. The survey also applied the observed outcome and qualitative question to detect the credit constraints. First, the sampled households were asked whether or not they applied for loan from any sources. Households who applied for loan are classified based on the outcome of their credit application-loan request rejected households, those who received loan but loan size lowered than the requested amount, usually classified as quantity rationed (constrained) households, and those whose demands were met, known as unconstrained households.

The result shows that most of the farm households did not have access to agricultural credit. From the total households in the sample, 272 (24.66%) had access to credit, while 831 (or 75.34%) of the farm households did not have access to agricultural credit. Among credit constrained households, 26.6% credit rationing appears because of the perceived too high interest rate (price rationed). About 56.3% farm households were credit rationed because farm households considered loan is too risky and they are afraid of the loss of loans or they are pessimistic about investment prospects. About 6.3% farm households did not applied for loan or did not get credit due to lack of collateral, 4.3% farm households withdraw from credit request made because they perceived that loan getting process is time consuming and fees attached to application were too costly, 6.5% farm households didn’t receive or apply for credit just because of the perceived too high interest rate and lack of collateral. As it can be seen from the table below, farm households were unable to take the larger amount of loans than they took in previous year due to lack of collateral, project not profitable enough, restrictive lending policy of the institution and fear of accumulation of debt. Among the unconstrained

households 39.7% had received the loan as per their demand. About 42.6% of households had no need for loan or had sufficient liquidity, while 17% households did not need loan because they had no profitable investment plan, had no land to cultivate and their religious does not allow taking the loan.

Table 1: Credit constraint status and main sources of credit constraints

Constrained households	**Freq.**	**Percent**
Price rationed	221	0.266
Quantity rationed	52	0.063
Risk rationed	468	0.563
Transaction cost rationed	36	0.043
Price and quantity rationed	54	0.065
Unconstrained households		
Received the loan	108	0.397
No need loan	116	0.426
Other reason(my religion does not allowed, no land)	48	0.176
Why did you not received extra(large loan)		
lack of collateral	8	12.9
project not profitable enough	3	4.84
lending policy of the institution	47	75.81
fear of debt	4	6.45

Sources: Authors' calculations from EPIICA 2013 survey.

4.1.2 Sources of Credit

Table 2 below illustrates the main sources of agricultural credit. Generally, rural households have received credit from three main sources such as formal, semi-formal and informal sources. The semi-formal credit sources include primary cooperatives, input suppliers, microfinance institutions, as well as non-governmental and governmental programs which provide subsidized loans to targeted groups of farmers. The informal credit sources include money lender, relatives and friends, and religious institutions. The researcher adopted this definition and considered institutional borrowers (other than banks) as semi-formal credit sources. Moreover, borrowing from individuals was considered as informal credit sources.

The result shows that among the credit participant farm households, none of the farm households received credit from formal sources (banks) and all credit obtained from semi-formal and informal sources. We found that 84.7% of households obtained credit from semi-formal sources. When disaggregated, semi-formal sources comprise primary cooperatives (64.6%), MFIs (16.84%), NGOs (2.5%) and Government program (1%). As can be observed from the table below, 25.3% of the households reported that they have got agricultural credit from informal sources (i.e., relatives (10.87%), private trader (3.5%), rotating credit and saving association (0.3%) and religious institution (0.3%)). The statistics proves that farm households still depend on loan from semi-formal, relatives and friends. This is mainly due to the perceived high transaction cost, complicated credit procedures and high credit risk attached with loan from formal financial institution.

Table 2: Sources of agricultural credit to the farmers in the Amhara region

Source of loan	frequency	percent
Primary society or cooperative	184	0.645614
Private trader or company	10	0.035088
Relatives/friends	31	0.108772
MFIs through RUSACC	48	0.168421
Rotating credit and saving association	1	0.003509
NGOs	7	0.024561
Government program	3	0.010526
Religious institution	1	0.003509

Sources: Authors' calculations from EPIICA 2013 survey.

5.1.3 Use of input and agricultural productivity by credit constraint status

The Table 3 below shows that the differences in use of input and farm productivity between constrained and unconstrained households. As stated above, credit constraint is attributed to financial institutions reluctance to advance loans to smallholders because they see agriculture production is more risky. This can be the reason that households cannot take advantage of profitable income generating activities. According to Feder et al. (1990) access

to credit helps improve access to requisite inputs which play critical role in increasing productivity especially for the poor who have no capital. Lack of credit limits effective utilization of inputs (Feder et al. 1989). As shown in the table below, the unconstrained households used more inputs than their counterpart.

The result shows that the unconstrained households on average used more fertilizer to about 84 kg per hectare as constraints (45.23 kg per hectare). Furthermore, unconstrained households used relatively more improved seeds (6.8 kg per ha) than constrained households (6 kg per hectare). However, constrained households applied more manure in their production rather than unconstrained households. In fact, manure and chemical fertilizers are substitutable products, such as credit constrained households can use manure instead of chemical fertilizers due to credit market failure

Table 3: Average use of inputs and agricultural productivity by credit constraint status

Use of input and agricultural productivity	Total		unconstrained		constrained	
	Mean	St.dr	Mean	st.dr	Mean	St.dr
Use of chemical fertilizer in Kg	104.854	125.8	104.631	125.9	104.926	125.84
Use of chemical fertilizer per ha	97.930	7525.6	83.934	93.34	45.230	8670.02
Use of improved seed in Kg	6.207	12.79	6.824	12.57	6.005	12.861
Use of improved seed per ha	12.934	251.12	5.886	11.10	5.241	289.25
Use of pesticide and herbicide in L	1.174	0.4976	1.098	0.499	1.199	0.497
Use of pesticide and herbicide in L	3.980	100.43	1.170	2.482	4.900	3333.3
Use of manure in Kg	672.787	1920.6	493	2.482	731.635	2108.7
Use of manure in Kg	748.255	2206	578.4	1463.9	803.835	2397.7
Agriculture productivity land in birr	56772.4	31000	17331	30167.2	12267.0	35700

Sources: Authors' calculations from EPIICA 2013 survey.

In addition, the credit constraint status explains the differences in productivity among rural households. The result revealed that the unconstrained credit households received a higher productivity than that of constrained households. The average agricultural productivity in Birr is to 17331.0 for unconstrained

and 12267.0 birr for constrained. It indicates that the technical efficiency is part of the access to credit. Unconstrained credit households are likely to use the inputs optimally, which provides higher productivity, which is attributed to the technical advice provided by financial institutions on how to combine their individual inputs adequately to maximize production.

5.1.4 Sampled farm household characteristics by credit constraint status

Table 4 below present some basic characteristics of sample households by classifying in credit constrained and unconstrained regimes from EPIICA 2013 survey. There was no significant difference in the age, land holding size, household member size and average education level between constrained and unconstrained regimes. The average age of household head is round 51 years. And it is 50 and 52 years for credit constrained and unconstrained farm households, respectively. This revealed that in both arrangements most householders are economically active and able to effectively perform their agriculture. This shows that being other things remain constant, there is a potential for improvement in farm income over the subsistence level.

The descriptive statistics shows that the majority of household heads are illiterate if some householders who are able to write and read the acquisition by informal sectors and there are some heads attending formal primary schools, secondary and upper secondary school in both constrained and unconstrained regimes. From the total sample households 60% were illiterate. Among literate household heads, 56% have attend informal education (religious, adult education), 24.8% percent have primary education and 18.8 % have attend the secondary and above education. The average land holding of the total sample household is 1.23 hectares. The average land holding in constrained regimes was 1.25, while it was 1.16 hectares for unconstrained households. It is also observed that credit unconstrained households have more irrigated land (0.16%) than constrained households (0.13 %). This suggested that farm households were mostly small scale producers in the region likewise in Ethiopia. In addition, credit constrained households are more risk averse than unconstrained.

Surprisingly credit constrained households saved money more than unconstrained households. This may be due to the reason that constrained

households forced to save more afraid of risk and smooth family consumption in the case of the credit market failure. Oxen are a very important asset for rural households, because agriculture in Ethiopia depends on animal traction. On average, both in the constrained and unconstrained regime households have two Oxen.

Table 4: Basic characteristics of the sampled farm households by credit constrained status

Variables	Total		Constrained		Unconstrained	
	Mean	St.dr	Mean	St.dr	Mean	St.dr
Age of the household head	50.621	13.3124	50.046	13.31	52.379	14.850
Sex of the household head	0.911	.28545	0.910	.2855	0.915	.27362
Can the household head read and write	0.398	.49371	0.419	.4937	0.335	.47314
Informal education	0.560	.42973	0.205	.4297	0.136	.44251
Primary education	0.248	.40329	0.243	.4033	0.265	.34399
Secondary education	0.188	.49953	0.549	.4995	0.596	.49197
Household member size	5.205	1.8605	5.207	1.861	5.199	1.8343
Household land holding in hectares	1.231	.83676	1.251	.8368	1.169	.70208
Percentage of irrigated land holding	0.155	.28406	0.132	.2841	0.163	.27476
Membership of primary cooperative	0.952	.20674	0.955	.2067	0.941	.22909
Membership of MFIs	0.247	.44574	0.273	.4457	0.165	37282
Net saver	0.178	.3923	0.201	0.675	0.107	.4567
Risk averse	0.425	.49619	0.438	.4962	0.386	.4872
Off –farm income	1241.05	9702.63	1415	9703	709.6	2715.2
Value of production asset	2005.89	26814.7	967.1	26815	2345.9	2034.4
Number of oxen owned by household	1.786	1.0524	1.811	1.052	1.710	.97204
Livestock tropical unit(TLU)	3.491	2.438	3.578	2.438	3.227	2.0145

Sources: Authors' calculations from EPIICA 2013 survey.

With regards to off-farm income, unconstrained households were earned less off-farm income than constrained. On average, the farm households of the constrained regime were earned up to 1,414 birr a year, but, the households of the unconstrained regime gained up to 790 birr annually. Credit unconstrained

households have more the production of goods in Birr than their counterpart. Value of production asset was 2345.928 birr in credit unconstrained regime, while 967.063 birr for constrained. No significant difference is observed in terms of their membership in a primary cooperatives (or farmer groups).

5.2 Empirical Estimation Result

As we mentioned above, the purpose of the study is to evaluate the impact of credit constraint on intensity of fertilizer adoption and agricultural productivity. We used the methods of estimating the full information maximum likelihood (FIML) to estimate an endogenous switching model of intensity of fertilizer adoption and agricultural productivity.

5.2.1 Determinants of credit constraints

In this section, we focus on the determinants of credit constraints in the selection equation.As it has been defined above credit constrained is an excess demand and farm households unable to borrow because of unfavorable credit conditions includes afraid of risk, required collateral too high, high interest rate, high transaction cost and loan process is much time consuming. Credit constraint is treated as binary outcome model, leveled the value “1” if the household being credit constrained and leveled the value “0” otherwise. In table 5 below the selection equation estimation presents the factors which affect the farm households’ probability of undergoing the credit constraint. The selection model result is derived from running probit regression within endogenous switching regressions for a dichotomous choice of being credit constrained. The selection equation includes the all explanatory variables from the intensity of fertilizer adoption and agricultural productivity as well as membership of MFIs, borrowing interest rate, bank account dummy, bank trust dummy, Muslim headed dummy and number of installments were administrate as set of instrumental variables that will strongly affect the credit status but weakly/not the intensity of fertilizer adoption and, agricultural productivity.

The result for selection equation (credit constrained) from table 5 and 6 show that age of household head have non-linear relationship with the households’

probability of being credit constrained. Age of the household head has the negative and significant effect on credit constraint while, age square has positive and significant. This implies initially when age increase it minimize the credit constraint, and then when household head become old age, household is more likely to face a credit constraint problems. Here we can understand that the households who have old age household head face credit constrained problems than the households who have young age household head. The possible reason for the nonlinear effect of age on the credit constraint because of the reason that younger farms are more productive and physical capable to their production scale expands, and more and more capital is required to fulfill their production inputs. When those farm owners enter their middle age, most farm operators maximize their production investment. Therefore, middle-age farm operators have higher probabilities of being credit constrained. This possibility decreases as they become older, when their interest in the production expansion declines, and they maintain or decrease their production scale until their retirements.

The selection equation estimates shows that if a household had more liquidity, its likelihood of being credit constrained decreased. To measure liquidity, we include two variables such as off farm income and farm income. High household off-farm income and farm income means less need for money and more advance ability for credit, and so such household is more likely to obtain credit. Sources of information were proxy by ownership of different media instruments such as TV, mobile, and radio. However, only ownership of radio dummy has negative and significant effect on credit constrained. This implies that the households own radio is less likely being credit constrained than their counterparts.

Farmers risk attitude has positive and significant effect on being credit constrained. The risk aversion farmers have more likelihood being credit constrained than risk taker farmers. The farmers' risk aversion is the more serious credit rationing becomes. This is mainly because risk averts usually demand more risk premium to reimburse risk cost, and thus they are affected by demanded risky credit rationing. In contrast, risk lovers focus more on investment returns and benefit, and they will seize investment opportunities

with the help of credit and consequently they are less likely to be influenced by credit rationing.

Having bank account by households is an important step towards obtaining loan or lines of credit from financial institutions. Having bank account by household has negative and significant effect on being credit constrained. This implies that households who have a bank account less likely credit constrained as compare to their counterpart. In addition to bank trust level by farmer, it was not as much of likely being credit constrained which showed the role that a great deal trust of banks by farmers reduces the probability of being credit constrained. It is not surprised to see that farm households with a membership in the MFIs have less likelihood to suffer the credit constraints. Since in Ethiopia MFIs members are issued with a certain loan amount each year based on their financial capacity status, it is much easier for a household with such membership to get the loan in time, compared with those without the MFIs membership. Bank account dummy, its odds of being credit constrained was less.

5.2.2 Impact of credit constrained on of intensity of fertilizer adoption

The objective of the study to compare the diverse extent of fertilizer adoption between credits constrained and unconstrained smallholder farmers, under imperfect credit market in Amhara region, Ethiopia. Table 5below present results from switching regression model for intensity of fertilizer adoption. In this study, we include various farm characteristics variables, resources endowment and institutional factors which are theoretically associated with the intensity of fertilizer adoption. The dependent variable is logarithm of intensity of fertilizer adoption by smallholder farmers. The intensity of fertilizer adoption is defined quantity of fertilizer used (in Kg) divided by total area of land (in hectare) cultivated by farmers.

The correlation coefficient roh_1 indicates the correlation between the credits constrained situation and the effects of credit constraint on intensity of fertilizer adoption by credit constrained households. The estimated result is negative and significant. The value is 0.17 which is a very strong correlation, the implication that being credit constrained has significant adverse effect on intensity of fertilizer adoption. Thus, the individuals that were credit

constrained used smaller fertilizer in their farming than a random individual from the sample would have. The correlation coefficient roh_2 indicates the correlation between the credit constrained situation and the effects of credit constraint on intensity of fertilizer adoption by credit unconstrained households. The value is positive and statically significant. The value is 0.24 which is a very strong correlation. This implies that those who were credit unconstrained used more fertilizer in their farming than a random individual from the sample would have. The likelihood-ratio test for joint independence of the three equations reported in the last row of table 5 showed that these three models are not jointly independent and should not be estimated separately.

As we observe from the table 5 below the result is diverse across credit constrained and unconstrained regime. The estimation result demonstrate that age of the household head has positive and significant effect on the intensity of fertilizer adoption in unconstrained regime, while age square of the household head has a negative and significant on the intensity of fertilizer adoption in unconstrained regime. This implies that age of the household head is not linearly correlated with intensity of fertilizer adoption. The result could be explained that younger people may be more adaptive and more willing than older people to try new methods like fertilizer and use more fertilizer to expand their production when they are credit unconstrained. However, both age and age square of household age have no significant effect on the intensity of fertilizer adoption in constrained regime. The household size had a positive and significant effect on the intensity of fertilizer adoption in the credit constrained regime but it had no effect on the intensity of fertilizer adoption in the unconstrained regime.

The result indicate that households' membership in primary cooperatives happen to determine the intensity of fertilizer adoption used positively and significantly in the credit unconstrained regime however, it had no significant effect on the intensity of fertilizer adoption in the constrained regime. The prior expectation is that as farmers belong to primary farm cooperatives they learn from others, and thus they will have access to information which enhances the adoption of new agricultural practices. Heterogeneity effect of primary cooperative membership on intensity of fertilizer adoption among

credit constrained and unconstrained regime can be explained by the fact that once the decisions to adopt fertilizer may be made based on the availability of information, the intensity of fertilizer adoption will depend on the ability of the farmer households to finance price of fertilizer from own resources and accessibility of credit. This implies that the effect of primary cooperatives membership on intensity fertilizer adoption is condition with the credit accessibility.

In this study, education of the household head is categorized into three informal, primary and secondary education. To avoid multicollinearity problem we used informal education as base dummy. The estimation result suggested that both primary and secondary education dummy has a positive and significant effect on intensity of fertilizer adoption in both regimes. The result can be explained that education may facilitate fertilizer use by improving access to information on and knowledge of fertilizer.

The financial liquidity availability is an important determinant of fertilizer use. In this study financial liquidity is measured by two variables such as off-farm income and farm income. Because off-farm income can a substitute for borrowed capital in rural economies where credit markets are imperfect. The regression result shows that off farm income has a positive but insignificant outcome on the intensity fertilizer adoption in both credit constrained and unconstrained regime. On the other hand the result shows that higher farm income had significantly promote the intensity of fertilizer adoption. The implication of the result is that intensity of fertilizer adoption decisions are significantly affected by a marginal change in farm income. Because farmers use additional liquidity to invest farm production like purchased fertilizer and other complementary inputs. The value of production assets which was used as a proxy for household wealth had a positive and significant effect on the intensity of fertilizer adoption in the credit constrained regime but it had no effect on the intensity of fertilizer adoption in the unconstrained regime.

Land holding size has negative and significant effect on the intensity of fertilizer adoption in the credit constrained regime, implying that per hectare fertilizer use decreases as farm size increased. While, it had a positive and significant effect on the intensity of fertilizer adoption in the unconstrained

regime. The result is consistent with the study by Weil (1970) the negative relationship between intensity of fertilizer adoption and land holding size may be caused by credit constraints. The positive effect of land holding size can be explained by capital may be more available for larger farms, so that even though all farms may wish to adopt, larger farms are more likely to do so. Thus, households with larger holdings are also likely to be wealthier, with increased ability for self-financing the purchasing of inputs and they have better probability to get credit as compare to smaller farmers.

With respect to percentage of irrigated land, the coefficient is positive and statistically significant in both the credit unconstrained and constrained regimes. The result is not surprising because firstly, irrigation enables crops to absorb more fertilizer, which motivates farmers to apply a greater quantity if no binding credit constraints or shortage of financial asset to finance the fertilizer price. Secondly, irrigated land has more protected yields under the situation of unpredictable rainfall, thus farmers face lower risks when applying the fertilizer more intensively. Average slope of land, average altitude of land and average ownership of land are significant and positive determinants of intensity of fertilizer adoption in the credit constrained regime whereas none of these variable are significant in the credit unconstrained regime.

Source of information is cited as an important determinant of fertilizer adoption and intensity of fertilizer adoption. Here source of information is proxy by ownership of Mobile, TV, and Radio. As we can see from the result ownership of mobile and TV had found the significant and positive determinants of intensity of fertilizer adoption in the credit unconstrained regime, however, only ownership of mobile dummy is positive and significant in the credit constrained regime. This provides the evidence that farmers who have own TV and Mobile may have better information on the use of fertilizer and new agricultural practice than their counter part, especially if there is no extension services in the area.

Farmers' risk attitudes determine farmers' intensity of fertilizer adoption and the consequences. The risk aversion dummy is significant and positive on the intensity of fertilizer adoption in the constrained regime, while it has no such effect on intensity of fertilizer adoption in credit unconstrained regime. This

heterogeneity effect may arise because credit constrained farmers will use fertilizer more intensively to increase their production, meet households needs and to avoid future consumption risks. The result may not be surprised to have negative and significant coefficient of manure in the extent of fertilizer adoption for both credit constrained and unconstrained farmers. This implies that manure plays an important role in farmers' decision making and generally offsets the use of chemical fertilizers. In fact inorganic fertilizer and manure are substitute inputs. Thus, farm households that have and apply sufficient quantities of manure would not require more chemical fertilizer.

Table 5: Parameters Estimates of credit rationing and fertilizer use intensity

	Constrained		Unconstrained		Selection (credit status)	
	Coef	**Std.err**	**Coef**	**Std.err**	**Coef**	**Std.err**
Male headed dummy	-0.139	0.235	-0.067	0.144	0.162	0.120
Marital status	0.163	0.209	-0.096	0.130	0.097	0.109
Log of Age of the household head	31.892	45.475	57.919*	26.253	51.518*	22.077
Log of Age square of the household head	15.676	22.255	-28.214*	12.844	-25.149*	10.803
Log Household size	-.2675*	0.130	-0.082	0.075	.163	0.064
Primary education dummy	.457**	0.146	.357***	0.077	-0.046	0.071
secondary education dummy	.425***	0.125	.439**	0.071	0.026	0.067
Primary cooperative membership dummy	-0.198	0.167	.362***	0.093	-0.063	0.081
Livestock ownership in TLU	-0.019	0.138	-0.102	0.075	-0.003	0.010
Log of number of ox	0.234	0.153	.329***	0.003	-0.148	0.078
Log of Off- farm income	0.035	0.021	0.019	0.010	-0.093***	0.015
Log of Farm income	.067**	0.023	.098***	0.014	-0.078***	0.012
Log of value production asset	.1397*	0.058	0.031	0.030	-0.028	0.027
Ownership of TV dummy	-0.289	0.256	.399**	0.132	-0.066	0.124
Ownership of mobile dummy	.188*	0.088	.118**	0.041	-0.078	0.040
Ownership of radio dummy	-0.175	0.112	0.084	0.057	-.108*	0.052
Hired labor dummy	0.192	0.108	.1405*	0.061	0.098	0.053
Average slope index (1 all parcel steeply sloped, 3 all flat)	0.184	0.097	-0.105	0.054	-0.058	0.047
Average altitude index(1=all parcel much above 5=all much below	.1674**	0.054	-0.002	0.034	-0.019	0.028
Average land ownership index(1=all parcel fully owned by hh 4= all rented)	.207***	0.060	0.043	0.029	-0.021	0.027
Ways of land cultivation	.775**	0.270	0.240	0.164	-0.084	0.138
Average distance of parcel from home	-0.004	0.002	-0.001	0.001	.0038***	0.001
Log of parcel in hectare	-.1566***	0.037	.2710***	0.022	-0.031	0.019

Percentage of irrigated land	.906***	0.204	.973***	0.098	-.239**	0.090
log of manure used	-0.010	0.017	-.043***	0.009	0.002	0.008
Dummy for households in North Wello	-.5023**	0.163	-.4246***	0.087	-.5023**	0.163
Dummy for households in south Wello	-.560***	0.130	-.408***	0.074	-.560***	0.130
Dummy for households in W/Gojjam	2.449***	0.124	2.267***	0.073	2.449***	0.124
Risk averse household dummy	1.0337***	0.2648	-0.0133	0.0863	0.3650***	0.0858
Membership of MFIs				-.427***	0.064	
Borrowing interest rate				.0190***	0.0047	
Bank account dummy				-.258***	0.066	
Bank trust dummy				-0.042	0.052	
Muslim headed dummy				-0.1571	0.086	
Number of installments				0.0007	0.014	
cons.	1.359	4.948	8.64**	-5.966*	2.397	
lns1	0.320***	0.0387				
lns2	0.322***	0.0124				
r1	-0.181	0.251				
r2	0.083762	.				
sigma_1	1.377	0.053				
sigma_2	1.3799	0.0171				
rho_1	-0.1797	0.2429				
rho_2	0.083567	.				
LRtestchi2(1)=80.2Prob=0.000						chi2 = 0

Statistical significance at the 99% (***), 95% (**) and 90% (*) confidence levels.

5.2.3 Average fertilizer used intensity: treatment and heterogeneity effect

Table 6below presents the expected value of intensity of fertilizer adoption under actual and counterfactual conditions. From the table, Cell (A) and (B) defined the expected value of intensity of fertilizer adoption observed in the sample. The expected value of intensity of fertilizer adoption by credit unconstrained households is higher than credit constrained households. This simple comparison between the observed mean values however, can be misleading and drive the researcher to conclude that on average the intensity of fertilizer adoption by credit unconstrained farmers is higher than for credit constrained farmers. To avoid this problem we used the counterfactual analysis. It can be by subtracting cell (C) from cell (A). The result from the table 6 indicate that mean intensity of fertilizer adoption would be higher if they are credit unconstrained. Average treatment effect(ATT) result shows that credit constrained households would have used about 42Kg fertilizer per hectares(54%) less than if they had credit unconstrained. Similarly, ATU can be calculated by subtracting cell (D) from cell (B). The ATU value of (1.51Kg) implies that unconstrained households would have used about 1.51 kg fertilizers per hectares more than if they had credit constraints. These results imply that access to credit could increase intensity of fertilizer adoption. The transitional heterogeneity effect is negative(-41.361), this evidence that access to credit has smaller effect for the farm household that actually credit constrained with respect to those that credit unconstrained.

Table 6: Average expected intensity of fertilizer adoption per hectares for credit constrained and unconstrained households.

Sub-sample	Decision Stage		
	Constrained	**Unconstrained**	**Treatment Effects**
Households being credit constrained	49.151(A)	91.022(C)	-41.871 (ATT)
Households being credit unconstrained	57.45(D)	58.96 (B)	1.51(ATU)
Heterogeneity effects	8.299	32.062	-41.361

5.2.4 Impact of Credit Constrained on productivity

Table 7 below reports the repressors estimated parameter used in the both the agriculture productivity per hectare (as continuous variable) and selection equation (credit constrained equation). The result revealed that for credit unconstrained farm households, productivity is increasing in the age of households head, while it decreasing in the age square. This implies that households with older household heads had lower productivity than those with younger household heads. On another hand both age and age square of household head have no significant effect on farm productivity in constrained regime. The result confirmed that younger farmers had higher productivity and get higher farm income when they are credit unconstrained. Agricultural production in Amhara region as well in Ethiopia is mostly labor intensive. Only without credit constraints can younger farmers make full use of their physical advantage.

Various literatures quoted education of household head is important determinant of the households' farm productivity. As stated above, education is categorized into three levels: informal education, primary education and secondary education. The variable informal education is used as the base and deleted from the regression to avoid singularity or multicollinearity problems. The result revealed primary education and secondary education dummy variable is positively and significantly affect household's productivity in both constrained and unconstrained regime.

Total cultivated land had found significant and positive effect on productivity for unconstrained. This implies that farmers with more land likely to increase productivity when they are credit unconstrained. The result can be explained large scale farmers are less risk averse and more inclined to make agricultural investment than small scale farmers and thus they can increase their productivity. Moreover, the positive correlation between farm size and productivity may arise from the economies of scale in acquiring information and getting input credit. However, cultivated land size is negative and significant for constrained. This indicating that credit constrained farmers with more land are unlikely to increase productivity. The negative effect of farm size on the productivity is consistent with the literature (Feder et.al., 1985;

Martey et al., 2013) indicated that management labor, required finance to purchase fertilizer and improved seed or other constraints limit the ability of larger farmers to be as productive and generate large income as smaller farmers. This problem serious particularly when the farmers are credit constrained. Regarding the percentage of irrigation land, it is significant and positive for both constrained and unconstrained regimes.

In fact geographic location of farms determines cropping pattern, rainfall amounts, soil productivity, access to market and access to different institutional services. In order to examine the effect of geographic location variation among farmers on farm income we used three location dummy (such as North Wello, south Wello and Gojjam to represent farmer's location and used north Shewaas base dummy and deleted from the regression to avoid singularity problem. The estimated result shows that South Wello had a positive and significant effect on productivity in both constrained and unconstrained regimes. This result confirms that South Wello farms were more likely to increased productivity as compared to farms in the North Shewa. The result is surprising because farmers in South Wello frequently affected by drought and the land less fertile as compare to North Shewa. This kind of result may arise because if the farmer frequently faced risk and their land less fertile they will made diverse activities and used land more intensively to meet subsistence needs. The North Wello dummy is significant negative in the unconstrained regime, while it is negative insignificant in the constrained regime. The result revealed that farm in North Wello unlikely to increased productivity as compare to farms in North Shewa. The result may be explained by productivity difference between two zones. North Wello zone is one of the degraded and less productive areas in the country and suffered with frequent drought. All these factors create unfavorable conditions for the farmer to increase agriculture productivity and thereby increase welfare.

The total livestock asset is measured using tropical livestock unit. It is significantly positive for unconstrained, but insignificantly positive for constrained. The result revealed that ownership of livestock would increase farm productivity. The number of oxen owned by households is also positively significant in credit constrained regime. The result may be explained various ways: if the households who have more livestock, they may

finance input cost by selling their livestock and thus increase the productivity as well farm income. On other hand, in fact crop production in Ethiopia is dependent on animal traction therefore farmers with more livestock they could be increase crop production and their income.

Based on the literatures the effect of off-farm income on household's farm productivity is ambiguous. Off-farm income is a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional. In other word off-farm income relaxed financial constraints by farmer which is required to purchase productivity enhancing inputs such as improved seed and fertilizers (Mary K. Mathenge and David L. Tschirley 2009).On the other hand, pursuit of off-farm income by farmers, higher return off-farm income and less risky nature may undermine farm activity. In this particular study off- farm income had a significant and negative effect on the productivity in both credits constrained and unconstrained regimes. This implies that as off-farm income increased could leads to decrease in farm productivity and farm income.

Table 7: Parameters Estimates of credit constraints and Farm productivity

Explanatory	Constrained		Unconstrained		Selection equation	
	Coef	Std.err.	Coef	Std.err.	Coef	Std.err.
Male headed dummy	-0.008	0.311	-0.127	0.177	0.162	0.120
Marital status	0.260	0.277	-0.002	0.159	0.100	0.108
Log of Age of the household head	-61.528	60.165	89.183**	32.622	52.218*	22.126
Log of Age square of the household head	30.006	29.444	-43.50**	15.959	-25.49*	10.827
Log Household size	-0.322	0.171	0.002	0.092	.160*	0.064
Primary education dummy	.852***	0.192	-0.169	0.095	-0.051	0.071
Secondary education dummy	.928***	0.161	-.528***	0.087	0.056	0.062
Primary cooperative membership dummy	-0.172	0.220	0.193	0.114	-0.062	0.081
Livestock ownership in TLU	0.142	0.182	.319***	0.092	-.1459*	0.066
Log of number of ox	.544**	0.203	0.141	0.112	-0.142	0.078
Log of Off- farm income	-.0609*	0.027	-.0325*	0.013	-0.004	0.010
Log of value production asset	.1397*	0.058	0.031	0.030	-0.022	0.027
Ownership of TV dummy	0.483	0.340	0.294	0.162	-0.059	0.124

Ownership of mobile dummy	.283*	0.115	0.069	0.051	-0.075	0.040
Ownership of radio dummy	-0.107	0.148	-0.114	0.071	-.1108*	0.052
Hired labor dummy	0.093	0.142	.291***	0.075	0.101	0.053
Average slope index (1 all parcel steeply sloped, 3 all flat)	-0.151	0.129	0.011	0.067	-0.058	0.047
Average altitude index 1 all parcel much above 5 fall much below)	0.073	0.071	-0.051	0.042	-0.020	0.028
Average land ownership index(1all parcel fully owned by hh 4 all rented)	0.004	0.079	0.044	0.036	-0.020	0.027
Ways of land cultivation	0.502	0.357	0.119	0.201	-0.082	0.139
Average distance of parcel from home	-.0052*	0.002	0.001	0.002	.0038***	0.001
Log of parcel in hectare	-.1575**	0.049	.3516***	0.026	-0.028	0.019
Percentage of irrigated land	1.756***	0.259	1.212***	0.120	-.215*	0.088
Log of chemical fertilizer used in kg	.0678***	0.047	.1082***	0.022	-.051***	0.016
log of manure used in kg	-0.026	0.022	-0.007	0.011	0.002	0.008
Use of improved seed dummy	.322***	0.164	.243***	.080	.1128	0.059
Dummy for households in W/Gojjam	0.008	0.164	-0.004	0.090	-0.110	0.066
Dummy for households in south Wello	.431*	0.171	.252**	0.092	-0.033	0.093
Dummy for households in North Wello	-0.385	0.217	-.5768***	0.109	-.2097**	0.076
Membership of MFIs					-.424***	0.062
Borrowing interest rate					.0191***	0.004
Bank account dummy					-.259***	0.067
Bank trust dummy					-0.048	0.054
Muslim headed dummy					-0.153	0.084
Number of installments					0.001	0.015
_cons	15.031*	6.516	-3.246	3.551	-5.922*	2.402
lns1	0.595***	0.023				
lns2	0.523***	0.012				
r1	-0.046	0.240				
r2	0.027	0.121				
sigma_1	1.814	0.041				
sigma_2	1.688	0.021				
rho_1	-0.046	0.239				
rho_2	0.027	0.121				

LR test of indep. Eqns.chi2 (1) = 61.63 Prob> chi2 = 0.0000

Statistical significance at the 99% (***), 95% (**) and 90% (*) confidence levels.

5.2.5 Average farm productivity: Treatment and Heterogeneity effect

The results discussed above suggest that household resource allocation and productivity is affected by credit constraints. In addition to these we also need to estimate the magnitude of how much productivity would increase if the credit constraints were removed. Table 8 below shows that the results of counterfactual analysis using the estimates from endogenous switching regression to calculate the actual (observed) and counterfactual productivity for both credit constrained and unconstrained households as well as to compute the productivity loss due to credit constraints. From table 8 Cell (A) and (B) defined the expected value of productivity observed in the sample. As we shown from the result the expected productivity for credit constrained is higher than unconstrained. However, ATT result indicates that if the credit constraints were removed, mean household productivity could be increased by 6571. 28birr which is about 18.85% increases. ATU is result revealed that productivity for credit unconstrained households could be decreased by 5689.8(16.83%) birr if they had credit constrained. The transitional heterogeneity effect is negative; this shows that access to credit has smaller effect for the farm household that actually credit constrained with respect to those that credit unconstrained.

Table 8: Average expected productivity per hectares for credit constrained and unconstrained households.

Sub-sample	Decision Stage		
	Constrained	**Unconstrained**	**Treatment Effects**
Households being credit constrained	38986.72(A)	45558(C)	-6571. 28
Households being credit unconstrained	28102.12(D)	33791.92(B)	5689.805
Heterogeneity effects	1884.6	11766.08	-881. 475

Sources: author's calculation 2016.

6. Conclusion and Policy Implication

The development of financial sectors and their products have been identified as a means to facilitate the adoption of farm inputs and boost agricultural

productivity in Ethiopia as well as in developing countries. In Ethiopia, however, the smallholder farmers are still credit rationed. Many of economic theory argued that providing credit at market interest rate will leads to the marginal benefit among the credit constrained households while, does no welfare enhancement effect for the unconstrained households. Therefore, intensifying technology adoption, boosting agricultural productivity and alleviating poverty in rural area in credit allocation require targeting the credit constrained households. The main objective of the study is to examine the impact of credit constraint on intensity of fertilizer adoption and agriculture productivity among household that vary in the credit constraint status.

The study was utilized a cross sectional farm household data collected in 2013 from randomly selected sample of 1165 in Amhara region, Ethiopia. With the data, an endogenous switching regression is applied because it taking into accounts the endogneity problems of credit constrained and intensity of fertilizer adoption and credit constrained status and agricultural productivity.

We find that credit constraints negatively associated with age of the household head, liquidity, ownership of radio, percentage of irrigated land, bank account and location dummy includes(North Wello and South Wello) but, positively associated with interest rate, risk averse , land distance from home and location dummy of Gojjam. Our result confirmed that factors have a different impact on the intensity of fertilizer adoption and agricultural productivity among credit constrained and unconstrained households. For, example, while age and age square of the household head had a non –linear and significant effect on intensity of fertilizer adoption in the unconstrained regime, it had no effect among constrained households. The effect of land size on extent adoption is also a variable with an opposite effect between the two regimes. Results indicated that while larger land holdings lead to used more mount of fertilizer in the unconstrained regime, it has a negative effect on extent of fertilizer adoption in the constrained regime maybe due to credit constraints.

Moreover, the result shows that intensity of fertilizer adoption for credit constrained households are affected by several factors such as primary cooperative membership, number of oxen source of information includes ownership of TV and mobile phone, percentage of irrigated land and hired labor, use of manure and location dummy (North Wello and South Wello),

while household size and land property (include altitude of land, ownership of land, way of land cultivation, percentage of irrigated land), Gojjam dummy and risk averse are important for intensity of fertilizer adoption of constrained households, implying that credit constraint status has made the significant in the intensity of fertilizer adoption.

Agriculture productivity associated with that Age and age square of the household head, TLU, hired labor dummy are the factors significantly affect the productivity in the unconstrained regimes. While number oxen, distance of land from home are significantly affect the agricultural productivity in the constrained. Land size has found the significant and negative effect on the productivity in the constrained regime but, it has the positive and significant effect in the credit constrained regime.

We also conducted the counterfactual analysis with the endogenous switching regressions and estimated the actual and counterfactual extent of fertilizer adoption and agricultural productivity for both credit constrained and unconstrained households in order to explicitly measure the impact of credit constraints. And the result shows that extent of fertilizer adoption would be decline by 55 kg per hectares if unconstrained households will be constrained. On the other hand, constrained are estimated to increase their intensity of fertilizer adoption by 33% if they are unconstrained.

Similarly, the counterfactual analysis between agricultural productivity and the credit constrained status revealed that agricultural productivity would be decreased by 16.83percent if unconstrained farm household will be constrained. Agriculture productivity would be increased by 16.85 percent if constrained farm households were unconstrained. The fact credit constrained higher impact on the intensity of fertilizer adoption and productivity among the credit constrained and unconstrained farm households justifies the need for credit targeting to boost the agricultural productivity and it can have far reaching poverty reduction implication especially in rural areas farming is the major source of income and food production. Therefore, provision of credit to poor with the market interest rate is a sound policy instrument to raise income of farm households and fight against poverty in the rural area. The policy implication is that the policy maker should account the credit constraint heterogeneity among farm households, when they design agricultural policy to increased intensity of fertilizer adoption and thereby boost productivity.

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Adoption Determinants and Welfare Impact of Agroforestry Technologies in Ethiopian Highlands

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Abstract

Deforestation and land degradation are one of the major causes of low and declining agricultural productivity and continuing food insecurity and rural poverty in Ethiopia. To reverse the problems of deforestation and land degradation, the government of Ethiopia and various development partners have promoted agroforestry trees and land rehabilitation technologies since 1970s. Despite continued efforts, several studies in Ethiopia show persistently low adoption of agroforestry trees and land rehabilitation technologies. This study applies the counterfactual outcome framework that models technology adoption as a selection processon a cross-sectional data from 416 farm households to assess possible reasons for nonadoption of agroforestry technologies by a large number of farmers in Ethiopia. Empirical findings show that gender of household head being male, high proportion of male family members, larger family size, larger land holding and household location being in higher altitudes are positively associated with adoption of agroforestry technologies. Furthermore, treatment effect estimates from matching and weighting estimators show that adopting agroforestry technologies confers additional household income and reduces food insecurity in this context. The result suggest that large scale adoption of agroforestry technologies requires addressing the gender gap, disparity in access to farm resources such as land and labour. The significant difference between adopters and non-adopters in household income and food insecurity suggests that the rationale behind large number of farmers' persistent rejection of agroforestry technologies, despite many years of research and development efforts, is more likely due to low welfare outcome potential of agroforestry technologies to non-adopters.

Key words: Agroforestry; Technology Adoption; Food security; Propensity Score Matching

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Highlights:

- We examine adoption constraints and welfare impacts of agroforestry technologies.
- Maleness, larger family labour and land holding facilitate adoption of agroforestry technologies.
- Adoption of agroforestry technologies is affected by agro-ecology.
- Adopting agroforestry technologies increases household income and reduces food insecurity.

1. Introduction

Deforestation and land degradation are one of the major causes of low and declining agricultural productivity and continuing food insecurity and rural poverty in Ethiopia (Ehui and Pender, 2005; Shiferaw and Holden, 1998; Tefera and Sterk, 2010). Identifying effective strategies for raising the use of soil conservation and land rehabilitation technologies has been a longstanding policy priority in Ethiopia. The government of Ethiopia and various development partners have madelarge scale investments in soil conservation and land rehabilitation measures to overcome the problem. For example, rehabilitation of degraded lands, which started through food-for-work relief assistance following the 1974-1975 famine, has become a major component of the government's approach to mitigate the impact of soil degradation in many regions of Ethiopia (Asrat et al., 2004; Yilma et al., 2011).In recent years, Sustainable Land Management Program (SLM) and Productive Safety Net Program (PNSP) have been implementing sustainable land management practices and agroforestry technologies in many parts of Ethiopia. Theoretical arguments, historical evidence and numerous field experiments have demonstrated that agroforestry trees make farmlands and landscapes more resilient. For example, there are a number of successful agroforestry trees that prevent soil erosion, fast-growing trees for fuel wood, indigenous trees to provide nutritious food, livestock feed and medicinal plant products (Ajayi et al., 2016; Dawson et al., 2014; Mbow et al., 2014; Verchot et al., 2007). Some species fix nitrogen from the air on their root systems, which helps maintain and improve soil fertility. Trees also play a key role in mitigating the negative effects of climate change. Following these facts, agroforestry trees including high-value fruit trees like apple, mango, avocado and indigenous medicinal

trees such as Moringa tree were promoted as one way of improving the livelihoods of rural households (Teklewold et al., 2013). These interventions were intended to reverse the problems of land degradation and desertification and to make farmlands and landscapes more resilient(Bishaw et al., 2013).While these interventions have led to commendable success in certain pockets, yet the country is struggling to scale up promising agroforestry technologies to a large number of farmers.

Several studies in Ethiopia have reported low adoption of land rehabilitation technologies among the majority of smallholders (Beshir et al., 2012; Iiyama et al., 2016; McGowan et al., 2013). This poses a question as to why the majority of smallholders have not adopted land rehabilitation technologies in Ethiopia. Both external factors, such as access to basic infrastructure and services, common pool resources and social stability, as well as internal factors, such as asset endowment, could determine the extent to which poor households implement technologies in agriculture, forestry, environment and climate change (Bryan et al., 2013; Wunder et al., 2014). Smallholders often have heterogeneous access to land, credit and technical advice, basic knowledge of the market system, and current information on market prices and conditions— all of which restrict their capacity to invest, expand their market surplus and add value to their produce (Dercon and Christiaensen, 2011). Despite the evidence that poor households vary in their asset levels, social networks and in the abilities to cope with shocks, many technology dissemination initiatives treat poor rural households as a uniform farmer group with the same response capacity(Di Falco et al., 2011; Jayne et al., 2010; Marenya and Barrett, 2007). Furthermore, technology scale up programs requires adequate policies to improve overall investment conditions, attract investment and provide better business services to increase farmer's competitiveness(Adimassu et al., 2012; Asfaw et al., 2013; Holden, 2004; Taddese, 2001). Despite advances in the understanding on factors affecting technology adoption in developing countries, there are a number of crucial issues on which our knowledge is still insufficient. One possible explanation for nonadoption of technologies could be differentials in welfare outcome potential between households (Suri, 2011). Yet measuring welfare outcomes of households in smallholder context is not straightforward. In the case of technologies used by profit-maximizing agents, it is clear that technology

profitability is the key measure. For technologies that improve an agent's utility, such as agroforestry technologies, measurement of outcomes is less straightforward. Agents choose to adopt a technology based on the gain in welfare, which cannot be directly measured. Hence, assessing welfare gains in terms of improved household income and food security is an innovative approach to answer the question of whether adopters and non-adopters of agroforestry technologies have inherent differences in welfare outcome potentials.

Agricultural household models have been used as a standard framework for technology adoption studies in developing countries using non-linear parametric models such as probit or tobit (Abdulai and Huffman, 2005; Adesina and Baidu-Forson, 1995; Doss, 2013; Feder and Umali, 1993; Shiferaw and Holden, 1998). Estimates by probit or tobit hinge on the assumption that the effects of unobserved factors do not vary across farm households. However, household-specific unobservable factors could be correlated with observable characteristics of households and can affect their adoption decisions. Hence adoption estimates derived from probit or tobit may yield biased estimates. Furthermore, there is limited evidence on whether previous projects have achieved the intended outcomes on the landscape and farmer's livelihoods. A review of previous studies on the impacts of large-scale degraded land rehabilitation initiatives show that local livelihoods impacts are not clear for many situations and lack clear indicators for monitoring (Adams et al., 2016). Program evaluations are often based on before-after comparisons of case studies, occasionally relying on observations by rounding out the field and expert opinion. They often use subjective methods such as performance management and participant evaluation approaches. Such evaluation approaches poorly predict causal relationship between the interventions and livelihood outcomes. For instance, too little is known about the impact of agroforestry technologies on household income and on household food security. Another limitation of previous adoption and impact studies has been that they treat technology adoption and impact evaluation as separate entities. Using a counterfactual outcome framework that models technology adoption as a selection process on a cross-sectional data from 416 farm-households in Ethiopian highlands, this paper examines the binding constraints to adoption of agroforestry technologies and adoption

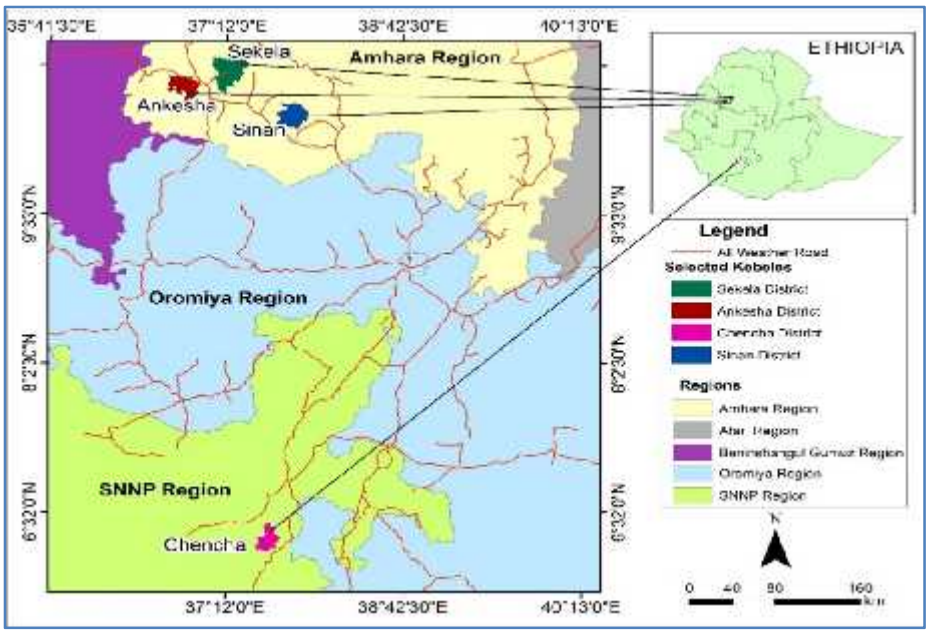
impacts on household welfare as measured in terms of household income and food security in Ethiopian highlands. We also use a combination of identification strategies to check internal validity of impact estimates. On the basis of research findings, we provide recommendations on interventions and investments that can improve the uptake of agroforestry technologies in Ethiopian highlands.

2. Materials and Methods

2.1 Sampling scheme and data

The data used for this study were collected from 416 sample households in four districts in Ethiopia. The four districts were selected based on the representativeness of the target areas of Sustainable Land Management Productive Safety Net Program (PSNP)-public works interventions. This study was conducted in Sinan, Sekela and Ankasha districts located in Amhara region and Chencha district located in the Southern region (Figure 1).

Figure 1: Map of the study sites



The survey was conducted by researchers from Ethiopian Environment and Forest Research Institute during April to May, 2016. A multistage sampling procedure was employed to select villages from each district and households from each village. First, one village was selected from each of the four districts: Sinan, Ankesha and Sekela in East Gojjam province of Amhara regional state and Chencha district in Gamo-Gofa province of Southern region. Second, based on proportionate random sampling, sample households were selected from the list of farm households in each village. The data were collected using a paper-based structured questionnaire through interviews with the household head or in his/her absence, the most senior household member available. Trained enumerators with experience in conducting farm household surveys collected the data. The variables of interest included information on household demographic characteristics, household farm resources and household assets, the inventory of crop, forest and livestock production activities, use of modern technologies, marketing practices, household access to credit and extension services, the distance a household resides from input and output markets and household monthly expenditure. The questions on monthly expenditure was used for measuring household cash income. The total monthly expenditure was computed by aggregating all expense categories (e.g. expenses for food items, clothes, school fees, weddings, funerals, loan repayment, membership fees to local organizations, church donations, etc.). Household dietary diversity scores (HDDS) are increasingly used as measures of food security and as a useful indicator for capturing some aspects of diet quality, as it correlates with adequacy of nutrient intake in recent years (Beegle et al., 2012; Behnassi et al., 2013; Ruel, 2002; Swindale and Bilinsky, 2006; Thorne-Lyman et al., 2010). We included questions about the number of food types or food groups consumed during the last seven days in the questionnaire to estimate HDDS. Household Food Insecurity Access Scale (HFIAS) was calaculated and used as proxy measures of household food insecurity (Swindale and Bilinsky, 2006). The HFIAS was assessed by asking a series of questions reflecting different domains of food security as experienced by the respondents (Swindale and Bilinsky, 2006). The HFIAS calculates as sum of the frequency-of-occurrence during the most food insecure month for the nine food insecurity-related conditions. In addition to the quantitative household survey, we conducted focus group and key

informant interviews to triangulate with the information obtained from empirical exercise.

2.2 Conceptual framework

Our guiding principle in exploring the determinants of household technology adoption and impact evaluation is grounded in the theoretical model of the agricultural household (De Janvry et al., 1991; Singh et al., 1986). Theoretically, the decision to adopt technologies is considered under the general framework of utility maximization. It is assumed that farmers are expected to choose enterprises or adopt the technology that gives the largest expected discounted net return, or utility. Here we focus on the adoption of agroforestry technologies (e.g., planting multipurpose trees and fruit trees). We assume that a farmer chooses agroforestry technology that maximizes utility subject to household demographic characteristics, household resource endowments and other determinants. The feasibility and attractiveness of any alternative within the choice set depends on access to livelihood assets as well as on the technical and financial performance of each alternative. The inclusion of the explanatory variables in the empirical model is based on a review of theoretical work and previous empirical adoption studies (Feder et al., 1985; Knowler and Bradshaw, 2007). Factors that are likely to affect adoption and impact of agroforestry technologies include household and individual characteristics (age, gender, household size, education, etc.), household asset ownership (livestock, land, number of major farm equipment and household furniture, etc.), access to institutional services (distance to extension office and number of contacts with extension agents); and location characteristics (e.g., distance to nearest market place and differences in agro-ecological zones) are included in the adoption analysis.

2.3 Estimation strategy

Probit model

In this paper, we use a probit model (Wooldridge, 2010) to estimate the influence of explanatory variables on adoption of agroforestry technologies. The probit model specification employs a latent variable y_i^* to an observable dependent variable y_i according to the rule:

$$y_i^* = x_i\beta_i + \varepsilon_i$$
$$y_i = \begin{cases} 1 \; if \; y_i^* > 0 \\ o \; otherwise \end{cases} \quad \textbf{(1)}$$

where x_i is a vector of explanatory variables, β_i is a vector of coefficients, and ε_i is a stochastic disturbance term.

Propensity score matching

Project impact is defined as the difference between observed outcome of project participants and the outcome that would have been obtained if the project participants did not participate in the project (i.e., counterfactual outcome) (Heckman et al., 1998; Rosenbaum and Rubin, 1983). As it is well known in the program evaluation literature, however, counterfactual outcomes are unobservable as an individual is either in one state or the other at a point in time. In non-experimental intervention, project participants and non-participants are not randomly assigned to the project. Propensity score matching (PSM) has been widely used to examine the impacts of technology adoption on household welfare using data collected through non-experimental study designs (Abebaw and Haile, 2013; Ali and Abdulai, 2010; Imbens, 2014; Mendola, 2007; Takahashi and Barrett, 2013; Wu et al., 2010). Propensity score matching method strives to overcome the selection bias that may arise due to non-random assignment of project participants by creating a comparison group of non-project participants that are as similar as possible in all relevant pre-project participation characteristics to the group of project participants (Rosenbaum and Rubin, 1983). The PSM method controls for observable characteristics and test for the robustness of results to handle the unobservable characteristics. The PSM approach balances the observed distribution of covariates across the project participants and non-participants based on observables.

More formally, we define two outcomes and a treatment indicator:

Y_{1i} denotes the outcome for a household ï" with treatment (within the present context, treatment denotes the observed adoption decision)

Y_{0i} denotes the outcome (within the present context, household income or Household Food Insecurity Access Scale) for household "ï" without treatment

$T_i \in \{0, 1\}$ indicates treatment status for household "ï"

Because a given household can only experience one of the two outcomes, we have the observation equation

$$Y_i = T_i Y_{1i} + (1 - T_i) Y_{0i} \quad \textbf{(2)}$$

where Y_i denotes the observed outcome for household ï". We use "treatment" as a generic term for programs and policies.

For treated household, we observe the treated outcome while the untreated outcome remains counterfactual. For the untreated household, we observe the untreated outcome while the treated outcome remains counterfactual. The difference between the treated outcome and untreated outcome defines the unobserved treated (or causal) effect for each household:

$$\delta_i = Y_{1i} - Y_{0i} \quad \textbf{(3)}$$

The literature focuses on particular average of δ_i, where the choice of which average depends on the policy question of interest, subject to constraints following from the identification strategy and the data. The most common causal estimate is the average Treatment Effect on the Treated (ATT), given by:

$$ATT = E(Y_1 - Y_0 | T = 1) \quad \textbf{(4)}$$

This parameter informs a cost-benefit analysis that addresses the question of whether to keep or scrap a program in its present form.

Kernel matching (KM) was used in this study as it is known to produce the best balance statistics (Becerril and Abdulai, 2010; Caliendo and Kopeinig, 2008). Kernel matches are based on a weighted average of the individuals in the comparison group, and the weight is proportional to the propensity score distance between the treated and untreated. The advantage of kernel matching is greater efficiency, as more information is used; however, the disadvantage is that matching quality may be limited, due to use of observations that may be bad matches (Caliendo and Kopeinig, 2008).

Inverse probability weighting estimator with regression adjustment (IPWRA)

The PSM is a base-case estimator. The PSM method is basically built on a strong assumption that observable covariates account for the selection process into the treatment and control individuals' conditions (un-confoundedness assumption. While propensity score matching is the most common method of estimating treatments effects, PSM estimates could be sensitive to bias when the treatment model or the outcome model is affected by confounding unobservable factors (Abadie and Imbens, 2006; Imbens, 2004; Imbens, 2014). The key limitation of PSM method is that if unobservable factors affect adoption decisions, estimated ATT may be biased due to those unobservable factors (DiPrete and Gangl, 2004; Rosenbaum, 2002). Furthermore, propensity score matching does not perform well in small samples in comparison with other estimators. In light of the emerging literature on these issues (DiPrete and Gangl, 2004; Rosenbaum, 2002), we had concerns that the estimated treatment effect by PSM may be biased due to unobservable factors. Therefore, we checked the validity of PSM estimates using inverse probability weighting with regression adjustment estimator (Cattaneo, 2010; Curtis et al., 2007).The IPWRA estimator has the double-robust property, which means that the estimates of the effects will be consistent if either the treatment model or the outcome model are miss-specified (Cattaneo, 2010). The doubly robust estimators give us an extra shot at correct specification. The IPWRA estimator models both the outcome and the treatment to account for the non-random treatment assignment (Cattaneo, 2010). IPWRA uses inverse probability weights to estimate corrected regression coefficients that are subsequently used to compute averages of treatment-level predicted outcomes.

3. Results and Discussion

3.1 Descriptive statistics

Table 1 reports results for the mean differences in various characteristics for adopters and non-adopters of agroforestry technologies, using the t-test to test the null hypothesis of equality of means. It is apparent that households who adopted agroforestry technologies have a higher and significant education level. On the other hand, farm-households who adopted agroforestry technologies have lesser number of livestock animals and reside close to

nearest major market place in comparison with non-adopters. Farmers without a nearby major market place to sell their produce from fruit trees are less likely to adopt agroforestry technologies liker fruit trees. Furthermore, technology adopters have significantly higher monthly consumption expenditure and lesser food insecurity scale.

Table 1: Descriptive summary of selected variables used in estimation (Standard errors in parentheses)

Variable	Adopters	Non-adopters	Diff
Age of household head (Years)	51.85(1.28)	52.24(0.81)	-0.40(1.50)
Sex of household head	0.89(0.03)	0.87(0.02)	0.02(0.04)
Education of household head (Years)	6.97(0.28)	5.53(0.14)	1.43(0.28)***
Family size (adult equivalent)	1.79(0.51)	2.93(1.48)	-1.19(2.07)
Total land holding (ha)	2.49(0.12)	13.92(8.01)	-11.43 (11.01)
Total livestock holding (TLU)	0.93(0.04)	1.12(0.04)	-0.19(0.07)***
Distance to nearest major market center	0.44(0.03)	0.6(0.03)	-0.15(0.04)***
Total monthly expenditure ($/month)	392.75 (33.09)	273.80 (14.82)	118.95(18.27)***
Household dietary diversity score (HDD)	4.21(0.21)	4.46(0.13)	-0.25(0.24)
Household food insecurity access score (HFIAS)	5.6(0.49)	7.13(0.37)	-1.53(0.63)**
N	144	272	416

Notes: *** p<0.01, ** p<0.05, * p<0.1

3.2 Estimation results

The Wald chi square test strongly rejected the null hypothesis of no association between adoption decision of agroforestry technologies and explanatory variables included in the model at 1% level [χ^2 (13) =74.17, Prob > χ^2= 0.00], indicating the validity of estimating the adoption equations jointly using probit model.

An analysis of new data from a survey of 416 smallholder farmers in Ethiopian highlands shows that gender of household head being male, proportion of male family members, family size and total land holding and district dummy for Chenchahighlands are positively associated with adoption of agroforestry trees.Adoption of this technology increases consumption expenditure and reduces food insecurity of households significantly. This

study also confirmed our expectations and previous adoption studies that adoption of agroforestry practices demands more labour and availability of land resources, which female headed and resource poor farmers often lack in adequate amounts. The finding contributes to the emerging literature on gender-related technology adoption gaps. Empirical results also pointed out that the disincentive created by distance to nearest major market and differences in agro-ecological zones (AEZs) in predicting technology adoption decision (Dillon and Barrett, 2016; Thompson and Scoones, 2009).

Table 2: Factors affecting adoption of agroforestry technologies (Standard errors in parentheses)

Variables	Adoption of agroforestry trees
Age of household head (Years)	-0.01(0.01)
Sex of household head	0.83(0.38)**
Education of household head (Years)	0.01(0.09)
Family size	0.12(0.04)***
Proportion of male family members	0.26(0.13)**
Total land holding (ha)	0.28(0.14)**
Land fragmentation (number of plots)	0.09(0.08)
Total livestock holding (TLU)	0.03(0.07)
Distance to nearest major market center	-0.16(0.19)
Distance to extension office	-0.25(0.31)
Membership in village credit association	-0.42(0.42)
Ankesha (if farmer is located in Ankesha district, 0 otherwise)	0.07(0.53)
Sinan (if farmer is located in Sinan district, 0 otherwise)	-0.35(0.47)
Chencha (if farmer is located in Chencha district, 0 otherwise)	1.12(0.40)***
Constant	-2.74(0.80)***
Observations	210

Notes: *** p<0.01, ** p<0.05, * p<0.1

The clear message of Tables 1 and 2 is that farmers are more likely to adopt agroforestry technologies in Ethiopian highlands depending on whether are resource-rich in terms of family labour and land and have better access to input and output markets. The findings in this study echoes the results of previous studies on adoption of agroforestry practices in different parts of Africa (Ayuk, 1997; Franzel, 1999; Franzel et al., 2001; Gyau et al., 2012; Kabwe et al., 2016; Lee, 2005; Meijer et al., 2015; Mwase et al., 2015; Nkamleu and Manyong, 2005). Significance of district dummy suggests that

households' production choices are constrained by various agro-ecological factors, such as climate and terrain. This is particularly true for Ethiopia as there are no private land markets in Ethiopia, households are restricted in terms of where they can live(Abdulai et al., 2011; Gebremedhin and Swinton, 2003). Smallholders who operate in areas near provincial towns with growing incomes, markets and employment are likely to have more market opportunities and take better advantage of them than farmers in less economically dynamic areas. In contrast to development approaches that focus narrowly on improving the capacities of smallholders to increase their productivity or better manage natural resources, significance of access to market challenges development organizations to work with diverse stakeholders to understand the performance of the value chain and identify mutually beneficial options for improving chain performance. The results found in this study is consistent with the findings of other studies in developing countries (Faltermeier and Abdulai, 2009), which report that households who do not meet minimum asset thresholds require specific, non-market-based interventions to create the necessary preconditions for their participation in technology scale up initiatives. These include, investments in basic infrastructure and services and resolution of land-tenure conflicts where they exist. The results suggest that research and development efforts in land rehabilitations interventions such as agroforestry technologies should target farmers who have farm assets and better market access. Blanket technology scale up strategy does not seem to be appropriate in smallholder settings. These interventions fall outside the realm of extension, but are critical for its success if the poorest sections of the rural population are to benefit.

The estimates for the average treatment effects on the treated (ATT) by PSM and IPWRA show that adopting agroforestry technologies has a positive effect on household income and reduction of household food insecurity. Investment in agroforestry technologies result in $43.48 more average monthly income or by 163.87% for households who adopted the technologies than the households in the control group. The result further shows that adaptors of agroforestry technologies reduces household food insecurity by a scale of 2.2 or 73.08 %. This result suggests that households who adopt agroforestry technologies are more likely to achieve better livelihood outcomes relative to non-adopters.

Table 3: PSM results on household welfare effects of adopting agroforestry technologies

Household welfare indicator	ATT	P>|t|
Household income ($/month)	107.82	0.00***
Dietary diversity score	-0.18	0.51
Household Food Insecurity Access Scale	-2.20	0.002***

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Results of IPWRA estimator on household welfare effects of adopting agroforestry technologies

Household welfare indicator	ATT	P>|t|
Household income ($/month)	40.99	0.01***
Dietary diversity score	0.12	0.68
Household Food Insecurity Access Scale	- 2.04	0.00***

Notes: *** p<0.01, ** p<0.05, * p<0.1

The results in Tables 3 and 4 suggest that investment in land rehabilitations interventions such as agroforestry practices are economically efficient and socially fair. The results are robust across different econometric methods used for impact evaluations. A lower magnitude of ATT estimate by IPWRA, as compared to the ATT estimate by PSM, can be attributed to selection bias arising from unobservable characteristics that may have affected adoption decision and outcome. The higher ATT values by PSM suggest that ATT estimates based on PSM alone can potentially lead to erroneous conclusion about the effect of technology adoption. These findings are consistent with the view that adoption of agroforestry technologies can improve household income and food security. This is a very strong evidence for supporting agroforestry based degraded land rehabilitation programs going forward.

4. Conclusion and Policy Implications

This paper examines the binding constraints to adoption of agroforestry technologies and adoption impacts on household welfare as measured in terms of household income and food security in Ethiopian highlands. Using a theoretically-grounded counterfactual outcome framework, we have shown that persistently low adoption of agroforestry technologies are associated with individual household's access to productive assets—such as availability of

family labour and size of land holding—and access to input and output markets. Empirical findings demonstrate that gender of household head being male, high proportion of male family members, larger family size and total larger land holding size and district dummy for Chencha highlands are positively associated with adoption of agroforestry trees. Moreover, the results reveal that adoption of agroforestry technologies significantly increases household income and reduces food insecurity. The significant difference between adopters and non-adopters in household income and food insecurity suggests that the rationale behind large number of farmers' persistent rejection of agroforestry technologies, despite many years of research and development efforts, is more likely due to low welfare outcome potential of non-adopters. The result of this study, however, does not support the large technology scale up strategy passionately followed by the government of Ethiopia. The technology scale us programs make an implicit assumption that household characteristics and the relationship between farmers' production goals and preferences are homogenous. On the other hand, the result supports the widespread wisdom among the development community that agricultural input and output markets function poorly for many smallholder farmers. This suggests that the issue of low technology adoption is mostly associated with structural (institutional and policy) barriers – often related to failures of accountability in public service delivery, rent seeking, uncertain and expensive contract enforcement and weak physical infrastructure that results in high transactions costs that systematically reduce the gains for poor farmers from adopting technologies. The high transaction costs involved in accessing the technologies and marketing outputs may lead to higher cost of using technologies greater than the potential benefits gained from the technologies. Many of the constraints to technology adoption identified in this paper are not limited to agroforestry technologies but relevant to most technologies intended to increasing productivity of smallholder systems in developing countries. Technological interventions that support small-scale farmers will have little impact unless they are complemented with policy changes that create a more conducive environment that help smallholders gain a fair share in profitable value chains. As the development community and Ethiopian governments increasingly strives to reverse land degradation in the highlands, the onus now falls on the government to address institutional and policy barriers that impede the scaling up of agroforestry technologies in rural Ethiopia.

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Resettlement and Sustainable Livelihoods in Ethiopia: A Comparative Analysis of Amhara and Southern Regions

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Abstract

Resettlement as a development discourse has become a worldwide phenomenon. This phenomenon is mainly caused by population pressure, war or prolonged hostilities between countries or groups within the country, irreversible environmental degradation and development projects. While there are diverse causes of resettlement situations, this study focused on state sponsored resettlement programmes caused by socio-economic, political and environmental problems in Amhara and the southern regions of Ethiopia. The main objective of this empirical study was to analyse the effects of planned government intra-regional resettlement programme on the sustainable livelihoods of resettled households in Ethiopia. The central research question was: Does a planned intra-regional resettlement programme provide sustainable livelihoods for settler households in the two selected regions of Ethiopia? If it does, what chain of factors explains the livelihood security? If it does not, what are the interacting variables and how have they generated a process of livelihood insecurity? To this end, the combination of Sustainable Livelihood Framework (SLF) and Impoverishment Risks and Reconstruction (IRR) models were used as the pillars of the theoretical and conceptual framework of the study. Mixed method design that combines both quantitative and qualitative data from primary and secondary sources were used in this study. Primary data were collected through a household survey, key informants interview, focus group discussion and field observation. A total of 250 households were surveyed and a total of 28 interviewees were contacted from the two regions. A total of 6 focus group discussions were also conducted with purposively selected participants. This study concludes that the effects of planned resettlement on the sustainable livelihoods of resettlers were mixed and challenged the generic representation of the scheme as a success or a failure. The adverse effects were mainly due to policy gaps, the mismatch between policy and practice, poor inter-sectoral and inter-regional integration and inadequate capacity building efforts. Recommendations were provided in line with these gaps. In addition, the study contributed to the methodological and theoretical advancement of resettlement and livelihood studies.

Key words: Amhara, assets, Decha, Ethiopia, IRR, Livelihood, Metema, outcome, resettlement, resettlers, risks, SLF, Southern, state, strategies.

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1. Introduction

With over 90 million inhabitants (United Nations 2013:10), Ethiopia is the second most populous country in Africa, and one of the poorest in the world. Ethiopia faced poverty, which is broad, deep and structural. Its economy is heavily dependent on agriculture and affected by recurrent drought, high population pressure and poor productivity (Devereux, Teshome and Wheeler 2005:121). Due to high population pressure, households' plot size has decreased and this has made them dependent on subsistence and traditional farming practices (FAO/WFP 2007:32-33). Hence, food insecurity and high population pressure are the most important development challenges in Ethiopia.

Thus poverty reduction is the central development agenda of the government of the Federal Democratic Republic of Ethiopia (FDRE) (FDRE 2002:13; Pankhurst 2009:140). Agricultural Development Led Industrialisation (ADLI) is designed as one of the building blocks/pillars in the fight against poverty, as well as ensuring sustainable development. According to FDRE (2002:13), "ADLI is a strategy in which agriculture and industry are brought into a single framework." This framework assumes that the development of agriculture is the key vehicle for industrialisation as it provides raw material, is used as a market base and surplus labour as well as capital accumulation. The government rationality is the agrarian nature of the country's economy and lack of capital for industrial development. The appropriate strategy for the government was, therefore, to focus on agricultural development first and then to industrial development as a final goal. With this logic, ADLI has remained an overarching policy framework for five-year strategic plans: Sustainable Development and Poverty Reduction Programme (SDPRP) (2003/03-2004/05), Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10) and Growth and Transformation Plan (GTP) (2010/11-2014/15).

Central to ADLI, the FDRE government has maintained the land as state property and peasants continue to have only use-rights over the agricultural land they cultivate. In the last 20 years the focus of the government has been on smallholders. The rationale is that the majority of the population lives in the

rural areas and can use the abundant land and labour to ensure economic growth and sustainable development (Alemu 2012:13; Berhanu 2012:4).

In line with the direction of ADLI, one way of using the abundant land is through resettlement programme. Resettlement in Ethiopia or elsewhere in the world is still continuing in a precarious way. The predicament of resettlement in the past shows it is mostly politicised, criticised and hastily implemented. Though the triggering causes are various, drought and famine took the lion share of causes in the Ethiopian context. Resettlement in Ethiopia has been a challenge since its inception in the 1960s. Since then, many scholars, civil society organisations, human right watchers and politicians have interpreted it in numerous ways. Some viewed it from a political perspective, some from an economic and the rest from a human health and human right dimension. This paper viewed it from the broader sustainable livelihood perspective.

Despite some historical records of migration as coping mechanism in a time of famine, planned resettlement with the state intervention is a recent phenomenon in Ethiopia. The first government sponsored resettlement programme took place during the imperial period (1940 – 1974). The second massive inter-regional resettlement programme took place during the Derg regime (1974 – 1991), with the objective of saving the lives of the destitute and making social service provision easier. The current government launched the third state-sponsored large-scale intra-regional resettlement programme in four regional states of Ethiopia (i.e., Tigray, Amhara, and Oromia and Southern regions) in 2003 with the objective of enabling 2.2 million chronically food insecure people (440,000 households) to attain food security (FDRE 2003b:5). Although resettlement is increasingly seen in development theory as an important livelihood strategy for poor people (Tan 2008:46), implementing state-sponsored resettlement schemes and bringing about livelihood change is a complex process. Experience in Ethiopia, elsewhere in Africa, and the world over, show the fact that things can often go very wrong in resettlement operations unless managed with meticulous care (Abbute 2003:2; De Wet 2004:59). Any resettlement programme involving the movement of hundreds of thousands of people over large distances has many risks and dangers attached to it. Even if in principle it is a good idea to move people from a less

fertile area to new productive areas, the question of how far in practice is a planned resettlement programme actually a good policy needs to be answered.

According to Abbute (2003:2), "hasty execution of the resettlement might have humanitarian and ecological consequences. Unless carefully planned, the scheme will extinguish the flora and the fauna and will accelerate soil erosion and hence deplete the ecology." This environmental depletion reduces the environment's ability to produce biomass for food and household energy. This also undermines prospects to fight poverty and achieve sustainable development (FDRE 2010:37).

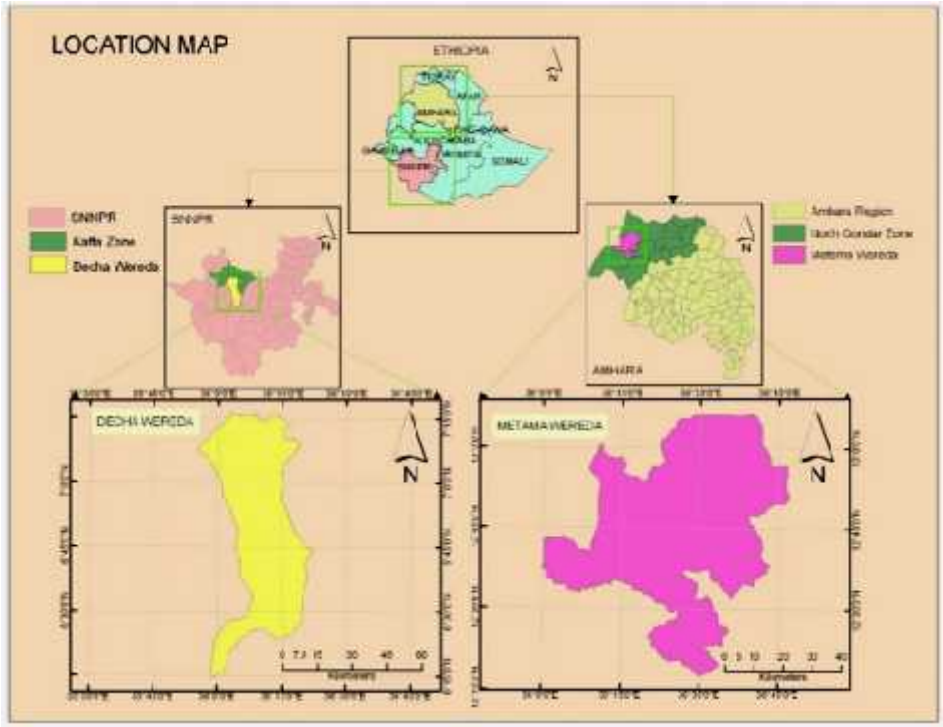
In the literature, there are many research works about the planning and implementation processes of the resettlement programme in Ethiopia. However, there is the gap of analysing livelihoods of resettled households in the context of planned intra-regional resettlement programme. This research project, therefore, tries to explain to what extent the planned intra- regional resettlement programme provides sustainable livelihoods for settler households by investigating the resettlement programmes of the Amhara and Southern regions in Ethiopia in order to come up with theoretical and practical explanations based on scientific evidences. The central research question of this study was- Does the planned intra-regional resettlement programme provide sustainable livelihoods for settler households in the two selected regions of Ethiopia? If it does, what chain of factors explains the livelihood security and sustainability? If it does not, what are the interacting variables and how do they relate to and generate a process of un-sustainability of livelihoods?

2. Scope of the Study

The primary intention of this research was to analyse the resettlement-livelihood nexus of all resettlement sites in Amhara and Southern regions. There are about five resettlement sites/districts in Amhara and six resettlement sites/districts in Southern regions. However, this study limits itself only to one district in Amhara and one district in Southern region because of the constraints of time, cost and availability of information. The study targeted the Metema district from the North Gondar Zone of the Amhara region and Decha district from the Kaffa Zone of the Southern region (see Figure 1). The

two districts were the main destination areas of the current resettlement programme.

Figure 1: Map of Ethiopia and the study sites



Many studies in the past have focused on specific aspects of resettlement; however, this study addressed many issues in a comprehensive way, using the framework of resettlement and sustainable livelihoods. In the past studies, focus has been given to involuntary and spontaneous resettlement programmes. In this study, however, focus has been given to the effects of planned voluntary resettlement on sustainable livelihoods of settlers in the two regions. Therefore, the analysis has been made based on the Impoverishment Risks and Reconstruction (IRR) and Sustainable Livelihoods Framework (SLF) model, and livelihood assets were assessed from five perspectives: financial, human, natural, physical and social capitals.

3. Research Procedures, Techniques and Methods

Choice of the Study Areas and Reasons

The study areas are located in the North West and South West parts of Ethiopia. The Amhara and Southern regions were selected purposively because both of them were food insecure regions and had started implementing the resettlement programme in 2003. However, their achievement in the resettlement programme was below 50 percent when compared to the other regions which were implementing the programme (Pankhrust and Piguet 2009:10). The Decha district from the Southern region and the Metema district from the Amhara region were chosen for this study. The researcher chose the two districts and three kebeles from each district purposively to capture as much livelihood heterogeneity as possible (both on-farm and off-farm activities) owing to the differences in ecology, accessibility, previous institutional interventions, infrastructures, bio-physical and socio-economic aspects and farming systems. In both districts, the study focused on the resettled households in 2003/04 (which means that resettlers in 1995 and 1996, according to the Ethiopian calendar, in both districts were targeted for the survey).

The reason for doing this was informed by the argument made by Rahmato. According to Rahmato (2003:61), it is worth considering the following scenario for new settlements: Phase 1, the first 2 to 3 years: a period of adjustment. Phase 2, the next 3 to 5 years: a period of consolidation. This is the transition stage that indicates what chances of success the project has. Phase 3, the next 5 to 8 years: sustainable progress. This study aimed to see the sustainable progress made by the resettlers and it was reasonable to conduct the study after the programme had been implemented for 10 years of.

The reasons for selecting the two districts were the following:

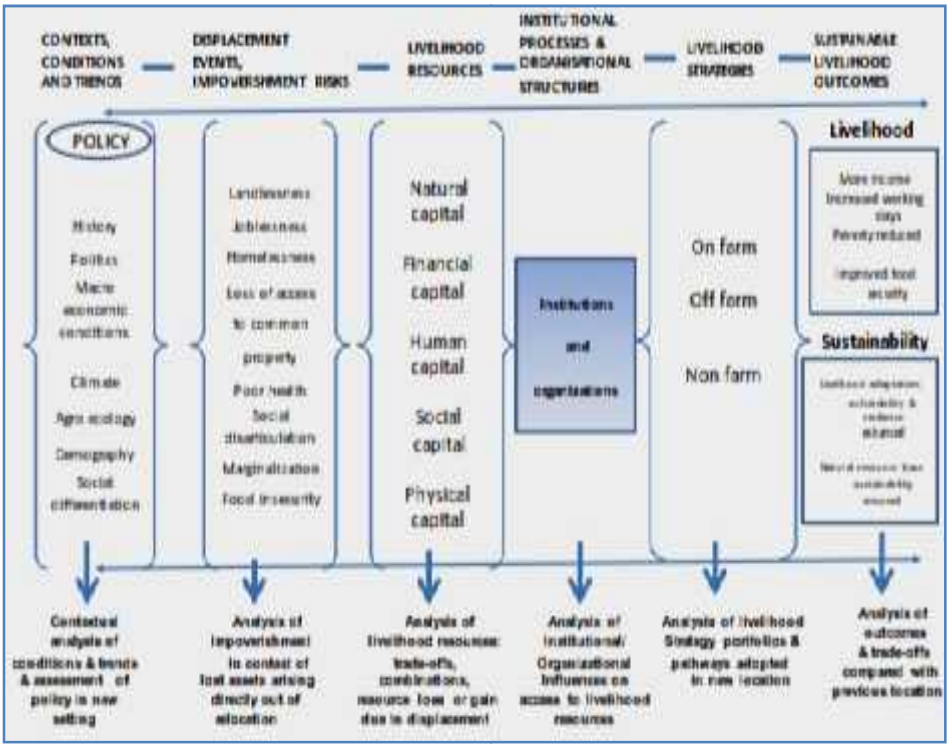
- Both districts started implementing the EPRDF government resettlement programme in 2003/04.
- Both districts had the experience of the failed resettlement programmes of the previous [military] government of Ethiopia.
- Both districts have a larger number of resettled households when compared to other districts in their respective regions.

- At the same time, both have enough land for future resettlement where the output of this study could be used as an input for future interventions.

Analytical Framework of the Study

The Framework for Analysis of Resettlement, Risks and Sustainable Livelihoods presented in Figure 2, shows that given a particular context [of policy setting, politics, history, agro-ecology and socio-economic conditions] and a certain level of impoverishment risks, [landlessness; joblessness; homelessness; marginalisation; increased morbidity and mortality; food insecurity; loss of access to common property and social disarticulation], what combination of livelihood resources [different types of 'capital'] result in the ability to follow what combination of livelihood strategies [agricultural, off farm and non-farm activities] with what outcomes?

Figure 2: Resettlement, Risks and Sustainable Livelihoods Framework



Source: adapted from Ellis (2000: 30), Scoones (2009: 177), and Mc Dowell (2002: 11)

Sample Size and Sampling Techniques

The population of this study comprises all resettlement districts in the Amhara and Southern regions of Ethiopia. However, by considering the scarcity of time and cost, two districts and 6 kebeles/villages from the two regions were selected purposively, followed by the selection of household settlers, using a systematic random sampling technique.

Table 1: Sample size in the two resettlement regions

Amhara Region				Southern Region			
Settlers' District	**Settlers' Kebeles**	**Total* HHs in 2012**	**Sample HHs**	**Settlers' District**	**Settlers' Kebeles**	**Total * HHs in**	**Sample HHs (6.2%)**
Metema	Kokit /M 2 3/	239	15	Decha	Shallo	520	32
	Mender 6,7 &	558	35		Bulkabul	480	30
	Dass Gundo	1282	80		Zenbaba	950	58
Total		**2079**	**130**			**1950**	**120**

*total resettled households currently living in the resettlement site.

Source: MDCO (2013) and DDCO (2013)

250 sample household settlers [130 from Metema and 120 from Decha] were selected using proportional systematic random sampling across six kebeles/villages because it provided all households with an equal chance of being included in the sample (see Table 1). First the lists of the total number of resettled households were obtained from the two districts' resettlement schemes and samples were taken randomly based on the lists of resettled households as a sampling frame. Sampled settler households included different categories of people, young and older, men and women, and people in different levels of livelihood security. A household survey focused on gathering the socio-economic data of settlers, their perception on resettlement and its benefits, the pull-push factors, risks, livelihood assets, strategies and outcomes as a result of resettlement.

For the key informant's interview, a total of 28 samples were taken purposively from different stakeholders at macro, meso and micro levels as shown in Table 2. Since resettlement is a national, regional and local level agenda, key informant interviewees could have adequate information about the issue of resettlement and the livelihoods of settlers.

Table 2: Key informants at macro, meso and micro level

Hierarchical Structure	Target group	Total No. of interviewees
Federal Level	• Department of food security, MoARD (1 person) • Programme Management Units (2 persons) • Forum for Social Studies (FSS) (1 person)	4
Regional level (2 regions)	• Bureau of ARD, food security department (2 persons) • Programme management units (2 managers and 2 experts)	6
District level (2 Districts)	• District administrators (2 persons) • District Agriculture office heads (2 persons) • District experts (development agents) (2 persons)	6
Kebele level (6 kebeles)	• Kebele administrators (6 persons) • Community representatives (6 persons)	12
Total key informants		**28**

Data Sources

In this study, both secondary and primary sources were used to investigate the effect of planned resettlement on the sustainable livelihoods of households in the selected research sites. Secondary sources concentrated primarily on a literature review of the subject. The researcher reviewed the literature on resettlement and livelihoods, policies and strategies, as well as on technical data relevant in the country and outside the country. The available literature was used to gain an understanding of the issues and also to compile the theoretical chapters. It was also used as a reference point to determine what other authors have discovered on this subject, which may or may not be similar to the author's findings. Primary sources include a household survey, key informants' interview and observations. The major primary data were collected through *survey of settler households* in the two selected regions to solicit a wide variety of information about their assets (physical, social, financial, human and natural), their livelihood strategies and the risks settlers faced, livelihood outcomes, etc. A key informants' interview was conducted by the researcher at macro, meso and micro level with professionals, experts, development/extension agents, politicians, resettlement task forces, community representatives and other stakeholders from private and civil society groups (see Table 2). Moreover, *observations* were employed by the researcher to gain a deeper understanding of the area. Observations were employed to obtain

a better grasp on processes of livelihood generation, the type, nature, state and use of household assets, livelihood strategies and outcomes.

Data Analysis

The analysis followed the framework indicated in Figure 2. The framework focused on the context of resettlement, risks of relocation, livelihood assets of settlers, institutional influences in access to livelihood assets, livelihood strategies and livelihood outcomes. The analysis was done, based on the before and after situation as well as on spatial comparison. The quantitative data collected through questionnaire were prepared by cleaning, coding and entering them into a computer. These data were then analysed with the help of the Statistical Package for Social Science (SPSS version 18) programme. Both descriptive and inferential data analysis techniques were used in this study. Firstly, descriptive statistical procedures including cross tabulations, frequency distributions, percentages, arithmetic means, graphs, indexes, etc. were used to provide comparisons between the two regions' resettled households livelihoods and their perceptions related to the resettlement programme. Secondly, inferential statistical analysis, namely the paired t-test and progress out of poverty indexes (Schreiner and Chen 2009:60-69) were used to determine if there were significant differences on selected variables based on the before and after comparison between resettled households in the two regions. The qualitative data collected by means of the household survey through open-ended questions, key informants' interviews, focus group discussions and observations were coded by a categorical system and analysed thematically together with the quantitative survey.

For all variables that were designed and collected by a Likert-scale on the level of agreement/disagreement, the Weighted Average Index (WAI) was applied in order to make the comparison easier and clearer (Miah 1993). The index value was obtained by multiplying the statement with its corresponding weight and dividing it by the total number of responses, which may be stated as follows:

Where,

$$I = \sum F\,iWi/N$$

Where:
I=WAI
Fi= frequency of response to a particular statement
Wi= weightage of statement
N= total number of responses

The index of level of agreement employed in the data analysis is:

$$\text{Index (AWI)} = (F_1W_1+F_2W_2+F_3W_3+F_4W_4+F_5W_5)/5$$

Where;
F_1 to F_5 represent the frequency of response answered 'strongly agree', 'agree', 'neither nor', 'disagree' and 'strongly disagree' respectively. W_1 to W_5 represent corresponding weights applied to different response classes (W_1=2, W_2=1, W_3=0, W_4=-1 and W_5=-2). N=total number of responses. Responses under category of no-opinion were also assumed as 'neither nor'.
The following index ranges and interpretations were applied for analysis and discussion.

Table 3: Weighted index and interpretation

	Scale	Interpretation
F_1	1.41 - 2.0	Strongly agree
F_2	0.25 - 1.4	Agree
F_3	-0.24 - 0.24	Neutral
F_4	-0.25 - (-1.4)	Disagree
F_5	-1.41 - (-2)	Strongly disagree

Source: (Miah 1993)

4. Findings of the Study

The central question addressed in this paper was whether the planned intra-regional resettlement programme provide sustainable livelihoods for settler households in the two selected regions of Ethiopia or not. To examine this, the

sustainable livelihood framework that incorporate the five categories of assets, namely natural, human, financial, physical and social, were examined during the field work and the analysis has been made in line with each assets as follows.

Natural Capital

Table 4 indicates that 54 percent of resettlers in Metema and 60 percent of resettlers in Decha had their own land before resettlement whereas 97 percent of resettled households in Metema and 100 percent of them in Decha had land after resettlement. All resettled households were supposed to receive 2 hectares of land after resettlement. However, 3 percent of the resettled households in Metema reported that they had no land due to the fact that their land was taken by others who had reclaimed ownership.

Table 4: Land ownership and size

Land ownership		Metema (n=130)		Decha (n=120)	
		f	%	f	%
Before	No	60	46	48	40
	Yes	70	54	72	60
After	No	4	3	0	0
	Yes	126	97	120	100

Land size, ha	Metema				Decha			
	Mean	SD	n	t	Mean	SD	n	t
Before	1.83	1.51	70		0.51	0.28	72	
After	2.06	0.48	126	-1.1(ns)	2.02	0.22	120	-33.4***

ns=not significant; *significant at p<.05; **significant at p<.01; ***significant at p<.001.

The total land holding size of sampled resettlers increased after the resettlement programme. As indicated in Table 4, the average land holding size before the resettlement programme was 1.83 in Metema and 0.51 in Decha, while after the programme this figure increased to 2.06 and 2.02 in Metema and Decha respectively. The result shows that the difference in land holding before and after resettlement programme in Metema was not significant. However, the difference in Decha was significant at p<.001.

Crop production is a function of the size, fertility and steepness of the farmland. These are the basic measures of the quality of land. Table 5 shows that the nature of the resettled households' land before resettlement was gentle (43 percent) and steep slope (29 percent) in Metema. However, after resettlement the majority of the respondents reported that their land was flat (78 percent). In Decha, the majority of resettled households land before resettlement was flat (64 percent) and a little gentle (35 percent). However, their land after resettlement was steep slope (35 percent) and gentle (57 percent). This was also witnessed during field observation as depicted in Figure 3.

Figure 3: Topography of resettlement sites

Metema, Gundo site **Decha, Shallo site**

Fertility is examined based on the local knowledge of the resettled households whether their land was fertile, moderately fertile and infertile. As indicated in Table 6, the majority of respondents in Metema reported that their land was infertile both before and after resettlement as compared to Decha. In Decha, 22 percent reported infertile land, 67 percent reported moderately fertile and 11 percent reported fertile land before resettlement. However, after resettlement only 1 percent reported infertile land, only 16 percent reported moderately fertile and 83 percent reported fertile land. Since resettlement was carried out in newly established forest land, it was relatively more fertile than the Metema sites.

Table 6: Steepness, fertility of land and conservation practice

	Metema				Decha			
	Before (n=70)		After (n=126)		Before (n=72)		After (n=120)	
Type of land	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Flat	20	29	98	78	46	64	10	8
Gentle	30	43	24	19	25	35	68	57
Steep slope	20	29	4	3	1	1	42	35
Land fertility								
Fertile	8	11	5	4	8	11	100	83
Moderately fertile	19	27	56	44	48	67	19	16
Infertile	43	61	65	52	16	22	1	1
Soil conservation practice								
Trace building	47	67	23	18	55	76	30	25
Planting trees	8	11	8	6	12	17	68	57
Rehabilitation	15	21	30	24	-	-	1	1
Others	-	-	3	2	-	-	4	3

In Metema, the majority of resettlers' land after resettlement was flat but infertile. However, in Decha, the majority of land was steep slope or gentle but fertile land. To control erosion on steep lands, trace building (25 percent) and planting trees (57 percent) were the major activities carried out by the resettled households in Decha after resettlement. This activity was also the case in Metema mainly before resettlement. However, after resettlement, they did more rehabilitation.

To sum up, soil infertility, weeds and water logging following the flatness of the land were serious challenges in Metema and soil erosion as a result of steepness of land was the challenge in Decha to maintain the quality and productivity of resettlers' land. Thus, appropriate training on soil conservation and tracing practices are highly recommended in Decha to minimise the effect of soil erosion on sloppy lands. In Metema, however, applying modern technology to dry the water logging and the use of fertilisers to increase productivity might be recommended.

A further natural capital is access and use of natural forests and trees. Although trees are the major sources for house construction and fuel wood

supplies, majority of households did not plant trees on their plots. Most of the respondents collected trees from scarce community forest lands, further aggravating the process of depletion of these resources. Data from key informants and focus group discussions showed that most of the resettlers cut trees for land clearing, housing construction and energy. This showed that they had access to use trees and forest products in uncontrolled ways. This worried the host community and environmentalists were arguing that such kind of use of natural resources would lead to environmental distraction.

The other variable for the measurement of natural capital is availability of water for human and livestock use as well as irrigation. Both districts are rich in terms of natural water resources, mainly rivers. However, the use of these water resources mainly for irrigation was very poor. Data from focus group discussion clearly showed that there was not much effort put in by the government to support resettlers in order to use the irrigation potentials in the resettlement areas. Only investors who had the capacity to buy irrigation facilities, and not the settlers, were using the water resource.

Table 7: Access to protected and clean water

Access to drinking water		Metema [n=130)		Decha [n=120]	
		f	%	f	%
Before	No	91	70	11	9.2
	Yes	39	30	109	90.8
After	No	1	0.8	115	95.8
	Yes	129	99.2	5	4.2

Time taken to fetch water

	Metema [n=130)				Decha [n=120]			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Before	1.00	30	13.30	8.70	0.50	30	6.19	5.81
After	0.20	20.00	7.77	7.16	10	20	12.5	5.0

Table 7 shows the access to clean water for human consumption before and after resettlement. In Metema, 99 percent of the resettlers agreed that there was a clean water supply for consumption after resettlement, compared to 30 percent before. However, in Decha is a complete reduction in access to clean drinking water after resettlement. The reasons, according to key informants and FGD participants, were poor integration between the federal,

regional and local levels in planning, implementation and maintenance of not only water service but also other social services. There was no clear mandate among different levels of government regarding funding and provision of social services. Local officials believed that with resettlement any social and infrastructure development was the responsibility of the federal or regional government. Federal and regional governments believed that after a year of establishment of these resettlement sites, it was the responsibility of local government to allocate and maintain social infrastructures. This unclear power share among government bodies at different levels affected social service provision negatively.

Although the survey data in the Metema site showed a positive response regarding water service, focus group discussion participants stated that in the study area there were borehole water facilities in almost all sites. But some of them were not functional and consequently, resettlers used river water as a main source for human and animal consumption. This in turn resulted in poor health conditions for the resettlers due to waterborne diseases. Nonetheless, it was asserted that the availability of water in the new village was better than it was before relocation in Metema; however, the aforementioned limitation needed due attention.

Table 7 also shows that the average time taken to fetch water reduced by half after resettlement in Metema and this reduced the burden of women's work, saving more time for other productive activities. However, in Decha the average time doubled after resettlement. This created a burden for women regarding their productive activities. Most of the resettlers in Decha used river water for drinking. The issue was discussed with key informants at village and district levels. They stated that efforts had been made to develop various drinking water supply sources in order to improve resettlers' access to sufficient and clean water. Although, deep and shallow wells were constructed at all spot of the resettlement areas, most of them were not functional due to maintenance problems.

Figure 4: Drinking water sources in Metema and Decha

Metema, Das Gundo site **Decha, Bulkabul site**

Decha, Zenbaba site

In summary, productive land, forests or forest resources and water resources were amongst the most important forms of natural capital to the livelihood reconstruction of resettlers in both districts. The capacity of the resettled households to restore their livelihoods was largely reliant on their access to these natural resources. In both districts resettlers did not receive the 2 hectares of land as promised. The resettlers' land in Metema was relatively flat but infertile and in Decha the resettlers land was steep slope or gentle but fertile. However, soil infertility, weeds and water logging following the flatness of the land were serious challenges in Metema and soil erosion as a result of steepness of land was the challenge in Decha to maintain the quality and productivity of land. Resettlers in both districts had access to natural forests for house construction and energy or fire wood. However, deforestation, land degradation and unsustainable use of natural resources

were some of the challenges. Access to forests for food and non-timber forest products was limited after resettlement. Resettlers did not have access to grazing land to rear livestock after resettlement. Access to rivers for irrigation was also limited. Water service improved in Metema and worsened in Decha after resettlement.

Human Capital

In this study, human capital is assessed based on household labour requirements, household family size, dependency ratio, quality of education and skill of household members, and quality of health services and members' health status.

a) Labour Supply

Table 8: Source of farm labour

Source of labour	Metema [n=130)		Decha [n=120]	
	f	%	f	%
Family	78	60	86	71.7
Hired	16	12.3	10	8.3
Both	36	27.7	24	20

As depicted in Table 8, the majority of respondents depended on family labour to meet the labour requirements of their various livelihood strategies. About 60 percent of respondents in Metema and 71.7 percent of the respondents in Decha depended solely on family labour to meet their labour requirements, about 12.3 percent in Metema and 8.3 percent in Decha hired their labour input and about 27.7 percent in Metema and 20 percent in Decha depended on both hired and family labour. Although resettlers used hired labour in their farming activities mainly during the harvest season, overall they were able to use their families for their labour requirements. However, it is not only the supply of labour that matters for good production but also the quality of labour in terms of good health, education and skills. Obviously quality of labour depends on the education skills and health status of the individual. To this effect, the quality of labour was examined across these factors.

b) Family Size

Labour supply is also directly related to the family size of the households to establish the availability of labour. Households with larger family size have better access to human labour compared to smaller size households. The size of the resettled household families was established during survey and the results are presented as follows.

Table 9: Resettled households family size

HH Size	Metema [n=130]		Decha [n=120]	
	f	%	f	%
1	-	-	1	0.83
2-3	27	20.77	14	11.67
4-5	46	35.38	44	36.67
>5	57	43.85	61	50.83
Mean	5.08		5.72	

As indicated in Table 9, the majority of resettlers in both districts had a family size of greater than 5. The family size in Metema resettlement villages was comparatively smaller (5.08) than that in the Decha resettlement villages (5.72). In this respect, households in Metema were disadvantaged due to their small-sized family compared to those in Decha. In both cases the household size was above the national average, which is 4.9 (FDRE 2012). This showed that, on the one hand, resettlers could have the opportunity to fulfil their labour requirements in the farming activities as a result of large family size, but on the other hand, large family size was a challenge to meet food security and improve livelihoods.

c) Dependency Ratio

Dependency ratio is another variable to measure human capital. The higher the dependency ratio, the lower the human capital development and its sustainability.

Table 10: Dependency ratio in both resettlement districts

Items	Metema			Decha		
	≤ 14	15-64	≥ 65	≤ 14	15-64	≥ 65
Household head	-	127	3	-	120	-
Family members	348	182	-	372	175	-
Total	348	309	3	372	295	-
Dependency ratio		1.13			1.26	

According to the survey result, resettlers had highest dependency ratio for the young population (1.12 in Metema and 1.26 in Decha), rather than for the old age dependency ratio (0.008 in Metema and 0.000 in Decha). This indicates that there was high fertility and probably mortality of the older group. In addition, households were investing more on satisfying the dependent members rather than on constructing future assets. The overall dependency ratio for the resettled households in Metema and Decha was 1.12 and 1.26 respectively. Multiplied by 100 it gives 112 in Metema and 126 in Decha. This means that every 100 persons within the economically active population groups in both districts supported not only themselves but also an additional 112 and 126 economically dependent persons with all basic the necessities. This figure is above the national average, since the national dependency ratio was computed to be 85.5 for 2014 (World Bank 2013).

d) Education

One of the factors that affect the quality of households' labour supply is the educational status of household heads and their members. The importance of educational status is clear and precise, as educated citizens are more skilled or potentially able to adopt new ideas and technology easily. Hence they have more access to employment compared to unskilled members. This study assessed the educational background of the resettled households, the availability of educational institutions and the level of satisfaction with the educational services by the family members.

The literacy level of resettled households is expected to have an implication on resettlers' food security, crop and livestock production and agricultural input application. As Table 11 indicated, the levels of education of the household heads in both districts varied but households in Decha were more literate than

in Metema. In Metema, more than 70 percent of the resettled household heads were either illiterate or attended adult/religious education. But in Decha, more than 80 percent of them were able to read and write. In addition, literacy of household heads up to high school was higher in Decha compared to Metema for males and females. In both districts not one household head had attained graduate and postgraduate levels of education.

Table 11: Educational Background of household heads and family members

Household heads	**Metema [n=130]**		**Decha [n=120]**	
	f	**%**	**f**	**%**
Illiterate	68	52.31	19	15.83
Adult/Religious	25	19.23	0	0.00
Primary [1-6]	30	23.08	52	43.33
Elementary [7-8]	6	4.62	26	21.67
high school [9-12]	1	0.77	23	19.17
Household members	**Metema [n=530]**		**Decha [n=547]**	
Illiterate/no education	237	44.7	171	31.4
Primary [1-6]	205	38.7	295	53.9
Elementary [7-8]	63	11.8	59	10.7
high school [9-12]	25	4.7	22	4

Regarding the education level of household family members, Table 11, and shows that the resettlement programme has shown a positive effect on the improvement of educational opportunities for the resettled households' family members. Over 55 percent in Metema and over 68 percent of family members in Decha attended the primary, elementary or high school level of education. It was, however, evident that children in the resettlement villages were attending school at the beginning of the academic year but school dropout increased after two or three months of attending school. Reasons mentioned were family health problems, supporting the family in livelihood activities, moving back home for various reasons and in Dehca, poor education facilities, teaching materials and absence of teachers.

Table 12: Availability of educational facilities

Availability		Metema (n=130)		Decha (n=120)	
		f	%	f	%
Before	No	18	14	2	2
	Yes	112	86	118	98
After	No	0	0	85	71
	Yes	130	100	35	29

As depicted in Table 12, with regards to education facilities, the situation in Metema was better both before and after resettlement. According to the key informant in Metema, since the resettlement, education programmes had been developed with the aim of improving both the construction of education infrastructure and capacity building. However, his concern was the quality of education and the skills of teachers. Since the area was lowland, many teachers did not have interest to work in the district. However, in Decha education facilities before resettlement were adequate compared to after resettlement. Unexpectedly, education facilities were scarce and of poor quality in almost all resettlement sites of the Decha district. In Decha, focus group participants stated that formal education was often undervalued because there was a lack of/or a poor quality of school facilities. Even when children had access to school, they often stopped attending at an early age in order to help their families with farming and other economic activities.

Figure 5: Schools in Metema and Decha sites

Metema, Gundo primary school	Decha, Shallo primary school
	

Figure 5 also illustrates that education service in Decha was relatively poor. The buildings and infrastructures were not adequate. As shown in Figure 5, students were attending classes in a very dirty classroom and students were not happy about the school buildings, teaching materials and other supporting mechanisms. Some students compared their situation with the nearby school of the host community villages and they stated that their schools were far better than the resettlers' schools. This is one way of discrimination.

e) Health

Health is an important factor in human capital development because healthy households are assumed to be productive in their livelihood strategies such as farming, off-farm and non-farm activities. This component has been reviewed in terms of the health status of resettlers, availability of health facilities and the overall satisfaction of resettled households in health service provision in the resettlement sites.

Table 13: Current health status of resettled household heads and family members

Household heads	**Metema (n=130)**		**Decha (n=120)**	
	f	**%**	**f**	**%**
Sick	58	45	54	45
Healthy	72	55	66	55
Family members	**Metema (n=530)**		**Decha (n=547)**	
Sick	8	1.5	81	14.8
Healthy	522	98.5	466	85.2

Table 13 shows that 55 percent of household heads in Metema were healthy and 45 percent were sick. In Decha also 55 percent of the resettlers were healthy and 45 percent were sick. In both districts the health status of resettlers was at risk. However, the health status of family members was relatively better especially in Metema.

Table 14: Availability of adequate health facilities

		Metema (n=130)		Decha (n=120)	
		f	%	f	%
Before	No	42	32	4	3
	Yes	88	68	116	97
After	No	72	55	120	100
	Yes	58	45	0	0.00

As depicted in Table 14, 68 percent of resettlers in Metema and 97 percent of resettlers in Decha agreed that there were adequate health facilities before resettlement in their places of origin. However, after resettlement only 45 percent of respondents in Metema stated that there was adequate health service in the new site. Unfortunately none of them confirmed the availability of health services in Decha resettlement sites. Key informants at village and district levels in Decha also confirmed that although Bureau of Health was responsible for the supply of health facilities and treatments for the resettled households, there were not enough facilities and drugs for treatments. The problem worsened during the summer season when the number of population increased due to labour migration from different parts of the country and when communication with the district and zones was interrupted due to road inaccessibility.

In Metema, key informants at village and district level stated that at the time of resettlement the health services were relatively good. There were health posts constructed in each resettlement site. However, currently some of the health posts were not functioning due to the government policy stating that 1 health post should serve 5000 population. Focus group discussion participants, however, stated that there had been a serious health problem since their arrival. One participant commented that “after arrival in 2003, there was a serious health crises related to malaria and kalazar. Many of the resettlers died and others returned to their home in fear of death. It was challenging to adapt to the environment.”

In Decha, in all studied sites, there were no health posts/clinics, health centres and any health facilities. In Bulkabul, there was one health extension worker giving her service in her grass house. She stated that in all resettlement villages drugs were handled improperly in grass houses. For vaccination, she

travelled 8 to 10 kilometres to bring drugs. Since there was no health post constructed, she did not have a refrigerator to keep drugs safely. Therefore, she had to travel daily to put the drugs in one of the health centres constructed for the host villages 10 kilometre away from the resettlement sites. She stated that she was assigned there to give house to house care but everything was challenging for her to keep drugs safe and give adequate health service.

Focus group participants in Metema, Mender 678 site and Das Gundo sites stated that there were health posts functioning in their villages. However, the health posts were not equipped with adequate health equipment, drugs and health staff. Due to this problem, when a household member became ill and needed treatment, access to medication and skilled medical assistance was very challenging. Thus, if the worst happened, the only choice they had was to go to Metema hospital which was almost 40 kilometers away from the villages. This was again exacerbated by lack of transport to get to the hospital.

In conclusion, the resettled households' human capital in both districts was deteriorating after resettlement. This was due to high dependency ratio, big family size, inadequate schools and health infrastructure, access to education and health facilities, as well as other livelihood trainings.

Financial Capital

This denotes the monetary resources people have access to and includes stocks of money such as savings, access to credit facilities, and flows of money such as remittances and wages. In this study, financial capital was assessed by earnings (income versus expenditure), access to credit and savings.

Table 15: Income and expenditure of respondents

Income and Expenditure		Metema (n=130)			Decha (n=120)		
		Mean	SD	t	Mean	SD	t
Average sum total of Income	Before	4407.06	4109.74	-8.045***	2537.2	2596.6	-9.896***
	After	12023.26	10750.81		7693.6	3974.0	
Average sum total of Expenditure	Before	3372.35	2978.33	-8.156***	3515.3	2083.1	-10.393***
	After	8323.26	7313.61		7078.0	3600.6	

ns=not significant; *significant at p<.05; **significant at p<.01; ***significant at p<.001.

The resettled households' income was determined by the source of income earned yearly (the year before resettlement and in the last 12 months pre-survey period). In this regard, attempts were made to identify the major sources of income of the sample households comparing the income before and after resettlement in both research districts. The income from crop output was computed by valuing the total output using average the market price. It was difficult to get genuine data of income particularly in communities whose income sources were highly diverse and inconsistent. This was also true for both data before and after resettlement. Even the household heads themselves might not exactly know what they actually earned in a month. Nevertheless, an attempt was made to capture the approximate level of income earned by households. For comparison purposes households' expenditure information was also collected.

The mean annual cash income of all sample households in the first one year before resettlement in Metema was 4407 birr and the corresponding mean cash income for the resettled households a year before survey was 12,023 birr. The result for Decha also shows an increasing trend, i.e. 2567 birr and 7693 birr before and after resettlement respectively. Resettled households' estimated annual expenditure was computed from the survey data as shown in Table 15. Accordingly, resettled households estimated annual expenditure in Metema was 3372 birr and 8323 birr before and after resettlement respectively. Similarly, in Decha, the estimated mean annual expenditure of resettled households was 3515 birr and 7078 birr before and after resettlement respectively. Overall, the income of resettled households improved after resettlement and also expenditure increased for social and economic values. Although expenditure increased as income increased, the net balance/saving was positive. This shows that resettlement created a positive effect on household income.

Table 16 shows the income share of the resettled households based on broad livelihood activities. According to the data, crop production was the main source of income in both districts before and after resettlement, followed by livestock production. The share of non-farm and off-farm activities was very low after resettlement compared to before. This shows that income

diversification after resettlement was minimal because the majority of the income came from farming.

Table 16: Percentage of income and expenditure sources

% of income source		Metema (N= 130)	Decha (N=120)
Crop production	Before	39 %	40 %
	After	53 %	60 %
Livestock production	Before	34 %	30 %
	After	27 %	28 %
Non-farm activities	Before	17 %	22 %
	After	8 %	8 %
Off-farm activities	Before	10 %	8 %
	After	11 %	4 %
% of expenditure source			
Food items	Before	76 %	67.5 %
	After	60 %	64 %
Non-food items	Before	24 %	32.5 %
	After	40 %	36 %

Table 16 shows that more than 60 percent of the resettled households' total expenditure was spent on food both before and after resettlement. The household expenditure share for food in Metema was 76 percent and 60 percent before and after resettlement respectively. The result in Decha also showed a similar trend. The food expenditure share was 67.5 percent and 64 percent before and after resettlement respectively. Since the share for food expenditure was higher before resettlement compared to after resettlement, the possibility for resettlers to be food insecure was also higher before resentment. Effort was also made to establish the expenditure on non-food items. The average share of non-food expenditure per household per year before and after resettlement in Metema was about 24 percent and 40 percent respectively. In Decha it was 32.5 percent and 36 percent before and after resettlement respectively. There was a relative increase in households' total annual non-food expenditure after resettlement compared to before resettlement.

Another indicator of financial capital is households' saving and credit practices, which could serve as proxy measure of access to financial capital.

The role of credit in providing support for agricultural development through financing inputs and marketing of farm products is vital for rehabilitation of resettlers and improvement of household food security. In this regard, respondents were asked whether they had borrowed money before and after resettlement and what were the sources of credits. In addition, they were asked whether they had ever saved money, if they answered yes, they were further asked the means of saving.

Table 17: Credit and sources

Received credit		**Metema (n=130)**		**Decha (n=120)**	
		f	**%**	**f**	**%**
Before	No	116	89	107	89
	Yes	14	11	13	11
After	No	51	39	58	48
	Yes	79	61	62	52
If yes, sources of credit:					
Before	Service cooperative	1	7	2	15
	Friends and relatives	7	50	10	77
	Micro finance institutes	6	43	-	-
	Others, specify	-	-	1	8
After	Service cooperatives	11	14	-	-
	Commercial banks	2	3	-	-
	Friends and relatives	20	25	2	3
	Micro finance institutes	44	56	60	97
	Local moneylenders	2	3	-	-
If yes, purpose of credit:					
Before	Purchase of seeds	1	7	-	-
	Purchase of fertilizer	2	14	1	8
	Purchase of oxen	2	14	-	-
	Purchase of farm implements	2	14	-	-
	For consumption	5	36	11	5
	For social obligation	1	7	-	-
	others, specify	-	-	1	8
After	Purchase of seeds	1	1	-	-
	Purchase of oxen	8	10	41	66
	Purchase of farm implements	62	78	-	-
	For consumption	8	10	13	21
	to build house	-	-	4	6
	others, specify	-	-	4	6

As depicted in Table 17, the survey result shows that only 11 percent of the sample households in both districts had ever borrowed money before

resettlement while about 61 percent in Metema and 52 percent in Decha had borrowed some amount of money after resettlement. Among those who borrowed money, the majority of the households (56 percent in Metema and 97 percent in Decha) borrowed money after resettlement from microfinance institutions, such as Amhara credit and saving institution in Metema and Omo microfinance institution in Decha. However, before resettlement the main source was friends and relatives in both districts. From the data it was clear that credit access to resettlers from formal banks was non-existent.

Table 17 also shows that the main reasons for borrowing money by resettled households in Metema was the purchase of farm implements followed by the purchase of oxen and for consumption after resettlement. In Decha, the main reason for borrowing was the purchase of oxen followed by consumption after resettlement. However, before resettlement the majority of them borrowed for consumption in both districts.

Although credit access improved after resettlement, key informants and focus group discussion participants stated that in Metema resettlement sites it was a challenge for resettlers to get access to loans for various reasons. One was due to the lending rule of ACSI. According to the rule, any person who had not repaid the previous loan, would not have access to take another loan. The majority of resettlers took loans at the time of resettlement and the majority of them stated that the money was given as a support. But the government wanted the money to be repaid. However, resettlers were not able to pay back due to a shortage of money. Therefore, resettled households who did not repay the loan at the time of resettlement did not have access to another loan. This problem, however, was not the case in Decha. In Decha resettlers could borrow money as long as they formed a group based on the requirements of the microfinance institutions.

Table 18 shows that 39.2 percent of the households in Metema and 58.4 percent of households in Decha had responded positively with regards to savings. The main place for their savings was microfinance institutions. The dominant microfinance institution in Metema was Amhara Credit and Saving Institution (ACSI) while in Decha it was Omo Microfinance Institution. These are the two partly government-owned microfinance institutions providing

credit and saving services. The role of formal banks in the resettlement sites of the two districts was non- existent.

Table 18: Saving habits after resettlement

	Metema (n=130)		Decha (n=120)	
Saving habit?	**f**	**%**	**f**	**%**
No	79	60.8	50	41.6
Yes	51	39.2	70	58.4
If Yes, where do you save?				
Amhara Credit and Saving Institution	51	100	0	0
Formal bank	-	-	1	1.4
House	-	-	1	1.4
Omo Microfinance Institution	-	-	68	97.2

In summary, three major types of financial capital have been explored in this section, namely earnings, savings and access to financial resources. Generally, financial capital is shown to have strengthened in both districts. For most households, earnings have been increased and savings have been improved following the resettlement period. Therefore, it is reasonable to conclude that the resettlers in both districts are facing an environment of improved financial capital after the resettlement though the credit access and saving capacity needs improvement.

Physical Capital

Physical capital comprises producer goods and basic infrastructure needed to support livelihoods. Producer goods are the tools and equipment that people use to function more productively. On the other hand, the provision of basic infrastructure such as access to shelter, clean water, health care, education, market and transport is critical for the livelihood of resettled households, increasing the efficiency and flexibility of their responses to economic changes. Where the provision and quality of infrastructure are deficient, resettlers' coping mechanisms are hampered.

Physical capital is directly related to human and financial capitals. Firstly, where physical capital comprises basic infrastructure to sustain life, then supporting infrastructure can be correlated to quality of life. For example,

without clean water and sanitation, the strength of human capital is diminished. Secondly, without functional roads and transport, access to markets is removed. Hence, the capacity of persons to sell their goods is decreased, which weakens financial capital. Moreover, without tools, fertilizers and pesticides, production capacity is reduced. Once again financial capital is affected. Clearly, physical capital is important to livelihoods. Therefore, physical capital in this study was assessed in terms of livestock holdings, housing, farm input use and infrastructure, as well as social services expansion.

a) Livestock Ownership

For resettled households the basic physical livelihood asset is their livestock ownership. In poverty studies, livestock ownership is considered as an indicator of savings in physical rather than financial assets. In the majority of highland areas in Ethiopia, oxen are used for farming. Combined with access to farmland, a pair of oxen determines the well-being and food security of a rural household. Households that lack oxen face critical problems in farming their land, being dependent on others for borrowing or hiring oxen.

The total livestock owned by the resettled households was calculated in terms of the number of livestock owned. Common types of livestock in the study areas include: cattle, goats, sheep, horses, donkeys, camels and bee hives.

Table 19 shows that about 67 percent of resettled households in Metema owned oxen/cows and these households had on average of about 3 animals; the difference between before and after resettlement was not significant. However, in Decha, about 96 percent of the resettled households owned on average about 3 oxen/cows after resettlement and the result was significant at ($p<.01$). The average number of bulls, calves, heifer, goats/sheep, horses/donkeys/mules, camels and chickens has decreased after resettlement in Metema, although the variation between before and after resettlement was not significant. In Decha, the average number of bulls, calves, heifer, goats/sheep, horses/donkeys/mules, camels and chickens has increased after resettlement. However, only the ownership of horses, donkeys, mules and camels was significantly different from before resettlement at ($p<.001$).

Table 19: Number of livestock owned by resettlers

		Metema				Decha			
		Mean	**SD**	**Valid N**	**t**	**Mean**	**SD**	**Valid N**	**t**
Oxen/cows	Before	2.78	1.71	90.00	-1.710 (ns)	2.09	1.50	79.00	-3.256**
	After	3.28	2.70	87.00		2.83	1.32	115.00	
Bulls/calf /heifer	Before	1.92	1.15	48.00	-2.411*	2.34	1.48	59.00	-0.740 (ns)
	After	2.75	1.76	53.00		2.38	1.49	97.00	
Goats/sheep	Before	1.33	0.65	42.00	-0.226 (ns)	1.11	0.32	27.00	-0.435 (ns)
	After	1.19	0.51	83.00		1.14	0.35	44.00	
Donkeys/Horses /Mules/Camels	Before	7.81	5.82	43.00	-1.026 (ns)	3.18	1.43	71.00	-4.696***
	After	5.24	5.78	50.00		4.13	2.23	94.00	
Chickens	Before	8.14	6.60	37.00	-5.06 (ns)	6.06	5.97	36.00	-0.263 (ns)
	After	5.69	4.52	36.00		6.34	3.58	89.00	
Bee hives	Before	5.11	4.09	18.00	-1.008 (ns)	8.07	7.96	15.00	NA
	After	5.80	5.91	15.00		2.67	2.08	3.00	

ns=not significant; *significant at p<.05; **significant at p<.01; ***significant at p<.001.

Overall, livestock ownership improved after resettlement in Decha but did not change much in Metema. The information during focus group discussion and key informants interview suggested that due to the inadequacy of available grazing land, many households in the resettlement villages in Metema had to cut down their large animal raising, and some families were even forced to stop raising large livestock completely as a consequence. This, as a result, could be an indication of the weakening of the resettlers' ability to restore or maintain this form of livelihood after resettlement. In Decha also, inadequacy of grazing land and lack of animal feed were the most critical challenges to rear livestock.

During focus group discussion and key informants' interviews, it was shown that some of the resettled households had received an ox on their arrival at the resettlement site as a starter packet in Metema, whereas, the remaining households received 120 birr instead of an ox which was actually repaid as rental for an ox labour to plough the farm. In Decha, however, all of the resettled households received an ox per household. Thus, it can be claimed that to have an ox at the beginning on their arrival could have had its own

impact on maintaining oxen ownership in the area. In contrast, it could also be argued that having an ox in the beginning was not a sufficient condition to improve livelihoods. This could suggest a search for other factors that caused the difference to occur. It has been confirmed by some of the respondents, who were able to own oxen starting from the scratch, that working as a labourer in a leisure time at large private farms in the neighbourhood had contributed to the increase in their income and as a result the ability to buy oxen. Also, despite the fact that there were a number of livestock in the area, there was no veterinary centre to help the livestock at all.

b) Housing

Housing is one of the basic needs of human beings and an important physical asset providing shelter. According to McDonald (2006:172), the provision of secure shelter is one of the most important components of physical infrastructure essential for the development of sustainable livelihoods, as it provides the people with protection, security and a place to live and work; hence, the reconstruction of the livelihoods. In the case of Metema and Decha, resettlers were entitled to receive a new house with the support of resettlement programme. Information was collected in the survey on ownership and quality of housing, types of construction materials and toilet facilities.

Most of the resettled households in both districts reported that their houses were constructions with mud walls and grass roofs, both before and after resettlement. This shows that resettlement had not changed the housing facilities of resettled households. Regarding toilet facilities, before resettlement, most of the resettled households used open pit/forests as latrines in Metema and private traditional latrines in Decha. However, most of them used private, traditional latrines in both districts after resettlement. During focus group discussion and key informants' interviews, it was stated that most of the resettlers were forced to construct their own private latrine, though it was traditional. Regarding housing, most of the resettlers shared their housing rooms with their domestic animals indicating that the housing facilities were inadequate and a high risk for their health. Overall, these findings suggested that there was no significant improvement in housing, and thus shelter as one type of physical capital had not improved with resettlement.

Table 20: Housing and related facilities

Type of house		Metema (n=130)		Decha (n=120)	
		f	%	F	%
Before	Mud walls and grass roofed	123	94.6	97	80.8
	Mud walls and tin roofed	3	2.3	21	17.5
	Cement walls and tin roofed	-	-	2	1.7
	Others	4	3	-	-
After	Mud walls and grass roofed	124	95.3	113	94.2
	Mud walls and tin roofed	4	3	7	5.8
	Cement walls and tin roofed	-	-	-	-
	Others	2	1.7	-	-
Type of toilet facility					
Before	Open pit/forest	105	80.7	9	7.5
	Communal latrine	2	1.7	9	7.5
	Private modern latrine	-	-	14	11.6
	Private traditional latrine	23	17.6	88	73
After	Open pit/forest	11	8.4	3	2.5
	Communal latrine	1	1	4	3.3
	Private modern latrine	-	-	4	3.3
	Private traditional latrine	118	91	109	90.8

c) Farm Input Use

Another physical capital is the use of different agricultural inputs such as fertilizers, pesticides, improved seeds and agricultural farm tools. As shown in Table 21, only 7 percent of the resettlers in Metema and 36 percent in Decha were able to use farm inputs before resettlement. However, 23 percent in Metema and 93 percent in Decha wer able to use farm inputs after resettlement. Among the resettlers who used farm inputs after resettlement, the majority used fertilizer, followed by improved seeds and pesticides in both districts. For those who had not used farm inputs both before and after resettlement, the main reason was the expensive price of these inputs. The majority of resettlers in Metema reported that they were unable to afford the price of fertilizers, improved seeds and pesticides both before and after resettlement compared to resettlers in Decha.

Table 21: Use of agricultural inputs for farming

Use of agricultural inputs for farming			Metema f	Metema %	Decha f	Decha %
Before		No	121	93	7764	
		Yes	9	7	4336	
After		No	100	77	98	
		Yes	30	23	11193	
If Yes, agricultural inputs used						
Before	Improved seed		3	33	42	98
	Modern agricultural farm tools		-	-	4	9
	Fertilizer		8	89	38	88
	Pesticides		1	11	6	14
	Others		2	22	1	2
After	Improved seed		5	17	99	89
	Modern agricultural farm tools		-	-	4	4
	Fertilizer		26	87	104	94
	Pesticides		4	13	66	59
	Others		2	7	-	-
If No, reason for not using inputs						
Before	Not Available		30	0.25	7	0.09
	Too Expensive		65	0.54	18	0.23
	Inadequate Supply		10	0.08	1	0.01
	Others		11	0.09	39	0.51
After	Not Available		4	0.04	0	0.00
	Too Expensive		75	0.75	4	0.44
	Inadequate Supply		0	0.00	1	0.11
	Others		22	0.22	5	0.56

In conclusion, most of the resettled households were well aware of the need to use agricultural inputs such as fertilizers and improved seeds. However, resettlers in Decha were able to afford and use these inputs whereas resettlers in Metema were not, due to various reasons.

d) Physical Infrastructure

The establishment and expansion of basic social infrastructure were measured based on subjective judgments and perceptions of the respondents in both districts. Thirteen variables were used to see whether physical infrastructure has improved or not after resettlement.

Table 22: Infrastructure and social services

Variables		Metema [n=130)			Decha [n=120]		
		Mean	SD	t	Mean	SD	t
Health institutions expanded	Before	.31	1.26	4.791***	1.46	.50	34.118***
	After	-.42	1.27		-1.44	.50	
Distribution of schools increased	Before	.82	.91	-1.881(ns)	1.34	.47	25.905***
	After	1.00	.62		-.93	.81	
Electricity established	Before	-.94	1.04	2.851**	1.19	.69	27.685***
	After	-1.20	.78		-1.38	.64	
Telephone services introduced and	Before	-1.05	.96	-5.635***	1.24	.53	14.099***
	After	-.38	1.22		-.41	1.16	
Postal services started	Before	-.98	.89	-1.710 (ns)	1.20	.73	24.259***
	After	-1.08	.84		-1.28	.66	
Safe drink water supplied	Before	-.56	1.24	-12.623***	1.49	.50	36.567***
	After	1.02	.80		-1.24	.50	
All weather Road constructed	Before	-.68	1.23	-3.278***	1.33	.52	35.929***
	After	-.19	1.20		-1.13	.38	
Credit facilities started	Before	-.15	1.22	-6.600***	1.22	.55	7.796***
	After	.74	.90		.33	1.15	
Market access improved	Before	-.96	1.07	-15.979***	1.38	.60	27.550***
	After	.84	.79		-1.08	.62	
Religion institutions expanded	Before	1.01	.66	-0.631***	1.20	.56	7.058***
	After	1.04	.58		.51	1.02	
Permanent toilet facilities established	Before	-.80	1.20	-14.116***	.98	.71	7.319***
	After	.79	.88		.13	1.04	
Farmers training center established	Before	-.76	1.13	-8.970***	1.01	.76	12.497***
	After	.35	1.10		-.51	.96	
Transport Service expanded	Before	-.73	1.20	-5.877***	1.35	.67	27.441***
	After	-	1.21		-	.57	

t-test: ns=not significant; *significant at p<.05; **significant at p<.01; ***significant at p<.001.

Interpretation of mean score: 1.41-2.0=strongly agree, 0.25-1.4= agree, -0.24-0.24=neutral, -0.25- (-1.4) = disagree, and -1.41-(-2) = strongly disagree

Table 22 shows that the total level of agreement of resettlers regarding the expansion and accessibility of social services after the resettlement in Metema and Decha districts was at moderate and low levels, respectively. Of the thirteen social infrastructure services rated by level of agreement in Metema district, resettlers agreed on seven variables (education, safe drinking water,

market access, credit services, farmers training centre, permanent toilet and religious institutions); the change after resettlement was significant at ($p<0.001$), except for education which was not significant. In addition, resettlers were neutral in two (all weather roads and transport services) variables and showed disagreement in the remaining four variables (health, electricity, telephone and postal services) at a significant level, except for postal services, which was not significant. Overall, the level of agreement in all variables in Metema was moderate.

Contrastingly, in the Decha district resettled households agreed on only two variables (credit services and establishment of religious institutions) and disagreed on nine variables (health, education, electricity, postal services, safe drinking water, road construction, transport service and market access); they were neutral on the remaining three variables (permanent toilets, telephones and farmers' training centre). The variation in both before and after comparison was significant at ($p<0.001$) for all variables. This means in the Decha resettlement sites there was improvement only on two variables after resettlement. However, in nine variables the situation before was far better than the situation after resettlement.

Figure 6, shows the road access and transportation facilities in the resettlement sites of both districts. Rural road access is an essential infrastructure for resettlers to transport and market their crop and livestock products and to buy essential consumer goods and agricultural inputs. In Decha, most resettled villages had no road access, and some were accessible only by foot. During the wet season, the sites could be virtually inaccessible, which made it more difficult for villagers to access markets or other public facilities. This was the critical problem in the Zenbaba site as shown in Figure 6. During the rainy season, resettlers did not have access to markets and health services because of the river that crossed the village. During focus group discussions and the key informants' interviews at village levels, it was confirmed that resettlers had asked the district government to construct a bridge that would link the resettlement villages to other areas for their market and health services. However, they had not received any response so far. The question was raised with the district and zonal government officials. They reported that it was out

of their budget, since the bridge had to be constructed by the federal government.

Figure 6: Transportation services at Metema and Decha sites

Road and transport service at M 678, Metema **Road at Zenbaba site, Decha**

Road and transport at Bulkabul, Decha

The road access in Bulkabul and Shallo site was a gravel road mainly only functioning in dry season. The areas were not accessible to buses and other safe transport services. The only transport service was an Isuzu car. When the researcher and 5 other data collectors were travelling from Bulkabul to the Chiri town, Decha district, the transportation was an Isuzu car and unfortunately after 20 minutes' travel from Bulkabul, there was a car accident while the researcher and data collectors together with the driver and other travellers were inside the car. Thanks to the Almighty God! No one had been injured seriously. This clearly shows how the transportation service was risky, not only for the villagers but also for other travellers.

In the Metema sites, however, the road access was relatively better than in Decha. According to key informants and focus group participants, the resettlement programme did improve rural roads. After resettlement they benefitted from dry weather and all weather roads. However, during the rainy season most of the rural feeder roads from village to village and from villages to district towns were interrupted. Problems encountered due to the absence of all weathered roads resulted in difficulties to get treatment, in access for marketing and limited farming activities especially during summer when most of agricultural activities were performed.

With regards to access to markets, the qualitative information showed that the resettlers were supposed to travel on foot to the nearest small town, which was about 10 – 20 kilometres away from their village in both districts. Meanwhile, in Metema, to sell their produces in the market those who had caro could load the produce; otherwise they were expected to pay some 20 – 30 birr per quintal to the owners of the caro. Alternatively, sometimes they were selling their products through a cooperative in their village, but since the cooperative did not give the money in time they prefered to travel about two to four hours on foot to the market. Furthermore, dry weather roads were available but public transport facilities had not been put in place as yet. Nevertheless, in Metema, it was confirmed that access to the market and availability of roads in the new village was relatively better than what it had been before resettlement. As opposed to Metema, market access in Decha was a challenge. The majority of resettlers used horses or donkeys to transport their produce to the local market. Sometimes they sold their products to the local collectors at a cheap price; else, they had to rent the Isuzu to sell their products at a better price. However, the price for the car rental was very high.

It was also evident that telephones or mobile phones and postal services for most resettled villages were almost non-existent even after resettlement in both districts. The isolation from communication technology made it more difficult to maintain their social connections with family and friends who lived outside the resettlement sites. In addition, resettlers did not have access to electricity in both districts.

In conclusion, the findings show a mixed result in the improvements of physical capital. In terms of livestock ownership and farm input use, Decha was better off than Metema. There was no change in housing in both districts. Regarding infrastructure and social services, it was reported that Metema resettlement sites were far better off than in Decha. However, in both districts, it was confirmed that the already established social services were ill-equipped with skilled manpower and other facilities. Taking these results into consideration, it can be concluded that the resettlers in Metema and Decha are experiencing mixed results regarding physical capital with resettlement.

Social Capital

Social capital is usually defined as the social networks and connectedness that are being used for welfare security of the households. According to Rose (2000:1), "social capital consists of informal social networks and formal organisations used by individuals and households to produce goods and services for their own consumption, exchange or sale". These social institutions are operational in the day-to-day activity of a society during death, weddings, and other feasts or religious activities in the community. In this study, social capital was assessed based on the networks and connectedness of resettlers with their family and relatives back home and in the new resettlement sites, as well as membership of formal and informal social institutions such as cooperatives, Iddir, Iqub, Mahber and Debo and participation in social leadership at village level.

a) Connectedness with relatives in places of origin

The survey data shows that the majority of resettlers in both districts were still connected with their family and relatives in their places of origin. Only a very small proportion of resettlers in Decha and Metema showed that they experienced disruption from their relatives back home.

The ability of resettlers to maintain regular contact with their relatives in their places of origin showed their connectedness. For some of them, the connection was even stronger. This was due to improved access to communication networks such as roads, transport, telephone lines and mobile phones, which previously were unavailable. However, for some, it was still a

challenge to visit their relatives due to high cost of transportation and for some of them the long distance from their origin.

The family network that resettlers had been sharing and that could eas a crisis such as the exchange of labour, food grain, gifts, draft animal, lending seed grain, remittance, etc. was still vital. Even in some instances relatives could take the custody of young children when a family faced a severe food crisis and hunger.

b) Relationship with host and other resettlers

The survey data (see Table 5.5) show that resettled households in both districts did have close relationships with the host community and other resettlers. This social connection within families, between friends and neighbours and amongst the community members remained strong for many resettled people in Metema compared to those in Decha. Some of the mechanisms for social connection were religion, mourning, marriage, language, land sharing, etc. In Metema, key informants indicated that the relative similarities in cultural background and language helped to maintain the social fabrics between the resettlers and the host community. However, in Decha, the connection between resettlers and the host community was relatively lost due to cultural differences such as religion, language etc.

Furthermore, to drink coffee with neighbours by serving coffee in one of the households in a reciprocal way was a very common practice in the study area as an information sharing strategy and trust building mechanism among them. However, in both districts, key informants and focus group discussion participants stated that the host-resettlers relationship was deteriorating from time to time. In both areas host community members were positive during the arrival of resettlers. They were contributing their labour, and even assets in the form of cash and in kind. This support and positive welcome, according to the participants, was due to 1) cultural hospitability of local people, and 2) expectation of better infrastructure provision from the programme. However, the perception of local people towards the programme changed after the arrival of the resettlers. According to the discussion, this was due to 1) unmet host community expectations to be benefitting from the provision of infrastructure and social service which were promised by the government but

not met as expected, and 2) ownership of resources, especially land, for their next generation that was in possible jeopardy due to expansion of the resettlement sites.

Due to these problems conflict was occurring between resettlers and host community members which affected the social capital necessary to establish sustainable livelihoods. This was supported by the survey data about conflict as depicted in Table 5.6.

c) Membership of informal and formal organisations

Informal social networks comprise face-to-face relationships among a limited number of individuals who know each other and are bound together by kinship, friendship or propinquity. Informal networks are 'institutions' in the sociological sense of having patterned and recurring interaction. However, they lack legal recognition, employed staff, written rules and own funds. In general, they are not formally structured as there is no principal but agents only exchanging information, goods and services. On the other side, formal organisations are legally registered and, hence, have a legal personality. They are rule-bound and have to follow formal procedures in their management. A formal organisation can have as its members both individuals and/or other organisations. In this case informal organisations that exist in Ethiopia in general are: Iddir, Iqub, Mahber, Senbete and Debo/Wobera. Formal organisations are cooperatives and different kinds of associations.

Table 23 shows that membership of organisations (both formal and informal) improved after resettlement in both districts. Only 20 percent of resettlers in Metema and 64 percent of them in Decha were members of social organisations before resettlement. However, after resettlement 58 percent in Metema and 76 percent in Decha were members of any one the social organisations. Respondents were also asked the types of organisations and 54 percent in Metema and 60 percent in Decha were members of Iddir and Iqub before resettlement. However, after resettlement 50 percent in Metema were members of Iddir/Iqub, followed by cooperatives (37 percent). In Decha 75 percent of the resettlers were members of Iddir/Iqub after resettlement, followed by religious associations.

Table 23: Membership in social organisations

Were you the member of social organisations?		Metema (n=130)		Decha (n=120)	
		f	%	f	%
Before	No	104	80	43	36
	Yes	26	20	77	64
After	No	54	42	29	24
	Yes	76	58	91	76
If Yes, the name of the associations					
Before	Religious	1	4	25	32
	Iddir/Iqub	14	54	46	60
	Saving	2	8	3	4
	Cooperatives	8	31	3	4
	Others	1	4	-	-
After	Religious	3	4	20	22
	Iddir/Iqub	38	50	68	75
	Saving	7	9	2	2
	Cooperatives	28	37	1	1
If yes, benefits gained?					
Before	Income increased	7	27	5	6
	Labour and social support	12	46	66	86
	Credit used	4	15	2	3
	Recognition in the	2	8	4	5
	Others, specify	2	8	-	-
After	Income increased	30	39	-	-
	Labour and social support	27	36	82	90
	Credit used	16	21	3	3
	Recognition in the	2	3	6	7

From the data it was evident that the majority were members of Iddir/Iqub in both districts. Despite the fact that the majority of Ethiopians belong to different church groups such as Mahber/Senbete, the involvement of resettlers in these institutions was minimal. This could be due to poor interaction of resettlers in terms of religion.

Resettlers were also asked the benefit gained as a result of membership to different social organisations. The majority in Metema (46 percent) and in Decha (86 percent) reported that the benefit before resettlement was labour and social support. This changed after resettlement in Metema and the majority (39 percent) confirmed that they gained more income followed by

labour and social support (36 percent). However, in Decha, 90 percent of the respondents stated that labour and social support was their benefit as a result of membership.

According to the qualitative information, although membership in church groups such as Mahber/Senbete was very common among the host community members in rural Ethiopia, the involvement of resettlers was minimal. According to discussants, membership to either of the church groups was open to everyone as far as the person was in a position to provide some food and drink for the group of members. Apart from the spiritual festivities and extending the social network, being a member of a senbete could also help the member to borrow some amount of money, which was collected from the members as a monthly fee by the senbete. Being a member of mahber has a spiritual goal in addition to social network formation; therefore, households who were participating in these groups had social networks to call upon for help when they were in need of help while others were unable to call for help. However, most of the resettlers were out of these groups. It was suggested that the reason behind the isolation of the resettled households was their inability to afford the costs for the social events.

In addition to church groups, debo or wobera was a labour exchange strategy where nearly all of the resettled households were participating. It was also a common phenomenon in their places of origin. In this labour exchange mechanism a farmer would be harvesting the crop with the contribution of friends, neighbours or relatives' labour in a group; in return this farmer would do the same when called upon. This had been cited as a more useful social capital for the peasants in both districts. During activities like farming, weeding, harvesting and threshing, the peasants pooled their labour and resources to help their fellow peasants. It was a reciprocal (give and take) type of relationship based on labour, often involving oxen services. Nevertheless, as was argued by one of the key informants, to work in debo or wobera became a losing activity as time advanced. The reason behind this was that the expensiveness of labour in the study area led farmers to work as labourers on large private farms in their leisure time.

In addition to the informal social networks, the attitude towards formalised groups and social organisations was also explored during the interviews to help assess the strength of the social capital of the resettlers. Since resettlement, many social associations and community-based unitsthat sought to represent different interest groups had been established. The Community Forest Management in Metema and Forest Management Cooperatives in Dehca, for instance, aimed to enable resettlers to develop and manage forest resources "by them and for them", which in turn would provide them with improved livelihoods and incomes. Resettlers were free to be members of these cooperatives and contribute or benefit from membership. As was confirmed in the field, the majority of resettlers in the Metema resettlement sites were members of natural resource and tourism development and marketing cooperatives. The advantage was to protect the environment by minimising deforestation and promoting afforestation. But the cooperative was not yet well organised to function properly.

d) Participation in social leadership

Table 24 shows that participation in social leadership also improved, following resettlement. 19 percent of the respondents in Metema were participating in social leadership before resettlement. However, after resettlement the respondents' percentage increased to 25 percent. In Decha it was 27 percent before resettlement and it became 53 percent after resettlement. This is more or less an indication of the resettlers' involvement in local leadership.

The majority of the respondents reported that their involvement in the leadership was mainly in informal organisations such as iddir and Iqub in both districts. However, their involvement in village leadership and other formal organisations was insignificant, indicating that resettlers were mostly isolated from the host community. Village leadership was the first point of contact with authority for the resettled community. It was a formal political group elected by the villagers, which represented the issues of all members of the village and was the main channel of communication between the village and higher levels of government. Qualitative information shows that since resettlers' participation in leadership was very limited in Metema, their basic rights and

the interests of the villagers were not protected, their concerns were not adequately addressed and entitlements were not delivered.

Table 24: Resettlers participation in social leadership

Participation in social leadership		Metema (n=130)		Decha (n=120)	
		f	%	f	%
Before	Yes	25	19	32	27
	No	105	81	88	73
After	Yes	33	25	63	53
	No	97	75	57	48
If yes, which organisation?					
Before	Iddir and Iqub	1	4	23	72
	Religious Organisation	5	20	5	16
	kebele/political	14	56	3	9
	Cooperatives	2	8	-	-
	Women/Youth/Farmers Association	1	4	-	-
After	Iddir and Iqub	22	67	40	63
	Religious Organisation	5	15	6	10
	kebele/political	3	9	15	24
	Cooperatives	1	3	2	3
	Women/Youth/Farmers Association	2	6	-	-
Benefit gained?					
Before	Salary	1	4	-	-
	Social Recognition/Acceptance	20	80	31	97
	Different Assets	2	8	1	3
After	Salary	-	-	1	2
	Social Recognition/Acceptance	32	97	62	98
	Different Assets	1	3	-	-

In Decha, at village level, there was relatively good participation of resettlers in leadership. However, the problem was at district and zonal level. According to resettlers' representatives, they believed that they did not have representation at district and zonal level. Overall, there was a sense of distrust against their local government officials, which suggested a breakdown in the relationship of trust between resettlers and the district leaders. Some stated that they did not even know the amount of the budget allocated to their village by the district government. They also suspected that district officials

embezzled the money allocated for the resettlement village's development fund from the federal government. When one considers these findings, it is reasonable to conclude that the relationship of trust between the resettled community members and their local authority or government has declined since the resettlement.

Figure 7: Public meetings for information sharing

Public meeting at Mender 678, Metema **Resettlers in coop office, Das Gundo, Metema**

Figure 7 shows the public meetings conducted during the field visit. In Mender 678, there was a meeting about the village development plan. The majority of the participants in the meeting were resettlers. In Gundo, cooperative members were gathered to discuss issues related to price determination. These mechanisms can be considered as good trends to improve social capital.

To sum up, social capital is important for the livelihood reconstruction of the resettlers, as it can be an essential precursor for gaining access to other livelihood capitals. The resettled people can still rely on their families, friends, relatives and neighbours for human capital (sharing information and knowledge and physical labour), and they can draw on social connections with families and friends at times for food, shelter, healthcare and other supports when financial capital is in short supply. While the informal social networks between their kin and friends and the attitude towards formalised groups proved to be strengthened significantly after the resettlement, the relationships of trust, specifically the relationship of resettled community members with their local authority, as well as the

relationship between resettlers and host community members appeared to be relatively declining.

Summary of Findings on Livelihood Assets of Resettlers

Natural assets

The total land holding size of resettlers in both districts increased after the resettlement programme. However, the increment was significant in Decha but not in Metema. In both
districts resettlers did not receive the 2 hectares of land as promised. Some resettled farmers in Metema had no land for cultivation at the time of survey and they organised their livelihood by renting land from others as well as doing labour work.

- Resettlers in both study areas did not receive formal land ownership or certification for their plots after 10 years of relocation. Resettlers confirmed that they had no guarantee if somebody claimed ownership right on their land. In principle, they were entitled to receive formal ownership right after three years of stay in the resettlement sites. In practice, this did not happen after 10 years of stay. No one had clear answer for this issue at local, regional and federal levels.

- The resettlers' land in Metema was relatively flat but infertile and in Decha the resettlers' land was steep slope or gentle but fertile. However, soil infertility, weeds and water logging following the flatness of the land were serious challenges in Metema and soil erosion as a result of steepness of land was the main challenge in Decha to maintain the quality and productivity of the land.
- Resettlers in both districts had access to natural forests for house construction and energy or firewood. However, deforestation, land degradation and unsustainable use of natural resources were the challenges. In both districts, the use of natural forests for food and non-timber forest products was limited. Resettlers' access to grazing land was also limited.

- Water service was improved in Metema and worsened in Decha after resettlement. Access to rivers for irrigation was limited, regardless of the availability of irrigation potential and rivers in both districts.

Human Assets

- Although large family sizes helped resettlers in both districts to meet their family labour requirements, it was also a challenge to meet food security and improve livelihoods.

- The survey data showed that resettlers in both districts had the highest dependency ratio of a young population rather than of the old-aged. This indicates that there was high fertility rate in these resettlement sites.

- This study showed that the availability of educational institutions and the level of satisfaction with the educational services were better in Metema than in the Decha district. As far as the educational background of the resettled households and their family members was concerned, Decha was relatively better off than Metema.

- The survey data showed that the health status of resettlers, availability of health facilities and the overall satisfaction of resettled households with health service provision were far better in Metema than in Decha. In comparison to the situation before resettlement, the health status of the resettled people and the availability of health facilities and services deteriorated significantly in the post-resettlement period in Decha.

- The overall assessment of the resettled households' human capital in both districts was declining after resettlement and it was worse in Decha as compared to Metema.

Financial Assets

- The survey data showed that the annual mean income and expenditure of resettled households in both districts increased after resettlement. Although expenditure increased as income increases, the net balance/saving was positive. This shows that resettlement created positive effects on overall household income.

- Crop production was the main source of income in both districts before and after resettlement, followed by livestock production. The share of non-farm and off-farm activities was very low after resettlement compared to before. This shows that the income source was less diversified and unsustainable after resettlement.

- The survey also showed that the highest expenditure share was spent on food compared to non-food items in both districts. Since the share for food expenditure was less after than before resettlement, the possibility for resettlers to be food secured was also high after resettlement.

- Access to credit and savings improved following resettlement in both research sites. However, there were many constraints related to credit access in both districts that needed attention.

- Overall, financial capital was shown to have strengthened after resettlement in both districts though the credit access and saving capacity needed improvement.

Physical Capital

- It was confirmed that that livestock ownership increased after resettlement in Decha but had not changed much in Metema.

- It was evident that resettlement did not change the housing and toilet facilities of resettled households in both research sites.

- Most of the resettled households in Decha were able to afford and use farm inputs in comparison to resettlers in Metema. One of the reasons mentioned was the high price of fertilisers, seeds and pesticides.

- Of the thirteen variables used to assess the improvements of infrastructure and social services, resettlers in Metema agreed on seven variables (education, safe drinking water, market access, credit services, farmers training centre, permanent toilet and religious institutions), were neutral on two variables (all weather roads and transport services) and

disagreed on four variables (health, electricity, telephone and postal services). In contrast, resettlers in Decha agreed on only two variables (credit services and establishment of religious institutions), were neutral on three variables (permanent toilet, telephone, and farmers training centre) and disagreed on nine variables (health, education, electricity, postal services, safe drinking water, road construction, transport service, and market access). This clearly shows that infrastructure and social services were relatively improved in Metema and deteriorated in Decha following resettlement.

Social Capital

- The survey data showed that the majority of resettlers in both districts were connected with their family and relatives in their places of origin. Only a very small proportion of resettlers
- in Decha and Metema showed that they experienced disruption from their relatives back home.

- The survey data showed that resettled households in both districts had relationships in various forms with the host community and other resettlers. However, this social connection within families, between friends and neighbours and amongst the community members remained stronger for many resettled people in Metema compared to those in Decha.

- It was also confirmed that resettlers' membership of organisations (both formal and informal) improved after resettlement in both districts.

- Resettlers' participation in social leadership also improved in both districts following resettlement. Resettled households' socio-political influence in their respective villages improved after resettlement in both districts.

- While the informal social networks and the attitude towards formalised groups proved to be strengthened after the resettlement, the relationships resettled households had with their local authority, as well as the

relationship between resettlers and the host community members appeared to be relatively declining.

- Resettlers had different forms of local associations in their places of origin such as mahber and senbete that strengthened the social ties amongst them in good and bad times. This social fabric was still present in the resettlement areas. However, it was not as expected for the resettlement being intra-regional.

5. Conclusions

This study analysed the themes of resettlement and livelihoods and answered the research questions related to the implementation processes and outcomes of the new state sponsored resettlement programme in Ethiopia. Some scholars argue that resettlement is a risky business that often leads to impoverishment and rarely results in sustainable livelihoods (Brown et al. 2008; Cernea and McDowell 2000; Hwang 2010; Ohta and Gebre 2005). Others argue that resettlement improves the living conditions and livelihoods of ressettlers (Agnes et al. 2009, Manatunge et al. 2009, Nakayama et al. 1999). This study concludes that the results are mixed and challenges the generic representation of the resettlement scheme as a failure or a success. The following are some of the conclusions made on the successes and challenges of the programme.

The study concluded that the effects of planned resettlement (and associated policy) were generally adverse in Decha as compared to Metema for livelihood capitals, with the exception of financial capital which is generally strengthened through the resettlement process. Natural, physical and social capitals were variably weakened and strengthened. Human capital was weakened with resettlement.

The resettlement programme did not support the resettlers to diversify their livelihood strategies and most of the resettlers dominantly exercised traditional agriculture. Resettlers' involvement in non-farm and off-farm activities is insignificant. It is clear that agriculture is highly vulnerable to environmental changes. Therefore, it was very important as part of

resettlement programme to include training in skills other than agricultural for use when arable agriculture fails or for further diversification of livelihoods.

The study concludes that the resettlement programme had positive effect on some livelihood outcome variables such as more income, food security and reduced poverty as stated above. However, these livelihood outcome changes were not sustainable because of poor adaptation, environmental destruction and unwise use of natural resources following resettlement. Livelihood can be sustainable only if there is a strategy to cope with vulnerabilities/shocks and to strengthen capabilities and assets both at present and in the long run.

From the overall conclusions made above, the effects of a government planned resettlement programme on sustainable livelihoods of resettlers' were not fully positive due to four main gaps: policy gaps, the mismatch between the policy and practice, insufficient integration and inadequate capacity building efforts of the government.

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The Impact of Vagaries of Nature and Institutions on Fastening Agricultural Economic Growth in Ethiopia

Hassen Beshir[1]

Abstract

The main objective of this study is to estimate the production function of Ethiopian's Agriculture sector and identify key factors that plays role in the economy using 1965–2014 data. Are there impacts of institutional transformation from public to private ownership of resources in improving agricultural growth? What are the sources of Agricultural productivity growth? Are there productivity changes in the performance of the agriculture sector during the period of 1965 – 2014. Aggregate production functions are specified by different economists for estimation. The major are CES and Cobb-Douglas. Cobb-Douglas production function is used to estimate the aggregate production of Ethiopian agricultural sector. In estimating aggregate production function for a country, it is better to consider the co-integration of variables in a time series analysis. In this empirical work, after determining the order of the vector autoregressive, co-integration test is conducted. Thereafter the structural long-run relationships of the variables are identified using vector error correction model. To this end a neoclassical and structuralist model of production function is developed. The result confirms that the variables are co-integrated at polynomial rank of order (2). The variables of production function are non-stationary at their level but stationary after differencing. The Engle Granger causality modeling shows that agricultural labor and Price of agricultural goods to non-agricultural goods Granger Cause agricultural productivity, Capital inputs in agriculture and Price of agricultural goods to non-agricultural goods Granger Cause agricultural labor, Rainfall Granger Cause ratio of Price of agricultural goods to non-agricultural goods and finally ratio of Price of agricultural goods to non-agricultural goods Granger Cause institutional capability. From the vector error correction model result, the coefficient of the co-integrating equation tells that about 45 percent of disequilibrium corrected each year by change in aggregate agricultural production. The overall performance of the model is well fitted, because the 64% of total variation of the dependent variable is explained by the independent

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variables included in the model. Moreover, the model selection criteria indicated the model is adequate to represent the real world and manageable to predict agricultural production behavior in Ethiopia. Vector error correction modeling of the sector shows that the Ethiopian agricultural sector is mainly dependent up on institutional capability, price ratio and rainfall in the long run. In the short run, it is determined by agricultural labor, previous agricultural production and rainfall. Finally, forecasting of the agricultural production and its associated sources of growth has been made to provide solution in future values. To circumvent the poverty trap in the country, therefore, the government needs to invest on human capital and irrigation development to reduce its dependence on vagaries of nature. Moreover, competent private-public partnership in increasing the capability of institutions on coordination and cooperation of resource use is also vital. There should be a tradeoff between private-public ownership and likewise between efficiency -equity in improving public welfare in Ethiopia.

Key Words: Cointegration, Error correction model, Aggregate production function, Short and Long run, Ethiopia.

1. Introduction

The agriculture sector is characterized by a wide range of different production systems with varying input usage. The spatial distribution of these systems is heavily influenced by physical aspects of the operating environment of Ethiopian smallholder farmers, namely climatic conditions, water availability, soil and topographical conditions and proximity to markets. Because most agricultural production systems rely heavily on the condition and productivity of the natural resource base, the management practices of farmers (including soil, fodder and water management) can exert an important influence on the sustainability of Ethiopian's natural resource base. A number of studies have also demonstrated that policies that encourage sustainable farm and environmental management practices are likely to be important for the future performance of the agricultural sector. Agricultural activities are different to production systems elsewhere in the economy. Many of these physical and biological factors, such as variations in rainfall and the onset of disease, are largely outside the control of farmers, yet they can have a significant effect on the level of production, input use, prices and the performance of farms. The

Agricultural sector is highly affected by erratic rain fall distribution. It is the backbone of the economy; it accounts for almost 38.5-42% of the gross domestic product (GDP), 80% of export and 80% the labor force; and 80 percent of the population lives in rural areas in 2016. However, Manufacturing and Construction and Service sector account 14% and 46% in the same period, respectively. The study tries to answer: What are the sources of Agricultural productivity growth? Are there productivity changes in the performance of the agriculture sector during the period of 1965 - 2016?

The main objective of this study is to estimate the production function of Ethiopian's Agriculture sector and identify key factors plays role in the economy 1965 - 2016. The study has the specific objectives of estimating sources of agricultural productivity and estimating factors affecting agricultural production in Ethiopia. The paper is organized as follows. Section two discusses the theoretical models in aggregate production function. Section three presents sources of data and its methods of analysis. Section four discusses empirical results of model estimation. Section five concludes.

2. Theoretical Model for Aggregate Production Function

In specifying the model different school of macro-modelers has used different approaches. In a macroeconomics context, after the Solow-Swan model, growth theory extensively employs aggregate production function and its parameters to come up with important conclusions (Alemayehu and Daniel, 2008). Mankiw *et al.* (1992) used a Cobb-Douglas production function to test the implications of the Solow model while Easterly and Levin (2001) used it for their growth accounting analysis on the relative importance of total factor productivity visa vise total factor accumulation. Building on a neoclassical production function framework, the Solow model highlights the impact on growth of saving, population growth and technological progress in a closed economy setting without a government sector.

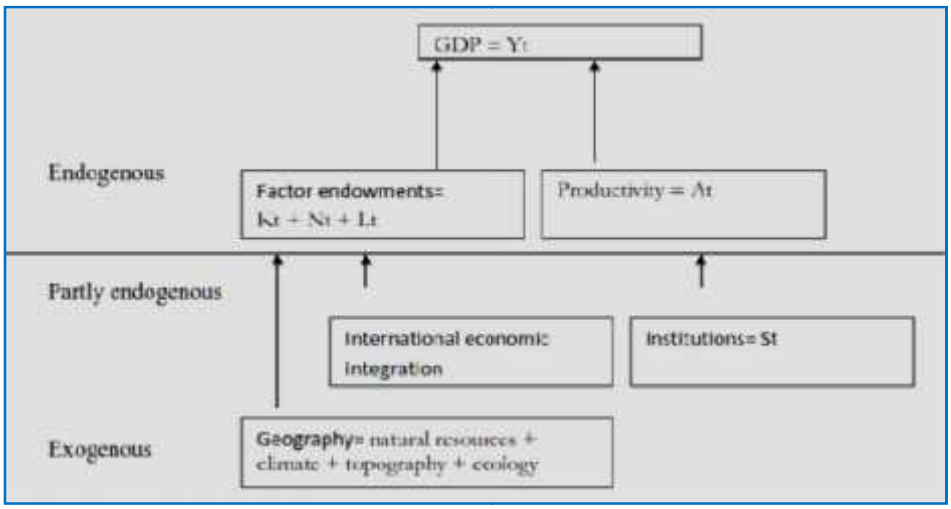
The Solow-Swan model used production function with labour and capital as endogenous inputs and technology as exogenous. The Solow growth model is built around the neoclassical aggregate production function and focuses on the proximate causes of growth: $Y=AtF(K,L)$ where Y is real output, K is capital,

L is the labour input and At is a measure of technology (that is, the way that inputs to the production function can be transformed into output) which is exogenous and taken simply to depend on time. Sometimes, At is called 'total factor productivity'.

The endogenous growth model of Paul Romer used production function with labor and capital. Paul Romer's (1986) model can be illustrated by modifying the production function. The production function includes technology (A) as an endogenous input: Y=F(K,L,A)

Dani Rodrik (2003) has provided a useful framework for highlighting the distinction between the proximate and fundamental determinants of economic growth. Figure 1 provides the model of specification of a production function.

Figure 1: Proximate and fundamental sources of growth



The proximate determinants of growth which is output being directly influenced by an economy's endowments of labour (Lt), physical capital (Kt), natural resources (Nt) and the productivity of these resources (At).

The major fundamental determinant of economic growth in his model includes international economic integration, institutions (social capability) and geography (natural resources, climate, topography, ecology). Social capability refers to the various institutional arrangements which set the framework for

the conduct of productive economic activities and without which market economies cannot function efficiently.

Institutions provide a structure within which repeated human interaction can take place, they support market transactions, they help to transmit information between economic agents and they give people the incentives necessary to engage in productive activities (North, 1991).

Given this pedigree, economists have tended to centre their analysis of the deeper determinants of growth on the role of institutions. Emphasis is placed on factors such as the role of property rights, the effectiveness of the legal system, corruption, regulatory structures and the quality of governance (North, 1990; World Bank, 1997; Olson, 2000; Acemoglu et al., 2001, 2002; Glaeser and Shleifer, 2002)

On the other hand, various writers suggest the nonexistence of aggregate production function when there is aggregation in input (Temple, 2008; Shaikh, 1974). They are arguing that if inputs aggregated in the GDP and are used again as input in the specified production function, the production function is humbug. To circumvent such problem, transformation of levels into log, unit roots test and other remedies were employed.

Based on this information, the aggregate production function of Ethiopian agriculture is specified as

$$Yt=A_tKt^{\alpha}Lt^{\beta}e^{\delta 1X1+\ \delta 2X2+\ \delta 3X3+Ut} \qquad \textbf{(1)}$$

where Y_t is agricultural GDP at time t in Birr, A_t is technology used to transform labour and capital into agricultural GDP at time t, K_t is capital stock in Birr at time t, L_t is agricultural labour employed in man days at time t, X1 is rainfall in millilitre at time t, X2 is price of agricultural product to price of non-agricultural product at time t, X3 stands for institutional capability of the country with the rest of the world at time t, e is exponential function, U_t is the disturbance term for measurement error, missed variables and others at time t and α, δ and β are parameters for Cobb-Douglas production function.

This function is preferred for the reason that labour and capital are hypothesized as the major endogenous resources that can be used for the production of agriculture in Ethiopia. Whereas it is hypothesised that rainfall, institutions and price are exogenous to the producers. That is rainfall depend on vagaries of nature which is not under the control of the producer. Farmers are considered as price takers. Institutional capability refers to regime shift from market economy to command economy which is not under the control of producers too. For this reason the model considered rainfall, institutions and price as exogenous for the producers in that they have nothing to do with the technology. Institution is used as dummy variable; it is one if there is open market economy and zero otherwise. The Dergue period is labelled as zero and the rest one. In natural logarithmic form the equation can be rewritten as:

$$\ln Y_t = \ln A_t + \ln K_t + \ln L_t + \delta 1X1 + \delta 2X2 + \delta 3X3 + Ut \qquad \textbf{(2)}$$

Using equation (2) we can estimate the parameters of interest. This is done in the next section.

2. Methodology and Data Requirement

2.1 Source of Data

The main source of data for this study is the annual data from national income accounts of Ethiopia as prepared and compiled by the Ministry of Finance and Economic Development (MOFED), Department of National Accounts. In addition, Ethiopian Economics Association (EEA), World Bank Africa database and National Bank of Ethiopia data are used when it is required. If data are available for long period of time, it is fairly long enough to analyze and use a co-integration of nine to ten variables with the reasonable lags. Hence scarcity of data for such period limits the study to analyze only for four to six variables with reasonable lag length.

2.2 Analytical Procedure

Aggregate production functions are specified by different economists for estimation. The major ones are CES and Cobb-Douglas. Cobb-Douglas production function is used to estimate the aggregate production of Ethiopian

agricultural sector. In estimating aggregate production function for a country, it is better to consider the co-integration of variables in a time series analysis. In this empirical work, after determining the order of the vector autoregressive, co-integration test is conducted. Thereafter the structural long-run relationships of the variables are identified using error correction model. The co- integration procedure requires time series in the system to be non-stationary in their levels. Moreover, it is imperative that all time series in the co-integrating equation have the same order of integration. Thus, the study first ascertains the time series properties of Agricultural production and other inputs and explanatory variables by using the augmented Dickey-Fuller (ADF) test for stationarity (Dickey and Fuller, 1979 and 1981). The equation estimated for the ADF test is stated as follows:

$$\Delta X_t = ¤_0 + {}_1 X_{t-1} + ¢t + \sum_{i=1}^{n} {}^{-}{}_i \Delta X_{t-1} + £_t \qquad \textbf{(3)}$$

Where, for example X_t=AGDP is the agricultural GDP in natural logarithmic, Δ is the first difference operator, t is the time trend, β, δ and θ are parameters, £ is the stationary random error and n is the maximum lag length. The null hypothesis is that the series contains a unit root which implies that ${}_1 = 0$. The null hypothesis is rejected if ${}_1$ is negative and statistically significant. To determine the long run relationship between agricultural GDP and explanatory variables, the Johansen co-integration procedure is used (Johansen and Juselius, 1990 and Johansen, 1991). The procedure involves the estimation of a VECM. Suppose that the two I(1) variables y_t and z_t are co-integrated and that the co-integrating vector is (1,-θ). Then all three variables $\Delta y_t = y_t - y_{t-1}$, Δzt and (yt-θzt) are I(0). The VECM used in the study is specified based on Green (2004) as follows:

$$\Delta \boldsymbol{y_t} = \boldsymbol{x'_t\beta} + \boldsymbol{\gamma}(\Delta \boldsymbol{z_t}) + (\boldsymbol{y_{t-1}} - \boldsymbol{\theta z_{t-1}}) + \boldsymbol{\varepsilon_t} \qquad \textbf{(4)}$$

Where, y_t is the dependent variable, z_t is the explanatory variables, x'tβ is the trend component, and Δ is represents the difference operator. The model describes the variation in y_t around its long run trend and the vector error correction (y_t- θz_t), which is the equilibrium error in the model of co-integration. The VECM allows causality to emerge even if the coefficients of

the lagged differences of the explanatory variable are not jointly significant (granger, 1983; Engle and granger, 1987; Miller and Russek, 1990; Miller, 1991; Dawit, 2003).

2.3 Definition, Measurement and Hypothesis of Variables

Variables considered in the model are defined, measured and hypothesized in the following table.

Table 1: Definition, Measurement and Hypothesis of Variables

Variable	Definition and measurement*
LYAGR (Y)	agricultural GDP at time t in Birr,
LLAGR (L)	agricultural labour employed in man days at time t
LCAPAG(K)	capital stock in Birr at time t
LRF(RF)	rainfall in millilitre at time t
PatoPna (P)	price of agricultural product to price of non-agricultural product at time t
S	Institution dummy, =1 if open economy and zero otherwise

L indicate natural logarithmic, *Real value of natural logarithms

2.4 Estimation Procedures

Obviously the econometric specification may differ from this general theoretical specification. Based on recent innovations in time series econometrics, the estimation is, in fact, carried out by formulating a Vector Error Correction Model. The estimation is undertaken for the period 1965-2013 using Eview 8 and Oxmetrics. The first step in dynamic modeling is to test for stationarity for the variables of interest. All variables considered are nonstationary at 1% significance level at their level. ADF test statistics suggest that the levels are nonstationary (Table 1). Whereas the first differences of each variable are stationary at 5% significance level. For example, the hypothesis that Agricultural GDP at its level has a unit root cannot be rejected but its difference has unit root can be rejected. So Agricultural GDP is I (1). Therefore as we observed from the following table, the levels of the variables are nonstationary and their first differences are stationary at 5% significance level. Then, the variables are Autoregressive of order (1). If we use the levels for regression analysis, our regression is spurious. On the other hand, if we use the differenced, we will loss the long run determinants of the model. Moreover, natural logarithm of each

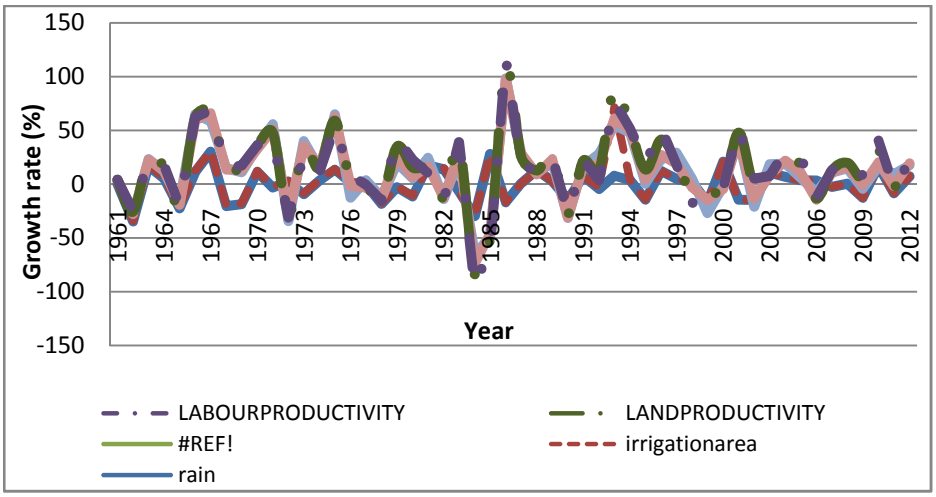
macroeconomics variable is required to avoid normality and heteroscedastic problems and help to estimate elasticities of the variable.

4. Empirical Results and Discussion

4.1 Description of Growth Rate of Productivities

The annual compound growth rate of labor, land and TFP varied with fluctuation and situation of rainfall from 1961 to 2012 (see Figure 1).

Figure 2: Annual Growth Rate of TFP, Labor and land productivity in Ethiopia



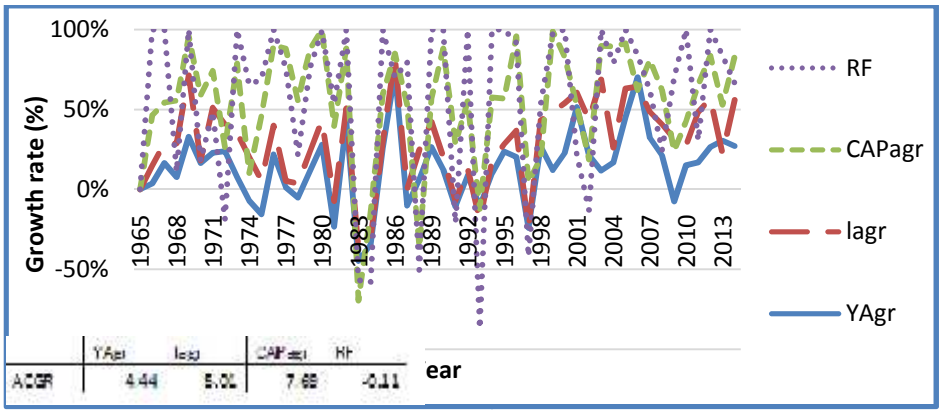
Source: Own Results (2017)

Table 2: Annual Compound Growth Rate of Factor and output productivity in Ethiopia

Variable Name	ACGR
Rain fall	-0.427
Irrigation	1.555
Labor use	2.611
Cultivated area	-0.538
Crop output produced	0.886
Livestock output produced	1.435
Fertilizer Use	12.172
TFP	-0.005
Land (output/ha)	3.032
Labor (output/Man days)	-0.130

The compound growth rate of irrigation used, rainfall, fertilizer applied, labour employed and agricultural area utilized was 1.55, -0.43, 12.17, 2.62 and -0.54 percent, respectively. The value of crop and livestock compound growth rate was 0.89 and 1.44 percent, respectively. The results confirmed that the major input that grows higher was fertilizer application. Based on these application and preconditions, the average annual compound growth rate (ACGR) for TFP, labour and land productivity was -0.01, -0.13 and 3.03 percent, respectively. This implied that agricultural and labour productivity and transformation was slow and weak implying a need to transform a capital intensive technology for better TFP.

Figure 3: Annual Growth rate of RF, Resources and Production (Agri)



Source: Own Results (2017)

Agricultural production in Ethiopia describes the volatility of rainfall highly influences its resource use, and output (Figure 2). The annual compound growth rate of rainfall over six decades is negative implying a reform on intensifying irrigation through ground and surface methods of water resource use.

4.2 Unit Root Test

The presence of a unit root in macroeconomic variables is not uncommon in time series analysis. If left uncorrected, this will lead to the problem of spurious regression when there is need to model relationships suggested by a researcher (Alemayehu *et al* 2008). Differencing the I(1) series would tackle the non-stationary problem. However, you would lose the long-run

information in the data, which is central to your theoretical model. Thus, you need to think of a mechanism by which you can tackle the problem of spurious regression and have the long-run information as well. This is managed by specifying vector error correction model. The first step in a time series analysis is to conduct unit root test for the variables. The formula to undertake stationarity test in macro variables is defined as follows:

$$\Delta X_t = ¤_0 + \ _1X_{t-1} + ¢t + \sum_{i=1}^{n} {}^{-}{}_i \Delta X_{t-1} + £_t \qquad \textbf{(3)}$$

Where X stands for the variables of interest for example Agricultural GDP and Δ stands for difference operator and θ and β are parameters to be estimated. ADF (Dickey and Fuller, 1981) test statistics indicate that all variables are nonstationary at their level but stationary after first differencing (Table 3).

In this empirical work, to take care of the non-stationarity of the variables and confirm whether there exists a long run equilibrium relationship, the co-integration concept based on Johansen's approach is used (Johansen, and Juselius, 1990 and Johansen, 1991). This concept basically refers to the condition that even if individual series are non-stationary, if there exists a linear combination of I(p) series in the regression equation, then the regression is not a spurious regression. There are two basic ways of testing the existence of co-integration between variables of interest and estimating the co-integrating vector which are the Engel-Granger and the Johansen Approach. The later approach helps to do with multivariate test and followed in this empirical work.

Table 3: Unit root results of variables

Type	ADF Test Statistic				
	Y	**L**	**K**	**RF**	**P**
Level	1.238557	2.45776	1.082607	-3.1081	0.803812
Difference	-5.72361	-3.68889	-4.35906	-6.9569	-5.87648
1% Critical Value*		-3.6117			
5% Critical Value		-2.9399			
10% Critical Value		-2.608			

Source: Own Results (2017)

4.3 Co-integration Test

The Johansson approach performs a test for non-zero eigen values which is tantamount to the test for the rank of a matrix, which in turn is a test for the number of co-integration vectors (Alemayehu et al, 2008). First I have estimated unrestricted VAR to determine the lag length. The appropriate lag length in this empirical work is one as it is shown from diagnostic test (see appendix 3 and 7). The SC, HQ and AIC test depicts similar pattern with F-test confirming the preference of order one which states that the VAR model with lowest value of SC, HQ and AIC shows the better integration at that order. There is problem of normality of the disturbance term. There is no serial correlation and heteroscedasticity problem (see appendix 2). Hence understanding this we proceed to the next step.

Once the order of the VAR is determined the next step is to determine co-integration rank. This tells that there is co-integration among the variables. The trace test suggests that the null hypothesis of zero co-integration relationship can be rejected in favour of one co-integrating vector (see appendix 3).

4.4 Engle-Granger Causality test

The next step is identification of unique beta coefficients by imposing a rank restriction in the co-integration space to obtain unique relationship (see Appendix 4). Finally hypothesis testing on the significance of coefficients of the variables in the long run structural equation is conducted. This helps to identify the long run determinant variables in the model. From the likelihood ratio statistics, rainfall and labour are the main sources of agricultural gross domestic product (GDP) in Ethiopia (Appendix 5). Using Granger causality test, price is also in influential variables for agricultural GDP (Appendix 4). Hence in the long-run structural equations labour, price and rainfall are the most important variables spanning the relationships. The capital stock and institutions are not influential variables in the long-run structural equations.

The test result suggests our co-integrating vector is unique and in terms of the structural long run relationship, some variables are significant variables in explaining the dependent variables. The next step is testing for weak

erogeneity (Table 4). This test is providing an indicator to separate endogenous (dependent) and exogenous (independent) variables as well as the Granger causality of each variable. Labour, rainfall and institutions are exogenous variables whereas the agricultural GDP is endogenous for the model. Based on Granger causality test labour and price are significant variables that Granger cause the dependent variable agricultural GDP. Hence the model is valid for the explanatory variables labour, rainfall and price.

Table 4: Pair wise Granger Causality Tests of factors and products

Null Hypothesis:	Obs	F-Statistic	Prob.
LLAGR does not Granger Cause LYAGR	47	2.79	0.05
LYAGR does not Granger Cause LLAGR		0.12	0.95
LCAPAG does not Granger Cause LYAGR	47	0.98	0.41
LYAGR does not Granger Cause LCAPAG		0.34	0.79
LRF does not Granger Cause LYAGR	47	1.38	0.26
LYAGR does not Granger Cause LRF		0.82	0.49
PATOPNA does not Granger Cause LYAGR	47	4.35	0.01
LYAGR does not Granger Cause PATOPNA		1.06	0.38
S does not Granger Cause LYAGR	47	0.75	0.53
LYAGR does not Granger Cause S		0.67	0.57
LCAPAG does not Granger Cause LLAGR	47	6.71	0.00
LLAGR does not Granger Cause LCAPAG		0.40	0.75
LRF does not Granger Cause LLAGR	47	0.90	0.45
LLAGR does not Granger Cause LRF		0.54	0.66
PATOPNA does not Granger Cause LLAGR	47	4.09	0.01
LLAGR does not Granger Cause PATOPNA		0.10	0.96
S does not Granger Cause LLAGR	47	0.74	0.54
LLAGR does not Granger Cause S		0.66	0.58
LRF does not Granger Cause LCAPAG	47	0.40	0.75
LCAPAG does not Granger Cause LRF		0.43	0.73
PATOPNA does not Granger Cause LCAPAG	47	0.56	0.64
LCAPAG does not Granger Cause PATOPNA		2.21	0.10
S does not Granger Cause LCAPAG	47	1.36	0.27
LCAPAG does not Granger Cause S		1.88	0.15
PATOPNA does not Granger Cause LRF	47	2.06	0.12
LRF does not Granger Cause PATOPNA		6.29	0.00
S does not Granger Cause LRF	47	0.39	0.76
LRF does not Granger Cause S		0.90	0.45
S does not Granger Cause PATOPNA	47	1.32	0.28
PATOPNA does not Granger Cause S		4.09	0.01

Source: Model Results (2017)

The Engle Granger causality modeling shows that agricultural labor and Price of agricultural goods to non-agricultural goods Granger Cause agricultural productivity, Capital inputs in agriculture and Price of agricultural goods to non-agricultural goods Granger Cause agricultural labor, Rainfall Granger Cause ratio of Price of agricultural goods to non-agricultural goods and finally ratio of Price of agricultural goods to non-agricultural goods Granger Cause institutional capability (Table 4).

4.5 Short run and Long run Determinants of Agricultural production

Our model is valid for one co-integrating equation by specifying the Agricultural GDP as dependent variable and the rest as explanatory variables. Therefore, the long run determinants of Current Agricultural GDP in Ethiopia include previous harvest on Agricultural GDP, Labour, rain fall, and price ratio. On the other hand, the short run determinant of Agricultural GDP includes previous harvest on Agricultural GDP, labour, rainfall and institutions.

Table 5: Estimation Results Short run: Dependent Variable (DY)

Variables	Coefficient	t-value	t-prob
DY_2	-0.364674	-2.79	0.009
DL_2	0.488944	3.53	0.001
DRF	0.000298824	4.18	0.000
DP	-0.0983301	-1.13	0.265
S	0.0439182	2.98	0.005
Diagnostic test			
AR 1-2 test:	F(2,31) = 0.10158 [0.9037]		
ARCH 1-1 test:	F(1,31) = 15.152 [0.0005]**		
Normality test:	Chi^2(2) = 10.917 [0.0043]**		
hetero test:	F(9,23) = 0.33948 [0.9519]		
hetero-X test:	F(19,13) = 0.13564 [0.9999]		
RESET test:	F(1,32) = 1.4821 [0.2323]		

Source: Own Results (2017)

However, when we use the levels for regression analysis (long run determinants), our regression is spurious. On the other hand, if we use the differenced, we will loss the long run determinants of the model.

Table 6: Estimation result long run: dependent variable (Y)

Variable	Coefficient	t-value	t-prob
Y_1	0.735024	5.45	0.000
Y_2	-0.389108	-2.90	0.007
Constant	4.64121	4.77	0.000
L_2	0.485943	3.91	0.000
K_2	-0.0844312	-2.50	0.018
RF	0.000259193	3.14	0.004
RF_1	-0.000194553	-2.16	0.039
P_1	0.203977	3.51	0.001
S_1	0.0369512	1.60	0.12
R^2	0.97437	F(8,30) = 142.6 [0.000]**	

AR 1-2 test: F(2,28) = 2.2147 [0.1280]
ARCH 1-1 test: F(1,28) = 7.6205 [0.0101]*
Normality test: Chi^2(2) = 19.751 [0.0001]**
hetero test: F(15,14) = 1.0433 [0.4708]
RESET test: F(1,29) = 0.28761 [0.5958]

Source: Own Results (2017)

4.6 Vector Error Correction Model Results

Once the co-integrating vectors are identified from the agriculture GDP (LYAG) VAR, an error correction model consisting of differenced endogenous and exogenous variables and error correction terms derived from the co-integrated VARs is estimated. The short run and long run co-integrating equation by VECM is presented as follows. In doing so several attempt is made to get the congruent vector error correction model. The final model is selected using coefficient of determination and significant of the co-integrating equation coefficient. The coefficient of determination tells that the error correction model is best fitted for the variables considered.

Due to the inherent problem of heteroscedastic and autocorrelation in time series econometrics, adjustment using Prais-Winsten Cochrane-Orcutt regression on estimation the production function of agriculture was conducted (see Table 7). Ethiopian Agricultural production exhibits decreasing return to scale ((0.76) implying that a proportionate increase in inputs provide a lesser proportionate increase in output of agriculture. The higher elasticity of labor ((0.5) than capital ((0.26) employed in agriculture implied that there is scope for input substitution through irrigation and higher productive machineries both at smallholder and large farms.

Table 7: Prais-Winsten Cochrane-Orcutt regression

lyagr	Coef.	Semi-robust Std. Err.	t	P>|t|
llagr	0.496	0.192	2.590	0.013
lcap	0.256	0.122	2.110	0.040
_cons	5.223	0.694	7.520	0.000

Number of obs = 49 F(2, 46) = 26.86
R-squared = 0.5202 Prob > F = 0.0000
Root MSE = .07933
Durbin-Watson statistic (original) = 0.742
Durbin-Watson statistic (transformed) 1.735592

Source: Model Results (2017)

From the vector error correction model result, the coefficient of the co-integrating equation tells that about 45 percent of disequilibrium corrected each year by change in aggregate agricultural production. The overall performance of the model is well fitted, because the 64% of total variation of the dependent variable is explained by the independent variables included in the model. Moreover, the model selection criteria indicated the model is adequate to represent the real world and manageable to predict agricultural production behavior in Ethiopia.

Table 8: Co-integrating Equation, CE1

Variable	Coefficient	Standard error	t-value
L(-1)	-0.0161987	0.0381	-0.425
K(-1)	0.332341	-1.7958	0.18507
RF(-1)	35.10722	-11.1944	3.13***
P(-1)	19.69533	-4.65063	4.24***
S(-1)	-6.38214	-2.09028	-3.05***
C	-279.951		

*** implies significant at 1% probability level
Source: Model Results (2017)

The Vector error correction estimate depicts that Ethiopian agricultural GDP in the short run is dependent up on agricultural labour employed, rainfall, lagged agricultural production and relative price. The elasticity of price in the short run is positive and negative in the long run. This implied that it is an incentive in the long run and sluggish in the short run. This is with consistent with the theory behind market signal for improving agricultural productivity.

In the long run, real agricultural production and productivity are determined by institutional capability, relative price ratio of agricultural to non-agricultural goods and services and rain fall as a vagary of nature.

Table 9: Vector Error correction estimate: Dependent variable (DLYAG)

Variable	Coefficient	Standard error	t-value
CointEq1	-0.454	-0.190	-2.396***
D(LYAGR(-1))	0.484	-0.225	2.151**
D(LYAGR(-2))	-0.494	-0.194	-2.555***
D(LYAGR(-3))	0.010	-0.210	0.046
D(LLAGR(-1))	-0.584	-0.265	-2.204**
D(LLAGR(-2))	-0.206	-0.290	-0.709
D(LLAGR(-3))	-0.298	-0.271	-1.100
D(LCAPAG(-1))	0.016	-0.142	0.110
D(LCAPAG(-2))	-0.062	-0.180	-0.344
D(LCAPAG(-3))	0.117	-0.194	0.601
D(LRF(-1))	-0.578	-0.159	-3.628***
D(LRF(-2))	-0.247	-0.141	-1.753*
D(LRF(-3))	-0.140	-0.118	-1.195
D(PATOPNA(-1))	-0.033	-0.202	-0.165
D(PATOPNA(-2))	-0.305	-0.183	-1.670*
D(PATOPNA(-3))	-0.114	-0.172	-0.664
D(S(-1))	0.005	-0.062	0.081
D(S(-2))	0.025	-0.058	0.432
D(S(-3))	0.081	-0.057	1.420
C	0.108	-0.047	2.331**
R-squared	0.640		
Adj. R-squared	0.352		
Sum sq. reside	0.126		
S.E. equation	0.071		
F-statistic	2.222		
Log likelihood	70.413		
Akaike AIC	-2.148		
Schwarz SC	-1.314		
Mean dependent	0.046		
S.D. dependent	0.088		

*, **,*** implies significant at 10%, 5% and 1% probability level
Source: Model Results (2017)

From this empirical estimate it can be interpreted that Price is very sluggish to be an incentive in Ethiopian agriculture GDP. In fact the majority of smallholder agriculture in Ethiopia is not producing for market rather for home consumption. This is possibly because of the reason that institutions are not favourable for functioning of markets both in open economy regime as well as

in command economy regime. This tells us that there is no structural change in the economy. Agriculture GDP is mainly dependent on labour, price ratio and vagaries of nature in the short run. When we see further the agricultural labour, it is mainly composed of unskilled labour. The variables are co-integrated with polynomial rank ranging from 1 to 5 with significant contribution to agricultural GDP. The results in this study show that Ethiopian agriculture is mainly dependent on vagaries of nature. Therefore relying on the majority of unskilled labour and nature, Ethiopia could not be out of the poverty trap. To circumvent the condition Ethiopia should have to invest on human capital and reduce its reliance on nature by developing irrigation which could boost agricultural production and productivity.

5. Concluding Remarks

In this empirical work, the aggregate production function of agricultural sector in Ethiopia is estimated using vector error correction model. The estimation result confirms that most of the variables are co-integrated of various ranks. There is an inverse impact of institutional transformation from public to private ownership of resources in improving agricultural growth the long run but not in the short run. Short run sources of Agricultural productivity growth- Rainfall, Labor, previous harvest and price while Long run sources of Agricultural productivity growth- institutional capability, rainfall and price. There are minimal productivity changes- decreasing RTS (0.76) mainly attributable to labor (0.5) and limited capital (0.26). Vector error correction modeling of the sector shows that the Ethiopian agricultural sector depicted that Main sources of growth depend on vagaries of nature. The Productivity improvement emerging mainly from labor. Finally, forecasting of the agricultural production and its associated sources of growth has been made to provide solution in future values. To circumvent the poverty trap in the country, therefore, the government needs to invest on human capital and irrigation development to reduce its dependence on vagaries of nature. Improving on labor productivity through quality, affordable and equitable education. Moreover, competent private-public partnership in increasing the capability of institutions on coordination and cooperation of resource use is also vital. This suggests for proper delegation of power and balance on efficiency and equity.

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Appendices

Appendix 1 Unrestricted VAR: 1966 to 2014

URF equation for: Y

	Coefficient	Std.Error	t-value	t-prob
Y_1	0.537222	0. 1691	3.18	0.003
L_1	0.248094	0.1509	1.64	0.110
K_1	-0.0167960	0.03816	-0.440	0.663
RF_1	0.000129281	-0.0001181	-1.09	0.282
P_1	0.141540	0.07610	1.86	0.072
S_1	0.0405989	0.02788	1.46	0.155
Constant U				
3.40133	1.140	2.98	0.005	

F-test on regressors except unrestricted: F(36,125) = 35.94 [0.0000] **

F-tests on retained regressors, F(6,28) =

Y_1	3.68140 [0.008]**	L_1	5.03772 [0.001]**
K_1	63.9640 [0.000]**	RF_1	3.30331 [0.014]*
P_1	7.55993 [0.000]**	S_1	15.2480 [0.000]**
Constant U	3.25418 [0.015]*		

Progress to date

Model	T	p	log-likelihood	SC	HQ	AIC	
SYS(3)	40	42	OLS	-5.6487579	4.1558	3.0236	2.3824
SYS(2)	39	78	OLS	30.815372	5.7468	3.6135	2.4197
SYS(1)	38	114	OLS	66.635419	7.4056	4.2408	2.4929

Source: Model Results (2017)

Appendix 2 Diagnostic Test statistics

Testing for Vector error autocorrelation from lags 1 to 2

Chi^2(72)= 91.617 [0.0593] and F-form F(72,92) = 1.1001 [0.3310]

Y…:	AR 1-2 test:	F(2,31) = 3.9399 [0.0299]*
Y…:	Normality test:	Chi^2(2) = 17.767 [0.0001]**
Y…:	ARCH 1-1 test:	F(1,31) = 0.13895 [0.7119]
Y…:	hetero test:	F(11,21) = 0.36619 [0.9556]
Y…:	hetero-X test:	F(26,6) = 0.75589 [0.7176]

Source: Model Results (2017)

Appendix 3 I(1): Cointegration analysis, 1966 to 2014

eigenvalue	loglik for rank	
	-55.56966	0
0.63158	-35.59930	1
0.45410	-23.49304	2
0.35344	-14.77120	3
0.26016	-8.744813	4
0.12235	-6.134779	5
0.024008	-5.648758	6

H0:rank<=	Trace test pvalue
0	99.842 [0.024] *
1	59.901 [0.239]
2	35.689 [0.417]
3	18.245 [0.558]
4	6.1921 [0.677]
5	0.97204 [0.324]

Source: Model Results (2017)

Appendix 4: Cointegrated VAR 1966 to 2014

Number of lags used in the analysis: 1

beta	
Y	1.0000
L	-1.0402
K	0.10587
RF	-0.0014069
P	0.19346
S	0.075092

alpha	
Y	0.16652
L	0.28028
K	0.0060513
RF	439.93
P	-0.058618
S	-0.58915

Reduced form beta	
L	1.0402
K	-0.10587
RF	0.0014069
P	-0.19346
S	-0.075092

Appendix 5: General cointegration restrictions on beta parameters

Y &6=0; LR test of restrictions: Chi^2(1) = 4.5519 [0.0329]*
L &7=0; LR test of restrictions: Chi^2(1) = 7.1067 [0.0077]**
K &8=0; LR test of restrictions: Chi^2(1) = 1.8596 [0.1727]
Rf &9=0; LR test of restrictions: Chi^2(1) = 13.661 [0.0002]**
P &10=0; LR test of restrictions: Chi^2(1) = 1.1349 [0.2867]
S &11=0; LR test of restrictions: Chi^2(1) = 2.1759 [0.1402]

Appendix 6: General cointegration restrictions on alpha parameters

L &1=0; LR test of restrictions: Chi^2(1) = 10.582 [0.0011]**
K &2=0; LR test of restrictions: Chi^2(1) =0.0035608 [0.9524]
RF &3=0; LR test of restrictions: Chi^2(1) = 7.3246 [0.0068]**
P &4=0; LR test of restrictions: Chi^2(1) = 0.18587 [0.6664]
S &5=0; LR test of restrictions: Chi^2(1) = 4.5424 [0.0331]*
Source: Model Results (2017)

Appendix 7: Johansen co-integration test with Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.689368	123.4846	94.15	103.18	None **
0.633608	77.88791	68.52	76.07	At most 1 **
0.421668	38.72987	47.21	54.46	At most 2
0.243274	17.37316	29.68	35.65	At most 3
0.137158	6.501742	15.41	20.04	At most 4
0.019005	0.748323	3.76	6.65	At most 5

*(**) denotes rejection of the hypothesis at 5%, (1%) significance level
L.R. test indicates 2 cointegrating equation(s) at 5% significance level
Source: Model Results (2017)

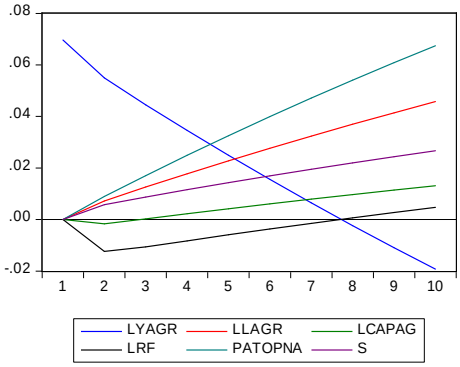
Appendix 8: Normalized Cointegrating Coefficients:

Y	L	K	RF	P	S	C
1.000000	1.046362	0.154629	0.007132	-1.918424	-0.587580	-17.75946
	(2.51940)	(0.30791)	(0.01043)	(2.63998)	(0.79647)	
Log likelihood	-8.128582					

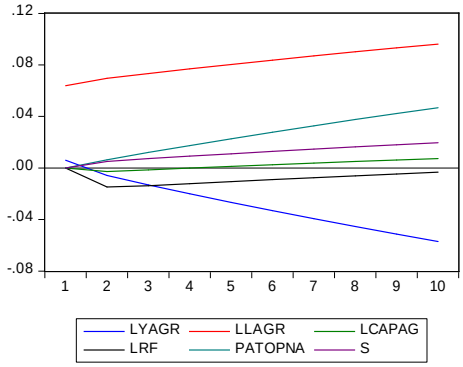
Source: Model Results (2017)

Appendix 9. Forecasting of key variables

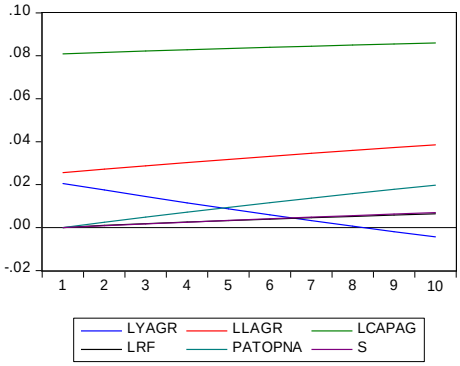
Response of LYAGR to Cholesky
One S.D. Innovations



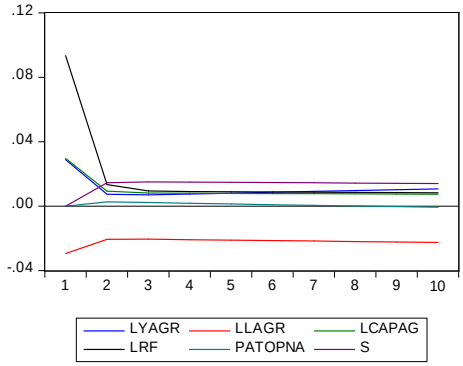
Response of LLAGR to Cholesky
One S.D. Innovations



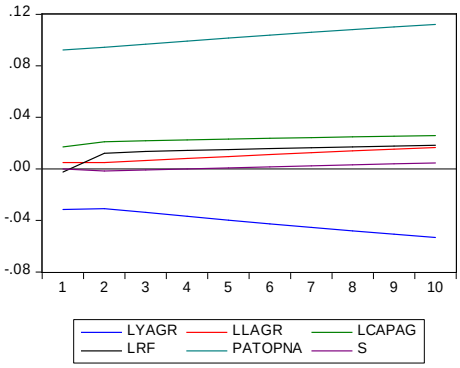
Response of LCAPAG to Cholesky
One S.D. Innovations



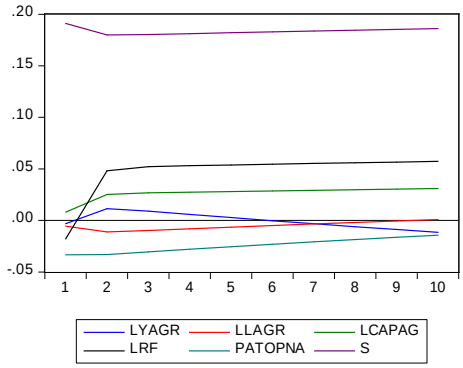
Response of LRF to Cholesky
One S.D. Innovations



Response of PATOPNA to Cholesky
One S.D. Innovations



Response of S to Cholesky
One S.D. Innovations



The Impact of Forest Cover on Potable Water Treatment Costs: Panel Evidence from Ethiopia

Dawit Woubishet[1] and Amare Fentie[2]

Abstract

Water purification is one of the regulating services of forest ecosystems. Quantitative assessment on the impact of forest land use on drinking water treatment cost is lacking in developing countries like Ethiopia. This study is therefore conducted to assess the impact of forest land cover on the water purification services using panel data from eight water treatment plants in Ethiopia. The panel data was collected from regional Water, Sewerage and Sanitation offices, Climate Research Unit at University of East Anglia and the land use data was extracted from Global Forest Change (2002-2014). Panel fixed effect regression was applied for the purpose of singling out the effect of forest cover on water treatment chemical costs in each treatment plants. A short run cost function which is used to value unpriced environmental inputs was employed for the analysis. The study found that forest cover both at the watershed and upstream level has a significant effect on water treatment chemical cost. In addition, the effect of forest cover with different buffer distances ; ranging from 2.5 km to 30 km; on total chemical cost and on cost of Aluminum Sulphate is analyzed and it is found that lower buffer distance forest cover contributes significantly to the reduction of treatment chemical costs as compared to the furthest buffer. Thus, the finding highlighted that protecting forests enhances water quality and reduces the chemical cost incurred to treat potable water.

Key Words: Forest, Water treatment cost, water purification, fixed effect, Ethiopia

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1. Introduction

It has been widely accepted that land use type and water quality are closely related. Land use and land cover significantly determines the type and amount of contaminants entering streams, lakes, and underground path ways. Changes in the land cover and land management practices are the key influencing factors behind the alteration of the hydrological system which lead to the change in runoff and water quality (Yong and Chen, 2002; Bai *et al.*, 2010). Advancements in science and technology have enabled water utilities to effectively treat most known contaminants from drinking water sources and provide safe drinking water. However, the advancements have contributed to a movement away from protecting and managing the water source areas, and the notion that the quality of raw water supplies is less important(Ernest 2004; Ernst *et al.* 2004).The continued conversion and development of forest land pose a serious threat to the ecosystem services derived from forested landscapes. The water purification service of ecosystems dictates that the water from forested land and other ecosystems is cleaner than water that comes from other land uses like agricultural, urban and industrial landscapes (Chichilnisky & Heal 1998; Dudley & Stolton 2003; Bruijnzeel 2004; Ernst 2004; Ernst *et al.* 2004; UN 2016; Vincent *et al.* 2016).

Ensuring access to clean water and sanitation is one of the 17 global goals that make up the 2030 agenda for sustainable development. Water scarcity affects more than 40% of the world population and it is projected to increase due to the rise of global temperatures as a result of climate change (UNDESA 2014). Protecting and restoring water related ecosystems such as forests, mountains and wetland is essential to mitigate water scarcity and unsafe water access. Protection and restoration of clean water sources such as forests reduce the costs associated with water treatment. Water purification is one of the regulating services of eco systems provided by the ecosystem to human beings (MEA 2005; TEEB 2010). Land use changes such as timber harvesting operations, agriculture based plantations, road construction, housing development; conversion of forest land to other land uses will lead to diminishing water quality. Contamination of water streams results in higher treatment cost of water (Rahim & Shahwahid 2011).Contamination of water causes the increment in treatment cost as additional chemical is needed to treat

water. A notable example for this comes from the synthesis of (TEEB 2010) report and it was the decision by the New York City authorities to pay landowners in the Catskill mountains to improve farm management techniques and prevent run-off of waste and nutrients into nearby watercourses in order to avoid building expensive new water treatment facilities, which otherwise would have been required by federal regulations. The water purification services of the watersheds can reduce the water treatment costs. A study by (Ernest 2004) showed that 50-55% of the variation in operating water treatment cost can be explained by the percentage of forest cover in the water source area. The same study finds that for every 10 % increase in forest cover in the source area, treatment and chemical costs decreased approximately by 20 %.Well managed ecosystems are resources with immense economic and ecosystem values to both the local communities and the rest of the world (Hanson et al. 2011). Societies have created strong cultural links with forests, and it is widely assumed that forests help to maintain a constant supply of good quality water. A large portion of the value of tropical forests arises from regulating services, such as water purification, carbon storage, erosion prevention, and pollution control. In many valuation studies, these regulating services account for around two-thirds of total economic value. In contrast, the supply of food, timber, genetic and other materials typically accounts for a relatively small share of forest value, although these are the benefits on which perceptions of the economic importance of forests are often based (TEEB 2010). Activities near water stream like timber harvesting operations, agriculture-based plantation, road construction, housing development and particularly conversion of forest land to other land uses will lead to diminishing in water quality. For effective water management, understanding the relationship between land use and water quality as well land use impact on water treatment cost play significant role.

2. Ecosystem service valuation of forests: A literature review

The economic value of forests is underestimated by policy makers, planners and resource managers which resulted in low priority for the sector despite its continuous deforestation and degradation.

The Climate Resilient and Green Economy (CRGE) strategy of Ethiopia identified the forest sector as one of the four pillars and has the largest potential in reducing emissions and increasing climate resilience in the country. Despite its significant contribution, the economic value of forest ecosystem services is not adequately measured and captured in Ethiopia. The contribution of forests to GDP is highly underestimated in Ethiopia. A study by Smith et al (2016) found Ethiopia's forests generated economic benefits in the form of cash and in kind income equivalent to 120 billion Ethiopian birr (which is around 18 billion USD) in the year 2012/13 with additional non market benefits of 2.4 billion Birr in relation to willingness to pay to maintain forests.

Forests are widely recognized as a land cover for the protection of water resources. Forests control erosion, improve water quality and regulate water flows in catchments (Muys et al. 2014; Abildtrup *et al.,* 2011). Rapid population growth and urbanization led to extensive land uses changes in developing countries which significantly affects the concentration of contaminants in drinking water around these land uses (Khaledian *et al.*, 2012). Several empirical Studies(Moore & McCarl 1987; Holmes 1988) indicated that water treatment costs are lower when the raw water processed by water treatment plants (WTPs) was less turbid (contained lower levels of suspended and dissolved solids). Other related studies also found that run off from forests is cleaner than run off from other land uses implying that forests can provide economically valuable water purification service (Dunne and Leopold, 1982; Hewlett, 1982; Carlson et al, 2014).

In Ethiopia, empirical studies about the valuation of forests for their ecosystem services are very scant, there are only few micro level empirical studies undertaken which assessed the economic value of forests (Ayenew and Tesfay, 2015; Gardei, 2006; Ayenew *et al*., 2015; Tilahun *et al.*, 2011; Smith *et al.*, 2016; Nyssen *et al.*, 2014). These empirical works emphasized on the value of ecosystem services of forest including water related services. Similarly Ayenew *et al., (*2015) and Tilahun *et al.* (2011) applied contingent valuation method to estimate the willingness to pay of the communities to protect the forest and evaluate the economic value forest. However, the value

of the regulating services of forest ecosystems (i.e. for water purification) is not well addressed by previous empirical works conducted in Ethiopia.

This paper is one of the very few in developing countries that deal with the impact of forest land use on chemical costs to treat water. Despite the land use changes from forests to agricultural land, housing, grazing, and other land use types in Ethiopia, to the best of our knowledge there is no rigorous empirical study conducted on the impact of forest cover on the chemical costs of treatment plants in Ethiopia though access to safe drinking water and sanitation is a prior agenda in environmental policies of the country. According the Ministry of Water, Irrigation and Electricity (MOWIE) 2015 report, there were 36 functional water treatment plants in Ethiopia of which this study covers eight treatment plants for the period 2002-2014. The treatment plants include two of the major water treatment sites of the capital city, Addis Ababa ("Gefersa" and "Legedadi") and six other treatments plants of regional state cities(Hawassa, Jimma, Gonder, Yirgalem, Shashemene and Dilla).

3. Methodology

This paper followed an approach applied by Vincent et al. (2016),to analyze the effect of forest land use on water treatment chemical cost using econometric methods. The treatment plants cost function used here is based on the theory of cost functions to value environmental inputs (McConnel and Bockstael 2005, Vincent 2011, Freeman et al 2014, Vincent et al 2016). Short run cost functions of firms which use one or more unpriced environmental inputs include four types of variables. These are; i) the firm's output level, ii) prices paid by the firm for labor and other non-environmental inputs, iii) the quantity of capital and other fixed factors, and iv) the quantity of environmental inputs used by the firm. Fixed effects regression applied to assess the impact of forest cover on chemical cost to treat water. The panel nature of our data can serve us to control unobserved confounders that might affect the true effects of forest land cover on chemical costs. Since chemical costs are operating costs, the study analyzed the short run effects of forest cover change on chemical costs. The panel fixed effects model can be specified as follows:

$$\ln(C_{it}) = L_{iy}\beta + \alpha \ln(q_{it}) + \gamma_1 \ln(r_{it}) + \gamma_2(\ln(r_{it}))^2 + \gamma_3 \ln(tem) + C_i + u_{it}$$

where C_{it} stands for the dependent variable; water treatment cost (disaggregated by chemical type used) and we estimated the given fixed effects model for the dependent variable (chemical cost), L_{iy} refers a forest land cover variable around the water treatment plants' catchment which is varied by year, q_{it} and r_{it} represent treated water volume and rainfall[3] (both varied by year and month). This cost function is similar with the generic cost function mentioned above; the treated water volume represents the first variable type (output level), fixed effects control for the second type and the third types of variables (input prices, capital and other fixed factors),and land uses variables represent the fourth type of variable in the generic cost function (environmental input). Theoretically, rainfall increases sediment loads in rivers in tropical regions by eroding soil and transporting sediment (Dunne 1979; Abdul Rahim and Zulkifli 2004). In addition there is also evidence that treatment cost is higher during wet periods (Sthiannopkao *et al.*, 2007; Dearmont *et al*. 1998). Dilution causes contaminants around the source water to be lower when stream flow is high. Dilution effect similarly could cause treatment costs to be lower when rainfall is higher. It is hypothesized that the dilution effect would dominate the soil erosion effect and reduce cost at lower, less erosive rainfall levels ($\gamma_1 < 0$), and increases the cost at higher level of rainfall ($\gamma_2 > 0$). tem refers to the average annual temperature around each treatment plants. Fixed effects are also included to control time invariant water treatment plant characteristics (C_i), and water treatment plant invariant annual characteristics. The major chemicals used to treat water in each treatment plants are Aluminum Sulphate, lime, and chlorine. The chemical cost represents the aggregate cost incurred for chemicals. Since fixed effect estimation is more robust to selection bias problems than random effect estimator, fixed effects model is employed for our analysis (Kennedy, 2008, p.290).

[3] Rainfall and land use variables refer to the water treatment plants' catchment.

Data sources and description of variables

Treatment plant level data: like water volume, costs of chemicals for water treatment are collected from respective water treatment plants of the Water, Sewerage and Sanitation bureaus. Variables selection for the fixed effect regression followed recent peer reviewed papers, such as Vincent et al 2016, and other scientific literatures which talks about the value of unpriced environmental inputs (McConnell and Bockstael, 2005; Vincent, 2011). Yearly average temperature and rainfall data for the years 2002 to 2014 were interpolated from the Climate Research Unit of University of East Anglia (http://www.cru.uea.ac.uk). For the land cover variables, the study used global Forest Change (2000-2014 high resolution land cover map to identify forest cover and the different buffered forest covers around the treatment plants (Hansen et al. 2013). The forest cover at different land cover buffer zones, upstream parts of the catchment, and the whole catchment area were used to assess the impact of forest cover on the cost of chemicals to treat water. The nature of the data is panel that ranges from 2002 to 2014. The buffer distances from the water treatment plants ranges from 2.5 kilometers to 30 kilometers.

4. Results and Discussion

Descriptive Statistics

The main explanatory variables that are included in the analysis are transformed in to their logarithmic forms for the purpose of normality and ease of interpretation. These variables are the forest cover at the watershed level, upstream forest cover (in square kilometers), treated water volume (in cubic meters), average annual precipitation and average annual temperature of the watershed of the treatment plants. These variables are treatment plant level variables and ranges from year 2002 to 2014.

From the summary statistics, the mean annual aggregate chemical cost (which includes Aluminum Sulphate, chlorine, Calcium hyper chlorite and lime) is

around 2.7 million Ethiopian Birr. Aluminum Sulphate[4] which takes the largest share has an average cost of 1.5 million Ethiopian Birr. The mean annual rainfall is also around 1156 millimeters and ranges from the minimum of 655.5 to a maximum value of 1780.5 millimeters. This mean annual rainfall refer to the water treatment plants' catchment area. Average watershed area (in square km) and forest area (for both watershed and upstream) are also reported with a mean of 210 and 204 square kilometers respectively. Like the data for annual rainfall and temperature, land use data variables (watershed and forest cover) refer to the catchment area. The mean annual treated water volume and water consumption in each treatment plants is respectively 9,232,181 and 5,651,713 cubic meters.

Table 1: Summary statistics

Variables	All water treatment plants (N=8)			
	Mean	**Std. dev.**	**min**	**max**
Aggregate chemical cost (cost in Birr)	2672827	3644481	119736	1.66e+07
Aluminium Sulphate (cost in Birr)	1476627	1972592	54350	1.40e+07
Average annual precipitation (in mm)	1156.455	200.0567	655.5	1780.5
Watershed area (sq. km)	1014.056	1601.812	73.97	5152.3
Watershed forest area (in sq. km)	210	353	0.47	1120
Upstream forest area (in sq. km)	204	189	0.14	574
Number of customers	31781	56960.42	1380.372	213383.3
Treated water volume (in cubic meter)	9232181	1.88e+07	34042.65	6.06e+07
Total water consumption (in cubic meter)	5651713	1.10e+07	47075.52	3.80e+07
Average annual temperature (^{0}C)	20.5	2.85	16.2	27.1

[4] Unlike other treatment chemical costs, the cost of Aluminum Sulphate is reported here due to its significant share compared to the costs of other treatment chemicals.

For analytical purposes, the study used three basic land use scenarios; the first scenario is analysis of the effects of the forest cover at the watershed level, the second analytical scenario is the effects of the upstream forest cover, and the last scenario dealt with the impact of forest cover with different buffer distances around the water treatment plants. To illustrate, we presented the map for the two water treatment plants found in Addis Ababa; Akaki-Gefersa and Legedadi water treatment plants. Figure 1 shows the whole watershed and the upstream parts of the watershed (indicated in yellow) of the two water treatment plants. In Figure 2, the watershed and upstream area of the water treatment plants with different buffer distances with range of 2.5 km, 5km, 10 km, 15km, 20km, 25km and 30km.

Figure 1: The watershed and upstream area of Gefersa and Legedadi treatment plants

Figure 1A: whole watershed of the two plants Figure 1B: The upstream area of the plants (in yellow)

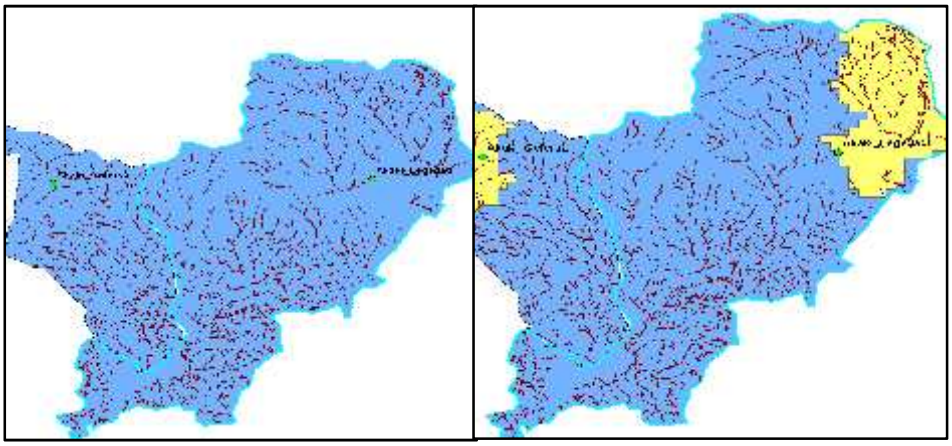


Figure 2: Intersected area between water treatment plant with buffers and upstream and the watershed

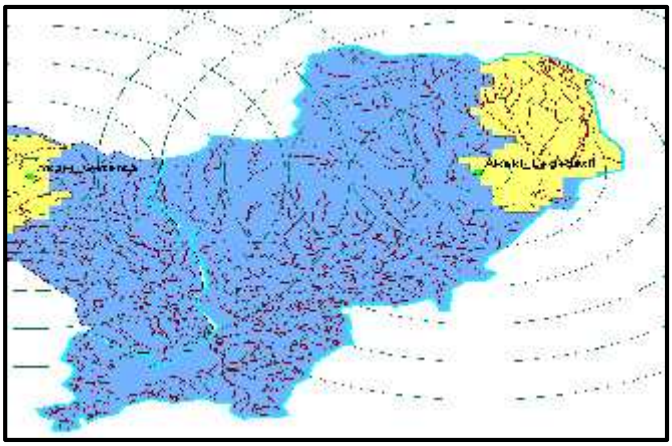
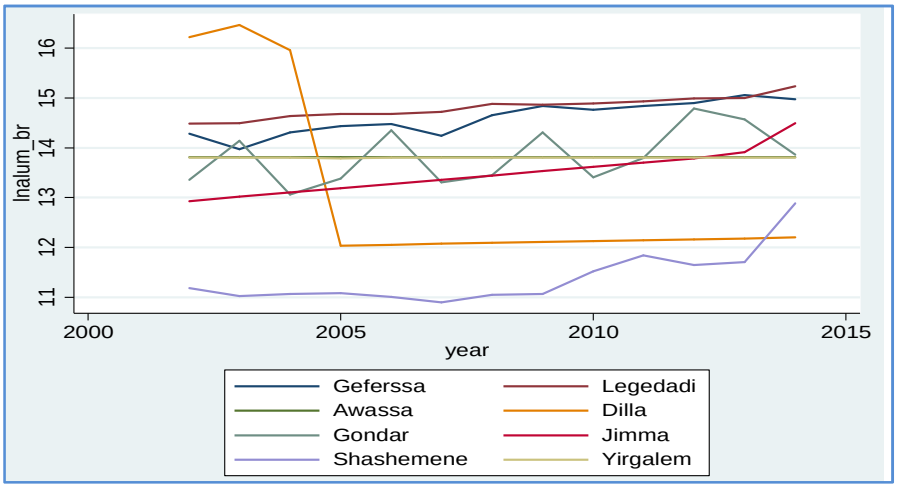


Figure 3: The variation of treatment chemical cost (Aluminum Sulphate in logarithmic form) over time

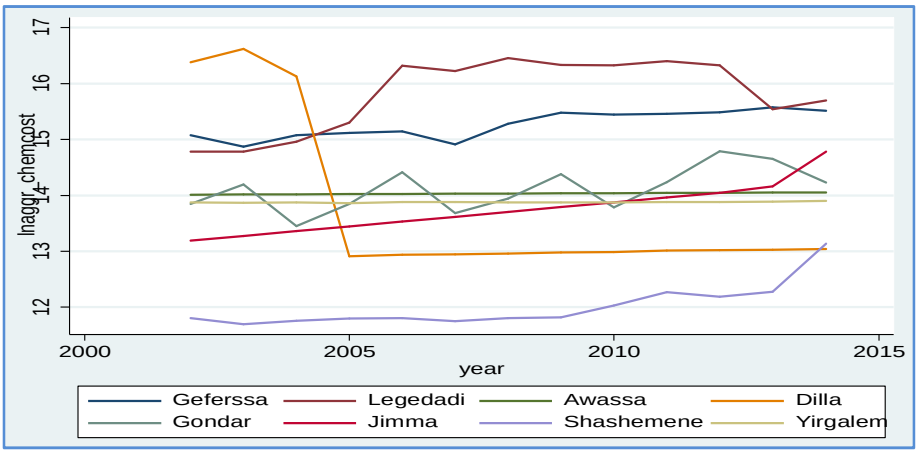


As Figure 3 depicts, the treatment chemical cost (for Aluminium Sulphate) varied across each treatment plants; it might depend on the size and water treatment chemical need fort heplants. The water treatment plants respectively are Geferesa, Legedadi, Hawassa, Dilla, Gonder, Jimma, Shashemene and Yirgalem. The cost of Aluminium Sulphate shows an increasing trend for

most of the water treatment plants though the rate differs across treatment plants.

The variation in aggregate treatment chemical costs has almost the same trends with the cost of Aluminum Sulphate presented in Figure 4.

Figure 4: Variation in aggregate chemical cost across treatment plants



The Impact of watershed forest covers on water treatment chemical costs

Given the panel nature of our data, we run a panel fixed effects regression and found relevant relationships between the aggregate treatment chemical costs[5].The effect of forest cover on water treatment chemical costs[6] is estimated based on three basic scenarios. First, we estimated the impact of forest cover on water treatment chemical costs at the watershed level. Second, we tried to estimate the effect of upstream forest cover on treatment costs and the third scenario is forest cover with different buffer distances is taken as a variable of interest to estimate its impact on water treatment chemical costs. Given the panel nature of our data, we run a panel fixed effects regression. All variables are in logarithmic form and can be directly interpreted as elasticity.

[5] The aggregate chemical cost is the sum of the costs of main treatment chemicals used in each of the 8 treatment plants. The three main treatment chemicals used are Aluminium Sulphate, chlorine, calcium hyperchlorite and lime. The cost is expressed in Ethiopian Birr.

[6] Water treatment chemical costs refer to both aggregate chemical cost and the cost for Aluminum Sulphate.

In this section the effect of forest cover on treatment chemical costs at the watershed level is assessed Logarithm of water treatment chemical costs (both aggregate and Aluminum Sulphate) are used as dependent variables. Watershed forest area, treated water volume at each treatment plant, average annual temperature and annual rainfall are used as independent variables (all with logarithmic form). The watershed forest cover has significant negative impact on the aggregate water treatment chemical costs. It also affects the cost of Aluminum Sulphate significantly (at 5% level of significance). The water treatment chemical cost decreases significantly when the forest cover increases. This finding is consistent with notable works which are conducted to analyze the relationship between forest cover and water treatment costs (Vincent et al, 2016; Ernst, 2004; Ernst et al, 2004). As expected, the effect of rainfall on treatment chemicals costs is negative at lower level of rainfall and positive at higher level of rainfall and the dilution and soil erosion effects[7] holds (its effect is significant at 5% for Aluminum Sulphate treatment chemical as portrayed in the regression results table).

Table 2: Fixed effects regression result

Variables	Panel fixed effect (Dependent: Log of aggregate treatment cost)	Panel fixed effect (dependent: log of Aluminum Sulphate)
lnwatsh_frsta	-8.30***(3.06)	-8.34**(3.47)
lnproduc_tp	-0.40(0.25)	-0.52*(0.28)
lnaver_tem	3.12(6.40)	5.2(7.24)
lnrf_annual	-40.50*(20.90)	-54.83**(23.61)
lnrf_annual2	2.85*(1.49)	3.86**(1.68)

*** Significant at 1%, ** Significant at 5%, * Significant at 10%, (s.e)

Effects of upstream forest cover on water treatment chemical costs

In this section, the forest cover of the upstream area is our variable of interest. Though our main focus is on the impact of forest cover on aggregate treatment

[7] At lower level of rainfall, the effect of rainfall on treatment chemical cost is negative (cost is decreasing due to stronger dilution effect) and at higher level of rainfall, the effect of rainfall on treatment chemical cost is positive (cost is increasing due to stronger soil erosion effect).

chemical costs, the other explanatory variables have also important implication for the validity of the model employed for the analysis. We found consistent results with previous studies both on the impact of forest cover and the significance of other covariates used in the regression analysis. One exception here is the impact of the treated volume of water on the cost of treatment chemicals; it negatively affects the aggregate chemical cost (at 10% level of significance). The higher the amount of treated water volume, the lower the cost of treatment chemicals. This finding is inconsistent with previous empirical studies in this subject (Vincent *et al.*, 2016). The nature of the data might contribute to this finding. The effect of the upstream forest cover found to be consistent with prior expectations. It significantly affects the water treatment cost (With increasing upstream forest cover, the treatment cost decreases significantly). This finding is similar with previous studies on the area (Vincent *et al*., 2016; Ernst 2004; Rahim and Shahwahid, 2011).

The other important finding is that the impact of annual rainfall on water treatment cost (though the level of significance is different across scenarios). As expected lower level of rainfall has a cost reducing impact due to what is called stronger dilution effect, and at higher level of rainfall, treatment cost increases with increasing amount of rainfall (significant at 10% level of significance) due to higher soil erosion effect. The rainfall variable takes quadratic form to test these two effects. As expected, rainfall significantly contributes to lower chemical cost at lower levels of rainfall and contributes to increase chemical cost at higher amount of rainfall. The mean annual temperature is not significant both for aggregate chemical costs and for cost for Aluminum Sulphate.

Table 3: Panel fixed effect results

Variables	Panel fixed effect (Dependent: Log of aggregate treatment cost)	Panel fixed effect (dependent: log of Aluminum Sulphate cost)
lnforest_area_upstream	-5.68***(2.08)	-6.982***(2.316)
lnproduc_tp	-0.526*(0.268)	-.720**(0.298)
lnaver_tem	3.64(6.36)	5.31(7.09)
lnrf_annual	-40.56*(20.88)	-54.60**(23.2)
lnrf_annual2	2.86*(1.48)	3.86**(1.65)

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

The impacts of forest cover at different buffer distances

For this particular study, there are about seven different buffer zones. The buffer distance started from 2.5 kilometers and ended at 30 kilometers. The regression result shows that forest cover within the lowest buffer distance has the highest impact on the aggregate chemical cost; the forest cover with in the buffer distance of 2.5 kilometers significantly affects the treatment cost compared to the forest cover found at higher buffer distances. The impact decreases with increasing buffer distance. Table 2 and 3indicate the regression result from the different buffer distance scenarios. As indicated in Tables 2 and 3, with increasing buffer distance the impact of the forest cover on both the aggregate chemical cost and Aluminum Sulphate except at forest cover with buffer distance 20 the impact of which is below the next two buffers. This might be due to lower forest cover in the given buffer area. The main reason for the inclusion of the cost of Aluminum Sulphate in the regression analysis is that all the eight treatment plants used it as treatment chemical and takes significant share from the total cost.

The rho in the last column shows the percentage of the variation explained by water treatment specific effects. Higher magnitude of rho shows robustness of fixed effects since most of the variation is not from idiosyncratic effects.

Table 4: The impact of forest cover with different buffer distances on aggregate chemical cost

Log of aggregate water treatment cost	**Buffer distances (in km)**						
Independent variables	2.5	5	10	15	20	25	30
Forest cover with in 2.5 km buffer area	-13.86*** (4.62)	-	-	-	-	-	-
Forest cover with in 5 km buffer area	-	-10.53*** (3.27)	-	-	-	-	-
Forest cover with in 10 km buffer area	-	-	-6.687*** (2.4)	-	-	-	-
Forest cover with in 15 km buffer area	-	-	-	-5.43*** (2.07)	-	-	-
Forest cover with in 20 km buffer area	-	-	-	-	-5.689*** (2.08)	-	-
Forest cover with in 25 km buffer area	-	-	-	-	-	-5.684*** (2.08)	-
Forest cover with in 30 km buffer area	-	-	-	-	-	-	-5.684*** (2.08)
lnproduc_tp	-0.30 (0.24)	-0.577 (0.26)	-0.58 (0.28)	-0.51** (0.27)	-0.53** (0.27)	-0.52** (0.26)	-0.53** (0.27)
lnaver_tem	-0.91 (6.64)	1.26 (6.38)	3.92 (6.36)	3.59 (6.40)	3.63 (6.38)	3.63 (6.38)	3.63 (6.38)
lnrf_annual	-50.67** (20.96)	-45.94** (20.61)	-41.94 (20.84)	-40.75* (20.94)	-40.58** (20.89	-40.56** (20.88)	-40.58** (20.89)
lnrf_annual2	3.55** (1.49)	3.24** (1.46)	2.96 (1.48)	2.87* (1.49)	2.86** (1.48)	2.88** (1.48)	2.86** (1.49)
rho	0.99	0.99	0.99	0.99	0.99	0.99	0.99

*** Significant at 1%. ** Significant at 5%, * significant at 10%. (s.e)

Table 5: The impact of forest cover with different buffer distances on the cost of Aluminum Sulphate

Log of Aluminum Sulphate	Buffer distances (in km)						
Independent variables	2.5	5	10	15	20	25	30
Forest cover with in 2.5 km buffer area	-16.08*** (5.16)	-	-	-	-	-	-
Forest cover with in 5 km buffer area	-	-13.084*** (3.62	-	-	-	-	-
Forest cover with in 10 km buffer area	-	-	-8.68*** (2.65)	-	-	-	-
Forest cover with in 15 km buffer area	-	-	-	-6.90*** (2.29)	-	-	-
Forest cover with in 20 km buffer area	-	-	-	-	-6.987*** (2.32)	-	-
Forest cover with in 25 km buffer area	-	-	-	-	-	-6.982*** (2.316)	-
Forest cover with in 30 km buffer area	-	-	-	-	-	-	-6.982*** (2.316)
Inproduc_tp	-0.44	-0.78	-0.82***	-0.71**	-0.721**	-0.720**	-0.72**
	(0.26)	(0.29)	(0.30)	(0.29)	(0.30)	(0.30)	(0.30)
lnaver_tem	0.15	2.37***	5.57	5.19	5.30	5.31	5.31
	(7.41)	(7.06)	(7.02)	(7.1)	(7.09)	(7.09)	(7.09)
lnrf_annual	-66.42	-61.26***	-56.29**	-54.78**	-54.61**	-54.60**	-54.60**
	(23.37)	(22.81)	(23.02)	(23.23)	(23.22)	(23.22)	(23.22)
lnrf_annual2	4.67	4.33	3.98**	3.87**	3.860**	3.86**	3.86**
	(1.66)	(1.62)	(1.67)	(1.65	(1.65)	(1.65)	(1.65)
rho	0.99	0.99	0.99	0.99	0.99	0.99	0.99

5. Conclusion

Quantitative empirical studies on the impact of forest land use on drinking water treatment chemical cost is very limited in developing countries. In the water sector, it is a common knowledge that with increasing forest cover, water treatment cost decreases. The theory of using cost functions to value

unpriced environmental inputs is used for the econometric analysis through taking the cost functions of each water treatment plants. Panel fixed effects regression is used to analyze the effect of forest cover at watershed level, upstream forest cover and forest cover with different buffer distances on the cost of water treatment chemicals. Aggregate chemical cost of treatment plants is used as short run operating cost which is comprised of main treatment chemicals namely Aluminum Sulphate, Chlorine and Lime. In addition to the aggregate chemical cost, the impacts of forest cover on the cost of one treatment chemical (Aluminum Sulphate) is analyzed. The main reason for the inclusion of the cost of Aluminum Sulphate treatment chemical in the analysis separately is that it is used in all the eight treatment plants in the given time periods unlike the other water treatment chemicals(the other treatment plants which make the aggregate chemical cost are incomplete in either by treatment plant or year).

The study found that with increasing forest cover around water treatments' catchments, the cost of water treatment chemicals significantly decreases. The finding is consistent for both the aggregate water treatment chemical cost and the cost for the single treatment chemical; Aluminum Sulphate. The other important finding is that as buffer distance increases, its contribution to the reduction in treatment cost declines though it still significantly affects the chemical treatment cost. Since improved water supply, sanitation and hygiene is one of the targets of the Growth and Transformation Plan (GTP) of Ethiopia and Sustainable Development Goals, protecting forests at the source of potable water significantly contributes to water purification and hence the reduction of water treatment costs.

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The Effect of Climate Change Adaptation Strategy on Farm Household's Welfare in Nile Basin of Ethiopia: Is there Synergy or Trade Off?[1]

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Abstract

Climate change is affecting different dimensions of human life. The effect is significant for rural farm households in Ethiopia. In response to this, farmers use different adaptation strategies. However, there is a gap in knowledge on the effect of different adaptation strategies on farm household's welfare. This study examines the effect of Crop Diversification (CD), as a climate change adaptation strategy, on farm household's welfare in terms of farm income and demand for labor in Nile Basin of Ethiopia. The study also identified the main determinants of adopting CD. The study explore whether there is synergy or tradeoff between the effect of CD on household income and labor demand. The relationship between Farm household's income and family labor demand are modeled by using Endogenous Switching Regression model (ESRM) containing household and farm characteristics including a set of geo referenced climate variables such as, temperature and growing season rain fall. The analysis is based on farm household data collected in 2015. The result indicates that, climate variables such as, the amount and variability of growing season rain fall and temperature are the most important factors affecting both household's income, demand for labour and adoption of CD. The study also shows that adopting CD is more likely in areas characterized by low rain fall and high temperature. In addition to this the study indicates synergy on the effect of adoption of CD, a positive and significant effect in enhancing farm household's

[1] This study was supported, by the International Development Research Center of Canada (IDRC) through the Ethiopian Development Research Institute (EDRI) and Environment and Climate Research Center (ECRC) so that it is gratefully acknowledged. The views expressed here are those of the authors and do not necessarily reflect the views of the donor or the authors' institution. The usual disclaimer applies.

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income and reducing family labor demand. Adopters benefited more in terms of reduction in labor demand than their non adopter counter parts. The findings of this study confirms that using crop diversification is a win-win climate change adaptation strategy that provides double benefit both in terms of productivity improvement and labor reduction. Thus, the result suggests the adoption of CD in the Nile Basin of Ethiopia to improve the wellbeing of farm household's and to build a resilient agricultural system for the catastrophic effect of climate change.

Key words: Climate change, adaptation strategy, household welfare, crop diversification (CD), Endogenous Switching Regression model (ESRM)

1. Introduction

Climate change is the most crucial problem facing the world. Developing countries are severely affected by climate change because many of these are heavily dependent on agriculture as their source of income which is highly vulnerable for climate change effects. They are also least equipped financially and technically to adapt to changing conditions (UN, 2007; IPCC, 2014). In Africa, many countries are hit hard by severe climate change scenarios. The continent is also highly lagging behind in the adoption of improved technologies like irrigation, capital and high yield varieties. Studies in the continent revealed that by 2100, every nation in Africa will experience the negative climate change impacts. In addition to this, the damage from climate change to African agriculture expected to range from 0.13% to 2% of GDP by the same year (Mendelson, 2000; WB, 2013).

Like other countries, Ethiopia is also suspected of future and current climate change effects. Agriculture is the mainstay of its economy, which accounts for nearly 46% of GDP, 73% of employment, and nearly 80% of foreign export earnings (ATA, 2014). Despite its immense contribution to the overall economy, this sector is challenged by many factors, of which climate-related disasters like drought and floods (often causing famine), are the major ones (Deressa,2007; Ferede *et al*, 2014). Temperature is projected to increase by 1.7-2.7^{o}c in the year 2050, which is very damaging and dangerous. Besides, GDP of the nation will be 10% lower compared to the no climate change

scenario (Yibeltal. *et al*, 2013; Sherman *et al*, 2012). In the literature it is thought that taking adaptation measures will be a relief for the overwhelming effect of climate change. However, the practice of taking climate change adaptation measures is very low in Ethiopia. . In the study area, Agriculture is highly rain-fed for many households with only 0.6% using irrigation water to grow their crops. 58% of farm households are not practicing adaptation measures for climate related shocks (Difalco et al, 2011; Ferede *et al*, 2014; and Bewket *et al*, 2015). The promotion of practicing different climate change adaptation strategies is mainly aimed at increasing the productivity of poor rural farmers. This helps to attain food security and alleviating poverty. However, a great caution should be given for the appropriateness of the strategies for the existing socio economic context of the adopters. Some strategies require complementary inputs that can compromise the benefits generated from the yield enhancing capacity of the adaptation strategy, while others boost farm productivity without bearing additional input costs. Crop diversification provides many yield enhancing benefits like increasing soil fertility, breaking the life cycle of pests; and improving weed suppression (Altieri, 1999; Di Falco et al., 2010; Jhamtani 2011; Liebman and Dyck, 1993; Tilman et al., 2002; Woodfine, 2009). Dispite its immense contribution to boost agricultural productivity its implication on farm household's welfare is not yet investigated.

Thus, in this paper we analyze the effect of crop diversification on rural farm household's welfare by considering the two dimensions of welfare; labor demand and net farm income. Specifically it has the following objectives,

- To examine the effect of climatic variables and other socioeconomic factors on the decision of Adopting Crop Diversification.
- To examine the differential effect of climate variables and other socio economic factors on farm income and household labor demand among adopter and non adopters of CD
- To explore the farm income and labor demand implications of Crop Diversification
- To show whether there is synergies and tradeoff between the joint effects of crop diversification on the two dimensions of household welfare (family labor and farm income).

This paper adds to existing literature on climate change adaptation strategies and impacts on household's welfare in the following ways. First, we investigate (for the first time, as to our knowledge) the existence of synergy or tradeoff opportunities of crop diversification in affecting the two dimensions of welfare (net farm income and labor demand). Second, we analyzed the effect of climate variables on farm household's welfare by using geo referenced climate data by taking growing season rainfall for the first time. Our third contribution is that the study investigates the heterogeneous effect of climate change adaptation strategy on farm household's welfare between adopters and non adopters. Previous studies consider that climate change adaptation strategies have homogenous effect. However, this approach is in appropriate since the effect of adaptation strategies is different for adopters and non adopters.

The rest of the paper is organized as follows. Section 2 provides a brief description of the data. Section 3 presents a conceptual and econometric framework for adoption selection model and estimation of average treatment effects. This is followed by a presentation of the empirical specifications of our estimation model. In Section 5, we discuss our estimation results. The final section concludes and draws key findings and policy implications.

2. The Data and Definitions of Variables

The study have used primary data which has been collected using structured questionnaire on 929 farm households and 4778 plots within the Nile basin of Ethiopia by ECRC/EDRI in 2014/15. The collected data comprises household characteristics, land characteristics, credit, social capital, and perceptions on climate change. The sampling frame considered traditional typology of agro-ecological zones in the country (namely, Dega,Woina-Dega, Kolla and Berha). Percent of cultivated land, degree of irrigation activity, average annual rainfall, rainfall variability, and vulnerability (number of food aid dependent population) were the set of characteristics by which the frame was developed to select sample districts purposely. The sampling frame selected woredas[2] in such a way that each class in the sample matched to the proportions for each class in the entire Nile basin of Ethiopia. Having these, twenty woredas were selected purposely and simple random sampling was then used in selecting

one village from each woreda and fifty households from each village. . One of the survey instruments was in particular designed to capture farmers' perceptions and understanding on climate change, and their approaches for adaptation.

Table1: Definition and summary statistics of variables used in the analysis

Variables	Variable description	Non adopters		Adopters	
		Mean	S.D	Mean	S.D
Household Characteristics					
FMSIZ	Family size (Adult Equivalent)	7.60	0.3	7.90***	0.31
AGE	Age of the head	50.59	12.69	52.34***	12.81
MARITALSTA	1 = for married)	0.87		0.83***	
REMITTANCE	1= the household receive remittance	0.81		0.12	
OFFFAR M	1= the household participate in off farm activity	0.22		0.18***	
GENDER	1= if the head is male	0.87		0.88**	
EDUCTHEAD	Years of education of the head, Number	2.06	3.13	1.65***	2.85
Assets and institutional factors					
VPFA	Total value of productive farm assets (ET Birr)	11849	1.43	12456.53*	0.63
FARMSIZE	Farm size(ha)	1.60	0.68	1.80*	0.63
TLU	Livestock herd size (in tropical livestock unit)	4.63	3.69	4.92***	3.5
CREDIT	1 = Credit constrained credit is needed but unable to obtain	0.44		0.43	
FARMSUPPORT	1= if the household get farm support	0.08		0.07	
TENURE	1= if the land is certified	0.8		0.87***	
GOVERNMENT EXTENSION	1= if the household get government extension service about Crop Diversification	0.57		0.43	
MEDIA INFORMATION	1= if the household get media information about Crop Diversification	0.26		0.19***	

INPUTMARKTDIST	Walking distance to input markets , minutes		50.02	0.12	50.00	0.12
ORGANIC FERTILZER	Amount of manure used in that specific plot, kilo gram		0.3		0.29***	
PESTICIDE	Amount of pesticide used in that specific plot, Liters		0.1	0.69	0.12	0.65
Plot characteristics						
PLOTDIST	Plot distance from home, minutes		1.74	1.43	1.92***	1.43
SLOPE	Slope of the plot	1= Flat	0.60		0.61**	
		2 = medium	0.39		0.34***	
		3 = steep	0.01		0.05	
FERTILITY	Fertility of the plot	1= highly fertile	0.14		0.11**	
		2= medium fertile	0.53		0.49***	
		3 = infertile	0.33		0.39	
SHOCKIND[4]	Index of shocks faced the household (Numbers)		0.10	0.06	0.30	0.04
Climate variables						
TEMP 0013	Average annual temperature (^{0}c) 2000-2013		20.02	2.55	19.92*	2.58
RAINFAL0013	Average growing season rainfall 2000-2013 (mm)		753.45	233.75	681.89***	230.79

Note: A test used to compare the means of explanatory variables between (adopters) and non-adopters under the assumption of unequal variance. SD is standard deviation;

* Denotes significance level at 10%.

** Denotes significance level at 5%.

*** Denotes significance level at 1%

[4] Shock index is calculated by dividing shocks happened in a plot to the seven shocks which are given to farmers as alternative to answer whether they are happened or not. These shocks are drought, flood, erratic rainfall, pattern animal attack, landslide, hailstorms, and other shock specified by the respondent. And shock index is calculated by dividing the total number of shocks faced by that farm household at the considered specific plot by seven. As the shock index goes to 1 it indicates that the considered plot is affected by many shocks.

3. Conceptual and Econometric Framework

The conceptual frame work of this study is dated back to the study of Roy (1951). In his study, Roy tries to show how individual's self selects themselves between two different occupations, hunting and fishing based on their comparative advantage. The decision to participate in either of the two occupations is conditional on the benefit that will be generated from the occupations (Maddala, 1986).

Similarly farm households will practice a given adaptation strategy by their own will. Households will self select in their decision to adopt a given strategy. However, the decision to practice a given adaptation strategy will depend on the expected utility of adoption. The farmer will practice a given adaptation strategy if the utility from that strategy is greater than the remaining strategies. Thus, the decision for taking adaptation strategies can be modeled in a random utility framework (Difalco, 2011; A, 2010; Kassie et al, 2011).

Let difference in utility from adoption (u_h,A) and non adoption (u_h,N) is denoted by T*. But the utilities are unobservable. To do so let we represent by the following latent variable model (observable function).

$$T_h^* = \beta_{Zh} + \mu_h, T_h = 1 \quad if \ \ Th* > 0 - \qquad (1)$$

Where $T_h^* = U_{hA} - U_{hN}$

T= 1 if a farmer practice at least one of the given adaptation strategies

T= o otherwise

β = vector of parameters

Z = vector of explanatory variables

μ = is the error term

Now if we assume the relationship between agricultural productivity and adaptation strategies is linear,

$$Y_h = \gamma X_h + \delta T_h + \varepsilon_h \qquad (2)$$

Where,

T- The indicator of the adoption decision

γ & δ - are vectors of parameters to be estimated and ε is the error term.

If we run the above regression the coefficient of adoption isδ, which measures the impact of practicing a given adaptation strategy/ies on the outcome variable. Yet, this measurement is not accurate. To be taken as an appropriate measure the decision to practice adaptation strategies should be random. In other words, the groups of adopters and non adopters should be randomly assigned. But in the case of practicing climate change adaptation measures farmers will decide to practice each adaptation strategy by their own consent. There is the problem of self selection which leads to selection bias. The decision for taking a given adaptation measure is likely to be affected by unobservable characteristics like, managerial skill, average land fertility, motivation etc that may be correlated with the outcome of interest.

When we look from the regression perspective it is similar with saying that ε is correlated with T orμ. If this is the case, the specified equation above failed to account self selection, ending up with a biased result.

Therefore, the appropriate approach is to follow a model that takes in to account selection bias correction. In the literature of selection model different bias correction methods had been flourished. Mainly the works of Lee (1983), Dubin and Mc Fadden (1984), and semi parametric alternatives proposed by Dahl (2002) are noticeable. However, the method given by Dubin and Mc Fadden are highly preferable to other methods as shown by Borguignon et al (2007).

In this study an Endogenous Switching Regression Model (ESR) with the Dubin and Mc Fadden method, which is improved by Borguignon et al (2007)[5] is implemented. This is to be in line with recent advances in the area and to lend the outcomes of this study for comparison with previous studies. Recently the approach is used by many researchers (Difalco 2011; Kassie et al, 2014; Teklwold et al, 2013; Difalco et al 2010).

[5] See Bourguignon et al (2007) for detail derivations of the specifications and the comparisons between different selection bias correction methods

3.1 Adoption Selection Model

A representative farm household will chooses to adopt CD if the expected utility from adopting is greater than the expected utility of not adopting. Now let A□ be the latent variable that captures the expected benefits from CD practice choice with respect to not practicing. Finally the criterion (selection) equation is described as follows:

$$A_i^* = X_i\beta + \varepsilon_i, \text{with } A_i = \begin{cases} 1 \text{ if } A_i^* > 0 \\ 0 \text{ other wise} \end{cases} \qquad (3)$$

Farm household *i*, will choose to practice CD (A_i=1) in response to long term changes in mean temperature and rainfall if$A_i^* > 0$, and will not practice otherwise. The vector X represents variables that affect the likelihood to practice such as the characteristics of the operating farm; farm head and farm household's characteristics; the presence of assets; past climatic factors; the experience of previous extreme events; whether farmers received information on CD; government and farmer-to-farmer extensions, which can be used as measures of access to information about adaptation strategies and other institutional factors such as credit and land tenure.

In overcoming the standard econometric method of using a pooled sample of CD adopters and non-adopters, endogenous switching regression model framework for household net farm income which is peroxied by the net revenue per hectare is employed. Accounting for endogienety and selection biases this measure can then be elicited in to two estimable functions where farmers face two regimes. (1) To practice CD, (2) not to practice and is defined as follows;

$$\begin{cases} \text{Regime 1} \square\ Y_{1i} = Q_{1i}\alpha_{1i} + \mu_{1i} \quad \text{if } A = 1 \text{ - - - - - - - - - - - - } (4) \\ \text{Regime 2} \square\ Y_{2i} = Q_{2i}\alpha_{2i} + \mu_{2i} \quad \text{if } A = 2 \text{ - - - - - - - - - - - } (5) \end{cases}$$

Where Y_i is the outcome variable which is farm household's net farm income in the two regimes and Q_{1i} and Q_{2i} represents a vector of exogenous variables

such as the past climatic factors, inputs, assets, farm households and plot characteristics included in X. α_{1i} and α_{2i} are vectors of population parameters that will be estimated in the model using the survey data. Further our model relies on the assumption that the error terms in equations (3), (4) and (5) have a trivariate normal distribution, with zero mean and covariance matrix of:

$$\begin{pmatrix} \delta_1^2 & \delta_{1\varepsilon} & \delta_{2\varepsilon} \\ \delta_{1\varepsilon} & \delta_2^2 & * \\ \delta_{2\epsilon} & * & \delta_\varepsilon^2 \end{pmatrix}$$

Where δ_1^2 and δ_2^2 are variances of the stochastic disturbance terms in the regime functions in equation (4) and (5). δ_ε^2 Is the variance of the stochastic disturbance term in the selection equation shown as equation (3). □ represents the covariance of the stochastic disturbance terms in equation (4) and (5) while it is not determined as Y_{1i} and Y_{2i}cannot be observed simultaneously. $\delta_{1\varepsilon}$ is the covariance of the error term of selection equation (ε_i) and the outcome equation of regime one(μ_{1i}). Likewise, $\delta_{2\epsilon}$ represent the covariance of the stochastic disturbance terms in the selection equation and the outcome equation of regime two (μ_{2i}). The variance for the error term in the selection equation (δ_ε^2) is assumed to be 1, since the coefficients are estimable only up to a scale factor (Maddala, 1983).

An important implication of the error structure is that, because the error term of the selection equation (4) ε_i is correlated with the error terms of the regime equations (5) and (6) which are

μ_{1i} and μ_{2i} the expected values of these two error terms conditional on the sample selection are nonzero.

Mathematically; $[\mu_{1i}|A_i=1] = \delta_{1\varepsilon}\frac{\phi(X_{i\beta})}{\Phi(X_{i\beta})} = \delta_{1\varepsilon}\lambda_{1i}$ and

$[\mu_{2i}|A_i=0] = -\delta_{2\varepsilon}\frac{\phi(X_{i\beta})}{1-\Phi(X_{i\beta})} = \delta_{2\varepsilon}\lambda_{2i}$where ϕ (.) Is the standard normal probability density function, Φ(.) the standard normal cumulative function, $\lambda_{1i} = \frac{\phi(X_{i\beta})}{\Phi(X_{i\beta})}$ and $\lambda_{2i} = -\frac{\phi(X_{i\beta})}{1-\Phi(X_{i\beta})}$ If $\delta'_{1\varepsilon}$ and $\delta'_{2\varepsilon}$ (estimated covariances) are statistically significant the decision to practice CD and household's welfare

are correlated which becomes an evidence for endogenous switching and in turn indicates the existence of sample selection bias. The above model described by equations (3) through (5) is known as a "switching regression model with endogenous switching" (Maddala and Nelson, 1975).

The commonly used approach to estimate models that involves self selection is by following the two stage procedure. However, this method is in appropriate and highly criticized. Because it requires some adjustment to derive consistent standard errors and it shows poor performance when there is high multicollienarity between the covariates of the election equation and the covariates of the outcome equation (Maddala, 1983). The appropriate and efficient method to estimate endogenous switching regression models is full information maximum likelihood (FIML) estimation. This method is very preferable to other approaches in many instances. First it is feasible with available software, it provides efficient estimate, in addition it allow restrictions to be applied and permit construction of likelihood ratio tests on the restriction (Lee and Trost, 1978; Winship et al., 1988). When similar variables affect the adoption decision (X) and the subsequent outcome equations (Q), lack of identification of the model will be a problem. Because, even though non linear correction terms are included, this may not be enough and resulting in to the problem of multicollienarity (Khanna, 2001; Wu and Babcock, 1998). To overcome this problem finding an instrumental variable is very tedious and impossible (if not). Therefore, in order to assure the admissibility of the model, we have used exclusion restrictions. These variables are hypothesized to affect directly the selection variable but not the outcome variable. Variables related to information sources like, government extension, farmer to farmer extension, and information from radio, and input market distances are used in the welfare function. The admissibility of these instruments is be established by performing a simple falsification test. i.e., if a variable is valid selection instrument then it will affect the decision of choosing an adaptation strategy but it will not affect the net revenue per hectare among farm households that did not adopt. The logarithmic likelihood function given the previous assumptions regarding the distribution of the error terms is:

$$lnL_i = \sum_{i=1}^{N} A_i \left[\ln \phi\left(\frac{\varepsilon_{1i}}{\delta 1}\right)\right] - ln\delta_1 + ln\Phi(Y_{1i}) + (1 - A_i)\left[\ln \phi\left(\frac{\varepsilon_{2i}}{\delta 2}\right) - ln\delta_2 + \ln (1-\Phi Y2i)\right] \quad \textbf{(6)}$$

Where $Y_{ij} = \frac{(X_{i\beta\rho_{ji}/\delta_1})}{\sqrt{1-\rho_j^2}}$ j = 1, 2 with ρ_j = the correlation coefficient between ε_i (the error term of the selection equation) and the error term μ_{ji} of the outcome equations (5) and (6), accordingly.

3.2 Estimation of Average Treatment Effects and counter factual analysis

ESR mode is very important model to compare the expected welfare of farm households that practice CD (7a) to farm households that did not adopt (7b). In addition to this, it is also possible to investigate the expected farm household welfare in the counterfactual case. That is, when farm households who have practiced CD did not practice (8a), and when farm households that had not adopted did adopt (8b). Following this approach not only solves selection bias due to unobserved heterogeneity, it also controls for selection bias due to observed heterogeneity.

The conditional expectations for household welfare in the four cases can be expressed as:

Adopters with adoption (actual adoption observed in the sample):

$$E\left(\frac{Y1i}{Ai} = 1\right) = Q_{1i}\alpha_1 + \delta_{1\varepsilon}\lambda_{1i} \quad \textbf{(7a)}$$

Non adopters without adoption

$$E(Y2i/Ai = 0) = Q_{2i}\alpha_2 + \delta_{2\varepsilon}\lambda_{2i} \quad \textbf{(7b)}$$

Adopters had they decided not to adopt

$$E(Y1i/Ai = 0) = Q_{2i}\alpha_1 + \delta_{1\varepsilon}\lambda_{2i} \quad \textbf{(8a)}$$

Non adopters had they decided to adopt

$$E(Y2i/Ai = 1) = Q_{1i}\alpha_2 + \delta_{2\varepsilon}\lambda_{1i} \quad \textbf{(8b)}$$

The expected values derived above helps to calculate unbiased estimates of TT. We can define the treatment effects as the difference between $(7a)$ and $(8a)$ or $(7b)$ and $(9b)$ i.e,

$$TT = E(Y1i/Ai = 1) - E(Y2i/Ai = 1)$$
$$TT = Q_{1i}(\alpha_1 - \alpha_2) + (\delta_{1\varepsilon} - \delta_{2\varepsilon})\lambda_{1i} \quad \textbf{(9).}$$

By following similar procedure we can also calculate the effect of adoption on the non adopters (TU) which is the difference between $8(b)$ and $9(b)$. i.e.,

$$TU = E(Y1i/Ai = 0) - E(Y2i/Ai = 0)$$
$$TU = Q_{2i}(\alpha_1 - \alpha_2) + (\delta_{1\varepsilon} - \delta_{2\varepsilon})\lambda_{2i} \quad \textbf{(10)}$$

The difference between (TT) and (TU) in equation (10) and (11) represents the so called "transitional heterogeneity" (TH) which indicates whether the effect of practicing CD is larger or smaller for the adopters than for the non-adopters.

4. Empirical Results

4.1 Factors Explaining the Adoption of Crop Diversification (CD)

The probit results of Endogenous Switching Regression model is presented in table 2 below. The model best fits the data reasonably well. The Wald test that all regression coefficients are jointly equal to zero is rejected [Wald chi2 (41) = 364.47; p = 0.000]. The results show that the estimated coefficients differ substantially across adopters and non adopters of Crop Diversification. Many variables are found significant determinants of using crop diversification. Emphasis is given for those significant variables.

An increase in mean temperature decreases the likelihood of adopting CD, which implies at lower temperature there is lower rate of adopting CD. However, this effect will be wiped out after some threshold level. This is indicated by the positive sign of average temperature square.

When the average temperature increases adoption of CD will be lower till some point and latter on the likelihood of adoption will increase with temperature. This shows that, CD will be effective at higher temperature and

lowland areas. This could be emanated from the moisture conservation potential of CD.

In similar vein, the relationship between average growing season rainfall and its square with adoption of CD is found non linear. When average rainfall increases the probability of adopting CD will increase continuously, but after some optimal level this relationship will become reversal. This is also evidence that supports the effectiveness of CD in low rainfall areas. Since CD conserves huge moisture adoption will be fruitful when the areas are drearier. The result of Teklewold et al (2013) also states that adoption of crop system diversification is high in areas where rain fall is favorable in its timing, distribution and amount.

Furthermore, the variability of rain fall and temperature are also found the significant determinants of CD adoption. According to the model results rainfall as well as temperature variability increases the likelihood of adopting CD. When there is high rainfall variability farmers will need a way to avoid its negative consequence. By using CD they can be benefited more and smooth their farm productivity; as CD provide enough moisture and boost soil fertility.

Though it is in significant the sign of the fertility is found as per the expectation of the study. When plot fertility increases the probability of adopting CD will decline. Because, CD might appropriate for poorly fertile plots to augment the productivity of the plot by increasing its moisture content and the fertility of the soil. Similar study in SNNP of Ethiopia by Rahima *et al* (2013) has found the same result. The study indicates that, the positive relationship might because fertile plot is promising to increase production and yield. The distance of the plot from the home stead is also found the other determining factor for adoption. Accordingly, the further the farm plot from the home stead the probability of adoption is higher and the reverse is true for nearly home stead plots. Assets of farm households including TLU, VPFA, and farm size are also included in this study as a determining factor. When VPFA is found a significant determinant of adoption, the remaining two are insignificant. When the amount of available productive farm asset increases the probability of adoption is found higher. Mesfin *et al* (2011) also found the

same result with this study however in contradict with the study by Benin *et al* (2004).

On the other hand, larger farm size contributes negatively for adoption of CD. This has actually an important implication. It indicates that, the best way to increase productivity is intensification than extensive farming. Probably farmers tend to increase farm income and household welfare by intensifying production. Farmers will increase their crop yield through intensification by using different yield enhancing strategies like, crop diversification at lower farm size. A similar result was found by Teklewold *et al* (2013) in Ethiopia.

The institutional factors considered in this study are credit constraint, land tenure, and farm support. Compared to farm households with credit access credit constrained households have found a higher chance of adoption. This is because credit is knowledge intensive and used mainly to control pest, crop diseases, and increasing soil fertility. Since it provide finance to buy pesticide, herbicides and fertilizer. But crop diversification can be a substitute for credit by controlling pest and weeds as well as by increasing soil fertility through increasing organic content of the soil (Lin, 2011). This reduces farmers cost of buying inputs and fertilizer. Due to this credit constraint farmers are highly exposed for adoption of CD. The results of Asfaw (2010); Teklewold *et al* (2013) also support this argument.

Table 2: Parameter estimates of adoption of CD — A Probit selection model

Model	**Endogenous Switching Regression**					
Dependant variable	Wald chi2 (41) = 364.47 Log pseudo likelihood = -14166.533 Prob >chi2 = 0.0000					
	Adoption of CD		**Household income for adopters of CD**		**Household income for non adopters of CD**	
	Column 2		**Column 3**		**Column 4**	
Adoption of CD	Coefficient	Robust Std.Err	coefficient	Robust Std.Err	coefficient	Robust Std.Err
Explanatory variables						
Climate variables						
Average rainfall	0.01***	0.001	-0.009*	0.003	-0.01**	0.007

Average temperature	-3.46***	0.49	6.65**	2.79	5.33***	1.12
Rain fall square	-0.001***	0.001	0.009	0.005	0.0001	0.008
Temperature square	0.09***	0.01	-0.16**	0.07	-0.13***	0.02
CV temperature	18.27***	6.84	25.23***	13.49	-70.22**	33.34
CV rain fall	6.15***	0.92	-6.44***	1.96	-8.25*	4.39
Household Characteristics						
Age	-0.005*	0.01	0.06**	0.02	0.08	0.05
Age square	0.002	0.009	-0.006**	0.002	-0.008*	0.004
Marital status	-0.03**	0.01	-0.10**	0.04	-0.03	0.07
Education	0.006	0.008	-0.02	0.01	0.01	0.03
Log household size	-0.03	0.07	-0.36**	0.16	-0.87***	0.30
Remittance	0.14**	0.06	-0.17	0.14	0.02	0.27
Off farm employment	0.11**	0.05	-0.15	0.12	-0.25	0.21
Gender	0.004	0.07	-0.20	0.19	-0.16	0.29
Plot Characteristics						
Fertility index	-0.02	0.12	-0.18	0.28	0.90*	0.51
Slope index	0.22	0.15	-0.13	0.33	-0.42	0.57
Shock index	0.55*	0.33	0.29	0.78	-0.25	1.45
Log plot distance	0.08***	0.01	-0.05	0.03	-0.05	0.07
Organic fertilizer	0.09*	0.05	0.08	0.11	0.17	0.21
Assets						
Log VPFA	0.03**	0.01	-0.03	0.03	-0.05	0.06
TLU	0.006	0.007	-0.07***	0.02	-0.09***	0.03
Log farm size	-0.007	0.04	-0.42***	0.10	-0.42*	0.16
Institutional factors						
Credit	-0.03	0.04	0.20**	0.09	0.35**	0.18
Farm support	-0.11	0.07	-0.27	0.19	0.03	0.30
Land Tenure	0.33***	0.06	0.36**	0.16	0.13	0.24
Crop type						
Barley	-0.18**	0.077	-0.84***	0.15	-0.39	0.31
Teff	-0.18**	0.09	0.56***	0.21	0.06	0.42
Maize	-0.35***	0.05	-0.73***	0.11	-0.66***	0.25
Sorghum	0.24**	0.11	-1.20***	0.22	-1.25**	0.55
Sample size	4778		3477		1301	

4.2 Average Adoption Effect of Crop Diversification

Table 3 presents the average effect of adoption of Crop Diversification on farm income and family labor. The number in the first row first cell of table 9 is the average income value (3715.63) for adopters of CD. The number in the

second cell (3137.23) indicates the average net farm revenue for adopters in the counterfactual case. Then the adoption effect on adopters can be found by subtracting the second from the first (578.54***). The result is positive and significantly different from zero. This suggests that, farm household's income for those who adopted CD is significantly higher than if they did not adopt. By using similar procedure the adoption effect of CD on non adopters can be calculated from the same table. In the second row first cell of the following table we get the value of net farm income for non adopters in the counterfactual case, while the second cell in the same row represents the same value in the actual case. Then by taking the difference between the first and the second cell we can get farm income of non adopters (1566.55***). The result indicates that, farm income will increase significantly if they adopt CD than the actual case of non adoption. Similar studies by Difalco (2011); Kuntashula *et al* (2014); Bhattacharyya (2008); Bradshaw *et al* (2004) also reported the same result with our study.

Table 3: Adoption Effects of CD on Net Farm Income

Decision stage			
	Adopters	**Non adopters**	**Adoption effect**
Adopters	3715.63 (59.92)	3137.23 (93.47)	TT= 578.54*** (113.45)
Non Adopters	2966.75 (80.9)	1400.20 (23.46)	TU = 1566.55*** (62.62)
Heterogeneity Effect			TH = -988.01

Note: TT=Adoption effect for adopters, TU= Adoption effect for non-adopters, TH (TT-TU) = transitional heterogeneity. ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level.

By following a similar procedure like the farm income analysis the average expected farm household's labor in the actual and counterfactual case is estimated for both adopters and non adopters. This estimation helps to know specifically the treatment effect on adopters (TT), treatment effect on non adopters (Tu) and also the transitional heterogeneity (TH).

The number in the first row first cell of table 3 is the average family labor (32.85) for adopters of CD. The number in the second cell (90.67) indicates

the average household labor for adopters had they been non adopter. Then the adoption effect on adopters can be found by subtracting the second from the first (-57.82***). The result is negative and significantly different from zero. This indicates that, farm household's can save 57.82 number of person days/hectare by adopting CD.

By using similar procedure the adoption effect of CD on non adopters family labor use can be calculated from the same table. In the second row first cell of table (4) we get the value of farm household's labor for non adopters in the counterfactual case, while the second cell in the same row represents the same value in the actual case. Then by taking the difference between the first and the second cell we can get farm household labor use of non adopters (-14.29***). The result shows that, Non adopter farm household's can get an advantage of family labor reduction amounted 14.29 person days per hectare if they adopt CD. This is in line with the works of Teklewold *et al (2013).*Finally the last cell in the second column gives the value for transitional heterogeneity (TH). This value is negative and significantly different from zero (-43.53) implying by adopting CD adopters are more benefited than the non adopters albeit both are beneficiaries from adoption.

Table 4: Adoption Effects of CD on family labor demand

Decision stage			
	Adopters	**Non adopters**	**Adoption effect**
Adopters	32.85 (0.30)	90.67 (1.43)	TT= -57.82*** (1.00)
Non Adopters	17.76 (0.15)	32.05 (0.51)	TU = -14.29*** (0.40)
Heterogeneity Effect			TH = -43.53

Note: TT=Adoption effect for adopters, TU= Adoption effect for non-adopters, TH (TT-TU) = transitional heterogeneity. ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level

5. Is there synergy or tradeoffs?

Either synergy or tradeoff is expected to happen between increasing farm household's welfare by boosting productivity and the extra labor burden on the household labor use which is resulted from the adoption of Crop diversification. Therefore, in this section the results that indicate whether there is synergy or tradeoffs are discussed. In this study synergy and tradeoffs are defined as follows. Synergy will occur if crop diversification increase net farm income without adding extra labor demand on the household. On the other hand tradeoff is when crop diversification increase both farm income and family labor use.

Based up on the above common understandings, the study revealed that crop diversification not only reduces the total per hectare family labor use but also it increases net farm income. Therefore, it can be taken as a best strategy to maximize household's welfare both in terms of leisure (measured by the reduction in family labor) and net farm income.

As we can see the results in table 3 and 4, adoption of CD increase farm income by 578.54 birr per hectare for adopters and 1566.55 birr per hectare for non adopters had they been adopters. By the same taken the reduction in family labor due to adoption of CD is found 57.82 number of person days for adopters and 14.29 for non adopters had they been adopters. In both of the two cases the result indicates the double benefit of adopting crop diversification and they are statistically significant.

Therefore, the bottom line is using crop diversification as an adaptation strategy can rescue the effect of climate change. Indeed it better improves farm household's welfare by increasing their farm productivity and minimizing the total family labor use. This confirms that, crop diversification has a synergetic effect by increasing farm household's welfare through increasing net farm income and reducing family labor that can provide extra time for leisure.

6. Concluding Remarks

The general objective of this study is to examine the effect of crop diversification on farm household's welfare. Specifically, it addresses the determinants of adopting CD, family labor use and net farm income. Synergies and trade offs are also explored. For the attainment of these objectives, the study used the 2015 survey database on 929 farm households collected in Nile Basin of Ethiopia by ECRE/EDRI. Our final analysis includes 4778 plots. In order to estimate the adoption effect on farm income along with the determinants of household net farm income and the adoption decision, simultaneous equation model which can capture the unobservable heterogeneity and selection bias was estimated. The following main conclusions can be drawn from the results of the study.

First, it was found that climate variables, household characteristics, and input market distance are the main determinants of adopting CD. The effect of both average growing season rainfall and temperature are found non linear. When temperature increases the likelihood of adoption declines up to some point but after maximum temperature the probability of adoption will decline. Off farm employment, remittance and marital status are also the key household characteristics that determine likelihood of adoption significantly.

Second, Crop diversification is found to be adopted in plots which are located in further distance to home stead and have tenure security. Plots that are far from the home stead fails to get manure and other wastes that can serve as an organic fertilizer. Indeed farmers cannot visit continuously due to their distance problem. In the same vein, the uncertainties of losing plot in the mean time discourage farmer's adoption behavior.

Third, for both adopters and non adopters diversifying crop can spur farm households welfare had they decided to adopt than they would if they had not adopt it. In addition, non adopters can get a largest payoff relative to adopters if both of the two groups decided to adopt.

Forth, the average treatment effect of adopting CD on family labor use is also significant for both adopters and non adopters had they been adopters. By

adopting diversification of crop, farmers reduce work load on their family and allowed to get extra time for leisure and other activities. In relative terms, the adopter's labor reduction is larger than the non adopters.

Finally, adoption of crop diversification has provided a double benefit for both adopters and non adopters. For both groups it can reduce family work load and increases the wellbeing of farm households at a time. More importantly, by adopting CD there is synergy than tradeoffs. This has an important policy implication. The current agricultural extension program should focus on the promotion and back-up of adopting CD to rescue rural farmers from the destructive effect of climate change. Even though both adopters and non adopters are benefited from adoption of CD, the extent of the treatment effect is not same and similar. This is an indication of the existed discrepancy between the two groups. So policy makers should take in to consideration this heterogeneity when they are attempting to advance the relevance of CD so as to unleash the full potential benefit of the practice.

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