Mekelle University

College of Business and Economics

Department of Economics

The Impact of International Potato Center's Nutrition Project on Smallholder farmers' Income and Adoption of Improved Potato Varieties: Tigray region, Northern Ethiopia

Prepared by: Teklemariam Tebabal Misikir

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Principal Advisor: Mesfin Tilahun (PhD)

Co-Advisor: Mohammed Adem (MSc)

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Declaration

I, **Teklemariam Tebabal Misikir**, do declare that the thesis entitled **"The Impact of International Potato Center's Nutrition Project on Smallholder farmers' Income and Adoption of Improved Potato Varieties: Tigray region, Northern Ethiopia",** submitted to the department of Economics, Mekelle University, in partial fulfillment of the requirements for the award of Master of Science in Economics, is my original work and it has not been presented for the award of any other degree, diploma or certificate. Sources of materials used for this thesis have been dully acknowledged.

Name: Teklemariam Tebabal Misikir

ID. No: CBE/PR: 033/05

Signature: _____.

Date of Submission: 17.06.2014

Place: Mekelle University, Tigray, Ethiopia

Certification

This is to certify that this thesis entitled **"The Impact of International Potato Center's Nutrition Project on Smallholder farmers' Income and Adoption of Improved Potato Varieties: Tigray region, Northern Ethiopia"** is a genuine work of **Mr. Teklemariam Tebabal Misikir (Id. No. CBE/PR: 033/05)**, who carried out the research under my guidance. Certified further, to the best of my knowledge, the work reported here does not form part of any project report or thesis on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

1. Mesfin Tilahun (PhD)	_____	17.06.2014 .
(Principal Advisor)	Signature	Date
2. Mohammed Adem (MSc)	_____	17.06.2014 .
(Co-Advisor)	Signature	Date

Abstract

Achieving national food security is one of the major challenges currently facing developing countries like Ethiopia. Despite the high production potential and the nutritional importance of the crops, potato and sweetpotato producers particularly smallholder farmers have not economically benefited much from their production. The nutrition project had been implemented by CIP-Ethiopia and was intended to encourage the production and consumption of the two crops using improved varieties. In view of that, the objectives of this study were: to assess the impact of the project on smallholder farmers' income as well as to identify the factors that affect the adoption of improved potato varieties. For this study, 150 sample households were selected by international potato center and the baseline data was collected between 28th June and 12th July 2011 before the intervention, 100 were participants in the project whereas 50 were non-participants. The follow-up data was collected last December 2013. While the difference in differences estimation procedure was implemented in assessing the impact, the logistic regression was employed to identify the determinants of adoption of improved potato varieties. The results showed that the project has resulted in bringing a significant income improvement in the treatment group i.e. the mean income difference in the treated group before and after the treatment was significantly greater than the corresponding mean income difference of the control group. This is true in terms of total income, potato income as well as sweetpotato income. On the other hand, six of the covariates used in the logistic regression function to find out the determinants of adoption of improved potato varieties were found to be significant. These include education level of the household head, access to extension services, participation in off-farm activities, participation in the project, having radio and cell phone are found to be positively and significantly related with adoption.

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I would first like to thank my advisor **Dr. Mesfin Tilahun** for his invaluable time sacrificed to this thesis which came in different ways. His intellectual guidance and constructive comments were among others. His encouragement during my work was undoubtedly beyond these words could say.

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Acronyms

ARARI	Amhara Regional Agricultural Research Institute
BoARD	Bureau of Agriculture and Rural Development
BW	Bacterial Wilt
CDF	Cumulative Distribution Function
CIP	International Potato Center
CLF	Cumulative Logistic Function
CSA	Central Statistical Agency
DID	Difference in Differences
EIAR	Ethiopian Institute of Agricultural Research
FAOSTAT	Food and Agriculture Organization Statistics
FEWSNET	Famine Early Warning Systems Network
Ha	hectare
HH	Household
HYVs	High Yielding Varieties
MoARD	Ministry of Agriculture and Rural Development
OLS	Ordinary Least Squares
P	Potato
RWH	Rainwater harvesting
PSNP	Productive Safety Net Program
SP	Sweetpotato
t	ton
TOT	Total
VAD	Vitamin A Deficiency

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I. Introduction

1.1 Background of the Study

1.1.1 Agriculture and Potato in Ethiopia

Agriculture is the mainstay of the Ethiopian economy. It generates over 45 percent of the GDP and 90 percent of the total export earnings of the country. Moreover, about 85 percent of the Ethiopian population, residing in the rural area, is engaged in agricultural production as a major means of livelihood. However, the agricultural productivity is low due to use of low level of improved agricultural technologies, risks associated with weather conditions, diseases and pests, etc. In addition, due to the ever increasing population pressure, the land holding per household is declining leading to low level of production to meet the consumption requirement of the households (Belay, 2003; Bezabih and Hadera, 2007).

A close look at the performance of the Ethiopian agriculture reveals that over the past three decades it has been unable to produce sufficient quantities to feed the country's rapidly growing human population (Belay, 2003). To ensure food security, the country needs to improve its agricultural sector in sustainable manner. It is for this matter that the Ethiopian rural development policy and strategy document has given weight to follow diversification and specializations in production systems, as one of the strategies to ensure households food security.

In Ethiopia, potato production could fill the gap in food supply during the―hungry months of July to August before the grain crops are being harvested. Potato in Ethiopia is currently planted in around 164,146 hectares producing an estimated total tuber yield of 940,087 tons. This implies that average yield in the country reaches only 7 t/ha when the potential for small holder is around 25 t/ha. There are many factors that have been identified as the causes for this low yield in Ethiopia and most of the East African countries, but the lack of high quality seed seems to explain most of the differential with the potential yields of the existing potato varieties. Increasing the availability of high quality seed at affordable prices would be a priority in order to significantly increase potato yields in the region (CSA, 2002).

Ethiopia is one of the major potato producing countries in Africa as 70% of its arable lands in the highlands are suitable for potato production (FAOSTAT, 2008). As put by Gildemacher *et al*.,

(2009) the Northwestern, Central and Eastern highlands of the country are under potato production. The same authors pointed out that virus diseases and potato Bacterial Wilt (BW) as the most important seed borne potato diseases in Eastern Africa including Ethiopia. The use of low seed potato quality is another factor contributing to reduction in potato yield in potato producing countries of Sub-Sahara Africa (Fuglie, 2007). Due to these and other biotic and abiotic factors, average potato yield potential (8 t per ha) of Sub-Saharan countries is very low as compared with the world average of 16 t per ha (cited in Bekele and Abebe 2013).

For about four decades now the National Potato Research Program of Ethiopia in collaboration with CIP and other stakeholders have been carrying out various research activities on potato and has made great stride in improved technologies generation. Worth mentioning, among other technologies, is the release of more than 25 potato varieties that has made possible a quantum leap in potato productivity from a mere 8t/ha or less with the use of late blight susceptible local varieties to a yield order of as high as 45 tons/ha.

Despite this success and a high demand by the growers, however, improved varieties did not reach to most of our potato growers yet simply because of failure to adequately multiply and disseminate their seeds. Potato is perhaps one of the few rewarding crops that has a high demand but failed to appeal much to seed companies and thus overlooked in the formal seed system. Consequently, the informal seed system reigns in much of the country. Although, the latter is an important technology transfer mechanism due to the gap in seed quality control mechanism, the incidence of diseases as bacterial wilt and late blight are becoming serious, in some areas, to the extent of deferring potato production.

Tigray regional state is located in the northern part of Ethiopia. It shares boundaries with Eretria in the north, Sudan in the west, Amhara in the south and Afar in the east. According to CSA (2008/09), the population of Tigray was estimated at 4,314,456 people of whom 50.8% are female. About 19.5% of the population resides in urban areas. The total land allocated to potato production in 2006/07 Meher season was estimated at 622 ha with a total production of 5,773.8 t. (CSA, 2007). The average yield was 9.29 t per ha. The total potato growers in the region were estimated at 37,361, which is about 5% of the households in the region. With the increase in the

introduction of irrigation technology, the potential for potato production in the region is growing (Bezabih and Mengistu, 2011).

As the world's top non-grain food commodity, potato has an important role to play as a popular source of affordable food for the world's growing urban populations. In Sub-Saharan Africa – and Ethiopia in particular – the potential of the potato crop is being researched by stakeholders keen to explore new opportunities for development (http//:www.cipotato.org). With global production over the past two decades expanding rapidly, potato is increasingly a highly dependable food security crop. Potato also generates more employment in the farm economy than other crops, and serves as a source of cash income for low-income farm households.

However, despite these trends potato has long been regarded as a lowly subsistence crop and is still an underexploited food crop. Potato has huge potential to improve food security, income and human nutrition and it is in Ethiopia where the potential of this crop is increasingly being realized and explored by farmers, private investors, and policy makers. While, national average yields are still far below attainable yields, ample opportunities exist to unleash this crop's potential for increased food security and income generation.

Food insecurity is a major problem in Ethiopia that is worsening. The early warning system (FEWSNET) reports that as of September 2010, 5.2 million people require emergency assistance. Underlying causes of food insecurity are widely recognized to include rapidly increasing population pressure, widespread environmental degradation, recurrent drought, low productivity of the agricultural sector, and limited market access. One of the consequences is poor nutrition, particularly among children and lactating mothers (Kothari and Abderrahim 2010).

Seed potato is efficient crop in converting natural resources, labor and capital into high-quality food and also it is superior to most food crops in calorie production. Moreover, it is one of the most nutritious crop of the world – higher protein to carbohydrate ratio and also known by higher production of vitamins (thiamin, riboflavin, niacin and vitamin C).

1.1.2. Irish Aid Nutrition Project

1.1.2.1. Strategic Context of the Project

Hailay *et al.*, (2011) mentioned that food insecurity and malnutrition are major problems in Tigray. Underlying causes of food insecurity are widely recognized to include rapidly increasing population pressure, widespread environmental degradation, recurrent drought, low productivity of the agricultural sector, and limited market access. Many farmers, even in a good rain season, cannot produce enough to cover their subsistence needs. One of the consequences of this is poor nutrition, particularly among children and pregnant/lactating mothers. Food or cash assistance is therefore relied on to fill the food gap. A recent report of the Tigray Regional Bureau of Agriculture and Rural Development (BoARD) shows that as of June 2011, 1.4 Million people were getting food/cash assistance through the Productive Safety Net Program (PSNP); and in addition, about 0.4 Million people were supported through emergency food assistance.

1.1.2.2. Project Rationale

A report of the Ethiopian Central Statistics Agency indicated that the prevalence of vitamin A deficiency (VAD) is a major problem in Tigray region where more than 60% of the children are vitamin A deficient. Major contributing factors of VAD include poverty, limited access to foods rich in vitamin A, lack of awareness of the nutritional value of fruits and vegetables, and traditional feeding practices limiting consumption of vitamin A-rich foods. Food insecurity and malnutrition cannot be alleviated by focusing on limited traditional crops such as maize, teff, sorghum and barley and wheat; it must be tackled on many fronts including by expanding the production and innovative use of potato and sweetpotato (Hailay *et al*., 2011)

Within the context of poverty alleviation and improved human nutrition and health, the International Potato Center (CIP), with the support of Irish Aid, has launched a nutrition project in five food insecure weredas of the Tigray region to promote production and consumption of potato and sweetpotato.

1.1.2.3. Project Goals and Objectives

The goal of the project is to improve human nutrition and health by diversifying traditional diets and stimulating the production and consumption of innovative potato and sweetpotato-based food products in Tigray.

Among its specific objectives are:

- Achieve greater impact toward improved human nutrition and diet quality by promoting potato
- Expand activities to new weredas in Tigray to increase the reach of potato in Ethiopia.
- Develop a strategy for the promotion of potato products in other parts of the country.

1.2 Statement of the Problem

The major challenges facing most of the developing countries like Ethiopia is ensuring food self-sufficiency of rural smallholder farmers. There is an ever-increasing concern that it is becoming more and more difficult to achieve and sustain the needed increase in agricultural production based on extensive farming, because there are limited opportunities for area expansion. Hence, the solution to food problem would depend on measures, which help to increase yield through intensification.

In Ethiopia, adoption of improved agricultural technologies has been a long term concern of agricultural experts, policy makers, and agricultural research and many others linked to the sector. However, evidence indicates that adoption rate of modern agricultural technologies in the country is very low (Rahmeto, 2007).

Tigray regional state is located in the northern part of the country. According to baseline survey report by International Potato Center (CIP-Ethiopia), on December 2011, potato was grown by around 23% of sample HHs and the area coverage of potato as compared to other crops was relatively low. Potato yields obtained by participants and non-participants were similar. On average a HH produced 17.4 quintal of potato per year, of which approximately 93% was sold. The remaining produce was used for seed and home consumption purpose which implies that potato is basically considered as a cash crop.

This report presents the findings of a baseline survey undertaken in the project "Alleviation of food insecurity and malnutrition in Tigray, Ethiopia, through promotion of potato and sweetpotato", in short "Nutrition Project". The project is funded by Irish Aid and implemented by CIP in collaboration with national partner organizations. The International Potato Center (CIP) and partners are implementing several projects in Ethiopia designed to develop and

promote potato and sweetpotato. So the research problem was to find out the income impact of this project on smallholder farmers in the study area, and what factors affect the adoption of improved seed potato varieties in the region.

1.3 Research Questions

a. What is the impact of the project on the income of smallholder farmers in the study area?
b. What are determinant factors affecting the adoption of improved seed potato varieties by smallholder farmers in the study area?

1.4 Objectives of the Study

- The objectives of the study:
  - To assess the impact of the nutrition project on the smallholder farmers' income in the study area
  - To find out the factors that affect adoption of improved potato varieties

II. Review of Related Literatures

2.1. Overview of Potato Production in Ethiopia

Adane and Prof. Dr. Admasu, (2008) indicated that Ethiopia has the total surface area of 112.3 million ha with 83 million people. Of 83 million people, the majority of 85 % lives in rural areas, and of 112.3 million ha area, 10.7 million ha is cultivated – 10 million ha arable land and 0.7 million ha under permanent crops. Potato has been grown in Ethiopia since 1859. 70 % of the total 10 million ha arable land is suitable for potato production. But surprisingly, an average yield of potato production has been stagnated at 6-8 t/ha for the last 20-30 years, while the area planted with potato increased from 0.03 million ha to 0.17 million ha which is still only 1.7% of the total potential. About 1.1 million households produce potato in meher season.

EIAR & ARARI, (2013), it is also stated that Ethiopia has a very high potential for potato production as its 70 % arable land or more than 6million ha is located in the mid and high altitudes, which is suitable for potato production. Close to half of the country‘s potato production comes from Amhara region. Potato is an important food security and a hunger reliever crop in Amhara region and in several other parts of the country by virtue of its ability to mature in advance of most other crops at the time of critical food need. In recent years, the production of this crop is expanding because of availability of improved technologies, expansion of irrigation culture, increased market value, production systems diversification—produced under rainy season, irrigation, residual moisture, short rains and recessed land.

Potato is an important crop in Ethiopia. Current cultivated area is nearly 70,000 Ha and the production is: nearly 786,000 metric ton (FAOSTAT, 2010). Potato production in Ethiopia is characterized by low yields and poor quality that stems from inadequate varieties, improper cultivation methods, pests and diseases and poor post harvest treatments. CIP involved in support to potato cultivation in Ethiopia with various capacity building activities and programs (http://www.moag.gov.il).

The low national mean yield observed for potato could be attributed to various constraints related to low adoption of improved agricultural technologies, drought, and lack of improved varieties, poor cultural practices, disease, and environmental degradation (Gebremedhin *et al*., 2001). In

essence of things, the generation and transfer of technologies is not an end by itself. Therefore, increasing productivity and production of potato will be realized if and only if the farmers adopt the technologies that are developed by research. Some efforts have been made by both research and extension systems for promotion of technology. Different research centres under Ethiopian Agricultural Research Institute have released different improved potato varieties with their agronomic practices and disseminated them among farmers with full package of information as a new innovation through MoARD.

Most studies reveal that quality seed of an improved potato variety is a key to increase the productivity of a potato crop. The genetic potential and other traits of a potato variety are determined or manifested by the use of healthy seed. Unavailability of healthy seed tubers in the required quantity and quality is probably the most important in contributing to the low yield in Ethiopia (Berga *et al*., 1994).

Nowadays, increasing production on a sustained basis by means of extensive farming is becoming more and more daunting agricultural undertaking owing to limited opportunities for area expansion (Legese *et al*., 2004). Hence, the solution to food problem would depend on measures that could allow the farmers increase yield through intensification which involves different improved agricultural practices (Million and Belay, 2004). Despite the significant contribution of adoption of agricultural innovations for increasing production and income, Legese *et al*.,(2004) and Kebede *et al*.,(1990) indicated that adoption rate of modern agricultural technologies in the country is very low. In order to raise the agricultural output and productivity on a sustainable basis in the developing countries, large-scale adoption and diffusion of new technologies is very essential**.**

Perceptions also play an important role especially at the first stages of the adoption process. As clarified by Duvel (1991), perceptions are understood to be of a more specific nature and are analyzed on the basis of attributes of innovations. For this purpose an inventory or list of attributes is required that is as encompassing as possible. Perception can be defined as any criteria, methods or stimuli by which a given farmer uses to differentiate one aspect of improved potato varieties in terms of its characteristics. In addition, any criterion used by farmers to differentiate the quality of a given varieties from other is also considered as perception.

Farmers use various frame of reference in appraising the relevance and usefulness of research and development products accessible to them. In appraising intervention from various sources, farmers refer to the expected added value in respect to their objective functions; practicability of what is being proposed and it's fit within the ongoing farmers' practices (Leeuwise, 2004). Therefore, considerations of reference used by farmers in appraising different interventions are crucial in promoting new crop production practices in order to increase the productivity of the crop in a given area.

2.2. Potato Production in Tigray

In the study area, Tigray region, Potato has been one of the important crops for the last several years. The agro-climatic conditions of the region particularly the eastern, southern, and central zones are ideally suitable for good quality potato production. The eastern and southern zones are particularly the highest potato producer, which accounts for more than 83% of the total area covered by potato and more than 74% of the total potato production of the region (CSA, 2002). According to CSA, potato is cultivated in nearly 575 ha with an average yield of 10 t/ha, and it is grown during the belg and meher seasons in Tigray. Guasa, Jalene, and Tolcha are popular varieties in Ethiopia. These are short duration varieties, white skinned, and have high dry matter and good keeping quality. There is no formal seed system existing in the region; if any, it is limited to the few crops and crop varieties (mainly cereals).

According to Berga *et al*., (1992), although various research activities have been undertaken to improve the production and productivity of potato in Tigray, smallholder farmers are still using traditional production techniques and low-yielding varieties. As a result, productivity of potato is very low in the region compared to other parts of Ethiopia. The major reason for the prevailing low productivity of potato in Tigray has been the shortage of good quality seed potato. The potato tuber used as seed in the region is being transported from Awassa, Holetta, and Wondo-Genet. In addition to the high transportation costs, the sprouted potato tubers are damaged during transportation. Moreover, the sources of the planting materials are unknown, which has led to the introduction of various diseases, (cited in Beliyu *et al*., 2010).

2.3. The Basic Concept of Adoption

Innovations are new methods, ideas, practices or techniques, which provide the means of achieving, sustained increases in farm productivity and income. The innovation may not be new to people in general but, if an individual has not yet accepted it, to that person it is an innovation. Some innovations originate from agricultural research stations, others from farmers (Van den Ban and Hawkins 1998). Diffusion is a process by which new ideas are communicated to the members of a social system over certain period of time (Rogers and Shoemaker, 1971).

Rogers (1962) defined the adoption process as, the mental process an individual passes from the first hearing of about an innovation or technology to a final adoption. According to Feder *et al.*, (1984) adoption may be defined as, the integration of an innovation into farmers' normal farming activities over an extended period of time. The author also noted that adoption is not a permanent behavior. This implies that an individual may decide to discontinue the use of innovation for variety of personal, institutional and social reasons one of which might be the availability of another practice that is better in satisfying needs.

However, for rigorous theoretical and empirical analysis, a precise quantitative definition of adoption was given (Feder *et al*., 1984).They distinguished individual (farm level) adoption from aggregate adoption depending on the coverage. Individual (farm level) adoption was defined as the degree of use of new technology in long- run equilibrium when the farmer has full information on potentiality of new technology. In the context of aggregate adoption behaviour, the same authors defined the diffusion process as the spread of new technology with in a region. This implies that aggregate adoption is measured by the aggregate level of use of specific new technology with a given geographical area or within the given population.

A number of empirical studies have been conducted by different people and institutions on the adoption of agricultural innovations both outside and inside Ethiopia. But the studies are mainly conducted around major cereal crops and due to this fact that studies conducted in the area of root crops, particularly on improved potato variety technologies are very limited. This suggests that there is a need to bridge this information gap through further research on the adoption of potato technologies. This necessitates the study of the adoption of improved potato technologies and its determinants.

For example, adoption of green revolution technologies has indicated that the new HYVs were adopted at rapid rates in those areas where they were technically and economically superior to local varieties. Several studies have indicated that the adoption of improved varieties are affected by many factors such as farm size, age, family size, education, access to information, etc (Dereje, 2006)..

Namwata *et al.*, (2010) found that being a male or married by a household head, access to extension services were positively and significantly associated with overall adoption of improved agricultural technologies for Irish potatoes.

In this regard, therefore, the study, for improved adoption of agricultural technologies for Irish potatoes, recommended that access to credit services by small scale farmers engaged Irish potatoes farming in the study area should be strengthened. Since being female by a household head lessened adoption, mainly due to limited household resource, therefore, special consideration for agricultural credits should be given to women. Agricultural extension services in the area should be improved so as to address varied needs of majority of farmers. Furthermore, since adoption was also positively associated with experience, extension personnel should not only concentrate with more experienced farmers, they should also work closely with new and less experienced farmers so as to stimulate more adoption of technologies in the area.

On the other hand, Onubuogu and *Onyeneke, (2012) undertook a study which focused on market orientation of root and tuber crop production in one of the states in Nigeria and reached the following conclusions. The market orientation of root and tuber crop production is affected by household demographic factors and institutional support services. Important factors determining market oriented production of the farmers include their age, education, household size, extension contact, farm size and income.

III. Methodology of the Study

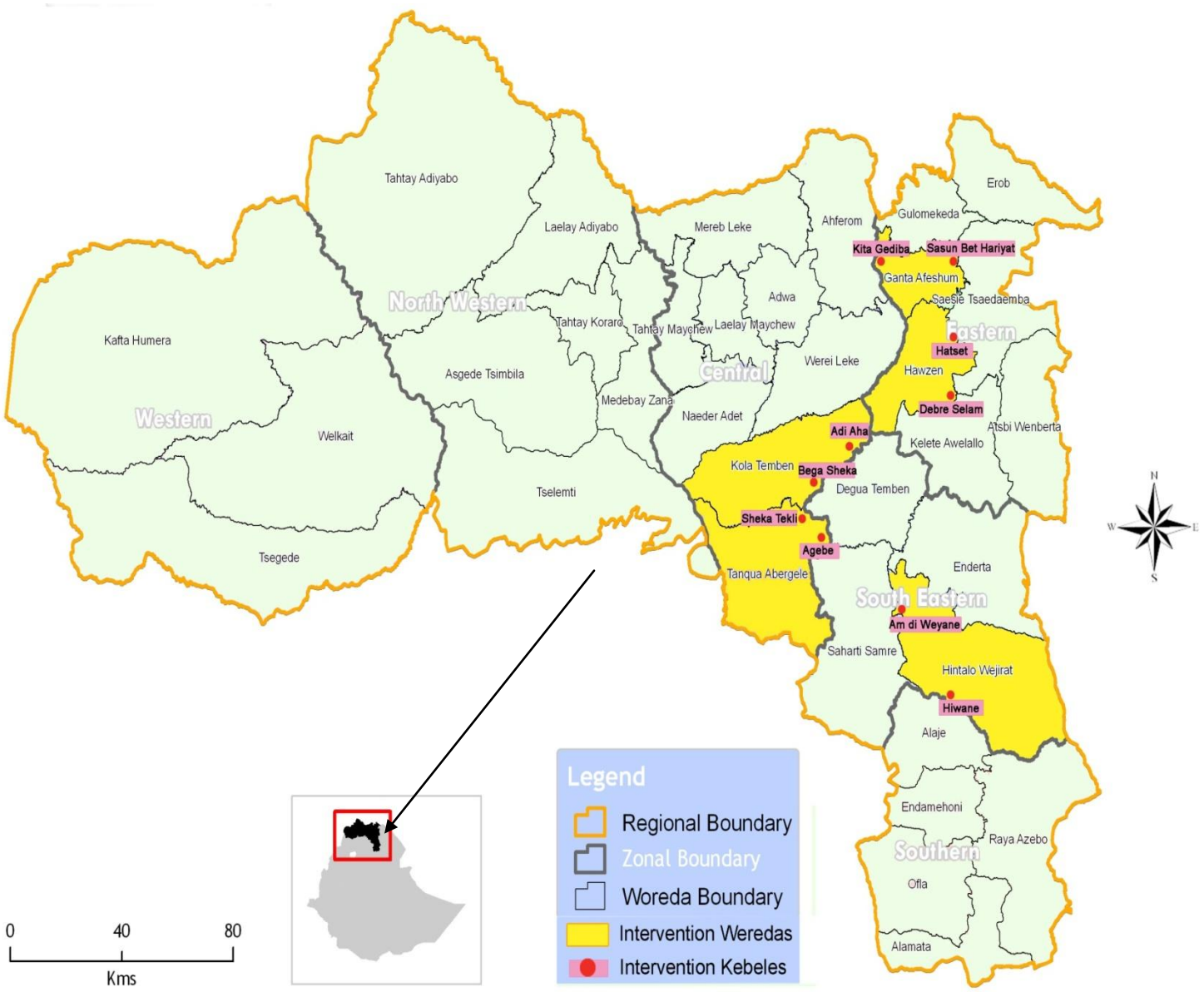
3.1 Area Description and Sampling

The baseline survey was conducted in June 2011 in the project intervention areas in Tigray. The survey was carried out in 15 tabias located in five selected intervention weredas (districts). The criteria used to select intervention weredas were (a) agro-ecology suitable for potato and sweetpotato production, (b) degree of food insecurity, and (c) proximity of weredas to one another. Once the weredas were identified with respect to the criteria indicated above, three tabias (two project intervention tabias and one non-participant) were selected from each wereda. The tabias were selected based on (a) the presence of an effective and active women association, (b) accessibility, (c) availability of a health center or school and (d) the potential for potato/sweetpotat production. In each wereda, the selection of tabias was performed by representatives of wereda agricultural office, health office and women association, (Hailay *et al.*, 2011).

In each of the ten project tabias, ten HHs intended to participate in project activities (in the following "participants") were interviewed. These were selected by agricultural and health development agents at tabia level based on the preset criteria of having own plot of land and interest and capacity to participate in the project. In five randomly selected nearby tabias ten HH not expected to participate in project activities (in the following "non-participants") were selected and interviewed . In case the HH head of the targeted HH was not found at home during the visit, a spouse was recommended to answer on behalf of the HH head. If both of them were not available, another nearby HH was interviewed to reach the required number of HHs to be interviewed.

The baseline data was collected from 150 HHs (100 participant and 50 non-participant households) in ten intervention and five non-intervention rural tabias of five weredas (districts) of the Tigray region. These five woredas are Ganta Afeshum, Hawzen, Kola Temben, Tanqua Abergele, and Hintalo Wajirat. More specifically, from Ganta Afeshum wereda, Kita Gediba and Sasun Bet Ariyat are the intervention tabias. Similarly, from Hawzen, Hatset and Debre Selam; from Kola Temben, Adi Aha and Bega Sheka; from Tanqua Abergele, Sheka Tekli and Agebe; and finally, from Hintalo Wajirat, Am di Weyane and Hiwan were the project intervention areas.

Hailay T. *et al.*, (2011) stated that the baseline survey took place from 28 – 12 July 2011. In addition, the follow-up data was collected through structured questionnaire at the end of last year (2013) after the project intervention had ended.



Source: baseline survey (Hailay *et al.*, 2011)

3.2 Method of Data Analysis

Both descriptive and econometric data analysis methods were used to analyze the data employing stata version 10. Descriptive statistics such as mean, standard error, frequencies, and percentages were used to have a clear picture of the characteristics of sample units. Chi-square test and an independent sample t-test were used to identify variables that vary significantly between adopters and non-adopter. The chi-square test was conducted to compare some qualitative characteristics of the adopters and non adopters, whereas t-test was run to assess whether statistically significant differences exist in the mean values of continuous variables for adopter and non adopter as well as some wealth measuring variables before and after the treatment.

As a matter of fact, the intervention was applied based on observational studies rather than controlled experiment. In other words, the treated group was selected attributing to some predetermined characteristics than randomization. Therefore, the traditional OLS method of estimation cannot be applied. Thus, in the econometric analysis, the study employed The Difference-in-Differences (DID) approach to see the impact of the project intervention on households' earnings.

Why Difference in Differences? DID estimation uses four data points to deduce the impact of a policy change or some other shock (treatment) on the treated population: the effect of the treatment on the treated. The structure of the experiment implies that the treatment group and control group have similar characteristics and are trending in the same way over time.

Since the work by Ashenfelter and Card (1985), the use of difference-in-differences methods has become very widespread. The simplest set up is one where outcomes are observed for two groups for two time periods. One of the groups is exposed to a treatment in the second period but not in the first period. The second group is not exposed to the treatment during either period. In the case where the same units within a group are observed in each time period, the average gain in the second (control) group is subtracted from the average gain in the first (treatment) group. This removes biases in second period comparisons between the treatment and control group that could be the result from permanent differences between those groups, as well as biases from

comparisons over time in the treatment group that could be the result of trends (cited in Marco and Reinhard, 2005).

3.2.1 Program Evaluation and the Difference in Differences Estimator:

A. Program Evaluation:

The study evaluated the impact of "Nutrition project" or literally treatment on an outcome variable income over the specified study area. There have been two groups indexed by treatment status T = 0, 1 where 0 indicates individuals who did not receive treatment, i.e. the control group, and 1 indicates individuals who did receive treatment, i.e. the treatment group. The first observation had been made on individuals in the baseline survey, t = 0, and the end-line survey was made at the end of 2013, t=1, where 0 indicates a time period before the treatment group received treatment, i.e. pre-treatment, and 1 indicates a time period after the treatment group received the treatment, i.e. post-treatment. Every observation was indexed by the letter i = 1...N; individuals will typically have two observations each, one pre-treatment and one post-treatment. For the sake of notation let $\bar{Y}_0^T$ and $\bar{Y}_1^T$ be the sample averages of the outcome for the treatment group before and after treatment, respectively, and let $\bar{Y}_0^C$ and $\bar{Y}_1^C$ be the corresponding sample averages of the outcome for the control group. Subscripts correspond to time period and superscripts to the treatment status.

A.1 Modeling the Outcome Variable

The outcome Y_i is modeled by the following equation (Heckman, Ichimura, Smith, and Todd, 1998; and Heckman and Robb, 1985).

$$Y_i = \alpha + \beta T_i + \gamma t_i + \delta (T_i \cdot t_i) + \varepsilon_i \quad \ldots\ldots (1)$$

where the coefficients given by the Greek letters α, β, γ, δ , are all unknown parameters and ε_i is a random, unobserved "error" term which contains all determinants of Yi which our model omits. By inspecting (1), one should be able to see that the coefficients have the following interpretation

α = constant term

β = treatment group specific effect (to account for average permanent differences between T and C group)

γ = time trend common to control and treatment groups

δ = true effect of treatment

The purpose of the program evaluation in this study was to find a "good" estimate of δ given the available data.

B. The Difference in Differences Estimator

Before explaining the difference in difference estimator, it is best to review the two simple difference estimators and understand what can go wrong with these. Understanding what is wrong about as an estimator is as important as understanding what is right about it.

B.1 Simple Pre versus Post Estimator

Consider first an estimator based on comparing the average difference in income Y_i before and after treatment in the treatment group alone.

$\hat{\delta}_1 = \hat{Y}_1^T - \hat{Y}_0^T$ …… (2)

Taking the expectation of this estimator we get

$E(\hat{\delta}_1^T) = E(\hat{Y}_1^T) - E(\hat{Y}_1^T)$

= [α + β + γ + δ] − [α + β]

= γ + δ ; which means that this estimator would be biased so long as $\gamma \neq 0$, i.e. if a time-trend exists in the outcome $Y_{i,}$ then we would confound the time trend as being part of the treatment effect.

B.2 Simple Treatment versus Control Estimator

Next consider the estimator based on comparing the average difference in outcome Y_i post-treatment, between the treatment and control groups, ignoring pre-treatment outcomes.

$\hat{\delta}_2 = \bar{Y}_1^T - \bar{Y}_1^C$ …….. (3)

Taking the expectation of this estimator

$E(\hat{\delta}_2) = E(\bar{Y}_1^T) - E(\bar{Y}_1^C)$

= [α + β + γ + δ] − [α + γ]

= β + δ; and so this estimator is biased so long as $\beta \neq 0$, i.e. there exist permanent average differences in Y_i between the treatment groups. The true treatment effect would be confounded by permanent differences in treatment and control groups that existed prior to any treatment. Note that in a randomized experiments, where subjects are randomly selected into treatment and

control groups, β should be zero as both groups should be nearly identical: in this case this estimator may perform well in a controlled experimental setting typically unavailable in most program evaluation problems seen in economics.

Shahidur *et al.,* (2010) stated that DID method, compared with propensity score matching (PSM), assumes that unobserved heterogeneity in participation is present—but that such factors are time invariant. With data on project and control observations before and after the program intervention, therefore, this fixed component can be differenced out.

Central to the implementation of double-difference is the construction of the treatment and comparison groups so that, at baseline, they are as comparable as possible. Matching methods of program evaluation construct a comparison group by "matching" treatment households to comparison group households based on observable characteristics. The impact of the program is then estimated as the average difference in the outcomes for each treatment household from a weighted average of outcomes in each similar comparison group household from the matched sample.

The difference in difference (or "double difference") estimator is defined as the difference in average outcome in the treatment group before and after treatment minus the difference in average outcome in the control group before and after treatment: it is literally a "difference of differences".

$$\hat{\delta}_{DD} = \bar{Y}_1^T - \bar{Y}_0^T - (\bar{Y}_1^C - \bar{Y}_0^C) \quad \text{(4)}$$

Taking the expectation of this estimator we will see that it is unbiased

$$E(\hat{\delta}_{DD}) = E(\bar{Y}_1^T) - E(\bar{Y}_0^T) - (E(\bar{Y}_1^C) - E(\bar{Y}_0^C))$$

= α + β + γ + δ − (α + β) − (α + γ − γ)

= (γ + δ) − γ

= δ

This estimator can be seen as taking the difference between two pre-versus-post estimators seen above in (2), subtracting the control group's estimator, which captures the time trend γ, from the treatment group's estimator to get δ. We can also rearrange terms in equation (4) to get

$\hat{\delta}_{DD} = \bar{Y}_1^T - \bar{Y}_0^T - (\bar{Y}_1^C - \bar{Y}_0^C)$; which can be interpreted as taking the difference of two estimators of the simple treatment versus control type seen in equation (3). The difference estimator for the pre-period is used to estimate the permanent difference β, which is then subtracted away from the post-period estimator to get δ.

It is common to find difference in differences estimators presented in a table of the following form.

	Pre	**Post**	**Post-Pre Difference**
Treatment	$\bar{Y}_0^T$	Y_1^T	$\bar{Y}_1^T - \bar{Y}_0^T$
Control	$\bar{Y}_0^C$	$\bar{Y}_1^C$	$\bar{Y}_1^C - \bar{Y}_0^C$
T-C Difference	$\bar{Y}_0^T - \bar{Y}_0^C$	$\bar{Y}_1^T - \bar{Y}_1^C$	$\bar{Y}_1^T - \bar{Y}_1^C - (\bar{Y}_0^T - \bar{Y}_0^C)$

Notice that the first row ends with the estimate $\hat{\delta}_1$, the second column ends with estimate $\hat{\delta}_2$, and the lower right hand corner entry gives the estimate $\hat{\delta}_{DD}$.

3.2.2 Adoption of Improved Potato Varieties and Binary Regression

Rogers (1962) defined the adoption process as, the mental process an individual passes from the first hearing of about an innovation or technology to a final adoption. According to Feder and Slade (1984), adoption may be defined as, the integration of an innovation into farmers' normal farming activities over an extended period of time. The author also noted that adoption is not a permanent behaviour. This implies that an individual may decide to discontinue the use of innovation for variety of personal, institutional and social reasons one of which might be the availability of another practice that is better in satisfying needs.

In order to assess the determinants of farmers' adoption of improved potato varieties, the following regression model equation was applied.

$$\mathbf{Y_i = f\ (X_{1i}, X_{2i}, X_{3i}, X_{4i}, X_{5i}, X_{6i}, X_{7i}, X_{8i}, X_{9i}, X_{10i}, X_{11i}, X_{12i})} \quad \text{.....(5)}$$

Where, the adoption of improved seed potato varieties by a farmer was used as a dependent variable (Y) and all Xs are independent variables. These independent variables are: education

level of household head (X_1), Age of household head (X_2), sex of household head (X_3), marital status (X_4), household size (X_5), farm size (X_6), accessibility to extension services (X_7), membership to organization/Social capital (X_8), if the household had off-farm income (X_9) and participation status in the nutrition project (X_{10}), radio (X_{11}), cell-phone (X_{12}) (equation 5). The subscript i refers to individual i.

3.2.2.1 Selection of appropriate econometric model

The logit and probit are the two most commonly used models for assessing the effects of various factors on the probability of adoption of a given technology. These models can also provide the predicted probability of adoption. (Gujarati, 2003 and Jefere, 2009) stated that it is, by formulation, a binary qualitative response model(or limited dependent variable model) that can conveniently be estimated with the maximum likelihood estimation method using the cumulative distribution function (CDF) through the probit estimation that uses the normal CDF, or the logit model which uses the cumulative logistic function (CLF).

The logit model follows a logistic distribution function, whereas the probit model follows a normal distribution function. Yet both models usually yield more or less similar results. The choice between the two models is thus a matter of convenience to the analyst (Gujarati, 1995). However, logit model is often preferred as it is more simple for estimation and interpretation of parameters than probit model is (Pindyck and Rubinfeld, 1981). Therefore, this study opted for the logit model and employed logit model to model factors influencing the adoption decision of improved potato varieties by farmer households in the study area..

An explanation of logistic regression begins with an explanation of the logistic function, which always takes on values between zero and one as written below in equation (6):

$$P(x) = \Pr(D = 1/X) = \frac{1}{1+e^{z}} = \frac{e^{z}}{1+e^{z}} \quad \text{..... (6)}$$

Following Hosmer and Lemshew (1989), the logistic distribution function for analyzing adoption of RWH technology and viewing z as a linear function of an explanatory variable x (or of a

linear combination of explanatory variables) (Cited in Aziz and Tesfaye 2013), the logistic function can be written as:

$$P(x) = \frac{1}{1 + e^{-(\alpha + \beta x)}} \quad \text{..... (7)}$$

Equation (7) will be interpreted as the probability of the dependent variable equalling a success/adoption rather than a failure/non-adoption. An adoption dummy variable denoting the household adopts new potato varieties or not.

3.3 Definition and Measurement of Variables Used in the Adoption Regression Model

Dependent Variable

Adoption of New Potato Varieties: since the farmers considered under the survey can decide on whether to adopt or not regardless of participation in the project, then the study tries to find out what factors could affect their likelihood to adopt new potato varieties. It takes 1 if the household adopts and 0 otherwise.

Independent Variables

Education: In almost all of the studies on agriculture, education has been taken as an important explanatory factor that positively affects the decision of the households to participate and practice new innovations. Education basically equips individuals with the necessary knowledge as to how to allocate their scarce resources to achieve optimal output and accordingly is positively associated with adoption. Mwanga *et al., (*1998) carried out a study in Tanzania and found that education level significantly affected the adoption of improved wheat varieties. Similarly, Studies carried out by Asfaw *et al*.(1997), and Tesfaye and Alemu (2001) ,indicated positive relationship between education and adoption.

Age: it refers to the age of the household head in years and it is a continuous variable. Usually, rural households spend much of their time and base their livelihood on agriculture. Farming experience is important household related variable that has relationship with adoption. Longer

farming experience implies accumulated farming knowledge and skill, which has contribution for adoption. Age of the farmer is, therefore, the best proxy variable for farming experience implying that older household heads may have a better productive practices than the younger ones making their counter parts less efficient. Different studies confirmed this position. Melaku, (2005) and Kidane, (2001) indicated experience on farm activities has a positive and significant relation with adoption. On the other hand, older household heads are more reluctant to adopt new technologies and innovations which can improve their potential. To this end, Ebrahim, (2006) found that farming experience is to have negative relationship with over all dairy adoption.

Sex: is a dummy variable which indicates whether the household head is male or female. A study by Namwata *et al.*, (2010), Fitsum, (2003), Burger *et al. (*1996) and Legesse, (1992) found that sex of the household head has an impact on the adoption of new improved technologies. These studies revealed that male-headed households have more likelihood to adopt new technologies than their female-headed counterparts. For instance, Namwata *et al.*, (2010) indicated that there is a positive link between male-headed households and adoption of new technologies for Irish potato. Fitsum (2003) indicated that the negative and significant relation between the decision to fertilizer use intensity and female-headed households. His explanation for this bias was the existence of difference in wealth status between male and female-headed households. Likewise, (Burger *et al.* 1996) revealed that the likelihood of adoption decision is higher among male headed farm households than female headed ones. Legesse, (1992) also reached at similar conclusion about the relationship between adoption and sex among farm households.

Marital Status: it is also a dummy variable taking the value 1 if the household head is married and 0 otherwise. The marital status of the household head is ultimately connected with their interaction in decision making with their parents/parents in law if s/he is unmarried, their spouses if s/he is married. Namwata *et al.*, (2010) found that married household heads had more willingness to adopt improved technologies for Irish potato than the unmarried counterparts.

Household Size: is the number of members in that family. It includes the household head, spouse, children, relatives (living in that family), and housemaids. Large household size is normally associated with a higher labour endowment, which enables farmers to accomplish various agricultural tasks. Farm households with a larger pool of labour are expected to adopt

new varieties and use it more intensively because they have labour shortages at peak times. Household size is associated positively with adoption. Arellanes, (2003) reported a significant positive relationship between family labor supply and adoption. Techane, (2002) concluded that family labor was positively related with adoption and intensity of fertilizer use. This suggests that larger households have higher household consumption and cash needs, and so are more likely to grow more productive root and tuber crops like potato.

Farm Size: farm size is also a continuous variable. It is associated with greater wealth. It will increase farmers' production thereby enhancing market oriented production. In order to be market oriented, however, the farmers need to first adopt new more productive potato varieties. It is measured in a local unit (acre[1]). Acre is a quarter of a hectare. For example a study carried out by Mwanga *et al.* (1998) in Tanzania has indicated that farm size level significantly affected the adoption of improved wheat varieties. Many others, Tesfaye and Alemu (2001), Mulugeta (2000), Million and Belay (2004) and Taha (2007), also reported positive relationship of farm size with adoption.

Extension service: Extension on adoption of new seed varieties represents access to the information required to make the decision to adopt better seeds. Many authors reported that enhancing farmers' access to extension will improve their perception about new and uncommon yet more productive and profitable varieties. For example, Namwata *et al.*, (2010) indicated that household heads who had access to extension services were more likely to adopt improved technologies for Irish potato than the ones who do not. Other authors, Chilot *et al.*, (1996) and Tesfaye and Alemu, (2001), also found significant relationship of access to extension to adoption of agricultural technologies.

Membership to Farmer Group/s: it is a dummy variable indicating whether the household head is a member of any farmer group/s which is built for the service of the smallholder farmers in the community (like credit services). Membership to farmer groups is basically related to social participation. Ebrahim, (2006) social participation contributed positively to the adoption of diary technologies. Similarly, Dereje, (2006) reported that social participation had significant and positive relationship with adoption.

[1]*Acre is a local land measurement unit equaling a quarter of a hectare.*

Off-farm Income: off-farm income is a dummy variable: 1 if any member of the family generates off-farm income and 0 otherwise. The households engaged in off-farm activities are better exposed to informal but important information about new innovations as well as building capacity and developing confidence on the advantages of improved agricultural technologies. It also gives them the chance to participate in different social demonstrations. In this line, Yishak, (2005) in his study of determinants of adoption of improved maize technology in Damote Gale district found that farmers' participation in demonstration had positive and significant relationship with adoption. In addition to that, they are also better endowed with additional income to purchase initial new seeds. Therefore, it is expected that participation in off-farm activities is positively related with adoption.

Participation Status: this is also a dummy variable whether the household is in the treatment group. It takes the value of 1 if the household is participant and 0 otherwise.

Access to Radio: information is important to make decisions on accepting new practices and adopting new varieties. Mass media exposure is one of communication variables availing information for farmers. At present in rural areas, radio is the popular means of mass communication. Many studies reported the positive and significant relationship of mass media with adoption of agricultural technologies. In line with this, Yishak (2005) in his study on determinants of adoption of improved maize technology indicated that ownership of radio had positive influence on adoption of improved maize technologies.

Access to Cellphone: under the current situation of rural areas, cellphone, by any means, is fast and timely source of information about different things related with the farmers' life. So just like other sources of information, the farmers with this service are exposed to adopt new varieties coming from outside of their communities.

3.4 The Research Hypothesis

- In relation to the project evaluation, positive results are expected from the intervention in terms of income of the participant farmers.
- Details for all variables involved in the adoption regression analysis and their expected effects as per literature are indicated in table 1.

Table 1: Variables for the adoption regression function and the expected signs

Variables	Description	Expected Effect (sign)
Dependent variable:		
Adoption (Y)	Adoption of improved seed potatoes: this is a decision variable decided by the household themselves: 1 if Adopter; 0 if Non-adopter	
Independent variables:		
Education (X1)	Education level of household head, Years in school: continuous	+
Age (X2)	Age of household head: continuous	+/-
Sex (X3)	Sex of household head: 1 if Male; 0 if female	+
Mstatus (X4)	Marital status of household head: 1 if Married; 0 if otherwise	+
Hsize (X5)	Household size (Number of individuals in a household): continuous	+
Fsize (X6)	Farm size (in acres): continuous	+
Extension(X7)	Access to extension services: 1 if Yes; 0 if No	+
Membership (X8)	Membership to organization (farmers group)/social capital: 1 if Yes; 0 if No	+
Participation in off-farm activities(X9)	If any member of the family participates in off-farm activities: 1 if yes; 0 if No	+
Participation status in the project(X10)	The household's participation status in the project: 1 if yes; 0 if No	+
Radio (X11)	Having radio: 1 if yes; 0 if No	+
Cell phone (X12)	Having cell phone: 1 if yes; 0 if No	+

IV. Results and Discussion

This chapter presents the descriptive and the econometric results of the income impact evaluation. In this evaluation, necessary tools for both descriptive and econometrics analysis were employed. In the descriptive analysis, an overview of the household characteristics is viewed before and after the treatment.

In the econometric analysis, the difference in differences technique is used so as to see whether the differences in outcome variables among participants and non-participants come from the project or other household characteristics. Furthermore, regression analysis is made to identify the determinant factors which supposedly affect the adoption of improved seed potato varieties from international potato center.

4.1 Descriptive Analysis of the Survey Data

This section presents the results of the descriptive analysis for the smallholder farmers in the study area. It describes the farmers in terms of household characteristics, livestock ownership, land ownership based on some selected group characteristics and makes comparisons.

4.1.1 Description of the Households' Characteristics

This section deals with household characteristics used in the adoption regression function. It discusses both qualitative and quantitative characteristics. It includes the household's education level, age, sex, marital status, family size, farm size as well as other factors like exposure to extension service, participating in off-farm activities, membership to farmer group, participation status in the project, having radio and having cell phone.

Table 2: Case summary comparing results of dummy explanatory variables by adoption

Dummy Variable Name		Adopter		Non-adopter		Overall		Pearson chi2
		Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	
Sex of the hh head	**Male**	51	57.3	38	42.7	89	59.73	0.2289
	Female	32	53.33	28	46.67	60	40.27	
Marital status of the hh head	**Married**	55	57.29	41	42.71	96	64.43	0.2755
	Unmarried	28	52.83	25	47.17	53	35.57	
Membership to farmer groups	**Yes**	68	60.71	44	39.29	112	75.17	4.5873**
	No	15	40.54	22	59.46	37	24.83	
Members participating in off-farm activities	**Yes**	63	80.77	15	19.23	78	52.35	41.6766***
	No	20	28.17	51	71.83	71	47.65	
Having radio	**Yes**	68	79.07	18	20.93	86	57.72	45.0017***
	No	15	23.81	48	76.18	63	42.28	
Having cellphone	**Yes**	68	61.83	42	38.18	110	73.83	3.3656**
	No	15	38.46	24	61.54	39	26.17	
Access to Extension Services	**Yes**	70	72.16	27	27.84	97	65.1	30.5195***
	No	13	25	39	75	52	34.9	
Participation Status	**Treated**	77	77	23	23	100	67.11	55.8867***
	Control	6	12.24	43	87.76	49	32.89	

Source: Author's own calculation

Note: *** statistically significant at 1%, ** statistically significant at 5% level of significance.

In the study, the researcher found a relationship between membership to farmer groups and adoption of improved potato varieties. Those farmers who are members of different cooperative farmer groups in a community are assumed to better interpret and use the available information related to new technology. Of the total sampled households, 112 (75.17%) had participated in cooperative membership while, 37 (24.83%) of the sampled household heads hadn't (table 2). Comparing the proportion of farmers' membership with in the category, 81.93% of adopter farmers have participated in group memberships, while only 66.7% of non-adopters had participated in farmers' group membership, with the percentage difference significant at 5% level. But one cannot be sure whether the membership caused the adoption decision or vise versa with chi-square test.

Of the total sample households, 52.35% households had at least one member participating in off-farm activities but the rest didn't participate. Table 2 also shows that there is a relationship between whether the household had a member participating in off-farm activities or not and adoption decision. The proportion of households with members participating in off-farm income generating activities within the adoption category is 75.9% whereas the proportion of households participating in off-farm activities within the non-adoption group is just 22.73%. The Pearson chi2 indicates that there is a statistically significant difference between the two proportions at 1% significance level.

The sample households were composed of household heads having radio or not having. Of the total, 57.72% of the sample household heads were under the category of having radio while 42.28% of household heads did not have radio (Table 2). The proportion of the household heads having radio under the adoption category was 81.93%. On the other hand, the proportion of the household heads that did not have their own radio under the non-adoption category were only 27.27%. The chi-square test of the two groups was run and found to be significant at 1% level.

The sample households were also composed of household heads having cell phone or not. Of the total samples, 73.83% household heads had their own cell phone but 26.17% didn't (table 2). And most of the heads in the adoption group (81.93%) had cell phone. On the other side, 63.64% in the non-adoption group were having cell phone. This proportional difference was statistically significant at 5% level. Adoption and having cell phone were found statistically not independent.

The survey results also show that 65.1% of the sample households had access to extension services while 34.9% didn't have access to extension services (table 2). 84.34% of the adopters had the service whereas only 40.91% of non-adopters had the access to extension services. And the Pearson chi-square test indicates that this percentage difference is statistically significant at 1% level. This implies that there is a positive link between having access to extension service and adoption of improved potato varieties.

Participation status in the project is also another statistically significant variable positively linked with the adoption decision of the households. Table 2 depicts that while 67.11% of the sample households were participants, the rest 32.89% were non-participants. The percentage of participants that adopted improved varieties was 92.77% and the percentage of participants who did not adopt the improved varieties was just 34.85%. This percentage difference between the two groups is statistically significant at 1% significance level.

Table 3: Case summary comparing results of quantitative explanatory variables by adoption

Continuous Variable Name	Adopter		Non-adopter		Overall		t value
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	
Household size	5.8	0.22	5.47	0.27	5.65	0.17	0.9357
Age of household head	44.76	1.2	50.02	1.39	47.12	0.93	2.8590***
Education level	5.29	0.35	2.18	0.33	3.91	0.27	6.3531***
Farm size	3.56	0.27	5.22	1.48	4.29	0.67	1.2246

Source: Author's own calculation

Note: *** statistically significant at 1% level

According to the survey data, the average age of the household heads was found to be 47 years. When the sample households are considered independently into adopters and non-adopters of improved potato varieties, a significant mean age difference between the two groups was observed. The mean age of the adopters and non-adopters were approximately 45 and 50 years, respectively. And this age difference was significant at 1% level of significance (table 3). This

result depicts the fact that adoption of new potato variety and age of the household head have an inverse relationship.

The average years spent in school by household heads, adopters and non-adopters were found to be 3.91, 2.18 and 5.29, respectively (table 3). The t statistics shows that the mean difference for years of education is also significant for the two groups at 1% significance level. This implies that there is a positive link between years spent in school and adoption decision of the household heads. In other words, on average, the households having longer years spent in school fall into the adoption group, whereas the households having shorter years spent in school are non-adopters.

However, when it comes to household size and farm size of the households, there is no statistical evidence about whether their mean differences are related with the adoption (table 3).

4.1.2 Livestock Ownership Before and After the Treatment

Farm animals have an important role in rural economy of developing economies. They are source of food such as milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport. Livestock is also kept both for generating income and traction power (Bayissa, 2010). Livestock holding size is also one of the indicators of wealth status of the households in the study area.

According to the survey data, the average cattle ownership of sampled households was 4.04 and 4.67 before and after the treatment, respectively. On the other hand, the mean number of sheep owned before the treatment was 3.51 and 4.4 after the treatment. While the households owned an average of 3.23 goats before the treatment and 3.77 after the treatment, they came to have 1 and 1.68 draft animals before and after the treatment, respectively. Nevertheless, all the mean differences in the average numbers of different types of livestock were found to be not significant (table 4). This might be attributed to the fact that the time span of the project was not long enough to show a wealth impact.

Table 4: Comparison of sample means before and after the treatment by livestock ownership

Variable Name	Time	Mean	Standard Error
Cattle	Before The treatment	4.04	
	After the treatment	4.67	
	Difference	-0.63	0.71
Sheep	Before The treatment	3.51	
	After the treatment	4.4	
	Difference	-0.89	0.96
Goats	Before The treatment	3.23	
	After the treatment	3.77	
	Difference	-0.54	0.98
Draft animals	Before The treatment	0.99	
	After the treatment	1.68	
	Difference	-0.68	0.67

Source: Author's own calculation, 2014

4.2 Econometric Results

4.2.1 Assessment of the Impact of the Project on the Farmers' Income

Here, the study presents the econometric results about the impact of the project (average treatment effect on the treated).

4.2.1.1. Contribution of Potato and Sweetpotato to Household Income of Participants

Potato and sweetpotato are two food crops that were the focus of the project intervention, and can offer farmers also the possibility to generate income. In this section, the study has evaluated a simple indicator that is measuring the importance of these two crops and the average treatment effect on the treated using difference in differences estimator. This indicator measures the average income effect of the crops produced by the HHs had it been sold to generate income. The study used the central statistical agency's surveys about the producers' prices, both in the baseline and end-line periods, for calculating the income for the crops the sample households produced (CSA 2011 and 2013). The incomes in the second period were adjusted for inflation so that the comparison would be in real terms.

Table 5: Project impact on the income of the farmers from potato

	Pre	Post	Post-Pre Difference
Treatment	2436.29	6227.658	3791.368
			(187.2773)
Control	2390.5	5472.629	3082.129
			(172.8118)
T-C Difference	45.79004	755.0295	709.2394**
			(293.8624)
		Difference in Differences = $(\overline{P}_1{}^T - \overline{P}_0{}^T) - (\overline{P}_1{}^C - \overline{P}_0{}^C)$ = **709.642**	
		t = 2.4135	
		Degrees of freedom = 147	
		Pr(|T| > |t|) = 0.0170	

Source: Author's own calculations, 2014

Note: ** means statistically significant at 5% level

The above table shows the income impact of the intervention on the farmers from potato alone. The mean income difference of the control group before and after the treatment is approximately Birr 3082. On the other hand, the mean income difference of the treatment group before and after the treatment was implemented is Birr 3791. So the true impact of the project (treatment) is the difference of the two mean differences, i.e. about Birr 710. And as the t-test shows, this mean income difference of the simple differences is significant at 5% level of significance.

Table 6: Project impact on the income of the farmers from sweetpotato

	Pre	Post	Post-Pre Difference
Treatment	934.13	5172.279	4238.149
			(395.5471)
Control	921.51	2938.535	2017.025
			(575.2496)
T-C Difference	12.62	2233.745	2221.125***
			(693.8355)
Difference in Differences = $(\overline{SP}_1{}^T - \overline{SP}_0{}^T) - (\overline{SP}_1{}^C - \overline{SP}_0{}^C)$ = **2221.125**			
t= 3.2012			
Degrees of freedom = 147			
Pr(|T| > |t|) = 0.0017			

Source: Author's own calculations, 2014

Note: *** means statistically significant at 1% level

The project has not just encouraged the production and consumption of potato, but it has also tried to bring farmers to understand the importance of sweetpotato especially in terms of alleviating vitamin A deficiencies. In other words, there was an encouragement for the households to produce and consume sweetpotato, too. So the income impact of the treatment specifically from sweetpotato production was about Birr 2221 which is significant at 1% level. The real potential income difference of the control group before and after the treatment is approximately 2017; whereas for the treatment group is Birr 4238. When the control and the

treatment group are combined together, the mean difference of the two groups before and after the treatment gives about Birr 3508.

This much (Birr 2221) impact of the project is very big as compared to the impact on potato which is only Birr 710. Before the implementation of the project, the farmers used to rarely produce this crop (sweetpotato). But as they started to understand its importance from the project, that was when sweetpotato began to be produced in more quantities and improved varieties facilitated the productivity. That could actually be why there was a big income difference in the treatment group before and after the treatment, and that huge average treatment effect on the treated might be attributed to this fact.

4.2.1.2 The Total Income Impact of The project

Table 7: Project impact on the total income of the farmers

	Pre	Post	Post-Pre Difference
Treatment	24810.16	33083.88	8273.716 (1832.279)
Control	24832.95	27879.21	3046.26 (1158.05)
T-C Difference	22.78906	5204.667	5227.456* (2743.678)
Difference in Differences = $(\overline{TOT}_1^T - \overline{TOT}_0^T) - (\overline{TOT}_1^C - \overline{TOT}_0^C)$ = **5285.28**			
t = 1.9053			
Degrees of freedom = 147			
Pr(|T| > |t|) = 0.0587			

Source: Author's own calculations, 2014

Note: * means statistically significant at 10% level

Generally, this total income, shown in the above table, is typically the average total farm income differences associated with all the crops produced. Regarding the farm income, the first mean

income difference of the non-treatment group before and after the treatment is approximately Birr 3046 while the first mean income difference of the treatment group is Birr 8274 (table 7). And the true income impact of the nutrition project (average treatment effect on the treated) then comes out to be Birr 5228. And this average income impact of the treatment is significant at 10% level of significance.

4.2.2 Adoption of improved potato varieties

To find out the determinant factors that affect the adoption improved seed potato varieties, the study used the end-line survey data.

From the regression result (table 8), education Level of the household head, access to extension services, having radio were found to be positively and significantly affecting the adoption decisions of the smallholder farmers at 5% level of significance.

Namwata B.M.L, *et al*., (2010) also found that the extension services given to the farmers were positively linked to the overall adoption of improved agricultural technologies for Irish potatoes. The farmers with extension services given to them are 43% more likely to adopt new varieties than their counterparts. This result was also consistent with Chilot *et al.*, (1996) and Tesfaye and Abebe, (2001), who found significant relationship of access to extension to adoption of agricultural technologies. Thus, this study's finding about a significant positive impact of the extension services on the adoption decision of household heads is consistent with these the findings of several studies.

Positively affecting the households' decision to adoption is also the education level of the household head. As the level of education increases by one year, the farmers' likelihood to adopt the improved seed potato varieties was found to be increased by 7%. Mwanga *et al.,* (1998) carried out a study in Tanzania and found this similar conclusion about the adoption of improved wheat varieties. Other studies conducted by Asfaw *et al*., (1997), Bekele *et al*., (2000) and Tesfaye and Alemu (2001) also confirm this result of the relationship between education and adoption.

Table 8 the maximum likelihood estimates of the Logit model.

Independent Variables	Coefficient	Marginal Effect	Standard Error
Education Level of the household head	0.26**	0.07	0.13
Age of the household head	0.023	0.01	0.032
Sex of the household head	1.797	0.42	1.395
Marital status of the household head	0.095	0.02	1.241
Household size	0.375	0.09	0.259
Farm size	-0.185	-0.05	0.149
Access to extension services	1.886**	0.43	0.843
Membership to farmers group	-0.817	-0.2	0.844
Participation in Off-farm Activities	2.378***	0.53	0.74
Participation in the project	4.053***	1.01	0.993
Having radio	1.889**	0.44	0.661
Having cell phone	1.378*	0.32	0.805
		Number of obs. = 149	
		LR chi2(13) = 131.37	
		Prob > chi2 = 0.0000	
		Pseudo R2 = 0.6420	

Source: Author's own calculations, 2014

Notes: *** means statistically significant at 1%, ** statistically significant at 5%, and * statistically significant at 10% levels.

The other significant variable is whether or not the household head has radio resulting in that ownership of radio had positive influence on adoption. The farmers who have radio are 44%

more likely to adopt new varieties than the ones who do not have. This result supports Yishak's conclusion in his study on determinants of adoption of improved maize technology in 2005.

Participation in off-farm activities has positive impact on the likelihood of the adoption of new potato varieties, and is significant at 1% level of significance. The farmers with off-farm income/participating in off-farm activities have 53% more likelihood to adopt new varieties than the farmers who do not engage themselves in off-farm activities. Yishak, once again, in his study of determinants of adoption of improved maize technology, got this similar result in 2005.

Furthermore, participation in the project is also found to have a strong positive impact in the adoption decision. Participants of the nutrition project obviously were found to have twice as much probability to adopt new potato varieties as the non-participants. It is consistent with the hypothesis resulting from one of the project's goal.

Having cell phone is also found to be significant at 10% level to positively affect the adoption decision of the smallholder farmers. Farmers with their own personal mobile phones are 32% more likely to adopt improved potato varieties for production as compared to the other farmers who do not have their own mobile phones.

V. Conclusions and Recommendations

5.1 Conclusions

Project interventions like the nutrition project by different institutions are supposed to positively affect the livelihood of the poor in developing countries like Ethiopia. This project in one of the nation's regional states, Tigray, was implemented in order to teach the smallholder farmers in rural areas how important potato and sweetpotato are and bring about attitudinal change towards adopting new innovations of these crops.

Food insecurity and malnutrition are major problems in Tigray. Underlying causes of food insecurity are widely recognized to include rapidly increasing population pressure, widespread environmental degradation, recurrent drought, low productivity of the agricultural sector, and limited market access. Many farmers, even in a good rain season, cannot produce enough to cover their subsistence needs. One of the consequences of this is poor nutrition, particularly among children and pregnant/lactating mothers. Food or cash assistance is therefore relied on to fill the food gap. Such food insecurity and malnutrition cannot be alleviated by focusing on limited traditional crops such as maize, teff, sorghum and barley and wheat; it must be tackled on many fronts including by expanding the production and innovative use of potato and sweetpotato.

This thesis tried to evaluate the impact of the project on the income of the farmers. And this welfare was measured by the potential income of the smallholder farmers from the production of the two crops specifically and from the total crops generally (if any).

In comparing the potential income between participants and non-participants from potato production, the project resulted in bringing a positive result on the treatment group. The farmers under the intervention were found to have a better income difference from the status quo, before the intervention, than the non-treated control group. Regarding the income from sweetpotato production alone, the researcher similarly observed a positive difference in favor of the participants than it was for potato. The project was also found to have a positive impact on the participants' total income.

Coming to the adoption regression function, education Level of the household head, access to extension services, having radio, participating in off-farm activities, participation status in the project and having cell-phone were found to be positively and significantly affecting the adoption decisions of the smallholder farmers.

The study found that the extension services given to the farmers were positively related with the farmers' adoption decision towards improved potato varieties. This is of course expected from the very purpose of extension services. Moreover, education was a determinant factor which is found to be positively and significantly influencing farmer's adoption decision of improved potato varieties. As the level of education increases, the farmers' likelihood to adopt the improved seed potato varieties was found to be increased. This might actually be attributed to the fact that the more the households learn, the more they would have the willingness to accept new innovations and new technologies and the less resistance they would have to adopt new varieties.

Whether the household has a radio of their own is also found to positively affect the adoption decision of the farmers. This could be because the farmers who have radio are well informed about different issues which can alter their decision behaviors positively as most of the programs from radio encourage adoption of new scientific innovations.

Having off-farm income by participating in off-farm activities and participation in the project were also found to increase the likelihood to adopt new potato varieties by the farmers. Generating off-farm income has an impact probably because the farmers going outside of their farm gives them an informal way of getting information about the innovations and other related stuff from different institutions and individuals which in turn affects their decisions to adopt.

On the other hand, whether a farmer was treated is a clear factor to affect their decisions to adopt new varieties including the Irish potato. This directly results from the fact that the intervention taught and encouraged the production of improved potato varieties for the treated group.

Having cell-phone is also found to positively affect the adoption decision of the farmers. This might basically mean that the farmers who have phones are likely to have more information necessary about the new varieties and their productivity than the others by timely communicating with different parties even from outside of their local community.

5.2 Recommendations

Comprehensive impact assessment of programs like the nutrition project that shows the change in the lives of beneficiaries as a result of participation in the programs should be undertaken. Accordingly, building on an accurate evaluation of the impact of programs helps those people who are concerned with the program to react to what is happening on the ground. More specifically, measuring as accurately as possible the impacts of an intervention helps to understand the processes of intervention and their impacts on the beneficiaries so as to improve those processes. The nutrition project is one of the pro-poor programs which was implemented in Tigray region targeting poor households in rural areas. Evaluating the potential income impact of the project is imperative to see what it has achieved in improving the welfare of the smallholder farmers. Thus, based on the findings of the study, this piece of work recommends the following policy options.

- **Focus on the Expansion of Such Projects as the Nutrition Project**

In the impact assessment part of the study, the findings show that the project brought positive results to the participants of the project. For instance, farmers in the treatment group have had more mean income in the potato production alone than in the control group. The same is true if one takes a look at the project's impact from sweetpotato and from the total income perspectives as well. Therefore, projects like the nutrition project should be expanded and should reach larger number of participant farmers and areas in order to bring some welfare improvement towards the poor rural households.

- **Provide Extension Services to the Farmers**

In the adoption regression function, the study drew the conclusion that the farmers who had the access to extension services, regardless of participation status in the project, were the ones who got the tendency to adopt new potato varieties. As previously explained the project's main goal was to bring attitudinal change to the farmers in order for them to produce and consume potato and sweetpotato and adopt new more productive varieties of these crops. Accordingly, for the effectiveness of the goals, an appropriate and effectives extension services can encourage

farmers to use improved potato varieties to boost their production and productivity. Thus, the researcher suggests that extension services should better be provided to the smallholder farmers.

- **Educate Famers**

The level of education of the farmers and the adoption decision of the farmers about new potato varieties were found to be positively related. In other words, the more the farmers are educated the more they are likely to adopt new ways of farm practices including the willingness to accept new and potentially productive seed varieties. The diffusion of the technology could, thus, be facilitated through educated farmers to be used as contact farmers, besides improving farmers' level of education. Hence, the researcher also recommends that the government or any other interested institution should work on providing formal or even informal education for the farmers for the effectiveness of bringing about attitudinal change towards new agricultural innovations like new seed varieties.

- **Help Farmers Get Media Access Such as Radio**

Access to relevant agricultural information is usually supposed to make farmers to be aware of and get better understanding of improved agricultural technologies. This will ultimately facilitate change in the behavior of farmers and lead to decision to take risk for technology adoption. Farmers get access to farm information in different ways including listening radio programs. This study found that having radio is a statistically significant covariate to influence the households' decision to adopt new potato varieties. Thus, the researcher recommends that helping the farmers get access to media like radio programs as one way of bringing attitudinal change among rural households to expand new scientific innovations in their farm activities.

- **Encourage Farmers to Participate in Off-farm Activities**

Off-farm activities are important activities through which rural households get additional income and exposure to informal ways of acquiring information. The income obtained from such activities helps farmers to purchase farm inputs including new varieties and informal information may affect their adoption decision. According to the study, off-farm activity of the households is positively related with their adoption decision. Thus, it is recommended that households have some form of off-farm income source in addition to their regular farm activities.

- **Implement such projects to Include Larger Participants**

The result of the study shows that participation in the project was strongly related with the adoption decisions of the households. One of the project's aims is to increase the production and consumption of the crop along with sweetpotato. Thus, such projects should be implemented in order to make farmers adopt new varieties.

- **Provide Access to Mobile Phone**

The mobile phone can have the greatest effects on farmers through driving down costs associated with travel and transaction costs in their day to day activities. The families can thus better financially manage their situation by incurring lower travel costs, more efficient action, improved access to information and fewer traumas. In addition to that, they can easily make well-informed decisions and access new innovations and improved varieties. Thus, the researcher recommends that the farmers should be provided with this service in order to achieve goals related with adoption of new technologies.

- **Undertake Further Research**

In this research, the researcher mainly tried to evaluate the income impact of the project on smallholder farmers in the study area. In doing so, the study used 150 same samples in the two periods. The sample size of the study may not correctly represent the population in five woredas. As a result, the findings of this research remain tentative not conclusive and further research is necessary.

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VII. Appendices

Appendix 1: calculating the potential farm income of the households

$Y_{i0}=P_{i0}.X_{i0}$ where i= crops produced by farmers in the study area

Y_{i0} is income from commodity i in the first period

P_{i0} the price of commodity i in the first period

X_{i0} is the total production of commodity i in the first period

$Y_{i1}=P_{i1}.X_{i1}$ where i= crops produced by farmers in the study area

Y_{i1} is income from commodity i in the second period

P_{i1} the adjusted price of commodity i in the second period

X_{i1} is the total production of commodity i in the second period

Appendix 2: Stata results for the adoption regression function

Command: logit Y X1 X2 X3 X4 X5 X6 X7 X8 X9 X10 X11 X12

Number of obs = 149
LR chi2(12) = 131.37
Prob > chi2 = 0.0000
Log likelihood = -36.624393 Pseudo R2 = 0.6420

Y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
X1	.2604898	.1304694	2.00	0.046	.0047745	.5162052
X2	.0229568	.0319854	0.72	0.473	-.0397334	.085647
X3	1.797024	1.394891	1.29	0.198	-.9369125	4.530961
X4	.0951601	1.240824	0.08	0.939	-2.336811	2.527131
X5	.3747096	.2590059	1.45	0.148	-.1329326	.8823519
X6	-.1847286	.1491716	-1.24	0.216	-.4770995	.1076423
X7	1.886072	.8429036	2.24	0.025	.2340111	3.538133
X8	-.8171401	.8443358	-0.97	0.333	-2.472008	.8377277
X9	2.377551	.74053	3.21	0.001	.9261385	3.828963
X10	4.052657	.9926653	4.08	0.000	2.107069	5.998245
X11	1.889097	.6607192	2.86	0.004	.5941112	3.184083
X12	1.378154	.8052314	1.71	0.087	-.2000701	2.956379
_cons	-10.90861	3.45929	-3.15	0.002	-17.68869	-4.128521

Marginal effects after logit

Command: mfx

y = Pr(Y) (predict)

= .49685374

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
X1	.0651199	.03265	1.99	0.046	.001133	.129106	3.91275
X2	.005739	.008	0.72	0.473	-.009936	.021414	47.1074
X3*	.4190129	.28223	1.48	0.138	-.134147	.972173	.402685
X4*	.0237814	.30991	0.08	0.939	-.583639	.631202	.644295
X5	.0936737	.06475	1.45	0.148	-.03323	.220577	5.65101
X6	-.0461803	.03724	-1.24	0.215	-.119172	.026811	4.29282
X7*	.4316665	.15721	2.75	0.006	.123532	.739801	.651007
X8*	-.1996989	.19849	-1.01	0.314	-.588735	.189337	.751678
X9*	.5325973	.13151	4.05	0.000	.274849	.790345	.52349
X10*	.7281264	.08718	8.35	0.000	.557251	.899002	.671141
X11*	.4378162	.1306	3.35	0.001	.181844	.693788	.577181
X12*	.3230852	.16443	1.96	0.049	.000802	.645369	.738255

Appendix 3: Link test after logistic regression

Command: .predict yhat (option pr assumed; Pr(Y))

.gen yhat_sq= yhat* yhat

.linktest

Logistic regression — Number of obs = 149; LR chi2(2) = 131.41; Prob > chi2 = 0.0000; Log likelihood = -36.602972; Pseudo R2 = 0.6422

Y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_hat	.9972001	.1734157	5.75	0.000	.6573115	1.337089
_hatsq	.007945	.0598782	0.13	0.894	-.1094142	.1253042
_cons	-.0237191	.3559594	-0.07	0.947	-.7213866	.6739484

Appendix 4: Stata results of the impact assessment

Command: ttest potato_income, by (participation)

Two-sample t test with equal variances

First Diff.	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
control	49	3082.129	172.8118	1209.682	2734.667	3429.59
treatmen	100	3791.368	187.2773	1872.773	3419.769	4162.967
combined	149	3558.128	140.2886	1712.44	3280.901	3835.356
diff		-709.2394	293.8624		-1289.98	-128.4987

diff = mean(control) - mean(treatmen) t = -2.4135
degrees of freedom = 147

Ho: diff = 0

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0085 Pr(|T| > |t|) = 0.0170 Pr(T > t) = 0.9915

Command: ttest sweetpotato_income, by (participation)

Two-sample t test with equal variances

First Diff.	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
control	49	2017.024	575.2496	4026.747	860.4076	3173.641
treatmen	100	4238.15	395.5471	3955.471	3453.298	5023.001
combined	149	3507.712	335.9927	4101.313	2843.75	4171.675
diff		-2221.125	693.8355		-3592.306	-849.9441

diff = mean(control) - mean(treatmen) t = -3.2012
degrees of freedom = 147

Ho: diff = 0

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0008 Pr(|T| > |t|) = 0.0017 Pr(T > t) = 0.9992

Command: ttest total_income, by (participation)

Two-sample t test with equal variances

First | Diff.	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
control	49	3046.259	1158.05	8106.353	717.8427	5374.676
treatmen	100	8273.715	1832.279	18322.79	4638.076	11909.35
combined	149	6554.619	1300.379	15873.15	3984.911	9124.326
diff		-5227.456	2743.678		-10649.6	194.6919

diff = mean(control) - mean(treatmen) t = -1.9053

degrees of freedom = 147

Ho: diff = 0

Ha: diff < 0 Pr(T < t) = 0.0293

Ha: diff != 0 Pr(|T| > |t|) = 0.0587

Ha: diff > 0 Pr(T > t) = 0.9707