ST. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

IMPACT OF AKAKI SMALL-SCALE IRRIGATION SCHEME ON HOUSEHOLD FOOD SECURITY

BY

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DECEMBER 2015,

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A Thesis Submitted to the School of Graduate Studies of St. Mary's University in Partial Fulfillment of the Requirements for the Award of Masters of Science in Agricultural Economics

BY:- MOLLA DERIBIE

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APPROVAL BOARD of EXAMINERS

The undersigned certify that they have read and hereby recommend to the St. Mary's University to accept the Thesis submitted by Molla Deribie and entitled " Impact of Akaki Small-Scale Irrigation Scheme on Household Food Security" in partial fulfillment of the requirements for the award of Masters of Science in Agricultural Economics.

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DECLARATION

Molla Deribie I.D. Number 182/2005 do hereby declare that this Thesis is my original work and that it has not been submitted partially; or fully, by any other person for an award of a Degree in any other university/institution.

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This Thesis has been submitted to St. Mary's University School of Graduate Studies for examination with my approval as university advisor.

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Page

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LIST of TABLES

Page

LIST of ABBREVIATIONS’

ANNO	Anonyms
N/A	Not available
CSI	Copying Strategy Index
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FANTA	Food and Nutrition Technical Assistant
Ha	Hectare
HDDS	Household Dietary Diversity Score
M	Meter
MoFED	Ministry of Finance and Economic Development
NGO	Non -Governmental Organization
Pcs	Packets
PASDEP	Poverty Accelerated and Sustainable Development and Eradication program
UN	United Nation
WFP	World Food Program

ABSTRACT

The study aims to evaluate the impact of Akaki small scale irrigation scheme on household food security of smallholder farmers. Out of 700 farming households with systematically stratified random sampling technique, this causal type of study analyzed 246 household survey based primary data (personal interview questionnaire) with inferential statistics (Heck man two stage). It shows that food security is not as such observed in the study area. At 0.05 probability level; sex, land size (ls), school year of the household head (ed), off farm income (offarmi), irrigation experience (exep) and distance from home to water source (dhomeland) are significant correlates of food security with respect to the three food security indicators (food consumption expenditure score, copying strategy index and dietary diversity score). At 0.05 probability level; sex, off farm income (offarmi), irrigation experience (exep) and distance from home to water source (dhomeland) are statistically significant determinants of the joint indicators and they reliably predict participation in small scale irrigation scheme, citrus paribus. Collective action among governments, NGOs and farming households on flood control and market linkage (perfect information on price of their product) should be taken to let farming households harvest two times per year and prosper.

CHAPTER ONE: INTRODUCTION

This study relies on impact of Akaki small-scale irrigation scheme on household food security. Introducing the whole study based on the research story is advisable. Background, problem statement, objectives, research hypothesis, significance of the study, organization of the study and conclusion are the brief synopsis of the content of the entire chapter.

1.1. Background

Alongside cities horizontal expansion foundation of urban and pre urban agricultural schemes do have an important indication for agricultural policy development. Even thought City Government of Addis Ababa has recognized urban agriculture as one of the important tools to end urban poverty; its contribution has remained negligible (Mpofu, 2013). Agriculture is indeed a not negligible reality of the urban economy, involving anywhere between about10–70 percent of urban households (Calogero et al, 2013). Among these established urban and pre urban agricultural schemes, small scale irrigation package/intervention is vital for reducing food insecurity problem of vulnerable groups in the city. On top of this City Government of Addis Ababa Bureau of Urban Farming has ratified a workable and sound policy of urban agriculture on small scale irrigation to ensure food security of urban settings. Based on that, stating background of food security pillars and impact of river Akaki small scale irrigation scheme on household food security is a crucial task. Food availability, accessibility, stability and utilization and income (adequate benefit from traditional irrigation and hold dairy cows) are the potential pillars of food security and impact of small scale irrigation scheme respectively.

Different economists highlighted that urban agriculture does appear to be associated with greater dietary diversity and calorie availability. Akaki small scale irrigation scheme households have availed/produced vegetables (lettuce, swiss charade, carrot, kale, cabbage, potato, cucumber, cauliflower, beans, tomato, pepper and onion) along river Akaki with surface irrigation for both their family and community. Regarding food accessibility these households have used the machine/generator to pull water from the source and gotten about 85% improved vegetable seeds from Agricultural Input Services Corporations (AISCO); the remaining 15% seed bulk is grown and supplied by farmers themselves. These farmers have supplied about 30 % of vegetable demand for Addis Ababa city (Tadesse et al, nd). Small scale irrigation facilities play a crucial role in ensuring food security. It is therefore paramount for government, NGOs, interest groups and individuals to give small scale irrigated agriculture the needed attention to ensure adequate food supply all year round as food stability (Ocloo et al, 2012). Water management as food utilization river Akaki small scale irrigation schemes was very poor and some of the traditional irrigations schemes are located in the river course and face frequent over flooding during the heavy rainy season. Apart from that there is great concern using fresh vegetables from this schemes as they are irrigated with municipal wastewater (Tadesse et al, nd). As far as food security role of small scale irrigation scheme is concerned, these four indicators should be fulfilled which are associated in with. Traditional irrigation and dairy cows benefit are impact of river Akaki small scale irrigation scheme.

How the world population is going to produce enough and health food to feed more than 9 billion world populations with in 2015 (World economic forum, 2014)? At the rethinking of global food security, world economic forum has focused and believed on a sustainable way of agricultural production as a means but not an end. One of the means is small scale irrigation facilities. It can play a crucial role in ensuring food security and improvement of the nutritional status of vulnerable populations such as children and the sick (Emmanuel and Thomas, 2012). Empirically as Henehan (2012) stated urban agriculture has improved food supply and security. Thirty percent of vegetable supply is urban or peri-urban produced. River Akaki small scale irrigation is a small but mighty scheme that is largely visible as far as urban household level food /nutrition security studies are concerned. Farmers get adequate benefit from traditional irrigation and dairy cows in river Akaki small scale irrigation scheme (Tadesse et al, nd).

In sum food availability, accessibility, stability and utilization are the potential pillars of food security in farm households. Farmers get adequate benefit/income from traditional irrigation and hold dairy cows in river Akaki. Therefore understanding of those factors which can reliably and significantly predict food security of Akaki small scale irrigation is a growing intention of every agricultural economist. To this end this paper has focused on estimation of food security on its determinant.

1.2. Statement of the Problem

During 2011 City Government of Addis Ababa Bureau of Urban Farming has endorsed a workable and sound policy of urban agriculture on small scale irrigation to ensure food security of urban settings. Identification of gaps of the past research findings which did align with this research area did not have taken time. Based on this stating the major research gaps clearly in this doing is rational. The major research gaps in this study area are enough information accessibility and methodology deficiency (indicators, conceptualization, construction of terms and research design problem) on net impact of Akaki small scale irrigation scheme on farm households' food security, correlates of households food security and determinants of participation on small scale irrigation scheme.

Accordingly, there has no study in this study area on net impact of small scale irrigation scheme on food security at large, correlates of households food security and determinants of participation on small scale irrigation scheme in particular. None whatsoever has evaluated the impact of Akaki small scale irrigation on its goal achievement; even the government. Urban agriculture in Addis-Ababa was benefitting urban farmers and had enabled them to bridge the food gap by supplying fresh vegetables (Abebaw,2012; Mpofu, 2013). Thirty percent of vegetables found in the city are grown in the city (60%-70% of leafy vegetables) (Abebaw, 2012). It is only food availability, but no indication of food security. It is a necessary condition of food security. More importantly there has no a quantitative type of research on food security impact of small scale irrigation at this study area. On the other hand urban farmers in Addis Ababa produced about 16,220 tons of different vegetables within an area of 433 ha (Mpofu, 2013). But this is something which has location issue, conceptualization and methodology deficiency /data analysis problem. In terms of data analysis, the above listed past researchers employed the descriptive approach. There is a methodology deficiency-data analysis and no economic measurement of food security performance of the households. Total production by any means cannot be a sufficient condition for food security. There are other food security indicators with pillars of food security (food availability, accessibility, utilization and stability).

On the other hand the past researchers did have failed on research methodology problem on correlates of households food security and determinants of participation on small scale irrigation scheme. Most of the above listed researches done were relied at regional level and economic sector at large (urban agriculture) so that they are more generic in purpose, environmental, qualitative and descriptive in type. Although many researchers have studied impact of small scale irrigation scheme on household food security in different areas, there did not have been a scientific research done at Akaki small scale irrigation scheme with this research area. Still the problem is existed. If this problem is not existed in this area, analyzing impact of small scale irrigation scheme on household food security cannot be compulsory.

In general, so far what this research project mean is the major research gaps in this study area are information accessibility and methodology deficiencies (indicators, conceptualization, construction of terms and research design problem) net impact of food security, correlates of households food security and determinants of participation on small scale irrigation scheme.

1.3. Objectives of the Study

General Objective:

In line with the research topic the general objective of this research is to evaluate impact of Akaki small scale irrigation scheme on household food security of smallholder farmers.

Specific Objectives:

1. To evaluate impact of Akaki small scale irrigation scheme on farm households food security;
2. To identify correlates of food security and
3. To identify determinants of access to small scale irrigation scheme.

1.4. Research Hypothesis

There are specific questions raised at the beginning of this study. As a positive economics so far this position is very clear in stressing to guess tentative answers for these questions. Questions related to objectives of the study require clear and unambiguous declarative sentence. Based on that a realistic set of hypothesis would be:

1. Coefficient of irrigation access estimator (lambda-λ) in the household food security function(yi) is expected to be significant, ceteris paribus;
2. Participation to irrigation (w) (if the household participate in irrigation=1, 0 other wise), family size (fs), sex of the household head (male household head=1, female=0), land size (ls), school year of the household head (ed), irrigation experience (exep), off-farm income (offfarmi), on- farm income (onfarmi), non farm income (nonfarmi) and distance from home to water source (dhomeland) are individually statistically significant correlates of household food security(yi), ceteris paribus;
3. Sex of the household head, irrigation experience, off -farm income, on farm income, non - farm income, access to generator and distance from home to water source are relevant variables of participation to small scale irrigation scheme, ceteris paribus;

1.5. Significance of the Study

The local government and community (farm households and researchers) at large will be benefited via solving food insecurity prevalence by doing performance evaluation so as to input for policy making or revision.

As part of the community, farm households will be benefited from this study is that it is going to highlight areas of nutritional concern in Addis Ababa urban settings at large and Akaki small scale irrigation farmers in particular. Not only this, even the study will draw the attention of food security to areas they should investigate further who would repeat this research area. And also it will be useful for academic reference for students at school.

All in all the local government and community (farm households and researchers) at large will be benefited from this study. The two decision makers will use this study as a tool for performance evaluation on small scale irrigation, solving food insecurity prevalence and input for policy making or revision.

1.6. Scope and Limitation of the Study

River Akaki small scale irrigation scheme is practiced by smallholder farmers who are more vulnerable to prevalence of food insecurity (Mulugeta, 2014). In the city of Addis Ababa there is a vast urban farming practice in the sub cities. But this research covered only river Akaki small scale irrigators and non irrigator farmers who are more vulnerable in food insecurity prevalence. Therefore, the result of this study accepted only with 95% of confidence level, 246 sample sizes for inferential statistics analysis and causal type of research limitations.

1.7. Organization of the Study

This is the structure of the research. Stating organization of the study clearly is an intersting. Chapter one, two, three, four and five are structures of the research.

Background, problem statement, objectives, hypothesis, significance, scope and limitation of this study are included in chapter one as an introduction. The later is chapter two. Theoretical and empirical literature are included under this chapter. Methodology; results and discussions and summary, conclusion and recommendation are the main constitute of chapter three, four and five in this study area respectively.

1.8. Conclusion

In sum potential pillars of food security, benefits of households, research gaps (information accessibility and methodology deficiencies, performance evaluation importance of the study limitation-location issue, concept, and methodology deficiency) were the main issues raised based on the review of different literatures in the entire chapter.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

Different researchers did have researches on food security. In this part this study outlines both theoretical and empirical evidence that will enable the researcher to estimate the magnitude and direction of explanatory variables quantitatively and to interpret the scheme role on household food security. In light of this different literatures have been organized based on sequential, topical, methodological and theoretical that have already studied. Theoretical (definition of concepts/food security indicators) and empirical literatures in connection with identifying strategies that have been attempted, results obtained, gaps or shortfalls of past studies and refining, revising and extending this research to some extent is the supportive reviews of this task.

2.2. Theoretical Literature

In this part the literatures has been reviewed based on the themes which have been written in the past by different authors. So that it has been carefully observed what has said about objectives of this research than ever before. Definition and Concepts of food security, impact of small-scale irrigation on household food security, correlates of food security, determinants of participation on small scale irrigation and mean value of food consumption expenditure given its factors have been reviewed from mathematical and econometric theory stand point of view.

2.2.1. Definition and Concepts of Food Security

Regardless of meanings of economic terms, defining concepts of key words prior to conceptual framework of different researches is believed to be important. World food summit (1996) has defined *food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.* Based on this defining different concepts has been emphasized. The potential pillars of food security (Food availability, accessibility, stability and utilization), label of food security/ insecurity and small scale irrigation are the key words that inquire definition.

There are four pillars of food security (Calogero et al, 2013):

Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

Food access: The access to adequate resources (entitlements) to acquire appropriate foods for a nutritious diet. Entitlements are defined here as the set of all commodity bundles over which a person can establish command, given the legal, political, economic and social arrangements of the community in which he or she lives (including traditional rights such as access to common resources).

Food utilization: The utilization of food through adequate diet, clean water, sanitation, and health care, to reach a state of nutritional well-being in which all physiological needs are met.

This highlights the importance of non-food inputs in food security. For example, it is insufficient for an individual to receive an adequate quantity of food, if he or she is unable to make use of the food due to illnesses resulting from inadequate sanitation or poor sanitary practices.

Food stability: The stability of access to adequate food at all times, independent of shocks (such as economic or climate related crises) or cyclical patterns. This includes issues of seasonal food insecurity, such as the agricultural period before harvest known as 'the hunger season. In doing so, what has not been said on this study is definitions on four pillars and indicators of food security about.

Having this in mind, USDA (2006) did have labeled ranges of food security/ insecurity.

High food security (old label=Food security) is to mean that no reported indications of food-access problems or limitations. Marginal food security (old label=Food security): one or two reported indications-typically of anxiety over food sufficiency or shortage of food in the house. There is little or no indication of changes in diets or food intake. Low food security (old label=Food insecurity without hunger): is to mean that there is a report of reduced quality, variety, or desirability of diet. There is little or no indication of reduced food intake. Very low food security (old label=Food insecurity with hunger): Reports of multiple indications of disrupted eating patterns and reduced food intake.

Small scale irrigation: Small scale irrigation scheme is, first and foremost, a policy intervention for curving food insecurity problem for those who are more vulnerable groups.

Smith et.al(2006) as cited by Calogero C. (2013) even though undernourishment[1] indicator has an advantage on allowing for frequent updated comparisons of energy deficiency across countries and over time nationally, it relies on often poor quality data and unwillingly to the analysis of food insecurity determinants' profiles below the national level. Using either household survey food consumption data or caloric intake [2] indicator (individual level) has a possible solution in this circumstance. Calogero C. (2013) stated even if household survey food consumption data and caloric intake indicators have big advantages on food security monitoring and analysis, these aggregates are therefore both have high data collection cost, data analysis time and skill level required.; as such, they are not always feasible to collect on a regular basis. Furthermore, collecting detailed food consumption data requires lengthy lists of food items, an approach that may be unattractive when the objective is to keep interview time to a reasonable length. In lieu this using coping strategy index[3] indicator is easy, feasible and observable in terms of cost to collect data. But it is a subjective measure, high susceptibility to misreporting, for focus group discussion and emergencies –for early warning purpose. Dietary diversity indicator[4] incur low data collection cost, data analysis time, moderately low skill level required and low susceptibility to misreporting, but does not record quantities and difficulty involved in interpreting comparisons across studies, since the food groupings as well as the reference periods often vary between approaches. To clear these ambiguities undernourishment, household survey food consumption data and caloric intake indicators have been taken out in favor of coping strategy index (food stability), dietary diversity and food consumption score[5] indicators jointly. Food consumption score lacks the ability to differentiate between processed and unprocessed foods utilization, the indicator is also unsuitable for emergency assessments. Regardless of food insecurity emergency, furthermore, this study also due considerations to food utilization (non food indicators) on the basis of joint indicators.

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[1] Undernourishment: it is FAO's food security indicator that measures average availability of food against requirements at the national level (Calogero C., 2013).

[2] Caloric intake: the most accurate measure of food security status of an individual (Calogero C., 2013).

[3] Coping Strategy Index: it measures household food consumption vulnerabilities (Calogero C., 2013).

[4] Dietary diversity indicator: number of food groups that a household consumes over a reference period (Calogero C., 2013).

[5] Food consumption score: FCS is calculated from the types of foods and the frequencies with which they are consumed during a seven-day period (Calogero C., 2013).

2.3. Empirical Literature

Unlike to theoretical, empirical review can benefits this study with what is happening in reality. In this part the literature has been reviewed based on the themes which have been written in the past like theoretical review. Objectives of this study have been thoroughly observed in line with past studies. Impact of small-scale irrigation on household food security, correlates of food security, determinants of participation to irrigation and food consumption expenditure score of farm household have been reviewed with empirical evidence accordingly.

Table 1: Summary of Review of Literature:

Bogale and Shimelis (2009)	two-stage random sampling procedure, survey, structured questionnaire and logit model.	Dire Dawa,	• The odds ratio in favor of the probability of being food insecure increases with an increase in the family size; • Access to better income opportunities are less likely to become food insecure than those households who had no or little access; • Use of irrigation showed a statistically significant and negative
Emmanuel Amankwah and Thomas O.(2012)	Questionnaires with structured and non structured inter-views, field observation and compilation of reports from relevant institutions.	Ghana	Small scale irrigation facilities play a crucial role in ensuring food security in the Upper West Region.
Ernest B.et al.(2013)	In-depth interview, schedules and observation and simple random sampling.	Ghana	irrigation scheme enhanced household food security and wellbeing during the off farming (dry).
Kinfe Asayehegn (2012)	Stratified random sampling, structured interview, descriptive statistics and causal (Heckman's two stage estimation)	Tigray, Ethiopia	Irrigation has positive consequences on food security,
Abonesh et.al(2006)	Stratified and simple random sampling, semi-structured questionnaire, descriptive and econometric (Heckman two-step procedure) techniques.	East Shoa, Ethiopia	• Off-farm employment is the most important copping strategy among both irrigators and non- irrigators; • Irrigators have small household size, higher level of education, large livestock holding size, and better quality (fertility) cultivable land and • Irrigation had positive significant impact on household food security.
Alberto and Luca (2010)	Causal type of research design, inferential and descriptive statistics , multivariate analysis,	Asia, Africa, Eastern Europe and	• Urban agriculture may have a role to play in addressing urban food insecurity problems and • Urban agriculture associated with food security

2.3.1. Impact of Small Scale Irrigation Scheme on Food Security

A number of scholars have disputed on the findings of Abonesh et.al (2006). Positive coefficient of irrigation access is the commonplace opinion on food security. Abonesh et.al (2006) and Kinfe (2012) have described participation with small scale irrigation do have a positive impact on household food security. Alberto and Luca (2010) described that a relationship with greater calorie consumption, with fruits and vegetables being the food group more consistently found to contribute to the increase in calorie consumption associated with the engagement in urban agriculture. Use of irrigation showed a statistically significant and negative relationship with food insecurity (Bogale and Shimelis, 2009). Use of irrigation showed a statistically significant and negative relationship with food insecurity (Bogale and Shimelis,2009). As Emmanuel Amankwah and Thomas O. (2012) concluded that small scale irrigation facilities play a crucial role in ensuring food security in the upper west region. On the other hand Ernest B.et al.(2013) the irrigation scheme enhanced household food security. But there is no such type of research at Akaki small scale irrigating scheme. That is why this study has conducted in this study area.

2.3.2. Correlates of Food Security

Economists generalized that food security can depend on food availability, food accessibility, food stability and food utilization. Bogale and Shimelis (2009) from table 1 hereinabove in their logit model analysis of household food security survey postulated family size, land size and level of agricultural production have got relative importance in determining whether a household is food secure or not. Among/between variables considered, family size, annual income, amount of credit received, access to irrigation, age of household head, farm size, and livestock owned showed theoretically consistent and statistically direct significant effect on food security. As can be seen from table 1 hereinabove, however Kinfe A. (2012) has described household with larger size of active labor force, sex of the household head, access to small scale irrigation, cultivated land size, self-help cooperatives, saving and credit associations and market information significantly influence food security status of farm household.

2.3.3. Determinants of Participation to Irrigation

Both hydrologic nature of water resource (efficient) and access to irrigation has deep roots in and close ties with issue of riparian and prior appropriation right (property rights structure-inefficient). The past researchers did have scrutinized that households that live around their catchment area and the first person to arrive (superior claim on the water) expected to have an access of small scale irrigation scheme. Abonesh et.al (2006) concluded that house hold size, size of cultivated land, on-farm income, livestock holding, farmers' perception of soil fertility status, access to credit, nearest to water sources and household size square are the significant variables of access to irrigation. On-farm income, large livestock holding size, ownership of relatively fertile land and nearest of water source have a probability to increase participation in irrigation. The marginal effect shows that as on-farm income of households increases by 100 ETB, the probability of a household's participation in small-scale irrigation increases by 1%. Large house hold size, large cultivated area and access to credit have a probability to reduce access to irrigation. Abonesh et.al (2006) and Kinfe (2012) access of credit is a determinant factor. But Rushad and Syed W. (2010) have stated in their findings sex of household head has not been found to be a statistically significant factor even at 10% level of significance, though the sign of the coefficient is negative. Furthermore Kinfe (2012) found access to market information and utilization of credit has positively and significantly associated with probability of participation in small-scale irrigation at less than 1% probability level.

On the other hand Alberto and Luca (2010) did have highlighted urban agriculture does appear to be associated with greater dietary diversity and calorie availability, both measures of an improved diet and hence closely related to food security.

To sum up from the table 1 above Kinfe (2012) and Alberto and Luca (2010) in their recent research found that irrigation have positive consequences on food security. Abonesh et.al (2006) summarized that 70% of irrigation users are food secure while 20 % non irrigators are food secure. In addition to that small scale irrigation is one of the viable solutions to secure household food needs, but it did not eliminate the food insecurity problem. But this research is going to focus on vegetable producers with small scale irrigation only.

On the one hand, Kinfe (2012) suggested irrigation can improve health condition of farm households. As he concluded, the health condition of 61.54% of the users of irrigation is improved due to capacity of the farm households for medication and purchasing power of medicines while for the rest is due to improved feeding system and hygiene. But whatever research is done in Ethiopia, non what so ever has done causal type of economic research at Akaki small scale irrigation scheme independently.

Empirically, impact of small-scale irrigation on household food security, correlates of food security and access to irrigation are results of empirical past studies that have been found out. But lack of empirical evidence on mean value of food consumption expenditure given its factors is one of the most variable that has found in the reviewed process. Bogale and Shimelis (2009), Kinfe (2012), Abonesh et.al (2006), Rushad and Syed (2010) and Alberto and Luca (2010) did have investigated better analytical evidence on impact of small scale irrigation on food security, correlates of food security and access to irrigation.

Positive relationship between food security and household irrigation access is how many researchers do better at all.

2.4. Conclusion

In sum, no other strategies have worked they tried to define concepts, evaluate impact of small scale irrigation on food security, identify correlates of food security and identify determinants of participation on irrigation, household food consumption score in cause and effect way with inferential statistical analysis and Heckman model at Akaki small scale irrigation scheme. Researchers did have tried for looking both quantitative and qualitative data from Akaki small scale irrigation scheme; they done cost benefit, environmental and health impact analysis. All kind these nothing works, but my method well.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

Different agencies have developed approaches that suit their individual needs on food security survey. Whatever the case, stating scientific ways of how this research project was studied is logical. Study area description, research design, sample size and sampling procedure, data sources/collection and analysis method are the main scientific constituents of this research methodology.

3.2. Study Area Description

Akaki kalit district is the place where both irrigators and non irrigators of vegetables producers found. Therefore describing Akaki small scale irrigation scheme with its tremendous attribute is important. Its location, population size and density, land use, irrigable land sizes are the main essence of this area.

Akaki small scale irrigation scheme is located at Akaki-Kality sub-city in the South of the city of Addis Ababa, Ethiopia through which river Akaki crossed. During the pilot study as a key informant Mulugeta (2014) stated this river has two tributaries namely, little Akaki- drains from Torhailoch and big Akaki- drains from bulbula/legedadi and they create the so called river Akaki at Aba Samuel and drainage in the city with in the area in general to the South-to River Awash basin.

Based on a report gotten from Federal Democratic Republic of Ethiopia population census survey commission (2008), there is total of 181,202 populations in Akaki kality sub city with 1,653.7 Population per meter square. As Mulugeta (2014) informed from his key note speech out of these populations 700 use this river actively for urban vegetables source. Right now this catchment area is an inhabitant of smallholder farmers.

Furthermore as Mulugeta (2014) said River Akaki small scale irrigation area is one of the catchment areas of urban agriculture (vegetable crop production) in the city of Addis Ababa. Out of 310 expected ha of arable land, 120ha is cultivated for beetroot, cabbage, carrot, garlic, lettuce, onion, pepper, pumpkin, tomato, salad with in bega/winter season.

3.3. Research Design

This research project has been technically designed on the bases of research method it followed. As research design is considered it can be either exploratory, descriptive or causal/joint. Causal type research design is clear in decision making; highly structured; confirmatory oriented, impact evaluation & no further research is needed (managerially action able) on the representative of a given population. Therefore, in this research due to amount of high certainty for decision making, research approach it follow, problem statement and objective of the study and nature of result; causal research design was preferred to both exploratory and descriptive research design.

3.4. Sample Size and Sampling Procedure

In the study area there are 700 farm households who are more vulnerable with food insecurity prevalence. These are both irrigator and no irrigator farmers. If this is so, it is better to stratify them as “households who use small-scale irrigation” and “households who are not using small-scale irrigation”. Out of 355 sampling frame of households who use small-scale irrigation with random sampling technique, 123 sample sizes were drawn. Out of 345 sampling frame of households who are not using small-scale irrigation with systematic random sampling technique, 123 sample sizes were drawn

Ethical considerations were taken on informed consent of the research participant, protect research participants from harm, honesty in presenting results and errors, participant’s rights to privacy; especially phone call & observational studies, refrain from data cooking/manipulation and confidentiality in sharing results in this research. Pilot study/pre test on program adjustment was conducted before the full research has done based on the sample draw.

As Scott Smith (2013) has conducted the correct sample size was determined by the following formula.

$$= \frac{(- \qquad)^2 * \qquad *(- \qquad)}{(\qquad)^2}$$

, where Z-score= Z-score of Confidence level at 95% (standard value of 1.96), =Standard of Deviation or estimated prevalence of food insecurity (.2).

In this study area, even if some studies have conducted, there is no margin of error. If this is so, Scott Smith (2013) has decided to use 5% margin of error which is the safe, forgiving number and ensures large enough sample in this case about.

$$= \frac{(\;.\;)^2 * \;\;.\;\; *(\;-\;.\;)}{(\;.\;)^2} = 246$$

Based on a report gotten from Federal Democratic Republic of Ethiopia population census survey commission (2008), there is a total of 181,202 population in Akaki kality sub city. Out of these population 700 are urban farmers (vegetable producers). Because of a complete list of the population exist in the sub city, with stratified random sampling technique 246 sample sizes were drawn from farm households by grouping the farming households in to two. Three hundred fifty five of these households are irrigators and the rest are none irrigators. Therefore, 123 samples from participant and non participant with systematic random sampling were drawn out of 700 households. Sample interval was determined by dividing total population with sample size; i.e 355/123=3 for irrigators and 345/123=3 for non irrigators. Then, the first respondent was determined by randomization table. That is number 2 from the list of 355 and 345 households between one and the sampling interval, every other respondent was selected every 3 interval up to the end (123) starting from number 2 to collect the necessary data from its source.

3.5. Data Sources and Data Collection Method

Stating data sources, variables and the way the data was collected from its source are certainly a crucial task. The basic variables in food security survey are undernourishment, household survey food consumption data, caloric intake, coping strategy index, dietary diversity and food consumption score which have stated herein above in the literature review part. No single indicator can able to fully capture food security. Due to poor quality data and unwillingly to analyze estimators of food security below the national level, high data collection and analysis cost, skill level required, undernourishment, household survey food consumption data and caloric intake indicators at an average was not selected in this study. In lieu this to clear these ambiguities, undernourishment, household survey food consumption data and caloric intake indicators in favor of coping strategy index (food stability), dietary diversity and food consumption score indicator jointly for data collection were omitted out.

In this study quantitative data type was collected from both primary and secondary data sources. With highly structural questionnaire and personal contact interview; primary data was collected as per the due date. According to WFP/ FANTA/FAO, household food security was measured with household food consumption expenditure score /household dietary diversity score/ coping strategy index indicators The food consumption expenditure score was collected from the types of foods and the frequencies[6] with which they are consumed during a seven-day period. The score produced is a continuous variable and statistics are usually presented including the mean over time and across categories. Dietary diversity was collected by recording the number of food groups that a household consumes over a reference period. On the other hand coping strategy index was collected from household food consumption vulnerabilities.

The person within the household (hereinafter called household head) who has primary responsibility for and most knowledgeable about this activity was asked a series of questions.

Unlike to primary data, secondary data were collected in such a way that reviewing *cross-sectional data*[7] from Ethiopian MoFED - Ethiopian Statistical Agency and Addis Ababa urban agriculture office with desk review for data analysis.

3.6. Data Analysis Method

It is the stage of application of reasoning and to generate meaningful information from the collected data. Once the quantitative data is collected; clarifying, categorizing- breakdown by socioeconomic category and /or livelihood group, processing and coding how the collected data was analyzed is better. Having this in mind, the collected data were analyzed in such a way that employing inferential statistics (Heckman's two-step procedures). However; significance of estimators and interpretation was based on post estimation of marginal effect.

Evaluating the effect of irrigation scheme on an outcome variable using regression analysis such as logit and probit models can lead biased[8] estimate if the underlying process which governs selection into the institution or a program is not incorporated in the empirical frame work. One solution to this problem in econometrics is the application of Heckman's two-step procedures through controlling of sample selection biases (Wooldridge, 2002; Zaman, 2001). If this is so, the collected data was analyzed with an econometric tool -Heckman model and its two-step estimator.

Impact of Small-Scale Irrigation on Household Food Security:

From Heckman model and its two-step estimator anyone can develop both mathematical and econometric models as:

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[6] Food frequency is determined by recording the number of days on which a particular food group is consumed over a reference period, usually 7 days.

[7] In a pure cross section analysis we would ignore any minor timing differences in collecting the data. If a set of families was surveyed during different weeks of the same year, we would still view this as a cross-sectional data set (Wooldrige, 2002)

[8] No response

Mathematical model

$$S = X\beta + \lambda p \quad (1)$$

Econometric theory

A model commonly employed in evaluating program impacts is the following:

$S = X\beta + \lambda p + \varepsilon$

where P is the participation dummy variable defined above. The estimate of λ is interpreted as the program net impact (Heckman, 1974,1978 and 1979).

In this study $y_i = \beta X_i + \lambda w^*_i + \varepsilon_i$, where the estimate of λ is interpreted as the small scale irrigation scheme net impact.

In short, theories on impact of small-scale irrigation on household food security are results of theoretical past studies that have been found out. But lack of information on theory of magnitude and direction of small scale irrigation on food security is one of the most important point in the review process. Heckman (1974, 1978, and 1979) and world food summit (1996) did have better theories on correlates of food security.

Correlates of Food Security:

In doing so this study has been outlined theoretical evidence that will enable to estimate the magnitude and direction of explanatory variables quantitatively and interpret the scheme net impact on household food security.

Mathematical Model

Food security is depend on four variables/pillars (World Food Summit, 1996).

$y = FA + FAc + FU + FSt$, Mathematical model (2)

,where y is food consumption expenditure score. Food availability (FA), food accessibility (FAc), food utilization (FU) and food stability (FSt) are the correlates of food security. But it lacks some relevant variables.

Food consumption=f (yd, s), Consumption theory (3)

yd is disposable income and s is saving of the consumer (household).

As disposable income of the household increases, then food consumption score so does, keeping other variables constant. This is to mean that they have a direct relationship.

$y = \beta X_i$, from Heckman model and its two-step estimator (4)

Econometric Theory

This can be framed by the Heckman model and its two-step estimator.

A sample selection model always involves two equations (Heckman, 1974,1978 and 1979):

a. the regression equation considering mechanisms determining the outcome variable and
b. the selection equation considering a portion of the sample whose outcome is observed and mechanisms determining the selection process.

As Heckman (1997) stated although logit and probit models offer practical solutions to various types of evaluation problems, they lead biased estimate if the underlying process which governs selection into the institution or a program is not incorporated in the empirical frame work. One solution for this problem is a treatment effect model. It is sensitive to model misspecification and producing improved estimates of average treatment especially when the causes of selection processes are known and are correctly specified in the selection equation. But Heckman (1997) criticizes this parameter of interest by stating that picking a millionaire at random to participate in program is not policy relevant or feasible, it may be of interest if the population of interest is appropriately defined. One solution to this problem in econometrics is the application of Heckman's two-step procedures through controlling of sample selection biases (Wooldridge, 2002; Zaman, 2001). Therefore Heckman model is more appropriate in correcting selection bias, consistent, program evaluation, asymptotically efficient estimates and estimating the probability (i.e., the propensity score) of a participant. If this is so, the collected data will be analyzed with an econometric tool (Heckman model and its two-step estimator).

Based on that to express the model, Heckman (1974, 1978 and 1970) stated there will be two equations, the regression equation of household food security and the selection equation of participating in small scale irrigation scheme. For the purpose of modeling any sample selection process, two equations are used to express the determinants of outcome y.

Regression equation: $y = ßX_i + u_1$ observed if w=1 (5)

Selection equation: $w^* = \gamma Z_i + u_2$, w=1 if $w^* > 0$ and w=0, otherwise, (6)

Prob $(w_i = 1|z_i) = \phi(z_i \gamma)$ and Prob $(w_i = 0|z_i) = 1 - \phi(z_i \gamma)$, X_i is a vector of exogenous variables determining outcome yi, and w* is a latent endogens variable, Z is a vector of exogenous variable determining the selection process or the outcome of w*, ɸ is the standard normal cumulative distribution function; and u_1 and u_2 are error terms of the two regression equations.

A model commonly employed in evaluating program impacts is the following:

$S = Xß + \lambda p + \varepsilon$ where P is the participation dummy variable defined above. The estimate of λ is interpreted as the program net impact (Heckman, 1974,1978 and 1979). If λ is statistically significant, then the program can show an impact.

In this study $y_i= ßX_i+\lambda w^*_i +\varepsilon_i$, estimate of λ is interpreted as the small scale irrigation scheme net impact, X_i and w^* are aggregated determinants of food security and access to irrigation respectively

Note that the selection equation indicates that household food security will be observed only for those households whose food security in terms of household food consumption expenditure score/ coping strategy index/dietary diversity were greater than 0 (i.e. households will be considered as having participated in the irrigation if and only if their food security on the basis of the three food security indicators survey was above a certain threshold value). Using a zero value in this equation is a normalization convenience small scale irrigation scheme will be greater than their reservation food security (i.e. $y > y^*$). The fact that the household food security of none irrigators (those are food insecure) will be less than their reservation food security (i.e., $y < y^*$) is expressed in the above model through the fact that these household food security will not be observed in the regression equation, that is it will incidentally truncated (Heckman, 1974,1978 and 1979):

Therefore, determinates of food security can be developed from (4) as:

$$y= ßX_i+ u_1, \text{ regression equation (food security)} \tag{7}$$

Determinants of participation on small scale irrigation scheme:

From Heckman model and its two-step estimator anyone can develop both mathematical and econometric models as:

Mathematical Model

$$w^*= \gamma Z_i \tag{8}$$

Econometric Theory

Someone can develop Econometric model from equation (8) as:

Selection equation: $w^*= \gamma Z_i+ u_2$, $w=1$ if $w^* >0$ and $w=0$, otherwise (8)

Mean Value of Food Consumption Expenditure Given Its Factors:

According to WFP/ FANTA/FAO, the concept of household food security (outcome -yi) will be measured with household food consumption expenditure score /household dietary diversity[9] score/coping strategy index. Food frequency is determined by recording the number of days on which a particular food group is consumed over a reference period, usually 7 days. The FCS is

9 If there are no unmeasured variables that predict selection into the sample/ selection into the sample is random, we can just include the selection factors in the outcome equation (Graduate Methods Master Class, 2005)

calculated from the types of foods and the frequencies with which they are consumed during a seven-day period. The score produced is a continuous variable and statistics are usually presented including the mean over time and across categories, as well as frequencies and cross tabulations for food consumption groups. The selection equation/irrigation participation (Maximum Likelihood Estimator) will be represented by w*and food security determinant will be represented by Xi.

Mathematical Model

Food consumption can be expressed as:

Food consumption (fc=y) = food consume at home (fh) + food consume outside of home (foh)

=f (yd, s) (9)

It is based on dietary diversity (food groups) and its frequency within 7 days.

Econometric Theory

A model commonly employed in evaluating program impacts is the following:

$S=X\beta+\lambda p+\varepsilon$ 10)

, where P is the participation dummy variable defined above. The estimate of λ is interpreted as the program net impact (Heckman 1974, 1978, and 1979).

In this case $y_i= \beta X_i+\lambda w^*_i +\varepsilon_i$, where the estimate of λ is interpreted as the small scale irrigation scheme net impact from empirical result.

3.7. Conclusion

In sum this causal type of research, stratified random sampling technique, 246 sample sizes, highly structured questionnaire-for quantitative primary data and desk review of performance reports-for secondary data and Heckman model and its two-step estimator was used to get accurate research result.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Introduction

In this study the current data on food security impact of small scale irrigation scheme was collected, analyzed and interpreted based on the data gathered from 246 farming household respondents. It is clreared that all objectives were adressed. Based on that it is important to state results and discussion in relation to past findings and theories done ever before. So some clear hints came from this analysis is that Akaki small scale irrigation scheme impact, correlates of food security and determinants of participation to small scale irrigation scheme were investigated on the basis of food consumption score, copying strategy index and dietary diversity score indicators of food security.

4.2. Model Findings

Descriptive Results: data distribution and location as per the sampled households.

Table 2: Description on Households Food Security Situation Between Targets:

Indicators	No. of food secure households			
	Irrigators		Non irrigators	
	Number	%	number	%
FCS	43	34.95	43	34.95%
CSI	44	35.77	44	52.00%
HHDDS	46	37.39	46	34.95%

At FCS, out of the total 246 sample households contacted 43 (34.95 %) were food secure while the rest 80 (65.05%) were food insecure for both irrigator and non irrigator households.

The proportion of food secure households at CSI consist 35.77% (44 household) of the total sample irrigator households contacted. Out of the total 123 sample non irrigator households contacted 64 (52%) were food secure while the rest 59 (48%) were food insecure.

Out of the total 123 sample contacted the total number of irrigator households have been reported by food secure in HHDDS were 46 (37.39%) while the rest 77 (62.61%) were food insecure. Furthermore, out of the total 123 sample non irrigator households responded 34.95% (43 households) of non irrigators were food secure while the rest 65.05% (80) were still vulnerable in food insecurity.

Table 3: Description of Average Family Size and Strata of Farming Households:

Family size (fs) strata	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
2-3	21	17.07	16	13.00
4-6	53	43.09	71	57.73
>6	49	39.84	36	29.27
Total	123	100	123	100

As can be seen from the above table someone can observe that the average family size in both targets does show significant variations. Twenty one households (17.07%) out of the total sampled irrigator households contacted did have family size of 2 to 3 while non irrigators did have 16 (13%). Out of the total sampled irrigator households contacted; 53 (43.09%) of them did have a family size of 4-6 while non irrigators did have 36 (29.27%). Forty nine (39.84%) and 36 (29.27%) are number of households/proportion that did have more than 6 family size in both irrigators and non irrigators respectively.

Table 4: Proportion of Estimators towards Household Characteristics:

Estimators	No. of households			
	Irrigators		Non irrigators	
	number	%	number	%
Sex	44	35.77	41	33.33
School year (ed)	42	34.15	43	34.95
Generator used	42	34.15	0	0.00

Out of the total 123 sampled irrigators interviewed 44 households (35.77%) were male while the rest 79 (64.23%) were female headed households. On the other hand out of the total sampled non irrigators contacted 41 households (33.33) were male headed while the rest 82 (66.67%) were female headed households. In this regard someone can conclude that female headed dominate households were observed in the sample. 34.15% of irrigators were literate (42 households) while the rest 81 households (65.85%) were illiterate. 34.95% (43 households) of non irrigators were literate while the rest 80 (65.05%) were illiterate. As can be seen from the above table someone can conclude that illiterate households were dominate in the sample.

Out of the total 123 sampled irrigators 42 (34.15%) were generator/water pump users while the rest 81(65.83%) were non users and non irrigators are non users. Generator users were small in proportion.

Table 5: Description of Land Size per Household (in hectare):

Land size (ls) strata	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
≤0.07	53	43.09	58	47.200
0.07-0.5	45	36.58	41	33.300
>0.5	25	20.33	24	19.500
Total	123	100	123	100

While the majority of irrigator and non irrigator households contacted 53 (43.09%) and 58 (47.2%) respectively did own less than 0.07 hectares of arable plot of land, 45 (36.58%) did have between 0.07 to 0.5 hectares as 41 (33.3%) non irrigators did own about. It is only 25 irrigator households (20.33% of the sampled) that reported did own more than 0.5 hectares of land size as non irrigator households 24 (19.5%) did own.

Table 6: Description on Off-Farm Income per Household (in ETB/month):

Income level	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
0	81	65.85	79	64.23
0-100	18	14.63	9	7.32
100-150	20	16.22	17	13.82
>150	4	3.30	18	14.63
Total	123	100	123	100

As long as off-farm income is considered, the majority of the two targets did have not gotten revenue in activities outside his/her farm by employment. Irrigator; 81 (65.85%) and non irrigator; 79 (64.23%) households did have not employed outside their farm so that they did have earn zero off-farm income. While 18 households (14.63%) of irrigators and 9 households (7.32%) of non irrigators did earned between 0 to 100 ETB off-farm income, nearly 20 (16.22%) of irrigators and 17 (13.82%) of non irrigators did have earn between 100-150 ETB. Furthermore, the proportion of those did have earn more than 150 ETB is very small for both irrigator; 4 (3.30%) and non irrigator 18 (14.63%) households.

Table 7: Description of Household On-farm Income Status (in ETB/month):

Income level	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
0	0	0	0	0
0-100	2	1.63	1	0.81
100-150	5	4.07	5	4.07
>150	116	94.3	117	95.12
Total	123	100	123	100

The survey revealed that non what so ever did have earned zero ETB among the two sampled targets. Only small number of irrigator; 2 (1.63%) and non irrigator; 1 (0.81) households did earn between 0 to 100 ETB as both irrigator and non irrigator households; 5 (4.07%) did earn between 100 to 150 ETB from the farm they cultivated. The vast majority of sampled irrigators contacted; 116 (94.3%) did earn more than 150 ETB as non irrigators 117 (95.12%) did earn.

Table 8: Description of Household Non - Farm Income Status (in ETB/month):

Income level	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
0	80	65.04	80	65.04
0-100	1	0.81	0	0
100-150	0	0	1	0.81
>150	42	34.15	42	34.15
Total	123	100	123	100

The vast majority of both sampled irrigators and non irrigators 80 (65.04%) did not have non farm income source outside farming activities. While sampled irrigators contacted only 1 household (0.81%) did earn non farm income between 0 to 100 as none of non irrigators earn from, nearly null irrigator and 1 non irrigator (0.81%) did earn non farm income between 100 to 150 ETB.

Table 9: Description On Farming Experience of Households (in year):

Year of experience	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
1-2	81	65.80	80	65.04
2-9	28	22.80	34	27.64
>9	14	11.40	9	7.32
Total	123	100	123	100

The vast majority of sampled irrigators; 81 (65.8%) and non irrigators; 80 (65.04%) contacted did have between 1 to 2 years of farming experience. As sampled irrigators; 28 (22.8%) and non irrigators; 34 (27.64%) did have between 2 to 9 years of farming experience, nearly 14 irrigator (11.40%) and 9 non irrigator (7.32%) households did have more than 9 years of farming experience.

Table 10: Description of Distance from Home to Irrigation Water Source (in k.m):

distance	Households characteristics			
	Irrigators		Non irrigators	
	number	%	number	%
≤0.1	51	41.50	61	49.50
0.1-0.5	70	56.90	58	47.20
>0.5	2	1.60	4	3.30
Total	123	100	123	100

This household survey reveals that endowment of resources (water and irrigation land) is as an expense of early settlement around the river bank. Out of sampled irrigators; 51 (41.50%) and non irrigators; 61 (49.50%) contacted do live at most 0.1k.ms far away from irrigation water source (herein after called river bank). While sampled responded irrigator; 70 (56.90%) and non irrigator; 58 (47.20%) households do live between 0.1 to 0.5k.ms far away from the river bank, it is 2 irrigator (1.60%) and only 4 non irrigator (3.30%) households do live more than 0.5 k.ms about.

Econometric Results: The quantitative analysis of results of actual economic phenomena were provided based on the hypotheses mentioned for conclusion and inference for decision makers as follows.

Results were interpreted and discussed showing how they agree or disagree with earlier published works based on meanings of observations made. These observations and findings were compared with those of other researchers result which have done ever before. Principles, relationships and generalizations that come out of the results were presented or discussed based on each respective specific objectives or hypotheses mentioned in the study.

4.2.1.1. Correlates of Food Security

Based on the marginal effect of the post estimation of food consumption expenditure score (annex1), copying strategy index (annex2) and dietary diversity score indicator of food security (annex3), irrigation participation (w), family size(fs), sex, land size (ls), educational level (ed), off farm income (offarmi), onfarm income (onfarmi), non farm income (nonfarmi), irrigation experience (exep) and distance from home to water source (dhomeland) were estimators of food security at 5% probability level. Therefore interpretation was based on the significance of estimators from marginal effect.

Food Consumption Expenditure Score Indicator of Food Security

Table 11: Food Consumption Expenditure Score Estimates of Heckman Two Stage Model:

Variables	Hechman analysis				Marginal effect
	Coef.	Std.err.	z	p>|z|	
w	0.016305	0.0114137	0.14	0.886	
fs	-0.0033991	0.0059858	-0.57	0.570	
sex	0.2629012	0.38449	6.84	0.000	
ls	0.061627	0.0306147	2.02	0.044	
ed	0.385457	0.0463756	8.30	0.000	
offarmi	0.0003656	0.0000816	4.48	0.000	
dhomeland	0.078725	0.0385255	-2.04	0.041	
onfarmi	7.78e-06	6.09e-06	1.28	0.201	
exp	0.0263073	0.0059483	4.42	0.000	
nonfarmi	0.0000135	9.01e-06	1.50	0.134	
cons	-0.0058235	0.0475748	-0.12	0.903	
Dependant variable	**Food Security**				
sex	1.61-e06	2642.941	0.00	1.000	0.2629012*
offarmi	6.70e-09	6.778054	0.00	1.000	0.0003656*
dhomeland	3.94e-06	3330.475	0.00	1.000	-0.078725*
onfarmi	4.16e-10	0.5325474	0.00	1.000	7.78e-06
exp	2.30e-07	472.33	0.00	1.000	0.0263073*
generator used	1.66e-06	1988.425	0.00	1.000	N/A
nonfarmi	7.12e-10	0.840.7871	0.00	1.000	0.0000135
lambda	-0.0003614	88.52443	N/A	N/A	N/A
cons	6.109908	1657.128	0.00	0.997	N/A
Dependant variable	**Household Irrigation Participation**				

Number of observations	246
Log likelihood	264.6417
Wald chi2(10)	7968.24
Prob>chi2	0.0000

Notice:* indicates significant at 0.05 probability level

At 0.05 probability level; sex, land size (ls), educational level (ed), off farm income (offarmi), irrigation experience (exep) and distance from home to water source (dhomeland) are significant correlates of food security in the regression result. Based on that as the model result showed Prob > chi2 =0.0000 which is less than 0.05, then null hypothesis is rejected. Here sample mean and population mean are similar. Therefore the model is good fit, accepted, reasonably good approximation of reality and good estimator of the true population. The Log likelihood = 264.617 is greater than 6.63, the probability of being food secured- happening by chance is less than 1%. So this model is 99% certain.

When sex estimator is considered; keeping other variables (land size, educational level, off farm income, irrigation experience and distance from home to water source) constant, the probability of being food secured(saying accepted) for male is higher by 26.29% than female household heads at 5% level of probability. This result confirms the result of Kinfe A. (2012) and contrary to Abonesh et.al (2006). As land size changes marginally; citrus paribus, then the probability of being food secured (saying accepted) is higher by 6.16%. This result confirms the result of Bogale and Shimelis (2009) and Kinfe A. (2012). The other significant estimator is school year of the house hold head. When school year changes by small amount marginally (1 year) keeping other correlates (land size, off farm income, irrigation experience and distance from home to water source) constant, then the probability of being food secured increased by 38.5%. Here households are well equipped and skill full in preparing fertility (decreasing soil aggregate/compaction problem and increasing soil infiltration rate) of their land and they have good preference and high food consumption pattern than non educated households. The other significant correlate of households food security is off farm income. As off farm income changes from its average (1.0 ETB birr), then the probability of being food secured (food consumption score) changes by 0.04%, citrus paribus. This implies that a unit increase in off farm income observed, then the probability of being food secured (saying accepted) increases by 0.04%, citrus paribus. This is because of both income and/or consumption multiplier effect of irrigation they earn from. Here 0.04 is the households' marginal propensity to consume food. Households have a potential to be employed to another farmers' farm to generate additional income. This result is consistent to the result of Abonesh et.al (2006). Experienced household heads have the probability of being food secured than non experienced. Irrigators have huge experience or skill (from 1966EC) than non irrigators. When irrigation experience changes marginally, then the probability of being food secured (saying accepted) increase by 2.63%, citrus paribus. Directionally this result is similar with the result of Bogale and Shimelis (2009) and Abonesh et.al (2006). Distance from home to water source is the other correlate of food security. Households live near the water source are food secure than households that live far from the water source. This is because of households who live nearest to the water source incur less cost of production. As distance changes marginally, then the probability of being food security changes by 7.87%. As distance decreased by one k.m, then the probability of being food secured can be increased by 7.87. Irrigators are living near the water source (they are early settler) and endowed resource than non irrigators. This result confirms the result of Abonesh et.al (2006).

Copying Strategy Index Indicator of Food Security:

Table 12: Copying Strategy Index Indicator of Food Security Estimates of Heckman Two Stage Model:

Variables	Heckman analysis				Marginal effect
	Coef.	Std.err.	z	p>|z|	
w	0.0117973	0.0142001	0.83	0.406	
fs	-0.0061169	0.0074471	-0.82	0.411	
sex	0.2534232	0.0478019	5.30	0.000	
ls	0.051071	0.0380887	1.34	0.180	
ed	0.3836407	0.0576974	6.65	0.000	
offarmi	0.0003737	0.0001016	3.68	0.000	
dhomeland	-0.0890844	0.0479307	-1.86	0.063	
onfarmi	0.0000125	7.58e-06	1.66	0.098	
exp	0.0247082	0.0074004	3.340	0.001	
nonfarmi	0.0000107	0.0000112	0.95	0.341	
cons	0.0004044	0.0591893	0.01	0.995	
dependant variable	**Food Security**				
sex	6.02e-07	2642.263	0.00	1.000	0.2534232*
offarmi	2.50e-09	6.508741	0.00	1.000	0.0003737*
dhomeland	1.47e-06	3329.566	0.00	1.000	0.0890844
onfarmi	1.55e-10	0.5277104	0.00	1.000	0.0000125
exp	8.57e-08	454.7253	0.00	1.000	0.0247082*
generator used	6.14e-07	1015.318	0.00	1.000	N/A
nonfarmi	2.66e-10	0.7699299	0.00	1.000	0.0000107
lambda	0.0002574	153.1081	0.00	1.000	N/A
cons	6.109907	1693.629	0.00	0.997	N/A
dependant	**Household Irrigation Participation**				

variable	
number of observations	246
log likelihood	210.906
wald chi2(10)	5088.98
prob>chi2	0.0000

Notice:* indicates significant at 0.05 probability level

At 0.05 probability level; sex, educational level (ed), off farm income (offarmi) and irrigation experience (exep) are significant correlates of food security in the regression result. Based on that as the model results showed Prob > chi2 =0.0000 which is less than 0.05, then null hypothesis is rejected. Therefore the model is good fit, accepted, reasonably good approximation of reality and good estimator of the true population.

Log likelihood = 210.906 is greater than 6.63, the probability of being food secured- happening by chance is less than 1%. So this model is 99% certain.

As a key informant, Mulugeta (2014) noted in the study area as a result of over flooding risk and uncertainty at rainy season, farmers were forced to produce crops in their irrigable land once per year.

As a result of this production of vegetable crops decreased so does income and food consumption of households. In lieu this they used to rely on less preferred and less expensive foods, restrict consumption by adults in order for small children to eat, reduce number of meals eaten in a day as a copying strategy index. when sex correlate of food security is considered; keeping other variables (ed, offi and ex) constant, the probability of being food secured changes by male changes by 25.3 % marginally than female household heads. Although female household heads are large in number in the study area, the result shows male household heads have a probability of being food secured This is because of male household heads have more power/energy to produce than female. The other significant of food security correlate is school year of the household head. Educated household heads have a probability being food secured by 38.3 % than non educated, citrus paribus. Literate households have a probability of being food secured by 38.3% than illiterate. As far as off farm income is considered, the probability of being food secured is 0.037%, as off farm income changes marginally by 1 ETB. This result confirms the result of Abonesh et.al (2006). Experienced households heads are more food secured than non experienced. The probability of being food secured for experienced household heads is 2.47% than non experienced. As irrigation experience changes by one year, then the probability of being food secured(saying accepted) changes by 2.4%.

Households Dietary Diversity Score Indicator of Food Security:

Table 13: Household Dietary Diversity Score Indicator of Food Security Estimates of Heckman Two Stage Model:

Variables	Heckman analysis				Marginal effect
	Coef.	Std.err.	z	p>lzl	
w	0.0040166	0.01152	0.35	0.727	
fs	-0.0012122	0.0058062	-0.21	0.835	
sex	0.2694272	0.0383332	7.03	0.000	
ls	0.0531168	0.0300659	1.77	0.077	
ed	0.3915751	0.046395	8.44	0.000	
offarmi	0.000366	0.0000816	4.48	0.000	
dhomeland	-0.0817047	0.038696	-2.11	0.035	
onfarmi	7.95e-06	6.14e-06	1.29	0.195	
exp	0.0256571	0.0059585	4.31	0.000	
nonfarmi	0.0000151	8.86e-06	1.70	0.089	
cons	-0.021203	0.00466486	-0.45	0.649	
Dependant variable	**Households Food Security**				
sex	1.49e-06	2630.316	0.00	1.000	0.2694272*
offarmi	6.28e-09	6.491465	0.00	1.000	0.000366*
dhomeland	3.64e-06	3331.409	0.00	1.000	-0.0817047*
onfarmi	3.85e-10	0.5292129	0.00	1.000	7.95e-06
exp	2.12e-07	451.9884	0.00	1.000	0.0000151
generator used	1.51e-05	1016.016	0.00	1.000	N/A
nonfarmi	6.56e-10	0.7577287	0.00	1.000	0.0256571
lambda	-0.0003356	94.20654	0.00	1.000	N/A
cons	6.109908	1689.125	0.00	0.997	N/A
Dependant variable	**Household Irrigation participation**				

Number of observations	246
Log likelihood	263.5313
Wald chi2(10)	5020.43
Prob>chi2	0.0000

Notice: indicates significant at 0.05 probability level

At 0.05 probability level; sex, educational level (ed), off farm income (offarmi), distance from home to water source (dhomeland) and irrigation experience (exep) are significant correlates of food security in the regression result. Based on that as the model results showed Prob > chi2 =0.0000 which is less than 0.05, then null hypothesis is rejected. Therefore the model is good fit, accepted, reasonably good approximation of reality and good estimator of the true population. Log likelihood = 263.5313 is greater than 6.63, the probability of being food secured- happening by chance is less than 1%. So this model is 99% certain.

As far as sex estimator of food security/ household diary diversity considered; keeping other correlates (ed ,offarmi, dhomeland and exep) constant, the probability of being food secured (saying accepted-eating diversity diet) is higher by 26.94% for male household heads than female at 5% of probability level. The other significant correlate of food security who eat diversify diet is educational level (ed) of the household. Educated household heads have a probability being food secured by 39 % than non educated, citrus paribus(sex, offarmi, dhomeland and exep). Literate households have a probability of being food secured by 39% than illiterate. As far as off farm income is considered; keeping other correlates (sex, ed, dhomeland and exep) constant, as off farm income changes marginally (1 ETB), then the probability of being food secured is higher by 0.037%. The other significant correlate of food security in household dietary diversity is distance from home to water source. Households live near the water source are food secure than households that live far from the water source. As distance changes marginally (from 1 k.m), then the probability of being food secured changes by 8.17%, keeping other variables (sex, offi and ex) constant. As distance decreased by 1 k.m, then the probability of being food secured can be increased by 8.17. Irrigators are living near the water source (they are early settler) and have the potential to use the resource than non irrigators. The other significant correlate of food security in household dietary diversity is irrigation experience of the household. Experienced household heads are more food secured. As irrigation experience changes marginally, then the probability of being food secured (saying accepted) changes by 2.56%, citrus paribus (sex, ed, offi and dhomeland).

4.2.1.2. Determinants of Participation to Small Scale Irrigation Scheme

Based on the marginal effect of the post estimation of food consumption expenditure score (annex1); copying strategy index (annex 2) and dietary diversity score indicator of food security (annex 3); sex, off farm income (offarmi), onfarm income (onfarmi), non farm income (nonfarmin), irrigation experience (exep) and distance from home to water source (dhomeland) were estimators of determinants of access to small scale irrigation scheme at 5% probability level.

Food Consumption Expenditure Score

Sex, off farm income (offarmi), irrigation experience (exep) and distance from home to water source (dhomeland) are statistically significant determinants and they reliably predict participation in small scale irrigation scheme, citrus paribus.

As far as sex estimator of access to small scale irrigation scheme is considered; keeping other correlates (offarmi, exep and dhomeland) constant, the probability of being participate in small scale irrigation (saying yes) is higher by 26.29% for male than female household heads. The other significant determinant of irrigation participation is off farm income (offarmi). As off farm income changes marginally(1 ETB), then the probability of being participate in small scale irrigation is higher by 0.04%, keeping other determinants (sex, exep and dhomeland) constant. Distance from home to water source is the other significant determinant of small scale irrigation participation. As distance from home to water source changes magically (by 1 k.m); keeping other variables constant, then the probability of being participate in irrigation can be changed by 7.67%. As distance decreased by 1 k.m, then the probability of being participate in irrigation can be increased by 8.17. Irrigators are living near the water source (they are early settler and endowed of both land and water source) and have the potential to use the resource than non irrigators. This result confirms the result of Abonesh et.al (2006). It is recall that more experienced household heads have a probability to participate in small scale irrigation. As irrigation experience changes marginally, then the probability of being participate (saying yes) changes by 2.63%, citrus paribus (sex, offi and dhomeland).

Copying Strategy Index Indicator of Food Security

Sex, off farm income (offarmi) and irrigation experience (exep) are statistically significant determinants and they reliably predict participation in small scale irrigation scheme, citrus paribus.

As far as sex estimator of access to small scale irrigation scheme is considered; keeping other correlates (off farm income and irrigation) constant, the probability of being participate in small scale irrigation (saying yes) is higher by 25.34% for male than female household heads. The other determinant of irrigation participation is household off farm income. As off farm income increased marginally(1 ETB), then the probability of being participate increase by 0.03%. It is recall that more experienced household heads have a probability to participate in small scale irrigation. As irrigation experience changes marginally, then the probability of being participate (saying yes) changes by 2.4%, citrus paribus. It is recall that more experienced household heads have a probability to participate in small scale irrigation. As irrigation experience changes marginally, then the probability of being participate (saying yes) changes by 2.63%, citrus paribus (sex and offarmi).

Dietary Diversity Score Indicator of Food Security

Sex, off farm income (offarmi), distance from home to water source (dhomeland irrigation experience (exep) are statistically significant determinants and they reliably predict participation in small scale irrigation scheme, citrus paribus.

As far as sex estimator of access to small scale irrigation scheme is considered; keeping other correlates (off farm income, distance from home to water source and irrigation experience) constant, the probability of being participate in small scale irrigation (saying yes) is higher by 26.94% for male household heads than female. The other determinant of irrigation participation is household off farm income. As off farm income increased marginally (1 ETB), then the probability of being participate increase by 0.03%. It is recall that more experienced household heads have a probability to participate in small scale irrigation. Distance from home to water source is the other significant determinant of small scale irrigation participation. As distance from home to water source changes magically (by 1 k.m); keeping other determinants (Sex, off farm income and irrigation experience) constant, then the probability of being participate in irrigation can be changed by 7.67%. As distance decreased by 1 k.m, then the probability of being participate in irrigation can be increased by 8.17%. Irrigators are living near the water source (they are early settler) and have the potential to use the resource than non irrigators. It is recall that more experienced household heads have a probability to participate in small scale irrigation. As irrigation experience changes marginally (by 1 year), then the probability of being participate (saying yes) changes by 2.56%, citrus paribus (sex and offarmi).

4.2.1.3. Food Security Impact of Small Scale Irrigation Scheme

As can be seen from the tables (Table 1,2 and 3) above the *lambda* (λ) values in the three food security indicators (FCS= 0.0003614, CSI= 0.0002574 and HHDDS= 0.0003356) result were statistically insignificant and do not reliable predict the probability of farming households' food security status and indicates the absence of selectivity bias in the sample. Food security was not as such observed among the three indicators in the study area. This is to mean that small scale irrigation scheme did not have impact on farm households food security. No matter how these farming households produce more; since they score insufficient food consumption expenditure, ate less diversify food groups and used copying strategy index (rely on less preferred and less expensive foods, restrict consumption by adults in order for small children to eat, reduce number of meals eaten in a day), they are food insecure. Therefore null hypothesis is accepted. This confirms the result of Bazezew A. (2012) and contrary with the results of Bogale and Shimelis (2009), Abonesh et.al (2006), Alberto and Luca (2010) and Kinfe Asayehegn (2012). This is because of a onetime agricultural crop harvesting season, low and fixed price of their product, diseconomies of scale, low market share and low sales volume problem they faced on. Farmers produce one time per year, because of over flooding risk fear. Flood in the rainy season is always out break on the field that damages their crop (disease, flood/canals damage).

4.3. Conclusion

In general correlates of food security, determinants of access to small scale irrigation scheme and Akaki small scale irrigation scheme role was investigated on the basis of food consumption score, copying strategy index and dietary diversity score indicators of food security.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

The overall study evaluated impact of Akaki small scale irrigation scheme on household food security of smallholder farmers. Indicating conclusions and recommendations reached for each specific objectives/research hypothesis mentioned clearly is a crucial task. Summary, conclusions and recommendations are a brief and main substance of this chapter.

4.1. Conclusion

Based on major debate/theory generalizations from findings as per each specific objectives, answers to hypotheses were provided in a broader and more encompassing/comprehensively way.

4.1.1. Correlates of food security

At 0.05 probability level; sex, land size (ls), educational level (ed), off farm income (of farmi), irrigation experience (exep) and distance from home to water source (dhomeland) are significant correlates of food security in the regression result of joint indicators, citrus paribus.

- male household heads have a probability to be food secured than female heads;
- all except distance from home to water source (dhomeland); land size, school year and experience have a positive impact on food security.

4.1.2. Determinants of Participation to Small Scale Irrigation Scheme:

At 0.05 probability level; sex, off farm income (offarmi), irrigation experience (exep) and distance from home to water source (dhomeland) are statistically significant determinants of the joint indicators and they reliably predict participation in small scale irrigation scheme, citrus paribus. Females had not access to irrigation as compared to male head

4.1.3. Food Security Impact of Small Scale Irrigation Scheme:

In general food security impact of Akaki small scale irrigation scheme study was investigated. No food security impact in the study area.

4.2. Recommendations

It is difficult to give remedies for the problems and answers for the questions if problems cannot be known. But, the problems are on hand in this study. Generally these recommendations are logically linked to both the research hypothesis and conclusions. Actionable and further study recommendations are the two distinct types of recommendations in this study.

4.2.1. Recommendations for action or practice/policy implication

Based on the study findings and conclusions made, actionable recommendations on correlates of food security, determinants and food security impact of small scale irrigation scheme are suggested.

As a researcher what I need to give some suggestions here is that the woreda administration and farming households should work hand in hand to curve problems faced on.

Government should open schools (farmers field school) to increase production or skill around the study area. Magnitude of gender (sex) estimate on food security is absolutely high. Therefore head of farming households should be male for irrigation activities. Not only that even the concerning bodies particularly Institute of Sustainable Development(ISD) and others let the farming households to share experience from outsiders.

Collective action among governments, NGOs and farming households on flood control and market linkage (perfect information on price of their product) should be taken to let farming households harvest two times per year and prosper.

4.2.2. Recommendations for Further Study

This investigation fails to consider impact of small scale irrigation scheme on households nutrition security in the study area and it focus only food security at household level. So if someone investigates this issue by emphasizing both food and nutrition security the finding may be relatively fruit full.

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APPENDIXES

Activity and financial plan

Table 2:- description of main activities, enumerator, indicator, output, administrative cost and time frame of the task:

R.no	Major activities	Responsible body	Indicator	Out put	Target	Time frame		Total
						Year 2015		
						Feb	Ma	
1	Collecting data	Researcher and enumerator	Collected data in number	A quantity of collected data	246	246		246
			Expense in ETB		9730	9730		9730
2	Analyzing data	Researcher	Analyzed data in number	A quantity of analyzed data	246	246		246
			Expense in ETB		2350	2350		2350
3	Reporting the result	Researcher	Reported document in number	A quantity of reported document	1		1	1
			Expense in ETB					
	um				12080	2080		12080

Table 3: material cost

R.no	Major activities	Description	Total quantity	U. cost(ETB)	T. cost(ETB)
2	Collecting data	Pen	1 pc	7	84
		Note book	2	20	40
		Digital photo camera	1	5500	5500
		Tape recorder	1	600	600
		meal and transport	8*3	500	12000
2.	Analyzing data	Software	3	50	150
3.	Reporting and presentation	Paper and others	1 pc	150	150
		CD	3	20	60
		Flash disk-4GB	1	125	125
	sum				18709

Table 4: Cost Summary

R. no	Description	Total cost	Remark
1.	administrative cost	12080	
2.	material cost	18709	
3.	Grand total	30789	
4.	Contingency (10%)	3078.9	
	sum	33867.9	

Questionnaires

Interview schedule prepared to assess impact of Akaki small scale irrigation scheme on household food security. I am the student of Agricultural Economics at St. Mary's University and for my MSc dissertation I am assessing the impact of Akaki small scale irrigation scheme on household food security. Therefore, I kindly request you to give your exact answers for the following questions. Your responses will be kept confidential and will be used to the intended purpose only.

I. Household demographic characteristics related questions

1. Respondent's full Name ____________________ ___________________

   Sex of the respondent:

   1. Male 2. Female (tick in one)

   Age of the respondent: ___________________

   Marital Status:

   1. Married 2.Unmarried 3.Divorce 4. Separated with death (tick in one)

2. Sub-city:__________________ wored: ____________House number________________
3. How many people did live in your house in the last 4 weeks of the current week?

   List based on their sex, age and School years:

No.	Sex	Age	School years	Remark
1				
2				
3				
4				
5				
6				
7				
Total				

II. General questions

Food accessibility related questions-

1. Do you participate in small scale irrigation scheme? 1. Yes 2. No
2. If your answer is "No "in question number 1, what are the factors that hinders participation on irrigation?

3. What is your land holding status? (two response allowed) 1. Own 2. Rent
4. What is the size of your plot of land in hectare?
   1. For lease__________________ 2. For own__________________
5. When did you start this scheme? __________________
6. How many oxen, cows and sheep do you have? Ox ______ cow ______ sheep ______
7. Do you use generator/dewatering machine in your production? 1. Yes 2. No

8. I would like to ask you about all the different foods that you have eaten in the last 7 days.

Food groups used	Food groups used for HDDS	Response(yes=1/no=0)
Cereals and grain	1. Cereals, roots, and tubers	
Roots and tubers		
Legumes / nuts	2. Pulses and legumes	
Orange vegetables (vegetables rich in Vitamin A)	3. Vegetables	
Green leafy vegetables		
Other vegetables		
Orange fruits (Fruits rich in Vitamin A)	4. Fruits	
Other Fruits		

Meat	5. Meats, fish and seafood, and eggs	
Liver, kidney, heart and / or other organ meats		
Fish / Shellfish		
Eggs		
Milk and other dairy products	6. Dairy products	
Oil / fat / butter	7. Oils and fats	
sum		

9. From the following list of food groups how many times did you consume in the last 4 weeks of the current week?

List of food groups and content of each group:

Food group	**Content of the group**	**Sum of Frequencies (1)**	**Weight (2)**	**weighted food group scores=(1)*(2)**	**Remark**
Food group 1	Cereals and grain products		2		
Food group 2	Starchy, roots, tubers and legumes		2		
Food group 3	Nuts, seeds and legumes		3		
Food group	Vegetables		1		

4					
Food group 5	Fruits		1		
Food group 6	Sugar, syrup and sweets		0.5		
Food group 7	Meat and poultry		4		
Food group 8	Fish and shell fish		4		
Food group 9	Milk and milk products		4		
Food group 10	Oil and fats		0.1		
Food group 12	Eggs		4		
Total FCS				x/112	

Food availability related questions

1. List your products, unit price (ETB), quantity, market place and total quantity consumed from your production in the last 4 weeks of the current week:

Product list	Total quantity (q.)	Unit price (ETB)	Total quantity sold (q.)	Market place	Total quantity consumed	Remark

2. Did you get off farm[10] income in the last 4 weeks of the current week?
   1. Yes 2. No
3. If your answer is "Yes" in question # 3, how much money did you get in the last 4 weeks of the current week? ___________________
4. Did you get non farm[11] income in the last 4 weeks of the current week?
   1. Yes 2. No
5. If your answer is "Yes" in question # 5, how much money did you get in the last 4 weeks of the current week? --
6. Did you get remittance from your relatives in the last 4 weeks of the current week?

[10] Off farm income refers to revenue gotten in activities outside his/her farm by emplacement

[11] Nonfarm income refers to revenue gotten outside farming activities.

1. Yes 2. No

7. If your answer is "Yes" in question # 7, how much money did you get in the last 4 weeks of the current week? --

Food stability (coping strategy index) related questions

1. Due to a shortage of food and money how many times in the last seven days your family member had to rely on the various coping strategies?

Coping strategy	Frequency	Severity weight (1-4)	Weighted Score = Frequency X Severity weight
Rely on less preferred and less expensive foods		4	
Borrow food, or rely on help from a friend or relative		2	
Purchase food on credit		2	
Consume seed stock held for next season		1	
Send household members to eat elsewhere		1	
Send household members to beg		1	
Limit portion size at mealtimes		4	
Restrict consumption by adults in order for small children to eat		3	
Feed working members of HH at the expense of non-working members		2	
Reduce number of meals eaten in a day		4	
Skip entire days without eating		2	
Total CSI			

Thank you!!!

Annex1 : Food consumption expenditure score estimates of Heckman two stage model and post estimation of FCS of marginal effect:

```
  Estimation results "Post estimation of FCS of marginal effect", produced by

     . heckman yi w fs sex ls ed offarmi dhomeland onfarmi exep nonfarmincome, twostep select(w = sex offarmi dhomeland onfarmi exep
       generatorused nonfarmincome) rhosigma

. margins, dydx( w fs sex ls ed offarmi dhomeland onfarmi exep generatorused nonfarmincome )

Average marginal effects                        Number of obs     =        246
Model VCE    : Conventional

Expression   : Linear prediction, predict()
dy/dx w.r.t. : w fs sex ls ed offarmi dhomeland onfarmi exep nonfarmincome generatorused
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
w	.0016305	.0114137	0.14	0.886	-.0207398	.0240009
fs	-.0033991	.0059858	-0.57	0.570	-.0151311	.0083328
sex	.2629012	.0384219	6.84	0.000	.1875956	.3382068
ls	.061627	.0306147	2.01	0.044	.0016233	.1216306
ed	.3850457	.0463756	8.30	0.000	.2941512	.4759402
offarmi	.0003656	.0000816	4.48	0.000	.0002056	.0005256
dhomeland	-.078725	.0385255	-2.04	0.041	-.1542335	-.0032165
onfarmi	7.78e-06	6.09e-06	1.28	0.201	-4.15e-06	.0000197
exep	.0263073	.0059483	4.42	0.000	.0146489	.0379657
nonfarminc~e	.0000135	9.01e-06	1.50	0.134	-4.14e-06	.0000312
generatoru~d	(omitted)					

```
. estimates title: Food consumption score indicator result of food security

. heckman yi w fs sex ls ed offarmi dhomeland onfarmi exep nonfarmincome, select(w = sex offarmi dhomeland onfarmi exep generatorused nonfarm
> income)

Iteration 0:   log likelihood =  264.64169  (not concave)
Iteration 1:   log likelihood =  264.64169  (backed up)

Heckman selection model                         Number of obs     =        246
(regression model with sample selection)        Censored obs      =          0
                                                Uncensored obs    =        246

                                                Wald chi2(10)     =    7968.24
Log likelihood =  264.6417                      Prob > chi2       =     0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
yi						
w	.0016305	.0114137	0.14	0.886	-.0207398	.0240009
fs	-.0033991	.0059858	-0.57	0.570	-.0151311	.0083328
sex	.2629012	.0384219	6.84	0.000	.1875956	.3382068
ls	.061627	.0306147	2.01	0.044	.0016233	.1216306
ed	.3850457	.0463756	8.30	0.000	.2941512	.4759402
offarmi	.0003656	.0000816	4.48	0.000	.0002056	.0005256
dhomeland	-.078725	.0385255	-2.04	0.041	-.1542335	-.0032165
onfarmi	7.78e-06	6.09e-06	1.28	0.201	-4.15e-06	.0000197
exep	.0263073	.0059483	4.42	0.000	.0146489	.0379657
nonfarminc~e	.0000135	9.01e-06	1.50	0.134	-4.14e-06	.0000312
_cons	-.0058235	.0475748	-0.12	0.903	-.0990684	.0874214
w						
sex	1.61e-06	2642.951	0.00	1.000	-5180.088	5180.088
offarmi	6.70e-09	6.778054	0.00	1.000	-13.28474	13.28474
dhomeland	3.94e-06	3330.475	0.00	1.000	-6527.612	6527.612
onfarmi	4.16e-10	.5325474	0.00	1.000	-1.043774	1.043774
exep	2.30e-07	472.33	0.00	1.000	-925.7498	925.7498
generatoru~d	1.65e-06	1988.425	0.00	1.000	-3897.241	3897.241
nonfarminc~e	7.12e-10	.8407871	0.00	1.000	-1.647913	1.647913
_cons	6.109908	1657.128	0.00	0.997	-3241.801	3254.021
/athrho	-.0043791	1072.787	-0.00	1.000	-2102.629	2102.62
/lnsigma	-2.494718	.0450835	-55.34	0.000	-2.58308	-2.406356
rho	-.0043791	1072.767			-1	1
sigma	.0825197	.0037203			.075541	.0901432
lambda	-.0003614	88.52443			-173.5051	173.5043

```
LR test of indep. eqns. (rho = 0):   chi2(1) =    -0.00   Prob > chi2 = 1.0000
```

Annex2 : Copying strategy index indicator of food security estimates of Heckman two stage model and post estimation of CSI of marginal effect:

```
. heckman yi w fs sex ls ed offarmi dhomeland onfarmi exep nonfarmincome, select(w = sex offarmi dhomeland onfarmi exep generatorused nonfarm
> income)

Iteration 0:   log likelihood =  210.90596  (not concave)
Iteration 1:   log likelihood =  210.90596  (backed up)

Heckman selection model                         Number of obs      =       246
(regression model with sample selection)        Censored obs       =         0
                                                Uncensored obs     =       246

                                                Wald chi2(10)      =   5088.98
Log likelihood =   210.906                      Prob > chi2        =    0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
yi           |
           w |   .0117973   .0142001     0.83   0.406    -.0160344     .039629
          fs |  -.0061169   .0074471    -0.82   0.411     -.020713    .0084793
         sex |   .2534232   .0478019     5.30   0.000     .1597331    .3471133
          ls |    .051071   .0380887     1.34   0.180    -.0235814    .1257235
          ed |   .3836407   .0576974     6.65   0.000      .270556    .4967255
     offarmi |   .0003737   .0001016     3.68   0.000     .0001747    .0005728
   dhomeland |  -.0890844   .0479307    -1.86   0.063    -.1830269    .0048581
     onfarmi |   .0000125   7.58e-06     1.66   0.098    -2.30e-06    .0000274
        exep |   .0247082   .0074004     3.34   0.001     .0102037    .0392128
nonfarminc~e |   .0000107   .0000112     0.95   0.341    -.0000113    .0000326
       _cons |   .0004044   .0591893     0.01   0.995    -.1156046    .1164133
-------------+----------------------------------------------------------------
w            |
         sex |   6.02e-07   2642.263     0.00   1.000    -5178.739    5178.739
     offarmi |   2.50e-09   6.508741     0.00   1.000     -12.7569     12.7569
   dhomeland |   1.47e-06   3329.566     0.00   1.000    -6525.829    6525.829
     onfarmi |   1.55e-10   .5277104     0.00   1.000    -1.034293    1.034293
        exep |   8.57e-08   454.7253     0.00   1.000    -891.2452    891.2452
generatoru~d |   6.14e-07   1015.318     0.00   1.000    -1989.987    1989.987
nonfarminc~e |   2.66e-10   .7699299     0.00   1.000    -1.509035    1.509035
       _cons |   6.109907   1693.629     0.00   0.997    -3313.342    3325.562
-------------+----------------------------------------------------------------
     /athrho |  -.0025072    1491.34    -0.00   1.000    -2922.975     2922.97
    /lnsigma |   -2.27628   .0450835   -50.49   0.000    -2.364642   -2.187918
-------------+----------------------------------------------------------------
         rho |  -.0025072   1491.331                            -1           1
       sigma |   .1026654   .0046285                       .093983      .11215
      lambda |  -.0002574   153.1081                     -300.0866    300.0861
------------------------------------------------------------------------------
LR test of indep. eqns. (rho = 0):   chi2(1) =    -0.00   Prob > chi2 = 1.0000
------------------------------------------------------------------------------

.


. margins, dydx( w fs sex ls ed offarmi dhomeland onfarmi exep generatorused nonfarmincome )

Average marginal effects                          Number of obs   =        246
Model VCE    : Conventional

Expression   : Linear prediction, predict()
dy/dx w.r.t. : w fs sex ls ed offarmi dhomeland onfarmi exep nonfarmincome generatorused


------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           w |   .0117973   .0142001     0.83   0.406    -.0160344     .039629
          fs |  -.0061169   .0074471    -0.82   0.411     -.020713    .0084793
         sex |   .2534232   .0478019     5.30   0.000     .1597331    .3471133
          ls |    .051071   .0380887     1.34   0.180    -.0235814    .1257235
          ed |   .3836407   .0576974     6.65   0.000      .270556    .4967255
     offarmi |   .0003737   .0001016     3.68   0.000     .0001747    .0005728
   dhomeland |  -.0890844   .0479307    -1.86   0.063    -.1830269    .0048581
     onfarmi |   .0000125   7.58e-06     1.66   0.098    -2.30e-06    .0000274
        exep |   .0247082   .0074004     3.34   0.001     .0102037    .0392128
nonfarminc~e |   .0000107   .0000112     0.95   0.341    -.0000113    .0000326
generatoru~d |  (omitted)
```

Annex3 : House hold dietary diversity score indicator of food security estimates of Heckman two stage model post estimation of HDDS of marginal effect:

```
. heckman yi w fs sex ls ed offarmi dhomeland onfarmi exep nonfarmincome, select(w = sex offarmi dhomeland onfarmi exep generatorused nonfarm
> income)

Iteration 0:   log likelihood =  263.53129  (not concave)
Iteration 1:   log likelihood =  263.53129  (backed up)

Heckman selection model                         Number of obs      =       246
(regression model with sample selection)        Censored obs       =         0
                                                Uncensored obs     =       246

                                                Wald chi2(10)      =   8020.43
Log likelihood =  263.5313                      Prob > chi2        =    0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
yi           |
           w |   .0040166     .01152     0.35   0.727    -.0185622    .0265954
          fs |  -.0012122   .0058062    -0.21   0.835    -.0125922    .0101679
         sex |   .2694272   .0383332     7.03   0.000     .1942954     .344559
          ls |   .0531168   .0300659     1.77   0.077    -.0058113    .1120449
          ed |   .3915751    .046395     8.44   0.000     .3006426    .4825075
     offarmi |    .000366   .0000816     4.48   0.000      .000206     .000526
   dhomeland |  -.0817047    .038696    -2.11   0.035    -.1575475   -.0058618
     onfarmi |   7.95e-06   6.14e-06     1.29   0.195    -4.08e-06      .00002
        exep |   .0256571   .0059585     4.31   0.000     .0139786    .0373356
nonfarminc~e |   .0000151   8.86e-06     1.70   0.089    -2.28e-06    .0000324
       _cons |   -.021203   .0466486    -0.45   0.649    -.1126325    .0702266
-------------+----------------------------------------------------------------
w            |
         sex |   1.49e-06   2630.316     0.00   1.000    -5155.325    5155.325
     offarmi |   6.28e-09   6.491465     0.00   1.000    -12.72304    12.72304
   dhomeland |   3.64e-06   3331.409     0.00   1.000    -6529.443    6529.443
     onfarmi |   3.85e-10   .5292129     0.00   1.000    -1.037238    1.037238
        exep |   2.12e-07   451.9884     0.00   1.000     -885.881     885.881
generatoru~d |   1.51e-06   1016.016     0.00   1.000    -1991.354    1991.354
nonfarminc~e |   6.56e-10   .7577287     0.00   1.000    -1.485121    1.485121
       _cons |   6.109908   1689.125     0.00   0.997    -3304.514    3316.734
-------------+----------------------------------------------------------------
     /athrho |   -.004049   1136.501    -0.00   1.000    -2227.506    2227.498
    /lnsigma |  -2.490204   .0450835   -55.24   0.000    -2.578566   -2.401842
-------------+----------------------------------------------------------------
         rho |   -.004049   1136.483                            -1           1
       sigma |   .0828931   .0037371                      .0758827     .090551
      lambda |  -.0003356   94.20654                     -184.6418    184.6411
------------------------------------------------------------------------------
LR test of indep. eqns. (rho = 0):   chi2(1) =    -0.00   Prob > chi2 = 1.0000
------------------------------------------------------------------------------
```

```
. margins, grand dydx( w fs sex ls ed offarmi dhomeland onfarmi exep nonfarminco
> me generatorused ) continuous

Average marginal effects                          Number of obs   =        246
Model VCE    : Conventional

Expression   : Linear prediction, predict()
dy/dx w.r.t. : w fs sex ls ed offarmi dhomeland onfarmi nonfarmincome exep
               generatorused

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           w |   .0040166     .01152     0.35   0.727    -.0185622    .0265954
          fs |  -.0012122   .0058062    -0.21   0.835    -.0125922    .0101679
         sex |   .2694272   .0383332     7.03   0.000     .1942954     .344559
          ls |   .0531168   .0300659     1.77   0.077    -.0058113    .1120449
          ed |   .3915751    .046395     8.44   0.000     .3006426    .4825075
     offarmi |    .000366   .0000816     4.48   0.000      .000206     .000526
   dhomeland |  -.0817047    .038696    -2.11   0.035    -.1575475   -.0058618
     onfarmi |   7.95e-06   6.14e-06     1.29   0.195    -4.08e-06      .00002
nonfarminc~e |   .0000151   8.86e-06     1.70   0.089    -2.28e-06    .0000324
        exep |   .0256571   .0059585     4.31   0.000     .0139786    .0373356
generatoru~d |  (omitted)
------------------------------------------------------------------------------
```

Following the recommendation of experts gathered in the Committee on World Food Security (CFS) Round Table on hunger measurement, hosted at FAO headquarters in September 2011, an initial set of indicators aiming to capture various aspects of food insecurity is presented here.

The choice of the indicators has been informed by expert judgment and the availability of data with sufficient coverage to enable comparisons across regions and over time. Many of these indicators are produced and published elsewhere by FAO and other international organizations. They are reported here in a single database with the aim of building a wide food security information system. More indicators will be added to this set as more data will become available.

Indicators are classified along the four dimension of food security -- availability, access, utilization and stability. To further facilitate their interpretation they are also classified as indicators of determinants and outcomes of food insecurity. Determinants, which can be either static or dynamic, refer to structural conditions that worsen food insecurity in absence of adequate policy interventions, including emergency assistance. Outcome indicators capture results in terms of inadequate food consumption or anthropometric failures.

(Last Updated: December 20th, 2013)

Table six

Type of indicator	Source	Coverage	New
Availability			
Average dietary supply adequacy	FAO	1990–2013	✓
Food production index	FAO	1990–2013	
Share of energy supply derived from cereals, roots and tubers	FAO	1990–2013	
Average protein supply	FAO	1990–2013	
Average supply of protein of animal origin	FAO	1990–2013	
Physical access (conditions for physical access to food)			
Percentage of paved roads over total roads	International Road Federation	1990–2009	
Rail lines density	WB	1990–2010	
Road density	WB, Transport Division	1990–2009	
Economic access (affordability)			
Food price level index	FAO/WB	1990–2010	✓
Utilization			
Access to improved water sources	WHO/UNICEF	1990–2010	
Access to improved sanitation facilities	WHO/UNICEF	1990–2010	
Inadequate access to food			
Prevalence of undernourishment	FAO	1990–2013	
Share of food expenditure of the poor	FAO	partial	✓
Depth of the food deficit	FAO	1990–2013	✓
Prevalence of food inadequacy	FAO	1990–2013	✓
Utilization (food-related anthropometric failures)			
Percentage of children under 5 years of age who are stunted	WHO/UNICEF	1966–2010	
Percentage of children under 5 years of age who are wasted	WHO/UNICEF	1966–2010	
Percentage of children under 5 years of age who	WHO/UNICEF	1966–2010	

are underweight			
Percentage of adults who are underweight	WHO	1974–2010	
Domestic food price volatility	FAO/ILO	1990–2010	✓
Per capita food production variability	FAO	1980–2010	✓
Per capita food supply variability	FAO	1980–2010	✓
Political stability and absence of violence/terrorism	WB WGI	1996–2010	
Value of food imports over total merchandise exports	FAO	1990–2009	
Percentage of arable land equipped for irrigation	FAO	1990–2009	
Cereal import dependency ratio	FAO	1990–2009	

List of food groups and content of each group:

Food group	Content of the group
Food group 1	Cereals and grain products
Food group 2	Starchy, roots, tubers and legumes
Food group 3	Nuts, seeds and legumes
Food group 4	Vegetables
Food group 5	Fruits
Food group 6	Sugar, syrup and sweets
Food group 7	Meat and poultry
Food group 8	Fish and shell fish
Food group 9	Milk and milk products
Food group 10	Oil and fats
Food group 11	Beverages
Food group 12	Eggs
Food group 13	mecselanouse

Initiation!

Why he did say the initiative did have not evaluated and no empirical information on it?

I have already taken part at the workshop of urban agriculture-urban agriculture policy implementation evaluation at Trade and Development Bureau of Addis Ababa in 2011. The workshop includes small scale irrigation as means but not as an end for poverty /food insecurity alleviation. In time, Shisema G/silasie, manager of Trade and Development Bureau of Addis Ababa on his key note speech as a conclusion says that after 5 years of implementation this initiative will be evaluated in the due course.

I requested Mulugeta (2014) how the small scale irrigation scheme in Akaki River has been going on in light of households' food security. However, Mulugeta did have said that the initiative did not have evaluated and no information on the basis of impact of food security empirically yet. In addition to that he said there is a slight change in their lively hood but no empirical information on it. Based on that, this project has been faced a great enthusiasm to evaluate impact of River Akaki small scale irrigation scheme on household food security.