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ADDIS ABABA UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

SCHOOL OF COMMERCE

ADOPTION OF COFFEE TECHNOLOGIES AND THEIR IMPACT ON ANNUAL YIELD IN JIMMA ZONE SOUTH WESTERN ETHIOPIA

MEGDELAWIT TEMESGEN

SEPTEMBER, 2022

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ADOPTION OF COFFEE TECHNOLOGIES AND THEIR IMPACT ON ANNUAL YIELD IN JIMMA ZONE SOUTH WESTERN ETHIOPIA.

A THESIS SUBMITTED TO THE GRADUATE STUDIES OF SCHOOL OF COMMERCE ADDIS ABABA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN DEVELOPMENT ECONOMICS

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SEPTEMBER, 2022

ADDIS ABABA

THESIS APPROVAL SHEET

As a member of examiners of the master of sciences (MSc.) thesis open defense examination, we have read and evaluated this thesis prepared by. **Miss, Belaynesh Aynalem** entitled **Value chain Analysis of vegetable production in Northwest Ethiopia evidence from of Fogera and North Mecha Woreda** we hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Science (M.Sc.) in **Agricultural Economics.**

Board of Examiner

Jemal (PhD)	_____________	September 23, 2022
Name of External Examiner	Signature	Date
Berhanu Denu (PhD)	_______________	September 23, 2022
Name of Internal Examiner	Signature	Date

THESIS APPROVAL SHEET

As a member of examiners of the master of sciences (MSc.) thesis open defense examination, we have read and evaluated this thesis prepared by. **Miss, Megdelawit Temesgen** entitled **Adoption of coffee technologies and their impact in annual coffee yield in south western Ethiopia.** we hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Science (M.Sc.) in **Development Economics.**

Board of Examiner

Jemal Mohammed (PhD)	_ ___ ___ ___	September 23, 2022
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DECLARATION

This is to certify that this thesis entitled“Adoption **of coffee technologies and their impact in annual coffee yield in south western Ethiopia**” submitted in partial fulfillment of the requirements for the award of the degree of master of science in **“Development Economics”** to the graduate program of **College of Business and economics Sciences**, Addis Ababa university by Miss. **Megdelawit Temesgen** is an authentic work carried out her under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

Megdelawit Temesgen	______________________	September 23, 2022
Name of the Student	Signature	Date

Name of the Advisors:

Sisay Debebe (PhD)	________________	September 23, 2022
Major advisor	Signature	Date

LIST OF ABBREVIATION AND ACRONYMS

ATT	Average Treatment Effect on treated
ATU	Average Treatment Effect on Untreated
CBD	Coffee Berry Diseases
CLR	Coffee Leaf Rust
CRD	Coffee Root Diseases
CSA	Central Statics Agency
EIAR	Ethiopian Institute of Agricultural research
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic Ethiopia
FGD	Focus group discussion
FTC	Farmers Training Center
HE	Heterogeneity Effect
IV	Instrumental Variable
m.a.s.l	Meters above sea level
MNESR	National Bank of Ethiopia.
MoARD	Minister of Agriculture and Rural Development
PSM	Propensity Score Matching
SPSS	Statical Package for the Social Sciences
STATA	Software for Statistics and Data Science

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ABSTRACT

Sector of agriculture plays a significant role in Ethiopian economy. Ethiopia has huge potential to increase coffee production as it endowed with suitable elevation, temperature, and soil fertility, indigenous quality plantation materials, and sufficient rainfall in coffee growing belts of the country. Adoption of improved coffee varieties and slashing with a recommended period of time together have a significant effect on coffee production. The study was aimed to see the determinant of adoption of coffee technologies and their impact on annual yield of coffee in Jima zone south western Ethiopia. 196 sampled households from three woreda in the zone and 430 plots of 196 farmers household is considered in the survey. This study develops a multinomial logit and a multinomial endogenous switching regression model to see determinant of adoption and impact respectively. The study revealed four major results. First adoption rate and intensity of coffee variety is greater than the management practice. Second, adoption of coffee technologies constrained by different factor like land shortage, inaccessibility in technologies, lack of information and high cost of labor constraint farmers in adoption coffee technologies in addition to these constraints the disease and weeds which faces in farmers land leads them to replace coffee by chat. Third, from the multinomial logit model farmers adoption of coffee technologies determined by three major category these are farmers resource factor, the second determining factor is the institutional factor, the third factor farmers specific characteristics. Fourth, greater annual coffee yield obtained from simultaneous adoption of both improved coffee variety and management practice. This implies that policy makers, coffee breeders, extension service provider and other stakeholders promoting a combination of technologies can enhance annual coffee production.

Key words: *coffee technologies, yield, multinomial model, southwestern Ethiopia*

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CHAPTER 1. INTRODUCTION

1.1 Background of the study

Agriculture is one of the central fields which shape the socio-economic development of any country (Mohamad and Gombe, 2017). Therefore, the life of all human beings is heavily dependent on agricultural products and its importance is going to increase day to day. Consequently, Agriculture has long been the backbone of Africa economy and the potential sources of economic growth in spite of all its weaknesses (Akhtar and Pirzada, 2014).

Agriculture plays a central role in increasing food availability and incomes, supporting livelihoods and contributing to the overall economy and a key factor to improve food and nutrition security. Ethiopia's economy is dependent on rain-fed agriculture. The sector contributes about 46.3% of the total gross domestic product (GDP), 60% of exports, and 80% of total employment Smallholders drive their benefits either in cash from the sale of a product or through their consumption of agricultural products. The production system constitutes crop and livestock rearing accounting for 70%, and the pastoral production system accounts for 30% (Solomon, 2020).

Ethiopia has huge potential to increase coffee production as it endowed with suitable elevation, temperature, and soil fertility, indigenous quality plantation materials, and sufficient rainfall in coffee growing belts of the country. Coffee is a shade-loving tree. It grows well under the large indigenous trees such as the Cordia Abyssinica and the Acacia species, in two regions of the country Oromiya and southern nation nationality and people regional state. In the country smallholder farmers on less than two hectares of land produces and supply Ninety-five percent of Ethiopia's coffee produces, while the remaining five percent grown on modern commercial farms (Taye, 2013 and USAID,2010). In Ethiopia, 764863.16 ha of land was allocated for coffee production and 494574.36 tones were obtained with average productivity of 0.64 tones ha-1 in 2018/19 Meher Season from which 30% of the total production belongs to South Nation Nationalities and Peoples Regional State (SNNPR) (CSA, 2019). From top 25 coffee producing districts in Ethiopia, Oromia dominates with 18 coffee producing districts and the remaining top coffee producing districts are located in South Nations, Nationalities and Peoples Regional State (James et al., 2015). Coffee land coverage and dependency of smallholder farmers on coffee is high especially in southwest Ethiopia. Diro S et al., (2019) found that the share of coffee income from total income in coffee producing districts of Jimma zone is 77%. On other hands, share of land allocated to coffee crop in these areas is more than 69%.

More than 120 Ethiopian Coffee exporters participated in processing and exporting coffee to all destination of the world. Among these export companies 95% are private companies 5% are Coffee growing farmers' cooperative unions and two of them are government enterprises In 2010/11 the top five coffee export destinations for the country are Germany, United stat of America, Saudi Arabia, Belgium and Italy (James et al., 2015). The country produces almost 200,000 metric tons of coffee every year. 95% of the coffee is produced in the forest area and is claimed to be organic. A major part of the Ethiopian coffee is exported in green coffee beans form, to the Rest of the World.

This study was designed to explore factors limiting adoption of coffee production technologies, constraints related to coffee production, relative benefits of coffee technologies on coffee annual yield among adopters of the improved technologies. The result of the study could be helpful for coffee related biological and physiological researchers, and policy makers.

In general, different packages of coffee production, protection and processing technologies have been promoted to beneficiaries since long period of time. Several institutions were also involved in disseminating these technologies through various extension approaches. However, there is no adequate information on demand for new coffee production and processing technologies and adoption by smallholder farmers in different agro-ecologies of Jimma zone. Moreover, the impacts of the technologies on the coffee annual yield are not adequately addressed and documented for different categories of households. Therefore, this study is focused to fill these gaps and generate information on the status of demand, adoption and impacts of coffee production technologies at smallholder levels.

1.2 Statement of the problem

Ethiopia has not yet fully exploited its position as the producer of some of the best coffees in the world. Coffee sector is highly dependent on international prices and affected by the structure and workings of the world coffee market. Ethiopia is one of the countries mostly affected by the crisis in world coffee prices (Cerda et al 2017)). The productivity of coffee is very less, not more than 6 qt/ha. To improve the productivity of coffee and enhance farmers' on-farm incomes, the national agricultural research system has generated and disseminated more than 30 improved coffee varieties and associated production packages. These technologies were promoted and disseminated to coffee producers through various mechanisms, such as demonstrations, seed distribution and farmer-to-farmer technology exchange mechanisms. Various development actors have also participated in the promotion and dissemination of coffee production technologies since the last decades. Some of the institutes engaged in dissemination of coffee production technologies included Jima Agricultural Research Center, Offices of Agriculture, and another institute.

Coffee diseases cause considerable losses when not treated. According to Cerda et al (2017), 57% yield loss was observed by the infection of disease-causing organisms on coffee crop also reported that the most economically important pathogenic coffee diseases are coffee berry disease (CBD), coffee wilt disease (CWD) and coffee leaf rust (CLR), and physiological disorder like coffee branch die back is caused by pseudomonas syringe and non-pathogenic agents. Similarly, CBD and branch dieback were causing high yield loss of coffee production. In the same way, insect pests such as Anthestia bug and coffee blotch miner are the major ones causing considerable damage. The assessment carried out in Eastern Ethiopia indicated that diseases and insect pests are causing considerable crop losses. CBD is major disease observed while CWD was considered as minor on few farmers' coffee farms. Similarly, major insect pest that affects coffee production in Eastern Ethiopia were coffee stem borer and coffee berry borer. On the other hand, insect pests such as coffee trips, green scale and coffee cushion scale were reported as important coffee production constraints in the country (Fekede & Gosa, 2015). Low production and productivity, which are mainly associated with poor adoption of recommended coffee technologies, were among the major problems. Adoption of improved technologies is one of the most promising ways to increase productivity and production in Ethiopia. Farmers are facing challenges, including increasingly erratic rainfall, rising temperatures, poor management of coffee trees, fluctuation of coffee prices and degradation of soil, that are adversely affecting their income opportunities the country's coffee production. Coffee production and productivity was used to develop appropriate technology for improvement and inform policy makers to understand the gap. However, the adoption and dissemination of these technologies is constrained by various factors. Different studies have been conducted on adoption of coffee technology in Ethiopia (Diro, S., & Erko, B. (2019), Diro, Samuel,et al.,2021, Mohammed (2018) and Million et al.,2019). Most of these research focus only on factor affecting adoption of coffee variety and few research was conducted on the adoption of the coffee technologies and agronomic practice impact on yield of coffee this research is designed to determine adoption rate of improved coffee varieties and associated packages of technologies. Moreover, the study will explore factors limiting adoption of coffee production technologies.

However, this study will examine the adoption level coffee Varity and agronomic practice also evaluate the impact of coffee variety and coffee agronomic practice and their impact in coffee yield. Thus, this study will fill the existing knowledge gap by assessing adoption and impact of coffee technology and impact on yield in Jimma zone taking with Mana, Gomma and Limu kosa district as a case study.

The findings of the study will help for coffee breeders to understand the key factors which determine farmers' preferences to improved coffee varieties. In their future breeding program, the coffee breeders will consider the influencing factors and merits which the farmers expect to exist on improved coffee varieties. In addition to this, extension service providers will get adequate information on the extent to which technology promotion and extension service provision mechanisms utilized so far worked or not. It will also provide information on the types of technology dissemination mechanisms which were effective in reach out to the farmers. Policy makers will also get information on the social, economic and environmental factors which determined the adoption of coffee production technologies, to identify constraints and opportunities related to coffee production, relative benefits of coffee technologies on coffee annual yield among adopters of the improved technologies. The result of the study could be helpful for coffee related biological and physiological researchers, policy makers and finally for the farmers.

1.3 Research question

- How are the rates and intensities of adoption of new coffee production and processing technologies?
- What are the major constraints of coffee production technologies adoption?
- What are the determinants of adoption of coffee technology?
- What is the impact of coffee technology in coffee yield?

1.4 Objective

1.4.1 General objective

- To assess adoption of improved coffee varieties and associated packages, and their impact on coffee yield in Jimma zone

1.4.2 Specific objective

- To analysis the rates and intensities of adoption of new coffee production technologies
- To identify the major constraints of coffee production technologies adoption
- To identify the determinants of adoption of improved coffee production technologies
- To analysis the impacts of coffee technologies on coffee yields

1.5 Significance of the study

This study provides information on the major coffee technology and their respective role, the determinants of coffee production yield impact of coffee production technologies in the study area. It is also used to identify the gaps in the adoption of coffee Varity and spacing and required interventions strategies to develop coffee production. Therefore, the study was used benefit development planners and policy-makers in drafting policies for adoption of coffee technology so as to make an intervention for coffee yield increment. Additionally, the study was generated information for research and development organizations, extension service providers, government and non-governmental organizations so as to formulate coffee technology adoption and guidelines for interventions that would improve efficiency of the coffee technology. It will also serve as source for future empirical literature for scholars and students interested in the area of coffee technology and source for further studies. Generally, this research aims at provide recommendation for future development of coffee production in the country.

1.6 Scope of the study

This study aims to identify the determinant factors of coffee technology adoption and its impact on coffee yield in three districts of Jimma zone including Limmu kosa, Mana, and Gera. Apart from this, the scope of the study is limited to assessing adoption status of improved coffee production technologies and its impact on coffee productivity.

1.7 Limitation of the study

The expected limitation of the study is that the study was used a cross-sectional data to assess adoption of improved coffee production technologies and its impact on coffee productivity in smallholder farmers which may not show the changes over time. Additionally, this study was used MNESR to analyze the impact of coffee technology on coffee productivity by comparing adopter and non-adopter households of coffee technology but this method has a limitation on.

1.8 Organization of the study

This research proposal paper is organized in to five chapters. The first chapter deals with introduction which contains background of the study, the statement of the problem, research questions, objectives of the study, scope of the study, the significance of the study, and limitation of the study. The second chapter was devoted to the review of related literature which includes the empirical and analytical reviews expressed in detail. The third chapter is about methodology which the study will use to conduct the research including description of the study area and maps, sampling technique and sample size, data collection and data analysis methods. The fourth chapter of this research thesis presents the result of the study the fifth chapter is the reference of different study the last chapter is the appendix of the study.

CHAPTER 2 LITERATURE REVIEW

2.1 Definition of basic terms and concepts

Adoption

Technology adoption is a term that refers to the acceptance, integration, and use of new technology in society. The process follows several stages, usually categorized by the groups of people who use that technology. Similarly, Saltiel etal (1994) defines adoption as a learning how to incorporate a new intermediate good into the production process. For Rogers (2003), adoption is a decision of "full use of an innovation as the best course of action available" and rejection is a decision "not to adopt an innovation" (p. 177). He defines it at the process in which an innovation is communicated thorough certain channels over time among the members of a social system

Coffee technology

Coffee technology is the application of techniques to control the growth, diseases, and harvesting of coffee products. Innovations of coffee technology are helpful to increase production, resolve chemo-physical, biological, and socioeconomic constraints related to coffee production systems.

Coffee Varity

Improved seeds can be characterized as seeds that aim at enhancing the quality and quantity of production of crops by having characteristics of early maturity period, high amount of yield and dry season resistant. Accordingly Afework Hagos et al (2018) characteristics improved seeds by separating into different pieces as open-pollinated seeds which are those produced by natural, random pollination. Hybrid seeds which are produced by crossbreeding two parent plants that have desirable characteristics. The improved coffee varieties are said to be drought tolerance, early maturing, disease resistant, high quality and high amount yield. The improved coffee varieties (together with progressed agronomic practices) have been introduced and dispersed to teff farming communities in various parts of Ethiopia through the expansion frame worked by the government An improved seed is one of the fore most essential agricultural technology for effective production.

Slashing

Weeds are plants that are unwanted in a given situation and may be harmful, dangerous or economically detrimental. They are responsible for substantial losses of farm production and extensive damage to the environment. Weeds, through competition with other plants, would almost always have deleterious effects on them and can have a lethal effect on livestock through consumption of weeds containing poisonous chemicals in the pasture. Weed invasion has become the most dreaded and deleterious impact of weeds in nature; it adversely affects agriculture, alters the balance of ecological communities, disrupts the natural diversity and interferes in the aesthetic value of the environment Bhowmik, P. C. (1997). Slashing is removing of those unnecessary plant from the agricultural land in order to efficient production of agriculture.

Coffee yield

It's defined as the amount of harvested coffee output divided by plot area. In this paper increment in coffee yield measured as the amount of harvested coffee output with adopted new coffee technology divided by plot area with amount of harvested coffee output divided by plot area that are not adopt coffee technology.

2.2 Theoretical review

2.2.1 Theories of adoption

2.2.1.1 Roger's adoption and diffusion theory

The process of adopting new innovations has been studied for over 30 years, and one of the most popular adoption models is described by Rogers in his book, Diffusion of Innovations (Sherry & Gibson, 2002). For Rogers (2003), adoption is a decision of "full use of an innovation as the best course of action available" and rejection is a decision "not to adopt an innovation" (p. 177). Rogers defines diffusion as "the process in which an innovation is communicated thorough certain channels over time among the members of a social system" (p. 5). Rogers identifies Four Main Elements in the Diffusion of Innovations the 1st one is an innovation which is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12), Communication Channels communication which is "a process in which participants create and share information with one another in order to reach a mutual understanding" (p. 5). the time aspect is ignored in most behavioral research. He argues that including the time dimension in diffusion research illustrates one of its strengths, Rogers (2003) defined the social system as "a set of interrelated units engaged in joint problem solving to accomplish a common goal" (p. 23). Since diffusion of innovations takes place in the social system, it is influenced by the social structure of the social system. For Rogers (2003), the innovation-decision process involves five steps: (1) knowledge, persuasion, decision, implementation, and finally the confirmation steps.

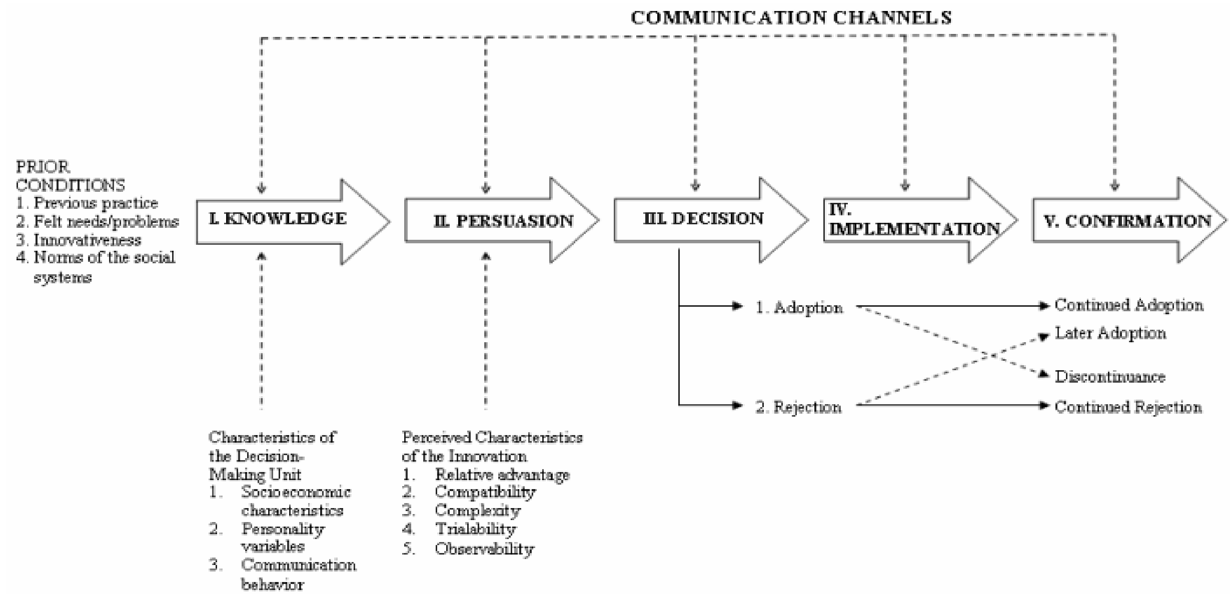

Figure 1A Model of Five Stages in the Innovation-Decision Process

2.2.1.2 Expected utility theory

Uncertainty is an important obstacle to the adoption of innovations. An innovation's consequences may create uncertainty: "Consequences are the changes that occur in an individual or a social system as a result of the adoption or rejection of an innovation" (Rogers, 2003;436). To reduce the uncertainty of adopting the innovation, individuals should be informed about its advantages and disadvantages to make them aware of all its consequences.

The expected utility theory stated that the decision maker chooses between risky and uncertainty prospect by comparing their expected utility value. In agriculture farmers maximize their utility subject to total land, family size, income, assets, and other constrained variable by adoption new agricultural technologies.

2.2.2 Measurement

2.2.2.1 Measurement of adoption rate

The rate of adoption of new agricultural technology is the pace at which a new agricultural technology is acquired and used by the public. This rate can be represented by the number of members of a society who start using a new technology or innovation during a specific period of time. The rate of adoption is useful for making comparisons. One group's rate is compared to the adoption rate of another, often of the entire society.

2.2.2.2 Measurement of Intensity of adoption

The amount of something transmitted from the source to the receiver. In agricultural technology adoption intensity is the adoption of new technology which shows how much the technology is covered the space. Intensity of adoption of coffee Varity is the ratio of land covered by improved coffee to total coffee land of the farmer own (Rogers, 2003).

2.2.2.3 Measurement of determinant of adoption of coffee technology

A dummy variable is a numerical variable used in regression analysis to represent subgroups of the sample in your study. In research design, a dummy variable is often used to distinguish different treatment groups. The dummy variables act like 'switches' that turn various parameters on and off in an equation.

Multivariate probit model

The multivariate probit is an appealing model of choice behavior because it allows a flexible correlation structure for the unobservable variables. However, until now, applications have been limited because they require high dimensional numerical- or simulation-based integration, and integration (or simulation) of the multivariate normal density over subsets of a Euclidean space is computationally burdensome. More generally, estimation of limited dependent variables models is often hampered by computational complexity. In particular, there is a widespread consensus in the literature that the use of numerical integration or quadrature techniques is possible in principle but it is too time consuming and/or imprecise to consider in practice, except for the case of low dimensional problems (Chib, S., & Greenberg, E. 1998).

2.2.2.4 Measurement of impact of coffee technology on Coffee yield

Impact evaluation assesses the extent to which a project has caused desired/undesired changes in the intended users. It is concerned with the net impact of an intervention on individuals, households or institutions, attributable only and exclusively to those interventions (Baker, 2000). Thus, impact evaluation consists of assessing outcomes of research and developmental changes resulting from interventions. There are two impact evaluation method those are experimental design (Randomization) and non-experimental (quasi-experimental designs).

Experimental design

Experimental designs, also known as randomization the treatment and control samples are randomly drawn from the same population. In other words, in a randomized experiment, individuals are randomly placed into two groups, namely, those that receive treatment and those that do not.

In this case observable and unobservable characteristics get uncorrelated thus no selection bias problem arises. This allows the researcher to determine project impact by comparing means of outcome variable for the two groups which yields an unbiased estimate of impact but it is difficult to extrapolate the results to a larger population (Nssah, 2006).

The outcome under this is very powerful because in theory the control groups generated trough random assignment serves as a perfect counterfactual free from the troublesome selection bias issue that exist in all evaluations. But it helps to simply interpreting the results in this method impact on the outcome being evaluated can be measured by the difference between the means of the sample of the treatment group and the control group (Baker, 2000).

Quasi-experimental method

Quasi-experimental (non-random) methods can be used to carry out an evaluation when it is not possible to construct treatment and comparison groups through experimental design. In this method, the treatment and comparison groups are usually selected after the intervention by using non-random methods (Gilligan *et al.*, 2008). There are four methods included under quasi-experimental: difference in difference, instrumental variable, regression discontinuity and endogenous switching regression.

This research design draw on the existing data source and are thus often quicker and cheaper to implement and they can be performed after a program has been implemented but it has its own disadvantage like the reliability of the result is often reduced as the methodology is less robust statistically, the methods can be statistically complex and there is a problem of selection bias in generating a comparison group rather than randomly assigning one many factor affecting reliability of result (Baker, 2000).

Difference-in-Differences (DID)

Method in which one compares a treatment and comparison group (first difference) before and after a project (second difference) it is panel data based. In this method program impacts are estimated by calculating the difference in outcomes between treatment and control groups after program implementation minus the difference in outcomes between treatment and control groups prior to the implementation (Jalan and Ravallion, 1999; Baker, 2000).

Instrumental Variables (IV)

The instrumental variable method deals directly with the selection on unobservable. The ATT of IV is identified if the researcher finds a variable, the instrument, which affects the selection into treatment but is not directly related with the outcome of interest or with the unobserved variables that determine it. Instrumental variable capture only unobservable heterogeneity, but the assumption is that the parallel shift of outcome variable can be considered as a treatment effect (Ahmed *et al*., 2017; Shiferaw *et al.*, 2014).

Regression Discontinuity Design (RDD)

RDD is a quasi-experimental pretest-posttest design that aims to determine the causal effects of interventions by assigning a cutoff or threshold above or below which an intervention is assigned. By comparing observations lying closely on either side of the threshold, it is possible to estimate the average treatment effect in environments in which randomization is unfeasible.

However, it remains impossible to make true causal inference with this method alone, as it does not automatically reject causal effects by any potential confounding variable (Imbens and Lemieux, 2008).

2.3 Empirical literature review

2.3.1 Determinant Adoption of coffee technology

According to Foster and Rosenzweig (1995), Carletto et al, (2007), there are two major drivers of successful agricultural technology in developing countries: first one is the availability and affordability of technologies; and second one is farmer expectations that adoption will remain profitable both which determine the extent to which farmers are risk averse. There are number of factors which drive the above expectations, ranging from availability and size of land, family labor, prices and profitability of agricultural enterprises.

Ketema et al (2016) investigation results on the factors that influence adoption of potato production technology package by smallholder farmers in eastern Ethiopia show that household size, farm land size, labor, access to irrigation, membership to cooperative and training service in potato, access to institutional services, and farmland distance from institutional services all had an impact on adoption of potato production technology. In the same way Ogada et al (2017) investigated in a simultaneous estimation of inorganic fertilizer and improved maize variety Farm technology adoption technology decisions in Kenya found out that household size, farm land size, labor, access to irrigation, membership to cooperative and access to institutional services like credit, and farmland distance from institutional services all had an impact on adoption of inorganic fertilizer and improved maize variety technology.

Obayelu et al (2017) Results of the findings from What Does Literature Say About the Determinants of Adoption of Agricultural Technologies shown that adoption of agricultural technology depends on a range factor which include among others: human specific factors, social factor, cultural factor, economic factor, characteristics of the innovation itself, education levels, capital, income, farm size, access to information, utilization of social networks, beside the cost of the inputs.

As Ketema et al (2017) find out in the factors affecting adoption of technology packages measured based on an index derived from five components of wheat technologies which included row planting, pesticide application, use of improved varieties, and application of inorganic fertilizers, namely, Diammonium Phosphate (DAP) and Urea. Among the variables included in the model, variation in district, gender, age of the household head, education status of the household head, farm size, distance to market, distance to FTC (Farmers' Training Centers), cooperative membership, dependency ratio, and annual income of the households were found to significantly affect the adoption of wheat technology packages.

As Abreham and Tewodros (2015) investigated on Analyzing Adoption and Intensity of Use of Coffee Technology Package in Yergacheffe District, Gedeo Zone, SNNP Regional State, Ethiopia indicated that respondent's level of education, social participation, access to credit, labor availability, and farm size and achievement motivation were important variables which had positively and significantly influenced adoption and intensity of use of improved coffee technology package. On the other hand, market distance had shown negative and significantly affected adoption and intensity of use of coffee technology package. Similarly Kasshaun (2021) on Adoption of garden coffee production technology package by smallholder farmers in Ethiopia the maximum likelihood estimates of Tobit model result shows that gender of household head , education level, the annual income of the household, farm size, availability of labor, credit facilities, coffee extension services (0.047) and farmer perception of improved coffee varieties were significant determinants of garden coffee production technology package in Dale district. Results of Kafle (2010) investigated on the review of determinants of adoption of improved maize varieties in developing countries revealed that extension contact, education, farm size, credit availability, use of fertilizer, low land area, yield and profitability are found to be major determinants which have strong positive influences on adoption of maize technology in developing countries.

Million et al (2020) binomial regression model results on Adoption Status and Factors Determining Coffee Technology Adoption in Jimma Zone as a result, age, sex, dependency ratio, membership to cooperatives and market distance have a negative correlation with adoption of coffee technologies and Family size, extension service income and credit was found to be significant and positively correlated with adoption of coffee technology. Similarly, as seen above Ogada etal (2017) results in investigated in a simultaneous estimation of inorganic fertilizer and improved maize variety Farm technology adoption technology decisions in Kenya found that male-headed households had four per cent higher probability of adopting both inorganic fertilizer and improved maize variety than the female-headed households. This possibly indicates that female-headed households are more resource-constrained. But according to as Samuel and Beza (2019) on Impacts of Adoption of Improved Coffee Varieties on Farmers' Coffee Yield and Income in Jimma Zone there was no statistically significant difference between male and female headed households in adoption of coffee technologies.

2.4 Conceptual frame work of the study

There are different factors that could affect adoption of coffee technology. These factors are interlinked with one another and operating at different scales. Among these factors, some have direct influence on coffee yield whereas others have indirect influence. For this study, the conceptual framework shows the direct effect of determining factors on coffee production technology and indirect effect on coffee productivity. It indicates that adoption of coffee production technologies is affected by demographic, socio-economic and institutional factors the level of adoption will decide the impact of on coffee productivity. The adoption of coffee technology enables to increase coffee production, if the new coffee production technology introduced to farmer it will enable the farmer to produce more by decrease coffee vulnerability to diseases and increase pre input production this in turn increase coffee production yield.

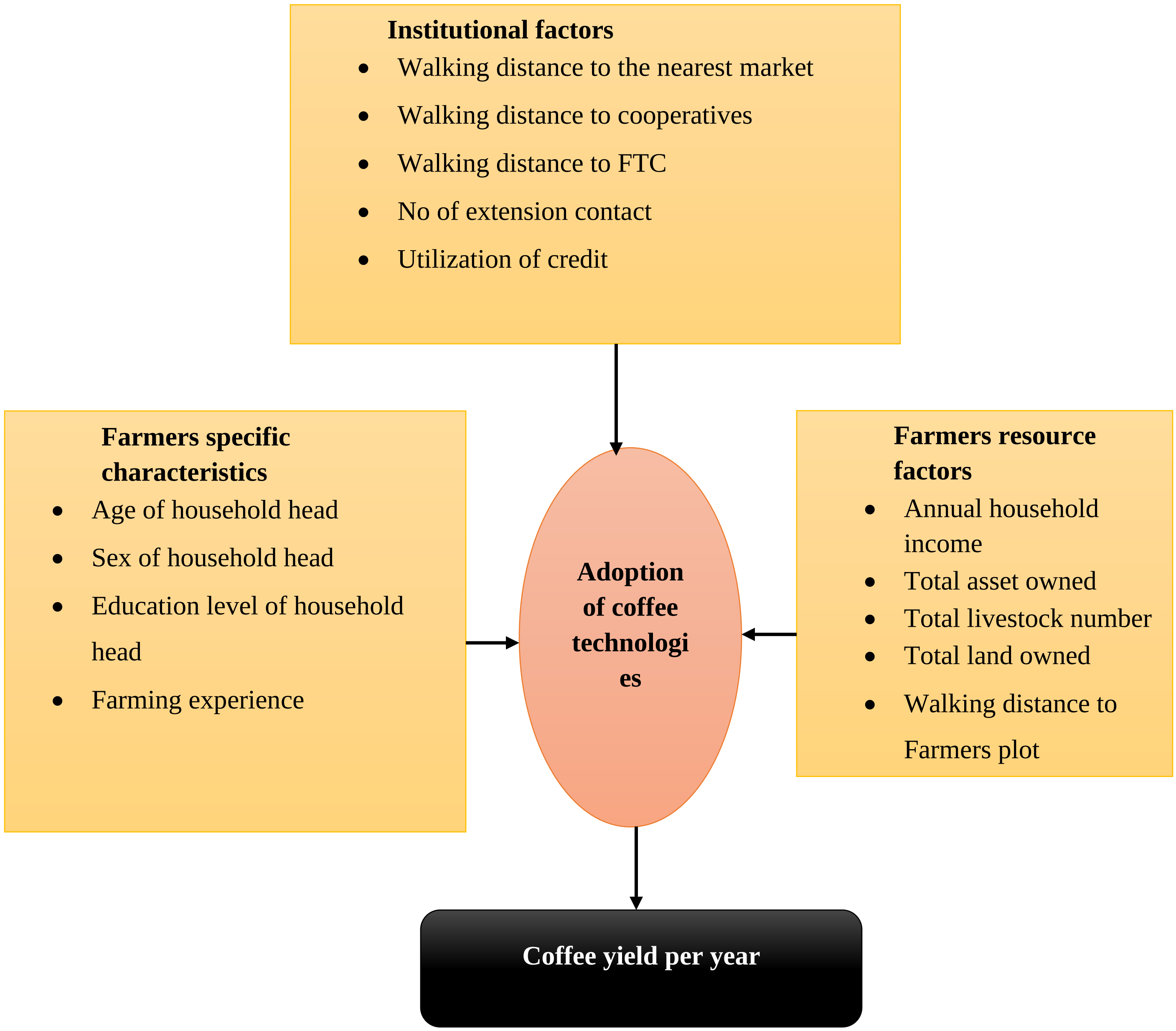

Figure 2: *Source: Adopted and modified from (Hudson, 1986 and Troe et al.,1999)*

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Description of the study area

Jimma is a zone in Oromia State of Ethiopia. Jimma is named after former Kingdom of Jimma, which was absorbed into the former province of Kaffa in 1932. Jimma is bordered on the south by the Southern Nations, Nationalities and Peoples Region, the northwest by Illubabor Zone, on the north by East Welega Zone and on the northeast by West Shewa Zone; part of the boundary with East Shewa Zone is defined by the Gibe River. The highest point in this zone is Mount Maigudo (2,386 m). Towns and cities in Jimma include Agaro, Limmu Inariya and Saqqa. The town of Jimma was separated from Jimma Zone and is a special zone now. Based on the 2007 Census conducted by the CSA, this Zone has a total population of 2,486,155, an increase of 26.76% over the 1994 census, of whom 1,250,527 are men and 1,235,628 women; with an area of 15,568.58 square kilometers, Jimma has a population density of 159.69. While 137,668 or 11.31% are urban inhabitants, a further 858 or 0.03% are pastoralists. A total of 521,506 households were counted in this Zone, which results in an average of 4.77 persons to a household, and 500,374 housing units. It has a latitude and longitude of 7°40′N 36°50′E. Prior to the 2007 census

The Central Statistical Agency (CSA) reported that 26,743 tons of coffee was produced in this Jimma zone in the year ending in 2005, based on inspection records from the Ethiopian Coffee and Tea authority. This represents 23.2% of the Region's output and 11.8% of Ethiopia's total output, and makes Jimma one of the three top producers of these goods, along with the Sidama and Gedeo Zones.

Table 1:Description of the study area

	Limu kosa district	**Mana district**	**Gera district**
Producer Altitude range	1200 to 3020 m.a.s.l	1774 up to 2410 m.a.s.l	1390 to 2980 m.a.s.l
Mean annual rainfall	1480 mm	1216.3 mm	1216.3 mm
Farming system	Crop-livestock mixed	Crop-livestock mixed	Crop-livestock mixed
Agro ecology	Dominantly humid climate zone	Dominantly classified as humid	Dominantly classified as humid
Woreda Population	161,338, of whom 81,462 were men and 79,876 were women	146,675, of whom 74,698 were men and 71,977 were women	112,395, of whom 56,488 were men and 55,907 were women
Type of perennial crop produced	Coffee, Chat, Avocado, Banana, Orange,	Coffee, Chat, Avocado, Banana, Orange,	Coffee, Chat, Avocado, Banana, Orange,
Cereal Crop produced	Maize, Finger millet, wheat, bean,	Maize, Finger millet, wheat, bean,	Maize, Finger millet, wheat, bean,

Source: (CSA, 2019)

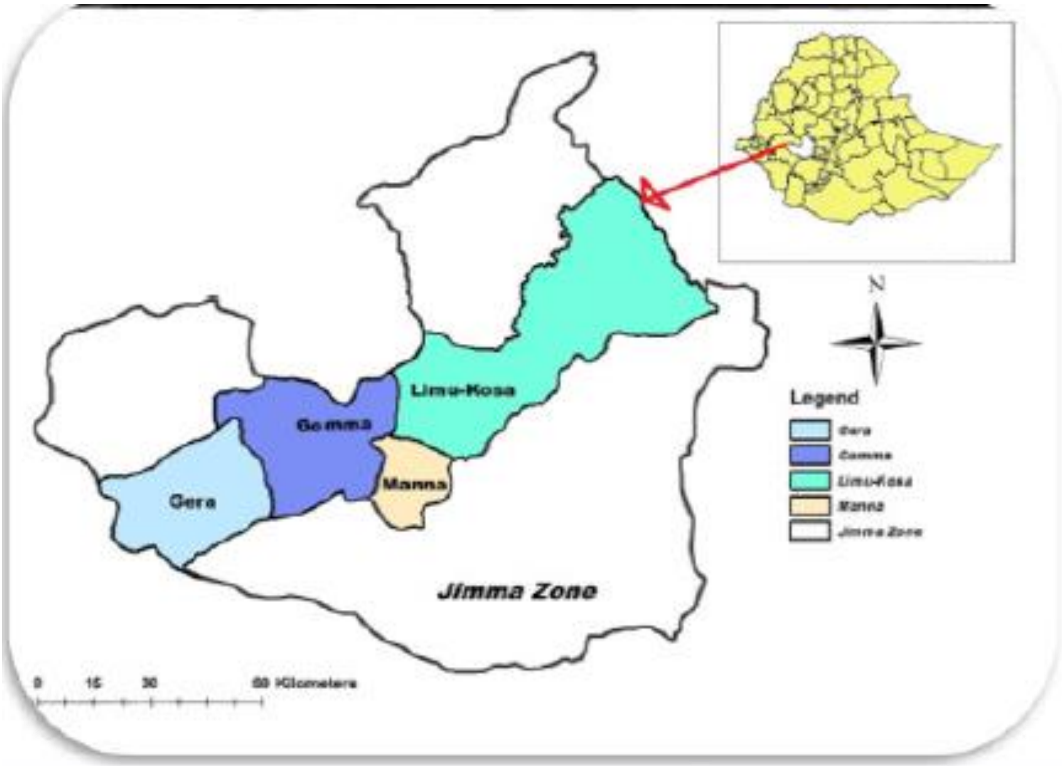

Figure 3: Map of the study area

3.2 Research design

The research design refers to the overall strategy that one may choose to integrate the different components of the study in a coherent and logical way. This was done in order to ensure that research problem was effectively addressed. Research design can also be considered as a blueprint or the roadmap for the collection, measurement, and analysis of data (Kothari, 2004).

The research design of the study was a cross-sectional research design. The survey was conducted to collect a primary data from a coffee grower farmer. The qualitative and quantitative data was collected from sample respondents in all selected areas. For rural household coffee growers, the primary data through different data collection method was collected.

3.3 Methods of Data Collection

The study was based on the cross-sectional data set. It was collected using both qualitative and quantitative data collection tools. The quantitative data collection tool was used to collect data from representative households through administrating an independent structure questionnaire (both close and open-ended questionnaire) to the producer personal interview. Before the Formal data collection structured questionnaires were pretested on the ground and modified accordingly. As far as the qualitative data collection tools are concerned, they were key informant interview, individual in-depth interview and focus group discussion. FGD was made with coffee producers. Key informant was purposively selected and interviewed who works in the area related to coffee production.

3.4 Sampling techniques

Both primary and secondary data was collected and used to investigate the problems. Primary data like farmers specific characteristics resource factor and other data collected service provided by the experts and other were collected from the respondents by using interview with questionnaire and the survey were held by using designed CSPro software and secondary data were collected from different information sources like experts in the zone and district, previous studies and others.

3.5 Sample size

The dataset used for this study is based on a farm household survey conducted in Ethiopia during October–December 2014 by the Ethiopian Institute of Agricultural Research (EIAR) in collaboration with the EU. A multistage sampling procedure was employed to select peasant district from the zone. First, based on their coffee production potential, three or four kebele from each district were selected then based on proportionate random sampling after selecting a potential district by a simple probability sampling techniques 12 to 16 household in each kebele were selected.

3.6 Data analysis

3.6.1 Descriptive analysis

Descriptive statistics such as means, percentage, and standard deviation were computed to explain different demographic and socioeconomic characteristics of the households. In addition, t-test and Chi square test was employed in order to see the relationship between hypothesized explanatory variables and the dependent variable. For this study t-test was used to check the mean difference of continuous independent variables between adopter and non-adopter households. On the other hand, chi-square test was employed to see the association of independent variables (discrete variables) with the dependent variable.

3.6.2 Econometric analysis

3.6.2.1 Determinant of coffee technology adoption

From the expected utility theory farmers under uncertain condition aim at maximizing the expected utility. From this theory it is assumed that farmers aim to maximize their expected profit, Ui, by comparing the profit provided by m alternative packages. The requirement for farmer i to choose any package, j, over any alternative package, m, is that $U_{ij} > U_{im}$ m≠j or equivalently $\Delta U_{im} = U_{ij} - U_{im} > 0$ m≠j The expected profit of U_{ij}^* that the farmer derives from the adoption of package j is a latent variable determined by observed household, plot and location characteristics X_i and unobserved characteristics $\mathcal{E}_i$:

$$U_{ij} = X_i\beta_j + \mathcal{E}_i \qquad (1)$$

where X_i is observed exogenous variables (household, plot and location characteristics) and $\mathcal{E}_i$ is unobserved characteristics. Let *(I)* be an index that denotes the farmer's choice of package, such that:

$$I = \begin{cases} 1 \quad \text{iff} \quad U_{i1} > \underset{\mathrm{m} \neq \mathrm{j}}{\max}\,(U_{im}^*)\, or\, \eta_{i1} < 0 \\ . \\ . \\ . \\ \mathrm{J} \quad \text{iff } 1{:}\, U_{ij} > \underset{\mathrm{m} \neq \mathrm{j}}{\max}\,(U_{im}^*)\, or\, \eta_{iJ} < 0 \end{cases} \qquad (2)$$

Where $\eta_{ij} = max_{\mathrm{m}\neq\mathrm{j}}\left(U_{im}^* - U_{ij}^*\right) < 0$ (Bourguignon et al., 2007). Eq. (2) implies that the ith farmer will adopt package j to maximize his expected profit if package j provides greater expected profit than any other package m ≠ j that is $\eta_{iJ} = max_{\mathrm{m}\neq\mathrm{j}}\left(U_{im}^* - U_{ij}^*\right) > 0$.

Multinomial logistic regression is often considered an attractive analysis because; it does not assume normality, linearity, or homoscedasticity. A more powerful alternative to multinomial logistic regression is discriminant function analysis which requires these assumptions are met. Indeed, multinomial logistic regression is used more frequently than discriminant function analysis because the analysis does not have such assumptions. Multinomial logistic regression does have assumptions, such as the assumption of independence among the dependent variable choices. This assumption states that the choice of or membership in one category is not related to the choice or membership of another category (i.e., the dependent variable). The assumption of independence can be tested with the Hausman-McFadden test. Furthermore, multinomial logistic regression also assumes non-perfect separation. If the groups of the outcome variable are perfectly separated by the predictor(s), then unrealistic coefficients will be estimated and effect sizes will be greatly exaggerated (Kwak, C., & Clayton-Matthews, A., 2002).

Assuming that Ɛ are identically and independently Gumbel distributed, the probability that farmer i with characteristics X will choose package j can be specified by a multinomial logit model (McFadden, 1973):

$$P_{ij} = \Pr\,(\eta_{ij} < 0|X_i = \frac{\exp\left(X_i\beta_j\right)}{\sum_{m\neq j}^{J}\exp(X_i\beta_m)} \qquad (3)$$

3.6.2.2 Impact of coffee technology on coffee annual yield

To analyze the impact of coffee technologies adoption on annual coffee yield, the observable and unobservable characteristics of the adopters and non-adopters must be captured. However, most impact assessment techniques using non-experimental data fail to capture both observable and unobservable characteristics that affect adoption and outcome variables (Million Sileshi et al., 2020). For instance, instrumental variables capture only unobserved heterogeneity, but the assumption is that the parallel shift of outcome variables can be considered as a treatment effect (Kabunga et al., 2012 and Musa Hasen et al., 2017). In contrast, using regression models to analyze the impact of a given technology using pooled samples of adopters and non-adopters might be inappropriate since it gives a similar effect on both groups (Menale Kassie et al., 2009; Menale Kassie et al., 2010; Musa Hasen et al., 2017).

Propensity score matching (PSM) was not used in this study since it does not control the unobservable characteristics. A methodological approach that overcomes these limitations of different impact evaluation methods is the ESR model, which is the most used method to analyze the impact of a given technology (Di Falco et al., 2011; Menale Kassie et al., 2010; Solomon Asfaw et al., 2012; Abdulai and Huffman, 2014; Bekele Shiferaw et al., 2014; Musa Hasen et al., 2017). The parametric ESR model is an appropriate model to reduce the selection bias and assure consistent results by capturing both the observed and unobserved heterogeneity that influences the outcome variable as well as the adoption decision (Million Sileshi et al., 2019).

The impact of coffee technologies on annual coffee yield under the MNESR framework follows two stages. In the first stage, adoption of coffee technologies is estimated using a multinomial logit model as selection as seen above, while in the second stage linear regressions after testing the assumption of classical linear regression were employed to assess the association between an outcome variable and adoption of coffee technologies (Bekele Shiferaw et al., 2014).

Farmers may endogenously self-select adoption or non-adoption, so decisions are likely to be influenced systematically both by observed and unobservable characteristics that may be correlated with the outcomes of interest. To disentangle the pure effects of adoption, model the farmers' choice of combinations of coffee technologies and the impacts of adoption in the coffee annual yield framework, a relatively new selection-bias correction methodology based on the multinomial logit selection model (Bourguignon et al., 2007). This approach allows us to get both consistent and efficient estimates of the selection process and a reasonable correction for the outcome equations (Bourguignon et al., 2007). This framework has the advantage of evaluating both individual and combined practices, while capturing the interactions between the choices of alternative practices (Wu and Babcock, 1998; Mansur et al., 2008).

Consistent estimates of the yield functions specified below are important to unravel the pure effect of coffee technologies on annual coffee yield. The relationship between coffee yield (Qji) and a set of exogenous variables Z (institutional access, demographic factors, resources, etc.,) is estimated for each chosen combination of coffee technologies following the Antle (1983) flexible moment-based approach and the Bourguignon et al. (2007) multinomial selection-bias correction framework. The base category, non-adoption of coffee technologies (i.e., V0W0), is denoted as j = 1. In the remaining combinations (j = 2, 3, 4), at least one coffee technologies are adopted. The stochastic production function to evaluate the annual yield implications of coffee technologies adoption for each regime (coffee technologies combination) j is given as:

$$\begin{cases} \text{Regime 1: } Q_{1i} = \alpha Z_{1i} + \theta Z_{1i} + U_{1i} \\ \quad \vdots \\ \text{Regime J: } Q_{Ji} = \alpha Z_{Ji} + \theta Z_{Ji} + U_{Ji} \end{cases} \tag{4}$$
$$j = 2,3,4$$

where Q is the coffee yield per hectare of the ith farmer on a plot in regime j, Z is as defined above, and u denotes error terms that capture the uncertainty faced by farmers and satisfies E(u) = 0. In order to get consistent estimates, equation (2) is augmented by including the mean of plot varying covariates, average plot size to control for the unobserved heterogeneity, including the level of inputs, can help to address plot-specific unobservable as they contain useful missing information regarding land quality. If farmers accessed private information about unobservable effects such as how good the soil is on the plot, they will accordingly adjust their factor input decisions (Fafchamps, 1993; Levinsohn and Petrin, 2003). If the u's and ε's are not independent, a consistent estimation of a h requires the inclusion of the selection correction terms of the alternative choices in (1). Bourguignon et al. (2007) show that consistent estimates of a and h in the outcome equations (1) can be obtained by estimating the following MESTR models:

$$\begin{cases} \text{Regime 1: } Q_{1i} = \alpha Z_{1i} + \sigma_1 \hat{\lambda}_{1i} + \theta \bar{Z}_{1i} + U_{1i} & I = 1 \\ . \\ . \\ \text{Regime J: } Q_{Ji} = \alpha Z_{Ji} + J \hat{\lambda}_{Ji} + \theta \bar{Z}_{Ji} + U_{Ji} & I = j \end{cases} \quad (5)$$

Here, e is the error term with an expected value of zero, r is the covariance between ε and u, k is the inverse Mills ratio computed from the estimated probabilities in equation (3) as follows:

$$\lambda_{ji} = \sum_{m \neq j}^{J} p_j \left[\frac{\hat{p}_{mi} \ln(\hat{p}_{mi})}{1 - \hat{p}_{mi}} + \ln(\hat{p}_{ji}) \right]; p \quad (6)$$

p is the correlation coefficients between ε and u. In the multinomial choice setting, there are J - 1 selection correction terms to be included in the production one for each combination of coffee technologies.

As shown by Antle (1983) the error terms in equations (5) and (6) are likely to exhibit heteroscedasticity. To deal with heteroscedastic problems, standard errors in equations (5) and (6) are bootstrapped. For equations (5) and (6) to be identified, it is important to use a selection instrument in addition to those automatically generated by the non-linearity of the selection model of adoption. Getting a true instrumental variable is a challenge (if not impossible) in many empirical analyses. In equation (5), we excluded the following set of instruments from the coffee yield function results using a simple falsification test (Di Falco and Veronesi, 2011) confirm that, in nearly all cases, these variables are jointly significant in the adoption.

Estimation of the counterfactual and treatment effect

Following Carter and Milon (2005), Di Falco and Veronesi (2014), and Teklewold et al. (2013), and the impact literature (Heckman et al., 2001), we describe how the multinomial endogenous switching treatment regression model can be used to compute the counterfactual and average adoption effects. The counterfactual is defined as the crop yield and downside risk of adopters which would have obtained if the returns (coefficients) on their characteristics had been the same as the returns (coefficients) on the characteristics of the non-adopters, and vice versa. In addition to addressing selection bias due to unobserved heterogeneity, this approach also controls for selection bias due to observed heterogeneity. From equation (4), the following conditional expectations for each outcome variable can be computed:

Adopters with adoption (actual)

$$\mathrm{E}\left[Q_{ji}|I = j, Z_{ji,}\bar{Z}_{ji}, \hat{\lambda}_{ji}\right] = \alpha_{ji}Z_{ji} + \theta_j\bar{Z}_{ji} + \sigma_j\hat{\lambda}_{ji} \qquad (8)$$

Non adopters with non-adoption (actual)

$$\mathrm{E}\left[Q_{1i}|I = 1, Z_{1i,}\bar{Z}_{1i}, \hat{\lambda}_{1i}\right] = \alpha_{1i}Z_{1i} + \theta_1\bar{Z}_{1i} + \sigma_{1\varepsilon}\hat{\lambda}_{1i} \qquad (9)$$

Adopters had decided to non to adopt (counterfactual)

$$\mathrm{E}\left[Q_{1i}|I = j, Z_{ji,}\bar{Z}_{ji}, \hat{\lambda}_{ji}\right] = \alpha_1 Z_{ji} + \theta_1\bar{Z}_{ji} + \sigma_{1\varepsilon}\hat{\lambda}_{ji} \qquad (10)$$

Non adopters had decided to adopt (counterfactual)

$$\mathrm{E}\left[Q_{1i}|I = 1, Z_{1i,}\bar{Z}_{1i}, \hat{\lambda}_{1i}\right] = \alpha_j Z_{1i} + \theta_j\bar{Z}_{ji} + \sigma_{j\varepsilon}\hat{\lambda}_{1i} \qquad (11)$$

Equations (7) and (8) represent the actual expected maize yield (or mean yield functions) actually observed in the sample for adopters and non-adopters, respectively, while equations (9) and (10) are their respective counterfactual expected maize yields. The use of these conditional expectations allows us to calculate the average adoption effects (average impact on yield) on adopters (ATT).8 The ATT is defined as the difference between equations (8) and (9)

$$ATT = \mathrm{E}\left[Q_{ji}|I = j, Z_{ji,}\bar{Z}_{ji}, \hat{\lambda}_{ji}\right] - \mathrm{E}\left[Q_{1i}|I = 1, Z_{1i,}\bar{Z}_{1i}, \hat{\lambda}_{1i}\right]$$

$$= Z_{ji}\left(\alpha_j - \alpha_1\right) + \bar{Z}_{ji}\left(\theta_j - \theta_1\right) + \hat{\lambda}_{ji}(\sigma_i - \sigma_1) \qquad (12)$$

Counterfactual difference is the ATU of the coffee technologies.

$$ATU = \mathrm{E}\left[Q_{1i}|I = j, Z_{ji,}\bar{Z}_{ji}, \hat{\lambda}_{ji}\right] - \mathrm{E}\left[Q_{1i}|I = 1, Z_{1i,}\bar{Z}_{1i}, \hat{\lambda}_{1i}\right]$$

$$= Z_{ji}\left(\alpha_j - \alpha_1\right) + \bar{Z}_{ji}\left(\theta_j - \theta_1\right) + \hat{\lambda}_{ji}(\sigma_i - \sigma_1) \qquad (13)$$

3.6 Definition of variable and hypothesis

3.6.1 Outcome variables

Yield: The total yield produced in a year. The amount of harvested coffee output divided by plot area. In this paper increment in coffee yield measured as the amount of harvested coffee output with adopted new coffee technology divided by plot area with amount of harvested coffee output divided by plot area that are not adopt coffee technology.

3.6.2 Dependent variable

Adoption of coffee technology: The study further analyzed the impacts of credit, extension access and simultaneous adoption of credit and extension on adoption. According to Samual and beza (2019) Adoption can be measured in terms of the number of persons who adopt the technology (adoption rate) or in terms of the total area on which the technology is adopted (adoption intensity). Intensity of adoption of improved coffee variety is the ratio of land covered by improved coffee to total coffee land of the farmer.

Table 2: Description of dependent variable

Technology	Data type	Description
Coffee Varity	Dummy	1 if the farmer use 0 if the farmer not use
3 times Slashing annually	Dummy	1 if the farmer use 0 if the farmer not use

3.6.3 Independent variable

Sex: a dummy variable take a value of 1 if the respondent are male and 0 for female respondent for According to Samuel and Beza(2019) There was no statistically significant difference between male and female headed households in adoption of coffee technologies. But as Ogada etal (2017) found that male-headed households had four per cent higher probability of adopting both inorganic fertilizer and improved maize variety than the female-headed households. This possibly indicates that female-headed households are more resource-constrained.

Education level: Education level of household head which is a continuous variable which take a value of total years a household head is taken in education. if the household head is illiterate, it will take a value of 0. Those household heads that attained formal and informal education are ready to accept new ideas and innovations, easily understand new technology of production and eager to apply it. This enhances farmers' willingness to produce more and increase volume of sales as compared to illiterates. According to Obayelu et al (2017) on What Does Literature Say About the Determinants of Adoption of Agricultural Technologies Education of the farmer has been assumed to have a positive influence on farmers' decision to adopt new technology. Education level of a farmer increases his ability to obtain; process and use information relevant to adoption of a new technology. Therefore, both informal and formal education was hypothesized to influence the adoption of farmer in coffee technology positively. Similarly, as Abreham K and Tewodros A (2015) investigated on Analyzing Adoption and Intensity of Use of Coffee Technology Package in Yergacheffe District, Gedeo Zone, SNNP Regional State, Ethiopia indicated that respondent's level of education, were important variables which had positively and significantly influenced adoption and intensity of use of improved coffee technology package

Age: This is a continuous variable measured in number of years. An old age people might acquire skill of production and marketing and also the agro ecological condition of the region so they might have accumulated capital as long as experienced farmers are older aged that might have many active family members which could tends to produce and participate more in the adoption of coffee technology. As Adesiina and Baidu-Forson, (1995) found age is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. However, there is contention on the direction of the effect of age on adoption. Age was found to positively influence adoption of sorghum in Burkina Faso. Similarly, Adesina and Forson (1995) found that Farmer's age may negatively influence both the decision to adopt and extent of adoption of improved poultry breeds. It may be that older farmers are more risk averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies. However, it could also be that older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice. Adesina and Forson (1995)

Family size: It is a continuous variable measured in man equivalent that is the availability of active labor force in the household. Since production is the function of labor, specifically as coffee production is labor intensive activity, a household which have more of active labor force able to expanding production and perform every activity on time which bring large supply to the market. Coffees are major cash perennial crops while it is absolutely necessary to improve the farmers' income. Million et al (2020) results on Adoption Status and Factors Determining Coffee Technology Adoption in Jimma Zone family size is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. Therefore, family size expected to have positive influence on adoption of coffee technology.

Extension service: measured as continuous variable which is the number of days that a farmer had contact with extension agent for agricultural work supervision related to coffee production and coffee technology in a year and representing extension services as a source of information on technology. Farmers who have frequent contact with extension agent were expected to be highly informed on how to increase the production of coffee and about the new release of Varity of coffee plus to farmer accessibility to an extension system will have This could possibly be due to constrained access to credit and relatively higher access to extension advice in the studied sample. Access to extension service allow the farmers to train about scientifically allowable space between each coffee plant, about time and technique of Applying fertilizer, the dose and precondition to apply chemical, technique and time of irrigation application, pre harvest mechanism to have produce normal weight and attracting color as well as post-harvest technique stay safe produce until it sell, having such information on the above circumstance capacitating household to adopt, produce and supply more. As Kafle, B (2010) investigated on the review of determinants of adoption of improved maize varieties in developing countries important determinants of improved maize varieties in different countries. Among these variables, extension contact, education, farm size, credit availability, use of fertilizer, low land area, yield and profitability are found to be major determinants which have strong positive influences on adoption of maize technology in developing countries. Similarly, Kasshaun (2021) on Adoption of garden coffee production technology package by smallholder farmers in Ethiopia result shows the maximum likelihood estimates of Tobit model result shows that farmers extension contact has a positive influence on farmers adoption of coffee production technology. Therefore, farmers extension contact expected to have positive influence on farmers adoption of new coffee technology

Plot size: plot size is a continuous variable measured in hectare. It is the total land the farmer owns which include shared land, rented land, and owned land. Land is important factors that affects the farmers' decision to adopt or not a coffee technology**.** The farmers owning a large size of land increase the probability to adopt new coffee technology. As Abreham K and Tewodros A (2015) investigated on Analyzing Adoption and Intensity of Use of Coffee Technology Package in Yergacheffe District, Gedeo Zone, SNNP Regional State, Ethiopia indicated that farm size were important variables which had positively and significantly influenced adoption and intensity of use of improved coffee technology package. Similarly, the Kassahun (2021) Tobit results on Adoption of garden coffee production technology package by smallholder farmers in Ethiopia showed that farm size is a determining factor in adoption of coffee production technology.

Farming experience: a continuous variable measured in number of years staying on production of coffee. Experienced people might acquire skill of production and marketing, might have accumulated capital as long as experienced farmers are older aged that might have many active family members which could tends to produce and participate more in the chain.

Livestock number: a continuous variable which is the farmers is the total number of livestock the famers own. Farmers' ownership to livestock has a positive impact on adoption of coffee technology because livestock ownership increases farmers income those income allow the farmers to adopt new coffee technology.

Distance to Market: It is a continuous variable measured in walking time (minute) which farmers spend time to sell their product to the market. A household closer to the market centers have regular contact with city consumer directly as well as strong social and economic ties with bulk buyer such as wholesaler thus initiated to supply more. As Abreham K and Tewodros A (2015) investigated on Analyzing Adoption and Intensity of Use of Coffee Technology Package in Yergacheffe District, Gedeo Zone, SNNP Regional State, Ethiopia shows that market distance had shown negative and significantly affected adoption and intensity of use of coffee technology package. There for distance to market are expected to have negative correlation with farmers adoption of new coffee technology.

Farmer's utilization of credit: A dummy variable take a value of 1 if the farmer has access to credit and take 0 if the farmer not access to credit. Access to credit might have different purpose it might enabling the farmer to access different kinds of input. Abreham K and Tewodros A (2015) found that farmers the interdependence of credit access and production capacity, where availability of additional financial resources resulted in investment in output enhancing technologies and processes, which is led to high output and improved in cash flows. Conversely, a financially constrained producer could not afford to enhance the productivity of their livestock. Similarly Ogada et al (2017) found that point to the importance of credit in improving CSA technology adoption in smallholder farming systems of Zimbabwe and Malawi. Agriculture extension individually proved to be more effective in promoting CSA technology adoption when compared to credit access only. As Kasshaun (2021) on Adoption of garden coffee production technology package by smallholder farmers in Ethiopia result shows the maximum likelihood estimates of Tobit model result shows credit facilities have a positive influence on farmers adoption of new coffee technology. Therefore, farmers access to credit expected to positive correlation with farmers adoption of new coffee technology.

Distant to the FTC center: It is a continuous variable measured in walking time (minute) which farmers spend time to reach the farmers training center. The farmers training centers provide a lot of training for the farmers the longer the distance the less likely the farmers incentive and information the farmers have on those training and extension service so the farmers home distance to the farmers training centers expected to have a negative relation with Farmers adoption of new technologies

Membership to cooperative: cooperative have different importance for the farmers accessibility to cooperative allows the farmers to access inputs like fertilizers seedling and other inputs in addition to that it allows the farmers to sell their product through those cooperatives which increase the adoption probability of the farmers. As Kasshaun (2021) on Determinants of adoption of sustainable production practices among smallholder coffee producers in Nicaragua found that coffee farmers who belong to cooperatives have adopted sustainable practices at higher rates than non-members, and that the odds of adoption are higher for members than for non-members**.** Similarly, Ogada et al (2017) results in a simultaneous estimation of inorganic fertilizer and improved maize variety farm technology adoption technology decisions in Kenya shows that membership to cooperative had a positive impact on adoption of inorganic fertilizer and improved maize variety technology. Therefore, membership to cooperative expected to have a positive correlation with adoption of coffee technology. The table 3 below shows the expected relationship between the dependent variable and the explanatory variable.

Table 3:Expected sign of relation of dependent variable with independent variable

Independent variable	**Data type**	**Expected relation sign**		**Reference**
		Adoption	**Impact**	
Sex	Dummy	+	+	Ogada etal (2017)
Education level:	Continuous	+	+	Abreham K and Tewodros A (2015);
Age:	Continuous	+	+/-	Million et al (2020); Ketema et al (2016) Adesiina and Baidu-Forson,
Experience in coffee farming	Continuous	+	+	Abreham K and Tewodros A (2015); kasshaun (2021) ;
Family size:	Continuous	+	+	Ketema et al (2016);
Extension service	Dummy	+	+	Kafle, B (2010)
Plot size:	Continuous	+	+	Ketema et al (2016);
Livestock number:	Continuous	+	+	

Walking distance to farmers plot	Continuous	-	-	Ketema et al (2016); kasshaun (2021)
Distance to Market:	Continuous	-	-	
Utilization of credit	Dummy	+	+	Million et al (2020);
Distant to FTC	Continuous	-	-	
Membership to cooperatives		+	+	Aniseh S etal (2019), Ketema et al (2016)
Total asset owned	Continuous	+	+	Ketema et al (2016); Abreham K and Tewodros
Total income	Continuous	+	+	Million et al (2020);

CHAPTER 4: RESULT AND DISCUSSION

This chapter presents the results and discussion section of the study. Descriptive and inferential statics results are presented to describe the socio-demographic and institutional characteristics of sampled households. Reasons why adopters are adopting and non-adopters not adopting the technologies are presented. Then, the econometric analysis, the driver of adoption of coffee technologies and its impact on annual production of coffee are presented in this chapter.

4.1 Descriptive statistics result

This study included a range of household and farm characteristics as independent variables in the adoption analysis at household level. The summary of descriptive statistics is given in Table3 and Table 4 below.

Sex of the household heads: Among the sample respondents 96.8% were male-headed and 3.2% were female-headed households from 214 total sampled populations (Table 4). From the total adopter of improved coffee varieties 3.25% of the household were female headed and 96.88% were male headed households from 3times slashing annually innovation 4.27% of the households were female headed and 95.73% of the households were male headed households.

The chi-square test result showed that there is no significant association between sex of the household and adoption of those coffee technologies.

Age of the household head: The descriptive statistics result showed the average age of the total sample household heads was 47.59 with standard deviation of 11.41 in the zones (Table 3). The average age of the sample household head of adopters and non-adopter of different coffee technologies were different. For improved coffee varieties adopter mean ages was 48.34 with standard deviation 11.13 and for non-adopters mean age was 45.87 with standard deviation 11.94). For 3 times slashing coffee innovation practice adopter mean 49.55 with standard deviation 11.96 and for non-adopters mean age was 45.34 with standard deviation 16.39. The ttest results of Age plays a key role in household decisions for the adoption of three coffee production technologies. This is proved by the t-test result that there is a significant mean difference between the adoption groups in the study areas.

Family size of the households: The descriptive statistics result of family size of household showed that average family size of the household was 5.98 with standard deviation of 2.28. The mean of households' family size was different for those different technologies for the adopters and nonadopters. For adopter of improved coffee variety, the mean family size was mean=6.10 with standard deviation of 2.43 and for non-adopters mean family size was 5.82 with a standard deviation of 2.07. For annually 3 times slashing coffee innovation practice adopter mean family size was 6.18 with standard deviation of 2.49 for adopters and for non-adopter mean=5.74, std dev=2.00.

The t-test result revealed that family size of the household has not have a statically significant mean difference between adopters and non-adopter of coffee technologies packages.

Farming experience of household head: The descriptive statistics result showed that the average farming experience of the household heads in coffee farming was 26.93 with standard deviation of 10.97 in the zones (Table 4). The mean farming head of the household head adopters of improved coffee varieties 29.72 with standard deviation 9.87 and for non-adopter mean farming experience 23.36 with standard deviation 11.32. For 3 times slashing coffee innovation practice adopter the mean farming experience was 29.68 with standard deviation 9.72 and for non-adopters the mean was 23.78 with standard deviation 11.51.

The t-test result revealed that the coffee farming experience of the farmers has a statically significant mean difference between adopters and non-adopter of coffee technologies. This is because the experience is the basic input of Ethiopian farmers in general and experienced farmers relatively have most adopters in the agricultural.

Education level of household head: The descriptive statistics result showed the average education level of the household head of the total sample household heads was 6.16 with standard deviation of 3.62 in the zones (Table 4). The mean education level of the sample household head of adopters of improved coffee varieties was 6.10 with standard deviation 3.67 and for non-adopters the mean=6.25 with standard deviation 3.57. For 3 times slashing coffee innovation practice mean education level was 6.06 with standard deviation 3.61 and for non-adopters the mean education level was 6.28 with standard deviation 3.64.

The t-test value revealed that education level of household head was not a statistically significant variable for the adoption of the whole coffee technologies packages,

Total number of livestock owned: The descriptive statistics result showed the average of livestock owned of the total sample household was 9.28 with standard deviation of 2.33 in the zones (Table 4). Total number of livestock owned for improved coffee variety adopters was 14.13 standard deviation with standard deviation 3.57 and for non-adopters the mean was 12.53 with standard deviation 5.94. For 3 times slashing coffee innovation practice adopter mean was7.58 with standard deviation 3.58 for adopters and for non-adopter the mean was 6.26 with standard deviation of 4.81

The t-test result revealed that total number of livestock owned has a statically significant mean difference between adopters and non-adopter of coffee technologies package. This is because livestock is among the basic asset of Ethiopian farmers in general and in addition to that livestock is among the farmers asset which is easily cashable than other assets which will expand farmers risk aversion nature of the farmers because wealth is inversely related with risk aversion.

Total number of household assets: The descriptive statistics result showed the average value of household asset was 162269.84 with standard deviation of 15541.66 in the zones (Table 4). The average value of assets of the household adopters of improved coffee varieties was 182846.3 with standard deviation of 18819.09 years and for non-adopters the mean was 135906.26 with standard deviation 14445.66). For 3 times slashing coffee innovation practice adopter the mean was 177580.59 with standard deviation of 95195.77 and for non-adopters mean was144707 with standard deviation 15937.04).

Annual household income: The descriptive statistics result showed the average of annual household income of the farmers was 72123.29 with standard deviation of 32495.56 in the zones (Table 4). The average household income of the sample household head adopters of improved coffee varieties was 92528.4 with standard deviation of 19765 for non-adopters the mean was 61604 with standard deviation 14534.45. For 3 times slashing coffee innovation practice adopter the mean was 82641.03 with standard deviation of 13138.7 for adopters and for non-adopters the mean was 71529 with standard deviation 11208.45).

The t-test result revealed that total number of incomes has a statically significant mean difference between adopters and non-adopter of coffee technologies packages. This is because income plays an important role in decision of individuals.

Total land owned: The descriptive statistics result showed the average age of the total sample household heads was 2.12 hectare of land with standard deviation of 1.87 in the zones (Table 4). The average land of the sample household head adopters of improved coffee varieties was 2.65, with standard deviation 1.97 and for non-adopters the mean was1.97 with standard deviation 1.43) and for 3 times slashing coffee innovation practice adopters mean was 2.55 with standard deviation 2.02) for adopters and (mean= 1.62 and std dev=1.58).

The t-test result revealed that total land owned has a statically significant mean difference between adopters and non-adopter of coffee technologies package with different significant label as seen in the table below. This is because land is the basic for Ethiopian farmers in general and in addition to that land is among the farmers asset which will expand farmers risk aversion of the farmers.

Walking distance to the nearest market: The descriptive statistics result showed the average walking distance of the farmers home to the local market was 2.83km with standard deviation of 2.86 in the zones (Table 4). The average walking distance to the nearest market of the sample household head adopters of improved coffee varieties was 2.51 with standard deviation 2.57 year for non-adopters mean was 3.23 with standard deviation 3.14) and for 3 times slashing coffee innovation practice mean was 2.64 and with standard deviation 2.77 and for non-adopters the mean was 3.05 with standard deviation 2.94).

The t-test result revealed walking distance to the nearest market has a statically significant mean difference between adopters and non-adopter of coffee varieties at 1% significant but for the other coffee technologies package the ttest result shows that there is no variation between adopters and non-adopters.

Walking distance to FTC: The descriptive statistics result showed the average walking distance to farmers training center was 5.55km with standard deviation of 4.32 in the zones (Table 4). The average walking distance to FTC improved coffee varieties adopter was 3.85 with standard deviation 7.88 and for no-adopters the mean was 4.57 with standard deviation 3.06 and for 3 times slashing coffee innovation practice the mean was 3.85 with standard deviation 2.53 for adopters and for non-adopters the mean was 4.86 with standard deviation 3.42.

The t-test result revealed that walking distance to the Farmers training centers has a statically significant mean difference between adopters and non-adopter of coffee technologies package at 10% significance label as seen in the table 4 below. This is because farmers training centers is among the major institute the farmers can obtained recent and updated information about their production and other issues related to agriculture.

Number of extensions contact: The descriptive statistics result showed the average age of the total sample household heads was 15.20 with standard deviation of 12.42 in the zones (Table 4). The average number of extensions contact of the sample household head of adopters of improved coffee varieties 20.03 with standard deviation 12.96 and for non-adopters the mean was 9.02 with standard deviation 8.34. For 3 times slashing coffee innovation practice adopters mean was 20.03 with standard deviation 13.04 and for non-adopters the mean was 10.73 with standard deviation 10.00.

The t-test result revealed that number of extensions contact has a statically significant mean difference between adopters and non-adopter of coffee technologies package at 10% significance label as seen in the table below

Utilization of credit: Among the sample respondents 47.03% were taken credit from different credit source and 52.97% were not taken credit from total sampled households (Table 3). From the total adopter of improved coffee varieties 66.67% of the household were utilizing credit and 33.33% were not utilizing credit. and from 3times slashing annually innovation 35.04% of the households were not taking credit and 64.96% takes credit.

The chi-square result showed that the association between adopters and non-adopters is significant for the three technologies packages. This is due to the fact that credit enables the farmers to obtain any relevant and important technologies.

Membership to cooperatives: Among the sample respondents 48.86% were members of cooperatives and 51.14% were not members of cooperatives from total households (Table 3). Among the improved coffee varieties adopters 63.41% were members of cooperatives and 36.59% were not members of cooperatives from total households (Table 3). and from annually 3 times slashing technologies adopters 62.39% were members of cooperatives and 37.61% were not members of cooperatives from total households (Table 3).

The chi-square result showed that the association between adopters and non-adopters is significant for the three technologies packages. This is due to the fact that cooperatives are among the farmers institution which provide different coffee varieties for the farmers enables the farmers to obtain a good profit by sending their coffee to international market.

Walking distance to farmers' plot: The descriptive statistics result showed the average walking distance of the farmers plot to home was 8.55min with standard deviation of 5.23 in the zones (Table 4). The average walking distance to the farmers plot adopters of improved coffee varieties was 13.85 with standard deviation 7.68 for adopters and for non-adopters the mean was 14.57 with standard deviation 8.16 and for 3 times slashing coffee innovation practice the mean was 11.85 with standard deviation 9.51 and for non-adopters and mean was 13.86 with standard deviation 7.42).

The chi-square result showed that the association between adopters and non-adopters is not significant for the three technologies packages.

The t-test result revealed that number of extensions contact has a statically significant mean difference between adopters and non-adopter of coffee technologies package at 10% significance label as seen in the table below

Table 4:t test for a continuous and a dummy variable

Variables	Coffee varieties						T-test	3 times slashing annually				T-test
	Total HH		Adopter		Non adopters			Adopter		Non adopters		
	Mean	Std dev	Mean	Std dev	Mean	Std dev		Mean	Std dev	Mean	Std dev	
Age of HH head	47.59	11.41	48.34	11.13	45.87	11.94	-1.54*	49.55	11.96	45.34	16.39	1.98*
Family size of HH	5.98	2.28	6.10	2.43	5.82	2.07	-1.43	6.18	2.49	5.74	2.00	-1.43
Farming experience of HHH	26.93	10.97	29.72	9.87	23.36	11.32	-4.43 ***	29.68	9.72	23.78	11.51	-4.10 ***
Education level of HHH	6.16	3.62	6.10	3.67	6.25	3.57	0.29	6.06	3.61	6.28	3.64	0.43
Walking distance to farmers plot	8.55	5.23	13.85	7.68	14.57	8.16	1.67 *.	11.85	9.51	13.86	7.42	1.78*
Total livestock owned	9.28	2.33	14.13	3.57	12.53	5.94	-2.58 **	7.58	3.58	6.26	4.81	-2.63 **
Total asset owned	162269.84	15541.66	182846.3	18819.09	135906.26	14445.66	-4.37 ***	177580.59	95195.77	144707	159374.04	-3.0 ***
Annual household income	72123.29	32495.56	92528.46	19765.41	61604	14534.45	-2.76 **	82641.03	13138	71529	11208	-3.36 ***
Total land owned	2.12	1.87	2.65	1.97	1.43	1.49	-5.02 ***	2.55	2.01	1.62	1.58	-3.73 ***
Walking distance to the nearest market	2.83	2.86	2.51	2.57	3.23	3.14	1.85*	2.64	2.77	3.05	2.94	1.04
Walking distance to the FTC	5.55	4.32	3.85	7.88	4.57	3.06	1.90 *	3.85	2.53	4.86	3.42	4.32 ***
Number of extensions contact	15.20	12.42	20.03	12.96	9.02	8.34	-7.23 ***	20.03	13.04	10.73	10.00	-5.26 ***

Table 5:Chi2 test for the dummy variable and depend variables

Variables		Coffee varieties			χ2 test	3 times slashing		χ2 test
		Adopter (%)	Non adopter (%)	Total (%)		Adopter	Non adopter	
Sex of HHH	Female	3.25	3.13	3.2	0.02	4.27	1.96	0.942
	Male	96.75	96.88	96.8		95.73	98.04	
Membership to cooperatives	Yes	63.41	35.42	48.86	16.91***	62.39	38.24	12.72***
	No	36.59	64.58	51.14		37.61	61.76	
Utilization of credit	Yes	66.67	21.88	47.03	43.4***	64.96	26.47	32.40***
	No	33.33	78.13	52.97		35.04	73.53	

4.2 Adoption rate and Adoption intensity of coffee technologies

4.2.1 Adoption rate of coffee technologies

Rogers (2003) defined the rate of adoption as “the relative speed with which an innovation is adopted by members of a social system” (p. 221). For instance, the number of individuals who adopted the innovation for a period of time can be measured as the rate of adoption of the innovation. The perceived attributes of an innovation are significant predictors of the rate of adoption. Rogers reported that 49-87% of the variance in the rate of adoption of innovations is explained by these five attributes. In addition to these attributes, the innovation-decision type (optional, collective, or authority), communication channels (mass media or interpersonal channels), social system (norms or network interconnectedness), and change agents may increase the predictability of the rate of adoption of innovations. For instance, personal and optional innovations usually are adopted faster than the innovations involving an organizational or collective innovation-decision. However, for Rogers, relative advantage is the strongest predictor of the rate of adoption of an innovation.

As seen in the graph below the adoption rate of coffee technologies was very low for the management practice only 28% of the sampled household was slash 3 times a year and for improved coffee variety 52% of the sampled household adopt an improve coffee variety.

4.2.2 Adoption intensity of coffee technologies

According to Rogers (2003) the innovation-diffusion is “an uncertainty reduction process” (p. 232), and he proposes attributes of innovations that help to decrease uncertainty about the innovation. Attributes of innovations includes five characteristics of innovations relative advantage, compatibility, complexity, trialability and observability. Rogers (2003) stated that “individuals’ perceptions of these characteristics predict the rate of adoption of innovations” (p. 219)

As investigated in this research the adoption intensity of the zone was shown in the figure 4 below as shown in the graph out of 329.64ha of land around 205.13ha of land which was around 62% of the total land was covered by an improved coffee variety. The types of the coffee Varaity which was used by the farmers due to different variety attributes is shown in the pie below according to this 44% of the farmers didn’t know the name of the variety even though the variety is improved 13% of the farmers know the name of they used 74110 which is released in 1974 Gregorian calendar the prefix 74 before the name of the variety stands for the released year the variety 74110 is a preferable improved variety which is chosen due to the relative advantage which means according to center profile of Jima agricultural research center it give 9-10 qt of coffee in hectare of land which is greater than the local variety 3qt/ha. The other 32% of the farmers uses a local coffee Varity due to different reason like inaccessibility of seedling, lack of information and other factors the other 11% of the farmers use 7440(0.22%), 7464(1.12%), 7487(1.34%), 74140(1.56%), 74158(1.11), 74165(0.67%) catimor-J19(0.67%), Gawe(0.89%), mansibu(0.89%), merdachero(0.44%), yachi(0.44%), 74112(0.44%), angefa(0.44%) and wush wush(0.44%),varieties.

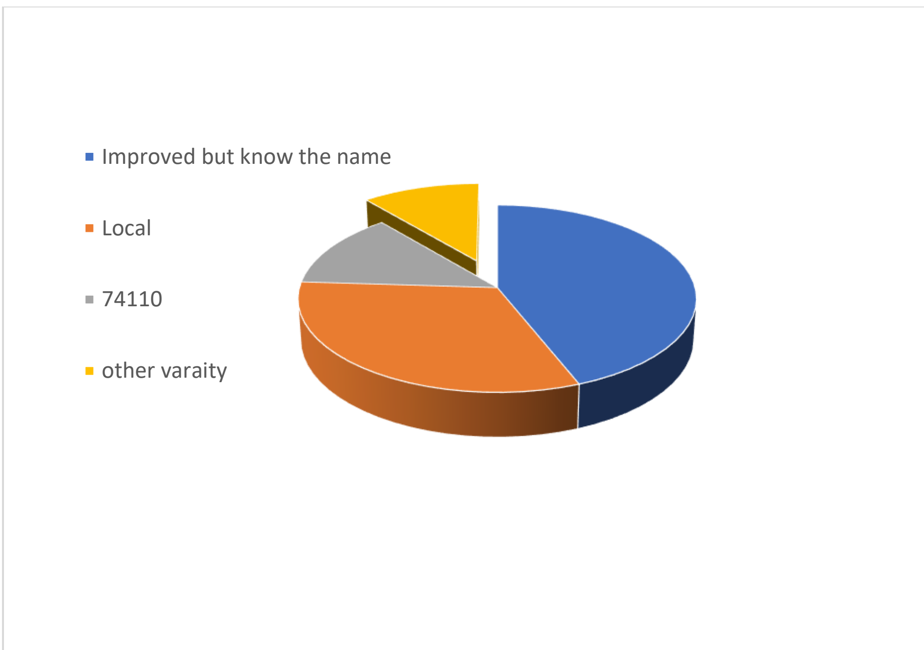

Figure 4:Types of local and improved seedling the farmers use

Farmers have different source of seedling like government, cooperatives, research centers, NGO and other seedling providers the figure 5 below shows the farmers primary source of seedling in production of coffee. As seen in the graph below the farmers' major seedling source was the government agricultural extension center and the next high source of the farmers source was the farmers own propagation and cooperatives NGOs and other source like research centers provide a minor amount for the farmers.

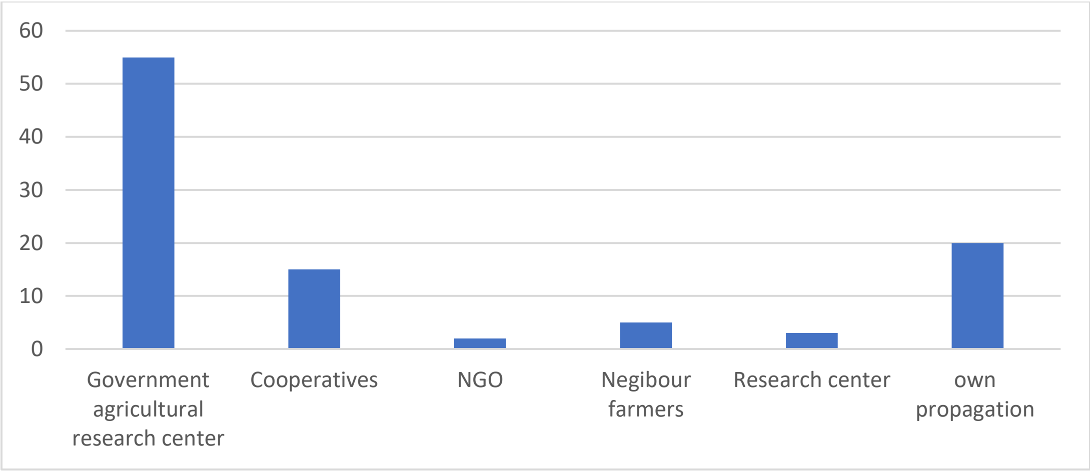

Figure 5:Farmers seedling source

3times of slashing or weeding throughout the year is the other innovation that is recommended for productive coffee growing because it minimized the coffee competing plants and will allow the coffee to get resource easily but the process of slashing have high cost it may take 2 or 3 days for 1 hectare of land with 10 peoples and 80-birr wage rate due to this the farmers face budget constraints and can't handle it for 3 times per year more than 60% of the farmers slash their coffee land 2 times per year only 27 percent of the farmers slash 3times per year, which is 89ha out of total land.

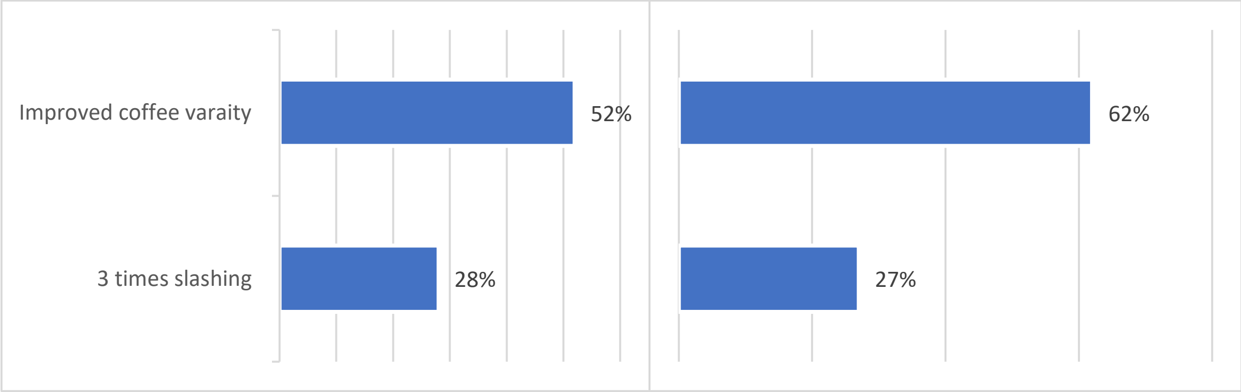

Figure 6Adoption rate and adoption intensity in the zone

Diseases and pests' farmers face

In the zone the farmers face different diseases and pests that affect the production of coffee as seen in the table below coffee berry and coffee wilt diseases are among the diseases that the farmers face highly in addition to those diseases root rot were 9.4% of the farmers problem. In addition to the disease the farmers affected by different kinds of weeds these weeds include broad leave weed a problem for 45% of the farmers' , .grassy weed a problem for 21.8% of the farmers and a parasitic weed is among the weed that affect farmers field and had a strass on the farmers. The level of stress due to those disease and weed in the farmers land was different but the level of strass due to weed were very high for more than half of the farmers.

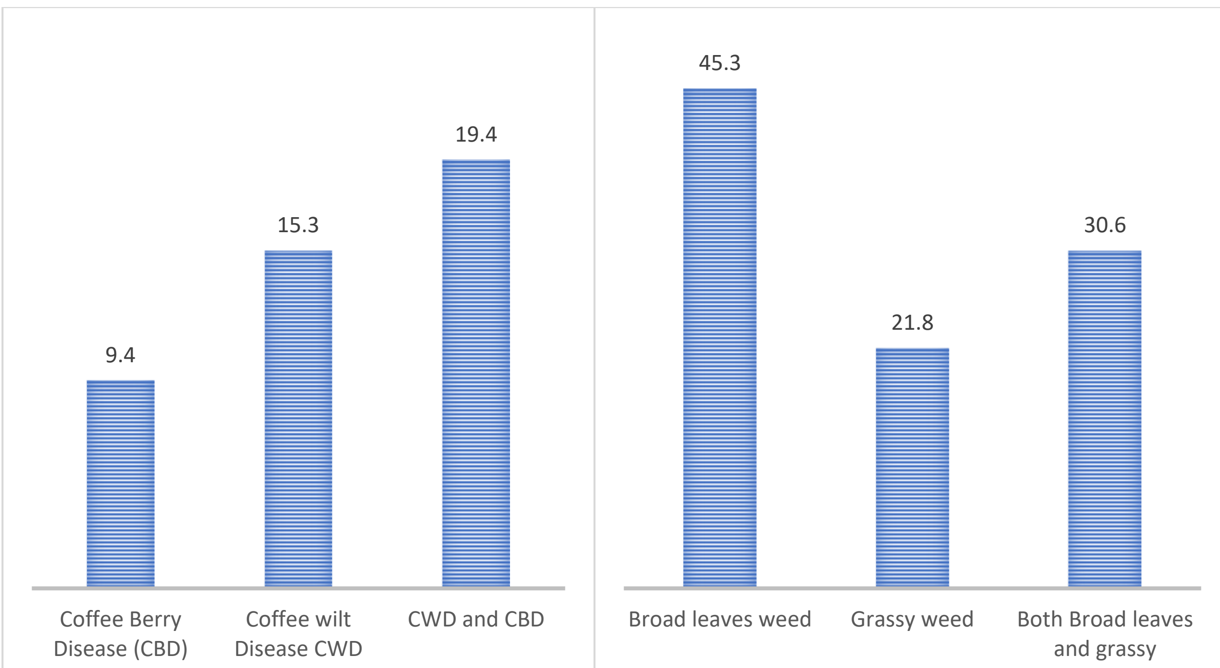

Figure 7:Coffee diseases and weed shown in the farmer's plot

The level of stress the farmers face due to those disease pests for more than 51% of the farmers were high. The major control measures the farmers uses to disease were cultural methods like uprooting, fumigation burn and replacing the coffee with other variety were the main major to controlling mechanisms but 49% of the farmers did nothing to control the diseases this may due to the fact that lack of knowledge about the spread of diseases. In relation to weed the level of stress the farmers face was high for more than 70% of the farmers as seen in the graph above broad leaves weed are the major cause of stress the farmers face in their coffee land the types of control measure the farmers uses to control those weeds were slashing regularly and digging of their land a minor farmer uses a chemical to control weeds. Only 2% of the farmers uses a chemical to minimize the stress in their coffee land the main problem in using chemical to control the disease and weed are those chemicals are lowering the test of organic coffee and limit its competitiveness to the international market.

4.2 Major constraints that limit famers adoption of coffee technologies

Beside the importance of coffee technologies there were a number of constraints the farmers faces to Adopte coffee technologies from the sampled survey the result show that for the adoption of improved coffee variety the constraints were the reason related to limited supply of improved coffee variety it accounts for 38.71% of the farmers challenges to adopt it in addition to the supply challenges lack of capital and need inputs was the second constraints the farmers faces it is about 19.45% of the farmers problem 24.98% was lack of information and knowledge on seedling propagation and the importance of improved seedling for the 15.94% farmers land shortage was the problem. For the second technology which is weeding three times a year the major problem for the farmers to adopt those new technology was the problem because now adays the per diam payment for the laborer is 80birr/day.

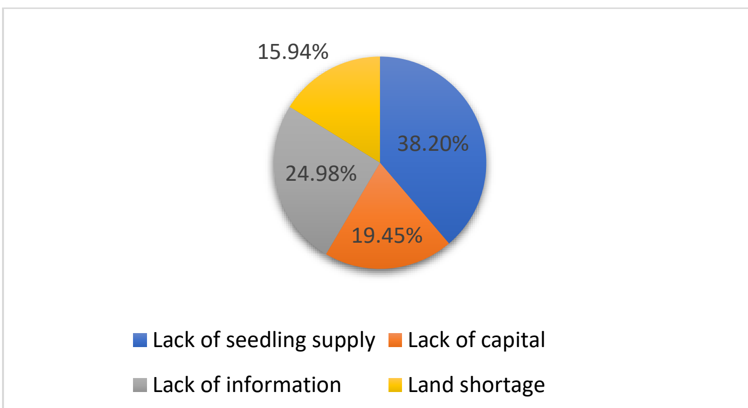

Figure 8: Constraints related to adoption of improved coffee variety

From the FGD data the result showed that nowadays planting coffee is not a profitable business. As they mentioned regarding to the favorable agroecology the environments had to other plant like chat and other fruit many farmers start replace coffee with other perennial crops like chat this is due to 3 major reason there are the low price of coffee in the market, weak linkage of coffee value chain actors in coffee and selfish broker the second reason is now adays planting chat is more profitable and have a good market access and lastly the disease and pests as seen above in figure 8 above is high in coffee land due to those fact the farmers are compel to replace coffee with chat.

4.3 Econometric model result

4.3.1 Determinate of coffee technologies adoption

As seen in the table below 29.77% of the sampled households were non adopter of both technology 27.21% of the household were adopter on an improved coffee variety and non-adopter of slashing 3 times annually. 16.05% adopt a 3 times slashing technology with a local coffee variety and 26.98% of the sampled households is adopter of both an improved coffee variety.

Table 6:Frequency of adoption of technologies

Dependent Variables	**Coffee varieties(V)**		**3 times slashing(S)**		**Frequency (%)**
	Adopter	Non adopter	Adopte	Non adopter	
V_0S_0		✓		✓	29.77
V_1S_0	✓			✓	27.21
V_0S_1		✓	✓		16.05
V_1S_1	✓		✓		26.98

Education level of household head: as seen in the table below the education level of household head was positively related with adoption of coffee varieties at 1% significance level. Similarly Obayelu et al (2017) findings from What Does Literature Say About the Determinants of Adoption of Agricultural Technologies found that an education is among the driving force in farmers adoption of agricultural technology the finding of as Abreham K and Tewodros A (2015) investigated on Analyzing Adoption and Intensity of Use of Coffee Technology Package in Yergacheffe District, Gedeo Zone, SNNP Regional State, Ethiopia indicated that respondent's level of education, were important variables which had positively and significantly influenced adoption and intensity of use of improved coffee technology package. This is due to the fact that perception about technology's ease of use and usefulness are affected by their level of education.

Number of family size: the study revealed that total number of family size the was a positive significance factor in adoption of coffee varieties and adoption both coffee varieties and the management practice at 5% level of significance similarly Ketema et al (2016) investigation results on the factors that influence adoption of potato production technology package by smallholder farmers in eastern Ethiopia show that household size and also Million et al (2020) results on Adoption Status and Factors Determining Coffee Technology Adoption in Jimma Zone family size is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. Therefore, family size expected to have positive influence on adoption of coffee technology.

Experience in coffee farming: it was another factor positively related with adoption of coffee management practice ($P<0.1$). Obayelu et al (2017) on what does literature say about the determinants of adoption of agricultural technologies identifies human capital as a determinant factor in adoption of technologies. This is due to the fact that as the farmers become more experience in coffee farming, he will become aware of the nature of the plant and will know when to do what.

Walking distance to farmers home to plot is another important factor which was negatively related to the dependent Variable adoption of coffee varieties and coffee management practice. This result is similar to the finding of (Berhanu Gebremedhin and Swinton (2003), Habtamu Ertiro (2006), Anley et al. (2007), and Daniel Asfaw and Mulugeta Neka, 2017) This might be due to the fact that one of the farmers seedling sources is market as the farmers become far from the market his access for the inputs will be decreased($P<0.01$).

Walking distance to FTC: it is another important factor which was negatively related to the dependent Variable adoption of management practice. This might be the fact that one of the farmers information sources on time of weeding or slashing is the farmer training centers as the as the farmers become far from the training centers his accessibility to those seedlings will decreased ($P<0.05$)

Total land owned: the results of the multinomial logit model reveal that, total land the farmers owed was positively and significantly affect farmers adoption of coffee technologies($P<0.01$). Similarly, the Kassahun (2021) Tobit results on Adoption of garden coffee production technology package by smallholder farmers in Ethiopia showed that farm size is a positive determining factor in adoption of coffee production technology. This is due to the fact that the risk aversion nature of the people as Arrow argues for a typical individual absolute risk aversion falls as wealth rises: the willingness to take a risk of a given absolute size increases as wealth rises and adoption of new technology is associated with risk and land is the farmers wealth. As the farmers more land the probability of adoption will increase or become less risk averse. However, this result is in contradiction to the study by Samual, (2017) state that Farmers having large farm sizes are less likely to adopt those improved agricultural technologies.

Annual household income: annual household income the farmers obtained by engaging in different activity both off farm and on farm activity is also a positive and significance factor in adoption of coffee varieties and coffee management practice at difference level of significance level 1% and 5% for coffee varieties and management practice respectively**.** Ogada et al (2017) investigated in a simultaneous estimation of inorganic fertilizer and improved maize variety Farm technology adoption technology decisions in Kenya revealed the same results in addition to this Obayelu et al (2017) Results of the findings from what does literature say about the determinants of adoption of agricultural technologies found out that income is among the major factor in farmers decision to adopt the technologies. This may be due to the fact that as the farmers have a good annual income its ability to buy a seedling from the market and other ability will also enable farmers to be updated with current information. However **(**Tenge et al., 2004; Eleni Tesfaye, 2008; Daniel Asfaw and Mulugeta Neka, 2017; Asnake Mekuriaw et al., 2018) results on adoption of different agricultural technologies argued the direct relation of income and probability of adoption. **Total number of assets** the multinomial logit model result shows that total number of assets the farmers owned also had positively affects the adoption decision of improved coffee varieties and the management practice which is slashing of coffee. From the finding of Obayelu et al (2017) on what does literature say about the determinants of adoption of agricultural technologies capital is among the factors that affects farmers decision positively. This is due to the fact that if farmers are owned assets like hoe and other assets, it can manage its field easily because it will not face assets scarcity.

Number of extensions contact the farmers have about coffee farming was other factors which was positively related to the adoption of coffee varieties at 1%, 1% and 5% level of significance for the three categories respectively. Similarly (Habtamu Ertiro (2006), Eleni Tesfaye (2008), Daniel Asfaw and Mulugeta Neka (2017), Adjepong et al. (2019), and Agere Belachew et al. (2020)) result on different area revealed the same results. This is due to the fact that as number of extensions contact increase farmers will able to update with the current and recent technology.

Farmers utilization of credit: it was a significant factor affecting farmers decision to adopt coffee varieties and both technologies at 5% and 1% level of significance. Thus, as credit becomes more available for farmers, they are more likely to adopt coffee technologies. The findings by (Tenkir Tenka, 2016) and Mideksa Debessa, 2020) support the finding of the current study by arguing for agricultural credit as it plays a vital role in the process of smallholder agricultural technology adoption. Due to the fact that credit allows the farmers to expand their finance this will leads to increase in farmers accessibility to those technologies like improved coffee seed.

Membership to cooperatives: it was another significant factor in affecting farmers decision to adopt coffee varieties. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being adopt will also increases at difference level of significance level. Thus, as credit becomes more available for farmers, they are more likely to adopt coffee technologies. The findings by Ogada et al (2017) and Mideksa Debessa, (2020) support the finding of the current study by arguing for agricultural cooperatives as it plays a vital role in the process of smallholder agricultural technology adoption. Cooperative in the area provide different services like selling of coffee to the international market and sometimes provide seedling to the member farmers with a minimum cost and other advantage this will leads the farmers to adopt improved coffee varieties and both technologies with 5% and 1% level of significance respectively.

Table 7: Multinomial result of adoption of coffee technologies

Variable	V1S0		V0S1		V1S1	
	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.
Sex of HH head	2.179	2.635	1.254	2.479	0.039	2.294
Age of HH head	-0.017	0.019	0.015	0.018	-0.009	0.017
Education level of HH head	0.097*	0.055	0.037	0.056	0.019	0.051
Number of family size	0.239**	0.099	0.078	0.099	0.213**	0.086
Experience in coffee farming	-0.014	0.020	0.036*	0.021	0.040**	0.018
Walking distance to plot	-0.022**	0.006	-0.031***	0.008	0.005	0.003
Walking distance to FTC	0.020***	0.011	-0.023**	0.013	-0.021**	0.011
Walking distance MKT	-0.082	0.086	-0.061	0.078	-0.054	0.065
Total land owned in ha	1.689***	0.185	1.477***	0.181	0.785***	0.130
Annual HH income	0.253***	0.075	0.187**	0.075	-0.092	0.067
Total asset owned	0.001	0.003	0.007***	0.002	0.005**	0.002
Total livestock owned	-0.001	0.002	-0.001	0.002	0.004**	0.002
Number of extensions contact	0.038***	0.020	0.038**	0.020	0.038**	0.019
Membership to cooperative	2.120***	0.685	0.638	0.649	1.124**	0.518
Farmers utilization of credit	1.312***	0.520	0.545	0.520	1.475***	0.459
Constant	-12.782***	3.169	-10.453***	2.969	-6.647**	2.595

Mean dependent var	2.402	SD dependent var	1.174
Pseudo r-squared	0.617	Number of obs	430
Chi-square	605.336	Prob > chi2	0.000
Akaike crit. (AIC)	661.912	Bayesian crit. (BIC)	856.973

**** p<.01, ** p<.05, * p<.1*

4.3.2 Impact of coffee technologies on coffee yield

The other objective of this study was to analyze the impact of adopting coffee technologies on annually yield of coffee status. The multinomial endogenous switching regression (MNESR) model was employed to answer this objective. In the first regime of the multinomial endogenous switching regression model, the researcher estimated the determinants of the adoption decision of households as discussed in Section 4.4. above the second stage of the MNESR model was used to estimates the effect of different variables on annual coffee yield for both adopters and non-adopters of coffee technologies. The selection equation after the participation equation includes all the variables in the participation equation and instrumental variables to improve identification. The instrumental variables used in the model were an average plot to home distance and walking distance to farmers training center for different category based on their significance for the dependent variable and the outcome variable. Based on the falsification test these variables were found to affect the adoption of coffee technologies significantly but have no direct effect on annual household income, suggesting that the variables meet the criteria to be instrumental variables were walking distance to farmers plot and walking distance to FTC the falsification test result is shown in the appendix as shown in there the falsification test approve those variables are an instrumental variable. From the MNESR model result, as seen in the appendix table different factors affecting the annul coffee yield for both adopters and non-adopters of coffee technologies. The model result is indicated in the table in the appendix.

The impact of coffee technologies adoption on annual yield is shown in Table 3 it is the value after comparing expected coffee yield (kg/hectare) under the actual case that the farm household adopted a particular combination of coffee technologies, and the counterfactual case that they did not; that is, the researcher compare columns (A) and (B) of Table 3. Column (C) presents the impact of each coffee technologies combination on annul coffee yield, which is the adoption effect (ATT), calculated as the difference between columns (A) and (B). Controlling for the effects of several covariates and the selection bias stemming both from unobserved and observed factors on mean yield, the adoption of coffee technologies is associated with significant coffee yield improvements. The highest yield effect, which is 5833.62kg/ha of red cheery coffee or 972.27 kg/ha of clean coffee because the ration of clean coffee to red cherry coffee is 1:6, is obtained from the joint adoption of coffee technologies (V1S1) which is greater than non-adopter by 391.81kg/ha of clean coffee, which is also greater than the effect of each practice independently, suggesting complementarity in benefits.

Before running a multiple linear model for the outcome variable, the tests for the assumption of classical liner model were tested using an appropriate method and the result of the test is shown in the append of the paper.

Table 8:Average expected coffee yield with adoption of coffee technology effects

	Treatment effect	Decision stage		
		To adopting (j = 2, 3, 4)	Not to adopting (j = 1)	Adoption Effects
$E\left(R_{ij}\middle\|I=2\right)-E(R_{1j}\|I=2)$	ATT	5220.68	3047.04	2173.63***
	ATU	5301.46	3252.96	2048.49***
	HE	80.78	205.92	125.14***
$E\left(R_{ij}\middle\|I=3\right)-E(R_{1j}\|I=3)$	ATT	4025.50	3230.75	794.75***
	ATU	3703.78	3252.96	450.81***
	HE	321.72	-22.21	343.94***
$E\left(R_{ij}\middle\|I=4\right)-E(R_{1j}\|I=4)$	ATT	5833.62	3482.71	2350.90***
	ATU	5353.68	3252.96	2100.71***
	HE	479.94	229.75	250.19***

***,1% level of significance; ATT=Average treatment effect on treated; ATU=Average treatment effect on untreated Note: (I) = (a)-(c) (II) = (d)-(b) (III) = (e)-(f) HE =ATT-ATU

Source: Own survey result (2022)

CHAPTER 5 SUMMARY, CONCLUSION ANDRECOMMENDATION

5.1 Summary and conclusion

This study was conducted on adoption of coffee technologies and their impact on annual coffee yield in Jima zone south western Ethiopia. Jima zone naturally endowed with a favorable agro ecology that encourage farmers to produce coffee. Objective of the study were to asses adoption rate and adoption intensity, to assess major constraints of adoption of coffee technologies, to asses determinant of adoption of coffee technologies' and to assess the impact of those coffee technologies in coffee annual yield.

The adoption rate and intensity result shows that the rate of adoption for coffee Varity was 52% and for the proper management technology 27% only this is due to different constraints like income and other related issue. The adoption intensity result showed that 62% of the farmers land from the sampled households is covered with an improved coffee variety and 28% of the farmers land is slash 3 times a year. In Ethiopia, coffee production is largely constrained by different factor like diseases, pests and other constraints. The main sources of seedling for the farmers are government agricultural research center and cooperatives.

Thus, the other aims of the study were to identify factors that influence the adoption of coffee technologies and the impact on annual yield of coffee using cross-sectional survey data. Descriptive statistics and inferential statics were employed. The multinomial logit model was used to analyze the driving factors for the adoption. The multinomial endogenous switching regression model was also employed to minimize the error that happened due to observed and unobserved factors for the outcome variable. The study involved an analysis of data collected from a total of 196 households in Jimma zone in south west Ethiopia. The primary data were gathered through various means for triangulation of data reality.

Based on the results of descriptive statistics most variables showed a significant association and mean. Annual coffee yield were outcome variables in this study. Its statistics showed that the adopters of coffee technologies were significantly higher than non-adopters. Despite this, the finding was not enough to conclude that the adopter of coffee technologies is beneficial than non-adopter without catch-up both observed and unobserved factors. As a result, MNESR model was run to estimate the average treatment effect for both treated and untreated households.

From the total 196 sample households and 430 plot, 26.98% were adopters of both coffee variety and 3 time slashing while 29.77% were non-adopters of both technologies. 27.21% of the sampled households were adopters of an improved coffee variety and non-adopter of proper management and 16.05% of the sampled household were adopter of proper management and non-adopter of improved coffee variety.

The multinomial model results showed that 9 variables were a prominent determinant for the adoption of improved coffee variety. These variables were Education level of household head, total land owned, annual household income, number of extensions contact, number of family size and membership to cooperative which affect positively and walking distance to FTC, walking distance to plot which negatively affect the adoption of coffee technologies. For the adoption of proper management or 3 times slashing 7 determinants were identified these are experience in coffee farming, total land owned in ha annual household income number of extension contact which affect positively and walking distance to FTC and walking distance to farmers plot which affect negatively. For both technology adopters 9 determinant is identified these are number of family size, experience in coffee farming total land owned, total asset owned total livestock owned number extension contact, membership to cooperative and farmers utilization of credit positively affect the adoption and walking distance to FTC and walking distance to farmers plot is negatively related to adoption.

The multinomial endogenous switching regression model showed that in terms of annual coffee per yield adopters of both technologies were increased by 3482.71. kg/ha red cherry coffee or 580.45kg/ha of clean coffee form non adopter of an improved coffee variety and proper management or slashing 3 times a year. Non adopter of an improved coffee variety and proper management adopter 764.75kg/ha of red cherry coffee or 127.45kg/ha of coffee is obtained. For an adopter of an improved coffee variety and non-adopter of proper management additional 2173.63kg/ha of coffee is obtained than the base category or non-adopter of both technologies. Based on this, we can conclude that coffee technologies adoption contributes to improving annual yield of coffee.

5.2 Recommendation

Since coffee technologies adoption is extremely important towards improving the annual yield of coffee, the following recommendations are formulated based on findings for policymakers, development intervention activities, and future research.

The results of the multinomial logit model revealed that a coffee cooperative can play an important role in the adoption of coffee technologies in the zones. It could play an effective role in supporting member farmers by supplying the price information, market and seedling that smallholder farmers often lack. However, the coffee cooperative in Ethiopia is not yet well-developed and needs to be strengthened its management capabilities and promote the expansion of coffee cooperatives.

Number of extensions contact, education level of the household head and experience of farmers in coffee farming significantly and positively determines farmers adoption of coffee technologies. Therefore, policies and strategies should place more emphasis on strengthening the existing agricultural extension service provision through providing incentives, short and long-term training, upgrading educational level and providing non-overlapping responsibilities to extension workers will help access to frequent extension contact in group.

Area allocated for coffee production, annual household income positively and significantly influenced the adoption of coffee technologies. Therefore, efficient utilization of the existing limited farm land can be taken as an alternative. This may include the consolidation and efficient utilization of existing unutilized land in the area followed by providing improved variety of seed that fit the agro ecology, diseases resistance and increasing of farmers income through providing market for the farmers will helps to increasing adoption.

Walking distance to FTC and walking distance to farmers plot negatively and significantly influenced the adoption of coffee technologies. Therefore, minimizing the walking distance to farmers training center by opening FTC nearby will help to increase the rate of adoption and intensity of adoption.

According to the MNESR result, the adoption of coffee technologies has a positive impact on annul coffee yield. Both the ATT and ATU findings indicated that adopting a coffee technologies system has a significant positive impact on annual coffee yield as compared to their counterfactual, and those other households' who did not adopt coffee technologies will be better off if they could adopt coffee technologies. Therefore, the concerned body should concentrate to motivate adopters to continue adopting coffee technologies and to bring non adopters to adopt coffee technologies through technology supply and access. This can be promoted based on extension approaches such as sustained demonstration and pre-scaling up activity by research centers, extension agents, and universities.

Based on the information gathered through FGD and key informant's participants, it was concluded that planting of coffee now a days is not profitable its comparative advantage is not low than that that of plant like chat this is due to the fact that coffee is highly affected by coffee diseases like CBD and low price the farmers get by market. As a result, research institutions, universities, NGOs, governmental organizations, smallholder producers, and any concerned stakeholders should involve in their responsibility regarded in the coffee disease and coffee value chain in the area.

5.3 Further research

This study was about the driver to the adoption of coffee technologies and its impact on annual yield of coffee. Hence, the researcher advises some further research thematic areas regarding coffee production such as assessment of the impact of coffee technologies on household nutrition and food security. In addition, assessment of the existing value chain marketing of coffee products and the development of market-oriented seedling production systems and recommend visible options to solve the market-related problem would be an important future research area.

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CHAPTER 7 APPENDIX

Tropical livestock conversion unit

No	Livestock	Category
1	Oxen	1.1
2	Cow	1
3	Heifer	0.5
4	Bull	0.6
5	Calves	0.2
6	Sheep	0.01
7	Goat	0.09
8	Donkey	0.5
9	Horse	0.8
10	Mule	0.7
11	Poultry	0.01

```
Multinomial logistic regression                 Number of obs     =        430
                                                LR chi2(45)       =     615.38
                                                Prob > chi2       =     0.0000
Log likelihood = -277.93299                     Pseudo R2         =     0.5254
```

coffee_technologies	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1	(base outcome)					
2						
sex_of_the_household_head1	2.179362	2.634508	0.83	0.408	-2.984179	7.342904
age_of_the_hosehold_head_1	-.0171906	.0186973	-0.92	0.358	-.0538366	.0194555
eduation_level_of_houshold_head	.0967948	.0549951	1.76	0.078	-.0109936	.2045832
number_of_family_size	.2388156	.09898	2.41	0.016	.0448184	.4328129
experiance_in_coffee_farming_in_	-.0141989	.0202624	-0.70	0.483	-.0539124	.0255147
walking_distance_to_plot	-.0223071	.0057245	-3.90	0.000	-.033527	-.0110872
walking_distance_FTC	.0202316	.0111479	1.81	0.070	-.0016179	.0420811
walking_distance_MKT	-.0816012	.0863006	-0.95	0.344	-.2507473	.0875449
area_in_ha_1	1.689348	.1847978	9.14	0.000	1.327151	2.051545
annual_houshold_income	.252663	.0749623	3.37	0.001	.1057395	.3995864
total_asset_number_owned	.0008129	.0026581	0.31	0.760	-.004397	.0060227
total_livestock_number	-.0010223	.0021708	-0.47	0.638	-.005277	.0032324
number_of_extension_contact	.038137	.0199804	1.91	0.056	-.001024	.0772979
memebership_cooperatives	2.120193	.6851593	3.09	0.002	.7773052	3.46308
farmers_utilization_of_credit	1.312046	.5196296	2.52	0.012	.2935906	2.330501
_cons	-12.78232	3.169404	-4.03	0.000	-18.99424	-6.570407
3						
sex_of_the_household_head1	1.254457	2.478765	0.51	0.613	-3.603833	6.112747
age_of_the_hosehold_head_1	.0147291	.0183709	0.80	0.423	-.0212772	.0507353
eduation_level_of_houshold_head	.0374451	.0564134	0.66	0.507	-.0731231	.1480133
number_of_family_size	.0781053	.0992527	0.79	0.431	-.1164264	.272637
experiance_in_coffee_farming_in_	.035556	.0210816	1.69	0.092	-.0057632	.0768753
walking_distance_to_plot	-.0310977	.0081861	-3.80	0.000	-.0471421	-.0150534
walking_distance_FTC	-.0229473	.0133364	-1.72	0.085	-.0490861	.0031915
walking_distance_MKT	-.0606801	.0775969	-0.78	0.434	-.2127672	.0914069
area_in_ha_1	1.47733	.1807614	8.17	0.000	1.123044	1.831616
annual_houshold_income	.1867932	.0749193	2.49	0.013	.0399541	.3336322
total_asset_number_owned	.007091	.0024049	2.95	0.003	.0023776	.0118045
total_livestock_number	-.0009752	.0023344	-0.42	0.676	-.0055506	.0036003
number_of_extension_contact	.0377616	.019952	1.89	0.058	-.0013436	.0768669
memebership_cooperatives	.6377763	.6488123	0.98	0.326	-.6338724	1.909425
farmers_utilization_of_credit	.5451137	.5196932	1.05	0.294	-.4734661	1.563694
_cons	-10.45266	2.968823	-3.52	0.000	-16.27145	-4.633874
4						
sex_of_the_household_head1	.0387667	2.293587	0.02	0.987	-4.456581	4.534115
age_of_the_hosehold_head_1	-.0092181	.0172765	-0.53	0.594	-.0430793	.0246432
eduation_level_of_houshold_head	.0192691	.0512732	0.38	0.707	-.0812244	.1197626
number_of_family_size	.2132952	.0855665	2.49	0.013	.0455879	.3810025
experiance_in_coffee_farming_in_	.0399753	.0180482	2.21	0.027	.0046014	.0753491
walking_distance_to_plot	.0050113	.0030425	1.65	0.100	-.0009519	.0109744
walking_distance_FTC	-.021056	.0105931	-1.99	0.047	-.0418182	-.0002938
walking_distance_MKT	-.0539049	.0647863	-0.83	0.405	-.1808838	.0730739
area_in_ha_1	.7851079	.1301132	6.03	0.000	.5300907	1.040125
annual_houshold_income	-.0922516	.0669522	-1.38	0.168	-.2234754	.0389723
total_asset_number_owned	.0048262	.0021966	2.20	0.028	.0005209	.0091315
total_livestock_number	.0035513	.0018994	1.87	0.062	-.0001716	.0072741
number_of_extension_contact	.0378995	.0194868	1.94	0.052	-.0002939	.076093
memebership_cooperatives	1.123747	.5184031	2.17	0.030	.1076959	2.139799
farmers_utilization_of_credit	1.474522	.4587295	3.21	0.001	.5754291	2.373616
_cons	-6.647485	2.595411	-2.56	0.010	-11.7344	-1.560572

Source	SS	df	MS			
				Number of obs	=	430
				F(15, 414)	=	42.97
Model	90995315.7	15	6066354.38	Prob > F	=	0.0000
Residual	58453440.6	414	141191.886	R-squared	=	0.6089
				Adj R-squared	=	0.5947
Total	149448756	429	348365.399	Root MSE	=	375.76

red_cherry_ha	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
sex_of_the_household_headl	32.05687	113.2082	0.28	0.777	-190.4776	254.5913
age_of_the_hosehold_head_1	-6.063	1.390591	-4.36	0.000	-8.7965	-3.3295
eduation_level_of_houshold_head	.4542246	3.592112	0.13	0.899	-6.606828	7.515277
number_of_family_size	-5.03528	6.29786	-0.80	0.424	-17.41505	7.34449
experiance_in_coffee_farming_in_	8.035473	1.476925	5.44	0.000	5.132267	10.93868
walking_distance_to_plot	.6213578	.3065564	2.03	0.043	.0187567	1.223959
walking_distance_FTC	.5319134	.7369333	0.72	0.471	-.9166842	1.980511
walking_distance_MKT	-12.28699	5.698396	-2.16	0.032	-23.48839	-1.085591
area_in_ha_1	152.1925	8.197981	18.56	0.000	136.0777	168.3074
annual_houshold_income	-7.947297	5.266452	-1.51	0.132	-18.29962	2.405022
total_asset_number_owned	.4903783	.1402288	3.50	0.001	.214729	.7660277
total_livestock_number	.3168502	.1442208	2.20	0.029	.0333539	.6003465
number_of_extension_contact	1.745512	1.15166	1.52	0.130	-.518317	4.009342
memebership_cooperatives	159.8117	48.36399	3.30	0.001	64.74209	254.8813
farmers_utilization_of_credit	122.4703	38.97261	3.14	0.002	45.86143	199.0792
_cons	1600.359	145.2203	11.02	0.000	1314.897	1885.82

Falsification test

```
. reg Coffee_yield_annuall walking_distance_to_plot walking_distance_FTC
```

Source	SS	df	MS			
				Number of obs	=	430
				F(2, 427)	=	1.27
Model	4903243.55	2	2451621.78	Prob > F	=	0.2812
Residual	822655404	427	1926593.45	R-squared	=	0.0059
				Adj R-squared	=	0.0013
Total	827558647	429	1929041.14	Root MSE	=	1388

Coffee_yield_annuall	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
walking_distance_to_plot	1.063771	1.087811	0.98	0.329	-1.074359	3.201901
walking_distance_FTC	-3.570591	2.784915	-1.28	0.200	-9.04444	1.903257
_cons	4646.542	93.54496	49.67	0.000	4462.676	4830.408

Multicolinearity test(VIF)

```
. vif
```

Variable	VIF	1/VIF
eduation_l~d	3.31	0.302186
experiance~_	2.51	0.398171
age_of_the~1	2.38	0.420208
area_in_ha_1	2.29	0.437619
total_live~r	2.10	0.475360
walking_di~t	1.75	0.571244
total_asse~d	1.40	0.713811
walking_di~T	1.31	0.760561
number_of_~t	1.28	0.782151
walking_di~C	1.24	0.804448
farmers_ut~t	1.15	0.866654
memebershi~s	1.06	0.941174
sex_of_the~1	1.06	0.945715
Mean VIF	1.76	

Contingency coefficient among discrete explanatory variables

	sex_of~1	farmer~t	memebe~s
sex_of_the~1	1.0000		
farmers_ut~t	-0.0669	1.0000	
memebershi~s	-0.0394	0.0846	1.0000

Hetrscedsticity test

```
. hettest , rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: sex_of_the_household_head1 age_of_the_hosehold_head_1
                    eduation_level_of_houshold_head number_of_family_size
                    experiance_in_coffee_farming_in_ walking_distance_to_plot walking_distance_FTC
                    walking_distance_MKT area_in_ha_1 annual_houshold_income total_asset_number_owned
                    total_livestock_number number_of_extension_contact memebership_cooperatives
                    farmers_utilization_of_credit

         F(15 , 414)  =     1.45
         Prob > F     =   0.1228
```

Factor affecting the outcome variable (yield) in different categories.

Red cheery per hectare	V0S0 Coef.	V0S0 St. Err.	V1S0 Coef.	V1S0 St. Err.	V0S1 Coef.	V0S1 St. Err.	V1S1 Coef.	V1S1 St. Err.
Sex of HH head	-18.772	70.033	-15.285	45.504	-106.049	170.851	-7.252	67.268
Age of HH head	-2.251**	.996	-.132	.615	-4.696***	1.642	-.413	1.147
Education level of HH head	-1.489	2.788	-.103	1.779	8.222*	4.853	-.978	2.499
Number of family size	3.149	4.808	10.192***	2.266	-8.664	12.842	18.685***	3.705
Experience in coffee farming	4.182***	.755	-.199	.69	2.743	2.466	3.394**	1.549
Walking distance to plot	-.393***	.13	.082	.164	.756	2.206	1.775***	.335
Walking distance to FTC	-.615*	.348	-.521**	.222	7.577***	1.708	-.085	.743
Walking distance MKT	-3.238	2.644	.862	2.306	-5.793	6.804	-4.123	5.734
Total land owned in ha	18.951**	9.038	58.023***	5.222	140.819***	17.816	30.874***	9.038
Annual HH income	7.274*	3.831	-.233	1.878	-10.086	10.772	11.716**	4.972
Total asset owned	-.055	.124	-.18**	.088	.666***	.226	-.11	.086
Total livestock owned	.042	.105	.005	.075	.179	.263	-.138	.092
Number of extensions contact	34.788***	4.118	1.292***	.47	-.465	.874	4.976***	1.338
Membership to cooperative	43.891*	22.549	6.974	21.137	-157.388**	73.458	67.072	41.479
Farmers utilization of credit	1.942	19.567	-19.436	13.377	-99.826*	53.038	-3.718	34.003
Constant	978.861***	102.312	2279.519***	72.305	2018.422***	258.59	2855.077***	109.231

	V0S0	V1S0	V0S1	V1S1
Mean dependent var	1582.031	2624.846	2346.087	2910.517
R-squared	0.719	0.825	0.867	0.760
F-test	19.114	31.802	22.955	21.156
Akaike crit. (AIC)	1570.478	1312.543	932.319	1487.429
SD dependent var	186.705	138.382	454.698	263.263
Number of obs	128	117	69	116
Prob > F	0.000	0.000	0.000	0.000
Bayesian crit. (BIC)	1616.111	1356.737	968.064	1531.486

**** p<.01, ** p<.05, * p<.1*

```
. ttest  Coffee_yield_annuall_21 =  Coffee_yield_annuall_24 ,unpaired /*ATT*/

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
Coffe~21 |     117    5220.684    12.37536      133.86    5196.173    5245.195
Coffe~24 |     117    3047.046    20.49859    221.7262    3006.446    3087.646
---------+--------------------------------------------------------------------
combined |     234    4133.865    72.19517    1104.374    3991.626    4276.104
---------+--------------------------------------------------------------------
    diff |            2173.638    23.94456                2126.461    2220.814
------------------------------------------------------------------------------
    diff = mean(Coffee_yield_~21) - mean(Coffee_yield_~24)        t =  90.7780
Ho: diff = 0                                     degrees of freedom =      232

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest  Coffee_yield_annuall_22 =  Coffee_yield_annuall_23 ,unpaired /*ATU*/

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
Coffe~22 |     128     5301.46    15.00892    169.8065     5271.76     5331.16
Coffe~23 |     128    3252.969    16.24761    183.8207    3220.818     3285.12
---------+--------------------------------------------------------------------
combined |     256    4277.214    65.08355    1041.337    4149.045    4405.384
---------+--------------------------------------------------------------------
    diff |            2048.491    22.11905                2004.931    2092.051
------------------------------------------------------------------------------
    diff = mean(Coffee_yield_~22) - mean(Coffee_yield_~23)        t =  92.6121
Ho: diff = 0                                     degrees of freedom =      254

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

.
end of do-file

. do "C:\Users\Admin\AppData\Local\Temp\STD2660_000000.tmp"

. ttest  Coffee_yield_annuall_31 =  Coffee_yield_annuall_34 ,unpaired /*ATT*/

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
Coffe~31 |      69    4025.507    75.45888    626.8086    3874.931    4176.083
Coffe~34 |      69    3230.755    50.32317    418.0157    3130.336    3331.173
---------+--------------------------------------------------------------------
combined |     138    3628.131    56.51741    663.9292    3516.372     3739.89
---------+--------------------------------------------------------------------
    diff |            794.7527    90.69986                615.3882    974.1172
------------------------------------------------------------------------------
    diff = mean(Coffee_yield_~31) - mean(Coffee_yield_~34)        t =   8.7624
Ho: diff = 0                                     degrees of freedom =      136
```

```
Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
Coffe~32 |     128    3703.787    74.23749    839.9013    3556.884    3850.689
Coffe~33 |     128    3252.969    16.37124    185.2194    3220.573    3285.364
---------+--------------------------------------------------------------------
combined |     256    3478.378    40.47705    647.6328    3398.666     3558.09
---------+--------------------------------------------------------------------
    diff |            450.8179     76.0212                301.1057    600.5301
------------------------------------------------------------------------------
    diff = mean(Coffee_yield_~32) - mean(Coffee_yield_~33)        t =   5.9302
Ho: diff = 0                                     degrees of freedom =      254

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

.
end of do-file

. do "C:\Users\Admin\AppData\Local\Temp\STD2660_000000.tmp"

. ttest  Coffee_yield_annuall_41 =  Coffee_yield_annuall_44 ,unpaired /*ATT*/

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
Coffe~41 |     116    5833.621    45.88186    494.1628    5742.738    5924.504
Coffe~44 |     116    3482.718    30.46677    328.1371    3422.369    3543.067
---------+--------------------------------------------------------------------
combined |     232    4658.169    82.07547    1250.136    4496.457    4819.882
---------+--------------------------------------------------------------------
    diff |            2350.903    55.07603                2242.385    2459.421
------------------------------------------------------------------------------
    diff = mean(Coffee_yield_~41) - mean(Coffee_yield_~44)        t =  42.6847
Ho: diff = 0                                     degrees of freedom =      230

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest  Coffee_yield_annuall_42 =  Coffee_yield_annuall_43 ,unpaired /*ATU*/

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
Coffe~42 |     128    5353.684    55.37052    626.4459    5244.116    5463.252
Coffe~43 |     128    3252.969    16.24761    183.8207    3220.818     3285.12
---------+--------------------------------------------------------------------
combined |     256    4303.326    71.80306    1148.849    4161.924    4444.729
---------+--------------------------------------------------------------------
    diff |            2100.715    57.70511                1987.074    2214.357
------------------------------------------------------------------------------
    diff = mean(Coffee_yield_~42) - mean(Coffee_yield_~43)        t =  36.4043
Ho: diff = 0                                     degrees of freedom =      254

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

.
```

Ethiopian Institute of Agricultural Research (EIAR), Agricultural Economics Research Directorate

Small scale farmers demand for coffee technologies, Adoption and Impacts of coffee production and processing technologies in Ethiopia

Farm Household Survey Questionnaire (2020/21 G.C or 2013 E.C)

MODULE A: HOUSEHOLD AND VILLAGE IDENTIFICATION

Household identification	Code
1. Region 1. Oromia 2. SNNP 3. Sidama 4. Amhara	
2. Zone	
3. District	
4. Kebele	
5. Village	
6. Name of household head (include grandfather name)	
7. Sex of household head 1. Male 2. Female	
8. Name of respondent	
9. Sex of respondent 1. Male 2. Female	
10. Cell phone number (Mobile number)	
11. Name of enumerator	
12. Name of supervisor	
13. Date of interview	
GPS:	
14. Altitude (m.a.s.l)	
15. Latitude (Nd mm ss.sss)	
16. Longitude (Edd⁻mm ss.sss)	

Household ID..........................Enumerator ID……………………..Region ID………………………

MODULE B : HOUSEHOLD COMPOSITION AND CHARACTERISTICS

(Household members=Persons who live together and eat together from the same pot (share food), including hired labor, students and spouse living and working in another location but excluding visitors).

B.1. Household demographic characteristics

ID CODE	Name of household member [Start with household head]	Sex 1 = M 2 = F	Relationship to the household head CODE 1	Age (complete years)	Marital status? CODE 2	Education (years) CODE 3	Primary occupation CODE 4	Secondary occupation (If any) CODE 4
	B11	**B12**	**B13**	**B14**	**B15**	**B16**	**B17**	**B18**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								

CODE 1		**CODE 2**	**CODE 3**	**CODE 4**	
1.Household head 2.Spouse 3.Son/daughter 4.Son/daughter-in-law 5.Grand son/grand daughter 6.Mother/Father 7.Brother/sister Nephew/niece 8. Nephew/Niece	9.Cousin 10.Brother/sister -in-law 11.Mother/father -in-law 12.Maid 13.hired labor 14. Other relationship (specify	1.Married living with spouse 2.Married living without spouse 3.Single/never married 4.Divorced/separated 5.Widowed	0. None/Illiterate 01. Religious education 1. Adult education or one year of education * Give other education in years	1. Agriculture self employed 2. Agriculture wage labour 3. Non-agricultural self-employment 4. Non-agricultural wage labour 5. Salaried worker 6. Domestic work 7. Student 8. Disabled 9. Retired 10. Kids/children	11. None 12. Petty trade 13. Fattening 14. Hand craft 15. Other, specify

B 2. Household socio-economic characteristics

Household ID.........................Enumerator ID……………………..Region ID……………………….

B2.1. Experience in coffee farming ---------------------------years

B2.2.Distance to village market ---------------------------- km ------------------ minute

B2.3 Transport cost per person to the nearest village market using a bus /other (ETB)________________

B2.4 Transport cost per quintal of crop to the nearest village market using a bus /other (ETB)________________

B2.5. Distance to the nearest main/district market --------------------- km ----------- minute

B2.6 Transport cost per person to the main/district market using a bus /other (ETB)________________

B2.7 Transport cost per quintal of crop to the main/district market using a bus /other (ETB)________________

B2.8. Distance to development agent office------------------ km ---------------- minute

B2.9. Distance to farmers' cooperative------------------------- km --------------- minute

B2.10. Is household head a member of farmers' cooperative? __________ (1=Yes, 2=No)

B.2.11. Is household head a member of any community leadership? __________ (1=Yes, 2=No)

B.2.12. Is there any association that produce and supply coffee seed and seedlings in your area? (1=Yes, 2=No)

B2.13. Number of month road to main market is passable for cars in a year------------months

MODULE C: PHYSICAL CAPITAL

C1: How many of the following assets do you own?

Asset Category	*Asset type*	Does the household own (1=Yes 2=No)	If yes, number. Owned	If yes, total value (ETB)
	C11	**C12**	**C13**	**C14**
Farm implements	Pruning scissor			
	Spade or shovel			
	Saw			
	Machete (ገጀራ)			
	Axe (መጥረቢያ)			
	Fork (ፎርኬታ)			
	Hoe (ገሶ)			
	Wheel barrow			
	Mesh wire			
	Water pump			

Household ID.........................Enumerator ID……………………..Region ID…………………………

Asset Category	*Asset type*	Does the household own (1=Yes 2=No)	If yes, number. Owned	If yes, total value (ETB)
	Coffee hand pulpier			
	Knapsack sprayer			
	Other, specify			
Transportation	Cart (any)			
	Bicycle			
	Motorbike			
	Bajaj			
	Car			
	Other, specify			
Communication and solar power	Radio			
	Mobile phone			
	Dish and receiver			
	TV			
	Solar energy			
House	Thatched roof			
	Tin (corrugated) roof			
	Separate store for coffee or other crops			
Other asset, specify				

Household ID..........................Enumerator ID……………………..Region ID……………………….

C2. How many of the following livestock do you have?

No	Animal type	Does the household own […]? 1=yes 2=No;	If yes, number owned	If yes, did you sell in the last 12 months 1=yes 2=No;	If yes, total value of this livestock (ETB
	C21	**C22**	**C23**	**C24**	**C25**
1	Cows				
2	Crossbred cows				
3	Oxen				
4	Bulls				
5	Heifers				
6	Calves				
7	Sheep				
8	Goat				
9	Donkeys				
10	Horse				
11	Mule				
12	camel				
13	Poultry (local chicken)				
14	Poultry (improved chicken)				
15	Traditional (ባህላዊ)bee hives				
16	Transitional (የሽግግር) bee hives with colony				
17	Modern (ዘመናዊ)bee hives				

MODULE D: IMPROVED COFFEE TECHNOLOGY KNOWLEDGE AND ADOPTION/ DISADOPTION

D.1 Coffee technology awareness, knowledge and demand

No	**Coffee technologies**	**Do you know this technology? 1.Yes 2. No. If NO, skip to next question**	**If yes, 1st source of information /knowledge CODE A**	**If yes, did you used/ practiced? 1.Yes 2. No(go to D16)**	**Unit of measurement CODE B**	**If yes, amount used/ practiced**	**If Not practiced, why? CODE C**			If Not practiced, do you have demand (willing and ability) to the technology? 1= Yes 2=No
							Reason 1	Reason 2	Reason 3	
	D11	D12	D13	D14	D15	D16	D18.1	D18.2	D18.3	D19
	Coffee varietal technology									
1	Pure line coffee variety									
2	Hybrid coffee variety									
	Agronomic technologies									
	3 times slashing annually									

Household ID.........................Enumerator ID…………………….Region ID……………………….

CODE A	**CODE B**	**CODE C**	
1. Government agric. extension agents 2. Farmer Coop or groups 3. Neighbor farmers 4. Relative farmers 5. NGOs 6. Research center 7. Radio/TV 8. Private coffee plantation/investor 9. Other, specify …….	1.Number 2.Hectare (ha) 3.Percent (%) 4. Meter (m) 5.Square meter (m2) 6.Kilogram (kg) 7.Other, specify	1. No supply of improved technology 2. It needs intensive inputs and labour 3. Lack of capital 4. Lack of information/knowledge 5. High cost which can't afford 6. Expensive that can't afford 7. Heavy to carry and transport from Nursery 8. Take large land area 9. The coffee is not at stumping age 10. Not have young coffee 11. No need	12. Negative perception (Assume loss its organic) 13. Not applicable 14. Wild animals damage 15. No premium price 16. My land is fertile 17. Greedy for the yield 18. Finished at red cherry no need to dry 19. Other, specify

MODULE-E: CROP PRODUCTION AND UTILZATION FOR CROPS GROWN BY THE HOUSEHOLD DURING THE 2020/21 Cropping SEASON (EXCEPT COFFEE)

E1: Agricultural practices, crops and varieties cultivated and cropping area

Plot ID	Main crops grown **ANNEX 1 CODE**	Variety used 1. Local 2. Improve 3. Both	Season 1. Rain fed 2. Irrigation 3. Both	Plot tenure 1. Own 2.Shared _ in 3.. Rented in 4. Other, specify	Unit of measurement 1.ha 2.No 3.Other, specify	Plot area (ha)	Yield (kg)	Did you sell this crop? 1. Yes 2. No	If yes, quantity sold (kg)	Price (ETB/kg)	Total sold (ETB)
E10	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**	**E18**	**E19**	**E20**	**E21**
						-					

Household ID.........................Enumerator ID……………………..Region ID……………………….

MODULE-F: COFFEE PRODUCTION AND UTILZATION GROWN BY THE HOUSEHOLD DURING THE 2020Cropping SEASON

F1: Plot Information: Agricultural practices, crops and varieties cultivated and cropping area

Plot ID (Coffee plots only)	Plot distance to residence (walking minutes)	Plot tenure CODE 1	Plot area (ha)	Variety used 1. Local 2. Improved 3.. Both	Name of varieties on plot? ANNEX 2 CODE	Source of planting materials CODE 2	Source of planting materials CODE 2	Age of coffee planted	Type of coffee 1. Garden coffee 2. Semi forest coffee 3. Plantation	Inter-cropping on this plot? 1=Yes 2=No	Intercropped crop and Yield (2020/21) (2013 E.C)				Coffee production per plot (2020/21)(2013 E.C)		Coffee production per plot (2019/20)-2012 E.C Previous Year	
											Crop 1 ANNEX 1 CODE	Yield crop 1 (kg)	Crop 2 ANNEX 1 CODE	Yield crop 2 (kg)	Red cherry (kg)	Dry coffee (kg)	Red cherry (kg)	Dry coffee (kg)
F11	**F12**	**F13**	**F14.**	**F15**	**F16**	**F17**	**F18**	**F19**	**F20**	**F21**	**F22.1**	**F22.2**	**F23.1**	**F23.2**	**F24.1**	**F24.2**	**F25.1**	**F25.2**
			-															

CODE- 1		**CODE-2**	
1. Owned 2. Rented in 3. Rented out 4. Shared in	5. Shared out 6. Other, specify	1. Do not know, inherited 2. Own seed/seedling preparation 3. Free seedlings from neighbor 4. Free seedlings from government nursery 5. Free seedlings from NGOs nursery.	6. Purchased from private nursery 7. Purchased from government nursery 8. Purchased from market 9. Other, specify

Household ID.........................Enumerator ID……………………..Region ID…………………………

MODULE M: COFFEE PRODUCTION AND UTILZATION GROWN BY THE HOUSEHOLD DURING THE 2020 Cropping SEASON (CONTINUED)

M 1. PLOT INFORMATION: INSECT PEST, DISEASE AND CONTROL MEASURE (CONTINUED)

Plot ID (Same order as in above plot ID)	Did insect pest seen on the plot 1. Yes 2. No	If yes, what type of insect pest seen? **CODE 1**	If yes, what control measures do you used? **CODE 2**	Did disease seen on the plot 1. Yes 2. No	If yes, what type of disease seen? **CODE 3**	If yes, what control measures do you used? **CODE 2**	What type of weed seen? **CODE 4**	If yes, what control measures do you used? **CODE 5**	**Stresses**				
									Have you seen any stress? 1. Yes 2.No	If yes, major stresses seen -1 **CODE 6**	Level of stress; **CODE 7**	If yes, major stresses seen -2 **CODE 6**	Level of stress; **CODE 7**
M11	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20.1**	**M20.2**	**M20.3**	**M20.4**	**M20.5**

Household ID……………………Enumerator ID…………………….Region ID………………………

CODE 1	CODE 2	CODE 3	CODE 4	CODE 5	CODE 6	CODE 7
1. Leaf feeder 2. Berry feeder 3. Stem borer 4. Termite 5. Other, specify	6. Did nothing 7. Used chemicals 8. Used resistance variety 9. Cultural control methods (Fumigation, uproot and burn, etc) 10. Replace the plot with other variety. 11. Replace the plot with other crop 12. Cut dry coffee and remove from plot 13. 7. Other, specify	1. Coffee Berry Disease (CBD) 2. Coffee wilt Disease CWD 3. CBD and CWD 4. Root rot 5. CWD and Root rot 6. CBD, CWD, and Root rot 7. Bacterial Blight of coffee (BBC) 8. Coffee Leaf Rust (CLR) 9. Trade blight 10. Other, specify	1. Broad leaves 2. Grassy 3. Both grassy and broad leaves 4. Invasive (parthenium). 5. Parasitic weed	1. Slashing 2. Digging 3. Both slashing and digging 4. Chemicals 5. Integrated 6. Cover crop 7. Other, specify	1. No Stress 2.Insects/pests 3.Disease 4. Drought 5 Drought spill 6.Weed 7.Animal damage 8.Other, specify	1. Low 2. Medium 3. High

Household ID.........................Enumerator ID…………………….Region ID…………………………

MODULE N: ACCESS TO INCOME SOURCE

N.1 Rank the most three source of income for the family 1st ______ 2nd. ______ 3rd. ______

1. From own agriculture product
2. Off farm business
3. Gift and remittance from GOV/ NGO
4. Gift and remittance from household/individual
5. Forest product (Charcoal, firewood)
6. Fattening
7. Pension
8. Other , specify

N2. INCOME SOURCES IN 2020

Source code	Sources of income	Did you receive income from the following items? 1=Yes 2=No	If yes, total income obtained (Birr)
	1	2	3
N21	Coffee		
N22	Annual crops		
N23	Chat		
N24	Sales of horticultural crops (Fruit, vegetables, root crops, etc)		
N25	Sales of spices		
N26	Sales of animals and product		
N27	Sales of honey		
N28	Rented/share cropped out land		
N29	Rental property other than land		
N210	Salaried/wage employment		
N211	Income from casual labor (farm and off-farm)		
N212	Income from trade (Petty trade, fattening, etc)		
N213	Pension income		
N214	Remittances		
N215	Drought/flood relief GO /NGO, safety net		
N216	Forest product (charcoal, firewood, timber, etc)		
N217	Income from sales of trees (Eucalyptus, etc)		
N218	Income from renting transport animals		
N219	Other sources (specify) _________		
N220	Other sources (specify) _________		

MODULE-P: ACCESS TO FINANCIAL CAPITAL AND EXTENSION SERVICES

P1. Access to financial capital during 2020**cropping year**

Ser No	**Purpose for credit**	**Needed credit? 1.Yes 2. No**	**If Yes in column 1, then did you get it? 1.Yes 2. No**	If yes to column 2, how much did you get, Birr	**If Yes in column 2, then source of credit, Codes B**	**If NO in column 3, then why not? Rank 3 (CODE C)**			**Did you save money? 1. Yes 2.No**	**If yes, where do you save? CODE D)**
						1st	**2nd**	**3rd**		
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1	Agricultural inputs									
2	Petty trade									
3	Fattening									
4	Coffee farm expansion									
5	Farm equipments									
6	Other, specify									

CODE A 1. Other, specify	Codes B: 1. Micro finance 2. Bank 3. Cooperative 4. Other, specify	**CODE D** 1. House 2. Bank 3. Micro finance 4. Other, specify	Codes C 1. Borrowing is risky 2. Interest rate is high 3. Too much paper work .4. Expected rejection, so did not try it	.5. Lenders don't provide the amount needed 7. Religion forbid interest payment 8.. Other, specify

P33. Have you visited coffee technology demonstration fields in the last three years?______

1= yes; 2= No

P34. Have you hosted coffee technology demonstration fields in the last three years? _____ 1= yes; 2= No

Household ID..........................Enumerator ID…………………….Region ID……………………….

Annex1: Crop Grown

Cereals	**Pulses/legumes**	**Oil Crops**	**Root crops, tubers and vegetables**	**Fodder legumes**	**Perennial crops**
1. Maize	18.Haricot bean	34. Niger seed (*Nug*)	46. Cassava	83. Lablab	68.Coffee
2. White eff	19. Soybean	35. Sunflower	47. Potato	84. Clover	69.Chat
3. Red Teff	20. Pigeonpea	36.Sesame	48. Sweet potato	85. Vetch	70.Banana
4. Mixed Teff	21. Groundnut	37.Linseed	49. Onion	86. Alfalfa	71.Organe
5. Bread wheat	22. Cowpea	38.Rapeseed (*Gomenzer*)	50. Garlic	87. Sesbania	72.Mango
6. Durum wheat	23. Cowpea	39.Lupin	51. Red pepper	88. Grass	73.Hope (*Gesho*)
7. Barley	24. Lentil (*Miser*)	40.	52. Tomato	89. Grazing land	74. Eucalyptus
8. Sorghum	25. Grass pea (*guaya*)	41................................	53. Cabbage(AbeshaGomen)	90………………	75.Pinapple
9. Finger Millet	25. Kabuli -	42..............................	54. Kale	91………………	76. Apple
10. Pearl millet	26.Desi -	43…………………………	55. Carrot	92………………	77. Avocado
11. Rice	27.Field pea(*Ater)*	44..............................	56. Beet root		78. Enset
12.Triticale	28........................	45…………………………	57. Spinach		79. Papaya
13 Emmer.	29.......................		58. Pumpkin		<u>**Spice and Herbs**</u>
14 Oats	30........................		59. Green pepper		80. Fenugreek
15……………	31.......................		60. Lettuce (Selata)		81. Ginger
16……………	32......................		61. Yam		82. Turmeric
			62. Taro (Godere)		83.Korerima
			63.		84.

Annex 2. Coffee varieties

Released **coffee v**arieties widely grown by smallholder farmers in Ethiopia					
No.	**Popular Name**	**Official Name**	**No.**	**Popular Name**	**Official Name**
1	741	741	**23**	Angefa	1377
2	744	744	**24**	Aba buna	Aba buna
3	7440	7440	**25**	Melko CH2	Melko CH2
4	7454	7454	**26**	Gawe	Gawe
5	7487	7487	**27**	Haru-1	W66/98
6	74110	74110	**28**	Chala	W76/98
7	74112	74112	**29**	Sinde	W92/98
8	74140	74140	**30**	Manasibu	78/84
9	74148	74148	**31**	Harus	H674/98
10	74158	74158	**32**	Moka	H736/98
11	74165	74165	**33**	Mechara 1	H823/98
12	754	754	**34**	Bultum	H857/98
13	75227	75227	**35**	Feyate	971
14	Dessu	F-59	**36**	Odicha	974
15	Catimor -J19	Catimor -J19	**37**	Koti	85257
16	Catimor - J21	Catimor - J21	**38**	EIAR50CH	Hybrid
17	Mioftu	F-35	**39**	MelkoIbsitu	Hybrid
18	Gesha	Gesha	**40**	TepiCH5	Hybrid
19	Merdacherko	8136	**41**	GeraCH1	Hybrid
20	BunoWashe	7416	**42**	Limmu1	L-55
21	Yachi	7576	**45**	Improved but do not know name	
22	Wushwush	7514			

Household ID.........................Enumerator ID……………………..Region ID………………………..