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The Impact of Mung Bean Production on þÿFarm Households Annual Inco Food Security in East Belessa Woreda

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BAHIR DAR UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

DEPARTMENT OF ECONOMICS

The Impact of Mung Bean Production on Farm Households' Annual Income and Food Security in East Belessa Woreda

By

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June, 2023

Bahir Dar, Ethiopia

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The Impact of Mung Bean Production on Farm Households' Annual Income and Food Security: A Case Study in East Belessa Woreda, Amhara Region, Ethiopia.

By

Habtamu Atalay Wubie

A Thesis Submitted to Bahir Dar University, College of Business and Economics, Department of Economics in Partial Fulfillment of the Requirements for a Degree of Master Science in Developmental Economics.

Advisor: Melaku Bogale Fitawork, Ph.D.

Bahir Dar, Ethiopia

June, 2023

DECLARATION

This is to certify that the thesis entitled "The Impact of Mung Bean Production on Farm Households' Annual Income and Food Security: A Case Study in East Belessa Woreda, Amhara Region, Ethiopia" submitted in partial fulfillment of the requirements for the degree of master of science in developmental economics of department of Economics, Bahir Dar University, is a record of original work carried out by me and has never been submitted to this or any other institution to get any other degree or certificates. The assistance and help I received during this investigation have been duly acknowledged.

Habtamu Atalay Wubie	Date	Place
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Approval of Thesis for Defense

I hereby certify that I have supervised, read, and evaluated this thesis entitled "The Impact of Mung Bean Production on Farm Households' Annual Income and Food Security: A Case Study in East Belessa Woreda, Amhara Region, Ethiopia" by Habtamu Atalay Wubie prepared under my guidance. I permitted the thesis to be submitted for oral defense under the authority of the Department of Economics.

Advisor's name	Signature	Date
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Department Head	Signature	Date
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Approval of Thesis

As members of the board of examiners, we examined this thesis entitled "The Impact of Mung Bean Production on Farm Households' Annual Income and Food Security: A Case Study in East Belessa Woreda, Amhara Region, Ethiopia''. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of "Masters in Development Economics".

Board of Examiners

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DEDICATION

My beloved mother Tirfie Garsie and my shield father Atalay Wubie, it is a result of your living sacrifice, your horrible yesterday and today for my future, your bare feet for my shoes, your stripping for my bright and beautiful clothes, your hunger for my satisfaction, your disclosure for my better life, your tolerance of hot and cold for my safety that enables me to be here. Take everything I have! I am here because of you and for you.

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ACRONYMS

ATE	Average Treatment Effect
ATT	Average Treatment Effect on the Treated
ATU	Average Treatment Effect on the Treated
CSI	Coping Strategies Index
DDS	Dietary Diversity Score
ECX	Ethiopian Commodity Exchange Market
FAO	Food and Agriculture Organization
FH	Food for Hunger
LCSA	Latin and Caribbean Food Security Scale
ETR	Endogenous Treatment Regression
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FH	Food for Hunger
GDP	Gross Domestic Product
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
HHS	Household Hunger Scale
IPW	Inverse Probability Weighting
KM	Kilo Meter
LR	Likelihood Ratio
OLS	Ordinary Least Squares
PSM	Propensity Score Matching
PSNP	Productive Safety Net program
SNNP	South Nation Nationality and Peoples
WFP	World Food Program

ABSTRACT

The cultivation of newly introduced mung bean, a short-season crop with drought resistance, is gaining prominence as a potential remedy for precipitation deficits in arid lands. This thesis aims to quantify the impact of cropping mung beans on household income and food security. Cross-sectional household-level data were collected from 384 samples in East Belessa Woreda, Amhara, Ethiopia. The food consumption score (FCS) was used to measure food security. Collected data were analyzed using a logit regression model and Propensity score matching (PSM). The logit model was applied to estimate the propensity score by taking mung bean production participation as a dependent variable. Mung bean appears more likely cultivated by households that are led by Young age, unmarried, educated household heads and spouses and have a higher number of active families, larger farm sizes, access to credit, and agricultural extension. PSM impact estimation result shows participating in mung bean production significantly impacted participant households' annual income by 17,287 birr ($323) *compared to the non-participants'. The finding reveals the need to expand agricultural extension services to create awareness about mung bean production in line with export standards and ways of mixing mung bean into the food diet. In addition, it necessitates smoothing the restriction on transacting mung bean from the Ethiopian commodity exchange authority to create a better market for the product.*

Keywords: Mung bean, Food consumption score, Impact evaluation, Propensity score matching

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Rapid and continuous worldwide agricultural productivity occurred during the past 50 years arising from expansion in technology, crop area, irrigation, and supportive institutional policies and initiatives (Kuma, 2019). For instance, according to World Food Program (2020), global production of primary crops increased by 52 % between 2000 and 2020, i.e., from 6.1 to 9.3 billion tons. As a result, relatively better food security was achieved. However, this is not the case when we come to Sub-Saharan African countries. One in three people in Sub-Saharan Africa are malnourished; the economy is still low and endangering everyone's way of life, especially in rural areas (Wudil et al., 2022). Being a developing country, Ethiopia shares the misery fact mentioned above. For instance, Fikre and Zegeye (2022) report that in Ethiopia, over half of the rural households experienced food insecurity during the years 2018 and 2019. This situation can be attributed to various factors such as drought, conflict, and instability. Furthermore, the predominantly subsistence-oriented and underdeveloped agricultural sector in the country significantly contributes to the prevailing rural food insecurity (Tigre and Heshmati, 2023).

As highlighted by Sibhatu and Qaim (2017) policy interventions targeting the agriculture sector hold significant promise for enhancing food security and nutrition. This is primarily due to the sector's pivotal role as the backbone of the country's economy and primary food source. For instance, agricultural development is the most powerful tool to improve food security for 80% of the world's poor and feed a projected 9.7 billion people by 2050 (Food and Agriculture Organization, 2009). In Ethiopia, for example, five major crops, namely teff, wheat, maize, sorghum, and barley, collectively contribute to 64% of the total calorie consumption, 29% of the agricultural gross domestic product (GDP) (equivalent to 14% of the total GDP), and encompass three-quarters of the cultivated land over the past decade (Se et al., 2021). These statistics underscore the critical importance of focusing on the agriculture sector as a key leverage point for effective policy interventions aimed to improve food security and nutrition outcomes.

In recent years, the adoption of cash cropping and the commercialization of agriculture has emerged as a promising approach for promoting rural economic growth and addressing food insecurity (Rubhara et al., 2020). Governments of low-income countries and development organizations have actively supported initiatives encouraging cash crop production, recognizing their potential to boost incomes and improve food security (Hashmiu et al., 2022). The cultivation of cash crops holds significant promise for smallholder farmers, as it can enhance their income levels, contribute to food security, and generate foreign earnings for the country. A notable example is coffee, often referred to as the "green gold" of the nation, which approximately 15 million smallholder farmers cultivate. Coffee production has consistently accounted for 4% of the GDP, 10% of the agricultural output, and 37% of export earnings on average over the past decade (Kuma et al., 2019). Moreover, Ethiopia also cultivates other major cash crops such as oilseeds, horticultural products, and chat, which are widely grown and contribute to the country's economic growth (Hordofa et al., 2020).

Mung bean (scientific name: Vigna radiata L.; Amharic name: Masho), is one of the significant cash crops in the legume group. It plays a crucial role in supporting the livelihoods and income generation of smallholder farmers. Mung bean exhibits a climate-smart nature with adaptability across various altitudes ranging from 5 to 1600 meters above sea level. One of its notable attributes is its ability to thrive with minimal moisture requirements while simultaneously enhancing soil fertility (Assefa et al., 2022). This versatile crop finds widespread cultivation in numerous Asian countries, including China, India, Myanmar, Bangladesh, and Pakistan, as well as in dry regions of Southern Europe, North and South America, and Australia. By 2019, over 7.3 million hectares of land are dedicated to mung bean cultivation worldwide, resulting in a global production volume of approximately 5.3 million tons annually (Hou et al., 2019).

Mung bean cultivation gained prominence in Ethiopia with its introduction to the Ethiopian Commodity Exchange (ECX) in 2014, marking its entry into the trading market. Since then, it has emerged as a valuable source of foreign exchange for the country. Notably, in just two weeks in January 2020, mung bean exports generated substantial revenue of $12,229,321 (Mohammed et al., 2017; Assefa, 2022). The Amhara region[1], particularly the North Shewa zone, has become a significant hub for mung bean production, accounting for 48% of the national area coverage and 53.1% of the crop's volume of production in the 2015/2016 season. Other regions such as Oromia, Southern Nations Nationalities, Peoples Region, and Benishangul Gumuz also cultivate mung bean (Kassa et al., 2022). Mung bean production in Ethiopia has witnessed active participation from over 327,788 smallholder farmers as of 2020/21, highlighting its importance in rural livelihoods and national agriculture (Kassa et al., 2022). Mung bean was first introduced to East Belessa Woreda in 2014 by Concern Worldwide in collaboration with the Woreda agriculture office. It covered 800 hectares then by providing 10 kg of mung bean seed to each selected model farmer. Onwards, it got remarkable attention from the farmers for its better market price and suitability of the Woreda's environment. By 2022/23, it was able to cover 10479-hectare land by mung bean. Of which more than half of the covered area (5556 hectares) was subject to different farm problems. Therefore, the actual mung bean output deviated from the estimated output by one-third[2] (East Belessa Woreda agriculture office, 2022).

Most previous studies show that the income and food security status of a household is impacted positively by participation in the production of cash crops. For instance, Li et al. (2020) depict the significant contribution of cash crop production on the nutrition and income of households. Other scholars such as

[1] It is the first administrative division in Ethiopia, and also called regional state alternatively.

[2] It was forecasted to have 8,902.5 ton mung bean by July, but post-harvest survey data shows a deviation from the forecasted by 3129.1 ton in actual output (East Belessa Woreda agriculture office, 2022).

Tankari (2017) found a negative impact of participation in cash crop production. Existing studies of mung bean in Ethiopia focus on market chain analysis of the product (Mohammed et al., 2017; Assefa et al., 2022); productivity of varieties (Kassa et al., 2022); opportunities of production (Kebede, 2022). To the best of my knowledge, no study has been undertaken on the impact of participation in mung bean production on smallholder farmers' income and food security in Ethiopia in general, and east Belessa Woreda in particular. It means the impact of participating in mung bean production on smallholder farmers' income is not quantified. Therefore, the purpose of this study is to quantify the impact of participating in mung bean production on participant smallholder farmers on household income and food security in East Belessa Woreda, Amhara region, Ethiopia.

1.2 Statement of the Problem

Globally, lowland arid regions are encountering reduced agricultural productivity due to pronounced and comparative water deficiencies. Consequently, this results in a severe food shortage in these regions (Gebremedihin et al., 2019). The cultivation of mung bean, a short-season crop with drought resistance and the ability to fix atmospheric nitrogen and enhance soil fertility is gaining prominence as a potential remedy for precipitation deficits in arid lands, and its better market value (Mohammed et al., 2017).

Being a recently introduced cash crop, mung bean remains relatively unknown, and its incorporation into Ethiopian local food culture is limited (Assefa et al., 2022). Implying an inadequate domestic consumer base and domestic market, and its exclusive production is for export purposes (Mohammed et al., 2017). Additionally, the perishable nature of the product, coupled with any deviation from export quality or a decline in international market prices, can lead to significant losses. This sets mung bean apart from other cash crops, such as coffee, cultivated in Ethiopia highlighting the necessity for comprehensive research encompassing all aspects of the crop, including its overall impact.

Existing researches on mung bean in Ethiopia have primarily focused on market chain analysis (Mohammed et al., 2017; Assefa et al., 2022), variety productivity (Kassa et al., 2022), and the potential for mung bean production (Kebede, 2022). However, to the best of my knowledge, no study has been conducted to evaluate the impact of mung bean production on the income and food security of smallholder farm households in Ethiopia. Therefore, it is crucial to quantify the effects of participating in mung bean production on smallholder farmers' income to facilitate a more comprehensive analysis and inform policy interventions.

How and under what circumstances cash crops impact smallholder farm households' income and food security is still inconclusive in the existing literature. For instance, cash crops are promoted in many developing countries as a poverty alleviation strategy (Li et al., 2020; Rubhara et al., 2020; Kuma et al., 2019). The main drivers of this promotion are better revenue, nutrition, the adaption of improved technology, specialization, and boosting investments in rural infrastructure. But other researchers argue against the positive impact of cash crop production (Tankari, 2017; Hashmiu et al., 2022). One justification is high vulnerability when food price crises exist in unstable food markets. Disaggregated small farms and risky plantation of cash crops, dependency on the price of cash crops, and off-farm opportunity costs following cash cropping are other reasons to argue against the positive impact of cash cropping.

Increased income from mung bean cash crops is expected to provide food access and improve producers' living conditions (Li et al., 2020; Rubhara et al., 2020). So it is necessary to raise the question of 'whether the income gained from mung bean could provide enough food and security needs of farming households?' especially in areas like East Belessa where food insecurity is alarming. It continues to be one of the areas in Ethiopia where food insecurity is a concern (Mekonen, 2020).

It is also highly probable that specialization in cash crop production cause the farmers to be dependent on the price of cash crop price susceptibility and food insecurity in the absence of stable markets (Hashmiu et al., 2022; Tankari, 2017).

This is assessed by considering the current price fall[3] of the mung bean cash crop and its respective consequence on the households of East Belessa.

Finally, existing cash crop impacts studies in Ethiopia (for instance, Abebe (2016); Minten (2017), Alemu (2017); Kuma (2019)) focuses on crops and fruits such as coffee and banana that are produced in bulk, adopted well by the society and have local consumers. So this study becomes distinct in this regard because it tries to evaluate the impact of a newly introduced cash crop (mung bean) that does not have a local consumer and market.

1.3 Objective of the Study

1.3.1 General Objective of the Study

The general objective of this study is to evaluate the impact of mung bean cash crop production on households' income and food security.

1.3.2 Specific Objectives of the Study

Under the umbrella of the general objective, we have the following specific objectives:

- ✓ Identifying the factors which affect farmers' likelihood to participate in mung bean production.
- ✓ Highlighting the food security status of smallholder farmers in the study area.

1.4 Research Questions

Based on the objectives mentioned above we have the following research questions:

1. What factors affect smallholder farmers' decision to cultivate mung bean?
2. What does the food security status of smallholder farmers resemble in East Belessa?

[3] The fall is around 4146 birr ($77.5) per 100 kg i.e, in January 2022 it was 8649 birr ($161.5) per 100 kg, and for the last five months on average 4500 birr ($84) per 100 kg was the offer for farmers from merchants. There were weeks in which the price of mung bean falls to 3000 birr ($56) per 100 kg (East Belessa woreda trade office, 2022).

1.5 Significance of the Study

Having a study that quantifies the impact of mung bean on farm household income and food insecurity could contribute in many ways. It contributes to the literature about the impact of cash crops in general and mung beans, particularly on households' income and food security. Thus it could fill knowledge gaps for researchers. The study also can be used as a stepping stone for agricultural development institutions, agencies, and community development organizations to expand agricultural services related to the crop. It could also locate policy entry points to devise an intervention by policy-makers. In addition, since the study focuses on household income and food security, it can be used by governmental and non-governmental organizations like safety net donors who are interested in working in the study area. The output of this thesis will also help the farmers in the study area by providing information about the contribution of participating in mung bean production to income and consumption levels. Finally, this thesis will serve as a recent source for individuals interested in working more in this area.

1.6 Scope of the Study

Geographically the study is conducted in East Belessa Woreda, Central Gondar zone[4], Amhara regional state, Ethiopia. It tries to evaluate the impact of participating in mung bean cash crop production on smallholder farm households' income and food security using propensity score matching. It means the study is concerned with the impact of participating in mung bean production only on smallholder farm households' income and food security status. Households are the main unit of analysis in this study. The study is based on data from only the 2022/23 production year.

1.7 Limitations of the Study

The study was conducted in a year in which mung bean cultivation was seen as a bad fate: from mung bean output deterioration to a devastating price fall. Another problem is faced during data collection. The respondents suspected that my

[4] It is the second administrative unit in the current Ethiopian administrative organization.

survey was for food aid, and most respondents answered by reducing their actual income.

1.8 Organization of the Study

This study is organized into five chapters. The background of the study, statement of the problem, objectives, scope, and significance of the study are presented in chapter one. The next chapter presents reviews of related theoretical and empirical literature about mung beans, food security, and household income. The methodology of the study is presented in chapter three. Outputs of different descriptive and econometric analyses are written before the last chapter. Finally, the conclusion and recommendation of the study are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature Review

2.1.1 The Origin and Production of Mung Bean

The mung bean (Vigna radiata L.), holds significant importance as an edible legume cash crop. It is believed to be native to India, with evidence suggesting its domestication by Indians around 1500 BC, followed by its dispersion to Asia and other regions of the world (Teame et al., 2017). Mung bean cultivation is widespread, particularly in Asian countries, arid regions of southern Europe, North and South America, and Australia. India and Myanmar are the leading producers, each contributing approximately 30% of the global production, while China and Indonesia account for 16.5% of the global production, respectively. Despite its extensive cultivation, mung bean yields per hectare are relatively low, averaging around 0.73 tons worldwide (Kassa et al., 2022). Currently, over 7.3 million hectares are dedicated to mung bean cultivation globally, representing approximately 8.5% of the world's pulse acreage. However, annual production does not exceed 5.3 million tons (Hou et al., 2019).

Pieces of literature underline mung bean as a recent introduction to the Ethiopian crop sector, even if they do not depict the exact time when it is introduced (Kassa et al., 2022; Assefa et al., 2022; Kebede, 2022). As a recently introduced cash crop, the annual area coverage, annual output, and per-hectare yields are relatively low (Mohamed et al., 2022). For instance, according to the 2021/2022 Meher season crop survey report from the central statistics agency (CSA), mung bean yield per hectare was only 11.36 and 10.74 quintals by 2019/20 and 2020/2021 respectively. The crop covered a total area of 49,123 and 48,022 hectares, producing 55,729 and 51,569 tons of mung bean in the respective crop years. In the 2020/21 crop season, approximately 190,029 farmers were engaged in mung bean production (CSA, 2021).

The mung bean is mostly grown in Amhara, Oromia, Southern Nations Nationalities, Peoples, and Benishangul Gumuz regional states (Kassa et al., 2022). Amhara region takes the lion's share in mung bean production relative to other regions. For instance, in the 2020/2021 crop year 155,037 farmers in the region were able to plant 32667 hectares of land with mung beans. 37,075.4 tons of mung bean yield was collected; which is around 70% of the Ethiopian total mung bean yield in the same year. The yield per hectare was also 11.35 quintals which is better relative to the country's per hectare yield in the same year i.e., 10.74 quintals (CSA, 2021). Debre Sina Zuria contributes the largest share of mung production in the region (Kassa et al., 2022).

East Belessa Woreda has had a growing and significant share in mung bean production in the region since mung bean was introduced first to farmers in 2014. For instance, 5134 hectares of land were planted by the 2021/2022 crop year (around 10% of the total national mung bean coverage in the same year). This mung cultivation coverage was doubled to 10,479 hectares in the following crop year i.e., 2022/2023. 5773.5 tons of mung was harvested in the same year. However, mung bean production in the Woreda has been challenged highly by insects, pests (pod-boring weevil Apion clavipes Gerst), drought, snow, and flood. For instance, from the total of 10,479-hectare land that was covered by mung bean by 2022/23, 3676 hectares was attacked by pest and insects, 1180 hectare faced rain shortage, 684 hectare was victim of snow, and 16 hectares were lost to flooding. Low and unstable yield and lack of input (because it is difficult to use the mung grain attacked by pests) remain the problem of mung bean production in the Woreda (East Belessa Woreda agriculture office, 2022).

2.1.2 Consumption Importance

Mung beans, known for their nutritional value and versatility, have gained increasing attention in recent years due to their potential health benefits, economic implications, and environmental considerations.

Increased intake of plant-based food is highly recommended for better prevention of chronic diseases and overall human health. Mung bean appears one of such recommended food crops for its better nutritional contents. It earned the nickname "the green gold" especially for its high protein and amino acid contents (Shen et al., 2018). On average, mung bean grain contains 26% protein, 62.5%

carbohydrates, and 1.4% fiber. As it is easy to digest, the scarce animal protein is tried to be replaced by it (Mulu et al., 2022). The mung bean diet is highly demanded by vegetarians and vegans. That is why mung bean is highly produced and consumed by Indians. Mung beans can be prepared and taken in the form of sweets, snacks, savory foods, cakes, sprouts, noodles, and soups (Dahiya et al., 2013). However, in Ethiopia, there is no trend in using mung beans as a diet (Mohammed et al., 2017). But recent problems are forcing society to look at including mung bean in their diet. For instance, the price fall of mung bean has forced the East Belessa Woreda agriculture office and trade chain office to advise the society to consume mung (East Belessa Woreda agriculture office, 2022).

2.1.3 Economic Importance

Green mung bean becomes the sixth product that ECX is trading in January 2014 next to coffee, sesame, white pea beans, maize, and wheat. Despite increasing export market potential, mung bean production does not show considerable improvement in terms of quantity and quality at the country level to provide it for the external market with the help of Ethiopian commodity exchange (Kebede, 2022).

Mung bean export standard quality is too tight. This is causing frustration in participating in mung bean production. For instance, a statement from the Ethiopian commodity exchange authority (ECXA) states “Mung bean shall have good natural color, free of objectionable odor, contain no weevil and other live insect, have a maximum of 13% moisture and free from fragments and toxic seeds.” (ECXA approval letter for ECX markets, 2021). So, any deviation in the quality of mung bean will force producers to take back the mung bean home.

To call add insult to injury, due to unknown reasons, the mung bean from East Belessa lost value and demand in the ECX market for the last six months. Since it is prohibited to buy and sell mung bean in local markets, it makes the price fall in East Belessa worse; which in turn evicts the work of farmers (East Belessa Woreda Trade Office, 2022). Low or zero levels of local consumption and demand, asymmetric market information, poor market chain, price instability, financial problem, low market promotion, and stakeholder commitment are other problems (Kassa et al., 2022; Kebede et al., 2022).

Generally, mung bean is serving as a good source of foreign exchange by passing through different tackles. For instance, Ethiopia earned $171.4 million in the first six months of 2020 from mung bean export, mainly destined for Indonesia, Vietnam, and Portugal (Mohamed et al., 2017).

2.1.4 Environmental Importance

Continuous cultivation of cereals would deteriorate soil quality. Crop diversification through soil-enriching legume crops can revive soil and sustain soil productivity. Like other legume crops mung bean does not require fertilization for nitrogen. It carries out biological nitrogen fixation. This could satisfy the own nitrogen demand of the crop and as a fertilizer for the next season's crop since the mung bean left nitrogen in the soil (Shanmugasundaram et al., 2010).

It grows at an altitude of 5 to 1600 meters above sea level. Little watering in germination and seedling time is enough. So it suits adverse arid and semiarid conditions. The crop has a climate-smart nature of wide adaptability, less moisture requirement, and the ability to improve the soil. In addition, it has a relatively short growth cycle i.e., 60-90 days depending on varieties. This means mung bean is a short life cycle crop that requires a maximum of three months to mature. Due to its rapid growth and early maturity, it can be used to alter planting patterns as a catch and intercrop crop (Assefa et al., 2022).

2.1.5 Contribution to Household Income and Consumption

The definition of household income needs pre-specification of the terms like household and annual household income reference to the accounting period (Smeeding and Wemberg, 2001). So, annual household income is a net addition of income generated in the accounting year (2022/2023). So if some action is taken to convert an already existing non-liquid asset to cash, then it will not be considered under the annual income measure (Hill, 1999; Kabunga, et al., 2014).

Farm household income can be classified as on-farm income, which is the income from current agriculture, off-farm income which includes the annual income of households from productive activities outside of the farm, and welfare and transfer incomes (Davis et al., 1997). So, for this study, farm household income follows this broad classification of annual household income. Cash crop production could contribute to income through these three broad classes and food security in different ways. Specialization allows individuals and households to get higher returns from the farm as well as off-farm income and solve liquidity constraints (Kuma et al., 2019). Higher price and output is another way in which cash crops contribute to farm income. The income generated is then used to improve nutrition, health and education, and other investments (Li et al., 2020; Li et al., 2022).

The contribution of cash crops to income and food security is a key area of debate. When we talk about the importance of cash crops it is not without negative impacts. Producing cash crops is also more susceptible to risks related to production (if output falls), and prices (Kuma et al., 2019). Then the price of food will have a huge impact on food security. Especially in areas where food crops are in high demand, it may lead to spending a huge part of their income from cash crops for their daily food consumption need; it is fetching water by spoon for producers (Tankari, 2017).

Figure 2.1 is a figure adapted from the work of Li et al. (2020) for a simple theoretical pathway in which cash crop production affects farm households' income and food security. The first pathway tells that cash crop production affects the crop yield first, with a direct impact on farm income. Higher yields lead to higher farm income and so higher household income. The second pathway shows that prices of cash crops can help to explain farm income and finally the food consumption level of households. The third pathway shows how cash crop production affects a household's non-farm income via labor hour allocation; and the resultant food security.

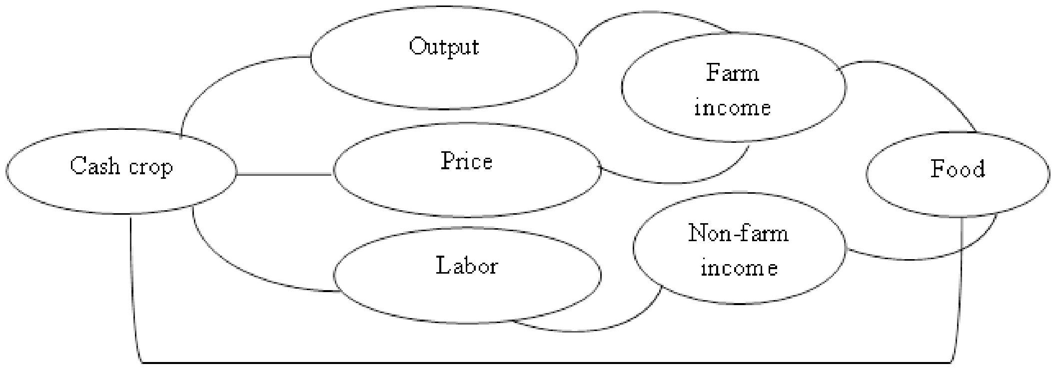

Figure 2.1: The relationship between cash crop, household income, and food security (Source; Li (2020)).

2.1.6 Measurement of Household Food Security

The 1996 Food and Agricultural Organization (FAO) food summit proposed the definition of food security as “all people at all times have economic, physical and social access to safe, nutritious and sufficient food to meet the dietary needs and food preferences for their active and healthy life”. This definition captures four dimensions of food availability (consistent availability of sufficient quantities of food), access to food (the ability to purchase, be given, or work for food), utilization (biological use of food), and stability of the above three dimensions over time (Faber et al., 2009).

A certain food security measurement would be the best measure if it was valid, reliable, and comparable, that captures all or most food security elements (components). But despite the development of many indicators, there is no single food security indicator that satisfies the above-listed criteria (Baumann et al., 2013). According to Maxwell et al. (2014), it is possible to categorize indicators as spending on food, consumption behavior, experiential measures, self-assessment measures, and dietary diversity and food frequency. Dietary diversity and food frequency category weight the food group or kind has taken with the number of frequencies to estimate food security. Household Dietary Diversity Score (HDDS) and Food Consumption Score (FCS) fall under this category. HDDS evaluates food security by asking a given household about the foods eaten the day before (Steyn et al., 2006).

According to the world food program (WFP), FCS asks for the frequency and type of food taken in the last 7 days and weights it to construct a food security status indicator. Under this method, foods are grouped into six groups which have weights of 0 up to 4. Condiments have no value in FCS and so it takes a value of 0. Food from the oil, fat, or sweat group will have a 0.5 value. Food from vitamin A-rich fruits, vegetables, and leaves will take 1; while cereals, white roots, and tubers take 2; pulses, legumes, and nuts are given 3 and the highest value of 4 is given for meat and egg including fish. FCS is then the summation after the frequency of food taken in the last seven days is multiplied by its food group weight. Then cut-off is applied to classify a household as food insecure FCS < 21, moderate 21 < FCS< 35, and secured FCS > 35 (WFP, 2008).

$$\begin{aligned} &Food\ Consumption\ Score \\ &= \sum(food\ group\ weight \\ &\times\ number\ of\ frequency\ of\ a\ given\ food\ taken\ in\ the\ past\ 7\ days) \end{aligned}$$

FCS is the working indicator for food security in this thesis for its quality of capturing the access, availability, and utilization components of the food security definition. In other words, it enables capturing the usual food diet, quantity, and quality of diet (Baumann et al., 2013). In this study, it was tried to capture the sustainability component by asking them for a month in which the household was forced to alter the dietary situation.

2.2 Empirical Literature Review

Various studies have produced diverse findings regarding the engagement of smallholder farm households in cash crop production. For example, in a study conducted in China, by Fan Li et al. (2022), data from 848 households collected between 2018 and 2019 were utilized to examine the behavior of farm households involved in commercial pulse cultivation. Employing the Heckman two-step model, the results revealed several influential factors. Market purchase prices, availability of agricultural technology services, access to loans for farmers, and government subsidies were found to facilitate smallholders' participation in commercial pulse farming. Conversely, factors such as production costs and perceived risks associated with climate change were identified as constraints on smallholders' commercial pulse production. These findings underscore the complex dynamics that influence the decision-making and behavior of smallholder farm households in cash crop cultivation.

In a study conducted by Fafchamps (1992) in Zambia, the drivers influencing crop production among smallholder farmers were examined through 200 informant interviews. The findings indicated that anticipated weather conditions, specifically the risk of drought, compelled farmers to prioritize the cultivation of drought-tolerant crops as a means to ensure food security. The structure of farming operations and access to markets were identified as factors positively influencing farmers' inclination towards cash crops, even in the presence of information about future adverse climate conditions. Additionally, perceived risks associated with climatic changes and the size of the farm had an impact on farmers' preference for cash crops. Farmers with larger plots of arable land tended to allocate a greater portion of their land to commercial crop cultivation (Fafchamps, 1992). These results shed light on the complex interplay of factors shaping the crop preferences and decision-making processes of smallholder farmers, with implications for agricultural practices and food security.

Ayele et al. (2015) studied the determinants of cereals, pulses, and khat production choice on irrigated land in Halaba, South Ethiopia using a sample of 265 households composed of irrigation users and nonusers by applying a multinomial logit model. The result they found revealed that male-headed families are more probable to grow cereals. Education and age are found to have positive and significant effects on cereals with khat and pulses with khat respectively.

Impact of Cash Crops on Household Income

Plenty of studies have been done in the world to show the positive impact of cash crop production on households' food security as well as household's annual income (for instance, Li et al., 2020; Klasen et al., 2013; Li et al., 2018). Li et al. (2022) used 848 households' data collected in 2018 and 2019 from Dali and Biacheng, China to examine the impact of commercial pulse farming on households' income by employing the endogenous treatment regression (ETR) method. They found a significant positive effect of being a commercial pulse farmer on household total income. An increase in cash pulses farming allocation by 1 % leads to household income increasing by 32.8 %.

Being characterized by societies that are poor and food insecure, many studies across the continent of Africa propose the production of cash crops to trap problems of low income and food insecurity (Anderman et al., 2014; Masanjala, 2006; Theriault et al., 2014). For instance, Rubhara et al. (2020) analyzed the impact of cash crops (cotton, tobacco, soya beans, groundnuts, maize, and sunflower) production on household food security by PSM using a cross-sectional data of 281 randomly selected smallholder farmers in Shamva District, Zimbabwe. Results show a positive impact of participation in cash crop production on household food security. The income effect of cash cropping, a higher economic return per unit of land they had devoted, and households' livelihood diversification are suggested reasons.

In Ethiopia, previous studies have emphasized much on crops that grow widely such as teff, coffee, banana, chat, oil seeds, and the like (Alemayehu and Tilahun, 2021; Abebe, 2016; Binalfew, 2017; Teferra, 2021). For instance, Kuma et al. (2019) assessed the impact of coffee production by collecting data from 1600 coffee farmers in the country. The study confirms households that have a large share of coffee income in their total income are less food insecure than other households almost by half i.e., 42 %.

A study conducted about the impacts of bananas on household income and food security in Gamo Gofa southern Ethiopia tells us; banana production has a significant contribution to food security, income generation, and employment opportunities. But it tells us a saddening fact majority of the value goes to wholesales and other intermediaries while only a low-value share goes to primary producers. Poor market structure, poor post-crop harvest, mono-cropping, and poor production systems are found to contribute to the diversion of the significant effect of banana production on food security and income (Alemu, 2017).

Some authors found a significant negative effect of cash crops on household food security as well as annual income in their scientific evidence. For instance, Hashmiu et al. (2022) collected 408 randomly sampled households' data from the forest savannah transition zone of Ghana, to evaluate the income and food security implications of cacao farming. The result shows income from cacao production alone was not sufficient enough to guarantee food security even if there is a positive relationship between cacao farming, household income, and food security. Thus reasonable complementary production of cash crops to boost annual income as well as purchasing power and food staples to minimize market dependency is advised. Brawn and Kennedy (2005) also found limited and short-term positive impacts of cash crop production on poverty alleviation in Nepal. In addition, they found that cash crop production aggravates the inequality between wealthier and small-scale farmers. Small-scale farmers found it difficult to withstand the cost of developing markets, capital-intensive production of large farmers, and inflation which make the immense revenue from cash crop sales null.

Tankari (2017) also found a negative effect of participation in cash crop production on farm households by taking data from Senegal's poverty survey monitoring through descriptive and standard instrumental variable techniques. A negative significant coefficient was found. The high opportunity cost of cash crop production and exaggerated price requirements to purchase food was suggested as a possible reason. In addition, the study reveals the heterogeneous effect of cash cropping on farm households in Senegal. The effect of involvement in cash crops was found to be more pronounced among rich and better-resourced households. Unstable and imperfect markets take the lion's share of the negative impact of cash crop production on household real income and food security. This makes cash crop producers more vulnerable to unexpected price falls of cash crops and a rise in the price of food crops (Hashmiu et al., 2022).

As highlighted above existing empirical findings are inconclusive and almost all studies are conducted on cash crops in general and adopted well in the farming system instead of a specific recently introduced crop like mung bean. So this thesis tried to estimate the impact of a recently introduced crop named mung bean on mung cropping participant households' income and food security status using propensity score matching.

2.3 Conceptual Framework

The hypothetical construct in Figure 2.2 is from Li et al. (2022) with some modifications. It shows the interconnection between the explanatory and dependent variables diagrammatically. The participation of smallholder farmer households in mung bean production is a function of households' socio-economic and demographic variables plus institutional factors.

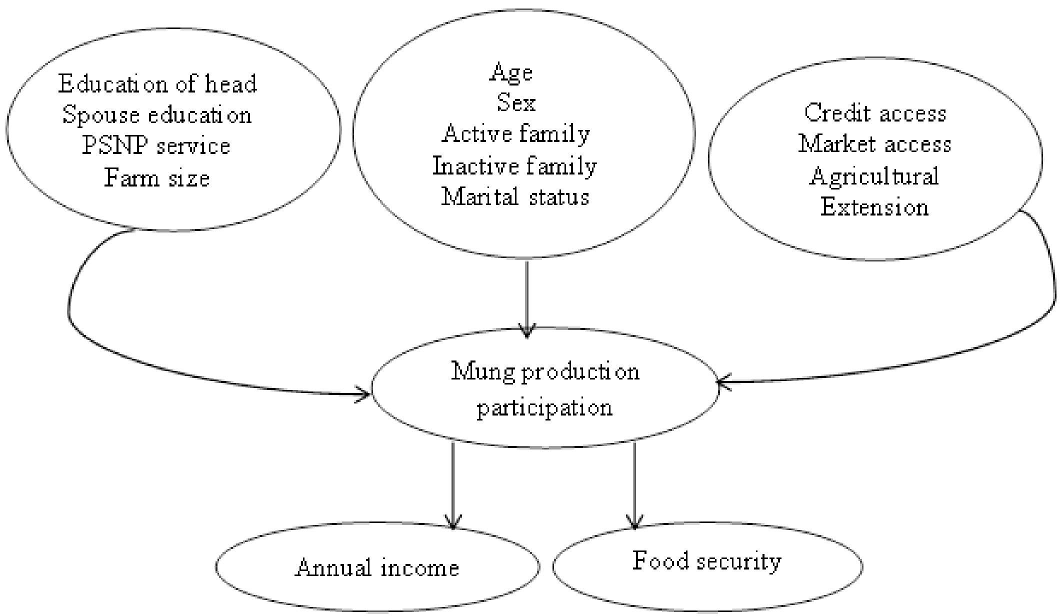

Figure 2.2: Conceptual framework of the study (source; Li et al. (2022)).

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1 Description of the Study Area

This study is conducted in East Belessa Woreda, located 117 km to the east of Gondar the capital city of the Central Gondar zone, 164km Northeast of Bahir Dar which is the capital city of Amhara regional state. It is bordered by Ibnat Woreda in the south, Jan Amora Woreda in the North, west Belessa Woreda in the west, and Sahila Seyemt and Dihana Woredas of Wag-Hemra zone in the east. It comprises thirty rural kebeles[5] and three small towns; Hamusit, Ṫaymin, and Woreda's administrative center Guhala.

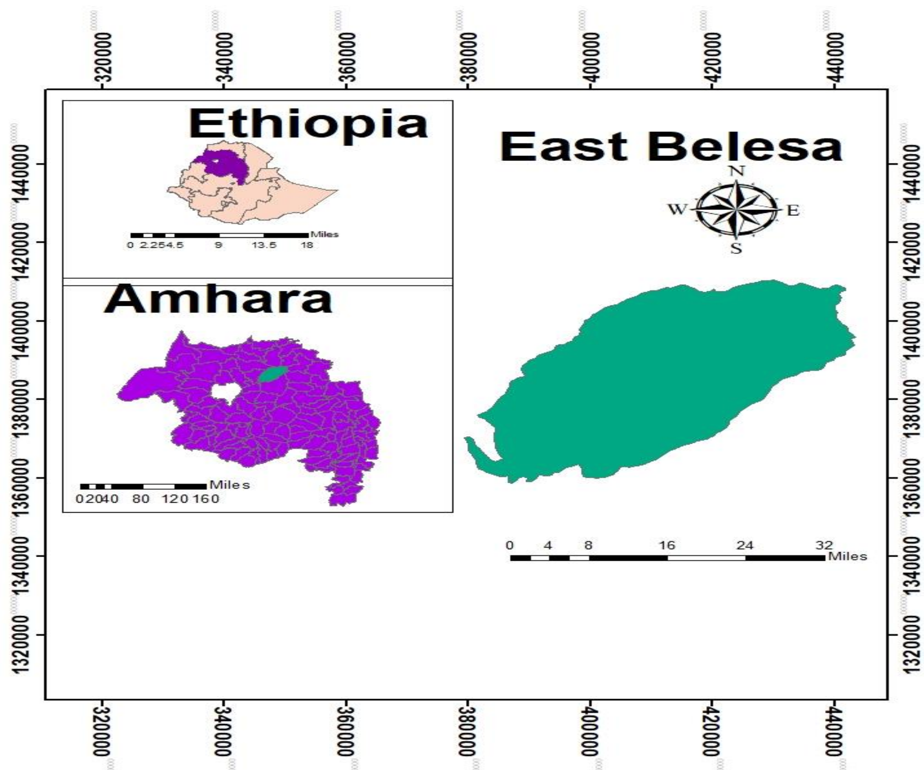

Figure 3.1: Location of the study area.

[5] Kebele is the smallest administrative unit in the current Ethiopian administrative organization.

According to the East Belessa Woreda plan commission, the total population is 158,305; 80,612 men and 77,693 women (East Belessa Woreda plan commission, 2022). About 90 % area of the Woreda has a rugged topography with Qolla climate conditions and the rest is woyna-dega (temperate). Altitude ranges from 1496 to 2000 meters above sea level. It has minimal annual rainfall and is vulnerable to frequent drought and famine (Mekonen, 2020). The land is highly degraded; added to the severe lack of most basic infrastructures; it is classified as one of 47 drought-prone and food-insecure Woredas in the region and one of the Woredas in the country where food insecurity is alarming (Mekonen, 2020). Traditional small-scale farming is the basic means of livelihood for most of the farmers in the Woreda. Cereals like teff, sesame, beans, maize, sorghum, barley, and wheat are some of the main crops grown in the Woreda. By 2022, the total arable land covered by mung bean crop production was 10479 hectares (East Belessa Woreda agriculture office, 2022).

3.2 Research Design

The primary objective of this study is to examine the impact of cash crop cultivation on smallholder farm households' income and food security. To achieve this objective, it required the use of a quantitative research approach along with cross-sectional data; a quasi-experimental causal analysis research design is employed. Quasi-experimental cause-effect research design is a study that aims to evaluate a cause-and-effect of interventions that do not use randomization. Therefore, this study utilizes a quasi-experimental research design, allowing for a rigorous assessment of the causal relationship between cash crop production and its impact on household income and food security.

3.3 Data Type, and Collection

Both primary and secondary data are used in the study. Primary data which helps to analyze the impact of participating in mung bean production on smallholder farm households' income and food security is collected from selected samples using structured questionnaires. Key informant interviews[6] and the researcher's observations are also used to enrich the thesis with qualitative data. Secondary data such as reports and literature are used to facilitate the study.

The questionnaire employed in this study is developed based on relevant research literature, considering the local context and study objectives. To ensure its effectiveness, a pre-survey test was conducted using the Amharic version of the questionnaire to assess farmers' comprehension. The questionnaire comprises three sections: The first section includes the study's purpose, instructions for completing the questionnaire, and other pertinent information. The second section collects essential respondent information necessary for the study. The third section focuses specifically on mung bean-related inquiries. The questionnaire includes a mix of close-ended and open-ended questions. To maintain respondent engagement, the questionnaire is designed to be completed within an average time of 10 minutes, aiming to avoid excessive length, complexity, and any potential confusion. Care has been taken to ensure clarity and avoid any construction that could impede understanding.

3.4 Target Population, Sampling Technique, and Sample Size

The target population of this study is smallholder mung bean producer and their comparable farmer households in East Belessa Woreda. It comprises 9,741 participant and 20,936 non-participant households. Multi-stage sampling technique is applied to select sample respondents. East Belessa is selected purposely for its growing mung bean production and the occurrence of price fall\ in its mung bean. Four kebeles are selected by considering the level of mung bean production engagement of farmers and the availability of counterfactuals. Finally, samples are selected by using a random sampling after grouping. Cochran's formula is applied to determine the sample size. It uses the level of significance with its t value, cash crop producers, and counterfactuals proportion to determine the sample size. The number of sample respondent's n equals, n = $t^2 \frac{pq}{d^2}$;

[6] Especially interviews made related to mung bean price fall are used.

Where t=1.96, p represents the proportion of producers, q represents the proportion of non-producers, and d represents the level of precision (Cochran, 1977). So using a 5% level of significance (t = 1.96), 50% mung bean producers proportion n will be

$$n = (1.96)^2 \frac{0.5 \times 0.5}{(0.05)^2} = 384$$

So there are 192 mung bean production participants and 192 non-participant smallholder farm households in the total sample population. According to the data from the East Belessa Woreda agriculture office, 1129 farm households participated in mung bean production in the sample four kebeles by 2022 (East Belessa Woreda agriculture office, 2022). The distribution of non-participant samples among kebeles was made based on the proportion of participant samples that each kebele took.

Table 3.1: Sample distribution among kebeles

Kebeles	Mung bean Producer households	Sample Participant	Sample non-participant
Achkan	247	43	43
Shamish	329	55	55
Taymen	386	66	66
Zoz Amba	167	28	28
Total	1129	192	192

Source: East Belessa Woreda agriculture office, (2022).

A total of 400 questionnaires were prepared and distributed, with 9 contingency for both groups. Then, a total of 380 questionnaires (192 participants and 188 non-participants) were collected successfully. The remaining 20 questionnaires were found invaluable due to missed data, misfiling, and the involuntariness of respondents after the data record is started. Therefore, the analysis made in this study is based on data from 192 participants and 188 non-participants.

3.5 Data Analysis

3.5.1 Descriptive Data Analysis Methods

After data encoding is accomplished, necessary descriptive analysis tools such as percentage, mean, standard deviation, and frequency measurements are applied to explain the behavior of sample respondents. Chi-square and t-tests are employed to detect the association and relationship between explanatory variables in addition to the ordinary correlation analysis.

3.5.2 Econometric Data Analysis Methods

3.5.2.1 Theoretical Model Specification

Impact Assessment Methods

Impact assessment of a designed program or intervention is crucial to show the effect of the program on participating group relative to the comparison group given similar pre-intervention socioeconomic characteristics (Gertler et al., 2016). Thus, estimating the impact of a program requires separating its effect from intervening factors which may be correlated with the outcomes, but not caused by the program (White, 2009).

In the experimental or randomized evaluation method, the contribution of the treatment to the outcome can be estimated without confounding bias as the difference between the outcomes of treated and comparison groups i.e., the problem of selection bias can be avoided as randomization takes place before the program begins. So it is a gold standard since it ensures that on average any difference in outcomes of the two groups after intervention can be attributed to the intervention (Ravallion, 2001; Baylis et al., 2016). On the other hand quasi-experimental method is the only alternative where randomization is impossible. The most frequently used quasi-experimental methods available for evaluating development programs include propensity score matching (PSM), difference indifferences (DD), regression discontinuity design (RDD), and instrumental variables (IV) (Khandker et al., 2009).

Propensity Score Matching (PSM)

Propensity score-based methods of impact assessment are the only alternative to be utilized where there is no baseline survey. It involves using statistical techniques to simulate the counterfactual, i.e., the outcome that would have prevailed had there been no intervention. Matching, stratification, and inverse probability of treatment weighting are some of the propensity score-based methods (Austin, 2011).

Among propensity score-based impact assessment methods, inverse probability weighting (IPW) and propensity score matching (PSM) are popular. Both try to equate observed explanatory variables across groups (treated and untreated) to avoid outcome bias arouse because of confoundings. When neither randomization nor a baseline survey is feasible, careful matching is crucial to control for observable heterogeneity (Leeuw & Vaessen, 2009). Since it is difficult to find baseline data, PSM is appropriate for this study. So PSM is the working impact evaluation method for this thesis. PSM converts multivariates into an index, named propensity score (PS) to match the beneficiaries and comparison groups.

Basic Assumptions

PSM average treatment effect estimation is based on a strong ignoreability assumption. According to Rosenbaum & Rubin (1983), it holds the following two pillar assumptions;

1. Conditional Independance: the researcher can observe all the variables (X) on which the treated and untreated group differs. This enables a researcher to verify the outcomes are independent of the treatment group after controlling for these covariates. In other words, the treatment assignment is “as good as random” after controlling for X

$$(Y0, Y1) \perp M / x,$$

where, Y represents the outcome variable, income and food consumption score in our case; M represents treatment which is mung bean production in our case and X represents a vector of confounding variables

2. Positivity (common support): this assumption states for each value of X, there should be a positive probability of less than one for each household either to

grow mung or not. For households with all observed characteristics x, it can be expressed as

$$0 < P(\text{M} = 1|X) < 1 \text{ so that}$$

P(M=0) will be equal to 1-P(M=1) where P represents probability.

Lack of common support shows participant and non-participant households that differ fundamentally with no overlap on certain characteristics. So, observations with propensity scores outside the common support region will not be used in the mung bean production participation impact estimation.

Choice of Estimand

Estimand means the effect of interest considering a particular target population. This effect of interest might be measuring the effect of a given treatment on participants, non-participants, or both; the average treatment effect on the treated (ATT), the average treatment effect on the untreated (ATU), or the average treatment effect on the population (ATE) respectively (Greifer and Stuart, 2021). Talking in our case, the choice is to estimate the mean effect of mung bean production participation on mung farming participant households (ATT), non-participant households (ATU), or both participant and nonparticipants (ATE).

The average treatment effect on the treated (ATT) estimates the average treatment effect among actual receivers of treatment in a population. Since the interest of the study is estimating the impact of participating in mung bean production on participants, ATT is the working estimand for this thesis. It tries to answer the question "How would treated household outcomes differ, on average, had they not received treatment?''. This means ATT measures the difference between the mean outcome observed for the treated and the mean outcome they would have had, had they not been treated. Other estimands include the average treatment effect on the untreated (ATU) which estimate the average treatment effect on non-participants and the average treatment effect on the population (ATE) which tries to capture the average treatment effect among all population (Greifer and Stuart, 2021).

The choice of estimand affects not only the interest of population and interpretation of the results of estimation but also affect the choice of matching method used to estimate the effect. For instance, ATE estimation requires adjustment of both participant and non-participant household groups to make them resemble the full sample. So methods like inverse probability weighting, full matching, and fine stratification are appropriate instead of pair matching. Because pair matching creates a sample that resembles either the participant or non-participant units instead of the full sample (Greifer and Stuart, 2021).

3.5.2.2 Empirical Model Specification

There are two impact assessments; one for the impact of mung bean production on households' income and the next for the impact of mung bean production on households' food security. But the way and steps of applying PSM are the same except for changing the outcome variables. Now let us proceed to look at the steps to be followed.

The Estimation of Propensity Score

The first step in the estimation of the treatment effect is the calculation of the conditional probability of a household being a mung bean crop producer given the values of confounding variables. Propensity scores try to account for the differences in baseline characteristics between sample mung bean producer smallholder farm households and sample non-producers (comparison group). Logit regression is more flexible than probit and other techniques to convert covariates into propensity scores. It is not mandatory for predictors to be normally distributed or linearly related to the dependent variable, and have equal variance within each group. So, the logit model is better to compute the propensity score.

The logit model is so specified as.

$$yi = \beta iXi + \sum i$$

Where yi represents the response variable i.e., 1 if a household is a participant in mung bean production and 0 otherwise; Xi represents a vector of explanatory variables and βi represents a vector of parameters to be estimated. Then the probability of being a producer is given by;

$$pi = \left(yi = \frac{1}{X}\right) = \frac{e^{zi}}{1 + e^{zi}}$$

Where z is a linear function of n-explanatory variables and can be stated as:

$$zi = \beta_o + \beta_1 x_{1i} + \beta_{2\,x_{2i}} + \beta_3 x_{3i} \dots + \beta_k x_{ni}$$

If pi represents the probability of being a cash crop producer, then the probability of being a non-producer will be

$$1 - pi = \frac{1}{1 + e^{zi}}$$

So, the expression $\frac{pi}{1-pi}$ which is the odds ratio will be;

$$\frac{p}{1-p} = \frac{e^{zi}}{1 + e^{zi}} \times (1 + e^{zi}) = e^{zi}$$

Taking the natural logarithm of the odds ratio, we get what is known as the logit model.

The estimation technique of the model can be written as follows

$$Li = \ln\left(\frac{pi}{1-pi}\right) = \beta_1 + \beta_2 x_i + \dots u_i$$

Where, βi measures the change in the log-odds ratio for a unit change in Xi.

The dependent variable has two values, 1 if a farmer is a mung bean producer and 0 otherwise.

$$M = \mu_0 + \beta i\ Xi + Ui$$

Where M is mung bean production participation, βi is the coefficients to be estimated, Xi is a vector of explanatory variables and Ui is the error term. The marginal effect can be computed as

$$\frac{\partial(E(Y\,|x)}{\partial x} = \frac{e^{zi}}{\left(1+e^{zi}\right)2}$$

Common Support

There should be sufficient overlap in the characteristics of the treated and untreated units. It is to ensure the basic characteristics (covariates) of the two groups are as similar as much as possible. This possibly can be analyzed using the propensity score of each observation. Based on minima and maxima criteria, the minimum propensity score from the treated group and the maximum propensity score from the comparison group will serve as the lower and upper thresh hold for the common support region, respectively. Samples that would not be matched (i.e., samples in which their propensity score is beyond the lower and upper thresh hold) would not be considered in estimating the ATT.

Choice of Matching Algorithm

A matching algorithm is about how to form pairs of participant and non-participant subjects based on their propensity score. It might be done with or without replacement. There are different methods of forming pairs. To choose the best matching algorithm, first, we have to try to estimate the impact using different matching algorithms. Then based on the output one can compare and contrast to choose the algorithm which fits the data best. While comparing and contrasting, the algorithm which gives an output with a low pseudo-R^2 after the match, a large matched sample size, a lower standard bias, and more variables with insignificant mean differences following matching should be selected (Austin, 2011).

For this study, the three most common matching algorithms at different widths are compared i.e., neighbor (1), neighbor (5), radius (0.05), radius (0.25), kernel (0.1), and kernel (0.06). Neighbor matching involves running through the list of treated units and selecting the closest eligible control unit to be paired with each treated unit; while radius matching is matching about a ring around each unit that limits to which other units that unit can be paired (Zakaris et al., 2018).

Assessment of Matching Quality (Balancing Test)

The distributions of covariates across groups should be balanced after matching by the propensity scores computed. This implies that, by matching participants based on their propensity scores, the distribution of variables across the treatment and comparison groups would be comparable. This is necessary to reduce outcome estimation bias which can be caused by a visible characteristics difference before matching. Matching allows researchers to lay the groundwork for causal inference. (Austin, 2011).

However, imbalances of baseline characteristics between participant and non-participant groups can still exist. This happens if the statistical model used to estimate the propensity score is not specified well. Therefore, there is a need to check the availability of statistically significant covariate differences between the two groups after matching. Corrective action will be necessary if matching fails to balance baseline characteristics i.e., disparities exist after matching (Zhang et al., 2019).

Absolute standardized mean difference (SMD) is probably the most widely used statistic to assess the balance after PSM. It is a measure of the distance between two group means in terms of one or more variables. This test is most often used as a balance measure of individual covariates. In addition in an ideal balance after PSM, all central moments (variance) are almost similar between the participant and non-participant groups. For continuous variables, the variance ratio would serve as a test of balance (Zhang et al., 2019). Rubin (2001) recommends an absolute SMD of less than 25 and a variance ratio between 0.5 and 2 for the samples to be considered sufficiently balanced.

Calculation of Average Treatment Effect on the Treated (ATT)

Smallholder mung farming participant households are the treatment group and non-participants are the comparison group. So the non-participants will serve as a comparison group while estimating the impact of taking part in mung farming on mung producer households' income and food security (ATT).

ATT can be estimated as

$$E\ (Y_{1i} - Y_{0i}\ /\ Mi = 1) = E\ (Y_{1i}/\ Mi = 1) - E\ (Y_{0i}\ /\ Mi = 1)$$

Where Y_{0i} represents the observation i's pre-treatment value of the outcome variable, Y_{1i} represents i's value of the outcome variable after treatment, and $E(Y_{0i}/M=1)$ represents the mean of the outcome variable for the comparison group.

$E(Y_{0i}/M=1)$ is estimated because the Y_0 of treated subjects is unobservable; it can be estimated from the comparison group's observation as

$$E(Y_0/M=1) = \frac{\sum WiYi}{\sum wi},$$

Where i represents an observation from the comparison group, and summation is over the set of this group; Wi represents the propensity score of i^{th} observation. But since Y1 is observable it can be easily computed as

$E(Y_1/ M=1) = \frac{\sum Yi}{N}$,   where N represents the number of treated samples.

Sensitivity Analysis

This stage of PSM intends to detect the existence of missed variables while specifying the model. This is to ensure the robustness of the calculated ATT. In other words, sensitivity analysis is necessary to check if the calculated ATT is unaffected by unobserved covariates. If all necessary variables which affect both treatment and outcome variables are captured in the model, the ATT estimation would be unbiased. Unless the strongly ignorable treatment assignment assumption would be violated and the estimated ATT would be biased. Rosenbaum bounding and Hodges-Lehmann point estimates for the average treatment effects method are used to determine whether the causal effect (ATT) calculated based on propensity score is solid and unaffected by variables out of the model. If zero is found between the lower and upper bounds of the Hodges-Lehmann estimates, there will be a chance of hidden bias.

3.5.3 Description and Selection of Variables

Dependent Variables

Household participation in mung bean production is the dependent variable in this study. It is a dummy variable given 1 for mung bean production participant households and 0 for non-participants. Households' annual income and food security status are outcome variables to be used in the impact evaluation of participation in mung bean production. Household annual income is a net addition of income generated by the household in a given accounting year (Hill, 1999). It is calculated by adding farm income, off-farm income, and transfers. Farm income is calculated by multiplying annual farm harvestings by the price of the product which existed at the time of data collection. It is measured in Ethiopian birr and expressed in terms of US Dollars when necessary using the January 2023 birr exchange rate[7]. Food security is measured using the food consumption score

[7] In January 2023 0n average one US Dollar was exchanged for 53.5 Ethiopian birr.

(FCS) which weights the frequency and type of food taken in the last 7 (Maxwell, 2014).

Explanatory Variables

In conducting a propensity score matching study, the confounding variables used to calculate the propensity score should be selected critically. But there is no consensus on the variables to include in the propensity score model. “Which baseline set of observed variables should be used to estimate a propensity score?”. All measured covariates, covariates associated with treatment assignment, covariates associated with the outcome, or covariates that affect both treatments (Austin, 2011). This thesis tries to include necessary baseline confounders which affect households' likelihood of participation in mung production by assessing the literature and considering local situations.

1. Sex of a household head (Sx): it is a dummy of 1 for male-headed households and 0 otherwise); It is hypothesized that male-headed households are more likely to participate in new technology adoption than their female-headed households.

2. Age of the household head (Ag): it is a continuous variable measured in years. Young household heads are expected to be more dynamic to take part in mung production. So the age of the household head is hypothesized to have a negative effect.

3. Marital status of the household head (Ms): it is a dummy with the married head given 1 and 0 otherwise.

4. Active aged household family member (L): it is the number of household members aged above 16 and below 65. Since young aged family member encourages working, it is hypothesized to have a positive influence on participation in mung bean production.

5. Old age and under age or inactive family member (D): it is the number of household members aged below 16 and above 65. it is hypothesized to have a negative influence on participation in mung bean production.

6. Education of the household head (Eh): It is if the household head had any education. It is a dummy variable taking 1 for any educational experience and 0 otherwise. It is hypothesized to have a positive effect on participation in mung

bean production. it is because education makes accessing technological information and critical thinking easy.

7. Education of a spouse (Es): It is if the spouse of the household head had any educational experience. It is a dummy variable taking 1 for any educational experience and 0 otherwise. It is hypothesized to have a positive effect on participation in mung bean production. This is because spouse education helps a household head to have better knowledge and decide well.

8. Size of cultivated land (Cl): it is the amount of land held by the household in a hectare. It is a continuous variable and is hypothesized to have a positive effect. This is because better land holding would enable one to participate in a newly introduced crop of mung bean production by taking risks on a plot of land that remained after food crop cultivation.

9. Access to credit: it is a dummy taking 1 if there is any access to financial credit opportunity and 0 otherwise. Since it solves financial constraints to adapt and participate in a newly introduced crop of mung bean production. It is hypothesized to have a positive effect on smallholder farmers' participation in mung production.

10. PSNP participation: it is a dummy given 1 if a household is beneficiary of PSNP. Since PSNP beneficiaries are low-income households it is expected o grow food crops to confirm their household food security. So it is hypothesized to have a negative effect on smallholder framers' participation in mung production.

11. Access to extension services (Exa): it is a dummy given 1 if a household gets any agricultural extension service and 0 otherwise. Extension access enables one to have better knowledge, experience, and practical skill to participate in a newly introduced crop of mung bean production. So it is hypothesized to have a positive effect.

12. Market[8] access: It is a continuous variable to be measured as the distance from households' homes to nearby markets in kilometers. it is challenging to get a secure and stable nearby market. Vulnerability to chain and agent evasion, and

[8] Market in this case refers to a local place where farmers transact farm inputs and outputs.

volatile price causes most farmers to incline for food crops to secure their food needs. It is hypothesized to have a negative effect on participation in mung bean production.

3.6 Ethical consideration

Respondents were asked to provide their responses voluntarily and the privacy of their responses is maintained. The truth of data collection, analysis, and reporting of results is also maintained. All research participants that were included in the study were appropriately informed about the purpose of the research.

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter presents the output of the study within two main subtopics. The output of the descriptive analysis result for explanatory and outcome variables is presented in the first subtopic. Results of the logit model, common support test, matching algorithm choice, balance test, average treatment impact, and sensitivity test are presented in the second subtopic.

4.1 Descriptive Analysis Results

4.1.1 Descriptive Analysis Result of Explanatory Variables

Table 4.1 presents the descriptive statistics analysis results for continuous explanatory variables. The t-test result shows that except for the distance to the market, there is a significant mean difference between participant and non-participant smallholder farm households regarding age, active household family size, inactive family size, and farmland holding. While variables age, land size, and active labor member are significant at a 1% significance level, the variable inactive family member is significant at a 10% significance level. The insignificant t-test result reveals the existence of an insignificant mean difference in the location of participants and non-participants in the market. This means mung bean production participant smallholder farm households are no more located nearer or far to the market relative to non-participant households.

From Table 4.1 below one can see that mung bean production participant smallholder farm household heads are younger, have larger active family members, lower inactive families, and more arable land relative to non-participant smallholder farm households. The mean age of the participant's group is 3 years less than the total mean which is 41 years. Further participant households have one more active labor force on average relative to non-participant households. Participant households have 3 active-aged family members on average. On the contrary mung bean production non-participant households have one more work-inactive household family member relative to participants. Participant households have only 1 inactive family member on average.

Table 4.1: Descriptive analysis results of continuous variables

Variable	Total (N=380)		Participant (N=192)		Non participant (N=188)		t-test
	Mean	Std. dev	Mean	Std. dev	Mean	Std.d	
Age	41	11	37	10	46	11	8.63***
Active age family	2.5	1	3	1	2	1	-6.5***
Inactive family	1.1	0.94	1	0.2	1.2	0.77	1.82*
Farm size	2.1	0.87	2.3	0.9	1.89	0.77	-5.1***
Access to market	12.2	7	11.7	7	12.7	7	1.3

Note: *significant at 10%, **significant at 5% and ***significant at 1 %

Source: own survey.

Finally, the average land holding in the study area is approximately two hectares. Mung bean production participant households owe almost half-hectare more land compared to non-participant households on average. The average land holding in non-participant households is 1.89 hectares; while land holding in participant households exceeds two hectares (2.3 hectares).

The descriptive analysis of categorical variables found in Table 4.2 below is composed of frequency, proportional analyses, and likelihood chi-square test. According to the likelihood ratio chi-2 test result, there is a significant difference between participants and non-participant households in the education of the head, marital status of the head, access to credit, access to extension service, and off-farm activity at a 1% significance level, while sex of household head is at 5%. On the other hand, the difference between mung bean farming participants and non-participant households regarding their spouse's education is insignificant.

Table 4.2: Descriptive analysis results of categorical variables

Variable		Total (N=380)		Participant (N=192)		Non-participant (N=188)		Chi-2
		Freq.	%	Freq.	%	Freq.	%	
Sex	Female	26	6.8	7	1.8	19	5	6.2**
	Male	354	93.2	185	48.7	169	44.5	
Marital status	Married	272	71.6	121	31.8	151	39.7	13.9***
	Unmarried	108	28.4	71	18.7	37	9.7	
Head-education	Educated	226	59.5	129	33.9	97	25.6	9.58***
	Uneducated	154	40.5	63	17	91	23.5	
Spouse-education	Educated	121	31.8	67	17.6	54	14.2	1.66
	Uneducated	259	68.2	125	32.8	134	35.4	
Agri. extension	Yes	288	75.8	161	42.4	127	33.4	13***
	No	92	24.2	31	8.2	61	16	
PSNP	No	321	84.5	178	46.9	143	37.6	-20***
	Yes	59	15.5	14	3.7	45	11.8	
Access to Credit	Yes	148	38.9	96	25.2	52	13.7	19.9***
	No	232	61.1	96	25.2	136	35.9	

Note: *significant at 10%, **significant at 5% and ***significant at 1 %

Source: own survey.

Of the total sample, 7 (1.8%) mung bean production participants and 19 (5%) non-participant households are headed by females. A household headed by a male is more probable to participate in mung bean production. In addition, a household that is headed by an unmarried member is more probable to grow mung bean. Of 108 households headed by unmarried members, 71 (18.7%) households take part in mung bean farming. A household headed by an uneducated member is less probable to farm mung beans. Of the total 154 households headed by an uneducated member, 91 (23.5%) households do not take part in mung bean farming. Households which get PSNP services are less probable to participate in mung bean production relative to those households which do not get PSNP services. Finally one could look at the difference between households that have access to credit and those who do not. A household with access to financial credit is more probable to grow mung bean.

4.1.2 Descriptive Analysis Result of Outcome Variables

Based on the t-statistics result which can be seen in Table 4.3 below, there is a significant annual income difference between mung bean production participants and non-participant households. On average households which grow mung bean earned 18902 birr ($353) more annual income compared to the households which do not grow mung bean. Non-participant households earn only 53,063 birr ($992) annual income on average.

Table 4.3: Descriptive analysis results of outcome variables

Outcome Variable	Total (N=380)		Participant (N=192)		Non participant (N=188)		t-test
	Mean	Std. dev	Mean	Std. dev	Mean	Std.d	
Income	62,614	15.48	71,966	12.53	53,063	12	-15***
FCS	29.2	6.8	29.6	6.9	28.8	6.7	-1.06

Note: ***significant at 1 %

Source: own survey.

The t-test statistics result in Table 4.3 above tells the existence of insignificant food consumption score difference between mung farming participants and non-participant households. This means households that grow mung do not have a better food security status relative to households that do not grow mung. The food consumption score in the study area ranges from 17 to 51. The mean food consumption score is 29.2 with a standard deviation value of 6.8 for the total sample. The food consumption status using the 2008 WFP threshold shows the majority of the sample households (246) have a borderline food consumption status. 49 respondent households have poor food consumption status. The remaining 85 sample households have acceptable food consumption status. Of which 47 households are mung bean production participant households. But for the question they were asked “If there was a month during which the household experienced a lack of food such that one or more members of the household had to go hungry?" more than half of the respondents underline the existence of one up to three months (July, August, and September) in which their household forced to alter consumption.

Table 4.4: Food consumption status of sample households

Treatment Group	Acceptable FCS (FCS ≥ 35.5)		Borderline FCS (21.5 ≤ FCS ≤ 35)		Poor FCS (FCS ≤ 21.5)	
	No.	%	No	%	No	%
Participant	47	12.4	121	31.8	24	6.32
Non-participant	38	10	125	32.9	25	6.57
Total	85	22.4	246	64.7	49	12.9

Source: own survey.

4.2 Econometric Analysis Results

4.2.1 Estimation of the Propensity Score

Since the dependent variable (treatment) is dichotomous, the binary choice logit model is used to estimate the propensity score. According to the Hosmer-Lemeshow test, the logit model fits the data; a significant P value would suggest that the model is incomplete; perhaps a necessity to add more independent variables. Here in this study, since the chi-2 value is 5.14 i.e., p-value 0. 742 is insignificant for Hosmer-Lemeshow, it shows the model fits the data. The multi-collinearity test is conducted for overall explanatory variables using the variance inflation factor (VIF). The result has a mean VIF of 1.17 which confirms the inexistence of a serious problem of multi-collinearity among variables included in the model since it is less than 10. The existence of the heteroskedasticity problem was checked by applying the Breusch-Pagan test. An insignificant chi-2 test value of 0.38 (Prob > chi2 = 0.5355) shows the null hypothesis of constant variance is accepted at a 5% level of significance. This indicates that the model has constant variance or the model is homoscedastic.

The logistic estimation result has a likelihood ratio (LR) chi-2 value of 162.83 and p > chi-2 value of 0.000. The log-likelihood ratio is the ratio of the log-likelihood values calculated for the specified model and the intercept-only model. So, a high value of LR claims the specified model is better and vice versa. And the test p-value puts the null hypothesis that an intercept-only model is correct. As such, a small P value would suggest that an intercept-only model is insufficient. So the p-value of 0.000 confirms at least one independent variable provides information to help prediction of the outcome. In other words, at least one independent variable has a non-zero coefficient. A high log-likelihood value (-181.95) confirms that the model is good. A relatively low pseudo-R^2 value of 30.9% shows that beneficiaries do not have more different characteristics than non-beneficiaries, in general. As such finding, a good match between participant and non-participant households becomes easier.

Nine explanatory variables out of twelve were found significantly affect the likelihood of smallholder farm households taking part in mung bean production. Age, marital status, PSNP service, farm size, education of the spouse, and number of active family members are significant at a 1% significance level; while education of the head, household credit access, and an important factor associated with mung bean production which is arguably access to extension are significant at 5%. Of these nine significant variables, age, marital status and participation in PSNP affect the likelihood of smallholder farm households taking part in mung bean production negatively; while the remaining six variables have a positive effect.

The age of the household head is significant with a marginal effect magnitude of -0.0191. An increase in the age of a household head by one year decreases the household's predicted probability to participate in mung bean production by 0.0191, ceteris paribus. The negative coefficient tells that age affects households' likelihood to participate in mung bean farming negatively. It means households headed by active-age young members are more probable to take part in mung bean production. This might be because the young are more dynamic to adopt new technology. So the decision to grow the new crop which is mung bean might be relatively easy for them. This result is consistent with a study conducted on crop choice and income dynamics in Indonesia. Klasen et al. (2013) found that households tend to cultivate cacao cash crops if the household head is relatively young. Ayele et al. (2015) have got the same finding in the study conducted on irrigated crops in Halaba, Ethiopia. It concludes that old-age-headed households do incline to grow cereals. It justifies this finding as the young have better access to information and adapt easily to new technologies. While Rabbi et al. (2019) contradicts this finding, as experience in farming is measured by the age of the household head; so an increase in age has a positive impact on market-oriented crop production participation.

Table 4.5: Marginal effect after logistic regression

Variable	dy/dx	Std. err	Z	P>z
Sex	0.0679	0.1420	0.48	0.633
Age	-0.0191	0.0034	-5.56***	0.000
Marital status	-0.3287	0.0729	-4.51***	0.000
Education of head	0.1479	0.0692	2.14**	0.033
Education of spouses	0.2233	0.0732	3.18***	0.002
Active age family	0.1175	0.0258	4.55***	0.000
Inactive family	0.0094	0.0352	0.27	0.789
Farm size	0.1223	0.0423	2.89***	0.004
Access to market	0.0005	0.0046	0.09	0.929
Access extension	0.1742	0.0770	2.35**	0.019
PSNP	-0.2986	0.0776	-3.88***	0.000
Access to credit	0.1630	0.0677	2.40**	0.016

Number of observation: 380
Likelihood ratio chi2(12) = 162.83
Prob > chi2 = 0.0000
Log likelihood = -181.95
Pseudo R2 = 0.309

Note: *** significant at 1% level of significance; ** significant at 5% level of significance. Source: own estimation.

The marital status of the household head is significant with a marginal effect magnitude of -0.3287. Ceteris paribus, being led by a married family member reduces the predicted probability to participate in mung bean production by 0.3287. Married household head gives priority to securing their household food needs first. So they incline to produce food crops to be self-sufficient.

The education of the household head is significant with a marginal effect coefficient of 0.1479. This means other things remain constant, being headed by educated members increases the probability of taking part in mung bean production by 0.1479. This is because education enables one to understand the market and be aware of the advantages of new technology adaption, technology management, and related things. In line with this Ayele et al. (2015) found households with an educated head tend to grow chat cash crops with cereals instead of cereals and pulses only. Governeh and Jayne (2003) found the same finding in a study conducted on cotton commercialization, in Gokwe, Zimbabwe. On the contrary Rabbi et al. (2019) founds that education has a negative effect on participation in cash crop production. Its justification is that education might enable farmers to incline toward non-farm income-generating activities after they come to be self-sufficient in food crops.

The education of the spouse of a household head is significant with a magnitude of 0.2233. The result shows other things keep constant, led by a head whose spouse is educated increasing the probability of taking part in mung bean by 0.2233. This is because a household with an educated spouse gets the advantage of getting better advice during decision-making. This includes knowledge of technology and the advantage of technology adaptation.

The size of active family members is found significant in determining households' likelihood to grow mung bean. It has a marginal effect magnitude of 0.1175. Here having one more active labor force increases the probabilities of a farm household to grow mung bean by 0.1175, other things keep constant. To justify, having more adults living in a household enables to have more labor which help for mung bean production. A study conducted by Klasen et al. (2013) in Indonesia found that households tend to cultivate cacao cash crops if the dependency ratio in the household is low. Stoeffler (2016) and has a similar finding on crop choice conducted in Burkina Faso. One of their justification is a household with a more active force could have sufficient and low-cost labor input, so reduced transaction cost. Against this finding Siziba et al. (2011) found a negative effect of active family size and tried to justify it as a larger household size reduces the probability to participate in cash cropping because there is a need for a large amount of food and food crops.

The size of farmland held by the household is significant in determining the likelihood of households to participate in mung bean production. It has a magnitude of marginal effect of 0.1223. Controlling other factors, an increase in households land holding by one hectare increases the probability of households growing mung bean by 0.1223. This is because more farmland enables to have an extra plot of land vested for mung bean farming after allocating land for food crops. This finding is in line with a study conducted in China by Li et al. (2022); which found households with large farm sizes are more likely to cultivate cash crops. Klasen et al. (2013) also found that households tend to cultivate cacao cash crops if they are well-endowed with land.

Access to extension is also significant in effect on households' probability to participate in mung bean production. 0.1142 is the marginal effect value; ceteris paribus, having access to extension service increases the likelihood of households to participate in mung bean production by 0.1142. This shows a better probability of households with access to an extension to participate in mung cropping relative to these which do not have access to the extension. The justification is that agricultural expert contacts enable one to have better agricultural knowledge and motivate participation in new technology. Li et al. (2022) have a similar finding in a study conducted about cash crop contribution to income and migration. It founds that investment and expansion in agricultural infrastructure and service is an important factor that determines households' decision to cultivate cash crops. Rabbi et al. (2019) have a similar finding and fantastic justification "Training will increase understanding”. The situation of extension services in East Belessa seems not impressive; in case farmers are unaware of the quality criteria of mung bean export, the health benefits of consuming mung bean, and even how to mix the product with the local diet.

Getting aid from the PSNP program is found negatively affect the probability to participate in mung bean cultivation with a marginal effect magnitude of -0.2986. Ceteris paribus, getting aid from PSNP reduces the likelihood to grow mung bean by 0.2986. Households that get a PSNP service are found less likely to participate in mung bean production relative to those that do not get a PSNP service, holding other factors. One can justify this as PSNP beneficiaries are low-income families, they tend to secure their food consumption by inclining to the production of food crops. Scholars Fafchamps (1992) revealed staple consumption is essential for the survival of low-income households. In the absence of stable markets in the third world, food security in low-income households is best achieved by a high degree of food self-sufficiency. So they incline to grow staple crops. Stoeffler (2016) with a similar finding justifies as low-income levels cause a household to face an initial capital shortage to join cash cropping and take risks.

Finally, controlling other factors, having an access to financial credit service increases the probability of growing mung bean by 0.163. This can be justified as more financial ability enables a household to adopt technologies easily. This study is in line with the finding from Stoeffler (2016), which founds that households who took credit were inclined to grow cotton in Burkina Faso. It justifies credit availability guarantees to take risks and creates an easy of solving liquidity problems to finance commercialization.

4.2.2 Common Support Region

After the estimation of the propensity score, the next step is assessing the existence of sufficient common support. In the region of common support, the propensity score for participant and non-participant households coincide. It is between the lowest propensity score for participants and the highest propensity score for non-participant households. In this study, the minimum propensity score for the participant household group is 0.0410188, and the maximum propensity score for the non-participant household group is 0.9783829. So the common support region is 0.0410188 < propensity score 0.9783829. From the common support test, 11 samples are found out of this region. This means 369 households (188 non-participants and 181 participants) are located in the common support region. This is sufficient to estimate the average treatment on the treated. Thus the common support condition is satisfied. Figure 4.1 below visualizes this. The green shaded part, which is only from participant group, represents off-support samples.

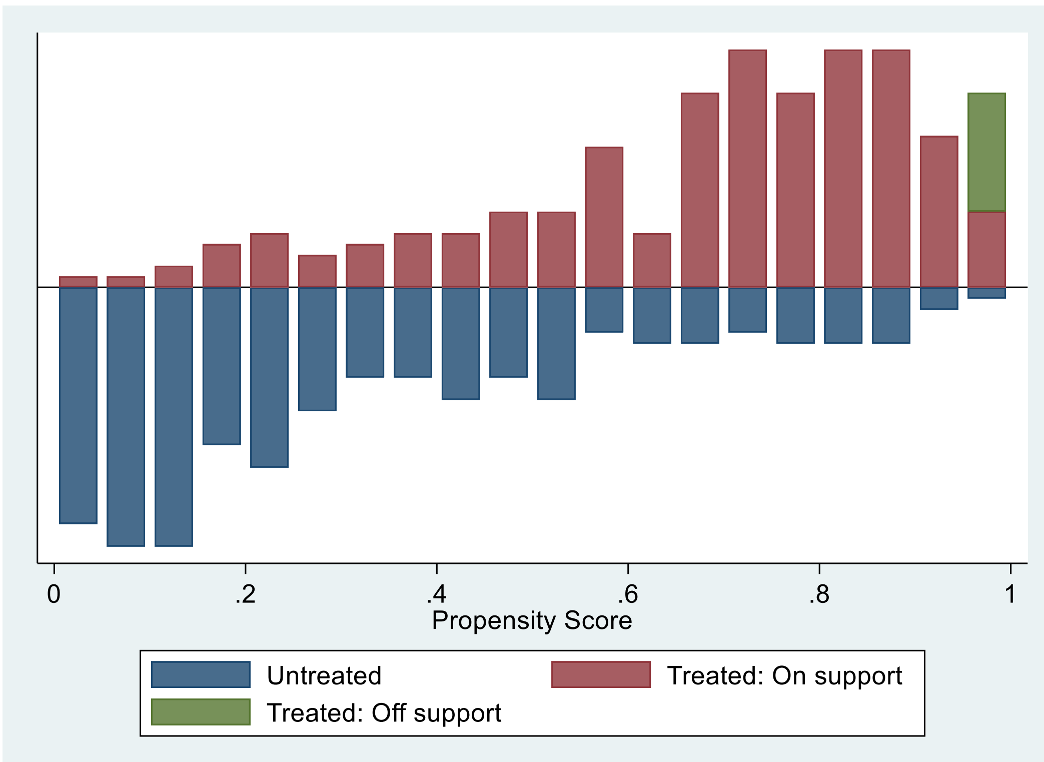

Figure 4.1: Common support region.

4.2.3 Matching Algorithm Choice

Finding the better and more effective matching estimator is done by comparing the result after trying to match the data using the three matching algorithms. Relatively low pseudo-R^2 or likelihood ratio chi^2, mean bias after matching, more matched sample, and a large number of insignificant mean differences after matching is the criterion used to choose a better matching algorithm. Table 4.6

below is a comparison of matching algorithms to choose one which fits best the data.

Table 4.6: Matching algorithm comparison

Matching Algorithm	Criterion to choose				
	LR Chi^2	Pseudo-R^2	Mean Bias	Matched sample	Balancing Test
Neighbor (1)	12.64	0.025	8.4	369	10
Neighbor (5)	10.38	0.021	7.2	369	11
Radius (0.25)	11.08	0.022	7.8	369	11
Radius (0.05)	6.63	0.013	5.7	369	11
Kernel (0.6)	19.26	0.036	10.2	380	9
Kernel (0.1)	19.26	0.036	10.2	380	9

Source: own estimation.

As can be seen from Table 4.6 above, radius matching with a caliper size of 0.05 outweighs the other matching algorithms. It has the lowest likelihood ratio chi^2, pseudo R^2, and mean bias result among others. Its total number of variables with an insignificant mean difference after matching is at least equal to other matching algorithms. Therefore, radius matching with caliper 0.05 better fit to estimate the average treatment effect of mung bean participation.

4.2.4 Balance Test of the Propensity Score

This test is about if the propensity score estimated has made the distribution of covariates between mung production participant and non-participant household groups comparable. It is tested using ps-test after matching using radius matching with caliper width 0.05. Table 4.7 is the joint covariate balance test result from the propensity score test (ps-test).

Table 4.7: Joint covariate balance test

Sample	Ps R^2	LR chi^2	$p>chi^2$	Mean bias
Unmatched	0.307	161.56	0.000	40.3
Matched	0.013	6.63	0.881	5.7

Source: own estimation.

The distribution of covariates among mung bean production participants and non-participant household groups is balanced. The insignificant likelihood ratio test for the joint covariate in the table above confirms this.

Figure 4.2 below visualizes the balance plot for K-density before and after matching. It shows better balancing after matching.

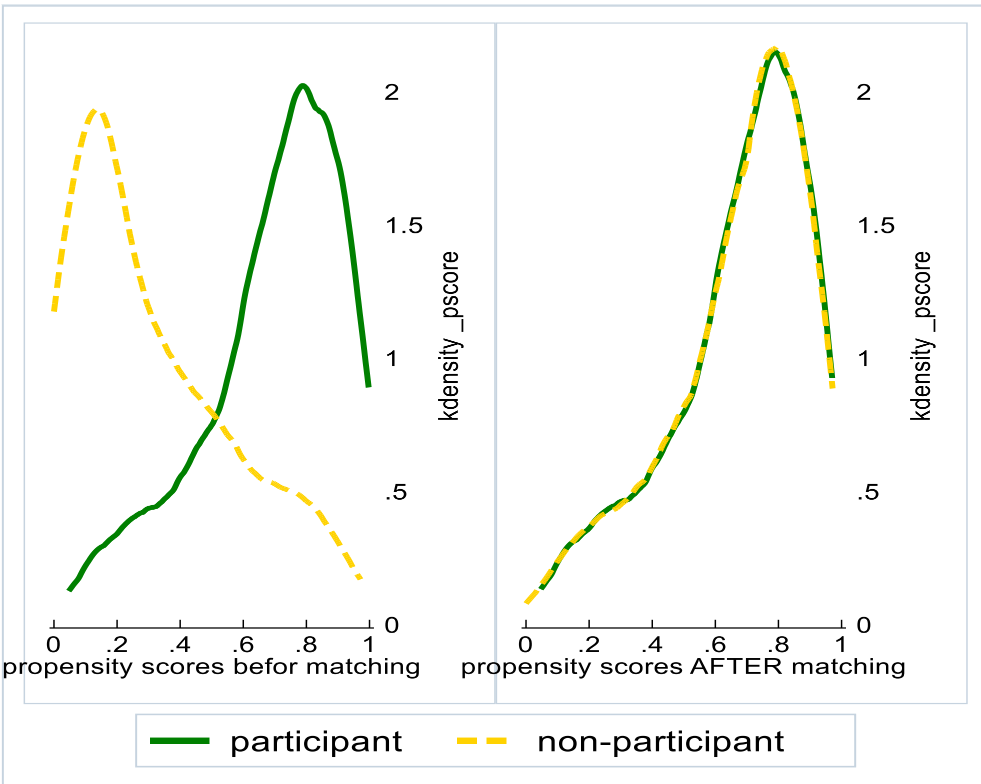

Figure 4.2: Balance plot before and after matching.

Now the estimation of the average treatment effect of participating in mung bean production can be reliable.

4.2.5 Estimation of Average Treatment Effect on the Treated (ATT).

4.2.5.1 Annual Income Effect

After adjusting for covariates, on average a mung bean production participant smallholder farm household has a 17,287.85 birr ($323) additional annual income compared to a non-participant smallholder farm household. Table 4.7 below shows this and the t-statistic result confirms it is significant at a 1% level of significance.

Table 4.8: Average mung cropping participation effect on the income of the participant

Sample	Participant	Non-participant	Difference	Std. err	t-test
Unmatched	71,966.14	53,063.83	18,902.31	1.259	15.01
ATT	70,861.87	53,574.02	17,287.85	1.842	9.38

Source: own estimation.

The average annual income effect of mung cropping is relatively low as it is seen in Table 4.8 above. Mung bean price fall has a great contribution to this relatively low annual income effect in addition to yield deterioration. On average each mung bean cultivation participant sample household produced 6.43 quintals of mung bean last year. Relative to last year's price of mung bean, the price fall caused a 25,720-birr ($480.7) loss on each mung bean production participant household. This means 4,938,240 birr ($92303.5) was lost by the total sample participants together. The restriction which obliged to trade mung bean only in ECX[9] contributed to this; because it is impossible to find at least an alternative market for his/her mung bean product. In addition, since it is illegal to trade mung bean except for ECX, it becomes difficult to sell mung bean product which does

[9] For some products such as mung bean, sesame and white beans, it is forbidden to transact the products in ordinary local markets. Only authorized merchants would receive from farmers and forward the product to ECX stores.

not satisfy the export quality standard. Thus the annual income difference is found to be relatively low.

4.2.5.2 Food Consumption Effect

The food consumption score is the proxy used to quantify the average consumption effect of taking part in mung bean production on participants. As it is seen in Table 4.8 the t-test statistic for ATT is insignificant. This means after controlling pre-participation household covariates, on average there is no consumption score difference between mung bean cropping participants and non-participant smallholder farmers. In other words, the income difference aroused from mung farming participation which we saw above is not able to create a consumption difference between the participant and non-participant households.

Table 4.9: Average mung cropping consumption effect

Sample	Participant	Non-participant	Difference	Std. err	t-test
Unmatched	29.609	28.86	0.747	0.702	1.06
ATT	30.154	30.063	0.091	1.037	0.09

Source: own estimation.

This is possible because that mung bean is not added to the farmer's food diet yet. In this study, almost all households are found to missing the incorporation of mung bean into the local diet. This highlights the need for knowledge creation about mung bean consumption, for instance, using mung bean in the form of mush (boiled bean) and grit stew (split beans) were easy ways of mixing mung bean into the local diet. Thus failing to mix mung beans into the local diet means mung bean does not have a direct effect on food consumption. In addition, the relatively low-income impact of mung bean production participation may be also another possible reason. Finally, the availability of food aid programs such as PSNP and Food for Hunger (FH) aids low-income households to have better food consumption. This possibly narrows the food consumption score gap.

4.2.6 Robustness Check

This is necessary to assure the estimated average effects are free from the effect of variables that are not included in the model. It is to assure the inclusion of key variables and the results estimated in the previous section are not susceptible to selection bias. Sensitivity is done by using Rosenbaum's bound sensitivity analysis. Table 4.10 shows the result of the Rosenbaum test of sensitivity. Except for 4.5 and 5 values of gamma, the p-critical value is significant starting from one. When we come to Hodges Lehman bounds which donate the significance level, it doesn't include zero between the upper and lower bound. Thus it is possible to conclude the estimated ATT is free from the effect of a variable that is not included in the model, and necessary or key explanatory variables that affect participation in mung bean farming and households' annual income are included.

Table 4.10: Rosenbaum's bound sensitivity analysis result

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	62,500	62,500	61,000	64,000
1.5	0	0	59,500	65,500	58,000	67,000
2	0	0	57,500	67,500	56,000	69,000
2.5	0	0	56,000	69,000	54,000	71,000
3	0	0	55,000	70,000	53,000	72,000
3.5	0	0	54,000	71,500	52,000	73,000
4	0	0	53,000	72,000	51,000	74,000
4.5	5.6e-16	0	52,000	73,000	50,500	75,000
5	1.5e-14	0	51,500	73,500	49,500	75,500

Gamma: log chances of unequal assignment caused by factors that are not visible.
Sig +: highest possible significance level (overestimation of treatment effect).
Sig-: minimum possible significance level (underestimation of treatment effect).
t-hat+: higher possible bound Hodges-Lehmann point estimate.
t-hat-: minimum possible bound Hodges-Lehman point estimate.
CI +: higher possible bound confidence interval (a = 0.95; overestimation of treatment effect).
CI-: minimum possible bound confidence interval (a = 0.95; underestimation of treatment effect).

Source: own estimation.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In recent years, cash cropping and the commercialization of agriculture has emerged as promising approach for promoting rural economic growth and addressing food insecurity. The mung bean, a drought-resistant and short-time cash crop has gained huge attention. As it is a recently introduced cash crop, the impact of participating in cropping mung bean is not quantified well in studies. So the main objective of this study was to estimate the impact of participating in mung bean production on the income and food security of smallholder farm households in East Belessa, Amhara region, Ethiopia. Different descriptive and econometric analysis tools were applied using data from 380 smallholder farm households in the area.

The descriptive statistical analysis result reveals there is a statistically significant difference between mung cultivation participants and non-participant households regarding their demographic and socio-economic factors. The logit model founds that the age, education, and marital status of the household head, education of the spouse, households' extension, and credit accessibility, safety net service, farm size, and number of active family members have a significant impact on the likelihood of a household to participate in mung bean production. The PSM result confirms that the annual household income difference aroused from mung cultivation participation status is 17,287 birrs ($323). Here one can see the difference is not satisfactory. The major reasons forwarded by farmers are the mung bean output decrement and the blaming mung bean price fall.

5.2 Recommendations

Conducting a treatment impact analysis enables one to identify entry points for policy interventions in addition to quantifying the impact of the treatment. The following recommendations are forwarded based on the findings of this study.

- ✓ Woreda agriculture office should provide better agricultural extension services in the area; especially in creating know-how about the production, export quality requirements, and food consumption use of mung beans. Extension service has a positive impact on households' mung bean production participation; therefore, in addition to initiating them to grow mung bean, it would help to create the idea of producing the product in line with the quality criteria and export standard, to create knowledge on how to mix the crop into farm households' daily meal.
- ✓ Relatively low annual income difference is found from the average income effect of cultivating mung bean on households who took part in mung cultivation. Mung bean price fall has the lions share for this. So Ethiopian commodity exchange authority need to smooth restrictions on the transaction of mung bean only through ECX markets. This enables to create more and better market for such low priced mung bean. In addition, it creates a vein to sell under quality mung bean, which does not meet export standard quality. This would enable farmers to get relatively better price and so better income from mung bean.
- ✓ Farmers necessarily need to mix mung beans into their consumption diet in easy ways such as, in the form of mush (boiled beans) and grit stew (split beans); instead of selling the nutritious mung beans at a devastatingly low price. These in turn could help the farmers to benefit more by consuming mung instead of selling the crop at a very low price like the last four months of 2022. Finally, it helps to transform the income differential into consumption differentials as well.

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APPENDICES

Appendix 1: Post-Logistic Estimation Diagnostic Tests

1A: Hosmer-Lemeshow goodness of fit test after logistic model

estat gof, group(10) Number of observations = 380 Hosmer-Lemeshow chi2(8) =5.14 Prob > chi2 = 0.7429	Variable: Mung Number of groups = 10

1B: Breusch–Pagan/Cook–Weisberg test for heteroskedasticity test

Hettest Assumption: Normal error terms H0: Constant variance chi2(1) = 0.38 Prob > chi2 = 0.5355	Variable: Fitted values of Mung

1C: Variance inflation factor multi-collinearity test

Variable	VIF	1/VIF
Sex	1.16	0.8655
Age	1.27	0.7888
Marital status	1.38	0.7246
Education of the head	1.15	0.8689
Education of the spouse	1.28	0.7764
Active family member	1.12	0.8912
Inactive family member	1.08	0.9251
Farm size	1.16	0.8637
Access to market	1.10	0.9131
Access to extension	1.06	0.9440
Access to credit	1.14	0.8808
PSNP	1.07	0.9321
Mean VIF	1.16	

Appendix 2: Balancing test after matching (pstest, both)

2A: Joint covariate balance test

Sample	PsR2	LR chi2	p>chi2	Mean Bias	Med Bias	B	R	% variance
unmatched	0.307	161.56	0.000	40.3	38.8	141.9	0.73	20
Matched	0.013	6.63	0.881	5.7	4.8	27.2	1.12	20

2B: Individual covariate balance test

Variable		Mean		Reduction in bias		t-test		V(t)/
		Treated	comparison	Reduc.	%Reduc.	t	p > ǀ t ǀ	V(c)
Sex	U	0.9635	0.89894	25.7	92.3	2.51	0.013	-
	M	0.9613	0.9563	2.00		0.24	0.812	-
Age	U	36.82	45.98	-88.5	96.5	-8.63	0.000	0.79
	M	37.18	36.86	3.1		0.35	0.726	1.86
Marital status	U	0.6302	0.8031	-39	89.5	-3.8	0.000	-
	M	0.6574	0.6392	4.1		0.36	0.718	-
Education of head	U	0.6718	0.5159	32.1	82.6	3.13	0.002	-
	M	0.6519	0.6248	5.6		0.53	0.593	-
Education of spouse	U	0.3489	0.2872	13.9	29.2	3.13	0.002	-
	M	0.3581	0.3088	9.8		0.53	0.593	-
Active family	U	3.1719	2.3138	66.9	80.2	6.52	0.000	0.85
	M	3.0884	3.2584	-13.3		-1.38	0.168	1.13
Inactive family	U	1.0521	1.2287	-18.7	97.5	-1.82	0.069	0.78
	M	1.1105	1.1061	-0.5		-0.05	0.963	0.86
Farm size	U	2.3646	1.8963	52.8	85.7	5.14	0.000	1.63
	M	2.2265	2.1596	7.5		0.79	0.428	1.07
Access to market	U	11.714	12.755	-14.1	85.3	-1.38	0.169	0.94
	M	12.26	12.413	-2.1		-0.20	0.843	0.88
Access to extension	U	0.8385	0.6755	38.6	66.7	3.77	0.000	-
	M	0.8287	0.7743	12.9		1.30	0.196	-
PSNP	U	0.0729	0.2393	-47	98.1	-4.59	0.000	-
	M	0.073	0.0742	0.9		0.11	0.912	-
Access to credit	U	0.5	0.2766	47.0	86.5	4.58	0.000	-
	M	0.4696	0. .4394	6.3		0.58	0.565	-

U –unmatched M- matched

Appendix 3: **Questionnaire**

Habitamu Atalay is an MSc student at Bahir Dar University conducting a study on "**The impact of mung bean cash crop production on household income and consumption**." The purpose of this survey is to gather data to analyze the mung bean (Masho) production participation and its impacts on farmers' livelihoods and food security in the wereda. In addition to partially fulfilling the criteria for the MSc in Development Economics, it aims to make a scientific contribution to the local mung bean sector.

The personal information that you give will remain confidential. I would like to thank you all for your cooperation and time.

A) Household information

1. Age of the household head _______________
2. Sex of the household head

   Male ☐ Female ☐

3. Marital status of the household head

   Unmarried ☐ Married ☐

   Divorced ☐ Widowed ☐

4. How many family members do you have? ___________
5. How many members are aged below 15 and above 65 fill in the next table.

Aged < 15		Aged between 16 & 64		Aged > 65	
Male	Female	Male	Female	Male	Female

6. What is the highest level of education attained by the household head and spouse?

A) Head. Never attained schooling ☐ High school ☐

Primary school ☐ Degree or higher ☐

B) Spouse. Never attained schooling ☐ High school ☐

Primary school ☐ Degree or higher ☐

7. How many animals does the family have?

Animals	Quantity
Cattles	
Sheep and goat	
Horse and mules	
Donkey	

8. How many acres of arable lands does the family have (in hectares)? ___________

8.1 How did you use this land last year (September 2015) crop year?

Crop produced	Land cultivated in hectares
Food crops e.g. teff, bean, sorghum	
Cash crops e.g. sesame, lentils	

9. Is there any other alternative like irrigation other than rain feed farming?

   Yes ☐ No ☐

   If yes, how many acres of irrigable land does the family have? ____________

10. How far your home is located from the nearby local market where you transact agricultural inputs and outputs? ____________

11. Do you have access to financial credit?

    Never ☐ Sometimes ☐ Always ☐

12. Do you have participated in informal borrowings like Arata or staple for cash crops?

    Yes ☐ No ☐

13. Are you a member of any safety net program?

    Yes ☐ No ☐

14. Do you have access to extension services by agricultural experts (Gibrina)?

    Never ☐ Sometimes ☐ Always ☐

15. Do you use improved technologies? Such as improved seed, fertilizer, pesticide, and insecticide?

Technology	Technology use		If 'yes' Specify the Quantity
	Yes	No	
Fertilizer			
Seed			
Pesticide			
Herbicide			
Others			

Household annual income information

No	Income type		Annual income in birr
1	Farm income	Crop	
		Animal	
		Bee	
		Forest	
2	Off-farm income	Trade	
		Labor sale	
		Weaving and Metalwork	
3	Safety net and transfers	Safety net	
		Transfers	
Total			

Households' consumption information

Household nutrition (FCS)

Fill the spaces for the following question regarding the nutrition you feed in the last seven days as 0 if you do not eat, 0.5 if oil or sugar 1 if you used vegetable or

Household Member	Food items used in the last two weeks			
	Break fast	Lunch	Dinner	Total
1				
2				
3				
4				
5				
6				
7				
9				
10				

fruit, 2 if main staple, 3 if pulses, and 4 if meat or milk and related diaries (WFP, 1996).

Was there a month during which the household experienced a lack of food such that one or more members of the household had to go hungry?

Yes ☐ No ☐

If yes list here

____

____

____

Household expenditure

Expenditure type		Amount in birr	The possible source of finance
Consumption	Food		
	Cloth and shoe		
Purchase of farm facility	Fertilizer		
	Pesticide		
	Herbicide		
	Seed		
	Others		
Asset accumulation	Land purchase		
	Animal purchase		
	House		
	Others		
Social interaction such as funerals, mahiber, and so on			
Debit financing			
Others			
Total annual expenditure			

Mung bean production-related information

16. Do you produce Mung bean? Yes ☐ No ☐
    If your answer is yes;
17. On how many acres of land did you crop mung bean? _________
18. Specify the amount of input used and output you got.

18.1 Total mung bean output in quintals ________

18.2 Inputs used to produce mung bean

Input	Quantity
Pesticide	
Herbicide	
Fertilizer	
Insecticide	

19. Do you use mung bean for household consumption?

Yes [ ] No [ ]

20. If your answer is yes to the question above specify the quantity, please?

____

21. What initiates you to produce mung bean?

The relatively better yield of mung bean per hectare	
The relatively higher price of mung bean	
Drought resistance nature of mung bean	
Poor nature of soil (arable land)	
Relatively less labor requirement for mung bean production	

Please specify if there is another reason

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22. Is there any negative consequence of producing mung bean?

Yes [ ] No [ ]

23. If your answer above is yes, what are these negative consequences?

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24. Have you faced a price fall when you sell mung bean last year (September 2015)?

Yes [ ] No [ ]

If your answer above is yes,

25. Specify the maximum price fall you faced. _____________
26. What do you think is the reason for a price fall in mung bean?

Reasons	Tick(√)
Lack of quality on mung bean	
Lack of demand for mung bean	
Supply chain intermediaries taking a higher share	
Higher supply of mung bean relative to demand	
Others	

27. What impacts does the price fall have on your family?

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