COLLEGE OF DEVELOPMENT STUDIES

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FACTORS AFFECTING *DEKOKO (Pisum sativum var. Abyssinicum)* PRODUCTION, DISTRIBUTION CHANNEL AND ITS IMPLICATION TO HOUSEHOLD FOOD SECURITY IN NORTHEASTERN ETHIOPIA

BY

GENET BERHANU GETACHEW

SEPTEMBER, 2020

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Genet Berhanu Getachew

September, 2020

Declaration

I declare that this thesis is my original work and has not been presented for a degree or certification in any other Universities, institutions and that all sources of material used for the thesis have been duly acknowledged.

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Approval Sheet

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As supervisor of the thesis, I certify that I have read and evaluated the thesis entitled "*Factors Affecting Dekoko Production, Distribution Channel and Its Implication to Household Food Security in Northeast Ethiopia"* and recommend for open defense as fulfilling the requirement for the degree of Master of Science in Food Security and Development.

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As members of the Examining Board of the Thesis Open Defense, we certify that we have read and evaluated the thesis entitled "*Factors Affecting Dekoko Production, Distribution Channel and Its Implication to Household Food Security in Northeast Ethiopia"* and recommend that it is acceptable thesis required for the degree of Master of Science in Food Security and Development.

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Acronyms and Abbreviations

CSA:	Central Statistical Agency
CSFLs:	Cool-Season Food Legumes
Das:	Developmental Agents
FAD:	Food Availability Decline
FAO:	Food and Agriculture Organization
FED:	Food Entitlement Decline
FGD:	Focus Group Discussion
FS:	Food Security
GPS:	Global Positioning System
HDDS:	Household Dietary Diversity Score
HFBM:	Household Food Balance Model
KII:	Key Informant Interview
MNLM:	Multinomial Logit Model
MVP:	Multivariate Probit
NGO:	Non - Governmental Organization
NMA:	National Metrological Agency
NNP:	National Nutrition Program
RUM:	Random Utility Model
TLU:	Total Livestock Unit
UNDP:	United Nations Development Programme
VIF:	Variance Inflation Factor
WFP:	World Food Programme
WFS:	World Food Summit

Abstract

Dekoko is a unique crop cultivated in Ethiopia and highly appreciated by its taste and high market value. However, currently the production is decline and the distribution is limited as well. The objective of the research is to examine factors affecting dekoko production and distribution channel and its implication to household food security in Northeastern Ethiopia. For this study, twenty one kebeles were selected by using stratified sampling technique and 288 respondents were sampled. Both descriptive and econometrics analysis were employed. In order to evaluate household food security household food balance model and household dietary diversity scores were employed. Multiple liner regression model was used to determine factors affecting dekoko production, whereas multi-nominal logistic regression was used to assess market channel choice decision. In addition, ordered econometric analysis was used to categorize and determine factors affecting household food security status. Results of descriptive analysis showed dekoko producers as compared with non-producers are characterized by having better wealth status, farmer status, participate in extension program, access to credit, younger age, irrigation and fertilizer. The result of household food balance model shows that dekoko producers were food secured as compared to non-producer. The dietary diversity results also indicate that there is a significant mean difference between the two groups in main food group. The multiple liner regression result revealed that age, family size, fertilizer use, household farm status, wealth status, education and total land size positively affect dekoko production, while participation in off-farm activity affects negatively. Finally, multinomial logistic regression indicates that family size, access to credit, off-farm activity, and livestock ownership are found to be affecting the extent of market channel choice decision negatively. The study concludes that producing dekoko has remarkable effect on the household food security status. Based on the finding of this study, it is recommended that improving farmer's awareness and perception through training, strengthening development agents capacity, introducing different improved dekoko variety with reasonable cost, continuous follow-up, improvement in input supply, strengthening market linkage and interventions are crucial to deal with constraints related to dekoko production and distribution.

Keywords: *Dekoko, Food Security, Market channel, Household Food Balance Model, Multinomial Logit Mode, Northeastern Ethiopia*

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Agriculture has continued to retain its importance in Ethiopia's economy and long-term food security as it offers about 80-85% of employment, more than 61% of the total export and 38.5% of gross domestic product of the country (Degaga and Angasu, 2017). Ethiopia has wide range of agro-ecological conditions that permits different agricultural systems and production of different crops. The existence of this diverse agro-ecology together with diverse farming systems, socio-economic, cultures and climate zones provided Ethiopia with various biological wealth of plants, animals, and microbial species, especially crop diversity (Atnaf *et al.,* 2015). This maintained diverse land races of field crops over millennia have made Ethiopia an important primary and secondary gene center and source of valuable germ plasm for many crop species including legumes (Varshney *et al.,* 2012).Among the various crops, grain legumes contribute to smallholder crop production, nutrition as a cost-effective source of protein accounting for about 15% of protein consumption and income as a high-value crop being the third-largest export crop next to coffee and sesame (Getachew, 2019).

In Ethiopia, about 12 legume crops are grown and these are categorized as highland and lowland legume crops. Among the highland legume crops, Ethiopia is considered as one of the center of diversity of field pea (*Pisumsativum L*.). Though wild and primitive forms also known to exist in high elevation of the country (Hagedorn, 1984), the species *P. Sativum* is known to dominate the production system (Mussa *et al*., 2006). Despite the fact that the progenitors of *P. Sativum* so far are known, Ethiopia, western and central Asia and the Mediterranean region are proposed as possible centers of origin because of the high pea genetic diversity sampled in these regions (Messiaen *et al*., 2006).There are two botanical cultivars of filed pea (*Pisum sativumL*.) known to grow in Ethiopia, namely *P. sativum var. sativum and P. sativum var. Abyssinicum* (Gemechu *et al.,* 2013). This study focuses only on *P. sativum var. Abyssinicum* pea, which is native to Ethiopia and locally named as *dekoko,* which means, "Minute seeded". It is also known as "Yagere ater" ("pea of my country") or "Tinishu ater" ("the smallest pea") in Amharic which show that an Abyssinian pea is native to Ethiopia (Haddis and Dargie, 2013).

Dekoko is grown in few localities in Northern and Southeastern parts of Ethiopia, and particularly in the highland areas of South Tigray and the Northern part of Wollo. This shows

that its distribution is limited to Northeastern Ethiopia (Yemane and Skjelvåg (2002). *Dekoko* can mature in just 80 days, which is a shorter lifecycle when compared to a vast majority of crops grown in the country. Its early maturity makes it a preferred crop in areas where the growing season is too short for other cool-season food legumes, as yield losses are common due to droughts even though the highland area of southern.

Dekoko pea is highly contributed to food security because these crops are a great source of nutritious food, feed for animals, and income to smallholder farmers. This pea is serves as an excellent source of carbohydrates and protein for those who cannot afford animal proteins or those who are vegetarian by choice. Its nutritional value is of special importance during the months-long fasting period where people avoid eating foods of animal products in Ethiopia (Yemane and Skjelvag, 2002). Additionally, *Dekoko* serves as a cash crop (farm output that is sold on a market) to generate income, and therefore improve access to food, inputs for their farm production and some goods for their home for those who earn that income. Even though the crop is highly important to enhance the food security status of smallholder farmers, due to inappropriate production practices and critical knowledge gaps, the production and productivity of these crops in Ethiopia is declining (Yemane and Skjelvåg, 2002). The major constraints accounting for this low production and productivity includes low input usage, limited availability of seed, lack of improved varieties, market problems and poor extension services. In addition, poor soil fertility, erratic rainfall, prolonged dry spell, diseases and pests such as pea weevil, and limited usage of modern agronomic practices constrain *dekoko* production and productivity (Asfaw *et al.*,2010; Atnaf *et al.*,2015; Getachew,2019; Habte *et al.*, 2018; Kabata *et al.*,2017).

Moreover, information on the impact of *dekoko* production on the livelihoods of smallholder farmers is very important. Hence, the design and effective management of extension programs would help to improve the productivity of *dekoko*. Improved *dekoko* production is widely considered as the key means of addressing most of the problems of shortage of income and improved nutrition of people living in the country especially smallholder farmers. Therefore, this study aimed to examine the role of *dekoko* production in increasing the livelihood of rural household and their food security, and to investigate factors that affect *dekoko* production and distribution channel and examine its implication to household food security in the study area.

1.2. Statement of the problem

Global food security has become increasingly dependent on only a handful of crops and over 50% of human kind's requirements for protein and calories are met with three crops (maize, wheat and rice). Whereas, 95% of the world's food energy needs are provided by 30 plant species (Bizimana, 2007; Williams & Haq, 2002), suggesting that most of the potential food crops are underutilized. With the modernization of agricultural practices, many species have been neglected (Williams & Haq, 2002). Hence, diversification of food crops should be one of the most important options in achieving food security of the country. Recently, Ethiopia has launched a National Nutrition Program (NNP) to attain food and nutritional security through improving underutilized crops that are nutritionally rich and genetically diverse (Tamirat, 2014).Noticeable among underutilized crops is *dekoko.* It is cultivated particularly in Northeastern parts of Ethiopia and have an important role in the lives of the farmers; it serves as a protein supplement in the cereal-based diets in Ethiopia (Kelley *et al.*, 2000).

Farmers and consumers call *dekoko* the "Dero-Wot of the poor" (chicken stew of the poor) to express its delicious taste. This crop has high nutritional value (sources of protein) for smallholder farmers and other consumers to whom meat is scarce and unaffordable (Yemane, 2003). It is also a source of income and animal feed in the growing areas of the region. Farmers producing this crop earns high market price for about twice the price of faba beans. Most often, *dekoko seeds are* decorticated /split/ before boiling or cooking. This activity brings additional income to rural women who sell split peas in towns and cities (Sintayehu, 2009).Even though the highland areas of Southern Tigray and North Wollo is potential for *dekoko* production, its production and productivity falls significantly below the potential because of combination of expensive price of *dekoko* seed to purchase for poor farmers and their small land holdings. During pilot surveys, it was observed that most of the farmers owned fragmented lands, and most of them owned less than a hectare. As a result, they give more emphasis for stable food crops than *dekoko*. A limited number of farmers produce this crop in a very small plot of land. The other reason is that pests and disease severely affect *dekoko* crop before and during the harvest. This might be due to poor agronomic practices applied. On the other hand, *dekoko* peas are hardly found in the central markets of the country, Addis Ababa city. Its distribution is limited to local markets in Northern part of the Ethiopia. Even in the Tigray region, supplies are very

limited and the product is slowly disappearing from local markets as well. This indicate that the crop has received little attention among farmers, extension workers and *woreda* officials compared to cereal crops in terms of crop management and input utilization(Atnaf *et al.*,2015; Muoni *et al.*,2019). The study of Gebreegziabher and Tsegay (2018) also showed that the crop distribution is currently limited to three to four districts and sown after other crops are harvested. They further showed that the major factors hindering its distribution are agro-ecological suitability, lack of intervention and preference of high yielding pea varieties.

Regardless of the above challenges and importance of *dekoko* to local farmers and consumers, only few studies have been conducted on this crop. Haddis and Dargie (2013) characterized *dekoko* using few qualitative traits, namely, flower color, seed size and seed shape and revealed the existence of high genetic diversity among populations implying that the crop can be improved through breeding. Haddis *et al.* (2015) conducted a follow up study where variations in attributes such as grain yield were recorded. A study by Teshome *et al*. (2015a) using limited number of newly developed EST-SSR markers has shown that most microsatellite markers developed for P. sativum ssp. sativum are transferable to *dekoko*, hence genomic resources developed for these two subspecies can be used interchangeably. Yemane and Skejelvag (2003) showed that *dekoko* has higher protein content, fat and sugar as compared to common field pea.

These researches have been mainly describing the physicochemical features of *dekoko* and few factors hindering distribution such as agro-ecological suitability, political disruption and less extensive awareness on the crop. However, as far as my knowledge concerned, there is no information available on the socio-economic status of *dekoko* producers and the challenges encountered relating to its production and distribution (market channel choose of decision) and its implication to household food security. Thus, this study attempted to bridge the current information gap on socio- economic situation of *dekoko* producers, knowledge and awareness related to *dekoko* production. It also dealt with constraints of *dekoko* production and distribution and its contribution to enhanced food security and overall improvement of livelihood of smallholder farmers who cultivate it as food and cash crop.

1.3. Objectives of the study

1.3.1. General objective

The main objective of this study was to investigate factors affecting *dekoko* production and distribution channel and its implication to household food security in Northeast Ethiopia.

1.3.2. Specific objectives

The specific objectives of this study was to

1. examine the knowledge of farmer about the agronomic characteristics of *dekoko* cultivation in the study areas.
2. investigate farmer preferences to produce *dekoko* in the study areas.
3. assess the contribution of *dekoko* to household food security.
4. examine the key factors affecting *dekoko* production and
5. assess market channel choice decision of *dekoko* in the study areas.

1.4. Research questions

This study intended to answer the following basic questions, which are derivatives of the above specific objectives:

1. Do farmer in the study area know about agronomic characteristics of *dekoko*?
2. Why farmers prefer to produce *dekoko* pea over a period of time in the study areas?
3. What is the implication of *dekoko* production on farm household's food security status?
4. How is the household food security status among producer and non-producer respondents?
5. What is the implication of *dekoko* production on household dietary diversity?
6. What are the main constraints in the area that decline *dekoko* production?
7. What are the factors affecting the preference of market channel choice decision of *dekoko* producer in the study *woreda*?

1.5. Scope of the study

The study focused on factors affecting *dekoko* production and distribution, and its implication to household food security. Therefore, its scope is limited in terms of coverage and depth owing to financial and time resources available. It is limited to only socio-economic factors, institutional and demographic related factors that determine household *dekoko* production and distribution channel. The study considered households who participated and not participated in *dekoko*

production. It terms of spaial scope, the study focused on potential *dekoko* producing *woredas* namely Guba Lafto, Raya Alamata, Raya Kobo, Ofla, Hintalo Wajirat, Endemehoni and Amba Alaje *woredas*.

1.6. Limitation of the study

Factors affecting *dekoko* production and distribution in the *woredas* was studied in twenty one representative *kebeles* by surveying a sample of 288 households. Since it was impossible to study all *woredas*, which produce *dekoko* and impacts of *dekoko* production on household food security, only potential *dekoko* producing areas were considered in this study. Hence, methodologically, this study might be limited in sample selection process. This study is also limited in few resources due to limitation of previous related study on productivity, nutritional analysis and comparison between *dekoko* pea and other crops.

1.7. Data validity and reliability

Validity of the instruments

Validity refers to the appropriateness, correctness, and meaningfulness of the specific inferences, which are selected on research results (Frankel and Wallen, 2008). It is the the degree to which results obtained from the data analysis actually represent the phenomenon under. This research study concerned itself with content validity. Content validity according to Kothari (2004) is the extent to which a measuring instrument provides adequate coverage of the topic under study. Content validity ensures that the data collection instruments covered the subject matter of the study as intended by the researcher. Therefore, content validity of the instrument was determined by colleagues and experts in research who looked at the measuring technique and coverage of specific areas (objectives) covered by the study. The experts then advised the researcher on the items to be corrected. The corrections on the identified questions were incorporated in the instrument hence fine-tuned the items to increase its validity. Validity was ascertained by checking whether the questions were measuring what they are supposed to measure such as the clarity of wording and whether the respondents were interpreting all questions in the similar ways. The researcher through revealing areas causing confusion established validity, ambiguity, and this will lead to reshaping of the questions to be more understandable by the respondents and to gather uniform responses across various respondents.

Reliability of the instruments

Reliability concerns the extent to which a measurement of a phenomenon provides stable and consist result (Carmines and Zeller, 1979). Reliability is also concerned with repeatability. For example, a scale or test is said to be reliable if repeat measurement made by it under constant conditions will give the same result (Moser and Kalton, 1989). Testing for reliability is important as it refers to the consistency across the parts of a measuring instrument (Huck, 2007). A scale is said to have high internal consistency reliability if the items of a scale "hang together" and measure the same construct (Huck, 2007, Robinson, 2009). The most commonly used internal consistency measure is the Cronbach Alpha coefficient. It is the most appropriate measure of reliability when making use of Likert scales (Whitley, 2002, Robinson, 2009). No absolute rules exist for internal consistencies, however most agree on a minimum internal consistency coefficient of 0.70 (Whitley, 2002, Robinson, 2009). For an exploratory or pilot study, it is suggested that reliability should be equal to or above 0.60 (Straub *et al.*, 2004). Hinton *et al.* (2004) suggested four cut-off points for reliability, which includes excellent reliability (0.90 and above), high reliability (0.70-0.90), moderate reliability (0.50-0.70) and low reliability (0.50 and below). Although reliability is important for study, it is not sufficient unless combined with validity. In other words, for a test to be reliable, it also needs to be valid (Wilson, 2010).

1.8. Ethical consideration

During the time of data collection, ethical considerations were seriously taken into account to ensure the protection, integrity, anonymity, confidentiality, honesty, continuity and consents of the respondent. Similarly, the respondent's identity was not identified during interview and discussion. Accordingly, the study initially prepared informant's consent in local language that fully informed the participants about the purpose and objective of the study to avoid erroneous perception of the study. The procedure and the total duration of the questionnaire was clearly explained, and participants were informed to withdraw at any time when felt inconvenient. The consent was to encourage participants to cooperate, and give honest and unbiased answers. Therefore, the study believes that the information gathered through the surveys, informant interviews and group discussions are correct and relevant. In addition, the researcher used respondents of photo by asking their permission and based on their positive responses during the time of data analysis and report.

1.9. Significance of the study

The output of this research would improve the knowledge about the role of *dekoko* production in rural farmer's food security, and would add information to the limited research done so far on the role of *dekoko* production and its impact in the region. Thus, this research was not aimed to replicate or duplicate what the others have done but to fill the gaps that were not observed in other research works. In addition to this, it helps to better design development projects or programs for the farmers to improve their livelihood options. Policy makers also benefit from the research output because they require information to formulate suitable policies with regard to negelected crops such as *dekoko*. Hence, identifying the major factors that influence production and productivity of *dekoko* is important. The result of this study would be used as a reference for other similar areas for further study. In general, the study was expected to generate grassroot information for different stakeholders in order to develop sustainable strategies that decrease drawbacks and other associated issues in this study.

1.10. Organization of the thesis

This thesis consists of five chapters. The first chapter presents the general introduction of the thesis that includes background of the study, statement of the problem, objectives and research questions, significance of the study, scope and limitation of the study. The second chapter is devoted to a review of related literature through which various concepts relevant to the study are discussed. The third chapter deals with methodological issues, under which the general descriptions of the study area, the data sources and acquisition techniques as well as method of data analysis are discussed. The fourth chapter is also devoted to discussion and analysis based on the processed primary and secondary data of the study. Finally, the fifth chapter presents the conclusion and recommendation based on the findings/results of the study.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1. Concepts and definitions

2.1.1. Concepts of food security

Since the World Food Conference in 1974, due to food crises and major famines in the world, the term Food Security was introduced, evolved, developed and diversified by different researchers. Maxwell and Frankenberger (1992) listed 194 different studies on the concept and definition of food security and 172 studies on indicators. A review that updates this literature (Clay, 1997) provides an additional 72 references. In the work of Maxwell and Frankenberger (1992), a distinction was made between process indicators (those that describe food supply and food access) and outcome indicators (those that describe food consumption). Food security was understood as adequacy of food supply at global and national levels until the mid-1970. This view favored merely food production oriented variables and overlooked the multiple forces, which in many ways affect food access. Evidences show that during the last two decades, food production has been increasing in the world. However, large amount of food at global level does not guarantee food security at national level. Moreover, availability of enough food at national level does not necessarily ensure household food security. For instance, in 1990, the calorie supply at global level was more than 110 percent compared to the total requirement. However, during the same period, more than 100 million people were affected by famine and more than a quarter of the world's population was short of enough food (UNDP, 1992). Although food production has been increasing from time to time, food insecurity, malnutrition and hunger and much more serious problems would remain the main agenda in the globe today (Barrett, 2002). Therefore, the conceptual framework of food security has also progressively developed and expanded.

The idea of food security attained wider attention since the 1980s after the debate on 'access' to food and the focus of the unit shifted from global and national levels to household and individual levels (Debebe *et al.,* 1995). This paradigm came with new concept and definition of food security and it led to two additional major shifts in thinking; from a first food approach to a livelihood perspective and from objective indicators to subjective perceptions (Maxwell *et al.,*1994).The most commonly accepted definition of Food security is "access by all people at all times to enough food for an active and healthy life" (World Bank, 1986).

During the debates that preceded the World Food Summit (WFS) held in Rome in 1996, it was established that "There is food security when all people at all times have sufficient physical and economic access to safe and nutritious food to meet their dietary needs including food preferences, in order to live a healthy and active life" (USAID, 2008). When an individual or population lacks, or is potentially vulnerable due to the absence of, one or more factors outlined above, then it suffers from, or is at risk of food insecurity. Based on the WFS (1996), the definition focuses on three distinct but interrelated elements, all three of which are essential to achieving food security:

- Food availability: having sufficient quantities of food from household production, other domestic output, commercial imports or food assistance,

- Food access: having adequate resource to obtain appropriate foods for a nutritious diet, depends on available income, distribution of income in the household and food prices.

- Food utilization: proper biological use of food, requiring a diet with sufficient energy and essential nutrients, potable water and adequate sanitation, as well as knowledge of food storage, processing, basic nutrition and childcare and illness management.

- Stability: the WFS says that stability must be present “at all times” in terms of availability, access and utilization for food security to exist.

The concept of food security also has spatial and temporal dimensions. The spatial dimension refers to the degree of aggregation at which food security is being considered. It is possible to analyze food security at the global, continental, national, sub-national, village, household, or individual level (Hoddinott, 1999).

Food insecurity is a situation in which individuals have neither physical nor economical access to the nourishment they need. A household is said to be food insecure when its consumption falls to less than 80% of the daily minimum recommended allowance of caloric intake for an individual to be active and healthy. In particular, food insecurity includes low food intake, variable access to food, and vulnerability a livelihood strategy that generates adequate food in good times but is

not resilient against shocks. These outcomes correspond broadly to chronic, cyclical, and transitory food insecurity, and all are endemic in Ethiopia (Devereux, 2000).

2.1.2. Concepts of distribution channel and marketing

Distribution is the allocation of income and assets within one society. Distribution encompasses a system of all activities that are related to the transfer of economic goods between manufacturers and consumers (Wirtschaft, 2011). Channel of distribution is the route along which goods and services travel from producer/manufacturer through marketing intermediaries (such as wholesalers, distributors, and retailers) to the final user. Channels of distribution provide downstream value by bringing finished products to end users (Coyle *et al.*, 2003). This flow may involve the physical movement of the product or simply the transfer of title to it. Also known as a distribution channel, a distribution chain, a supply chain, a marketing channel, a market channel, and a trade channel (Ostrow, 2009, 59).

Marketing is a societal process, by which individuals and groups obtain what they need through creating, offering and freely exchanging products, services and values with others. It also includes all activities of exchange conducted by producers and midd lemen in exchange for the purpose of satisfying consumer demand (Kilingo and Kariuki, 2001). Marketing also involves the movement of produces from their point of production to the point of consumption (Gindi *et al.,* 2014). Markets and improved market access plays an important role in improving rural incomes of smallholder farmers (Ouma, *et al.,* 2010).

Participation of smallholder farmers in markets in most sub-Saharan Africa countries remains low due to a range of constraints. One of the limiting constraints faced by smallholder farmers is linked to poor market access (Makhura, 2001). In rural areas, farmers lack sufficient means to overcome the costs of entering the market due to high transaction costs (Barrett, 2008; Komarek, 2010). Poor infrastructure and weak institutions cause transaction costs to rise, which considerably alter production and market-participation decisions. The majority of smallholder farmers are located in remote areas with poor transport and market infrastructures, contributing to the high transaction costs they are already facing. In addition, they lack reliable market information as well as information on potential exchange partners (Ouma *et al.,* 2010). Furthermore, in many instances, the poor do not possess the level of assets required to protect

themselves from market, natural, political and social shocks (Handley *et al.,* 2009). According to Barret (2008), private asset accumulation, public infrastructure and services are the prerequisites that smallholders need to escape from subsistence production and produce marketable surplus.

2.2.Theoretical approaches to food security

There are different theory related to food security, such as food availability decline, Food entitlement decline approach, food economy theory, political economy theory, vulnerability theory, ethno-cultural approaches and livelihood approaches. Those approaches generally have pointed out a number of environmental and socio-economic attributes assumed to explain famine and food security. The principal ones include rapid population growth, war and civil strife, drought, ecological degradation, government mismanagement, unequal access to resources and unequal exchange, socio-economic and political dislocation (Getachew, 1995). From those approaches, food availability decline approach and food entitlement decline approaches are more fitted with this study. The argument of this approach is that one or a combination of these can disrupt production and productivity of *dekoko* as well as its distribution.

2.2.1. The Food Availability Decline (FAD) Approach

The food availability decline approach had been a dominant theoretical explanatory framework for food crises since the eighteenth century until the year 1980. Sen (1980) defined FAD as "The availability decline per capita of food for consuming unit". Diana (2007) believes that famine mainly occurs because of natural disasters that destroy crops e.g., drought, floods and other calamities that undermine crops; or demographic factors, i.e., vegetative growth that goes beyond supply. The central argument of this model is that "anything which disrupts food production such as drought, flood disease and pests, poor agronomic practices lack of improved variety and low input required can cause low production and famine. The logic being that a drought, flood causes crop failure and reducing the availability of food in the affected region, and that such a food availability decline for an extended period by definition constituents of famine" (Markos, 1997; Devereux, 1988: as cited in Degefa, 2002). Hence, this argument indicates that there are different factors which causes decline in food production, and hence *dekoko* production. It is claimed that hunger and famine do not necessarily evolve from lack of food supplies in the provide market, but lack of resources in sectors to produce or purchase them. This criticism over FAD ended up in the alternative model of 'Entitlement' proposed by the economist Sen in 1981.

2.2.2. The Food Entitlement Decline (FED) Approach

Sen's influential book 'poverty and famine' (1981) decisively shifted the focus of famine analysis from supply side to the demand side. The entitlement approach emphasizes access to food, or people's relationship to the food, rather than the availability of food (Devereux and Maxwell, 2003). The main argument of this model is the mere presence of food in the economy or in the market does not entitle a person to consume it and thus starvation can set in without any obvious aggregate available fall (Getachew, 1995). Some of the catastrophic famines have occurred without FAD. For example, the Bengal famine of 1943, the Ethiopian famine of 1973 and 1984, and the Bangladesh famine of 1974 occurred due to lack of entitlement rather than due to lack of availability short fall (Fasil, 2005). Among many positive features of the FED approach over FAD, the following are very important: First, it has emphasized upon demand rather than supply. Second, it allows vulnerable groups to be identified. Finally, it suggests more appropriate policy intervention (Devereux and Maxwell, 2003). Although this approach has the above-mentioned strength upon FAD, it has also its own limitations. Generally, food security signifies the combination of the above two approaches and food utilization because enough food must be available, and households must have the capabilities to acquire it (Degefa, 2002).

2.3.Overviews of grain legumes production and productivity in Ethiopia

Legumes are grown traditionally in area of Mediterranean basin, Ethiopia, central and east Asia and northern Europe. More than 80% of faba bean cultivation is still being performed in developing countries where research funding and expertise approach is limited (Ana Torres and Carmen, 2011). Faba bean, chickpea, grass pea, and lentil are the most important crop within the crop livestock production system across the east African country (ICARDA, 2017). They are considered a vital crop for achieving food and nutritional security for both poor producers and consumers. It is estimated that, on average, the mean annual world grain legumes production was nearly 75.68 million tons during 2008 - 2017 (FAO, 2019). From 2006–2012, India stands first being the world's biggest producer of grain legumes, holding 32% of the world grain legumes harvested land and accounting for more than a quarter of global production (Ferede *et al.,* 2014) and followed by Myanmar, Canada, and China contributing 7% each. Africa as a whole account for 22% of the global production of grain legumes (Koroma *et al.,* 2016).Globally, soybean, faba bean, and groundnut have the highest yields, ranging between 1.5 tons/ha and 2.4 tons/ha.

Chickpea, pigeon pea, lentil and dry bean have yield levels of about 850 kg/ha. Cowpea has comparatively low yields at 0.5 tons/ha, but its yield levels are growing at an average rate of 2.9% per annum. The legume crops' yields in the developing regions are very low. However, in the case of chickpea, dry bean, lentil, pigeon pea and soybean, some developing regions have exceeded the developed countries in terms of yield levels (Nedumaran *et al.*, 2015). During 2014, dry beans accounted 33% and 38% of the production and area coverage, respectively, followed by chickpea, which accounted 16% in production and acreage of global grain legumes production.

Grain legumes are Ethiopia's second most important group of crops, after cereals, and together they provide food and income to more than 10 million households. The current data showed that Ethiopia belongs to the major legume-producing areas with marginal contribution in term of grain legumes production (3%) and area (2%) which means overall output of 3 million tons and overall acreage of production close to 2 million hectares (Atnaf *et al.*, 2015; Ferede *et al.*, 2014). Besides, Ethiopia is one of the top 10 producers of total grain legumes in the world, the second-largest producer of faba beans after China, the fifth- or sixth-largest producer of chickpeas and is the second-largest producer of grain legumes in the common market for eastern and southern African countries (COMESA region) following Sudan. Sudan and Ethiopia have 32% and 22% share of the total COMESA grain legumes production, respectively. The favorability of soil and climate conditions of Ethiopia for grain legume crops cultivation makes the country to be a huge producer and supplier of grain legumes in the international arena (GAIN, 2018; Getachew, 2019).

Ethiopia produces over 2.86 million metric tons of legume grain from a total area of 1.74 million hectares of land (CGIAR, 2012). Legume crops are grown as both cash crops (vegetables and potentially grain) and fodder crops. As rain fed crops, legumes are mostly mixed or intercropped with cereals or cultivated lone. Around twelve pulse grains are grown in the country; of these, faba bean (*Vicia faba L.*), field pea (*Pisum sativum L.*), chickpea (*Cicerarietinum L.),* lentil (*Lens cultinaris Medik.),* grass pea (*Lathyrus sativus L.),*fenugreek (*Trigonellafoenum-graecum L.)* and lupine (*Lupinusalbus L.)* are categorized as highland pulses and grown in the cooler highlands. Conversely, haricot bean (*Phaseolus vulgaris L.),* soya bean (*Glycine max L.),* cowpea (*Vignaunguiculata L.),* pigeon pea (*Cajanuscajan L.)* and mung beans are predominantly grown

in the warmer and low land parts of the country. Though pulses are grown throughout the country, mostly the production is concentrated in highland areas of the country. The productions of legumes vary across the national regions of Ethiopia, where Amhara and Oromiya accounted the major pulses production.

Table 2.1: Major legume producing regions in Ethiopia

Production of major pulse crops	Production shares (%) out of the country pulse production					Total crop production ('000tonnes/year)
	Amhara	Oromiya	SNNPR	Tigray	Ben-Gumz	
Faba beans	48	37	10	4	0	696
Field peas	20	58	18	1	2	330
Chickpeas	62	30	3	5	0	312
Haricot beans	42	37	15	5	0	268

Source: Chilot *et al.,* 2010

Ethiopia is the second center of diversity of legume grains and one of the nine major agro-geographical production regions of faba bean (Asfaw *et al.,* 1994).It is the high legume crop widely used in human alimentation and livestock feeding. Field crops such as faba bean are grown throughout the highlands and are most common in Woinadega between the altitudes 1800 m.a.s.l and 2400 m.a.s.l (Asfaw, 1985). Similarly, Ethiopia is one of the major producers of chickpea in the region occupying about 60% of the total area under legumes (Karanja, 2016). The recommended area for chickpea production is 200-1800 m.a.s.l. In Ethiopia, chickpea do well in Oromiya (East Shewa zone) and in Amhara (North Shewa and Gonder zone). The yield of chickpea ranges 1100-3800kg/ha of land based on the agro ecological condition and the level of improved farm input applied.

Considering the scheme of crop income of smallholder farmers, legume yields higher income compared to that of cereals (Chilot *et al.,* 2010). They demonstrated that pulses are generally more profitable than cereals and giving incentive to legume, farmers will have indirect impact for enhancing production of other crops. There is considerable scope for increasing legume production by popularizing the improved methods of intercropping, growing pulses even in non-traditional areas, cultivating them in off-season or growing them together with another crop in a

traditionally mono-cropped area. The most common agricultural technologies applied in legume farming includes high yielding varieties of seeds, use of chemical fertilizers and pesticides, irrigation and improved planting and weeding practices (UNCTAD, 2010). Improved seed is the lifeblood of legume farming. Good quality of seed that have genetic and physical purity, health standards, and high germination and moisture practices can increase farmers' production by 20-30% (Mula, 2012).

2.3.1. Field Pea production in Ethiopia

Agricultural biodiversity is the reservoir of irreplaceable genes and cluster of functionally related genes of several crops (Atta-Krah, 2004). Agricultural biodiversity is currently being lost at a rapid rate through genetic erosion. Agricultural biodiversity loss is because of the displacement landraces by modern varieties, dynamics of agriculture and land uses, destruction of natural habitats, and drought that finally lead to less productivity (Esquinas-Alcazar, 2005). Some crops, which were common in the past, have recently, become rare. Field pea (*Pisum sativum L.)* has been grown in Ethiopia since antiquity (Gemechu *et al.*, 2013). There are two botanical cultivars of *Pisum sativum* known to grow in Ethiopia, namely *P. sativum var. sativum and P. sativum var. Abyssinicum* (Gemechu *et al.,* 2013). The botanical cultivar *P. sativum var. Sativum* dominates the production system in the highlands of Ethiopia (Messiaen *et al.,* 2006) while P. sativumvar. Abyssinicum is limited to sporadic growth in some pouches, particularly in Wollo and Tigray (Gemechu *et al.*, 2013).

Like all other cool-season food legumes, the productivity of field pea in general and that of the Ethiopia pea in particular was very low in Ethiopia (Kelley *et al.*, 2000), which, among many other factors, may be attributed to poor soil fertility (Gemechu *et al.*, 2013; Berhane *et al.*, 2018). Nevertheless, field pea is widely grown in mid to high altitude and fourth most important legume crop in Ethiopia after faba bean, haricot bean and chickpea accounts for 13% of the total grain legume production and the average yield of 1.26 t/ha until 2011 which is very low (CSA, 2011). However, by 2015 the average yield of field pea in Ethiopia was stated to increase in yield (Cherinet and Tazebachew, 2015). This may be because of an increasing number of high yielding and disease-resistant varieties, good management practices, the supplement of organic and inorganic fertilizers, and reduction in insect and disease problems. Both field pea and Ethiopian pea are consumed as a protein supplement in the cereal-based diets of Ethiopia; however, there is

no national yield record yet for Ethiopian pea (Sintayehu, 2009). This signifies the current review to assess the distribution and productivity of the crucial crop.

2.3.2. *Dekoko* production and distribution in Ethiopia

Ethiopia is the largest producer of Cool-Season Food Legumes (CSFLs) in Africa and unique producer of *dekoko* (*Pisumsativum var. abyssinicum A. Bruan*) in the world. Hence, *dekoko* pea is native to Ethiopia (Haddis and Dargie, 2013). It has very low genetic diversity and possesses a distinct set of phenotypic characteristics (early flowering, an adaptation useful for avoiding drought periods; unipinnate and strongly serrate leaflets), as well as unique alleles at particular loci (Petr *et al.,* 2015). The taxon *Pisum sativum Var. Abyssinicum,* as its name implies, was initially found in the northern region now forming Ethiopia with two ethno linguistic regions of the country, Tigray and Amhara regions in the northern part of Ethiopia. According to some earlier views, *dekeko,* which was once common, is now very infrequently grown in some area of South Tigray and North Wollo. It had not reached other similar agro-ecological areas of the country although the crop was said to have been common in 'the era of Haile Selassie'. Yet it is important festival foods and, despite its high price, it is bought from Mekelle market in small quantities, four or five times a year (Wetterstrom, 2006).

According to Keneni *et al.* (2013), *dekoko* accessions may show genetic similarities regardless of the differences in places of origin. This may be related to the fact that the Abyssinian field pea exists in confined adjacent regions that could be considered similar in terms of both agro-ecology and crop production system under which distinct pattern of evolution may not be expected. A study also suggested that differences in eco-geographic origin might not necessarily suggest presence of genetic divergence for other morpho-agronomic traits (Keneni *et al.,* 2013).

Dekoko is an important crop in mixed farming and is widely mixed with the main cereal crops growing in south Tigray such as sorghum, barely and *teff* and is the potential grain growing or cultivated in the region with chickpea, linseed, grass pea and fenugreek as reported by Girmay *et al.* (2014). CSFLs including *dekoko* are largely produced by subsistence farmers and serve as supplementary protein sources and soil fertility restorers. Yields are very low, mainly limited by soil fertility Yemane and Skjelvag (2002) as CSFLs are cultivated in poor soils, often without fertilization. However, CSFLs require an adequate supply of nutrients for optimum growth and

yield (Yemane and Skjelvåg, 2002). Therefore, enhancing the productivity of CSFLs through improved agronomic practice, such as fertilization, expanding in distribution of localized crops like *dekoko* to other agro-ecological area contribute to sustainable crop production in Ethiopia. Knowledge on the distribution and productivity of native important crops but underutilized is crucial for the discovery of modern productive crops. Because, modern crops have been gradually derived from their wild ancestors through continual selection for larger size, improved fruit, and other desired traits (Esquinas, 2005).

2.3.2.1.*Dekoko* and food security

FAO defines food security as: "exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"(FAO, 2010b:8). *Dekoko* can play an important role in supporting rural livelihoods and in addressing food and nutritional security problems and have impact on the different dimensions of food security. The availability and getting enough food in the rural household mostly depends on their production and productivity amount. Food availability relates to physical presence of sufficient quantity and appropriate quality of food from own production, stocks, markets, food aid and communal resources. Improving the production and diversified household food intakes, depends on improved *dekoko* production has vital role on production and food security of households (Siamwalla & Valdes, 1980; Ziervogel & Ericksen, 2010).

Increasing *dekoko* production and productivity plays an important role on rural livelihood of farmers in terms of income diversity of the farmers, source of cash for family need and expenditure for school fee by increasing production and productivity. On the other hand, household food diversity and food availability are the criterion for the nutritional effects. Generally, grain legumes particularly *dekoko* are not only a source of protein and other minerals but are also considered to play important roles in the nutritional and health of many rural small holder farmers. They form a major diet for the rural household who cannot afford the relatively more expensive animal proteins. *Dekoko* seeds contain higher Crude Protein (CP) than Ater both in the cotyledon (251 vs. 242 g/kg DM) and whole seed flours (235 vs. 229 g/kg DM) also the cotyledon flours contain higher CP than whole seed flours in *dekoko* seeds. The higher crude protein in *dekoko* relatively from common pea is due to less incorporation of the seed coat in to the *dekoko* seeds. In general,

the CP contents for *dekoko* seeds are within the ranges reported by a number of workers (Zdunczyk *et al.*, 1997 in Yemane and Skjelvåg, 2003b), which are in the range of 207–264 g/kg DM for different pea varieties. Such broad variation in protein content could emanate from genetic differences and variations in growth conditions (soil, fertilizer, etc.). Peas, in general, are known to have low fat contents. It is in the range of 1-2% (Yemane and Skjelvåg, 2003b).

Fat content of *dekoko* is higher than Ater, which contains both in the cotyledon (16.6 g/kg DM) and whole seed (15.3 g/kg DM) flours than those of *dekoko* cotyledon and whole seeds. Fat is an important source of energy. Its presence also makes food more palatable (Yemane and Skjelvåg, 2003b). The appreciation of the local people for *dekoko*, in terms of its taste, could be attributed to its relatively higher fat content, although there could be other factors that affect the sensory taste of consumers.

Dekoko had a higher NDF content in its cotyledon (131 g/kg DM) than that of Ater (109 g/kg DM) (Yemane and Skjelvåg, 2003b). NDF measures a fraction of the dietary fiber-the insoluble fraction (Yemane and Skjelva˚g, 2003b), which is mainly composed of cellulose, hemicelluloses, and lignin. Among the 20 building block proteins (standard amino acids) glutamine is found in highest level, followed by asparagines and arginine in *dekoko* and its relative common pea, Ater. These amino acids constituted about 39% of the total amino acid content in both peas. Glutamine is lower in *dekoko* than in Ater, but they have a difference in relativity only by 4%. Sulfur containing amino acids (methionine and cysteine) exist in smaller quantities (3.01 in *dekoko* and 2.23 g/16 g N in Ater), like in other legumes reported by a number of workers, which are in the range of 2.2 - 3.5 g/16 g N. The sulfur containing amino acids (methionine and cysteine) values for *dekoko* are also higher than those reported values for a number of pea cultivars, with the maximum value for *dekoko* about 2.8 g/16 g N even if it is limited to a single accession with a single study report. According to Yemane and Skjelvåg (2003a), the higher total sulfur amino acids content of *dekoko* compared with common pea might indicate its primitive nature, as primitive and small seeded peas exhibit a higher relative amount of total sulfur amino acids (Yemane and Skjelvåg, 2003b).

In addition to this *dekoko* is considered as cash crop and known by its high prices. Cash crops (defined as farm output that is sold on a formal agricultural market) are an integral part of

strategies to improve food security, both at the level of governments as well as farm households in developing countries with a substantial agricultural sector. The price of *dekoko* pea (more than 70Ethiopian birr per kilogram) is two times more than the price of common pea during the market survey time in all agro-ecologies nearby markets analogous to the assertion by Yemane and Skjelvåg (2003). Therefore, the crop is used to generate more income and therefore improve access to food for those who earn that income. The access dimension of food security includes the physical access (ability to acquire food physically), economic access (ability to buy food) and social access (ability to acquire food through social capital) (WFP, 2004). Farm revenues from *dekoko* pea are often invested in food production and others, for example in the increased use of farm inputs, raising food production, cover some goods for their home, clothes, and other expenses for their children.

On the other hand, the income, which they get from *dekoko*, is important for stability of staple food. Because *dekoko* is early mature pea, they can be produce two or more than two times in a year and prepared for the market. So that they can full fill what they need and helpful to expand the prescience of staple food in their home for long time. Generally, income growth also has implications for food availability, utilization and stability of food.

2.4.Review of empirical studies

2.4.1. Contribution of grain legumes to smallholder livelihoods

Grain legumes hold a vital consequence in Ethiopia with various roles at diverse levels ranging from the farm household to the national economy at large. According to a report by Ferede *et al.* (2014), more than 8.5 million smallholder farmers are engaged in grain legumes production to generate their livelihoods. Because most legumes produce several products and serve for various purposes, during their growth or after harvest and are often referred to as being multi-purpose (Muoni *et al.,* 2019). These benefits include improving food and nutrition security, supplying income, soil fertility improvement, providing livestock feed, improving soil fertility, controlling soil erosion, water conservation, acting as a source of fuel and a range of other benefits. The contributions of grain legumes are illustrated below:

Provision of household food and nutrition

Grain legumes are well known for their nutritional values. Their seeds contain protein, soluble and insoluble fiber, slowly digested starch, micro and macronutrients, vitamins and numerous bioactive phyto-chemicals, such as flavonoids and other antioxidants (Watson *et al.*, 2017). In terms of household consumption, grain legumes provide a cost-effective source of protein that accounts for approximately 15% of protein intake in Ethiopia (Yirga *et al.*, 2010). In Ethiopia, grain legumes are used for the preparation of various traditional foods although the `methods of utilization of these food legume crops show somehow a sort of variability. For instance, "Wot" (grain legume stews) is the most widely served traditional dish in Ethiopia prepared from whole or dehusked and split legume seeds and/or its flour, which can also be mixed with other food grains to prepare different traditional food items such as "Shiro" and bread.

Legume crops are widely considered as healthy foods, and constitute important components of the vegetarian dietary system for millions of low-income people in the developing world. It is estimated that, on average, legume crops contribute to 7.5% and 3% of the total protein and calorie consumption in developing countries, respectively (Ferede *et al.,* 2014). Therefore, the nutritional study of the legume crops is of paramount importance, and accordingly, nutritional profile of the major food legumes has been analyzed, and existing varieties have been ranked according to their nutritional qualities. Breeding efforts on micronutrient (iron, zinc) enrichment in lentils and common beans have also resulted in the release of some micronutrient dense legume cultivars (Fikre, 2016).

Income source and generation

Grain legumes are important export commodity and sources of cash income for smallholder farmers as they are highly demanded in local and export markets (Ferede *et al.,* 2014).They have an income benefit both in terms of diversification and as they produce a higher gross margin than cereals. According to Yirga *et al.* (2010), grain legumes are generally more profitable than cereals, giving smallholders an economic incentive to their livelihood. Income generation from grain legumes can be through selling the products from legumes including grain, construction poles, livestock feed or livestock products derived from better feeding (Muoni, 2019).

Besides, grain legumes gained the momentum to become strategic export commodities in diversifying and generating the sources of Ethiopian foreign exchange earnings (Yirga *et al.,*

2010). According to a report by Ferede *et al.* (2014), there has been a major improvement in export performance and income generation in terms of grain legumes value, volume and composition. For instance, the export revenue from grain legumes has increased from 35 million USD in 2005/06 to 160 million USD in 2011/12 with a corresponding growth in volume from 110 metric tons to 226 metric tons. Further, Ethiopia exported 340,000 metric tons of grain legumes in 2016/17, earning 255 million USD of which dried kidney beans (haricot beans) were the top-exported grain legumes, accounting for about half of all export volume (USDA Foreign Agricultural Service, 2018).

Ethiopian grain legumes export has been increasing significant over the last decade mainly due to the ongoing promotion of commercialization of smallholder farmers and better incentives from global legume markets. For instance, in terms of composition of export, haricot bean stands first by contributing about 45% and 43% of the total grain legumes export volume and value, respectively, followed by chickpea (24%), faba bean (20%) and mung bean (6%). Lentil is the fifth major legume export commodity by accounting for nearly 4% of the total legume export volume. Moreover, there is a varying trend in the composition of grain legumes export where legume export commodities such as chickpea, faba bean, and lentil have emerged to take a significant position in export trade. Generally, smallholder income could be increased by at least 40–70% per hectare of legumes planted with better inputs and sound agronomic practices. In other words, there is an opportunity to stabilize and increase supply by improving production up to the full potential which would meet domestic demands. In addition, Ethiopia could expand its foreign market presence through increased production levels, which will lead to at least doubling of its current annual exports (Atnaf *et al.*, 2015; Getachew, 2019).

Soil fertility improvement

Grain legumes serve as an important crop in different cropping systems for maintaining soil fertility through fixing atmospheric nitrogen into the soil and enhancing the biological turnover of phosphorous. It is estimated that globally, about 190 million ha of grain legumes contribute around 5 to 7 million tons of nitrogen to soils (Vidigal *et al.*, 2019). Legumes have nitrogen-fixing properties that can reduce fertilizer usage for cereals in the next season by up to 60%. Given that cereal production causes higher soil nutrient depletion, intercropping and rotating

between legume and cereal contribute towards maintaining soil health and can also reduce fertilizer usage (Yirga *et al.,* 2010). Legumes used as green manures can also provide considerable amounts of nitrogen to the soil that can greatly benefit subsequent crops. Leaf fall during crop legume development in the nodulated roots is also reported to contain up to 40 kg nitrogen ha−1 (Srinivasarao *et al.,* 2012). There is recent evidence that using grain legumes in agricultural system increases organic matter and improves soil structure (Vidigal *et al.,* 2019).

However, soil fertility benefits of legume depends on the legume cereal ratio, the duration of legume biomass production and residue management. For instance, edible legumes are usually harvested and their leaves are used as a vegetable or for forage thereby reducing nutrient input to the soil. The nitrogen benefit of including a grain legume in a rotation has been estimated as0–90 kg N ha−1 for short or medium-duration soybean and generally higher for a longer-duration legume, such as pigeon pea that grows for about 180 days (Kerr *et al.,* 2007).

Livestock feed and fodder

In addition to human consumption, legumes can be used for fodder due to their high protein content compared to many other fodders that are used to feed livestock. The fact that most legumes have a dual purpose (i.e., human and animal feed) makes them ideal for inclusion in crop livestock systems that characterize smallholder agricultural system. Grain legumes can be utilized flexibly in diets of all ruminant species either in concentrate compound feed or as whole-crop forage (Watson *et al.,* 2017). Moreover, the value of grain legumes in livestock production has been explored for forage legumes such as alfafa (Medicago sativa), clover (Trifolium spp.) and vetch (Vicia sativa) (Chibarabada, Modi, & Mabhaudhi, 2017).

Inclusion of grain legumes in animal feed reported to be critical for sustainable meat and dairy production (Graham & Vance, 2003). Ibeawuchi (2007) reported that legumes are widely grown across. Legumes have also been shown to improve both the quantity and quality of fodder, and thus, sustain feed production during the dry season and increase livestock productivity. Research in Ethiopian highlands also showed that forage legumes significantly increased the total fodder yield of barley and maize straw plus forage (Kassie, 2011). Grain legumes can also be used to make concentrates for livestock feed. For instance, unprocessed seeds of lupins and cowpea among others can be used to feed livestock. Groundnut is a potential livestock feed, where both

haulms and seeds can be fed to livestock. The haulms may be fed directly or mixed with other fodder crops (Muoni, 2019).

Soil protection from erosion and water conservation

Legumes contribute to soil and water conservation in several ways including provision of soil cover during and after cropping seasons. The soil cover could be from crop residues laid as mulching material or from the live crop. High soil cover blocks the sun from directly heating the soil, which reduces evaporation of water (Muoni, 2019). The residues from grain legumes cultivation can also preserve soil moisture, prevent soil erosion, and increase yields in the same piece of land (Vidigal *et al.,* 2019). In the intercropping system, legumes control soil erosion by preventing rain drops from hitting the bare soil where they tend to cover surface pores, prevent water from entering the soil and increase surface runoff. In maize-cowpea intercropping system, cow pea act as the best cover crop and reduced soil erosion. Similarly, sorghum-cowpea intercropping reduced runoff by 20–30% compared with sorghum sole crop and by 45–55% compared with cowpea monoculture. Taller legume crops act as wind barrier for short crops and controlling soil erosion especially in intercrops of taller cereals with short legume crops (Matusso *et al.,* 2014; Nweke, 2018).

Provision of fuel

Approximately 80% of households in Sub-Saharan Africa use solid fuel for cooking and this result in a high demand for wood energy (Muoni, 2019). Hence, legumes are an integral part of household subsistence needs providing fuel wood. Especially, fast-growing legumes are commonly used for fuel wood. Additionally, crop residues of grain legumes including soybean, cowpeas and beans are used as kindling and occasionally for cooking (Duncan *et al.,* 2018).

2.4.2. Major constraints of grain legumes production in Ethiopia

Although Ethiopia has huge potential to produce different grain legumes and benefit from their multiple uses, a number of constraints and considerable gaps affects the production and productivity of grain legumes in the country. Research and extension services in Ethiopia are very often weak and information provided to farmers is usually limited (Koroma *et al.,* 2016).Due to this, grain legumes have received less attention as compared to cereal crops in terms of crop management and input utilization by different development actors' especially

smallholder farmers (Atnaf *et al.,* 2015; Muoni *et al.,* 2019). Getachew (2019) indicated that the production and productivity of grain legumes in Ethiopia appears to be severely constrained by four major factors. These are limited or no use of chemical fertilizers, improved seeds, limited use of conventional agronomic practices, and human factors such as access and control over resources. Mainly, the limited availability of chemicals to control plant diseases and pests caused low productivity of legume crops. Smallholder farmers encourage mono cropping and continuous cultivation of the same piece of land with limited use of agricultural inputs and soil amendment practices which result in soil nutrient depletion and create better conditions for pests and diseases thereby reducing the production and productivity (Habte *et al.,* 2018; Koroma *et al.,* 2016).

The available high-yielding legume varieties with market-preferred traits have not reached farmers on a large scale, and hence, the productivity of the crop has remained one of the lowest in the world. Farmers use local landraces, which do not meet the quality and quantity requirements of international market despite their preference by domestic markets. Poor and inadequate seed systems, shortage of quality seed, lack of timely delivery and insufficient access to production credit to farmers are also major constraints of producing legumes in larger (Asfaw *et al.,* 2010). Besides, declining soil fertility, insect pests and diseases are constraints limiting the production of grain legumes (Habte *et al.,* 2018; Schneider & Anderson, 2010). Marketing and connected problems are another reason for the low production of grain legumes in Ethiopia. The link between producers and the export markets is weak due to a large number of ineffective intermediaries operating in the value chain. The intermediaries have failed to acquire large scale and only operate in limited geographic areas. The fragmentation of intermediaries between the producer and consumer markets also creates a lack of transparency in markets (Yirga *et al.,* 2010). High operational costs due to high transport costs, inadequate and poorly designed storage facilities, inadequate flow of market information, quantity and quality of supplies are among the sources of high marketing costs affecting the production and marketing of grain legumes (Atnaf *et al.,* 2015; Habte *et al.,* 2018).

Furthermore, Muoni *et al.* (2019) indicated that legumes production and productivity is lower than expected in East Africa including in Ethiopia due to five important constraints. First, farmers are not willing to test legumes species that are new to them due to limited resources and

technologies; Second, insecure land tenure system in smallholder farms; Third, limited access to inputs and output markets; Fourth, high disease and pest incidences associated with management of legumes; and Fifth, cereal dominated farming system. Generally, the low potential of grain legumes production and productivity is primarily due to low input usage, limited availability of seed and limited familiarity with the variety of existing legumes, and limited usage of modern agronomic practices, market problems and poor extension services.

2.4.3. Market channels and outlets

Recent empirical studies of market outlet choice show that smallholder farmers considerd a set (bundle) of possible outlets and choose the particular marketing outlet that maximizes expected utility (Takele *et al.,* 2017; Kassa *et al.*2017; Mekonin, 2017; Addisu, 2018). Wheat supply chain in Ethiopia consists of seven to ten marketing channels or outlets (Woldehanna *et al.,* 2010). Smallholder farmer‘s decision to select a given market outlet is made by evaluating the return in expected utility, taking into account the related investment and transaction costs (Urquieta, 2009).

There are a number of empirical studies on the determinants of market outlet choice of agricultural commodities. The gender of the household head is expected to affect the type of marketing channel used in that female producers are expected to use direct marketing channels (sell to other households) compared to male producers. Female farmers have differential levels of wealth, knowledge of trader networks and access to market information, and hence differences in the extent and nature of their transactions in out put markets is expected (Hills, *et.al.,* 2009).

Addisu (2018) employed Multivariate Probit (MVP) model to identify factors affecting market outlet choice of teff producers in Dendi district of Oromia, central Ethiopia. The multivariate probit model results revealed that variables like household size number of equines owned, education level of the household head, size of land under *teff* production, distance from the nearest market, current market prices of *teff*, and cooperative membership affected the choice of appropriate market outlets of producers. Takele *et al.* (2017) identified on important determinants of market outlet choice of smallholder mango producers in Boloso Bombe *Woreda*, Wolaita zone, Southern Ethiopia using multivariate probit model. Theresult showed that variables such as family size, distance to the market, quantity of mango produced, the price

offered, access to market information and access to non- farm income determined the decision of choice of wholesaler, collector, retailer and consumer market outlets at different significance level. Shewaye (2016) used MVP model to identify factors affecting haricot bean market outlet choices in East Badawacho district, Southern Ethiopia. The result of MVP model revealed that distance to all weather roads and distance to the nearest district market positively affect the probability to choose rural assemblers market outlet whereas number of equine owned and use of credit has a negative effect.

Number of livestock owned positively affects the probability to choose direct consumers outlet. Number of equine owned, use of credit, membership in cooperative and price information positively affect the probability to choose urban traders outlet, whereas distance to the nearest district market negatively affect the probability to choose the urban traders outlet. Sultan (2016) identified factors affecting wheat market outlet choice of producers at Sinana district of Bale zone using multinomial logistic regression model. He indicated that compared to accessing assembler market outlet, wholesalers market outlet are influenced by frequency of extension contact, distance from market place, own price of the commodity and membership to cooperative while that cooperative wheat market outlet influenced by price given to the commodity at different outlets.

In a study on infrastructure and market access in Madagascar, Minot (1999) showed that the choice between traders is negatively related to the distance to market sites. Thus, the author concluded that a great deal of the trade in agricultural products happens in regular market sites while only a minority happens in the village itself. Thus, the closer the village is to a market site, the higher the probability that farmers will have choice between traders. Hence, the expectation is that distance will negatively affect decision to sell and that the longer the distance the more farmers sell locally to other households. Off-farm employment reflects off farm income. Income from other sources other than the farm may enable the farmer to purchase necessary inputs to meet quality requirements of the sustainable beans marketing channel (Angula, 2010).It is expected that off farm employment will have an impact on amount harvested and hence an impact on market participation. Off-farm employed farmers are expected to sell beans to private traders to accommodate more bulky sells that accords them a chance for other activities.

Mekonin (2017) used MVP model to determine market outlet choice and livelihood outcomes of coffee producing farmers in Lalo Assabi district in Oromiya region. He confirmed that extension contact, education, market distance, non/off-farm income, and cooperative membership influence outlet choice decisions in all outlet channels selected. Sunga (2011) identified basic factors influencing bean producers 'choice of marketing channels in Zambia. He indicated that the choice of marketing channel is directly influenced by the price of beans, scale of operation (as measured by the quantity of beans harvested, and quantity sold), distance to the market, farming mechanization used and livestock ownership were significant determinants of bean producers' choice in Zambia.

2.5.Literature gap

From the above theoretical and empirical literature reviewed, it can be understood that, most of the study focused on different types of grain legumes (except *dekoko* pea) and determining factors or implication of rural household income and market channel choice decision. However, this study tried to examine factors that affect the production of *dekoko* pea, factor affecting market channel choice decision of *dekoko* pea producers, as well as its implication on the rural household food security. Therefore, information from this study is contribute to fill the knowledge gap regarding to food security and in drawing the attention of researchers related to this area. Generally, this study investigated *dekoko* pea for its importance as anti-famine food security source by subsistence farming system, and that it will receive greater attention and interest from many international research and development organizations working in the country and beyond.

2.6.Conceptual framework

The framework is constructed based on experiences and reading of various literatures related to *dekoko* production and distribution in different time and place. The framework contains different factors affecting the production and distribution channel of *dekoko*. These are institutional, socio-economic, biophysical and demographic factors. Socio-economic factors that relate to social activities and capital of farmers like wealth status of household, sociial position of household head, irrigation use, fertilizer use, household farm status, the household Total Livestock Unit (TLU) and engagements with off-farm activities. The other major factors considered are institutional factors. Such factors include credit availability and access, participation in extension

program and access to market are the major factors farmers faced in the institution side. The other factor one is biophysical like pest and diseases, rainfall, soil type, seeding rate, management practices. The last one is demographic factors including education level of farmers; the age and sex of the household head also have a big role in the productivity of *dekoko* in rural households.

In addition, *dekoko* production and productivity directly affects the four key dimensions of Food Security (FS) including food availability, food access, food utilization and stable required living an active and healthy life. *Dekoko* can contribute to meeting both nutrition and food security; provide a good source of plant based protein as well as contributing to a healthy, balanced diet and uses as source of income, feed of livestock and other ways. When the productivity of *dekoko* increases, the access to generate income is increases and availability of adequate and diversified food increases. The same is true when the production increases the stability of staple food increases. The farmer market channel choice is also depend on the amount of the products produced. So, the more they produce the more they prefer to sell their product for wholesaler than retailer. Therefore, it can be distributed to other areas of the country. However, when the production and productivity decreases by those factors (socio-economic, demographic, biophysical and institutional) in one way and another affects the distribution channel as well as the food security status of the households.

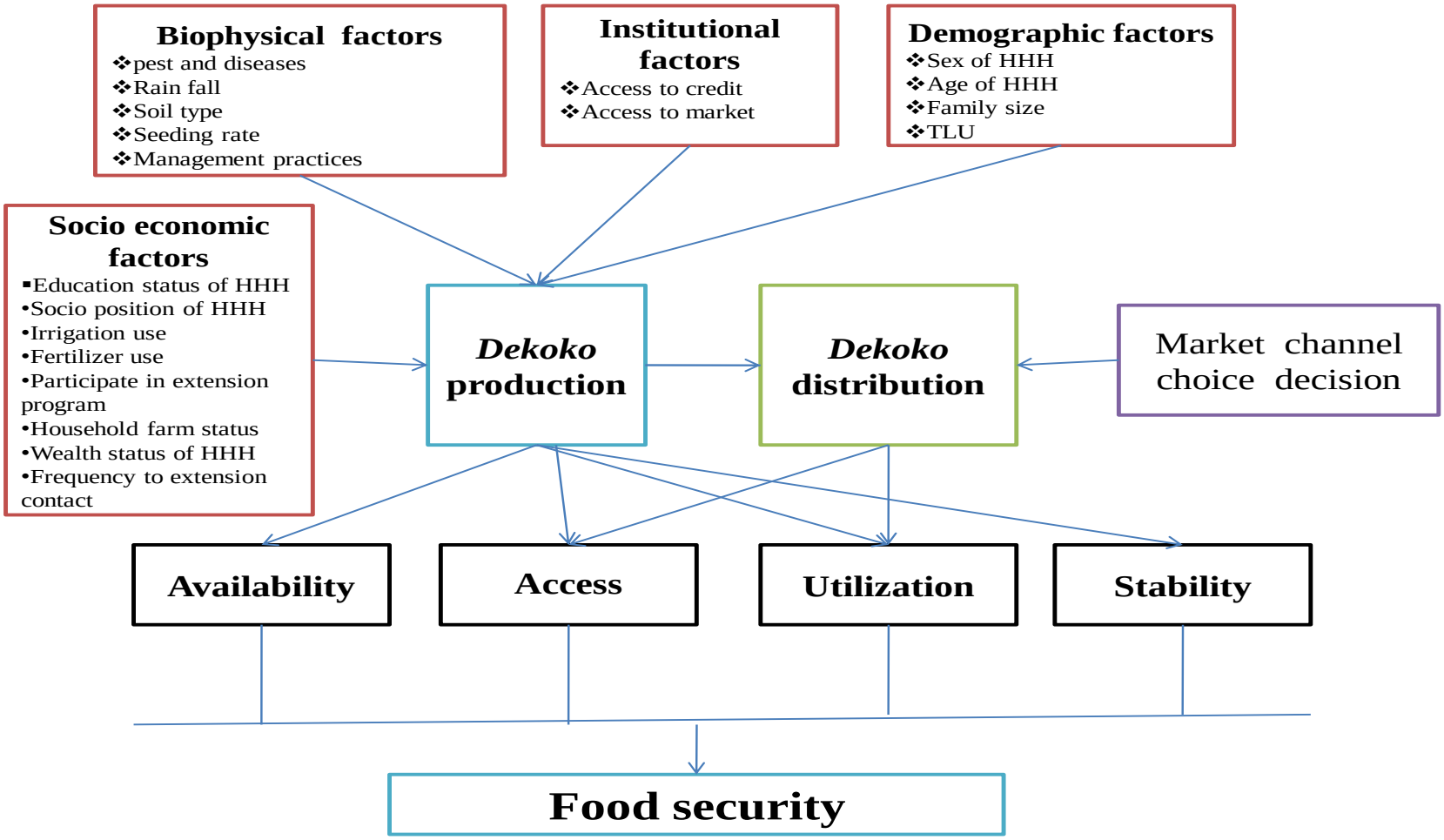

Figure 2.1: Conceptual framework of factors affecting *dekoko* production, distribution channel and its implication to household food security.

Source: Own construction based on the literature reviewed.

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA AND RESEARCHMETHODS

3.1.Description of the study area

The study was conducted in the Northeast Ethiopia in Amhara and Tigray regions (Figure 3.1) Ethiopia. Southern zone of Tigray is one of the seven administrative zones in the Tigray National Regional State. It is located at 680 km North of Addis Ababa, the capital city of Ethiopia and 180 km South of Mekelle, the capital city of the Tigray regional state. Geo-graphically, it is located between 12° 15′and 13° 41′ North latitude and 38° 59′and 39° 54′ East longitude with an altitudinal range of 1350–3925 m.a.s.l. There are six *Woredas* in the zone and has a total population of 613,563, of which 51 percent are female (CSA, 2008). The zone has bimodal rainfall with erratic pattern. "*Belg*" rain is the small rain occurring usually from February to April. The second rainy season is "*keremt*" from June to early September. Despite the shortage and variability in its occurrence, the bimodal pattern of rainfall has allowed the production of two cropping seasons in some *Woredas* of the zone (South Tigray zone Agriculture and Rural Development Office, 2009). Southern zone of Tigray was purposively selected for its main *dekoko* growing potential.

The North Wollo administrative zone is one of the eleven zones of the Amhara regional state of Northern Ethiopia. The zone is geographically located between 11^0N to 13^0 North latitude and 38^0E to 40^0 East longitude. The altitude of the zone varies from 600 to 4284 m.a.s.l. The administrative zone has nine *Woredas*, namely, Guba Lafto, Habru, Delanta, Meket, Wadla, Bugna and Gidan. Its administrative town, Woldia, is located 380km North East of Bahir Dar and 521km north of Addis Ababa. According to 2007 census, the zone has a total population of 1,500,303, and 355,974 households. The North Wollo East Plain livelihood zone encompasses Habru, Raya Kobo and the lowland areas of Guba Lafto districts; Northeast Midland mixed cereal livelihood zone includes Bugna, Lasta and parts of Gidan.

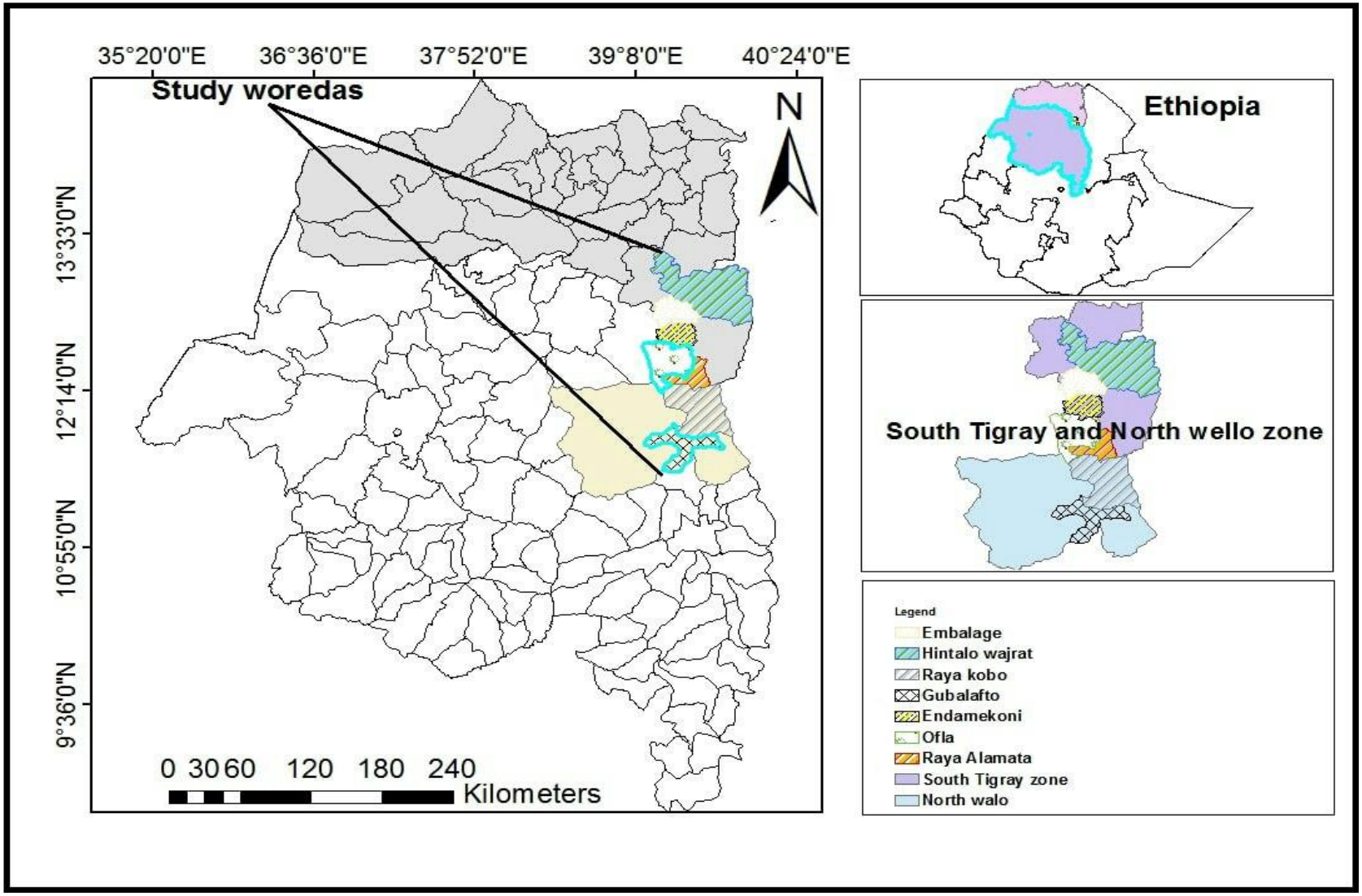

Figure 3.1: Map of Northeast Ethiopia, *dekoko* producting areas

Source: CSA 2015, Ethio-GIS 2020

Table 3.1: Geographical and climetical features of the study area

Region/ Zone	*Woreda*	Major agro-ecology	Altitude of *woreda* (masl)	Annual rainfall(mm)	Average annual Temp (^{0}C)	Dominant soil types	Dominant crops grown
South Tigray	**Ofla**	High land	1700-2457	980.5-1050	22.28 - 7.69	Vertisols	Wheat maize, barley, teff and legume crops.
	Emba Alaje	High land	2116- 3840	580-845	14- 22	Eutric cambi sols with eutric rego sols/litho sols	wheat, barley, pea and bean and different varieties of vegetables and fruits
	Endamekhoni	High land	2100-3250	850 – 1110	22 – 28	Chromic vertisols with Eutric cambisols	wheat, barley, faba bean and maize
	Hintalo Wejerat	Mid land	1400-3050	350-700	16.8	Black soil	wheat, barley, and teff
	Raya Alamata	Low land	1178-1800	831	16-27	Chromic verti sols with eutric Cambisols	Sorghum, maize, teff and irrigated fruits
North Wollo Amhara	**Guba Lafto**	High land	1379-3200	500-800	13.5-25.4	Lithic Leptosols, Eutric Cambisols and Eutric Leptosols	barley, wheat, oats, pulses and flax
	Raya Kobo	Low land	1100-1470	500-850	11.68-26.82	fluvisols, vertisols, cambisols, regosols, xerosols, leptosols, and andosol	Sorghum, teff, maize, barley, filed pea, chick pea, and onion

Source: Ethiopa National Metrological Agency (NMA), 2020

3.2.Research design

A research design provides a context within which a study is conducted (Daniel, 2010). A cross-sectional study design was used to determine factors affecting *dekoko* production, distribution, and its implication to household food security of *dekoko* producer. A questionnaire survey is usually the best method of data collection in such a design. Mixed approach or both qualitative and quantitative approach was used to collect data from primary and secondary sources in order to produce a comprehensive analysis of the study. The methodology that was employed in the study was quantitative, involving the collection of data using a structured questionnaire and analytic result supplemented by qualitative data in order to make the result sound. In order to make a triangulation and increase the validity of the data, the collected data were compared with other sources of information, particularly by interviewing the representatives of *dekoko* producers and agriculture research center in each *Woredas*.

3.3.Sampling technique and sample size determination

This specific study was employed multistage sampling procedure. In the first stage, purposive sampling technique was used to select seven *Woredas* from the two Zones; Amba Alaje, Endamehoni, Raya Almata, Hintalo Wajirat and Ofla were selected from 19 *Woredas* of South Tigray region, and Guba-Lafto and Raya Kobo from 11 *Woredas* of North Wollo Amhara region were selected based on the current production potential of *dekoko* crop. In the second stage, stratified sampling technique was employed to select three rural *Kebeles* from the total rural *Kebeles* in the *Woredas. Kebeles* in the *Woreda* were stratified based on their existing agro-ecological zones, which are high and mid altitude areas (*Weynadeg*a, *Dega)* to ensure most representation stratum. The sample *Kebeles* are where *dekoko* crop cultivated according to the data obtained from the *Woreda* agricultural office. In the third stage, within the three *Kebeles* in each *Woredas*, the respondent households were stratified into two groups: *dekoko* producers and non-producers. At the end, simple random sampling technique was applied to select the sample household farmers. A total of 288 samples were selected, out of which 112 are producers and 176 non-producers. According to this study, non-producer households are households who were not producing *dekoko* in the last five years and producer households are households who produce *dekoko* in the last five years. The sample of the respondent households was selected in a representative way of selection with ± 5% precision level, and 95% confidence interval. The

main reason was to get enough number of matches that enabled to give generation on research objectives. In order to determine respective samples from twenty one *Kebeles* of reach stratum, selected by using probability proportional to size of population. Finally, representative sample for each stratum was selected by using probability proportional to size across each *Kebele*. The sample size for the study is identified by using Cochran's (1977) formula.

$$n = \frac{pqz^2}{u^2}$$

Where,

n = the desire sample size

p = the estimated proportion of *dekoko* producers an attribute that is present in the population (expected prevalence of producer households)

q= 1-p (P is the estimated proportion of producers an attribute that is present in the population)

Z = Z- Score (critical value associated with appropriately chosen level of confidence)

u = the desired level of precision or marginal error

To estimate the sample size, the expected prevalence for the study area is not known for there were limited similar studies carried out. Therefore, assume p=25% (maximum expected prevalence). Accordingly, the desired level of precision 5% with 95% level of confidence the Z value equals 1.96.

$$\frac{0.25*0.75*(1.96)^2}{0.05^2} = 288$$

Table 3.2: Sample size *Woredas*

Study *Woredas* and *kebles*		Sample *Kebles*	Population size (N)		Sampling size (n)		Total sample
			Dekoko producer 25%	Non-producer 75%	Sample households from *dekoko* producer	Sample households from non producer	
NORTH EAST ETHIOPIA	Ofla	Hashenge	65	1638	5	13	18
		Hegum berda	130	1458	2	6	8
		Merewa	73	1535	6	7	13
	Endemhoni	Tathaya	188	1320	3	6	9
		Semorat	87	1518	7	10	17
		Tsbet	101	1819	8	11	19
	Entalo Wajerat	Bahir Tseba	168	1820	2	5	7
		Adikeyhe	55	1578	4	8	12
		Adimseno	90	1650	7	7	14
	Emba Alaje	Astela	173	1525	7	9	16
		Ayeba	333	1659	8	12	20
		Sesat	264	1801	6	10	16
	Raya Almata	Tsestra	143	1497	2	5	7
		Merwaz	90	1248	7	10	17
		Akjera	146	1375	1	6	7
	Raya Kobo	Ayeda	148	1753	5	8	13
		Deno	105	1569	8	11	19
		Jmedo	98	1819	7	10	17
	Guba Lafto	Gubarja	375	911	8	7	15
		Wedmen	497	1040	7	8	15
		Shema feje	248	890	2	7	9
Total			**3,577**	**31,423**	**112**	**176**	**288**

Source: Owen computation, based on the data obtained from the study *woreda's*

3.4.Data types, source and collection techniques

All relevant primary and secondary data source were employed in the study. Primary data was collected from household survey, minutes of launching workshop, key informant interviews and field observations, while secondary data were collected from reviewed various published and unpublished works on *dekoko* production and food security related materials.

3.4.1. Household surveys

Questionnaire based surveys was administered to sample farmer households by obtaining the consent of the respondents as a research ethics. The questioner was translated in to Tigrinya and Amharic for the purpose of simplicity of communication between enumerators and respondent with this technique data related to socioeconomic, institutional, demographic features that listed in the explanatory variables includes the determinant factors that affect *dekoko* production and distribution as well as its implication to household food security. Data collector's were oriented on issues related to data collection procedures and ethics. Pilot study was undertaken for pre-testing the questionnaire in order to estimate the time needed to complete and implement it.

3.4.2. Minutes of launching workshop

A launching workshop was carried out in Addis View Hotel, Addis Ababa, Ethiopia. The program was fully financed by the US Department of Agriculture (USDA) Foreign Agricultural Service (FAS). This workshop brought together scientists from Universities, Federal and Regional Agricultural Research Institutes, Heads of *Woreda* Bureaus of Agriculture, Extension workers and model farmers from "*Dekoko*" growing areas in order to collect their opinion. Hence, minutes of launching workshop was used as a source of data for this study. In addition, those participants were respectfully requested for their consent, time and the information. The qualitative and quantitative description about the *dekoko* production status and the factors that influence *dekoko* production as well as the implication to household food security was discussed.

3.4.3. Key Informant Interviews (KII)

Key informant interviews were carried out to collect required primary data that led to discussion with concerned bodies to obtain information about the issues related to the study objectives. The interviews was carried out with the head of *woreda* agriculture office, agriculture research center experts and *kebele* level extension agents. The interview washeld using check list.

3.4.4. Field observation

Field observation was carried out to in the selected study areas to validate the information provided through primary and secondary data collection techniques. In addition, information such as the socio-economic situation of the study area, *dekoko* crop at maturity stage and market situation were observed during field visits.

3.4.5. Secondary data sources

Secondary data was collected by reviewing of published and unpublished literatures such as books, journal articles, reports and e-resources. Documents from various official websites such as; Ministry of Agriculture, Ethiopian Institute of Agricultural Research (EIAR), Central Statistical Agency (CSA), National Metrological Agency (NMA) were reviewed.

3.5.Method of data analysis

The data analysis employed both qualitative and quantitative techniques. The quantitative data analysis involved descriptive statistics such as mean, standard deviation, percentage and frequency distribution. Inferential statistics such as chi-square test (for categorical variables and t-test (for continuous variable) were used to show the difference between *dekoko* producer and non-producer households. In addition to this, econometrics models were employed for the analysis. In this regard, logistic regression model, multiple linear regression and multi-nominal regression were used for this study. The model helped to describe the relationship between the outcome variable and a set of explanatory variables. Quantitative data were managed and analyzed using STATA Version 14 software. The information gathered from key informant interviews, workshop minutes, field observaitons were qualitatively analyzed.

3.5.1. Analysis of food security

Food security is supposed to measure the availability, accessibility, consumption or utilization and stability of food at the global, national household and individual levels. A state of food insecurity also expressed when the people lack access to adequate and safe supply of food on stable basis. Internationally food security is defined as the ability of people to secure adequate food. To assess the food security status, there are a number of measurement tools available of household and it differs based on the scope and purpose of the assessment. Likewise, a combination of tools was used to generate data. In this study, two food security measurement

techniques were applied i.e., the Household Food Balance Model (HFBM) and Dietary Diversity Score (DDS). At the household level, food security is measured by direct survey of income, expenditure and consumption and comparing it with the minimum subsistence requirement. In this regard, income and expenses are used to compute the status of food security. The minimum level of income, which is required per adult equivalent, was calculated on the basis of amount of food required by an adult person. The government of Ethiopia has set the minimum acceptable weighted average food requirement per person per day at 2100 kilo calorie (Kifle, 1999), which is estimated to be 225 kg of food (grain equivalent) per person per year. Consequently, a threshold level is set by computing the value of this amount of cereal by the existing local market price of grain. Thus, those households beyond this thresholds level was deemed to be food secured, and otherwise not food secured.

Household food balance model (HFBM)

HFBM was employed to compute the net quantity of per capita food. The net available food per household, as reported from household recall, is converted into dietary energy equivalent using EHNRI/FAO (1998)'s Food Composition Table. Then, the medically recommended level of calorie per adult equivalent (2100kcal/day/person for Ethiopia) is used as a cut-off point for food insecure and food secure households or individuals. The following simple equation of HFBM, previously used and modified by Messay (2011), and was used in this study.

NGA = (GP + GB + FA + GG + CC + MP + DP) - (HL+ GU + GS +GV)

Where, NGA =Net grain available (quintal/household/year

GP = Total grain production (quintal/household/year)

GB = Total grain bought (quintal/household/year)

FA = Quantity of food aid obtained (quintal/household/year)

GG = Total grain obtained through gift or remittance (quintal/household/year)

MP = Meat, meat based products and poultry (kilogram/household/year)

DP= Dairy and dairy based products ((kilogram/household/year)

HL= Post harvest losses due to grain pests, disasters, thievery, etc (quintal/household/year)

GU = Quantity of grain reserved for seed (quintal/household/year)

GS= Amount of grain sold (quintal/household/year)

GV= Grain given to others within a year (quintal/household/year).

Hence, households are food secured if the daily calorie intake is greater than 2100kcal per person per/day, and households are food insecured when the daily calorie intake is less than 2100kcal per person per /day (FAO, 1998 cited by Messay, 2012).

1 $if y$< 2100Y(x) =⌊⌋

Where, y(x) food security status of households. The result is 1 if *y<2100,* and0$if y$> 2100

Household Dietary Diversity Score (HDDS)

It is a measurement of household food access and availability through measuring the quality and quantity of food to meet all household members nutritional requirement for productive lives. In this case, it helps to provide an approach to measure household's dietary diversity. HDDS is measured by a number of food group consumed over a given reference period. The reference period can vary, but is most often the previous day or week (FAO& WFP 2009). HDDS reflects a quality diet, the number of different food groups consumed is calculated, rather than the number of different foods consumed. The following set of 12 food group were used to calculate the HDDS; cereals, root and tubers, vegetables, fruit, meat, poultry and offal, egg, fish and seafood, pulses/legume/ nuts, milk and milk products, oil/fat/, sugar/honey/, miscellaneous. Data for HDDS indicator were collected by using the respondent a series of yes or no question. First, the HDDS variable is calculated for each household. The value of this variable will range from 0 to 12, to represent food group.

Total number of food groups consumed by members of the household, will be "0" or "1"
$(A+B+C+D+E+F+G+H+I+J+K+L)$ ————————————————————————(3)

Second, the average HDDS indicator is calculated for the sample population.
$(HDDS)$ = $(HDDS)\ Totalnumberofhousehold$———————————————— (3.1)

3.5.2. Econometric analysis

Logistic model

Binary logistic regression model was used to identify factors affecting food security status of household. A logistic model is specified to identify the determinants of food insecurity and to

assess their relative importance in determining the probability of being food insecure. The analysis of the logistic regression model was shown that changing an independent variable alters the probability that a given individual becomes food secure, and helped to predict the probability of achieving food security.

Following Gujarati (2004)), the functional form of logit model is specified as follows: For ease of exposition, we write (1) as:-

Logit (pi) = β0+β1+X1+β2X2……..+βnXni+ei----------(3.2)

Where, Pi= a dichotomous dependent variable (1 if *dekoko* producer takes place, 0 otherwise)

p(i)= is the i^{th}value of dependent variable

Xi =X is the i^{th}value of the independent variable

Bi = parameters to be estimated

ei= is "error" variability of the dependent variable not explained by independent variable term

n= is the number of independent variables.

$Odds=\frac{pi}{1-pi}$----------(3.3)

An odd ratio is the way to present the probability of the event, which indicates the probability of x household to produce *dekoko* or not. In order to know the probability of producing *dekoko* for each farm household, the predictable probability was calculated as suggested by Rosenbaum and Rubin (1985); Baker (2000); Walle (2001).According to them, the treatment groups were compared with control groups using logistic regression. Similarly, in this study, the marginal effect of explanatory variables was estimated as follows:

1. The dependent variable y is modeled as follows:
   $y=(y|X)+\varepsilon$----------(3.4)
   Where, $(y|X)$is the conditional mean function, x is the vector explanatory variable and$\varepsilon$is the error term.
2. Marginal effect is measured as the instantaneous effect that changes in particular

Explanatory variable has predicted probability of y when the other covariant kept constant.

∂E(y|x)$\partial x=[\partial F(\beta' X\partial\beta' X]\beta$---------- (3.5)

3. The change in the intensity of production with respect to a change in an explanatory variable among producers

$\partial E(AIiAIi>0\partial Xi=\beta i[1-Zf(z)F(z)-(f(z)F(z))2]$————————————————————(3.6)

Where,

F(z) is the cumulative normal distribution of Z,

f(z) is the value of derivative of the normal curve at a given point and

To check the collinearity of variables, two measures are often suggested to test the existence of multi-collinearity of the variables. Variance Inflation Factor (VIF) for association among the explanatory variables and the contingency for dummy variables in this study. Variance inflation factor was used to test multi-collinearity problem for continuous and dummy variables.

Following Gujarati (1995), VIF is defined as:

$1(Xj) = [2] - (1)$

$1 - Rj$

Where:

Xj = the j^{th} quantitative explanatory variable regressed on the other quantitative explanatory v variables.

R2j = the coefficient of determination when the variable Xj regressed on the remaining explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10 that variable is said to be highly collinear and it can be concluded that multi-colinearity is a problem (Gujarati, 1995). It is also evident that there might be interaction among qualitative variables, which could lead to the problem of multi-collinearity. To detect this problem, contingency coefficients were computed for each pair of qualitative variables.

Ordered logistic regression model

The ordered logit model is used to predict an ordinal dependent variable given one or more independent variables. Ordinal regression was enabling to determine, which of our independent variables (if any) have a statistically significant effect on the dependent variable. The dependent variable is measured in an ordinal level. The four independent variables are categorical or ordinal. The independent variables are highly correlated with each other, proportional odds *i.e.* that each independent variable has an identical effect at each cumulative split of the ordinal dependent variable (Gujarati, 2004).

In this study, ordered logit model was used to estimate the linkage between the food security status of households and *dekoko* production. The food security status was categorized into four: Food secured, mildy food insecured, moderately food insecured and food insecured. Hence, the ordered logit categories dependent variables in to four: 1 for Food secured, 2 for mild, 3 moderate and 4 food insecure according to (Stata Corp, 2013). The probability of a given observation for ordered logit model were:

$$y(x) = \begin{bmatrix} 1\ secured \\ 2\ mild \\ 3\ moderate \\ 4\ insecured \end{bmatrix}$$

Where y(x) = status of food security condition of farm household

The order Logit model becomes for each category or order =ß0+ß1 SEX + ß2 AGE + ß3 FAMILYSIZE +ß4 SOCIOPOSITION + ß5 WEALTH + ß6 FAMEXP + ß7 CREDIT + ß8 ACCESMA + ß9 TOTLAN SIZE + ß10 IRRIGATION + ß11 FERTILIZER + ß12 TLU + ß13 OFFARM + ß14PARTCIPATEEXTINTION + ß15HOUSEHOLDFARMSTATUS + U

Where:

ß0 = Y-intercept

ß1, ß2 ---------- ß are the slopes of the equation in the model

U = disturbance term/Error term

For this analysis, post-estimation test were done after logistic regression. In order to test the existence of multi-collinearity, both continue and discrete explanatory variables were checked using Variance Inflation Factor (VIF). This statistical analysis indicates that there is no strong association among the variables. As a rule of thumb, if the VIF of a variable exceeds 10 that variable is said to be highly collinear and it can be concluded that multi-collinearity is a problem (Gujarati, 1995). And also, link test and goodness -of- fit test was calculated to auto correlation and appropriateness of data with model.

Multiple regressions: generally explains the relationship between multiple independent or predictor variables and one dependent or criterion variable. A dependent variable is modeled as a function of several independent variables with corresponding coefficients, along with the

constant term. Multiple regressions require two or more predictor variables, and this is why it is called multiple regressions. Multiple regression formula is used in the analysis of relationship between dependent and multiple independent variables and formula is represented by the equation Y is equal to a plus bX1 plus cX2 plus dX3 plus E where Y is dependent variable, X1, X2, X3 are independent variables, a is intercept, b, c, d are slopes, and E is residual value. The multiple regression equation explained above takes the following form:

$$y = mx1 + mx2 + mx3 + \ldots + mx19 + b$$

Where,

Y= the dependent variable of the regression

M= slope of the regression

X1=SEX,X2=AGE, X3=FAMILYSIZE, X4=FAMEXP, X5=SEX, X6=AGE, X7=SOCIOPOSITION, X8=ACCESSTOCREDIT, X9=ACCESMA, X10=IRRIGATION, X11=FERTILIZER, X12=TLU, X13=OFFARM, X14=NOLABO, X15=PARTCIPATEEXTINTION, X16=HOUSEHOLDFARMSTATUS, X17=WEALTHSTATUS, X18=EDUSTATUSHHH, X19=TOTLANDSIZE

B= constant

Multinomial logit model: It is known that farmer's decision to choice one market outlet or another is categorized as a function of a set of incentives and capacity that allow the fulfillment of individuals demand. Hence, I have formulated channel selection as a three alternative choice (direct channel, retailer channel and wholesaler channel). We have applied the multinomial logit model to estimate marketing channel choice with discrete dependent variable. Multinomial models are appropriate when individuals can choose only one outcome from among the set of mutually exclusive, collectively exhaustive alternatives. Based on the rational choice theory, we assume individuals choice mutually exclusive alternative marketing channels to maximize utility and choose the channel with maximum expected utility given their socioeconomic and demographic characteristics and relevant resource constraints. The producer's market channel choice can be conceptualized using a Random Utility Model (RUM). RUM is particularly appropriate for modeling discrete choice decisions such as between market channels. It is an indirect utility function where an individual with specific characteristics associates an average utility level with each alternative market channel in a choice set. In our sample, smallholder

farmers' did sells *dekoko* product using different channels. Producers are mapped into three mutually exclusive channels: direct channel, retailer channel and wholesaler channel.

Let decision maker choose from a set of mutually exclusive alternatives, j = 1, 2, -…., J. The decision maker obtains a certain level of utility Uij from each alternative. The discrete choice model is based on the principle of the decision maker chooses the outcome that maximizes the utility. The smallholder farmers make a marginal benefit marginal cost calculation based on the utility achieved by selling to a market channel or to another. We do not observe his/her utility, but observe some attributes of the alternatives as faced by the decision maker. Hence, the utility is decomposed into deterministic (V*ij*) and random (ε*ij*) part:

$Uij = Vij + \varepsilon ij \forall ijN$ (1)

A smallholder farmer selects market channel j=1 if

$Uik > Uk$ (2)

Where U*ik* denotes a random utility associated with the market channel j=k, and V*ij*is an index function denoting the smallholder farmers average utility associated with this alternative. The second term ε*ij* denotes a random error, which is specific to a producer's utility preference (McFadden, 1974). Now, in our implementation model, market channel choice is modeled as:

$Mij = \beta j\ Xij + \varepsilon ij$ (3)

Where *Mij*is a vector of the marketing choices (j = 1 for Direct channel; 2 for Retailer channel; and 3 for wholesaler channel of ith smallholder farmer, β*j* is a vector of channel-specific parameters, ε*ij* is the error term assumed to have a distribution with mean 0 and variance 1. *Xij*is a vector of smallholder farmer's characteristics that together reflect the incentive, risks, capacity variables and other shifters influencing the producer's indirect utility, and hence his/her market channel decision.

Let Y be the unordered categorical dependent variable that takes on a value of zero or one for each of the *J* choices. The model for choice of supply channel can be given by:

$$\Pr\ (Y_i = j) = \frac{\exp\ (\beta_j\ 'X_i)}{\sum_{j=0}^{J} \exp\ (\beta_j\ 'X_i)} \quad \text{for j} = 1,2,3 \qquad (4)$$

Where:

Pr(*Y j*) *i* = is the probability of choosing either direct channel, retailer channel and wholesaler channel the direct channel as the reference supply channel strategy category,

J is the number of supply channel in the choice set,

j = 1 is direct channel, j= 2 is retailer channel, j = 3 is whole saler channel.

i X is a vector of explanatory factors conditioning the choice of the jth alternatives,

βis a vector of the estimated parameter.

The estimated equations provide a set of probabilities for the *J* + 1 choice restricted for a decision maker with characteristics. In order to remove an indeterminacy in the model, a convenient normalization that solves the problem is β0 = 0. Therefore, one can define the general form of the probability that individual i th choose the alternative jth in the following way:

$$\Pr\ (Y_i = j\ /\ X_i) = \frac{\exp\ (\beta\ '\ j\ X_i)}{1 + \sum_{j=0}^{J} \exp\ (\beta\ '_j\ X_i)'} \qquad \text{for all j} > 0 \qquad (5)$$

The MNL coefficients are difficult to interpret and associating the *βj* with the *j* the outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually used and derived as (Greene, 2003):

$$\delta_j = \frac{\partial P_j}{\partial X_j} = P_j\left[\beta_j - \sum_{j=1}^{j} P_j \beta_j\right] = p_j\left[\beta_j - \bar{\beta}\right] \qquad (6)$$

The marginal effects measure the expected change in probability of a particular outcome being made with respect to a unit change in an explanatory variable (Greene, 2003).

3.6.Definition of variable

The data covered the information necessary to make farm level indices of demographic, institutional, socio-economic factors that influence *dekoko* production and distribution channel in the study area. The variables were continuous and discrete variables in order to answer the research questions of the study, and hence, the following variable were identified and considered in the study.

3.6.1. Dependent variables

The dependent variable is factor determining *dekoko* productions. The values used to identify the determinant of *dekoko* production were obtained from multiple linear regression models. The household who has been participating in *dekoko* production take the value of 1, and the household who did not produce *dekoko* production take the value of 0 for. Another dependent variable that employed to see the proportion or extent of market channel choice decision of farmer among *dekoko* producer and the result was obtained from multinomial logistic regression models, and these were used to analyze factor affecting market channel choice decision for their *dekoko* production.

3.6.2. Outcome variables

It represents the probability of the household to be benefited from *dekoko* production or not. This can be a continuous or discrete variable. The impact of the benefits was examined in household food security by using household food balance model and dietary diversity score. Based on the scope of the study the following hypothesis was made for outcome variables**.**

Household Dietary Diversity (HDDS): which is an indicator to measure household food security status is measured by the household intake of diversified food group over 24-hour recall; it reflects food access and availability. It was expected the producer household and non-producer household have a significant difference in their food security status and dietary diversity diet.

Household Food Balance model (HFBM): It is a continuous variable and employed to compute the per capita food avaiability in the household. The net available food per household, as reported from household recall, is converted into dietary energy equivalent using EHNRI/FAO (1998)'s Food Composition Table for use in case of Ethiopia. Then, the medically recommended level of calorie per adult equivalent (2100kcal/day/person for Ethiopia) is used as a cut-off point for food insecure and food secure households or individuals. Through the above explanation, it was expected that producer households and non-producer household will have a significant difference in their food security status and dietary diversity. Thus, the hypothesis is that producing *dekoko* has a positive influence on household food security.

3.6.3. Independent variables

The independent variable for the study were identified based on reviewing the different literature and those are factors affecting *dekoko* production and distribution and its implication on the outcome variable. Based on this, household socio-economic, institutional and demographic variables are identified as independent variable. The independent variables are clearly shown in both empirical literature reviews and conceptual framework. The independent variables are;

Household head sex (SEX): Is dummy variable representing the sex of the head of the household, where, female take 1, male 0. As Baten and Khan (2010) indicated female-headed households can find it difficult than men to gain access to valuable resource, access to quality extension services**,** access to inputs and the quality of the plot which helps them to improve production and gain more income. In Ethiopia, gender differences in economic production remain a challenge with the majority of women still facing discrimination, this in turn, increases their probability of being food insecure(Brauw *et al.,* 2008). Women farmers may need a long adjustment period to diversify their income sources and become food secure (Christina *et al.,* 2001). Empirical evidence drawn from Ethiopia found that male-headed households are more food secure than female headed households (Belayneh, 2005). Therefore, it is hypothesized that female-headed households are less likely to produce *dekoko* and become food secure compared to male headed households.

Age of household head (AGE): Age is a continuous variable measured in years. Previous study indicated that age has a significant effect on household food security and the age of the household head can determine the agricultural activity of a family (Walker, 2003). That is the older the household head, the more experience he has in farming and weather forecasting, and become more risk averter. Hence, experienced farmers are expected to enhance the productivity *dekoko.* As a result, the chance for such household to be food secure is high. However, it is not without limit as older farmers lack the required physical strength on the farm and lowers the probability of technology adoption (Moussa, 2011)**.** Therefore, it is hypothesized that the age of household head has a positive impact on household food security and negative impact on *dekoko* production and distribution channel.

Household family size (FAMILYSIZE): It is a continuous variable. It refers to the total number of household members within the given household. It is believed that labor constraint affects household's ability and willingness to use a new technology that helps to improve agricultural production and household food security (Feder *et al.,* 1985).The larger is the family size, the more labor is expected within that household. Accordingly, it is hypothesized for this study that it positively affects household's food security. An increase in number of family member increases the probability choice of retailer market channel and it is positively affecting the probability choice of the retailer market channel and consistent with the hypothesis set. In subsistence economy coupled with limited agricultural inputs, seed expensivence, having large family size will decline *dekoko* pea production (Gemechu *et al.,* 2016). Therefore, it is expected that household size positively related to food security negatively related to *dekoko* production and distribution channel.

Education level of the household (EDUSTATUS): It is a continuous variable measured in number of years in schooling. Education is one of the important variables, which increase an individual's ability to acquire process and use agricultural information (Namara E, 2003). A large body of literature noted that household heads with better education status are believed to have a chance to diversify household's income sources, adopt better production technologies, accept technical advice from the extension workers and can better manage their farm as compared to the illiterate ones (Bogale,2009). This, in turn, increases total yield. Literate households are more aware of market channel and able to get market information for their produce and help to choose the best market channel that expected to give better price for their produce. The result in this finding is consistent to Abrahm, (2013). It is expected that the educational status of the household head on *dekoko* production and household food security have a positive association.

Total land size (TOTLANDSIZE): It is a continuous variable measured in hectares and has positive impact on household food security (Mulugeta, 2002; Ayalew, 2003). This variable represents the total cultivated land size owned. A larger size of cultivated land implies more production and availability of food grains and vice versa (Mitiku *et al.,* 2012). Therefore, higher production and the increased availability of grains produced help to ensure food security status of

households (Asmelash 2015).Hence, the size of cultivated land was expected to have a positive impact on extent of food security and negatively related to *dekoko* production.

Access to credit (ACCESSTOCREDIT): A dummy variable takes a value of 1 if households have access to credit and 0, otherwise. Farmers who have access to credit may overcome their financial constraints and therefore buy inputs and allows farmers to purchase inputs such as fertilizer, improved crop varieties, and irrigation facilities. It enhances food production and ultimately increase household food energy intake (Stephen and Samuel 2013). In this study, it was expected to affect extent of households' food security positively. Credit provides the opportunity to use inputs and this promotes production. Households that have an easy access to credit service have the possibility to invest in different farming and some other income-generating activities and improve their production. As a result, household's income and food consumption pattern will improve (Bogale *et al.,* 2009; Beyene *et al.,* 2010; Kifle and Yosef, 1999). In addition to this, credit services affect negatively the probability choice of retailer market channel. Therefore, it is rational to expect a positive association between access to credit service and *dekoko* production and food security.

Total Livestock Unit (TLU): It is a continuous variable measured in tropical livestock unit TLU. Livestock are important source of food and income for rural households. Households with more livestock produce more milk, milk products and meat for direct consumption. Besides, livestock enable the farm households to have better chance to earn more income from selling livestock and livestock products, which assist them to purchase stable food during food shortage. More income enables to invest in purchasing of farm inputs that increase *dekoko* production, and ensure household food security (Mitiku *et al.,* 2012; Gemechu*et al.,*2015). Increase in number of total livestock unit in TLU reduces the probability choice of wholesaler market channel. Thus, this study hypothesized that owning more TLU of livestock was expected to have positive effect on *dekoko* production and market channel choice and the extent of food security of households.

Distance to the market (MARKET DISTANCE): It is a continuous variable measured in walking minutes; it will take from the home of the household to the nearest market place. Proximity to the market may create opportunity of more income by providing off/non- farm employment opportunities, which determine income level of rural households (Gemechu *et al.,*

2015; Dorward *et al.*, 2003). In addition, the closer the farmer is to the market the more likely the farmer gets valuable information, purchase agricultural inputs and final products required for family consumption. Therefore, this variable was expected to positively determine households' extent of food security.

Fertilizer use (FERTILIZER): is dummy variable represented as 1 if fertilizer is available on time, and 0, otherwise. Availability of fertilizer on time had positively and significantly influences the probability of *dekoko* production. On the other hand, decline in soil fertility in the high potential crop production areas is a major problem, while fertilizer use on legume crops is usually low (Asfaw and Shiferaw, 2009).

Off-farm activities (OFFARM): It is treated as a continuous variable measured in the amount of money a given household generates from participation in off-farm activities, which takes a value of 1 if the household participated in off-farm and/or non-farm activities and 0, otherwise. Most farmers commonly generate their income from their farm. However, they occasionally look for the external source of off-farm incomes and non-farm activities to purchase clothes, inputs, food and food-related items (Markos, 1997). Many literatures noted that the ability to get access to off-farm/non-farm activities determines the success of households and their members in managing food insecurity, which could serve as livelihood diversification strategies (Barrett, 2005; Gemechu *et al.*, 2016; Tirfe and Hamda, 2011). On the other hand, off-farm activities can take labor away from agriculture and may decrease conservation investments and these are threats to food security. On the other hand, increase in number of total livestock unit in TLU reduces the probability choice of wholesaler market channel. Thus, off/non-farm income was expected to affect extent of *dekoko* production, market channel choice and food security positively.

Participate in extension program (PARTCIPATEEXTINTION): Is dummy variable taking a value of 1 if the household patcipate in extension program and 0, otherwise. It refers to the number of contact between extension agent and the farmers and is the average number of visit made by the extension agents to a household per month. Farm households that use advisory services by development agents are more likely to produce and advance in their production. It is expected that extension service widens the household's knowledge with regard to the use of

improved variety and agricultural technologies and has positive impact on household food security and *dekoko* production. Therefore, it is hypothesized that the frequency of contact with extension agents positively influences *dekoko* production and food security.

Irrigation (IRRIGATION): Is dummy variable taking a value of 1, if the household used small-scale irrigation and 0, otherwise. Irrigation use in the Ethiopian context refers to smallholder farms with the size of scheme amounting less than 200 ha (Mengistie and Kidane, 2016). Irrigation, as one of the technology options available, enables smallholder farmers to directly produce consumable food grains and/or diversify their cropping and supplement moisture deficiency in agriculture so that it helps to increase production and food consumption (Van der Veen and Tagel,2011). Accordingly, it is hypothesized that irrigation use would have a positive influence on *dekoko* production and food security of the household.

Access to market (ACCESS MARKET): Is dummy variable taking a value of 1 if the household have access to market to sell their *dekoko* product nearly from their homes and 0, otherwise.

Pests and disease: Mainly, the limited availability of chemicals to control plant diseases and pests caused low productivity of legume crops. Smallholder farmer's encourage mono cropping and continuous cultivation of the same piece of land with limited use of agricultural inputs and soil amendment practices. This results in soil nutrient depletion and create better conditions for pests and diseases thereby reducing the production and productivity (Habte *et al.,* 2018; Koroma *et al.*,2016)

Lack of improved *dekoko* seed varity: Lack of improved varieties lead to low harvest, high susceptibility to diseases and insect pests, flower drops, lack of short duration varieties, intermediate growth habits, poor response to inputs and instabilities in performances are the few of the varietal constraints needs immediate attention (Singh *et al.,* 2013; Ramakrishna *et al.,* 2000). In combination with chemical fertilizers, improved varieties of seeds are critical agricultural inputs that help farmers to obtain high *dekoko* production yields. Seeds that fulfil the quality requirements have a positive impact on the productivity of the pea. Accordingly, it is hypothesized that lack of improved seed would have a negative influence on *dekoko* production and food security of the household.

Table 3.3: Explanatory variable description and its expected sign

No	Variables	Description	Variable type	Measurement	Expected sign
1	AGE	Age of the household head	Continuous	Years	+/-
2	SEX	Sex of the household head	Dummy	1, if Female and 0, If Male	+/-
4	FAMILYSIZE	Number of household family size	Continuous	Number	+/-
5	EDUSTATUS	Education Status of Household Head	Continuous	Year	-
6	MARKET DISTANCE	Market distance from the home	Continuous	Hours	+/-
7	SOCIOPOSITION	Household Head have social position in the Community	Dummy	1, if yes and 0, If no	-
8	OFFARM	Income from participation in off-farm activities	Dummy	1, if yes and 0, If no	+
9	ACCESSTOCREDIT	Access to credit	Dummy	1, if yes and 0, If no	-
10	PARTCIPATEEXTINTION	Access for extension contact service	Dummy	1, if yes and 0, If no	+
11	TLU	Total Livestock Unit	Continuous	Number in TLU	-
12	IRRIGATION	Using Irrigation	Dummy	1, if yes and 0, If no	+
13	FERTILIZER	Using Fertilizer	Dummy	1, if yes and 0, If no	+
14	HOUSEHOLDFARMSTATUS	Farm Status of Household Head	Dummy	1, if model farmer and 0, If not model farmer	+
15	TOTLANDSIZE	Land size of Households	Continuous	Hectare	+
16	ACCESMA	Access to Market	Dummy	Category	+
17	WEALTHSTATUS	Wealth Status of Households	Dummy	1, if better and 0, If poor	+/-
18	Pests and disease	Pests and disease	Dummy	1, if yes and 0, If no	-
19	Lack of improved *dekoko* seed Varity	Lack of improved *dekoko* seed Varity	Dummy	1, if yes and 0, If no	+/-

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents the main results and discussions of the study. It divided into six sub-sections. The first sub-section describes the socio-economic and demographic characteristics of the sample respondent household with respect to identified explanatory variables. The second sub-section presents the agronomic characteristics of *dekoko* cultivation. The third sub-section describes farmer's preferences to produce *dekoko* pea over a period of time and the fourth sub-section describes household food security status using household food balance model and dietary diversity of the two group and the constraints of non-producer household. The fifth and sixth sub-section describes the key factors affecting *dekoko* production and assess market channel choose decision of *dekoko* in the study areas. The final section presents the result of Focus Group Discussion (FGD) and Key Informant (KII) Interview.

4.1.Demographic and socio economic characteristics of respondents

This sub-section has described the characteristics of household that explain the information on demographic, socio-economic characteristics, which are assumed to positively or negatively influence *dekoko* production. As indicated in the Table 4.1, the mean age of the producers is 52.08 while, it is 49.03 years for producers the mean age of the producers is greater than the mean age of the non-producers in *dekoko* production. Thus, the mean variation was found to be statistically significant with (p-0.019) value, suggesting that there is significant difference in the mean age of the household head in the two groups at ($p<0.05$) level of significant. This suggests that young peoples tend to be less producers of *dekoko* than the old aged people.

Results presented in Table 4.1 further revealed the total land size who engaged in *dekoko* production result indicated that there is a significant mean difference between the two groups. The mean value for producer and non-producer found to be 0.46 and 0.32 respectively. Besides, the difference is statistically significant with 1% level of significant. This implies that the mean difference was found to be statistically significant at $p<0.01$. Accordingly, the result indicated that farmers who produce *dekoko* pea have large scale of farmland than non- producers. This result asserts that as the size of the farmland increases, the tendency of *dekoko* producing increases.

Table 4.1: Demographic and socio-economic characteristics for continuous variables

Name of the variables	Producers (N=112)	Non-producers (N=176)	Total Mean	T-value	P-value
	Mean value	Mean value			
Age (year)	52.08 (12.64)	49.03 (12.08)	50.22 (12.37)	9.9480	0.019**
Education (grade)	2.06 (1.07)	2.21 (1.23)	2.17 (1.21)	2.8423	0.724
Total land size (hectare)	1.13 (0.46)	1.07 (0 .32)	1.09 (0.38)	9.1086	0.0000***
Family size (number)	2.01 (0.8)	2.1 (0 .8)	2.08 (0.8)	2.7814	0.427
TLU (number)	4.42 (2.74)	4.20 (2.98)	4.28 (2.89)	0.6220	0.5344
Market distance (walking distance in minutes)	1.93 (0.83)	2.04 (0.82)	1.99 (0.82)	1.9077	0.592
Farm experience (year)	2.04 (0 .80)	2.13 (0.77)	2.09 (0 .78)	3.2798	0.350

Note:***, **, *,show significance at p<0.01, and p<0.05 respectively

( ): means standard deviation

Source: Computed from own survey (2020)

Table 4.2 below shows that sex of the household head has no mean difference between producers and non-producers. The sex distribution of sample households, from the total sample household, 80.5% of them were male and 19.5% of them were female headed. With regard to the sample respondents, 83% of *dekoko* producers were male household head while the rest 17% was female. From the non-producers' household side, around 79% and 21% of the total respondents were male and female respectively.

Similarly, from the *dekoko* producers about 99% were participating in extension program and about 1%of them were not participating in extension program activities. While from non-producers, 69%isparticipating in extension program activities and 31% are not parts of it. The chi-square result indicated that there is a variation between producers and non-producers at (p<0.01) significantly with (x2=0.000).

Table 4.2: Demographic and socioeconomic characteristics for dummy variables

Name of the Variables	Category	Producers (N=112)		Non-producers (N=176)		Total Value (N=288)		P-value
		Count	%	Count	%	Count	%	
Sex	Male	93	83	139	79	232	80.5	0.396
	Female	19	17	37	21	56	19.5	
Participate in extension	Yes	111	99	121	69	232	80.5	0.000***
	No	1	1	55	31	56	19.5	
Access to market	Yes	107	95.5	159	90	266	92.4	0.106
	No	5	4.5	17	10	22	17.6	
Social postion	Yes	92	82	73	41.5	165	57.2	0.746
	No	58	51.8	65	36.9	123	42.7	
Household farm status	Model farmer	110	98	60	34	170	59	0.000***
	Not model farmer	2	2	116	66	118	41	
Access to credit	Yes	101	90	104	59	205	71	0.000***
	No	11	10	72	41	83	29	
Wealth status	Beter off	102	91	55	31.2	157	54.5	0.000***
	Poor	10	8.9	121	68.8	131	45.4	
Participate in off-farm activities	Yes	42	37.5	75	43	117	40.6	0.389
	No	70	62.5	101	57	171	59.4	
Irrigation	Yes	50	45	53	30	103	36	0.012*
	No	62	55	123	70	185	64	
Fertilizer use	Yes	55	49	56	31.8	111	38.5	0.000***
	No	45	40	120	68	165	57	

Note:***,*, show significance at $p<0.01$, and $p<0.1$ respectively

Source: Computed from own survey (2020)

Access to market of the household has no mean difference between producers and non-producers. With regard to the sample respondents, 95.5% of *dekoko* producers had access to market household while the rest 4.5% have not access to market. From the non-producers' household side, around 90 % and 10% of the total respondents were have access to market and have no access to market, respectively.

Regarding to household farm status, 59% of producer households responded, as they are model farmer while the rest 41% did not. It means that around 2% of producers group and 66% of non-producers respond that they are not model farmer. On the contrary, 98% of producers and 34% non-producers group was model farmers. Based on this, the chi-square test result revealed that there is statistically significant association between producers and non-producers in farming status of household head and *dekoko* production at ($p<0.01$) level of significant. Similarly, access to credit could possibly increase the production of *dekoko*. Regarding to this, 90% of producer households were access to credit while 10% did not part of it. Likewise, about 59% of the non-producers found to be access to credit and 41% was not. Based on this, the chi-2 test shows that there was statistical significance difference between *dekoko* producer and non-producer households on the access to credit at ($p<0.01$) level of significant.

Participation in off-farm activities of the household has no mean difference between producers and non-producers. With regard to the sample respondents, 37.5% of *dekoko* producer households had participated in off-farm activities while the rest 62.5% had not. From the non-producers' household side, around 43% and 57% of the total respondents participated in off-farm activities and not participated in off-farm activities, respectively. On the other hand, the effect of wealth status was found have a significant effect on *dekoko* production at ($p<0.01$) level of significant. About 54.5% of producer households responded as they had better wealth status while the rest 45.4% did not. It means that, around 91% of producers group and 31.2% of non-producers respond that they had better wealth status. In the reverse, 8.9% of producers and 68.8% non-producers group had not better wealth status or they are poor, respectively. Based on this, the chi-square test result revealed that there is statistically significant association between producers and non-producers in wealth status of household head and *dekoko* production.

Regarding to irrigation use of the respondent households, 36% of producer households responded, as they are use irrigation while the rest 64% did not. It means that, around 55% of producers group and 70% of non-producers respond that they were not used irrigation for crop production. In the reverse, 45% of producers and 30% non-producers group was used irrigation for their crop production. Based on this, the chi-square test result revealed that there is

statistically significant association between producers and non-producers in irrigation use of households and *dekoko* production at ($p<0.1$) level of significance.

Similarly, fertilizer use could possibly increase the *dekoko* production. Regarding to this, 49% of *dekoko* producer's households were applied fertilizer, while 40% did not. Likewise, about 31.8% of the non-producer's found to be fertilizer user and 68% was not. Based on this, the chi-2 test shows that there was statistical significance difference between *dekoko* producer and non-producer households on the fertilizer use at ($p<0.01$) level of significant. Ethiopian farmers are among the lowest users of fertilizer and the other major constraint on productivity of crop production especially in grain legumes (Atnaf *et al.*, 2015)

Table 4.3: Distribution of respondents according to the amount of *dekoko* produced in the year 2019/20 in the study *woredas*

	Woredas							**Total (%)**
	Emba Alage	**Endemhoni**	**Guba Lafto**	**Hintalo Wajirat**	**Ofla**	**RayaAlamata**	**Raya Kobo**	
Options	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	
50-100kg	0 (7.3)	7 (1.7)	2 (1.4)	1 (3.0)	0 (0.5)	1 (2.2)	2 (0.6)	13(16.7)
100-500kg	1 (2.3)	4 (1.8)	6 (0.1)	8 (0.0)	2 (16.6)	8 (0.0)	11 (0.0)	40 (20.8)
500-1000kg	1 (1.9)	2 (7.2)	2 (1.2)	3 (0.9)	0 (0.0)	1 (1.2)	0 (1.8)	9 (14.2)
1000-1500kg	3 (2.2)	3 (1.1)	1 (1.9)	0 (0.6)	3 (0.8)	0 (1.1)	1 (0.1)	11 (7.8)
1500-2000kg	3(0.4)	2 (1.7)	3 (6.7)	0 (1.0)	7 (0.1)	0 (1.8)	0 (2.0)	15 (13.7)
2000-3000kg	10 (9.8)	0 (2.3)	1 (1.0)	1(0.1)	0 (1.7)	0 (0.8)	2 (0.2)	14 (15.9)
3000-4000kg	1 (1.0)	0 (0.3)	0 (0.2)	0 (0.2)	0 (0.2)	0 (0.3)	1 (1.2)	2 (3.4)
above 4000kg	2 (0.7)	0 (0.9)	2 (1.1)	0 (0.5)	1 (0.7)	0 (1.0)	3 (2.6)	8 (7.5)
Total	**21(25.6)**	**18(17.0)**	**17(13.)**	**13 (6.3)**	**13(20.6)**	**10 (8.4)**	**20 (8.5)**	**112(100)**

Source: Field survey, 2020

As shown in Table 4.3, the farmer has applied diffirent amount of output ranging from 50kg to more than 4000kg. However, 20.8% of the respondents applied output ranging from 100kg to 500kg. From the *Woredas*, Embaje *Woreda* were more generate output (25.6%) and followed by Ofla, Endemhoni, Guba Lafto, Raya kobo, Raya Almata and Hintalo Wajerat, respectively which gives a monthly average of about 10193.97kg of output for majority of the farmers.

Table 4.4: Distribution of respondents according to major food crop produced by farmers in the area

Options	*Woredas*							Total (%)
	Emba Alage	**Endemhoni**	**Guba Lafto**	**Hintal Wajirat**	**Ofla**	**Raya Alamata**	**Raya Kobo**	
	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	
Teff	13(2.5)	0(3.0)	33(17.)	13(0.0)	11(3.6)	21(15.1)	29(13.)	120(41.7)
Maize	1 (2.4)	13(8.0)	1(12.5)	10(1.6)	25(5.0)	23(27.0)	1(4.8)	59(20.4)
Sorghum	4(3.4)	0(0.3)	1(1.9)	20(12.)	0(1.4)	27(39.7)	10(12.6)	54(18.8)
Wheat	43(8.7)	36(19.)	33(1.6)	31(17.)	29(9.2)	7(9.3)	36(18.2)	195(67.7)
Barley	32(7.0)	23(16.)	25(0.1)	22(16.)	15(4.7)	0 (10.1)	30(15.5)	174(60.4)
Chickpea	3(1.1)	13(0.4)	0(11.8)	0(3.4)	0(0.9)	0 (0.5)	1(3.3)	30(10.4)
Lentil	4(1.8)	9(1.1)	0(29.2)	0(0.1)	1(0.7)	0 (3.3)	0(4.5)	47(16.3)
Haricot bean	27(2.6)	4 (7.3)	1(14.4)	0(0.1)	0(0.0)	0 (2.4)	0(0.8)	39(13.5)
Filed pea	0(0.0)	3(4.2)	1(2.5)	17(10.9)	2(2.0)	0(5.5)	8(3.6)	68(23.6)
Dekoko	21(8.5)	18(20.6)	17(13.6)	13 (6.3)	13 (3.2)	10 (8.4)	20(8.5)	112(38.9)
Sesame	0(2.6)	0(0.7)	0(10.2)	3(2.8)	11(18.5)	1(1.0)	1(2.3)	24(8.3)

Source: Field survey, 2020 (Multiple responses)

Table 4.4 shows the major food crops produced in the areas as indicated by the respondents. Emba Alaje *Woredas* of the respondents indicated that wheat, barley, faba bean, and *dekoko* are the major food crops produced in the areas. Of the major crop production in Ofla *Woreda* which include wheat, maize, barley, teff and *dekoko.* Amongst other cereal crops sorghum, maize, teff, and *dekoko* are the major food crops produced in Endemhoni *Woreda*. Guba Lafto *Woredas* of the respondents indicated that wheat, barley, teff, sorghum and *dekoko* are the major food crops produced in the areas. Of the major crop production in Raya Kobo *Woreda,* which include wheat, barley, teff, sorghum and *dekoko*. Similarly, in Raya Almata sorghum, maize, teff and *dekoko*are the major food crops produced in the areas. Amongst other cereal crops, wheat, barley, sorghum, filed pea, *dekoko* and sesame are the major food crops produced in Hintalo Wajerat.

4.2.Farmers knowledge about the agronomic characteristics of *dekoko* cultivation

Respondents from all *Woreda* of both regions knew *dekoko* very well. However, due to less cultivation practice in the agro-ecologies 4.6% of respondents do not know the crop in the study areas. Most of the respondents knew the crop for the last thirty years ago actually even Abyssinian pea is a primitive landrace that displays traits usually associated with initial steps in the domestication process (Weeden, 2007).

Table 4.5: Indigenous knowledge of farmer about the agronomic characteristics of *dekoko* cultivation

Variables	Options	Study *Woreds*						Total value
		South Tigray			North Wello			
		Highland	Midland	Low land	Highland	Low land	Midland	
		Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)	Freq.(%)
Dekoko knowledge	Yes	52 (4.7)	31(24.3)	39(3.5)	20 (8.5)	36(1.0)	31 (2.8)	237(46.5)
	No	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)
Cultivation *dekoko* depend on rain season	Yes	50(4.9)	31(22.7)	36 (3.7)	17 (4.9)	36 (0.5)	29 (2.9)	227(42.4)
	No	2 (1.0)	0 (0.9)	3 (0.0)	3 (1.3)	0(0.0)	2 (0.1)	10(3.8)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)
Soil color prefer	Black soil	4(0.1)	12(1.5)	5 (0.2)	12(2.0)	0(0.0)	0(0.0)	39(4.2)
	Brown soil	8 (0.0)	2 (3.0)	0 (0.6)	1 (0.9)	22(1.7)	8(2.1)	41(8.3)
	Red soil	25(1.9)	9(3.3)	23 (5.4)	7 (2.1)	10 (2.7)	2(3.7)	89(20.8)
	Sandy soil	15(0.4)	8 (0.8)	11(0.2)	0(4.0)	4 (3.2)	21(4.1)	68(12.8)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)
Time *dekoko* cultivation	March to may	0(0.0)	1(0.4)	8(2.8)	1 (0.1)	7 (1.8)	2 (0.7)	27(13.2)
	August to September	2 (1.4)	21(2.7)	5 (1.3)	7 (2.0)	23 (4.2)	14(2.3)	79 (14.1)
	June to July	50(4.8)	9 (1.9)	25 (3.3)	12(2.0)	6(2.1)	15 (2.4)	129(18.1)
	other specify	0 (0.4)	0 (0.3)	1 (0.0)	0 (0.0)	0 (0.3)	0 (0.2)	2 (2.5)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)

Plowing Time	Once time	46(6.6)	21(3.2)	12(3.3)	11 (1.0)	32 (4.8)	6 (0.3)	140(20.3)
	Two times	6(1.3)	10 (0.1)	20(2.2)	8 (2.1)	0(0.3)	0(0.4)	55 (11.7)
	Three times	0 (0.0)	0 (0.9)	7 (1.7)	1 (1.6)	0(0.0)	23(3.4)	38(7.7)
	Other specify	0(0.7)	0(1.0)	0 (0.5)	0(0.0)	2(1.9)	2(0.7)	4 (6.5)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)
Seeding rate	10-15kg/ha	24(3.7)	1 (0.3)	10 (1.0)	14(1.5)	6(1.1)	4(1.6)	65 (11)
	16-20kg/ha r	16(1.3)	1 (0.1)	2(0.8)	3 (0.1)	7 (1.0)	1 (0.6)	31 (4.4)
	21-25kg/ha	5 (0.3)	0 (0.0)	2 (1.7)	0(0.0)	5(0.0)	24(3.4.)	36 (5.4)
	26-30kg/ha	0 (0.0)	3(0.0)	3 (0.0)	0 (0.0)	10(2.6)	0(0.0)	20(2.7)
	31-35kg/ha	2 (0.8)	4(0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	6 (0.9)
	36-40kg/ha	5 (1.1)	22(7.0)	19 (2.4)	3 (0.4)	8 (1.0)	2 (0.3)	72 (13.4)
	40-60 kg/ha	0 (0.8)	0(0.6)	3 (1.4)	0(0.4)	0(0.6)	0(0.9)	7 (8.3)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)
Management	Herbicides	1 (0.4)	1 (0.1)	0 (0.4)	2 (1.0)	0 (0.4)	0 (0.3)	4 (3.1)
	Pesticides	4 (1.9)	6(1.4)	14(4.1)	3 (0.1)	10 (0.1)	7 (0.0)	48 (8.3)
	Top-up UREA fertilizer	12(1.3)	3(0.5)	1(1.1)	4(0.4)	3 (0.5)	4 (0.1)	32 (4.2)
	Weeding	21(5.0)	12(2.2)	17 (3.0)	6(0.6)	13(1.0)	12(3.0)	92(15.8)
	No measurement	14(0.1)	9(1.8)	7 (0.0)	5 (2.2)	10(2.4)	8(2.6)	61(9.1)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)
Dekoko time taken to mature	60 days	25(5.2)	20(2.8)	2 (0.3)	7 (0.8)	20(3.5)	5 (1.1)	80(14.7)
	60 to 90 days	26(0.5)	5(1.8)	20(0.6)	8 (2.8)	12 (1.4)	26 (6.7)	115(15.9)
	90 days	0 (0.2)	1 (0.2)	0 (0.1)	1 (6.8)	4 (0.1)	0(0.1)	6(7.7)
	more than 90 days	1(0.2)	5(1.3)	17(4.5)	4(0.3)	0(0.1)	0(0.0)	36(8.2)
	I don't know	0 (0.5)	14(2.4)	0 (0.3)	13 (0.8)	3 (0.1)	0 (0.3)	51 (4.6)

Source: Field survey, 2020

Respondents indicated that cultivation of *dekoko* depend on rain season, 42.4% of the respondents (of both regions) in the study areas cultivate *dekoko* by keeping the seasonal rainfall. Farmers from Guba Lafto highland areas, low land of Raya kobo and highland of Ofla areas grow *dekoko* crop completely depending on the long rainy season. *Dekoko* can perform good yield with about two good raining season all soil types and agro-ecologies. This is mostly common to highland areas that have higher humidity because peas have the ability to benefit from some rain at flowering and seed set with 70% relative humidity (Winch 2006).

However, 3.8% of respondents indicated that they were not completely depending on seasonal rainfall. Rather, they started using irrigation. Particularly in the lowlands of Endamehoni and midland areas of Ofla and Amba Alaje there is irrigation based *dekoko* cultivation starting. Photo taken during field observation in the Ofla *woreda* is an evedence that farmers in the areas are cultivating *dekoko* using irrigation (Figure 4.1)

Figure 4.1: Photo taken during field observation in the study area a) *Dekoko* field b) Different variety of *dekoko* crop

Source: Field survey, 2020

Majority of respondents indicated that *dekoko* thrives better in red soil in all agro-ecologies of both study *Woredas* in general and sandy soil color in the highland and midland areas of Tigray region in particular. This result is in line with Gebreegziabher and Tsegay (2018) that indicated *dekoko* crop is better on Nitisols soil followed by Leptosol and Vertisol soils, respectively. Farmers from Amba-Alaje and Endamehoni areas grow the crop on Leptosols. The existence of more than half of all Nitisols in tropical Africa in the highlands (>1000 m.a.s.l) and 12.5% of the Ethiopia highlands, where field pea is dominant pulses (IUSS Working Group WRB 2015; Keneni *et al.,* 2013) give an impression of the crop adaption for this soil. *Dekoko* has excellent root protuberance on Nitisol soils.

Time for *dekoko* cultivation is varying in different agro-ecological condition. About 18.1 % of respondents indicated they cultivated *dekoko* crop from June to July months. In lowland, midland and highland areas of Northern part of Wello sow *dekoko* pea during long rainy season (kremt season). 14.1%offarmers in the mid land areas of Ofla, Endemhoni and Raya Almata were cultivated *dekoko* from August to September.13.2% of respondents in lowland areas of Northern part of Wello and south Tigray sow *dekoko* pea from March to May months (during belg season) after other crops like *teff* are harvested followed by the long rainy season. The sowing time of the crop in the midland and lowland areas of Tigray is both during belg season and the long rainy season. Other few respondents experienced different *dekoko* cultivation times. This result is consistent with Harvest Choice (2010), sowing time was evaluated to understand the growing seasons and to improve the crop harvest as growing seasons define geographical areas suitable for crops.

Respondents were also enquired the seeding rate for *dekoko* crop they used different kg per hectare during sowing. 13.4% of the respondents in midland areas of south Tigray and low land of south Tigray and North wello areas have an exprenced to use a seeding rate of 36-40kg per hectare; even it varies enormously within the agro-ecologies. The variation may be due to planting date, soil type, relative humidity, temperature and the like factors the agro-ecologies possess. Still the seeding rate of the crop is below the seeding rate stated by Winch (2006) for early variety, with small seed that is planted in good time on infertile soil in a dry region may need a seeding rate of about 50 kg ha-1.

Majority of respondents (20.3%) indicated that they are not plowing *dekoko* crop more than one times. Even though, it varies enormously within the agro-ecologies, 11.7% of respondents plow two times and other more than two times. Majority of the farmer (15.8%) after sowing *dekoko* crop they were only undertake weeding management. While 9.1% of the farmer they do not undertake any managements after sowing *dekoko* crop. The rest of the farmers are using some pesticides, herbicides and fertilizer during cultivation of *dekoko*. With regard to management practice for *dekoko* pea, KI1[12]described, *"in the previous years I had only weeding management once time after sowing the seed. However, pests and insects were affecting the crop even before harvesting and then I started using pesticides and insecticides. Now, there is a variation among the productivity of dekoko pea"*.

Majority of the respondents indicated that *dekoko* crop mature from 60 to 90 days.To become *dekoko* matured in highland and lowland areas of South Tigray and f North Wollo areas, it takes from two up to 90 days.14.7% of them indicated only 60 days is enough to be matured. While 8.2% of them indicated that *dekoko* crop needs more than 90 days to be matured. This duration is varying within the agro ecology of the study areas. *Dekoko* matures in about two months and fifteen days earlier (Weller *et al.* 2012; Rubenach *et al.* 2017). Early maturing helps peas for better seed set during dry season (Winch 2006). This is similar to the growth period for green seed or pods, even there is variation depending on farmers' cultivar, climatic conditions, and planting date of the agro-ecologies (Winch 2006).

4.3.Producers reason for *dekoko* production over time

Reasons for the production of *dekoko* over a period of time by the respondents were analyzed across selected *Woredas*. The finding indicates that respondents who grow *dekoko* for a period in the study area indicated that *dekoko* production choice for its productivity, disease and pest resistance, marketability, taste (consumption), early maturity, lack of alternative crop. About

[1]Key informant (KI) interview are numbered as follows to cite them in the text easily hereafter.

- KI1, KI2 and KI3 are belongs to Highland
- KI4and KI5 are belongs to mid and KI6 are belong to low land

Note: KI1, KI3, and KI5 are female informants and participants while the rest are male.

34.9%, 7.6% and 5.2% of respondents preferred to produce *dekoko* crop for its productivity, diseases and pest resistance and lack of alternative crop respectively. Hence, the *dekoko* crop quality such as its taste (consumption) quality, early maturity to provide reasonable yield with marketability are the major reasons for its preference. As specified from the Figure 4.2, 78.5% of respondents prefer to produce *dekoko* because of its taste. Similarly, Sintayehu (2009) indicates that farmers in Ethiopia appreciate it in different ways; "urban stew", "stew for recipient of hospitality" and "chicken stew of the poor" for its delightful taste. Accordingly, KI2 indicate that, *"the taste of dekoko pea is differ from other pea, it looks like doro wet (chicken stew) especially when I cook without decorticating it. Most of the time I use during weeding ceremony and factising season in both kikwot (decorticated dekoko stew) and defen (whole dekoko stew)".*

About 75.1% of respondents prefer to produce *dekoko* crop because of its early maturity. Regarding to its earliness, *dekok*o crop is named as "fetnoderash" (early maturing) referring to its short life cycle. *Dekoko* can mature in just 80 days, which is a shorter lifecycle when compared to a vast majority of crops grown in the country. Its early maturity makes it a preferred crop in areas where the growing season is too short for other cool-season food legumes.

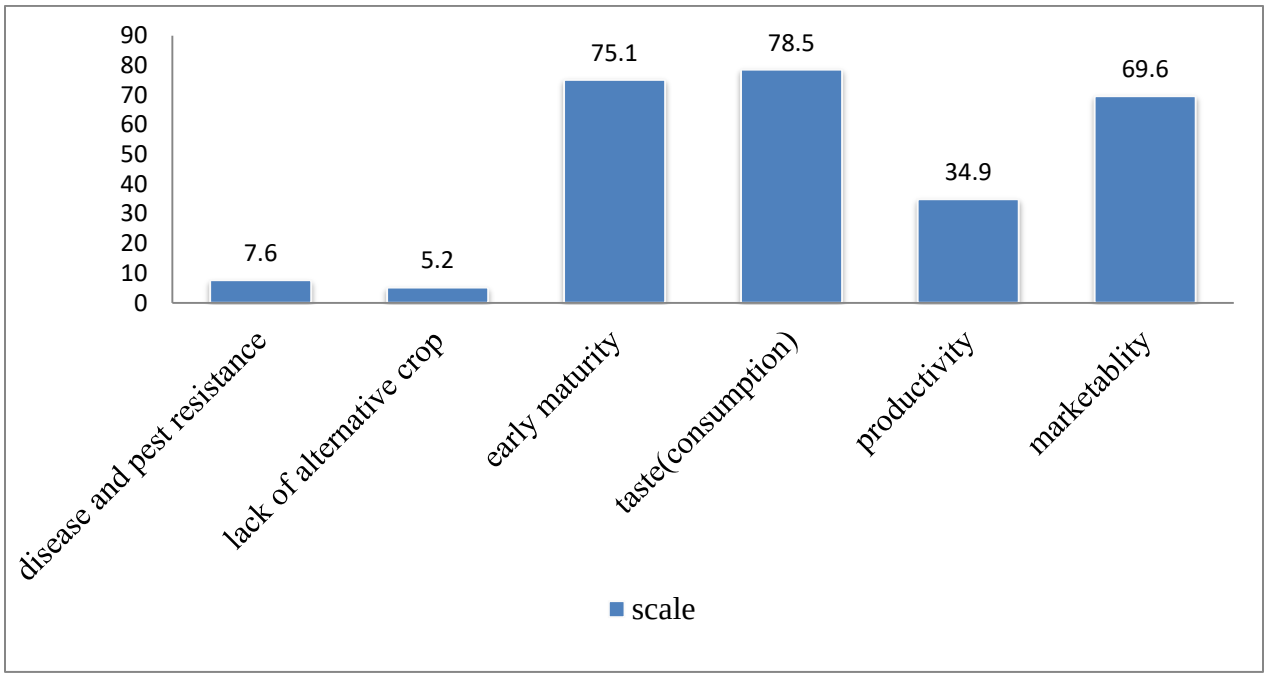

Figure 4.2: Producers reason for *dekoko* production over time

Source: Computed from own survey (2020)

Dekoko is important legumes crop not only for its early maturity but also its marketability compared to other crops. About 69.6% of respondents preferred to produce *dekoko* because they earn high market price. During the surveys, it was observed that the market price of *dekoko* was twice better than the price of common pea. According to some KII 15 and minutes of launching workshop participants "because of high market price *of dekoko pea we prefer to produce this pea for a long period of time. It provides us as a source of income and helps us to buy other crops and other food items we need for consumption. In addition to this it contributed to preserve our staple food for long time because, we did not to obligate to sell it to cover all expenses"*

Dry seeds of *dekeko* are decorticated and split ('split peas') before boiling. Figure 4.3 shows *dekoko* crop for sale in local market, in the forms of whole grain and decorticated one. It was observed during the field visits in the local market that the price of decorticated *dekoko* was higher, compared to the whole *dekoko*. Hence, most women in the town are engaged in decorticating this crop and sale it to market to generate additional income. The result is consistent with the findings by Yemane and Skjelvåg (2003).

Figure 4.2: *Dekoko* crop for sale in local market, South Tigray zone: a) whole *dekoko* b) decorticated *dekoko*

Source: Field survey, 2020

4.4. Descriptive statics on association among food security and *dekoko* production

Descriptive statics on House Hold Food Balance Model (HHFB)

Household food balance model were employed to evaluate the household food security status of the study households. The value of NGA (net grain available) in kuital was calculated using crop produced in the 2009/2010 E.C production year. It was computed by adding grain production, grain bought, quantity of food aid obtained, grain obtained through gift or remittance, meat, meat based products and poultry, dairy and dairy based products and subtracting post harvest losses due to grain pests, disasters, thieves, quantity of grain reserved for seed, grain sold, grain given to others within. All food items, avaiilable for household consumption was included. Those food items includes cereals, vegetables, root and tubers taken in to account to measure the food security status of the households in the study areas. Those food items were converted into kilocalorie based on FAO (2003) food energy calorie conversion factor. Finally, the kilocalorie was divided to days in one year and to each members /family size.

Food security status in *dekoko* producers

Among the total number of sampled households, 112 was found to be participating in *dekoko* production, while 176household heads did not participate in *dekoko* production. Similalry, among the *dekoko* produces, 60.87% were food secured and while 39.13%, of household heads were food in secured. On other hand, among the non-producer household, 11.02% were food secured and 88.98% were food insecured. From this result of survey, it is conceivable to say that those households who engaged in *dekoko* production were more food secured compared to households who did not produce *dekoko* crop. The statisitical analysis also shows the significant diffirence between the two groups.

Table 4.6: Food security status of producer and non-producer

Food security status	Food secured		Food in secured		Total		p-value 0.000***
	N	%	N	%	N	%	
Producer	98	60.87	14	11.02	112	38.89	
Non producer	63	39.13	113	88.98	176	61.11	

Source: Analyzed from own data, 2020

Socio-economic and demographic characterisics of households and their food security status

The result shows that there is a mean difference between food secured and insecured in terms of social position at ($p<0.1$) (Table 4.7). Household who had social position in the community from the study area was found food secured than those who did not. This is due to the household who participated in social position had in a better position to access information and have better understanding about the *dekoko* production and productivity.

Table 4.7: Socio-economic factors vs on food security status of households

Variable	Food secured (N=112)		Food in secured (N=176)		p-value
	Mean	Std	Mean	Std	
Sex	1.1	0.3	1.2	0.4	0.156
Age	49.1	12	53.7	12.9	0.164
Education	2.1	1.1	2.2	1.2	0.369
Family size	4.4	1.6	4.7	1.7	0.2786
Social position	4.9	1.6	4.5	1.6	0.0619*
Wealth status	3.2	0.62	2	0.12	0.0339**
Access to Credit	2.2	0.45	1.4	0 .5	0.0394**
Farm experience	29.7	31.8	3.2	35.5	0.4876
Access to market	1.02	0.22	1.09	0.31	0.0302**
Total land size	0.7	0.37	0.6	0.8	0.4566
Irrigation	1.6	0.5	1.7	0.5	0.0631*
Fertilizer	1.4	0.4	1.3	0.5	0.1210
TLU	4.5	2.9	3.9	2.9	0.1315
Off-farm	1.6	0.5	1.5	0.5	0.7351
Household farm status	1.4	0.5	1.5	0.5	0.0054***

Note: ****, **, *, show significance at $p<0.01$, $p<0.05$, and $p<0.1$ respectively*

( ): means standard deviation

Source: analyzed from own data, 2020

As shown in Table 4.7, families with better wealth status are more food secure than those poor household. A household's wealth status forms the other important source of livelihood for farming households. *Dekoko* contribute to households' economy in different ways, e.g. as source of cash income and source of supplementary food (Kang'ara *et al.,* 2001). Household who produce *dekoko* crop in the study area was found food secured than those who did not produced *dekoko* crop at 5 % significance level. This is because households who produced this nutritious and cash crop benefit in diffirent ways.

There is a mean difference between food secured and in secured in terms of access to credit. Having access to credit increases households' probability of food security at ($p<0.05$) level of significance. Household who had access to credit from the study area was found food secured than those who did not access to credit. This implies that those households who had access to credit service have more chance of being food secure than without access ones. This is due to the fact that access to credit gives the household an opportunity to be involved in income generating activities so that derived revenue increases financial capacity and purchasing power of the household to escape from risk of food insecurity. Moreover, it helps to smooth consumption when household face with temporary food problem (Okyere, 2013).

Similarly, there is a mean difference between food secured and in secured in terms of access to market at 5% level of significance. This implies that households who have access to market are more likely to be food secure than who have not. This is because households living far from the market center obtain little information about the market condition and thereby use their entire production for home consumption rather than bringing it to the market (Gemechu, 2016).

The result from the study shows that there is a mean difference between food secured and in secured in terms of irrigation use at 1 % level of significance. Household who use irrigation for crop production from the study area was found food secured than those who did not use. This implies that households who had access to irrigation are more likely to be food secure than those who had no irrigation access. This is due to the fact that irrigation helps farmers enhance their agricultural production through mitigating water stress and reducing risks of crop failures and obtains more yields; thereby reducing the risk of food insecurity among the households. This finding is in line with the findings of Van der Veen (2011). The result implies those model

farmers are more food secure than non-model farmer at p<0.01. This is because model farmers had better opportunity to get information by particiating in different tannings.

4.5.Econometric results

Result to show linkage between food security and *dekoko* production.

4.5.1. Model diagnosis test results

The necessary model diagnosis test including model specification test for the overall model fit (goodness of fit), multi-collinearity problem and model specification error test was conducted. Model test was carried out before running the logistic regression, while model specification error tests (link test) were carried out after running the regression. The explanatory variables were checked for existence of multi-collinearity or association between the dependent variables to identify the determinant factors that affecting *dekoko* production. Multi-collinearity was tested using variance inflation factor (VIF). Accordingly, the result revealed that there is no problem of multi-collinearity observed because the tolerance greater than 10% among explanatory variable as indincated in Table 4.8 below.

Table 4.8: Test estimation

Tests	**Test name**	**Factors of *dekoko* production**
estat gof	Pearson>chi2	0.9977
link test	Hat	0.000
	Hatsq	0.174
VIF	Multi-collinearity	1.17

Source: Analyzed from own data, 2020

The model fitness test of the logistic equations justified the fact that the models are enough to explain the dependent variables. This evidenced by the fact that the Pseudo R^2statistics of the model is 0.9977, which lies between 0 and 1. The result confirmed that the explanatory variables (independent variables) of the model could explain the dependent variable and well fitted. The link test identified the model specification error occur when the relevant variables are omitted from the model or one or more irrelevant variables are included in the model. The null hypothesis shows there is no model specification error. In this specific study, the p-value of hatsq shows is not significant then we fail to reject the null hypothesis and conclude the model is correctly specified. In this regard, for the linkage between food security and factor affecting

dekoko production, the p-value is 0.174. The p-value implies it is not significant so we fail to reject the null hypothesis and conclude that there is no model specification error.

4.5.2. Logistic regression model for household food balance model

The result of logistic regression show that six variables were found to have a significant effect on household food security those variables are age, social position, access to credit, irrigation, participate in extension program and household farm status. As indicted in the result, participating in *dekoko* production had a significant effect on household food security status, as the age of the household increases by one the probability to be food secured increases by 3.5%.

Table 4.9: Logistic regression model for house hold food balance model

Variables	Coefficient	std. Err	Z	p>z	Marginal effect (dy/dx)
SEX	0.079	0.232	0.34	0.733	0.079
AGE	0.034	0.063	-0.55	0.0485**	0.035
FAMILYSIZE	0.076	0.053	1.43	0.152	0.076
SOCIOPOSITION	0.141	0.047	2.97	0.003***	0.141
WEALTH	-0.035	0.127	-0.28	0.783	-0.035
FAMEXP	-0.002	0.002	-1.05	0.294	-0.002
ACCESSCREDIT	0.404	0.167	2.41	0.016**	0.404
ACCESSSMARKET	0.132	0.285	0.46	0.643	0.132
TOTLAN SIZE	0.137	0.137	1.00	0.316	0.137
IRRIGATION	0.431	0.148	2.91	0.004***	0.431
FERTILIZER	-0.151	0.157	-0.96	0.339	-0.151
TLU	-0.035	0.028	-1.25	0.213	-0.034
OFFARM	-0.231	0.157	-1.47	0.142	-0.231
PARTCIPATEEXTINTION	-1.005	0.423	-2.37	0.018**	-1.006
HOUSEHOLDFARMSTATUS	0.368	0.162	2.27	0.023**	0.368
_cons	2.781	0.830		0.001	

(**) dy/dx is for discrete change of dummy variables from 0 to 1

Source: Analyzed from own data, 2020

NB: ***p<0.05, **p<0.05,*p, 0.1

Having social position in the community helps farmer's to benefit from economies of scale to lower their costs of acquiring inputs or hiring services. Participating in the community with

different social position enable farmers to improve product and service quality and reduce risks. Social position in the community significantly increased the probability of producing different variety of crops especially nutritious and cash crops like *dekoko*. Generally, the more farmers are involved in farmer organizations' meetings and different activities, the more they will access new information about the use of producing nutritious and cash crop. The more she/he will easily develop positive attitude towards the producing nutritious, cash crop, the better is increasing production, and eventually the household become food sufficient family, which help him to overcome food insecurity. The result shows that farmers who are actively participating in social organizations had increased likelihood of *dekoko* production and become food secured. Thus social position in the community had a significant effect on household food security at ($p<0.01$)level of significance. The result shows that participation in social position increases the probability of the household food security status by 1.4% (Table 4.9)

Other result from the econometric analysis provided that access to credit had a significant effect on household food security status. This implies that access to credit increase by one unit, the probability of to be food secured increases by 4.0%. In addition, irrigation use is one of the factors, which had a significant effect on household food security at ($p<0.05$) (Table 4.9). As the household increases to use irrigation, the probability to be food secures increases by 4.3%. Similarly, as noted by Abdulai and Huffman (2014), access to small-scale irrigation enabled the households to grow crops more than once a year; to ensure increased and stable production, income and consumption; and improve their food security status.

As indicted in the result, participation in extension program had a significant effect on household food security status. As the frequency of contact with extension agent decreses, the probability of the household to be food secures decreases by 1.0% (Table 4.9). Awareness raising training service by development agents and experts to farmers plays a vital role in household food security through promoting this endogenous nutritious crop and increase in production of household, which consequently led to food security. As indicted in the result household farm status had a significant effect on household food security status, household those model farmers were more food secured. The more farmers become model farmer, the more they will access to credit services, and improved crops variety, the more she/he will easily develop positive attitude towards the adoption of production technologies. This would enabe to increase crop production,

and eventually the household become food sufficient family, which helps to overcome food insecurity. The result shows that farmers who are model had increased likelihood of producing *dekoko* crop and become food secured so household farm status had a significant effect on household food security at ($p<0.05$) level of significance.

Linking food security and *dekoko* production

The issue of food security is a multifaceted and multi-dimensional problem, and hence a single econometrics analysis may not be enough to adders the food security status of the house hold. Therefore, ordered logit model was applied to analyse the status food security based on the results of the recommended daily kilocalorie requirement calculated using HFBM. The food security status of the study households were classified as food secured, marginally food insecured, moderately food insecured, and severely food insecured (Table 4.10). This type of food insecurity classification was adapted from FAO-WFP (2009).

Table 4.10: food security status by classification

Food security status of household	Proportion of household in%
Food secured (greater than 2100 kcal)	55.90
Marginally in secured (1800-2100 kcal)	9.38
Moderately in secured (1500-1800)	12.50
Severely in secured (less than 1500 kcal)	22.22

Source: Analyzed from own data, 2020

As indicated in the Table 4.10, households were classified in to four categories depending on the households' consumption kilocalories recommended per day. Hence, the relationship between the household food security status and independent variables were analyzed using ordered logit model. Table 4.11 presents the results of ordered logit model for household food security analysis.

The result shows that the age of household head had negative significant effect on food secured, marginally and moderately insecure household at $P <0.001$, and had positive significant effect on severely food insecured at $P<0.001$. The result implies that when the age of the household head increases by one, participating in *dekoko* crop production decreases by 1%. Again, it has

negative effect on household food security. When the age of the household head increases by one, the probability to be food insecure increases by 0.9%.

Table 4.11: Ordered logit model for house hold food security analysis

Variables	ME(dy/dx) food secured	ME(dy/dx) Marginally in secured	ME(dy/dx) moderately in secured	ME(dy/dx) severely in secured
SEX	-0.033**	0.002***	0.006***	-0.033**
AGE	-0.009***	-0.001***	-0.002***	0.009***
FAMILYSIZE	-0.028**	0.002***	0.005***	-0.028**
SOCIOPOSITION	0.051*	-0.004***	-0.010***	0.051*
WEALTH	-0.003***	0.000***	0.001***	-0.003***
FAMEXP	0.001***	-0.000***	-0.000***	0.001***
CREDIT	0.164	-0.012**	0.033**	-0.164
ACCESMARKET	-0.032**	0.002***	0.006***	-0.033**
TOTLANDSIZE	-0.049**	0.004***	0.009***	-0.049**
IRRIGATION	-0.176	0.013**	0.035**	-0.177
FERTILIZER	0.063*	-0.005***	-0.013**	0.063*
TLU	0.010***	-0.001***	-0.002***	0.010***
OFFARM	0.090*	-0.007***	-0.018**	0.090*
PARTCIPATEEXTINTION	0.444	-0.033**	-0.089*	0.444
HOUSEHOLDFARMSTATUS	-0.146	0.011**	0.029**	-0.146

Source: Analyzed from own data, 2020

NB***p<0.01, *p<0.1, ** p<0.05

Social position of the household head has also statistically positive significant effect on food secured and severely food insecure at P<0.05. Whereas, negative effect on moderately and marginally food insecure household at P<0.05. This suggests that when a household head had position in the community he/she has access to information to help increase production. The more the household increase production, the probability to be food secure increases, hence, it has positive effect. Whereas, when the household head had not any position in the community he/she

is far from information related to how to increase productivity and other so it have a negative effect on household food security .

Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. The credit access positively affects the *dekoko* production Tiamiyu and Leake (2014). Household who have access to financial service and agricultural input had ability to feed all his family without food shortage. Access to credit had positive effect on food secured and moderately food insecure households at 0.1641 and 0.0122, respectively. Whereas negative effect on marginally and severely food insecure at 0.0122 and 0.164 respectively. The result shows that have access to credit has positive effect on food secured households, through the production *dekoko* crop and on improvements in food security.

Irrigation use had positive effect on moderately and marginally food insecure at 0.013 and 0.036, respectively. Whereas negative effect on food secure and severely food insecure at 0.177 and 0.176, respectively. Participation in extension program is also statistically significant effects on food security status of the study households. Participation in extension program improves access knowledge gap on access to improved technologies. Besides, households who participated in extension program would have higher social connections and interactions with other farm households, which give them better access to information about agricultural productivity. This enables to increase their production and made them to be food secured, as the result estimated that participation in extension program had positive significant effect on food secured house hold at 0 .445. Whereas, negatively affect moderately and marginally food insecure households at 0.033 and 0.089, respectively (Table 11).

Finally, household farm status had positive effect on food secured and moderately food insecure households at 0.147 and 0.029, respectively. Whereas, it negatively affects the marginally and severely food insecure households at 0.0109 and 0.146, respectively. The result further shows that model farmer are food secured households. As they participate in the production of *dekoko* crop, it positively affects their food security status.

4.5.3. Household Dietary Diversity Score (HDDS) of the respondent

As it is depicted in Table 4.12 food group were consumed by local population in varying percentages. All sample households consumed cereal products like bread, *injera* made of *teff*,

wheat, and barley as it was the main staple food in the study area. About 42.74 % and 50% for producer households and 57.26% and 50% of non-producer households' consumed root crops and vegetable, respectively. On the other hand, about 71 % and 86.49% for producers and 28.92% and 13.51 % of non-producers consumed fruit and meat food group, respectively.

Table 4.12: Household dietary diversity of different food groups among producers and non-producers

Food group	Producer(N=112)	Non-producer(N=176)	T-value	P- value
	Mean value (%)	Mean value (%)		
Cereal or staple food	288(100.00)	288(100.00)		
Tubers roots yams cassava	0.53(42.74)	0.14(57.26)	-0.4820	0.6302
Any vegetable	0.97(50.00)	0.61(50.00)	7.4296	0.0000***
Any fruit	0.54(71.08)	0.13(28.92)	7.8318	0.0000***
Meat Poultry and meat made food	0.28(86.49)	0.02(13.51)	6.8382	0.0000***
Any eggs	0.47(40.32)	0.44(59.68)	0.5477	0.5843
Fish or dried fish	0.19(61.76)	0.07(38.24)	2.6722	0.0080***
Beans pulses lentil	0.89(59.52)	0.38(40.48)	9.7856	0.0000***
Any *dekoko*	0.90(67.57)	0.27(32.43)	12.8614	0.0000***
Milkandmilkproductscheese	0.59(88.16)	0.05(11.84)	12.8539	0.0000***
Fat oil	0.90(40.32)	0.84(59.68)	1.2734	0.2039
Sugar honey	0 .68(64.41)	0 .25(35.59)	7.6505	0.0000***
Coffee tea condiments	0.73 (40.11)	0.35(59.89)	0.5553	0.5791

***, show significance at p<0.01

( ): shows percentage

Source: Own computation (2020)

Similarly, the result shows that from egg and fish food group, 40.32% and 61.76% for producers and 59.68% and 38.24 % of non-producers consumed fruit and meat food group, respectively. Whereas, 59.52% and 67.57% of the consumption of the household fall in the pulses and *dekoko,* respectively. Table 4.12shows that about 88.16% and 40.32% of the household consumed milk and milk products such as cheese and butter, respectively. Similalry, 64.41% and 40.11% of the

sample household consumed sugar and coffee tea condiments food groups, respectively. Further, the mean difference between two groups in terms of the food consumed is clear. *Dekoko* producers consumed more vegetable, fruit, poultry and meat, fish or dried fish, beans, lentil, *dekoko*, milk and milk products and sugar consumption than the non-producer. The statistical result also shows that the mean variation was found to be statistically significant at ($p<0.01$) significant level.

The producer's consumption of diffirent food group is greater than the non-producers with $p<0.01$ for all vegetable, fruit, meat poultry and meat made food, fish or dried fish, beans pulses lentil, *dekoko*, milk and milk product and sugar, respectively. This suggests that the producer's household are tend to comsume diversified food than the non-producers. Food from root crops, eggs, fat and oil consumption of the households has found to be statistically insignificant to determine the household's intake of dietary diversity food. The mean value of the roots crops food group was found to be 0.53and 0.14 for producers and non-producers households respectively. Similarly, for eggs and fat oil consumption of the producers and non- producers households is 0.47and 40.32, respectively. The result revealed that there is no significant mean difference between two groups in mentioned above food group.

4.5.4. Reason for decline of *dekoko* production

Table 4.13 presented some of the factors contributing to the decline in *dekoko* production. The results indicated that 50.2% of the respondent stated that disease and pests outbreak constrain *dekoko* production. About 38.8% of them responded that lack of improved *dekoko* variety is the reason for the decline in *dekoko* crop produciton. Whereas, 36.7%, 34.7%, 32.5% and 26.6% respondent's raised that shortage of farm land, lack of knowledge, recurrent drought and lack of applying appropriate management practices are the main constraints, respectively. Furthermore,18.0% and 12.1% the household responded that lack of applications of improved input, and high input required are the main constraints for decline in *dekoko* production, respectively.

Table 4.13: Reason for decline of *dekoko* production (multi response)

Constraints /reasons/	Frequency	%
Lack of knowledge	100	34.7
Shortage off-farm land	106	36.7
Lack of improved *dekoko* variety	112	38.8
High input required	35	12.1
High labor demand	18	6.2
Disease and pests outbreak	145	50.2
Recurrent drought	94	32.5
Poor application of improved input	52	18.0
High seed market price	17	5.9
Lack of applying appropriate management	77	26.6

Source: Computed from own survey (2020)

According to the information obtained from minutes of launching workshop, the following constraints realted to *dekoko* production were identified.

- Primarily, there is lack of improved *dekoko* seeds because of which farmers use landraces passed from generation to generation. Wholesale of harvested *dekoko* seeds by farmers may sometimes lead to seed shortage.
- There is also a misconception that *dekoko* does not require fertile land. *Dekoko* is grown on marginal lands that are not used for growing other staple crops such as wheat, barley and *teff*. As a result, the annual production produced does not meet even the local demand.
- It is one of the most neglected crops and less research has been done on its improvement compared to other pulses such as field pea, chickpea and lentils.
- Lack of socio-economic studies including indigenous knowledge on agronomic practices, crop protection, nutrition and marketing.
- Lack of awareness creation through government extension workers on food security, nutritional and income generation values of the crop.
- Biotic constraints such as diseases, caused by fungi, bacteria, virus or `nematodes, and pests such as aphids stem borer, worms, etc and weed have huge impact on low production of *dekoko* pea.

4.6.Determinants of *dekoko* production

The multiple linear regression model result shows that out of the seventeen factors included to determine factors affecting *dekoko* production, eight variables were found to have a significant effect on the probability of *dekoko* production of the farm households (Table 4.14). These variables are age of the household head, family size, fertilizer use, off-farm, household farm status, wealth status, education status and total land size. Six of the variables were statistically significant at p<0.5, where as the reaminng two variaibles were signifincat at P<0.01.

Table 4.14: Multiple liner regression for factor affecting *dekoko* production

Variables	Coef.	Std. Err.	T	P-value
SEX	6.484	106.297	0.06	0.951
AGE	-92.263	45.761	-2.02	0.045**
FAMILYSIZE	155.067	60.131	2.58	0.010**
FAMEXP	-48.300	50.973	-0.95	0.344
SOCIOPOSITION	33.286	24.973	1.33	0.184
ACCESSTOCREDIT	-130.352	94.150	-1.38	0.167
ACCESMA	-171.558	151.071	-1.14	0.257
IRRIGATION	-39.491	83.217	-0.47	0.636
FERTILIZER	-201.772	85.047	-2.37	0.018**
TLU	-3.369	14.475	-0.23	0.816
OFFARM	198.399	81.182	2.44	0.015**
NOLABO	-12.914	22.313	-0.58	0.563
PARTCIPATEEXTINTION	-71.379	108.104	-0.66	0.510
HOUSEHOLDFARMSTATUS	-221.573	81.281	-2.73	0.005***
WEALTHSTATUS	-191.907	97.207	-1.97	0.049**
EDUSTATUSHHH	-93.401	34.398	-2.72	0.004***
TOTLANDSIZE	-182.522	88.575	-2.06	0.040**
_cons	2341374	1814191	1.29	0.198

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Note*** and **show significance at p<0.01 and p<0.05 respectively

Source: Computed from own survey (2020).

The result reveals that age of the household head found to have significant relationship with *dekoko* production at (p<0.5) level of significant with (p=0.045).Accordingly, as the age of the household head increases by one unit, the total product is decreases by 92.263kg. This implies

that even though the farmers experienced and highly dependent on their previous knowledge of farm practices in cultivating *dekoko* production there is a limitation as they become older. Older farmers lack the required physical strength on the farm productivity and lower the probability of technology adoption (Moussa *et al.*, 2011; Burton, 2013).Whereas, younger household heads have the ability to comprehend new technologies and will therefore readily adopt improving timeliness of operations as well as reducing loses of production(Matungul *et al.*, 2001).

Family size of the household negatively influences the probability of *dekoko* production with the p-value of (0.010). This implies that when the family size increase by one unit, the total product is decreases by 155.067kg. A large household size indicates that a large number of family members can avail their labour to farm activities and thus labour constraints would not be a problem. However, in some instances, despite a large household size, *dekoko* product on may be negatively affected, as some family members may not take part in the production activities or due to diminishing marginal returns to labour (Ahuja 2000). On the other hand, when inactive family member increases in the household, the income of the household decreases and they face a problem to buy inputs and other materials for *dekoko* production.

The result also reveals that fertilizer use of the household found to be negatively affect *dekoko* production at ($p<0.5$) level of significant with ($p=0.018$).This implies that when the use of fertilizer increased by one Kg per hectare the total product is decreases by 201.772kg where other effects are held constant. According to Getachew (2019), the production and productivity of grain legumes in Ethiopia appears to be severely constrained by fertilizer use. Household engaged in off-farm activities significantly and positively affecting the probability to produce *dekoko* with p-value of (0.015). This indicates that source of additional income from off-farm activities increases the purchasing power of the household's different farm input, which helped to increase production and productivity.

The farm status of the household significantly and negatively influences the probability of *dekoko* production at ($p<0.01$) level of significance. When the household farm status decreases by one unit, the total product also decreases by 221.573kg. This implies that model farmer and non-model farmer differ in terms of wealth status, as model farmers are rich farmers who owned larger number of TLU and larger area of arable land. This study is hormony with findings of Dixon *et al.* (2012) and de Graaff *et al.* (2011).Wealth status of the household significantly and

negatively influences the probability of *dekoko* production with p-value of (0.049). When the household wealth status decreases by one unit, the total product is also decreases by 191.907kg. This implies that due to the higher price of the *dekoko* seed at the market and avaliablity of small plot of land, poor farmers have very little chance to produce this crop.

The result of this analysis shows that education status of the household have negative and significant effect for *dekoko* production. Education status of the household head negatively influences the probability of the households to produce *dekoko* with the p-value of (0.007). As the education level of the household decreases by one unit, the total product is also decreases by 93.401kg. This is because information and knowledge are prerequisites for farmers to adopt technology, access input, change ways of doing things and market their produce (Chowa *et al*., 2012). This was also confirmed by the key informants interviewed, *''educated farmers know more about the importance of dekoko pea interms of nutrition and source of income. Hence, they produce more by using irrigation; two and more times in a year".*

The total land size of the household is found to be negatively affect the probability to produce *dekoko* at ($p<0.5$) level of significant with ($p=0.040$). Accordingly, as the total land size of the household decrease by one, the total product also decreases by 182.522kg. The possible reason might be the fact that majority of the farmer in the study area owned small plot lands (fragmented); less than one hectare. Due to this, the farmers are more concerned about their staple food crop than *dekoko* pea, or other pea that is used for stew.

4.7. *Dekoko* market outlet choice in the study areas

Farmers choose different market outlet to supply their *dekoko* crop product. The identified *dekoko* supply channel is direct sell to consumer, retailer and wholesaler. Thus, 50% of *dekoko* producer of the study areas sell their *dekoko* crop directly to the available local market where as the remaining 28.6% and 21.4% were supplied their *dekoko* through the retailers and wholesaler channels, respectively (Table 4.15)

Table 4.15: Percentages of households by *dekoko* crop market outlet

Vegetables market outlet	***Woredas***							**Total (%)**
	Emba Alage	**Endemhoni**	**Guba Lafto**	**Hintalo-Wajirat**	**Ofla**	**Raya-Alamata**	**Raya-kobo**	
Options	Freq. (%)	Freq. (%)	Freq. (%)	Freq.(%)	Freq. (%)	Freq. (%)	Freq. (%)	
Directly sell to consumer	17(14)	3(2.7)	10(7.9)	4(3.6)	7(6.2)	3(2.7)	12(10.7)	56(50)
Retailers	2(1.8)	5(4.4)	3(2.7)	7(6.2)	6(5.3)	5(4.4)	4 (3.6)	32(28.6)
Wholesaler	7(8.9)	5(7.1)	4(3.6)	2(1.8)	0(0)	2(1.8)	4(3.6)	24(21.4)
Total	**26(32.1)**	**13(11.6)**	**17(12.2)**	**13(11.6)**	**13(11.5)**	**10(8.9)**	**20(15.9)**	**112(100)**

Source: Own survey data (2020)

Determinants of market outlet choice for major *dekoko* crop

In the next econometric analysis, Multinomial Logit Model (MNL) was employed to estimate the determinants of *dekoko* market outlet choice by households in setting three options of *dekoko* market outlet in the model. In this analysis, 12 explanatory variables were incorporated in the model and interpreted at the marginal effects. The goodness fit of the model was 0.062 which is significant at 5%. Likewise, hetero skedasticity and Multi-collinearity test was conducted for the variables used in the model and found no serious problem i.e. less than 10%.

The result show that family size of the household is negatively affects the probability choice of the consumer and positively affects the probability choice of the retailer market channel. The number of the family significantly decreases the probability choice of consumer by 3.6% at 5% probability level. Whereas, increasing in the number of family member increases the probability choice of retailer market channel by 3.5% and significant at 5% probability level. This indicates that the more family size helps to supply *dekoko* to different retailer in the local markets and shops in different prices.

Table 4.16: Marginal effect estimates at mean from multinomial logit model

Market outlet choice									
Directly sell to Consumer Channel				**Retailer Channel**			**Wholesaler Channel**		
Variables	**dy/dx**	**Std.Err.**	**P>Z**	**dy/dx**	**Std.Err.**	**P>Z**	**dy/dx**	**Std.Err.**	**P>Z**
SEX	0.073	0.079	0.360	-0.081	0.074	0.276	0.008	0.069	0.907
AGE	-0.006	0.029	0.836	0.003	0.026	0.892	0.002	0.025	0.924
FSIZE	-0.035	0.017	0.041**	0.035	0.015	0.024**	0.000	0.015	0.974
Edustatus	-0.034	0.024	0.167	0.012	0.022	0.576	0.021	0.021	0.310
HOUSEHOLDFARMSTATUS	-0.054	0.056	0.340	0.093	0.049	0.062	-0.039	0.049	0.435
WEALTHp	-0.068	0.047	0.145	0.024	0.043	0.585	0.045	0.042	0.286
SOCIOPOSITION	-0.017	0.018	0.333	-0.002	0.016	0.904	0.019	0.016	0.228
ACCESSTOCREDIT	0.106	0.065	0.101	-0.119	0.061	0.052*	0.014	0.057	0.812
ACCESMA	-0.069	0.115	0.545	0.067	0.097	0.491	0.003	0.105	0.979
DISTANCETOMARKET	-0.039	0.035	0.262	0.046	0.031	0.138	-0.007	0.031	0.807
TLU	0.008	0.010	0.444	-0.026	0.010	0.010**	0.018	0.008	0.027**
OFFARM	0.089	0.058	0.125	0.033	0.053	0.530	-0.122	0.048	0.012**
PARTCIPATEEXTINTION	0.131	0.075	0.082	-0.068	0.073	0.347	-0.062	0.068	0.363

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Note***, **, *, show significance at p<0.01, p<0.05, and p<0.1 respectively

Source: Computed from own survey (2020).

Access to credit services positively and significantly affects the probability choice of retailer market channel by 6.15% at 10% probability level. The sign of the finding indicate that credit is advantageous to produce the *dekoko* crop at bulk that rarely marketed to retailers. This shows that the better households have access to credit services, the more they increase the amount of *dekoko* products produced and sale it to market. Because credit facilitate condusive condition to acquire inputs such as motor pump, water can and other inputs that leads to produce more *dekoko* crops which attracts wholesaler. This result is consistent with Mebrat (2014). She indicated that credit has positive effect in vegetables production in rift valley of Ethiopia.

Off-farm participation of households significantly determines the *dekoko* channel choice. Being participate in off-farm activities decreases the probability choice of wholesaler channel by 12.2%. This result is hormone with Marenya (2010). Off-farm employed farmers are expected to sell their *dekoko* crop to private traders to accommodate more bulky sells that accords them a chance for other activities.

Livestock are important in contributing to household income. The sign obtained for this variable also indicated that an increase in number of total livestock unit in TLU reduces the probability choice of retailer whereas increases the probability choice of wholesaler market channel by 1.0% and 1.8% and significant at 5% probability level, respectively. This may indicate that households who have more livestock allocate more land for grazing area, which tends to reduce land used for *dekoko* production.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1.Conclusion

This study has been conducted in Northeastern Ethiopia in Amhara and Tigray region. The main purpose of the study was to analyze factors affecting *dekoko* production and distribution channel and its implication to household food security. Results of descriptive analys generally showed that producer of *dekoko* differ from the non- producer in various demographic, socio-economic and institutional related perspectives. The results showed that availability of small plot of land, poor wealth status, lack of fertilizer use and low education level are major constraints for *dekoko* pea production. However, since *dekoko* pea is early mature crop and can be produced using irrigation, they can able to produce it even after they harvested the staple food crops. Hence, not only better of farmers but also poor farmers are able to produce the pea by renting-in the land after the harvest season.

It has been pointed out in the discussions that even though the household in the study areas knows the agronomic characterstics of *dekoko* very well, the mangment practice given to the crop is very poor. However, if *dekoko* pea get proper management practices it becomes more productive. Still, some farmer preferred producing *dekoko* for its delicious taste, early maturity and marketability. The price of *dekoko* is twice better than the price of common pea, which will help improve the purchasing capacity of the households. Besides, *dekoko* pea may provide the households to cope up with seasonal food shortage.

The finding of the research also indicates that participating in *dekoko* production had a significant effect on household food security status. The quantitative result shows that households head with better social position and becomes model farmer she/he can obtain better information about the use of producing nutritious and cash crop and the more he/ she contacts extension agents to improve *dekoko* production and the more he/ she get access to credit to overcome their financial constraints. Household that has access to financial service able to buy agricultural inputs and improve the crop production and had ability to feed all his family without food shortage. In addition, households that have access to irrigation may able to produce more than two times in a year. Thus, the household can able to improve there productivity and food security status. This suggests that the producer's household are tend to get more diversified food than the non-producers.

Identifying factors affecting *dekoko* farmers' market outlet choice is important for the development of *dekoko* value chain. Family size, off-farm participation, total livestock unit, and institutional factors contribute a lot for marketing *dekoko* pea. In addition, the result indicates that most farmers directly sell *dekoko* to market. However, small number of them choose wholesaler and retailer channel. However, the volume of *dekoko* pea production plus farmers' productive assets determines what channel to choose. Hence, the less the *dekoko* pea produced the more they choose retailer and vice-versa. The result suggests that increasing the productivity of *dekoko* increases farmers' market channel choice.

Generally, biophysical related problems such as erratic rainfall distribution, recurrent drought, soil type, sowing time, pests and diseases, lack of improved seed and poor mangment practice are the main constraints for decline of *dekoko* production. These factors lead households to loss the income from the crop and they are obligated to sell staple food crops to buy agricultural inputs and increase household vulnerability to food insecurity. Moreover, age of household head, social position, access to credit, irrigation use, and household farm status and participate in extension program have a key role to enhance the productivity of *dekoko* and household food security. Thus, large and inactive family size, shortage of fertilizer use, limited participation in extension program, poor economic activities of the farmers would aggravate the problem of *dekoko* production and food insecurity.

5.2.Recommendations

Based on the finding of the study, the following recommendations were forwarded.

1. The small landholding size of the area may be a problem for the farmer, as they do not produce *dekoko* pea. However, *dekoko* pea can be produced two and more times in a year after the main or staple crops are harvested. Therefore, agricultural experts and extrension workers should encourage farmers to produce *dekoko* on the available small plot land.
2. The extension agents and administrators' attitudes that farmers are change resistant and do not know what is best for them should be changed. Farmers are rational, eager and highly committed to making livelihood changes and feeding their families. Therefore, the government officials in the rural areas should be estricted to extension egents as they observed in the field and provide awareness about the importance of *dekoko* production.
3. Cooperatives at the *woreda* level should facilitate the way of the farmers' access imporoved seed and aware farmers to share available seed.
4. Other big issue raised in this research was the need to improve the agronomic practice for *dekoko* pea. There is misconception that *dekoko* does not require fertile land. However, the annual production does not meet even the local demand. Therefore zonal and *woreda* level agricultural agronomist should give training to *dekoko* producers in order to give proper mangment for the crop.
5. To enhance the food security and nutritional value of *dekoko* in the study *woredas* and in other areas, the Agricultural mechanization (such as improved *dekoko* pea variety) and food science research/ interventions should be strengthened. Extension workers and development agents working in the respective study *woredas* should motivate farmers to produce more *dekoko* is crucial. However, in order to get more result in declining food insecurity in the study areas, the regional and *woreda* level agricultural offices should collaborate with regional and national research center to widely spread and distribute *dekoko* crop.
6. The finding indicated that majority of respondents prefer to sell their product directly to consumer. This was because there is no market linkage. Therefore, in order to overcome this problem and distribute this pea to other areas of the country, the regional agricultural office and farmers cooperatives should facilitate market linkage. This is important for *dekoko* produces to benefit more by selling their production with fair price.

Generally, *dekoko* pea has a valuable role in order to enhance food security status of household's interms of nutritional value and income generation. Therefore, in order to improve *dekoko* production and food security status of the households, the responsible bodies like regional and national food security offices should work together in development and awareness creation.

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Appendixes

Appendex 1: Collinearity test for logit model

```
. pwcorr HBCC SEX AGE FAMILYSIZE SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FERTILIZER T
> LU OFFARM NOLABO PARTCIPATEEXTINTION HHCATGO NOPLOTLAND LANDFERTILITY
```

	HBCC	SEX	AGE	FAMILY~E	SOCIOP~N	WEALTH	FAMEXP
HBCC	1.0000						
SEX	0.0799	1.0000					
AGE	-0.0114	0.3088	1.0000				
FAMILYSIZE	0.0931	0.5009	-0.0085	1.0000			
SOCIOPOSIT~N	-0.1437	-0.0242	0.0149	0.0032	1.0000		
WEALTH	0.0389	0.1138	0.0491	-0.0023	0.1402	1.0000	
FAMEXP	-0.0647	0.0143	0.0549	0.0501	0.0676	-0.0331	1.0000
CREDIT	0.0719	0.1415	0.0004	0.0639	0.1705	0.0477	0.1027
ACCESMA	0.0801	-0.0036	-0.0023	-0.0199	-0.0497	0.1618	-0.0515
TOTLANDSIZE	-0.0584	0.0202	-0.0224	0.0394	0.1253	-0.1288	0.0449
IRRIGATION	0.0999	0.0400	0.1777	0.0484	0.0203	-0.0284	0.0936
FERTILIZER	-0.0926	-0.0441	-0.0096	-0.0006	0.1914	-0.0380	-0.0372
TLU	-0.1035	-0.0375	-0.0050	0.0771	-0.0512	-0.2588	0.1142
OFFARM	-0.0326	-0.0402	-0.0964	-0.1478	-0.0329	0.1145	-0.0878
NOLABO	-0.0433	0.1098	0.0169	0.1940	-0.0910	-0.1923	0.0460
PARTCIPATE~N	-0.0811	0.1135	0.0110	0.0507	0.0327	0.1396	-0.0263
HHCATGO	0.1532	-0.0353	-0.0242	-0.0691	0.0996	0.2900	-0.1492
NOPLOTLAND	-0.1130	-0.0342	0.0852	0.1318	0.0158	-0.1869	0.0681
LANDFERTIL~Y	-0.0879	-0.0146	0.0777	0.0428	0.0378	-0.2510	0.0413

	CREDIT	ACCESMA	TOTLAN~E	IRRIGA~N	FERTIL~R	TLU	OFFARM
CREDIT	1.0000						
ACCESMA	0.2269	1.0000					
TOTLANDSIZE	0.0370	-0.0741	1.0000				
IRRIGATION	-0.0806	0.0444	-0.0439	1.0000			
FERTILIZER	0.0887	0.0044	0.1219	-0.1188	1.0000		
TLU	-0.0056	-0.0541	0.2886	0.1482	0.0142	1.0000	
OFFARM	0.2534	0.0392	-0.0531	-0.0088	-0.0197	-0.0441	1.0000
NOLABO	0.0803	0.0261	0.1649	0.0829	0.0682	0.1391	-0.0700
PARTCIPATE~N	0.0792	0.1106	0.0151	0.0106	-0.0531	-0.0666	0.0267
HHCATGO	-0.0746	0.0454	-0.1827	-0.1136	-0.0980	-0.3429	0.0055
NOPLOTLAND	-0.0528	-0.0277	0.2441	0.1695	-0.1174	0.2356	-0.1402
LANDFERTIL~Y	-0.0495	-0.2181	0.2280	0.2816	-0.0224	0.2103	-0.1364

	NOLABO	PARTCI~N	HHCATGO	NOPLOT~D	LANDFE~Y
NOLABO	1.0000				
PARTCIPATE~N	-0.0874	1.0000			
HHCATGO	-0.1799	0.1530	1.0000		
NOPLOTLAND	0.1749	0.0011	-0.3196	1.0000	
LANDFERTIL~Y	0.1754	-0.0621	-0.2712	0.3515	1.0000

Appendix 2: Vif test for ordered logit

```
. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
         SEX |      1.68    0.596166
  FAMILYSIZE |      1.52    0.657298
LANDFERTIL~Y |      1.41    0.708477
     HHCATGO |      1.40    0.713612
  NOPLOTLAND |      1.38    0.722073
      CREDIT |      1.29    0.776759
         TLU |      1.29    0.777870
      WEALTH |      1.27    0.790234
 TOTLANDSIZE |      1.24    0.803590
         AGE |      1.23    0.810781
  IRRIGATION |      1.22    0.819261
     ACCESMA |      1.19    0.842927
SOCIOPOSIT~N |      1.18    0.844127
      OFFARM |      1.18    0.844728
      NOLABO |      1.17    0.855482
  FERTILIZER |      1.14    0.876273
      FAMEXP |      1.08    0.926792
PARTCIPATE~N |      1.08    0.928143
-------------+----------------------
    Mean VIF |      1.28
```

Appendix 3: House hold food security by household food balance model depending up on kilocalorie in take into HBC≥2100 and HBC≤2100

```
. tab HB

         HB |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |        161       55.90       55.90
          2 |        127       44.10      100.00
------------+-----------------------------------
      Total |        288      100.00
```

Appendix 4: Demographic factors for food security

Variables		Food secured		Food in secured		Total		P- value
		N	%	N	%	N	%	
Sex	Male	136	84.47	99	77.95	235	81.60	
	Female	25	15.53	28	22.05	53	18.40	0.156
Education	Elementary school	27	16.77	24	18.90	51	17.71	
	High school	5	3.11	1	0.79	6	2.08	
	Secondary school	30	18.63	16	12.60	46	15.97	0.369
	Read and write	39	24.22	41	32.28	80	27.78	

	Illiterate	59	36.65	44	34.65	103	35.76	
	Other specify	1	0.62	1	0.79	2	0.69	

Appendix 5: Food security category based on FAO classification

```
. tabulate  FS DEKOPROD , chi2
```

FS	DEKO PROD 1	2	Total
1	98	63	161
2	7	20	27
3	3	33	36
4	4	60	64
Total	112	176	288

Pearson chi2(3) = 77.4715 Pr = 0.000

Appendex 6: Regression of food security

```
. reg FS SEX AGE FAMILYSIZE EDUSTATUSHHH SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FERTI
> LIZER NOLABO PARTCIPATEEXTINTION HHCATGO
```

Source	SS	df	MS		
Model	56.017178	15	3.73447854	Number of obs	288
				F(15, 272)	2.56
Residual	396.951572	272	1.45938078	Prob > F	0.0014
				R-squared	0.1237
				Adj R-squared	0.0753
Total	452.96875	287	1.57828833	Root MSE	1.208

FS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
SEX	.1784941	.2304844	0.77	0.439	-.2752661	.6322542
AGE	-.0376882	.0627639	-0.60	0.549	-.161253	.0858766
FAMILYSIZE	.0620492	.0524313	1.18	0.238	-.0411736	.1652719
EDUSTATUSHHH	.0798185	.0618717	1.29	0.198	-.0419898	.2016269
SOCIOPOSITION	-.1387271	.047434	-2.92	0.004	-.2321115	-.0453427
WEALTH	.0132852	.1258764	0.11	0.916	-.2345307	.2611012
FAMEXP	-.0018285	.0021978	-0.83	0.406	-.0061554	.0024984
CREDIT	.3755924	.1621756	2.32	0.021	.0563134	.6948714
ACCESMA	.2260302	.2791907	0.81	0.419	-.3236191	.7756796
TOTLANDSIZE	.0566418	.1299509	0.44	0.663	-.1991958	.3124793
IRRIGATION	.3503695	.1414923	2.48	0.014	.0718102	.6289287
FERTILIZER	-.0923987	.1550063	-0.60	0.552	-.3975633	.2127658
NOLABO	-.0502727	.0413322	-1.22	0.225	-.1316445	.0310991
PARTCIPATEEXTINTION	-1.003272	.4244009	-2.36	0.019	-1.8388	-.1677441
HHCATGO	.5125496	.1527493	3.36	0.001	.2118284	.8132708
_cons	1.333317	.7551476	1.77	0.079	-.1533599	2.819994

Appendix 7: Ordered logitmodel for food security

```
. ologit FS SEX AGE FAMILYSIZE EDUSTATUSHHH SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FE
> RTILIZER TLU OFFARM NOLABO PARTCIPATEEXTINTION HHCATGO

Iteration 0:   log likelihood = -328.66372
Iteration 1:   log likelihood = -306.75099
Iteration 2:   log likelihood = -306.37521
Iteration 3:   log likelihood = -306.37394
Iteration 4:   log likelihood = -306.37394

Ordered logistic regression                     Number of obs     =        288
                                                LR chi2(17)       =      44.58
                                                Prob > chi2       =     0.0003
Log likelihood = -306.37394                     Pseudo R2         =     0.0678
```

FS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.3116139	.3795526	0.82	0.412	-.4322955	1.055523
AGE	-.0633348	.1070812	-0.59	0.554	-.2732102	.1465405
FAMILYSIZE	.0940117	.0902189	1.04	0.297	-.0828142	.2708375
EDUSTATUSHHH	.1322858	.1087922	1.22	0.224	-.0809429	.3455146
SOCIOPOSITION	-.2550884	.0812955	-3.14	0.002	-.4144245	-.0957522
WEALTH	.1143736	.2229748	0.51	0.608	-.3226489	.5513961
FAMEXP	-.0034353	.0039314	-0.87	0.382	-.0111407	.0042701
CREDIT	.8284235	.284921	2.91	0.004	.2699887	1.386858
ACCESMA	.2827373	.4409906	0.64	0.521	-.5815884	1.147063
TOTLANDSIZE	.1708049	.2062647	0.83	0.408	-.2334666	.5750764
IRRIGATION	.738689	.2499395	2.96	0.003	.2488166	1.228562
FERTILIZER	-.2142121	.260694	-0.82	0.411	-.7251629	.2967388
TLU	-.0557183	.0453418	-1.23	0.219	-.1445866	.03315
OFFARM	-.3844407	.2690981	-1.43	0.153	-.9118633	.142982
NOLABO	-.0960263	.0696275	-1.38	0.168	-.2324936	.040441
PARTCIPATEEXTINTION	-2.086943	.8798488	-2.37	0.018	-3.811415	-.3624712
HHCATGO	.8085791	.2621052	3.08	0.002	.2948623	1.322296
/cut1	.4557751	1.44269			-2.371845	3.283395
/cut2	.9022826	1.444151			-1.928202	3.732767
/cut3	1.596433	1.44713			-1.23989	4.432756

Appendix 8: mfx one for food secured household

```
. margins, dydx(*) predict(outcome(1))

Average marginal effects                        Number of obs     =        288
Model VCE    : OIM

Expression   : Pr(HBCC==1), predict(outcome(1))
dy/dx w.r.t. : SEX AGE FAMILYSIZE SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FERTILIZER
               TLU OFFARM NOLABO PARTCIPATEEXTINTION HHCATGO NOPLOTLAND LANDFERTILITY
```

	Delta-method					
	dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	-.0332792	.0822884	-0.40	0.686	-.1945615	.128003
AGE	.0095585	.0229069	0.42	0.676	-.0353381	.0544551
FAMILYSIZE	-.0279528	.0193734	-1.44	0.149	-.0659239	.0100183
SOCIOPOSITION	.0511979	.0166055	3.08	0.002	.0186516	.0837441
WEALTH	-.0033974	.0469583	-0.07	0.942	-.095434	.0886392
FAMEXP	.000829	.0008311	1.00	0.319	-.0008	.002458
CREDIT	-.1641262	.0582233	-2.82	0.005	-.2782419	-.0500106
ACCESMA	-.0328497	.0962482	-0.34	0.733	-.2214928	.1557934
TOTLANDSIZE	-.0490041	.0446641	-1.10	0.273	-.1365442	.038536
IRRIGATION	-.1768141	.0525631	-3.36	0.001	-.2798359	-.0737923
FERTILIZER	.0632514	.0561269	1.13	0.260	-.0467552	.173258
TLU	.0104818	.0096394	1.09	0.277	-.0084111	.0293747
OFFARM	.0903743	.0571662	1.58	0.114	-.0216694	.2024179
NOLABO	.0176298	.0150341	1.17	0.241	-.0118366	.0470961
PARTCIPATEEXTINTION	.444552	.1828334	2.43	0.015	.086205	.8028989
HHCATGO	-.1465372	.0549372	-2.67	0.008	-.2542121	-.0388623
NOPLOTLAND	.0385122	.0339986	1.13	0.257	-.0281238	.1051483
LANDFERTILITY	.0407554	.0380209	1.07	0.284	-.0337641	.1152749

Appendix 9: mfx two for food secured household

```
. margins, dydx(*) predict(outcome(2))

Average marginal effects                        Number of obs     =        288
Model VCE    : OIM

Expression   : Pr(HBCC==2), predict(outcome(2))
dy/dx w.r.t. : SEX AGE FAMILYSIZE SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FERTILIZER
               TLU OFFARM NOLABO PARTCIPATEEXTINTION HHCATGO NOPLOTLAND LANDFERTILITY
```

	Delta-method					
	dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.0024756	.0061216	0.40	0.686	-.0095225	.0144738
AGE	-.0007111	.0017055	-0.42	0.677	-.0040537	.0026316
FAMILYSIZE	.0020794	.0015645	1.33	0.184	-.000987	.0051459
SOCIOPOSITION	-.0038086	.0016257	-2.34	0.019	-.0069949	-.0006223
WEALTH	.0002527	.0034985	0.07	0.942	-.0066041	.0071096
FAMEXP	-.0000617	.0000635	-0.97	0.331	-.000186	.0000627
CREDIT	.0122093	.0054815	2.23	0.026	.0014657	.022953
ACCESMA	.0024437	.0072671	0.34	0.737	-.0117995	.0166868
TOTLANDSIZE	.0036454	.0035078	1.04	0.299	-.0032297	.0105206
IRRIGATION	.0131532	.005379	2.45	0.014	.0026105	.0236959
FERTILIZER	-.0047053	.0044347	-1.06	0.289	-.0133971	.0039866
TLU	-.0007797	.0007538	-1.03	0.301	-.0022573	.0006978
OFFARM	-.0067229	.0045537	-1.48	0.140	-.0156481	.0022022
NOLABO	-.0013115	.0011717	-1.12	0.263	-.0036079	.0009849
PARTCIPATEEXTINTION	-.0330702	.0162541	-2.03	0.042	-.0649276	-.0012128
HHCATGO	.0109009	.0050367	2.16	0.030	.0010291	.0207727
NOPLOTLAND	-.0028649	.0026668	-1.07	0.283	-.0080918	.002362
LANDFERTILITY	-.0030318	.002973	-1.02	0.308	-.0088588	.0027953

Appendix 10: mfx three for food secured household

```
. margins, dydx(*) predict(outcome(3))

Average marginal effects                        Number of obs     =        288
Model VCE    : OIM

Expression   : Pr(HBCC==3), predict(outcome(3))
dy/dx w.r.t. : SEX AGE FAMILYSIZE SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FERTILIZER
               TLU OFFARM NOLABO PARTCIPATEEXTINTION HHCATGO NOPLOTLAND LANDFERTILITY
```

	Delta-method					
	dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.0066855	.0165528	0.40	0.686	-.0257573	.0391284
AGE	-.0019202	.0046114	-0.42	0.677	-.0109585	.007118
FAMILYSIZE	.0056155	.0039991	1.40	0.160	-.0022227	.0134537
SOCIOPOSITION	-.0102852	.0036889	-2.79	0.005	-.0175154	-.0030551
WEALTH	.0006825	.0094335	0.07	0.942	-.0178068	.0191718
FAMEXP	-.0001665	.0001686	-0.99	0.323	-.0004969	.0001638
CREDIT	.0329716	.0127093	2.59	0.009	.0080619	.0578814
ACCESMA	.0065992	.0194212	0.34	0.734	-.0314656	.044664
TOTLANDSIZE	.0098445	.009108	1.08	0.280	-.0080068	.0276959
IRRIGATION	.0355205	.01185	3.00	0.003	.012295	.0587461
FERTILIZER	-.0127067	.0114767	-1.11	0.268	-.0352005	.0097871
TLU	-.0021057	.0019672	-1.07	0.284	-.0059614	.00175
OFFARM	-.0181555	.0117647	-1.54	0.123	-.0412139	.004903
NOLABO	-.0035417	.0030565	-1.16	0.247	-.0095323	.0024489
PARTCIPATEEXTINTION	-.0893069	.0391861	-2.28	0.023	-.1661103	-.0125035
HHCATGO	.0294381	.0118949	2.47	0.013	.0061246	.0527517
NOPLOTLAND	-.0077368	.0069362	-1.12	0.265	-.0213316	.005858
LANDFERTILITY	-.0081874	.0077595	-1.06	0.291	-.0233959	.007021

Appendix 11: mfx four for food secured household

```
. margins, dydx(*) predict(outcome(4))

Average marginal effects                        Number of obs     =        288
Model VCE    : OIM

Expression   : Pr(HBCC==4), predict(outcome(4))
dy/dx w.r.t. : SEX AGE FAMILYSIZE SOCIOPOSITION WEALTH FAMEXP CREDIT ACCESMA TOTLANDSIZE IRRIGATION FERTILIZER
               TLU OFFARM NOLABO PARTCIPATEEXTINTION HHCATGO NOPLOTLAND LANDFERTILITY
```

	Delta-method dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.0241181	.0597226	0.40	0.686	-.0929361	.1411723
AGE	-.0069272	.0166222	-0.42	0.677	-.0395061	.0256516
FAMILYSIZE	.0202579	.0141284	1.43	0.152	-.0074333	.0479491
SOCIOPOSITION	-.037104	.0124774	-2.97	0.003	-.0615593	-.0126488
WEALTH	.0024621	.0340283	0.07	0.942	-.0642322	.0691564
FAMEXP	-.0006008	.0006058	-0.99	0.321	-.0017881	.0005865
CREDIT	.1189453	.0435511	2.73	0.006	.0335868	.2043038
ACCESMA	.0238068	.0696495	0.34	0.732	-.1127038	.1603173
TOTLANDSIZE	.0355141	.0324763	1.09	0.274	-.0281382	.0991664
IRRIGATION	.1281404	.0397475	3.22	0.001	.0502366	.2060441
FERTILIZER	-.0458394	.0407813	-1.12	0.261	-.1257692	.0340904
TLU	-.0075963	.0070092	-1.08	0.278	-.0213341	.0061414
OFFARM	-.0654959	.0419839	-1.56	0.119	-.1477829	.0167911
NOLABO	-.0127766	.0109712	-1.16	0.244	-.0342798	.0087266
PARTCIPATEEXTINTION	-.3221749	.1357433	-2.37	0.018	-.5882269	-.0561228
HHCATGO	.1061982	.0410012	2.59	0.010	.0258372	.1865591
NOPLOTLAND	-.0279105	.0247431	-1.13	0.259	-.0764061	.0205851
LANDFERTILITY	-.0295362	.0276363	-1.07	0.285	-.0837024	.0246301

Appendex 12: Dekoko kilo calories

Protein =251 gram * 4kcal = 1004

Fat = 19 gram *9 kcal = 171

Carbohydrate = 31.7 gram * 4 kcal = 126.8

Fiber = 130 gram * 2.0 kcal =260

Starch = 370 gram * 4.1788 kcal = 1546.156

Total = 3107.956 kcal from 801.7

801.7 = 3107.956

100 X

801.7 X = 100 * 3107.956

X = $\frac{100 * 3107.956}{801.7}$

X = $\underline{387.67}$

Appendix13: Multinomial logistic regression

```
. mlogit pereftosell SEX AGE FSIZE  Edustatus HOUSEHOLDFARMSTATUS WEALTHp SOCIOPOSITION  ACCESSTOCREDIT ACCESMA DIST
> ANCETOMARKET TLU OFFARM  PARTCIPATEEXTINTION

Iteration 0:   log likelihood = -312.00614
Iteration 1:   log likelihood =  -294.9768
Iteration 2:   log likelihood = -287.47088
Iteration 3:   log likelihood = -285.92072
Iteration 4:   log likelihood = -285.48941
Iteration 5:   log likelihood = -285.37525
Iteration 6:   log likelihood = -285.34969
Iteration 7:   log likelihood = -285.34388
Iteration 8:   log likelihood =   -285.343
Iteration 9:   log likelihood =  -285.3429
Iteration 10:  log likelihood = -285.34288

Multinomial logistic regression                 Number of obs     =        288
                                                LR chi2(39)       =      53.33
                                                Prob > chi2       =     0.0629
Log likelihood = -285.34288                     Pseudo R2         =     0.0855
```

pereftosell	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
0						
SEX	-16.37695	12924.97	-0.00	0.999	-25348.86	25316.11
AGE	12.34275	1772.516	0.01	0.994	-3461.725	3486.41
FSIZE	8.308089	375.2086	0.02	0.982	-727.0872	743.7034
Edustatus	-4.221922	1726.458	-0.00	0.998	-3388.017	3379.573
HOUSEHOLDFARMSTATUS	-4.997423	2190.698	-0.00	0.998	-4298.686	4288.691
WEALTHp	-9.031278	2121.72	-0.00	0.997	-4167.526	4149.464
SOCIOPOSITION	6.829895	1534.654	0.00	0.996	-3001.038	3014.697
ACCESSTOCREDIT	-4.889987	5277.442	-0.00	0.999	-10348.49	10338.71
ACCESMA	12.04905	6349.543	0.00	0.998	-12432.83	12456.92
DISTANCETOMARKET	10.5499	1939.361	0.01	0.996	-3790.528	3811.628
TLU	-2.150148	458.3978	-0.00	0.996	-900.5934	896.2931
OFFARM	-19.66976	2633.283	-0.01	0.994	-5180.809	5141.47
PARTCIPATEEXTINTION	-8.507547	13243.58	-0.00	0.999	-25965.44	25948.43
_cons	-93.45812	10661.04	-0.01	0.993	-20988.72	20801.8
1	(base outcome)					
2						
SEX	-.4725518	.4189877	-1.13	0.259	-1.293752	.3486489
AGE	.0275974	.1489129	0.19	0.853	-.2642664	.3194612
FSIZE	.214153	.0908789	2.36	0.018	.0360336	.3922723
Edustatus	.1268315	.128563	0.99	0.324	-.1251473	.3788103
HOUSEHOLDFARMSTATUS	.4736935	.2886752	1.64	0.101	-.0920995	1.039487
WEALTHp	.2504587	.2455598	1.02	0.308	-.2308296	.731747
SOCIOPOSITION	.0334459	.0930364	0.36	0.719	-.148902	.2157938
ACCESSTOCREDIT	-.6960151	.3504771	-1.99	0.047	-1.382938	-.0090926
ACCESMA	.4127658	.5550273	0.74	0.457	-.6750676	1.500599
DISTANCETOMARKET	.2656784	.1794917	1.48	0.139	-.0861189	.6174757
TLU	-.1144209	.0579181	-1.98	0.048	-.2279382	-.0009035
OFFARM	-.084759	.30767	-0.28	0.783	-.6877811	.5182631
PARTCIPATEEXTINTION	-.5643143	.407523	-1.38	0.166	-1.363045	.2344162
_cons	-1.663336	1.429677	-1.16	0.245	-4.465451	1.13878
3						
SEX	-.1366441	.4259123	-0.32	0.748	-.9714169	.6981287
AGE	.0246102	.1574571	0.16	0.876	-.2840001	.3332205
FSIZE	.0858745	.0974742	0.88	0.378	-.1051714	.2769205
Edustatus	.1713146	.1314193	1.30	0.192	-.0862626	.4288917
HOUSEHOLDFARMSTATUS	-.0393205	.312163	-0.13	0.900	-.6511487	.5725078
WEALTHp	.3552158	.2611789	1.36	0.174	-.1566854	.867117
SOCIOPOSITION	.1238033	.0987441	1.25	0.210	-.0697315	.3173381
ACCESSTOCREDIT	-.1916423	.3509911	-0.55	0.585	-.8795722	.4962877
ACCESMA	.1754249	.6537385	0.27	0.788	-1.105879	1.456729
DISTANCETOMARKET	.0598221	.1910284	0.31	0.754	-.3145867	.4342309
TLU	.0588519	.0510851	1.15	0.249	-.041273	.1589768
OFFARM	-.7329124	.312628	-2.34	0.019	-1.345652	-.1201729
PARTCIPATEEXTINTION	-.5734983	.4138206	-1.39	0.166	-1.384572	.2375751
_cons	-1.209092	1.508684	-0.80	0.423	-4.166059	1.747875

Appendix14: Marginal effect of multinomial

```
Expression   : Pr(pereftosell==1), predict(outcome(1))
dy/dx w.r.t. : SEX AGE FSIZE Edustatus HOUSEHOLDFARMSTATUS WEALTHp SOCIOPOSITION ACCESSTOCREDIT ACCESMA
               DISTANCETOMARKET TLU OFFARM PARTCIPATEEXTINTION
```

	Delta-method dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.072735	.0794631	0.92	0.360	-.0830099	.2284798
AGE	-.0060276	.0291069	-0.21	0.836	-.0630762	.0510209
FSIZE	-.0355255	.0173956	-2.04	0.041	-.0696201	-.0014308
Edustatus	-.0339311	.0245465	-1.38	0.167	-.0820415	.0141792
HOUSEHOLDFARMSTATUS	-.0540432	.0566508	-0.95	0.340	-.1650769	.0569904
WEALTHp	-.0688153	.047193	-1.46	0.145	-.1613119	.0236813
SOCIOPOSITION	-.0173626	.0179387	-0.97	0.333	-.0525217	.0177965
ACCESSTOCREDIT	.1061008	.0647172	1.64	0.101	-.0207427	.2329442
ACCESMA	-.0695333	.1149898	-0.60	0.545	-.2949091	.1558426
DISTANCETOMARKET	-.0390735	.0348432	-1.12	0.262	-.1073649	.0292179
TLU	.0077722	.0101446	0.77	0.444	-.0121107	.0276552
OFFARM	.0888606	.0579966	1.53	0.125	-.0248107	.2025318
PARTCIPATEEXTINTION	.130772	.075114	1.74	0.082	-.0164487	.2779927

```
. margins, dydx(*) predict(outcome(2))

Average marginal effects                        Number of obs     =        288
Model VCE    : OIM

Expression   : Pr(pereftosell==2), predict(outcome(2))
dy/dx w.r.t. : SEX AGE FSIZE Edustatus HOUSEHOLDFARMSTATUS WEALTHp SOCIOPOSITION ACCESSTOCREDIT ACCESMA
               DISTANCETOMARKET TLU OFFARM PARTCIPATEEXTINTION
```

	Delta-method dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	-.0808418	.0741458	-1.09	0.276	-.2261648	.0644812
AGE	.0035958	.0263673	0.14	0.892	-.0480831	.0552747
FSIZE	.0350156	.0155596	2.25	0.024	.0045193	.0655118
Edustatus	.0125867	.0224868	0.56	0.576	-.0314866	.05666
HOUSEHOLDFARMSTATUS	.0929672	.0498232	1.87	0.062	-.0046846	.1906189
WEALTHp	.0237107	.0434372	0.55	0.585	-.0614246	.1088461
SOCIOPOSITION	-.0020016	.0165753	-0.12	0.904	-.0344886	.0304854
ACCESSTOCREDIT	-.1197219	.0615492	-1.95	0.052	-.2403561	.0009123
ACCESMA	.0668198	.0971006	0.69	0.491	-.1234939	.2571335
DISTANCETOMARKET	.0466015	.0313793	1.49	0.138	-.0149008	.1081037
TLU	-.025796	.0100087	-2.58	0.010	-.0454128	-.0061793
OFFARM	.0334377	.0532077	0.63	0.530	-.0708473	.1377228
PARTCIPATEEXTINTION	-.0687737	.0731984	-0.94	0.347	-.21224	.0746925

```
. margins, dydx(*) predict(outcome(3 ))

Average marginal effects                        Number of obs     =        288
Model VCE    : OIM

Expression   : Pr(pereftosell==3), predict(outcome(3 ))
dy/dx w.r.t. : SEX AGE FSIZE Edustatus HOUSEHOLDFARMSTATUS WEALTHp SOCIOPOSITION ACCESSTOCREDIT ACCESMA
               DISTANCETOMARKET TLU OFFARM PARTCIPATEEXTINTION
```

	Delta-method dy/dx	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.0081071	.069316	0.12	0.907	-.1277498	.1439641
AGE	.0024316	.0255496	0.10	0.924	-.0476446	.0525078
FSIZE	.0005098	.0155421	0.03	0.974	-.0299521	.0309716
Edustatus	.0213445	.0210075	1.02	0.310	-.0198293	.0625184
HOUSEHOLDFARMSTATUS	-.0389239	.0498831	-0.78	0.435	-.1366929	.0588451
WEALTHp	.0451047	.042239	1.07	0.286	-.0376823	.1278917
SOCIOPOSITION	.0193641	.0160657	1.21	0.228	-.0121241	.0508523
ACCESSTOCREDIT	.0136212	.0571332	0.24	0.812	-.0983579	.1256003
ACCESMA	.0027133	.105189	0.03	0.979	-.2034534	.20888
DISTANCETOMARKET	-.0075281	.0308036	-0.24	0.807	-.0679021	.0528458
TLU	.0180238	.0081379	2.21	0.027	.0020739	.0339738
OFFARM	-.122298	.0488517	-2.50	0.012	-.2180456	-.0265504
PARTCIPATEEXTINTION	-.0619981	.0681579	-0.91	0.363	-.1955851	.0715888

Appendix 15: Conversion factors used to estimate TLU

Livestock	Conversion factor
Cow	1
Ox	1
Bull	0.60
Heifer	0.75
Calves	0.20
Donkey/Mule	0.70
Horses	1.10
Shoats	0. 13
Poultry	0.013

Source: Stock *et al.*, (1991)

Appendix 16: Food energy factor (KCL/100g

Food item category	Food item	KCAL/100g
Cereals	Teff	357
	Barley	378
	Wheat (70-74% extraction)	403
	Wheat (97-100% extraction)	378
	Macaroni, spaghetti	412
	Other cereal	412
Fruits and vegetable	Root and tubers	384
	Vegetables	357
	Fruits	360
Legumes	Legumes	407
Milk and milk products meat	Milk and milk products	387
	Meat	427
	Egg	368

Appendix 17: Questionnaire

Household survey questionnaire on the production and distribution of *Dekoko* (Pisumsativum var. Abyssinicum a. Braun) and household food security nexus,

Part I. General information

1.	Household Identification Number		
2.	Date of Interview		
3.	Time of interview:	Starting time	
		Finishing time	
4.	Name of interviewer		
5.	Woreda		
6.	Kebele		

Part II. Household socio-cultural related information

No	Questions		Code
1.	**Sex of household head:** 1. Male 2. Female		
2.	**Age of household head**		
3.	**Family size**		
3.1.	Number of family members in the household	1. Male	
		2. Female	
		3. Total	
4.	**Education status of household head**: 1. Illiterate 2. Read and write 3. Elementary school (1-4) 4. Secondary school (5-8) 5. High school (9-10) 6. Preparatory (11-12) 7. Other, specify		
5.	**Health Status**		
5.1.	Is the household head active/capable to work? 1. Yes 2. No		
5.2.	If 'no' to question # 5.1., why? 1. Sick 2. Aged 3. Disable 4. Other, specify		
6.	**Labor available**		
6.1.	Number of permanent family labor for farming activities at time of survey	1. Male	
		2. Female	
		3. Total	

7.	**Social status**	
7.1.	Household head social position in the community: 1. Chairman 2. Secretary 3. Development team leader 4. Religious leader 5. Elder 6. No leadership position 7. Other, specify	
7.2.	Household category in terms of wealth status: 1. Better-off 2. Middle 3. Poor	
8.	**Extension**	
8.1.	Do you participate in agricultural extension programs? 1. Yes 2. No	
8.2.	Have you contacted development agents and/or other agricultural experts on crop production, livestock production and soil management? 1. Yes 2. No	
8.3.	If your response is 'yes' to Q#8.1., how often do you contacted them? 1. Once a week 2. Every month 3. Every three months 4. Twice a year 5. Once a year 6. Other, specify	
8.4.	Household category in terms of extension use: 1. Model farmers 2. Non-model farmer	
8.5.	Did you obtain support or technical advice from extension workers on your farming activities? 1. Yes 2. No	
8.6.	If 'yes' to question # 8.5, what type of advices did you get? (multiple response is possible) 1. Land preparation 2. Application of improved seed and fertilizer 3. Application of herbicides and insecticide 4. Soil and water conservation 5. Other, specify	
9.	**Land certificate**	
9.1.	Do you have a land certificate?1. Yes 2. No	
10.	**Farming experience in years**	
11.	**Credit services**	
11.1.	Do you have access to credit services? 1. Yes 2. No	
11.2.	If 'yes' to question # 11.1, for what purpose do you receive credit? (multiple response is possible) 1. To purchase improved seed 2. To purchase fertilizer 3. To purchase farm equipment/ tools 4. To start income generating activities 5. Other, specify	
12.	**Access to market**	
12.1.	Do you have access to market? 1. Yes 2. No	
12.2.	Please tell us the distance from home to nearby market (in hours)	

Part III. Household economic and farm related information

1. Farmland

1.1.Please indicate the type of land use you owned, means of access to it, size in Timad and the number of plot(s) for each type of land uses you owned.

Land use types	1.1.1. 1. Yes 2. No	1.1.2 **Means of access (Multiple response is possible)** 1.Land distribution 4. Sharecropped-in 2. Inherited from parents 5. Rented-in 3. Shared with relatives 6. Other, specify	1.1.3 **Size in *Timad***	1.1.4 **Number of plot/plots**
Cultivated land				
Grazing land				
Homestead area				
Other, specify				
		Total		

1.2.Would you tell us the characteristics of each cultivated farm plots you have?

Plots	**1.2.1.** **Slope** 1. Flat 2. Gentle 3. Steep	**1.2.2.** **Soil color** 1. Black 2. Red 3. Brown 4. Sandy	**1.2.3.** **Distance** from home (Minutes)	**1.2.4.** **Fertility status** 1. Poor 2. Medium 3. Good	**1.2.5.** **Erosion experience** 1. Low 2. Medium 3. Severe	**1.2.6.** **Irrigated** 1. Yes 2. No	**1.2.7.** If 'yes' to #1.1.6, indicate the source of water: 1. River 2. Pipe 3. Pond 4.Other,specify
Plot 1							
Plot 2							
Plot 3							
Plot 4							
Plot 5							
Plot 6							
Plot 7							
Plot 8							
Plot 9							
Plot 10							

2. Crop production

2.1. Would you tell us the type of crops have you grown, amount of crop products you produced and income obtained in the year 2010/11 E.C.

Type of crop cultivated	**1. Yes 2. No**	**Cultivated area (Timad)**	**Quantity produced (Qt)**	**Quantity retained for consumption (Qt)**	**Quantity sold to market (Qt)**
Teff					
Maize					
Sorghum					
Wheat					
Barley					
Chickpea					
Lentil					
Haricot beans					
Field peas					
Dekoko					
Grass peas					
Sunflower					
Neug					
Linseed					
Sesame					
Other, specify					

2.2.	How do you evaluate your crop products that you have been harvesting per unit of farm plots over the last five years? 1. Improving 2. Declining 3. The same 4. I do not know	
2.3.	If 'declining' to question # 2.2., please indicate what constrained you to improve your crop products over the last five years? Indicate their level of importance/rank order?	

No	**Constraints**	**2.3.1.**	**2.3.2.**
		1. Yes 2. No	**Rank order**

1.	Shortage of rainfall		First	
2.	Erratic rainfall distribution		Second	
3.	Shortage of soil moisture		Third	
4.	Soil erosion		Fourth	
5.	Poor soil fertility		Fifth	
6.	Crop pests and diseases			
7.	Poor application of improved inputs			
8.	Lack of capital to purchase input			
9.	Inability to apply erosion control measures			
10.	Shortage of farm-tools/farm-oxen			
11.	Other, specify			

3. Inputs applied

3.1. Would you tell us farm inputs you applied for different crop typesto help you increase production in 2010/2011?

No	Inputs applied	**Major crop types (Code: 1. Yes 2. No; Quantity used in Kg)**								
		Teff	Wheat	Sorghum	Barley	Maize	H/Beans	F/Peas	Dekoko	Other, specify
1.	**Chemical fertilizer**									
1.1.	Have you used DAP?									
	If 'yes', tell us quantity used?									
1.2.	Have you used UREA?									
	If 'yes', tell us quantity used)									
1.3.	Have you used NPS?									
	If 'yes', tell us quantity used									
2.	**Natural fertilizer**									
2.1.	Have you applied compost?									
	If 'yes', quantity used?									
2.2.	Have you used manure?									
	If 'yes', quantity used?									

4. Farm-implements

4.1.	Do you have farm implements for farming activities? 1. Yes 2. No	
4.2.	If 'yes' to question # 4.1., which type/s of farm implements do you have? (multiple response is possible) 1. Farm oxen 2. Plough and yolk 3. BBM 4. Flat hoes 5. Shovel 6. Hammer 7. Other, specify	

5. **Livestock production**

5.1.Would you tell us the types of livestock you have, their number and income obtained from sale of livestock's in the year 2008/09 (2015/16)?

No	**Livestock types**	5.1.1.	5.1.2.	5.1.3.	5.1.4.
		1. Yes 2. No	**Number owned**	**Livestock sold**	**Income obtained**
1.	Oxen				
2.	Cows				
3.	Bulls				
4.	Heifers				
5.	Calves				
6.	Sheep				
7.	Goats				
8.	Horses				
9.	Donkeys				
10.	Chicken/poultry				
11.	Other, specify				

5.2.Would you tell us livestock products you produced, products sold to market and estimated income obtained from sale of livestock products in the year 2008/9 (2015/16)?

No	**Livestock products produced**	5.2.1.	5.2.2.	5.2.3.	5.2.4.
		1. Yes 2. No	**Estimated amount produced**	**Estimated amount sold to market**	**Estimated income obtained (Birr)**
1.	Milk				
2.	Cheese				

3.	Butter				
4.	Eggs				
5.	Honey				
6.	Other, specify				

5.3.	How do you evaluate your livestock production over the last five years? 1. Improving 2. Reducing 3. The same 4. I do not know
5.4.	If 'reducing' to question # 4.3., please indicate what constrained you to improve livestock production over the last five years? Indicate their level of importance/rank order?

No	**Constraints**	5.4.1.	5.4.2.	
		1. Yes 2. No	**Rank order**	
1.	Shortage of feed resources		First	
2.	Lack of supplementary forages		Second	
3.	Livestock disease prevalence		Third	
4.	Poor veterinary services		Fourth	
5.	Shortage of water		Fifth	
6.	Lack of appropriate skill for livestock production			
7.	Poor extension services			
8.	Other, specify			

6. **Income generating activities**

6.1.	Do you have any off-farm income generating sources? 1. Yes 2. No	
6.2.	If 'yes' to question # 5.1., would you tell us about the type of activities and estimated income obtained in the year 2008/09 (2015/16)?	

No	**Type of off-farm activities**	6.2.1.	6.2.2.
		1. Yes 2. No	**Estimated income obtained**
1.	Petty trades		
2.	Grain retailing		
3.	Livestock retailing		
4.	Wage labourers		
5.	Handicrafts/weaving		
6.	Other, specify		

Part IV. Farmer's perception on Dekoko production and distribution

1.	Do you know Dekoko 1. Yes 2. No	
2.	If 'yes' to question # 1., for how long do you know the crop (mention in years)?	
3.	Do you know that Dekokohas been currently produced in different regions of the country, other than this woreda and region you live in? 1. Yes 2. No	
4.	If 'yes'to question #3, where? (mention in number)	
5.	If no to question #3 what do you think that the reason?	
6.	How do you evaluate the production status of Dekoko as compared to other food crops you produced? 1. Higher 2. No difference 3. Lower 4. I don't know	
7.	If 'lower' to question # 5, what are the reasons for low production? (Multiple response is possible) 1. Require fertile soil 2. Require higher soil water availability 3. High preference for cereal crops 4. Limited application of improved inputs 5. Susceptibility to pests and diseases 6. I do not know the reason 7. Other, specify	
8.	Is cultivation of Dekoko dependent on seasonal rainfall? 1. Yes 2. No	
9.	From where do you get Dekoko seed for cultivation? 1. Own reserved seed 2. From neighboring farmers (seed exchange) 3. Bought from local market 4. Office of Agriculture 5. Other, specify	
10.	What type of soil color does Dekoko crop prefers during cultivation? 1. Black soil 2. Red soil 3. Brown soil 4. Sandy soil 5. Other, specify	
11.	Please tell us the time of Dekoko crop cultivation in your area? 1. June to July 2. August to September 3. April to May 4. Other, specify	
12.	For how many times do you plough the land for Dekoko crop cultivation? 1. Once time 2. Two times 3. Three times 4. Other, specify	
13.	Please tell us the seeding rate of Dekoko per ha? 1. 10-15 kg/ha 2. 16-20 kg/ha 3. 21-25 kg/ha 4. 26-30 kg/ha 5. 31-35kg/ha 6. 36-40 kg/ha 7. Other, specify	
14.	What types of management measures are applied for dekoko crop after cultivation? 1. Weeding 2. Top-up UREA fertilizer 3. Pesticides 4. Herbicides 5. No measures	
15.	How long does Dekoko crop takes to become matured and harvested? 1. 60 days 2. 60 to 90 days 3. more than 90 days 4. Other, specify	
16.	Would you tell us the estimated price of Dekoko per Kg in the current production	

	year? (Birr)	
17.	How do you evaluate the market price of Dekoko crop as compared to other food crops? 1. Good 2. No difference 3. Low 4. I don't know	
18.	For whom do you prefer to sell your Dekoko crop? 1. Consumers 2. Retailers 3. Rural wholesalers 4. Urban wholesalers 5. Other, specify	
19.	Would you tell us the reasons why you Produced Dekoko over time? (Multiple answer is possible) 1. For its disease and pest resistance 2. Lack of alternative crop 3. For its early maturing 4. For its taste (consumption) 5. For its better production 6. For its marketability 7. Other, specify	
20.	Do you face problems related to Dekoko crop production? 1. Yes 2. No	
21.	If 'yes' to question #19, what do you think are the main causes?	

No	**Constraints**	**20.1.**	**20.2.**	
		1. Yes 2. No	**Rank order**	
1.	Lack of knowledge		First	
2.	Shortage of farm land		Second	
3.	Lack of improved dekoko variety		Third	
4.	High input required (fertilizer, improved seed)		Fourth	
5.	Lack of credit to buy improved inputs		Fifth	
6.	High labour demand			
7.	Diseases and pests outbreaks			
8.	Recurrent drought			
9.	Poor application of improved inputs			
10.	Low market price			
11.	Lack of applying appropriate management measures			
12.	Other, specify			

Part VI: Food utilization information (Household Dietary Diversity Score)

QUESTIONS AND FILTERS	CODING CATEGORIES
Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night.	
Read the list of foods. Place a one in the box if anyone in the household ate the food in question, place take the value of 1 if any of the disaggregated food groups were consumed; they will take the value of 0 if none of the disaggregated food groups were consumed.	
A. Any [INSERT ANY LOCAL FOODS, E.G. UGALI, NSHIMA], bread, rice noodles, biscuits, cookies, or any other foods made from millet, sorghum, maize, rice, wheat, or [INSERT ANY OTHER LOCALLY AVAILABLE GRAIN]?	\ A.....|___|
B. Any pumpkin, carrots, sweet potatoes that are yellow or orange inside?	B.....|___
C. Any white potatoes, white yams, manioc or any other foods made from roots or tubers?	C.....|___|
D. Any green leafy vegetables such as spinach, pepper?	D.....|___|
E. Any other vegetables?	E.....|___|
F. Any ripe mangoes, ripe papayas or [INSERT ANY OTHER LOCALLY AVAILABLE VITAMIN A-RICH FRUIT?	F.....|___|

G. Any other fruits? |	G.....|___
H Any beef, pork, lamb, goat, chicken, duck, or other meats? |	H.....|___
I. Any eggs?	I.....|___
J. Any fresh or dried fish or shellfish?	J.....|___|
K. Any foods made from beans, peas, or lentils? Is there any one from your household who ate dekoko cooks yesterday, during day and night?	K.....|___| ……
L. Any cheese, yogurt, milk or other milk products?	L.....|___

Thank you for your time!