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Factors Affecting Adoption of Improved Teff Varieties in Cheha District of Guraghe Zone, Ethiopia

A research by

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ACRONYMS AND ABBREVIATIONS

ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
EIAR	Ethiopian Institute of Agricultural Research
ETB	Ethiopian Birr
GDP	Growth Domestic Product
HYV	High Yielding Varities
MoA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
NGOs	Non Governmental Organizations
SNNPs	South Nations,Nationalities and Peoples
TLU	Total Livestock Unit
WB	World Bank

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ABSTRACT

Adoption and wider diffusion of improved varieties is playing vital role in reversing the present situation of food insecurity in many parts of Ethiopia. However, the uses of improved teff varieties are constrained by various factors. Hence, in this study, an attempt was made to examine factors affecting the household's decision to adopt improved teff verities in Cheha woreda. The study was based on the cross-sectional data obtained from 93 teff producers collected through semi-structured questionnaire. A multi-stage random sampling technique was employed to select sample respondents. Descriptive statistical like mean, standard deviation, percentage, and frequency distribution and Probit model was used to address the objectives of the study. The result of the econometric analysis using probit model confirmed that age of household head, size of land allocated for teff and distance from the nearest market affect the husehold's adoption decision negatively and significantly whereas frequency of extension contact, off/non-farm income, household's livestock holding, improved teff seed availability were found to affect the household's adoption decision positively and significantly. Therefore, providing frequent and reliable extension contact, providing good transport facilities for farmers through infrastructural development, smoothening the access to and availability of improved teff seeds, enhancing household's non-farm income generation capacity and supporting households to enhance their livestock holding are the primary focus areas that need policy intervention to enhance the adoption of improved variety so that their productivity will be improved which inturn will enhance the households food security.

Key words: Adoption, Cheha, Improved seed, teff, Probit

1. INTRODUCTION

1.1. Background of the Study

According to MoFED (2016) report, agriculture accounts for nearly 37.2% of Ethiopian GDP, more than 80% of employment, 90% of foreign export earnings and about 70% of raw material requirement for existing large and medium scale industries. However, the majority of the agriculture sector in the country is made up of smallholder farmers who own less than two hectares of land and produces below their potential. Maize, wheat, and Teff are the most important cereals in terms of volume, accounting for a total of 77% of all cereal production while maize, Teff, wheat and sorghum have made 26.80%, 16.76%, 15.81% and 16.20% of the grain production respectively (CSA, 2016).

As it had been indicated under Ethiopian Agricutural Transformation Agency (ATA) 2015 report, *Teff* is one of the staple food and cash crops in Ethiopia. It is believed to be originated, domesticated and diversified in this country. It is a highly important crop to Ethiopians, both in terms of production and consumption. It accounts for about 15% of all calories consumed in the country. It ranks first in area coverage and second after maize in total production. The crop accounted for about 28.7% of the total grain cultivated land (CSA, 2016). It is a multipurpose crop, being utilized in different forms where the grain is used to make the Ethiopian staple food, Injera. It is also valued for its fine straw, which is used for animal feed as well as for reinforcing mud for plastering wooden walls of buildings (Bekabil et al., 2011). The popularity of teff can be also explained with its high price. It is the highest priced cereal grown in Ethiopia and is an attractive cash crop for farmers. Combined with the high share of the final price obtained by the farmers, income from teff is much higher than income from other cereals and even 34% higher than income from coffee, the major export crop in Ethiopia (Minten et al., 2013; Worku et al., 2014).

About 25-30 million people are directly depend on teff production. The higher teff price followed by an increasing commercialization of smallholder farmers represents an opportunity to directly increase the living standard of rural communities in Ethiopia (Hauenstein, 2015). However, the national average productivity and yield level of *teff* (1200 kg/ha) is very low and

bellow the potential; attributed to different socio-economic and natural factors. Asrat and Frew (2011) argue that, using local variety seed is one and the main attribute of this low productivity and adoption of improved agricultural technology is one and most important strategies for improving the production and productivity.

In Ethiopia, adoption rate of modern agricultural technologies is very low (Berihun *et al*., 2014). The use of improved variety is considered as an important input for the achievement of increased agricultural productivity and food security status of farm households in Ethiopia. In this regard, there has been an increasing effort to improve crop productivity primarily through agricultural intensification, involving an increased use of inputs, including seeds of improved crop varieties (Byerlee *et al*., 2007). In order to promote the adoption of improved *teff* varieties in smallholder farmers, a number of extension activities have been done in the major *teff* growing areas of the country (ATA, 2013). In line with this, nearly thirty two improved varieties were released by EIAR (MoA, 2010).The research-extension program of the national agricultural research system played key role in the dissemination of improved *teff* varieties through on-farm verification and demonstration (Setotaw, 2013).

Setotaw (2013) showed the presence of significant gap between the potential *teff* yield and the actual farmers' yield. This is due to low adoption of available improved varieties by smallholder farmers. There has been a wider consensus that, the weak seed system in Ethiopia is also one of the limiting factor for the slow dissemination and low rate adoption of improved *teff* Varieties since the formal seed sector which consists of both the private and public seed enterprises is driven by profit. In Ethiopia, the formal seed sector covers only 5% of the *teff* seed requirement (Dawit *et al*., 2007).

There are different stakeholders participating in the regional farmers based improved *teff* varieties or seed multiplication; the South Nations Nationalities and peoples Agricultural Research Institute (SNNPARI), NGO's and the farmers themselves. In Cheha district, improved *teff* verities are being promoted by the government. However, study on the adoption of these improved varieties was not conducted in the study area so as to know the gap. In order to improve production and productivities of *teff*, identifying factors affecting adoption was found to be important.

1.2. Statement of the Problem

Despite the multidimensional importance of teff in Ethiopia, its productivity remains low. The low *teff* yield is partly explained by the limited knowledge about the possible avenues for improving *teff* productivity, together with the problems inherent to its botany. Moreover, *teff* yield is low because of lodging, low modern input use, use of local variety seed, traditional way of sowing, socio-economic factors such as lack of access to market information, post-harvest and processing losses and lack of high yielding cultivars (Bekabil *et al*., 2011; Tareke *et al*., 2011). In Ethiopia, however, access to and adoption of new agricultural technologies have been greatly limited by socio-economic, logistical and institutional obstacles (Mekuria, 2013; Minten *et al*., 2012).

Eventhough there are several improved varieties developed and disseminated to Ethiopian farmers along with their optimum management practices to improve their crop productivity, different area-specific evidences indicate that adoption rate of improved *teff* varieties in the country is low. This low rate of adoption decisions of farmers is usually determined by various factors which need to be identified and investigated through intervention to improve teff productivity (Setotaw, 2013).

Acccording to Guragie Zone office of agriculture 2014 report (GZANRs, 2017), the adoption rate of improved teff variety in the zone as well as in Cheha woreda is very low mainly because of different factors affecting the farmers decision to adopt. However, very limited effort has been taken from the research perspective to identify the factors affecting the adoption of improved teff variety indicated that there is high related research and information gap in the area. All the existing conditions in Cheha Woreda and the existing research and information gaps discussed so far, directly call for further related scientific studies in this area. Hence, this study was designed to identify factors affecting the adoption of improved teff verities in Cheha woreda and therefore fills the existing related information and research gap and highly contributes for improving teff productivity in the woreda.

1.3. Scope and Limitation of the Study

The study was limited to Cheha Woreda Gurage Zone. This study was confined only to the determinants of adoption and adoption status of house holds' improved *teff* varieties at farmers' level. Moreover, one crop namely *teff* is selected for this study due to its importance for domestic food consumption and commercialization in Ethiopia. The limitation of this study is related to the types of data collected. The study mainly utilized cross-sectional data generated from the sample household survey of only one cropping season and was not also incorporate information generated from farming plot characteristics.

1.4. Significance of the Study

The study analyzes the adoption and adoption status of improved *teff* varieties in Cheha district. Therefore, this study can help to identify factors influencing adoption decision of improved *teff* varieties in the study area. In addition, the significance of this study lays ground to provide information for further improvement of the adoption of the varieties. The findings of this study is used as an input for policy makers in designing future policies and strategies for *teff*. Hence, an investigation of the underlying factors associated with adoption of improved *teff* varieties will benefit local and regional governments, researchers, policy makers, extension workers, farmers and other stakeholders.

1.5. Research Questions

This study tried to answer the following research questions:

1. What are the important factors determining the adoption of improved *teff* varieties in the study area?
2. What is the status of improved teff varities adoption looks like in the study area?

1.6. Objectives of the Study

The general objective of this study was to analyze determinants of the adoption of improved *teff* varieties: in Cheha District, Gurage Zone of SNNP Region, Ethiopia.

The specific objectives of the study were:

1. To identify factors affecting the adoption of improved *teff* varieties and,
2. To asses adoption status of improved *teff* varieties in Cheha district.

2. LITERATURE REVIEW

2.1. Basic Concepts and Definition

Adoption is viewed as a variable representing behavioral changes that farmers undergo in accepting new ideas and innovations in agriculture. The term behavioral change refers to desirable change in the knowledge, understanding, and ability to apply technological information; changes in feeling behavior such as changes in interest, attitudes, aspirations, values and the like and changes in overt abilities and skills. Adoption is also defined as a decision-making process, in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision-making process is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Ray, 2001).

However, as emphasized by Ray (2001) adoption does not necessarily follow the suggested stages from awareness to adoption; trial may not always be practiced by farmers to adopt new technology. Farmers may adopt the new technology by passing the trial stage. In some cases, particularly with environmental innovations, farmers may hold awareness and knowledge but because of other factors affecting the decision making process, adoption does not occur.

2.2. Origin and Distribution of *Teff*

Teff (*Eragrostis teff* [Zucc.] Trotter) is an allotetraploid cereal crop grown primarily in Ethiopia. It is traditionally harvested crop in Ethiopia, where it was first domesticated between 1000–4000 BC even before the ancient introduction of other crops (Rose, 2011). It is entirely cultivated in Ethiopia and Eritrea as food crop and distributed to several other countries and grown on a limited basis a grass for livestock forage in Australia, India, Kenya and South Africa . Vavilov (1951) identified Ethiopia as the center of origin and domestication for *teff* that is highly adapted to diverse agro-ecological conditions. It is endemic to Ethiopia and its major diversity is found only in that country as with several other crops.

Most of the time *teff* is grown at middle elevations between 1,800 and 2,200 m.a.s.l and in regions that have adequate rainfall (Minten *et al*., 2013). It can also be grown in low rainfall and drought prone areas characterized by prolonged growing seasons and frequent terminal moisture stress. The crop grows on various soil types ranging from very light sandy to very heavy clay soils. Moreover, it grows better on marginal soils. Cultivation of *teff* in Ethiopia has in part been motivated by its relative advantages over other cereals in the use of both the grain and straw (Miller, 2010).

2.3. Production and Economic Importance of *Teff* in Ethiopia

In most parts of Ethiopia, *teff* is usually sown during the main summer rainy season between July and August, while harvesting is done in most cases from November to February. Seeds are broadcasted on a well ploughed soil and lightly covered with soil until germination (Kebebew *et al*., 2011). The sowing period of the crop is different from location to location on which wet sowing is preferred to avoid false start to improve seedling establishment (Araya *et al*., 2010).

The duration of *teff* growing period ranges from 80 to 85 days. Farmers typically broadcast seeds in a scattered way by hand at high seed rates. This hampers *teff* yields since uneven distribution of the seeds makes weeding difficult and increased competition with weeds (Tareke *et al*., 2011). Technologies such as row planting and transplanting, where the seed rate is reduced and more space between seedlings is given, are assumed to be superior to traditional broadcasting because they allow for weeding and diminish competition between seedlings (Bekabil *et al*., 2011).

Teff has a vital role for growth yet it has been given little attention in research and development. It is still competitive to other cereals and is increasing in acreage. Moreover, it has remained an economically indispensable crop to Ethiopian farmers for several reasons namely: generation of household income, fulfilling concerns of nutritional needs, the price for its grain and straw are higher than other major cereals and its grain can be stored for a long period of time without being attacked by weevils. There is a potential to boost agricultural output like *teff* production by improving the efficiency of farmers through promoting new production innovation and technologies (CSA, 2013).

2.4 Teff consumption in Ethiopia

Teff is a staple food crop for most households in rural and urban areas in Ethiopia. It is primarily grown to prepare Injera, bread, and some native alcoholic drinks (MoA, 2010). It is more eagerly eaten by urban households than by rural households. Guush et al. (2011) based on national household consumption data, found that urban consumption of teff per capita being as high as 61kg per year. This compares to 20 kg per capita per year for rural areas. In urban areas, the share of per capita teff consumption in total food expenditure is 23%, while in rural area this is only 6%.

In addition, teff is gluten free, rich in phosphorous, copper, aluminum and thiamine and is considered as better source of protein, amino acids and carbohydrates. The flour of the crop is a desirable ingredient in health products particularly for celiac disease patients. Teff can replace gluten-containing cereals in products such as pasta, bread, beer, cookies and pancakes. It is also higher in calcium, iron and zinc content than maze, wheat, rice and other cereals which makes it a preferable crop in Ethiopia (Kaleab, 2014).

2.5. Overview of Agricultural Technologies Adoption in Ethiopia

In Ethiopia, adoption of improved agricultural technologies has been a long-term concern of agricultural experts, policy makers, agricultural researchers, and many others linked to the sector. However, evidence indicates that adoption rate of modern agricultural technologies in the country is very low. Empirical studies on adoption of agricultural technologies are limited in geographical coverage. It is pertinent to undertake area-specific studies to assess the status of adoption and identify constraints that hamper further adoption of technologies (Admassie and Ayele, 2004).

The adoption of improved seed varieties developed as a result of modern breeding practices in Ethiopia has raised production. However low uptake of improved seed has been attributed to supply being less than demand resulting in inconsistent availability which may continue to be the main constraint for widespread adoption of improved varieties (Tesfaye, 2013). Ethiopia's low productivity of the agricultural sector together with the rapid population growth relative to food

production have forced the nation to be recipient of food aid and importer of commercial food grain (Belay, 2004). Hence, it is vital that agricultural production as well as productivity have to be increased at a proportionate rate through adoption of new technologies.

But, as stated by Byerlee *et al*. (2007) the opportunity to increase production through area expansion is limited practically in the Ethiopian highlands. As a result, WB (2008) suggests that yield could be increased through more intensive use of improved technologies such as fertilizer and HYVs and the farmers need to adopt these new technologies so as increase production and productivity.

2.6. Theoretical Perspectives of Adoption

The concern of agricultural technology adoption by smallholder farmers is one of the development focuses in low income countries. This is mainly due to its contribution to improve agricultural production and productivity, income and food security of farm households. Hence, exploring the drivers for agricultural technologies adoption of smallholder farmers is believed to be vital to speed up the uptake and diffusion of the practices. However, understanding adoption is still a challenge and drivers of adoption were poorly understood. This is both at farmers' level, which practices were adopted and which is not. But also looking at vertical scaling, adoption takes place in the more institutional setting. Adoption accelerates to utmost when about half of the individuals in the system have adopted (Blazy *et al*., 2010).

Households' level of adoption considers the decision made by the household head to comprise new or improved variety in usual farming practice. The decision made to adopt or otherwise depend on different factors. Farmers' decision to adopt improved agricultural technologies is assumed to be the product of a complex preference comparison made by a farm household. To adopt or not to adopt a technology or innovations is often a discrete choice (Guerre and Moon, 2006). These innovations consists of new ideas, methods, practices or techniques that provide the means of achieving sustained increase in farm productivities and income. The innovation may not be new to people in general but, if individual has not yet accepted it, to that person it is an innovation (Ray, 2001).

In wide ranging, farmer adoption decision of a given cultivar is usually a process, which passes through several stages. The first step is for the farmers to get to know the variety. Upon an initial assessment of the expected returns from the technology, the farmer may then decide to try out the technology. Depending on the performance of the technology, the evaluation by the farmer may take several growing seasons. If the technology is found attractive in terms of either increased profitability or reduced risk for risk-averse farmers, and if socioeconomic constraints do not limit the decision process, the farmer will decide to switch from the old to the new technology. Otherwise, the farmer will decide to reject the technology (Bekele *et al*., 2007).

2.7. Empirical Studies on Adoption of improved Teff Varities

Hence review of empirical studies is important for various reasons. First, it helps to assess the present state of knowledge of the adoption process. Second, it helps to enhance the interpretation of empirical models and their results and its implications as against the conceptual or theoretical models. Adoption is the behavioral choice at a particular time and space while diffusion is the adoption pattern over time.

Debelo (2015) assessed factors influencing adoption of improved *teff* variety in Wayu Tuqa district of Ethiopia using logit model. Results of the study revealed that family size, education level of the household head, livestock holding (TLU) and frequency of extension contact were enhancing the decision to adopt improved *teff* while, age of household head, and distance from household residence to market center were found to influence adoption of improved *teff* negatively.

Similarly, Tsibuk (2015) analyzed the factors affecting adoption of improved *teff* variety in Medebayzana woreda of Tigray region, Ethiopia using binary logit model. The result from the econometric regression binary logit model indicated that family labor availability, access to credit service, frequency of contacts with extension agents and mass media exposure are important variables which affect the adoption of improved *teff* variety and had positive and significance influence on both the adoption decision and the extent of adoption. While, market distance had negative and significance influence on both the adoption decision and the extent of adoption.

Getahun (2003) indicated that income and credit were the most important factors influencing adoption and intensity of use of improved teff varieties. The impacts of adopters of improved teff varieties also portray the able increase of the farmers' production of wheat varieties and improve their incomes as farmers adopted teff technologies.

Bayissa (2014) use double-hurdle model to estimate the improved *teff* planting decision and intensity use of households in Diga district of East Wollega Zone. Results of double-hurdle model confirmed that both adoption and intensity use of improved *teff* were positively and significantly influenced by sex of the household head, farming experience, participation on crop production training, educational level, yield superiority and maturity period of new varieties. While, the author found that distance to the nearest market place had negative and significance influence on the adoption and intensity use of improved *teff* varieties.

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

Cheha Woreda is found in Gurage Zone; Southern Nations Nationalities and Peoples Regional state of Ethiopia. It is bordered in south by Enemorina Eaner Woreda, Guraghie zone, in west by the Oromia Region, in north by the Wabe River which separates it from Abeshge and Kebena Woreda of Guraghie zone, in the east by Ezha Woreda, Guragie zone, and in the southeast by Gumer and Geta Woreda of Guragie zone. The administrative center for Cheha Woreda is Emdibir which is 195km far from Addis Ababa and 40 km far from the Wolkite town, the capital of Guraghie Zone (GZSA, 2014).

As it had been indicated in the same source, the altitude in the Woreda ranges from 1710 to 2800 m.a.s.l. The mean annual temperature of the woreda ranges from18^{o}C to 27^{o}C. The climate of the woreda is classified in to two agro-climatological zones: dega (20%) and (80%) woyina dega. The average annual rain fall of the woreda ranges from 900 mm to 1500mm.

According to Cheha Woreda Office of Agriculture 2014 report, the Woreda covers the total land area of 69,764 ha classified in to 42 kebeles (39 rural and 3 town kebeles) and it is considered as one of the potential crop producing Woredas of the zone. According to the population projection reports of CSA (2010), the total number of rural household in 39 rural kebeles of the woreda is 18, 088, out of these 15, 047 are male headed and 3041 are female headed. The total population of the woreda is 137,665 out of which 67509 (49%) are male and 70,156 (51%) are female.

According to Cheha Woreda Office of Agriculture 2014 report, agriculture is the main stay of the Woreda and hence it provides the largest share of the livelihood for the population. The woreda is characterized by mixed farming system where crop and livestock production are the main activities and crops play the dominant role in terms of contribution to farmer's income given major share for cereals. *Teff*, wheat, maize, sorghum, inset, potato, oilseed and chat are the major crops produced in the Woreda. Moreover, *teff*, chat and oil seed are the most important cash crops for the overwhelming majority of the households. However, the agricultural sector remains

subsistence in its nature and characterized by lack of access to modern agricultural technologies, appropriate market, dependency on rainfall and lack of small-scale and large scale irrigation practice resulting in very low productivity.

3.2. Data Type, Sources and Methods of Data Collection

The study used data generated from both primary and secondary sources. Interview schedule was mainly used as a data collection tool. Accordingly, primary data were collected by interviewing smallholder farmers growing *teff* during the 2010 production season. Cross sectional data of 2010 production season was used. This contains both quantitative and qualitative data collected from selected households with semi-structured questionnaire. During the personal interview, primary data on key demographic, institutional and socio-economic factors affecting adoption decision of improved *teff* varieties were collected. While, secondary data were collected from books, journals and other published and unpublished documents, from district agricultural offices, websites and other related sources to supplement primary data.

3.3. Sampling Procedure and Sample Size Determination

The target population for this study was all households of Cheha woreda. In this study, two stage random sampling procedure was used. In the first stage, out of 39 kebeles two kebeles namely Eiwan and Gasore were randomly selected. In the second stage, 93 sample households from the selected kebeles were selected randomly.

Yamane (1967) formula was used to determine the representative sample size. For determining the size of samples representing small and homogenous population, it comparatively minimizes the sample size related biasness and hence it is preferable (Yemane, 1967).

According to him, for a given finite population with certain confidence level and precision (e), the sample size can be calculated as:

$$\mathrm{n} = \frac{N}{1+\mathrm{N}e^2}$$

Where; n =the sample size to be determined, N= Total no of households under sample frame of the study, e = degree of precision.

Therefore; by taking e as 10% and N = 1368 the total number of households in the sample kebeles, the sample size for this study was estimated as:

$$n = \frac{1368}{1+1368(0.1)^2} = 93.18 \approx 93$$

Thus, a total of 93 household heads were selected randomly from the identified two kebeles of Cheha Woreda for an interview of the questionnaire.

Then we have to apply proportionate sampling to obtain how many respondents are select from each stratum by using formulas: nh = n (Nh)/N

Where: nh = Sample size for stratum h

Nh is the numbers of households for stratum h

N is the total numbers of households and n is the total sample size.

Nh1 = n (Nh1)/N nh2 = n (Nh2)/N

= 93(660)/1368 = 93(708)/1368

Nh1 =44.87~45 nh2 = 48.13~48

So that, nh1=45 and nh2=48 are the sample size of the strata to the kebele, Gasore and Hewan respectively.

3.4. Methods of Data Analysis

The study used both descriptive statistics and econometric model for analyzing the data.

3.4.1. Descriptive Analysis

Descriptive statistics such as means, and percent, were used to characterize the agricultural system of the study area. Inferential analysis is used to explain the different socio-economic characteristics of the sample households. These include t-test and $\chi 2$-test of occurrence for the adopter and non-adopter of farmers in improved teff varieties in study district.

3.4.2. Econometric Analysis

Model Specification

The data analysis, interpretation and discussion will depend on the dependent and independent variables that are listing in the following econometric model parts to analyze the factors affecting the adoption of improved teff varieties.

The Probit Model

The response (dependent) variable of this study is dichotomous taking two values, **1** if adopter and **0** if non-adopter. In this regard, a probit and logit model is used to estimate the dummy variable taking two values. In most applications the models are quite similar, the main difference being that the logistic distribution has slightly fatter tails but, there is no compelling reason to choose one over the other. Probit model is one of the most, which to estimate the factors affecting the adoption of improved teff varieties by some explanatory variables.

These probit and logit models are appropriate when the dependent variable is a binary variable. In this study the response (dependent) variable is dummy variable taking two values, **1** if adopters and **0** if non- adopters. Because of the fact that the binomial probit model is preferred in this study due to easier to estimate and simpler to interpret, this regression model is used in this study.

The PROBIT procedure computes maximum likelihood estimates of the parameters β and C of the probit equation using a modified Newton-Raphson algorithm. When the response Y is binary, with values 0 and 1, the probit equation is

$P = Pr(Y = 0) = C + (1 - C) F(x'\beta)$

Where:

β is a vector of parameter estimates

F is a cumulative distribution function (the normal, logistic, or extreme value)

P is the probability of a response

C is the natural (threshold) response rate

X is a vector of explanatory variables which is a vector of variables explaining level of adoption. In this case these variables are Sex, Age, Education, Family size, Land size, Distance from the market, Improved seed availability, Access to credit, Total livestock owned.

Yi is the output variable that can take either 1 or 0, given the input variable xi is assumed to be

$P(yi=1/xi)=F(xi\beta)$

Where

F(x)= is the cumulative distribution function of the standard normal distribution and β is a Kx1 vector of coefficients.

$P(yi=0/xi)=1- P(yi=1/xi)= 1-F(xi\beta)$

3.5. Variables Definitions and Working Hypothesis

Dependent variables: In the analysis of this study, probit models was employed. The dependent variable takes a dichotomous value depending on the farmers' decision either to adopt or not to adopt improved *teff* varieties.

Independent variables: The independent variables of the adoption decision of agricultural technologies more particularly improved *teff* varieties are discussed below. These variables were chosen based on the available literature reviewed.

Sex of the household head: It is a dummy variable which takes a value of 1 if the household head is male and 0 otherwise. According to Adebiyi and Okunlola (2013) male headed households would have better opportunity to adopt and use more improved technology since they are exposed to new information and tend to be risk takers. Hence, sex of household head was hypothesized to positively affect adoption and intensity of use of improved *teff* varieties.

Age of the household head: It is a continuous variable and measured in number of years from birth. Age of the household head is an important factor that would help to explain adoption decisions and intensity of use of improved technologies. According to Teklewold *et al*. (2006) and Sulo (2012) it is assumed that as farmers' age increases the probability of adoption is expected to decrease because as the farmer's age increases, they become conservative and their ability to perform various farm operations diminishes. On the other hand, older farmers may have more experience and resource that would allow them for trying new technologies. Therefore, the coefficient for this variable was hypothesized to be positive/negative for adoption decision and intensity of adoption of improved *teff* varieties as well.

Education level of the household head: It is a categorical variable defined as the level of grades by the household heads. As stated in Rafael (2011) educated farmers are believed to acquire, analyze and evaluate information on different agricultural inputs and technologies. Hence, the higher their educations level, the more likely the farmers to adopt improved technologies. Therefore, education level of the household head was expected to have positive relation with adoption decision and intensity of adoption of improved *teff* varieties.

Cultivated land size: This is a continuous variable measured in hectare. It is likely to influence households' decision to adopt or not to adopt new technologies. As stated by Abera (2013) those farmers with large cultivated land size could adopt and use more improved technologies mainly to increase productivity. On the other hand, those with small cultivated land size could not be in

a position to adopt improved technologies. Because, those farmers with small cultivated land size may fear the risk associated if there is crop failure. Hence, the coefficient this variable was hypothesized as positive for both adoption decision and intensity of adoption.

Family labor: Family labor was measured in terms of adult equivalent with the availability of active and productive family member in the household. Availability of family labor is likely to influence the gross margin of the adoption of the technology. A household with larger number of workers per unit of land area is more likely to be in a position to try and continue using a potentially profitable innovation and it was expected to influence adoption positively. Hassen (2014) found positive relationship between family labor availability and adoption. Hence, this variable was hypothesized to have positive relationship with adoption and intensity of adoption of improved *teff* varieties.

Distance from the nearest market: This is a continuous variable measured in kilometers. The longer the distance of farmers' residence to the nearest market, the improbable will be to get inputs and to sell outputs at the right time when they need and the lower will be their adoption decision for improved technologies. The closer the market is to the residence, the more likely that the farmers will receive reliable market information and transaction cost will also decrease. As confirmed by Hassen *et al*. (2012) and Bayissa (2014) an increase in market distance between farmers' residence and the market center decreases the adoption and intensity of use of improved technologies. It was hypothesized to affect adoption and intensity of adoption negatively.

Access to credit: It is dummy variable; representing 1 if the household had credit access and 0 otherwise. Credit access reduces liquidity problems that household could face while intending to purchase agricultural inputs and hence paves the way for timely application of inputs thereby increase the overall productivity and farm income. Since farmers with access to credit are more capable in accumulating capital than their counterparts who do not have access, these farmers adopt more (Anik and Salam, 2015). Hence, this variable was hypothesized to have positive relationship with adoption and intensity of use of improved *teff* varieties.

Frequency of extension contact: It is a continuous variable representing number of days a household is visited by extension agents. Farmers' visited by extension agents are believed to be exposed for different, new, and updated information used to adopt. Frequency of contact with extension agents also increases the availability of information about improved technologies and affect positively and significantly adoption decision of farmers (Leake and Adam, 2015). Hence, both for adoption decision and intensity of adoption, number of days contacted with extension agents' was expected to have a positive sign.

Livestock holding: It is a continuous variable measured in TLU; where those who possess a flock of TLU are expected to adopt improved *teff* varieties better than they have not. Livestock holding is an important indicator of wealth status for the farm community. It is an important source of cash, manure, draft power and food for the agricultural community. The presence of tropical livestock unit can solve the liquidity problem that farm households face while intending to purchase and adopt improved *teff* varieties (Debelo, 2015). Hence, livestock holding was hypothesized to positively affect adoption and intensity of use of improved *teff* varieties.

Off/non-farm income: It is treated as a continuous variable which represents the amount of income the farmers earned in the year other than on-farm activity. It is the amount of income (in ETB) generated from activities other than crops and livestock. These include petty trading, charcoal selling, firewood selling, remittance, selling beverage, handcraft and others. This is believed to be the one source of capital for purchasing agricultural inputs. According to Hassen *et al.* (2012) and Brkalem (2015) households with relatively higher off/non-farm income are expected to better adopt improved technologies. Hence, off/non-farm income was hypothesized to affect adoption and intensity of adoption of improved *teff* varieties positively.

Improved *teff* seed availability: is a dummy variable that takes 1 if improved *teff* seed is available and 0 otherwise. In order to make use of the technologies, farmers should be able to get seeds either in the formal or informal distribution systems. Ghimire (2015) showed that institutional variables such as seed availability significantly and positively affect the incidence of adoption improved technologies. Thus, improved seed availability was hypothesized to positively influence the adoption and intensity of use of improved *teff* varieties.

4. RESULT AND DISCUSSIONS

In this chapter overall findings of descriptive and econometric analysis and discussions are presented. It is divided into two sections. The first section provides descriptive analysis of both adopters and non-adopters. While, in the second section the econometric analysis results from probit model are presented and discussed.

4.1. Descriptive Analysis

This section presents and discuses demographic, socioeconomic and institutional characteristics of sample respondents such as age, sex, family size, level of education, land size, livestock holding , access to credit, frequency of extension contact, and the like.

Descriptive statistics such as mean, standard deviations, frequencies, and percentages as well as the probability levels of all explanatory variables were used to analyze and interpret the data. While, inferential statistics, such as t-test for continuous and chi-square tests for dummy and categorical explanatory variables were used to examine data for differences and associations between adopters and non-adopters.

4.1.1. Descriptive Statistics for Dummy and Categorical Variables

Sex of house hold: In this study, out of the total 93 sample households 72(77.42%) were male-headed households and the rest 21 (22.58%) were female-headed households. From the total of 72 adopter households, 57 (79.16%) are male-headed and the remaining 15 (20.84%) are female headed household and out of the 21 non-adopter households 15 (71.42%) are male headed and the remaining 6 (28.58) are female headed household. This can partly confirmed that the male headed household are better adopters of the improved variety seed than female headed households in the study area.

Education level of household head: As indicated in the Table 1, about 25.81% of sample households had no schooling years at all (illiterate), 25.81% were able to read and write, about 24.73% had at least primary education and 23.66% of sample households were at educational level of secondary school. Out of 72 adopters 15 (20.8%) were illiterate, 21 (29.16%) were able to read and write, 20 (27.77%) had primary education and the remaining 16 (22..22%)of the adopters went to high school. Out of 21 non-adopters about 9 (42.85%) were illiterate, 3 (14.28%) were able to read and write and 3 (14.28%) were attended their primary education and 6 (28.57%) were attended high school. This analysis indicated that education has no visible effect on the adoption decision of the households because there are illiterate household heads who adopt and there are non-adopter households who learn up to high school. The chi-square value of this variable also confirmed that it was statistically significant at 1% level of significance.

Improved *teff* seed availability: Availability of improved seed varieties induces farmers to use the recommended varieties. The result of this analysis showed that the majority (77.42%) of the total sample respondents had access to improved *teff* seed in the study area, while 22.58% of sample households had no access to seed. About 83.33% of the adopters and 57.14% of the non-adopters reported that they had access to improved *teff* seeds from different sources. The chi-square analysis result revealed that the difference between the two groups with respect to this variable was statistically significant at 5% probability level.

Access to credit: As shown in Table 1, out of the total sample respondents, only 38.71% got credit service from the woreda credit service delivering institutions to run their agricultural production accordingly. Additionally, only 41.67% of the adopter and 28.57% of non-adopter sample households had access to credit services during the survey year. This confirmed that majority of sample households have no access to credit service. The chi-square analysis result revealed that the difference between the two groups with respect to this variable was found to be statistically significant at 5% probability level.

Table 1: Descriptive statistics of Dummy and categorical variables

		Adopters		Non adopters		Total		X2-value
Variables		N	%	N	%	N	%	
Sex of hh	Male	57	79.16	15	71.42	72	77.42	0.5569
	Female	15	20.84	6	28.58	21	22.58	
Education of hh	Illiterate	15	20.83	9	42.85	24	25.81	5.9246
	Read&write	21	29.16	3	14.28	24	25.81	
	Primary	20	27.77	3	14.28	23	24.73	
	High school	16	22.24	6	28.59	22	23.66	
Improved seed availability	Yes	60	83.33	12	57.14	72	77.42	6.3793
	No	12	16.67	9	42.86	21	22.58	
Access to credit	Yes	30	41.66	6	28.57	36	38.71	1.1751
	No	42	58.34	15	71.43	57	61.29	

Source: Own survey, 2019

4.1.2. Descriptive Statistics for Continuous Explanatory Variables

Age of the household head: As indicated in Table 2, the mean age of sample respondents at the time of the survey was 48.41 years with standard deviation of 15.46. The age structure of the sample respondents showed that adopters were younger (average age of 46.944 years with standard deviation of 14.654) than the non-adopters (average age of 53.476 years with standard deviation of 17.377). The two groups were found to be significantly different in terms of age at 10% probability level.

Family size: The availability of large working labor force in the household is considered as the number of individuals who resides in the household's house to perform production activities. In this study, the average family size of sample households was about 5.312 with standard deviation of 5.294. The average family size of sample adopter and non-adopter households was 5.375 and 5.092 with standard deviation of 2.388 and 1.97 respectively which shows no significant difference in their adoption status.

Off/non-farm income of sample households: As Table 2 depicts, the average off/non-farm income of sample households in per year was about 17329.71 ETB with standard deviation 10083.78. On average, off/non-farm income of adopters was about 17,856.25 ETB with standard deviation 10101.71 while non-adopters had 15,523.33 ETB with standard deviation 10052.72. This analysis confirmed that the improved seed adopter households were generated higher average non-farm income than non-adopters.

Land size: Crop production requires primarily the availability of suitable cultivated land. In this study, the average cultivated land size of sample households was found to be 4.194 Timad which is equivalent to 1.0485 hectare with standard deviation of 2.232. The average cultivated land size for non-adopter group was 4.905 Timad (1.22625 hectare) with standard deviation of 2.606 and for adopter was 3.986 Timad (0.9965 hectare) with standard deviation of 2.086. Hence, the t-test result showed that the mean difference between adopter and non-adopter farmers with respect to cultivated land size was statistically significant at 10% probability level.

Livestock holding in TLU: Livestock is the farmers' important source of income and draught power for crop cultivation and is one of the main cash sources to purchase production inputs. In the study area livestock production constitutes an important element of the farming system of the community. As indicated in Table 2, the average livestock holding of the sample households was 7.344 TLU with standard deviation of 7.408. It was observed that adopters of improved *teff* varieties had livestock holding of 8.028 TLU with standard deviation of 8.122 and non-adopters had 5 TLU with standard deviation of 3.286 which can confirm that the adopters were found to own more livestock than their counterparts. The test statistics indicated that, the difference among adoption categories related to livestock holding was statistically significant at 10% probability level.

Frequency of extension contact: Extension service is important institutional service that is required to increase agricultural productivity through the adoption of new technologies. It enables farmers being aware of the benefit of new technologies. The survey results in Table 2 shows that, sample households in the study area were made an average contact of 2.097 times per year with standard deviation of 0.753. The survey result of his study indicated that the adopter households were more frequently contacted with the non-adopter households. Accordingly, The adopter's average extension contact per year was 2.139 with standard deviation of 0.737 whereas for the non-adopters it was 1.952 with standard deviation of 0.805 during the same year.

Distance from the nearest market: As indicated in Table 2, the average distance of sample respondents' home from the nearest market place was found to be 5.237 km with standard deviation of 1.697. On average adopters were located about 5.222 km far from the nearest market with standard deviation of 1.655 and non-adopters were about 5.286 km far from the nearest market with standard deviation of 1.875.

Table 2: Descriptive analysis of Continuous variables

	Adopters		Non adopters		Combined		t-value
Variables	mean	Std.Dev	Mean	Std.Dev	mean	Std.Dev	
Age of hh	46.944	14.654	53.476	17.377	48.419	15.457	1.7220
Family size	5.375	2.388	5.0952	1.972	5.312	2.294	-0.4898
Non-farm income	17856.25	10101.71	15523.33	10052.72	17329.46	10083.78	-0.9322
Land size	3.986	2.086	4.905	2.606	4.194	2.232	1.6754
Frequency of extension contact	2.139	0.737	1.952	0.805	2.097	0.753	-0.990
Total livestock of hh	8.028	8.122	5	3.286	7.344	7.408	-1.6637
Distance from market	5.222	1.655	5.286	1.875	5.237	1.697	0.1501

Source: Own Survey, 2019

4.2. Econometric Model Results

In this section, results and discussions from an econometric model analyses were presented. Accordingly, probit model was used to analyze the influence of various demographic, socio-economic and institutional variables on adoption of improved *teff* varieties.

This section presents maximum likelihood estimates of probit model to identify determinants of adoption of improved *teff* varieties. The dependent variable for the probit model is the adoption decision of sample households. A total of eleven explanatory variables, of which four dummy and seven continuous, were included in the model. Out of eleven explanatory variables, five variables were found to be significantly determined adoption of improved *teff* varieties.

The likelihood ratio of chi-square result revealed that the overall fitness of the model was found to be significant at 1% probability level. According to Wooldridge (2002) the probit regression coefficient gives signs of the partial effects of each explanatory variable on the response probability of the dependent variable. Significant variables from this model are discussed as follows.

Table 3: Marginal effect after probit analysis

```
Marginal effects after probit
      y  = Pr(resp) (predict)
         =  .85514544
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
sex*	.0864589	.11857	0.73	0.466	-.145939	.318857	.774194
age	-.0049455	.003	-1.65	0.099	-.010824	.000933	48.4194
edu	.0280142	.03911	0.72	0.474	-.048635	.104664	1.46237
fams	.0291539	.02167	1.35	0.179	-.013323	.071631	5.31183
nonfarmi	8.84e-07	.00000	0.20	0.840	-7.7e-06	9.5e-06	17329.5
lands	-.0368933	.01979	-1.86	0.062	-.075687	.0019	4.19355
extc	.0571923	.05939	0.96	0.336	-.059218	.173603	2.09677
tlu	.0220384	.01176	1.87	0.061	-.001019	.045095	7.34409
imsa*	.2683643	.14335	1.87	0.061	-.012591	.54932	.774194
dis	-.0159832	.0243	-0.66	0.511	-.063608	.031642	5.23656
acc*	.2003301	.07721	2.59	0.009	.048993	.351667	.387097

Source: Own Computation (2019)

Age of the household head: Age of household head was found to be negatively and significantly influenced the probability of adoption of improved *teff* varieties at 10% level of significance. This indicated that, a unit increases in the age of the household decreases their probability of adopting improved teff seed by 0.49%. This consistent with the finding of Zinabu (2016); who confirmed that the younger farmers can have better capacity of performing farm operations well and have better access to participate on education and other supportive activities and therefore they can easily accept the new technology.

Land size: The model result showed a negative and significant relationship between proportion of cultivated land allocated for *teff* and probability of adoption of improved *teff* varieties at 10% level of significance. Other variables held constant, a percentage increase in proportion of land size allocated for *teff* would result in 3.68% decrease on the probability of adoption of improved *teff* varieties. This result implied that farmers who allocate relatively higher proportion of land for *teff* are less likely to adopt improved *teff* varieties than farmers who allocate relatively smaller proportion of land for *teff* production. Samson *et al.* (2012) had a similar finding that an increase in the size of the land allocated for crops can affect their willingness to accept the newly introduced technologies. They argued that this because of the fact that farmers usually fear to take larger risks in one side and they will be unable to purchase improved seeds to sow large hectares of land so that they will be enforced to use locally available seeds with low cost.

Livestock holding: The number of tropical livestock unit (TLU) affected positively and significantly the probability of adoption of improved *teff* varieties at 10% probability level. Other variables held constant, as the number of livestock increase by one TLU, the probability of adoption of improved *teff* varieties increases by 2.2%. This result showed that those farmers with large number of TLUs are more likely to adopt improved *teff* varieties than those who own small number of livestock. Livestock could be a source of income that can be used to purchase inputs such as improved seeds, fertilizer and chemicals. It also enhances the shock absorbing capacity of the households in case of crop failure. Previous empirical findings by Solomon *et al*. (2011), Debelo (2015) and Leake and Adam (2015) confirm this result. According to their study being owner of more livestock increases the probability of adoption of improved agricultural technologies.

Improved *teff* seed availability: Availability of improved *teff* seed was found to be positively and significantly influenced the probability of adoption of improved *teff* varieties at 5% probability level. Other variables held constant, a percentage increase in the timely and easy availability of improved *teff* seed increases the household's probability of adoption of improved *teff* varieties by 26.83%. The result implied that those farmers who get improved seed are more likely to adopt improved *teff* variety than those who do not have access to improved seed. The possible explanation for this finding could be ti mely availability of seeds either in the local stores or in the market eases the households to purchase and cultivate new improved varieties in their fields. The result is consistent with studies by Ghimire (2015) and Verkaart *et al.* (2016) who found that the higher the availability improved seeds the more the probability of adopting improved varieties.

Access to credit: Access to credit was found to be positively and significantly influenced the probability of adoption of improved *teff* varieties at 5% probability level. Other variables held constant, a percentage increase in the availability of credit gives about 20.03% increase in the probability of household's adoption of improved *teff* varieties. This might be due to the fact that, farmers with access to credit are more capable in accumulating capital and have no liquidity problem to purchase inputs than their counterparts who do not have access, these farmers adopt more (Anik and Salam, 2015).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclussions

This study was aimed to identify factors influencing the adoption of improved teff varieties in Cheha Woreda of Gurage zone, Ethiopia. The study was also tried to investigate the status of the farmer's adoption behavior. Teff is an important crop, which serves as a source of food and cash for the farmers in Chea woreda. A total of 93 sample households selected from 2 *kebeles* were interviewed using structured interview schedule. Mainly Chi-square test and t-test were used to test the variation of the sample group towards the adoption of improved *teff* varieties. Descriptive statistics like mean, standard deviation, frequency and percentage and the probit econometrics model was employed to address the objectives of the study. The assessment of the adoption status of the households indicated that the farmers are better adopted the improved teff variety. The descriptive analysis of the survey data indicated that, the adopter households have higher average family size, non-farm income, TLU, and frequency of extension contact than non-adopter households. Whereas the adopter households have lower age, less land size and less distance from the nearer market than the non-adopters. The descriptive analysis therefore confirmed that the households with access to credit services, better education level the household head, farmers having large land size; own large number of livestock, located near to input delivery institutions (market distance) are found to be better adopters of improved teff varieties than their counterparts. The econometric analysis of the data showed that age of the household and land size affects the probability of household's adoption of improved teff varieties negatively. However improved seed, access to credit and total livestock owned by house hold are positively affecting the household's decision on the adoption of improved teff verities in study area.

5.2. Recommendations

Based on the finding of this study the following basic recommendations have been forwarded and been considered as important for policy makers, teff producers and other responsible bodies accordingly. Therefore, the result can be used by policy makers to promote technological change that is directly needed for the economic development of the country. The following are the major recommendations forwarded based on the finding of this study:

- As Access to credit is one of the factors which significantly affecting the adoption of improved *teff* variety with the highest coefficient, the woreda's agricultural office should focus on providing credit service for the farmers especially during main agricultural seasons.
- Availability of improved seed is another factor which highly and significantly affecting the farmers adoption decision. As a result, policy makers and other responsible bodies in the area have to smoothen easy availability of improved variety seed with rational cost.
- As owing large number of livestock and having higher non-farm income contributes positively for the households adoption of improved *teff* variety, great attention should be given to support the households to have more number of livestock and to improve their non-farm income.
- Extension contact was also another factor highly contribute for the variability in the adoption rate of the households, woreda agricultural office, policy makers and other responsible bodies have to provide frequent and more reliable extension contact for the farmers.
- Advising the farmers to sow the size of land based on their capacity and providing better transportation facility to solve farmers marketing problem is also another strategic area which need due attention in order to improve their crop productivity in the study area.

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APPENDIX

Appendix I: Tables

Appendix Table 1. Probit analysis of factors affecting the adoption of improved teff variety

```
Probit regression                                 Number of obs    =         93
                                                  LR chi2(11)      =      25.28
                                                  Prob > chi2      =     0.0083
Log likelihood = -37.039284                       Pseudo R2        =     0.2544
```

resp	Coef.	Std. Err.	z	P>|z|	[90% Conf.	Interval]
sex	0.345	0.435	0.794	0.427	-0.370	1.060
age	-0.022	0.013	-1.656	0.098	-0.043	-0.000
edu	0.123	0.173	0.711	0.477	-0.162	0.408
fams	0.128	0.095	1.343	0.179	-0.029	0.285
nonfarmi	0.000	0.000	0.201	0.840	-0.000	0.000
lands	-0.162	0.088	-1.836	0.066	-0.307	-0.017
extc	0.251	0.270	0.930	0.353	-0.193	0.695
tlu	0.097	0.058	1.662	0.096	0.001	0.193
imsa	0.940	0.414	2.271	0.023	0.259	1.620
dis	-0.070	0.107	-0.654	0.513	-0.247	0.106
acc	0.982	0.449	2.188	0.029	0.244	1.721
_cons	-0.382	1.084	-0.353	0.724	-2.165	1.400

Source: Own Computation (2019)

Appendix II: Survey Questionnaire

1. Household characteristics

1.1. *Kebele* of the household head_____.

1.2. Type of respondents: 0) Improved *teff* non-adopters 1) Improved *teff* adopters

1.3. Sex of the household head: 0) Female 1) Male

1.4. Age of the household head: _____ years.

1.5. Educational level of the household head: 0. Illiterate 1. Read and write 2.Primary 3. High school

1.6. Marital status the household: 1. Single 2. Married 3. Widow 4. Divorced

1.7. Religion: 1. Muslim 2. Orthodox 3. Protestant 4. Others_____

1.8. Family size**:** Male_____Female_____Total_____

2. Off/non-farm income

2.1. Have you involved in off/non-farm activities in 2010 production season? 0) No 1) Yes

2.2. If yes, what is the type of off/non-farm activity you involved in and the income earned?

No	Type of off-farm activities	Income earned in birr
1	Petty trade	
2	Handcraft	
3	Daily labor	
4	Others	
Total off/non-farm income		

3. Cultivated land size

3.1. Do you own land? 0) No 1) Yes

3.2. Total land Size_____ in Tsimad and_____number of plots

4. Livestock Holding

4.1. Did you own livestock? 0) No 1) Yes

4.2. If yes, what is the total number of livestock you own in TLU?_____

5. Extension service

5.1. Have you ever consulted extension agents on agricultural activities? 0) No 1) Yes

5.2. If yes, how frequently do the extension agents visit you? _____

5.3. If no, why? Specify the reason_____

6. Improved seed availability

6.1. Is improved *teff* seed available on time in your area? 0) No 1) Yes

6.2. If yes, from where did you get improved *teff* seeds? 1. Research Centre

2. Own 3. Market 4. Neighbors 5. NGOs 6. Others, specify _____

6.3. If no, specify the reason_____

7. Distance from the nearest market

7.1. Do you sell *teff* this last cropping season? 0) No 1) Yes

7.2. How far do you travel to buy improved *teff* seed (round trip) and to sell your agricultural product (round trip)? ____ Km.

8. Access to credit

8.1. Did you receive credit facility from financial institutions in 2010 year? 0) No 1) Yes

8.2. If your answer to question 12.1 is yes, is the amount of loan sufficient? 0) No 1) Yes

8.3. If your answer to question number 12.1 is no, why you did not obtain? 1. I don't need credit 2. I can use other sources 3. Inadequate loan amount 4. High interest charge 5. Lack of collateral 6. Other reason, please specify_____