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RESEARCH METHODOLOGY

This chapter incorporates two main sub subject matters; the research justification and methods of study which incorporates the design, components of data collection and methods of analysis. This was also similarly corroborated by Zachariadis M., Scott S. and Barrett M. (2010), stating that there exists a distinct variations between the tools or methods and the methodology itself. Zachariadis M., Scott S. and Barrett M. (2010) also added that balance should be maintained between the philosophical level where the study is initially predisposed, the level of reasoning which underpins it and lastly at the data level. The philosophical stances to be discussed are believed to strongly influence both the research reasoning and the data required and its analysis to fulfill the study.

Research methodology generally refers to the procedures and principles of the logical thought practices that are applied for a scientific investigation. Consequently, research methodology can be considered as the overall plan and approach to accomplish the objectives and aims of a particular research. Whereas, research methods are merely the tools, as a consequence within a given research methodology, various distinct research methods and tools are used to attain the objectives and aims of a research.

Research Justification

The three major types of research studies are explanatory, exploratory and descriptive. Phase about the knowledge of a research topic which is ideal, signifies the nature of the study. Explanatory or casual research mainly discuss on why events appear by labeling the cause and effect relationship

within variables, and this kind of studies are appropriate once research problem is well documented and harmonized and when a discovered causality is helpful in understanding and predicting the outcomes of the assessed problem.

On the other hand, descriptive research studies portray an exact picture by using figurative words and numbers which present profiles such as who, where, when and how. At this stage exploring new concerns and problems is less of a concern for descriptive studies than describing on how things are. Whereas in exploratory research, in-depth assessment is employed to break down broad problems into smaller well defined diminutive problems. Exploratory studies are familiar in the preliminary stages to have a better understanding of a problem.

With this in mind, the design selected for this study is descriptive research design in its suitability of describing the characteristics and information about what is being studied. More specifically, the design is imperative to see how people, particular groups and other complimentary things behave. Thus, a descriptive research design seemed ideal for identifying the most food insecure segment of smallholding farmers, to assess their food insecurity level and finally to investigate how they came to be the vulnerable groups.

Statement of the Problem

In Ethiopia, the agricultural sector has received a priority attention in the country's development plans from the 1970's till the recent undertaking Five Year Growth and Transformation Plan, yet food insecurity remains to be a major problem. Ethiopia is among the poorest and most food insecure countries in the world, where about 38% of its population live below the national poverty line (WB, 2015); and 37 % of the rural population live below the national food poverty line (Birara E., 2015). Efforts by leaders, development practitioners and researchers to make effective food

security strategies have been constrained by lack of reliable and relevant information concerning the causes of food insecurity. As a result, interventions have too often become inappropriate that fail to consider the actual facts (Leidy H. J., 2011). This has created a gap between major determinants of food security, livelihood resources and areas of interventions by government to achieve it.

Numerous studies have confirmed that there is a problem of food insecurity in Ethiopia with wide range of area to be covered and large number of people to be attended for different identified causes of food insecurity problems. Among these causal factors per capita land holding, population growth, education, existing livestock holdings, per capita income of the household both from agricultural and non-agricultural activities, soil fertility, conflict and underfunded agriculture are the major and commonly mentioned factors (Devereux S., 2001; Ayalneh B., 2010).

Most famines and food crises in the country have been geographically dispersed along two broad belts of Ethiopia. The first belt includes mixed farming production system area of the Northern and Central highlands, stretching through Northern Shewa and Wollo to Tigray. In these parts of the country, resources' especially soil and vegetation have been highly degraded because of the interaction between some environmental and human factors such as climate, population pressure, over cultivation, deforestation and overgrazing. The second belt is made up of the low lying agro-pastoral lands ranging from Wollo in the North, through Hararghe and Bale to Sidamo and Gamo Gofa in the South (Degafa T., 2002).

Smallholder agriculture is the most important sector of Ethiopia’s economy. About 80% of the population live in the rural areas by engaging in agriculture as a main source of income. The agricultural sector contributes for about 45% of the GDP, almost 90% of the country's exports and

85% of employment (MoARD, 2009). However, the sector remains dominated by subsistence, low input-output rain fed farming system in which droughts periodically reverse performance gains with devastating effects on household food security and poverty levels (Ashenafi G., 2008).

In order to combat threats of famine and pervasive poverty and thereby ensure food security for its population, the food security strategy designed in 1996 (and reformulated in 2001) has rested on ensuring access to food for food deficit households and increasing the availability of food grains through significant investments in agricultural technologies (such as high yielding varieties of seeds, fertilizer), services (extension, credit, inputs), and rural infrastructure (roads, markets and communications). The impact of this strategy, however, has been less effective as there are still millions of people who experience hunger in the country (Ayalneh B., 2010).

In order to fight food insecurity at household level, two intervention programs - the integrated household level extension program known as the Food Security Package (FSP) program and Food for Work (FFW) program were implemented. The FSP was launched in 2002 with an overall aim of generating and diversifying the rural employment and income that can reduce risks for food insecure households especially within the two belts. At the household level, the FSP program was intended to secure food through diversifying the income base of the poor by providing credit facilities and a range of different packages. Even though, the constituents of the package for which loans are granted for, differ from area to area to suit the agro-ecological and other factors, the basic ones include livestock (oxen and cows), small animals (sheep and goats), poultry, beehives, improved seed and fertilizer packages. In 2003, the number chronically food insecure households covered by the Food Security Package program were 49,427, and the number of beneficiaries increased to 629,328 rural households in 2008 (Tagel and Ane, 2010).

In 2002, Regional Food Security Strategy was designed in different regions of the country including Tigray, Amhara, Oromia, and Southern Nations, Nationalities and People (SNNP). In Tigray, under conservation-based agricultural development policy, the food security strategy designed in 2002 was an integrated approach. It aimed at ensuring food security and environmental rehabilitation in the region. Furthermore, the study gave a big emphasis to the rural part of Ethiopia mainly for the reason that the majority of the population as well as the most disadvantaged and food insecure segments of the population live in.

Similar studies revealed that, with the exception of direct food aid, the success stories in recent periods over food security are results of various interventions. Interventions targeting extension services and productive safety net had a positive effect on the food security of households while direct food aid had a very low significant impact on household food security in Tigray (Berhane H., 2009). Survey done by Tagel and Ane (2010), in order to investigate the effectiveness of government policy interventions addressed in improving food security in Tigray region, show that food self-sufficiency has improved both at the regional and *Woreda* level. As the study shows, food deficit has declined by 32% over the time period and the Self-Sufficiency Ratio (SSR), which is measured as the ratio of the sum of net production of cereals to the requirement of food, has shown an increment of 8.6%.

In spite of these improvements over the recent periods, 31 *Woredas* are food insecure out of 48 *Woredas* in the region in 2012 according to Bureau of Planning & Finance Tigray Region (2015). Most studies conducted so far in the field gave more emphasis to the macro level food production, consumption and deficit problems which shows the crude regional picture. Moreover, there is a core gap in the assessment methods while assessing food security by employing Calorie Deprivation Indicators. One of the major limitations of calorie indicators is uneasiness to measure

at individual level. Yet, IFPRI (2012) study revealed that in many countries it appears to be found that a very low or no correlation between calorie deprivation and food security outcomes, also reached the same conclusions in Ethiopia.

In concomitant to the above, there are hundreds of studies made in this vicinity for diverse purposes reminiscent of academic fulfillment, governmental and non-governmental office researches, project monitoring and evaluation and etc. However, apart from few isolated case studies, most of them have abandoned the subject matter that household/individual level food security should not be alienated from the livelihood strategies on those particular premises of study for better sympathetic. Moreover, research which cannot delineate accordingly to local based clarifications as its foundation for recommendation, revealing numbers and figures would just be presenting a report which cannot address the needs of people. Studies subject to baseline surveys, have similar limitations of raising the local voice which should have been a base for concluding remarks. With this in mind, the issue of food security and livelihood resources should be integrated basing on specific area local situation to reach for a substantiated results which could be obliging for identification of better and innovative ways of intervention for various interested stakeholders.

This research is therefore, an attempt to fill the existing gaps on food security and livelihood resources, and hence, identifying and describing those factors which contribute for food and livelihood insecurity in Kilte Awelalo is the main concern of the study. Research undertakings in such issues at the household level are essential since the results may possibly give a spot of light to development planners and practitioners in order to combat food and livelihood insecurity and vulnerability at household level.

Objectives of the Study

The overall purpose of this study is to generate food security and livelihood resources information which is well organized and sound to assist policy and decision makers design and implement programs that will contribute to the reduction of rural food insecurity and enhance livelihood resources base in the study areas.

The specific objectives of the study are;

1. To analyze the magnitude of household food security condition of smallholding farmers in the study areas,
2. To examine the extent of control and access of livelihood resources by smallholding farmers,
3. To identify factors determining rural food security and livelihood resources at Household level, and
4. To identify local coping mechanisms employed by the smallholding farmers for food and livelihood insecurities

Research Questions

Kilte Awelalo *Woreda is* one of the most vulnerable areas in Tigray region. This study gives the opportunity to the livelihood approach to be tested and put into practice within the concept of food security. Accordingly, key questions that are dealt in the course of the study include;

1. What is the food security condition of smallholding farmers and how the magnitude of food problem looks like in the study areas?

2. To what extent do the smallholding farmers in the study areas have access and control to basic livelihood resources to detach themselves from vulnerability?

3. What are the major determining factors of household food security and livelihood resources in the study areas?

4. How do farming households respond during food crisis and the major coping mechanisms and strategies households employ in case of food and livelihood resources shortages?

Rationale of the Study

The relationship and subject matters defining livelihood and food security are multifaceted and the factors influencing are wide and vary in nature. With this in mind, clarifications for these variable factors and the trails through which they influence and manipulate households' food security and livelihood resources would serve in the identification of a more elaborated version of the issue which is up to date. Other than the academic fulfillment, it would serve as a stepping stone for governmental and non-governmental bodies, development practitioners and other interested donors to identify the major food security and livelihood resources impacting indicators, improve their intervention designs and enhance the practical experience of those selected *Tabias* of the study.

Research Methods

This part of the chapter presents site selection and justifications behind, research design, sampling technique, tools of data collection, sources of data collection and finally the methods of data analysis.

Selection of Study Areas

The areas selected for this study are found in the Regional State of Tigray, which is located in the northern part of Ethiopia. From the region Kelete Awelalo *Woreda,* commonly known as Wukro was selected. Kelete Awelalo is located 41KMs from Mekelle which is the capital city for the Regional State of Tigray. Moreover, it is 824KMs away from the capital city of Ethiopia, Addis Ababa.

Kelete Awelalo Woreda has 19 rural *Kebeles* (*Tabias*) and from these, three Tabias were selected; Ayenalem, Genfel and Tahetay Adikesanded. The main considerations made for taking the above listed study areas are; first, areas selected are highly drought prone areas where in the past few years the food insecurity and livelihood struggles in these areas revealed that households in these areas are either chronically or temporally food insecure with limited livelihood options. Secondly, the areas selected for the study are suitable in different facilities like weather (agro ecology) variability, transportation and safety security for conducting the research from highly food insecure areas in the *Woreda*.

Sampling Technique

After the sampling design is in place, sample size will be determined. The areas selected for the study are Ayenalem, Genfel and Tahetay Adikesanded. Other than the above listed reasons, these areas are also selected because of their relatively high density of population which will assist the study to look at variations carefully. The areas selected have a total 4,826 households (HHs); Ayenalem 1,966, Genfel 1,605 and Tahetay Adikesanded 1,255 households. The unit of analysis for this study is household level.

There are several ways of determining the sample size and for this study the researcher used a simple formula from Yamane to determine the sample size. The formula is depicted as follows;

$n = \frac{N}{1+N(e)^2}$ where, n is sample size , N is total population and e is level of precision

$$n = \frac{4{,}826}{1 + 4{,}826(0.05)^2}$$

$$\underline{n \approx 370}$$

$$\approx 7.65\% \; of \; t \;\; e \; total \; population$$

The sample population to be studied of the three major high density areas is 370 households. Moreover, for determining the appropriate sample units, *7.65*% of households from each three districts were taken for the representation and during the data collection, households were selected randomly to appraise their chance of being selected for the study.

Table 4.1 Number of selected '*Kushets*' and samples

No.	Kushets	Number of Households	Samples
1	Ayenalem	1,966	151
2	Genfel	1,605	123
3	Tahetay Adikesanded	1,255	96
	Total	4,826	370

Source: Own calculation, 2014

Data Sources, Type and Methods of Collection

Throughout the study both primary and secondary sources of data which included both quantitative and qualitative types were used to generate a valuable and relevant information. A common consensus has been established that mix of both qualitative and quantitative research studies provide more robust and useful findings (Zachariadis M., Scott S. and Barrett M., 2010). In line

with this, for the primary data collection, a structured interview schedule was administered to 370 households and alongside an interview was conducted for Woreda Food Security Task Force committee (WFSTF) and Development Agents (DA's).

Regarding secondary data, the study used different secondary data information where they are appropriate. Secondary data sources were collected through reviewing various documents and reports which are readily available documents and official reports that were written basing on an evidence from the study area. To mention few, officially published and unpublished materials from various governmental and non-governmental organizations such as baseline surveys of the region, Ministry of Agriculture and Rural Development bulletins and governmental annual reports.

In general, two instruments were employed to collect a relevant primary data from different stakeholders;

1. Household Survey

To collect data concerning food security and livelihood conditions of smallholding farmers, a household survey was conducted which emphasized on issues related with households scocio-economic background information, food consumption patterns, qualities and variations, income and expenditure, social capital, health and sanitation, livestock holdings and their strategies for income diversification and etc. To accomplish this, a structured interview schedule was conducted by the researcher with an additional assistance of one research assistant (inviglator). The interview schedule was prepared primarily in English and was translated to Amharic for the ease of communication between the researcher and respondents.

Before conducting the final household survey, the interview schedule was pre-tested with 25 households in the study areas. The pre-test was done to minimize errors, ambiguities,

redundancies, and other common mistakes in the interview schedule. Upon completion of the pre-testing, important modifications were made on issues such as ordering and wording of questions and the scope coverage of the interview schedule. Moreover, the pre-test enabled the researcher to know whether the respondents had clearly understood the questions in the easiest possible way. As a result, some questions were overlooked and were redesigned. In addition to this, other pre causations were taken into considerations like days of fasting and religious celebrations which may possibly distort the food consumption pattern data of households.

Finally, by using both open and close ended questions in the structured interview schedule, primary data was collected through personal interview. As stated, the interview schedule was administered by using the researcher and the trained research assistant and in order to enhance the reliability of the surveyed data, reduce linguistic and technical problems at the farm level, the researcher was present with the research assistant during all the surveys.

2. Personal Interview

Right after the completion of the household survey, the researcher arranged a schedule for interview for different key informants who are essentially involved with food security and livelihood conditions of smallholding farmers in the study areas. Key informants are people who are in a position and experienced with a capability of answering critically important questions about the area. This includes staffs of governmental or non-governmental offices, local leaders, farmer's associations' leaders or traders. Ultimately, a good key informant could be almost anyone from the area who has an interest and experience to make up a good representation about the aspects of how people live.

Accordingly, the interview was primarily dealing with issues to substantiate the household survey and points which may not be possibly be answered by the household survey; like issues which needed more of a qualitative explanation. The interview was designed for two primary key informants under two phases; the first interview under phase one was conducted for local and regional government officials; who are responsible for the *Woreda* food security and early warning, and development agents and the second phase of the interview was held for local community representatives.

In the first phase, the interview was held with 2 Regional Food Security and Early Warning coordinators. Secondly, interview was held with the local government officials incorporating 3 Woreda Food Security Task Force committee (WFSTF) and 3 Development Agents (DA's) of the three study areas. From the three WFSTF's, first one was the *Woreda's* Agricultural and Rural Development Office head, second was with the Food security coordinator of the Woreda and finally the third one was the Early Warning coordinator of the Woreda. In the second phase, interview was held with 6 local community representatives, where two representatives were selected from each of the three study areas.

Methods of Data Analysis

After the data is collected, its administration, analysis and interpretation are the most important part of the study as the outputs from these will delineate the results and findings of a particular research. Accordingly, the collected data was coded, then entered to computer database and finally was analyzed with the help of statistical software packages. In the study, a mix of descriptive and regression analysis were used. The descriptive analysis in the study is used to look through the social, cultural and economic characteristics of the households in the selected areas and households' access and control over basics resources to sustain their basic necessities. Data

analysis was initially started by calculating frequencies, percentages, mean, minimum/maximum values (range) and similar statistical techniques with the assistance of tables, charts and graphs. Similar statistical tools were employed for summarizing different sections of the analysis in the study.

Moreover, econometric regression method is employed to look through the determinants on the efforts made by households towards sustenance and stability of securing their means of livelihood and food. With regard to food security determinants, three distinct regressions are done basing on the availability, accessibility and utilization aspects of food security. Firstly to assess the determining factors for food availability of smallholding farmers in the study areas, a dependent variable: Months of Adequate Household Food Provisioning was selected and various independent variables. Secondly, to assess the determining factors of food access, households' food consumption score final computation was taken as a dependent variable and it was regressed by using Ordered Probit regression. The food consumption score was selected as a dependent variable because it seems ideal in its ability to show to what extent households have access to particular groups of food items within a given specified period of time. Lastly, regarding utilization of food in the household, body-mass index (BMI) was taken as a dependent variable and it was regressed by using Ordinary Least Square (OLS) regression. For this, SPSS and STATA software packages were used to prepare the simple quantitative tools like frequencies, percentages and means, and to study the explanatory variables impacts in the regression models respectively.

Model Specification

The model specification is incorporated as part of the methods of analysis to reveal the econometric regression models which are employed in identifying various independent variables' impact on livelihood strategies and food security conditions of smallholding farmers in the study areas. With

regard to livelihood strategies, Probit model is used to determine important factors which determine the probability of a farmer in employing other allied off/non-farm activities. Probit model is used in the study because Linear probability Model (LPM) is plagued by several problems, such as non-normality of the error term u_i, heteroscedasticity of the error term u_i, possibility of estimated Y_i lying outside the 0–1 range, and the generally lower R^2 values (Gujarati D. N., 2004). The specification of the Probit model, which is adopted from preference analysis of McFadden (1973) as cited in Gujarati D. N., (2004), is given below. In addition, the dependent variable is off/non-farm activities participation and takes a value of 1 if a farmer engages other allied off/non-farm activities and 0 otherwise.

Farmers employ off/non-farm activities when their marginal cost (MC) of engaging is less than the marginal benefit (MB), implying when net benefit (NB) is greater than zero.

$NB = MB - MC$ 1

Note: NB= Net Benefit MB= Marginal Benefit MC= Marginal Cost

Assuming NB is linear in parameter, it will take the following matrix form. Where X is vector of independent variables and β is their parameter.

$NB = X\beta$.....2

However, some of the X's are not observed, so they are represented by error term (ξ), and all observed independent variables are represented by vector X_0.

$NB = X_0 \beta_0 + \xi$.....3

Where X_0 and β_0 represent observed independent variables and their parameters respectively. The error vector represents the average effect of all unobserved variables.

$$\left\{\begin{array}{l}\text{If NB} \geq 0 \text{ then P (I)} = 1 \\ \\ \text{If NB} < 0 \text{ then P (I)} = 0\end{array}\right\} \quad \text{.....4}$$

Where I is 'Involvement' in off/non-farm activities, and the above equation implies that if the net benefit of involving in off/non-farm activities is positive, farmers will engage in more diversified livelihood strategies.

$$P(1) = P(\ I \geq 0\ ) = P\ (X_0\ \beta_0 + \xi \geq 0) = P\ (\xi \geq X_0\ \beta_0)$$

$$P(0) = P(\ I < 0\ ) = P\ (X_0\ \beta_0 + \xi < 0) = P\ (\xi < -\ X_0\ \beta_0) \quad \text{.....5}$$

If we assume that the error terms are independently (I), Identically (ID) and Normally (N) distributed with mean of 0 and variance of 1 or ξ # IIDN (0, σ^2), equation 5 can be written as

$$P(1) = P(\ I \geq 0\ ) = P\ (X_0\ \beta_0 + \xi \geq 0) = P\ (\xi \geq -\ X_0\ \beta_0) = P\ (\xi < X_0\ \beta_0)$$

$$P(0) = P(\ I < 0\ ) = P\ (X_0\ \beta_0 + \xi < 0) = P\ (\xi < -\ X_0\ \beta_0) = [1\text{-}P\ (\xi < -\ X_0\ \beta_0) \quad \text{.....6}$$

Given they are independent the Probit likelihood function (LF) is given as

$$LF = \prod_{i=1}^{n} [p(\xi i < Xoi\beta o)][1 \quad p\ (\xi i < oi\beta o)] \text{.....7}$$

Where i = 1, 2, 3 . . . n and represents elements of the sample of n size. Taking a natural logarithm of both sides, we will get the log likelihood function (LL)

$$LL = \sum_{y=1} ln[p(\xi i < Xoi\beta o)] + \sum_{y=0} \ln[1 \quad p\ (\xi i < Xoi\beta o]$$

$LL = \sum_{y=1} ln[F(\text{Xoi}\beta\text{o})] + \sum_{y=0} \ln[1 \quad \text{F (Xoi}\beta\text{o}]$.....8

In the above equation 8, F (a) is the cumulative probability from normal distribution evaluated at α. By maximizing this log likelihood function we can estimate the parameters of the latent variables (I) and the marginal effects on the probability of involvement can be estimated by the following formula,

$\frac{\partial \text{P}(I)}{\partial x} = \beta_0 f\left(x_0\bar{\beta}_0\right)$.....9

The marginal effect is the effect of the independent variable [X] on the probability of involvement in off/nonfarm activities [P(I)] and is equal to the parameters of the latent variable β_0 times the normal density function values $f\left(x_0\bar{\beta}_0\right)$ evaluated at average of predicted value or $x_0\bar{\beta}_0$.

In accordance, the dependent variable is involvement in off/nonfarm activities and the following are selected as explanatory variables to assess the determining factors of livelihood strategies; sex, age, education, household size, livestock holding, farm land size, membership of peasant associations and local informal institutions, agricultural extension agents visits, participation in safety net program and finally the estimated distance from residence to main market.

Moreover, the model specification for food security determinants has been designed in three phases. There are three indices specified for each of the three phase components; Food consumption score has been selected to assess determinants of food access, for food availability Months of Adequate Household Food Provisioning (MAHFP) and lastly, Body-Mass Index has

been selected to assess the significant and determining factors of food utilization. Each of the regression models are discussed below with their respective specifications.

A. Food Access

With regard to food access, Ordered Probit model is used to determine the crucial factors which determine the probability of households' access to a sufficient and nutritious food to meet their dietary needs. For this, household's Food Consumption Score (FCS) value is used as a dependent variable to see households access to sufficient and nutritious food. As part of the household survey, households were enquired to recall the frequency of consumption and types of food varieties consumed in the 7 days of the week prior to the survey week. Subsequently, the frequency of each food group consumption was multiplied by the assigned weight which bases on the nutritional content. Household's Food Consumption Score can have a maximum value of 126 and depending on whether the surveyed households fall into typical threshold category which consumes oil and sugar on daily basis, the thresholds vary as shown in the table below (See Annexure 2).

Table 4.2 Food Consumption Score Thresholds

Typical threshold	**Thresholds with oil and sugar eaten on daily basis**	**Profiles**
0-21	0-28	**Poor** food consumption
21 -35	28.5-42	**Borderline** food consumption
>35	>42	**Acceptable** food consumption

Source: ACF (2011)

As the dependent variable is Food Consumption Score (FCS) and accordingly households may fall in the above three listed consumption score lists, the regression that is selected for this is ordered logit/probit. As the dependent variable has three probabilities as seen in the table above, a normal logit/probit regression cannot be employed as the dependent variable has more than two

probabilities. Accordingly, the dependent variable (Y) is observable as represented by food consumption frequency of households in terms of the three listed classifications.

Accordingly, food access of households here is taken as a function of food consumption score. Food access of households is determined by various distinct factors. In line with this, food consumption score as a measurement for assessing the determinants of food access of households may possibly face theoretical errors such as the index FCS alone may not effectively capture food access of households, measurement errors and recall errors of respondents. Therefore, an error term ϵ is included additionally to FCS so as to cover the unobservable factors which can impact food access of households. Thus, the error term is additive which can be added to food consumption score. Thus,

Food Access (FA) = Food Consumption Score (FCS) + ϵ ……1

In the above equation 1, food access (FA) is not observable whereas food consumption score (FCS) is observable, and thus FA is the latent variable. Therefore, by employing the typical threshold food consumption score as a base,

$$\begin{cases} \text{If } FA < 21 \longrightarrow \text{(P) Poor food consumption} \\ \text{If } 21<FA<35 \longrightarrow \text{(B) Borderline food consumption} \\ \text{If } FA > 35 \longrightarrow \text{(A) Acceptable food consumption} \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Now we can estimate FA non-linearly by using Ordered Probit starting from the Y values. Thus,

$P(P) = P(FA<21)$

$P(B) = P(21<FA<35)$…….3

$P(A) = 1\text{-}P\ (FA<35)$

Now let's put equation 1in to equation 3,

$P(P) = P(FCS+ \epsilon <21)$

$P(B) = P(21< FCS+ \epsilon <35)$……………………………………………………………4

$P(A) = 1\text{-}P\ (FCS+ \epsilon <35)$ s

Where $FA = XB+ \epsilon$ is a standardized version of equation 1 and a simple arithmetic manipulation will give us,

$P(P) = P(21 - FCS > \epsilon)$

$P(B) = P(21 - FCS< \epsilon < 35\text{-}FCS)$………………………………………………………5

$P(A) = 1\text{-}P\ (35 - FCS < \epsilon)$

After assigning 2 cut off points in FA in the form of C_1 and C_2,

$$\phi(C_1) = P(P)$$
$$\phi(C_1) - \phi(C_2) = P(B) \quad \text{……………………………………………………………………6}$$
$$1 - \phi(C_2) = P(A)$$

If we impose any symmetric distribution which includes either normal or logistic we can get Ordered Probit or Ordered Logit, respectively. Imposing distribution we will get;

$$P(Y = P\ ) \ = \ \Phi(21 - X\beta)$$
$$P(Y = A) \ = \Phi(21 - X\beta)\ \text{-}\ \Phi(35\text{-}X\beta) \quad \text{…………………………………………………………………7}$$
$$P(Y = B) \ = \ 1 - \Phi(35 - X\beta)$$

And we can follow to estimate likelihood function in form of assuming the error terms are independent

$$L = \prod_{i=1}^{n_1} \Phi(21 - X\beta) \prod_{i=1}^{n_2} \Phi(21 - X\beta) \text{ - } \Phi(35\text{-}X\beta) \prod_{i=1}^{n_3} 1 - \Phi(35 - X\beta) \text{.....8}$$

However, there are some limitations in employing a standalone regression model with Ordered Probit to some specific instances like this one on food consumption score. The index food consumption score is having three probabilities; Probability of a household to fall in poor, borderline or acceptable food consumption. With instances like this one with just three probabilities of a dependent variable, there happens a problem of ambiguity with the middle density, where the marginal effects of the repressors "X" on the probabilities are not equal to the coefficients. In this case, what happens to the borderline food consumption probability is ambiguity. This is because referring to the Ordered Probit regression graph, increasing one of the X's while holding $\boldsymbol{\beta}$ and μ similar is equivalent to shifting the distribution slightly to a right side shift which creates an overlapping and ambiguity to the middle probability of borderline consumption. In general, the relative signs of the coefficients, only the signs of the changes in the probability of the first and the last (the probability of poor and acceptable food consumption) are unambiguous (Gujarati D. N., 2004).

Similarly, in case of this particular study, it has been found that only 10 households (2.70%) were falling in the acceptable food consumption which will create a big hindrance to put Ordered Probit regression as the only regression to estimate food access with food consumption score index, as the ordered Probit only emphases on the probability of the Poor and Acceptable food consumption. Therefore, the study has used a normal Probit regression as supplementary change to the ordered one.

With this regard, for assessing food access of households Probit regression is used and the same food access measurement index is used to determine significant factors which deter the probability of households to dwell in borderline food consumption. Probit model is used in the study due to the reason that Ordered Probit regression will not be able to outline the borderline food consumption. In concomitant to this, Linear probability Model (LPM) is plagued by several problems, such as non-normality of the error term ui, heteroscedasticity of the error term U_i, possibility of estimated Y_i lying outside the 0–1 range, and the generally lower R^2 values (Gujarati D. N., 2004).

But these problems are surmountable. For instance, we can use Weighted Least Square (WLS) to resolve the heteroscedasticity problem or increase the sample size to minimize the non-normality problem. By resorting to restricted least-squares or mathematical programming techniques, we can even make the estimated probabilities lie within 0–1 interval. But even then, the fundamental problem with the LPM is that it is not logically a very attractive model (Gujarati D. N., 2004)

Moreover, to explain the behavior of a dichotomous dependent variable, the study has chosen a suitable Cumulative Distribution Function (CDF). There is no compiling grounds to prefer Logit to Probit or vice versa, the only difference is on their shape; i.e. logit is flatter at its tail. Therefore, the selection among these two depends on the researchers interest (Gujarati D. N., 2004). The specification of the Probit model, which is adopted from preference analysis of McFadden (1973) as cited in Gujarati D. N., (2004), is given below. In addition, the dependent variable is FCS and will take value of 1 if a household falls with a score above the borderline food consumption and 0 if not.

Assuming food consumption score (FCS) is linear in parameter it will take the following matrix form, where X is vector of independent variables and their parameters β;

$$FCS = X\beta \quad \text{.....1}$$

However, some of the X_0 are not observed, so they are represented by error term ξ, and all observed independent variables are presented by vector X_0.

$$FCS = X_0\beta_0 + \xi \quad \text{.....2}$$

Where X_0 and β_0, represent observed independent variables and their parameters, respectively. The error vector ξ represents the average effect of all unobserved variables. Here, similar to the ordered Probit regression model specification, food access is not observable whereas food consumption score is observable and thus FA is the latent variable. Thus, just by employing the typical threshold food consumption score as a base,

$$\left\{\begin{array}{l} \text{If FA} \le 21 \\ \text{If FA} > 21 \end{array}\right\} \begin{array}{l} \longrightarrow \text{ (P) Poor food consumption} \\ \longrightarrow \text{ (B) Borderline food consumption} \end{array} \quad \text{.....2}$$

Thus,

$$\left\{\begin{array}{l} If\,..X_0\beta_0 + \xi \le 21..then..P(\text{FA}) = 0 \\ If\,..X_0\beta_0 + \xi > 21..\text{then}..\text{P(FA)} = 1 \end{array}\right\} \quad \text{.....3}$$

With a simple mathematical substitution

$$\begin{array}{l} P(0) = P(\text{FCS} \le 21) = \text{P}(\text{X}_0\,\beta_0 + \xi \le 21) = \text{P}(\xi \le -\text{X}_0\,\beta_0) \\ \text{P}(1) = \text{P}(\text{FCS} > 21) = \text{P}(\text{X}_0\,\beta_0 + \xi > 21) = \text{P}(\xi > -\text{X}_0\,\beta_0) \end{array} \quad \text{.....4}$$

If we assume the error terms are independently, identically and normally distributed with mean of 0 and variance of 1, equation 4 can be written as;

$$P(0) = P(\text{FCS} \leq 21) = \text{P}(\text{X}_0 \beta_0 + \xi \leq 21) = \text{P}(\xi \leq -\text{X}_0 \beta_0) = [1 - \text{P}(\xi \geq \text{X}_0 \beta_0)]$$
$$\text{P}(1) = \text{P}(\text{FCS} > 21) = \text{P}(\text{X}_0 \beta_0 + \xi > 21) = \text{P}(\xi > -\text{X}_0 \beta_0) = P(\xi < \text{X}_0 \beta_0) \quad \text{.....5}$$

Given they are independent, the Probit likelihood function (LF) is given by;

$$LF = \prod_{i=1}^{n} [1 - \text{P}(\xi \geq \text{X}_0 \beta_0)][\text{P}(\xi < \text{X}_0 \beta_0)] \quad \text{.....6}$$

Where i=1, 2, 3, …n, represent elements of the sample of n size. Taking natural logarithm of both sides we will get the log likelihood function (LL)

$$LL = \sum_{Y=1} \ln[1 - \text{P}(\xi_i \geq \text{X}_{0i} \beta_0)] + [\text{P}(\xi_i < \text{X}_{0i} \beta_0)] \quad \text{.....7}$$

Independent variables

Based on various literatures reviewed and discussion held with stakeholders; local administration officers, Food Security Coordinators, Early Warning Coordinators, Peasant Associations and Development Agents, the explanatory variables for this study were classified broadly as socioeconomic, natural and institutional factors. A range of demographic and socio-economic variables that are presumed to influence or else determine the household food security status are described and hypothesized below as explanatory variables;

1. Education level of the household head: is a continuous variable and is expected to positively influence food consumption of the household. Education enhances the perception and response level of farmers to interpret new knowledge and thus, the more the literate the

household heads are, the more likely they will be determined to enhance the food habit and consumption patterns of their household. In addition to this, the more the literate the household head is, the more he/she will have a better understanding on the food types and their combinations for a better nutritional diet. Thus, it is expected to have a positive relation with food consumption of households.

2. Household size: This is also a continuous variable, which is the total number of household members living together in the house. As the number of mouths to feed in a household increases, the chance of the household to have a better nutritionally quality diet will decrease. Thus, it is expected that the larger the household size the less nutritionally balanced diet that the household will consume. Therefore, it is assumed that household size and food consumption to have a negative relation.

3. Total size of cultivable land: This is also a continuous variable which is expected to have a huge impact on the food consumption quality of households. Land is one of the crucial resources which impacts majority of the smallholding farmers' production yield. As the total size of cultivable land increase, households will have the chance to plant more diversified food types in more quantities, keeping other factors constant. Even in cases where land holding per adult and the soil fertility conditions are low, households with larger cultivated land size will have better options to diversify and increase their production. Hence, it is assumed that households with a better land holding size are expected to have a better food consumption pattern and thus size of cultivable land is expected to have a positive impact on households' food consumption pattern.

4. Land fertility: The fertility level of the land is also one variable which determines the productivity yield of households. This variable has been inquired directly by asking respondents perception about the relative fertility level of the land. It is expected that farmers with higher land fertility to have a better production output and food consumption score.

5. Total livestock holding: This is another continuous variable which is measured in tropical livestock unit and total livestock holding of a household is considered as crucial asset which can play a major role in the food production, consumption pattern and income generation capacity of households. The importance of livestock holdings goes beyond its importance as a protection against crop failure and other similar shocks. It has also a huge importance in changing the food varieties consumption pattern of households. Livestock and their variety products such as meat, milk, eggs and etc. can be used as one important meal containing high protein for households. In addition to this, in the Food Consumption Score also regarded meat, fish, milk and their similar products with the highest weight (See Annexure 2). Therefore, the more livestock holdings among households, the more the chance the household members will have in consuming high protein foods, and it is expected that livestock holdings have a positive impact on the food consumption and access of households.

6. Distance to the main market: this variable is treated as a continuous variable, and it is the estimated distance between the main market to the respective households' residence. Distance to the main market has a big impact on the food consumption pattern of the households, in that, during the survey it has been observed that majority of the households consume different varieties of food on the day of marketing. Thus, it is hypothesized that the nearer the distance of households' residence to the main market, the more likely they will have the chance to purchase or exchange for varieties of food, keeping other factors constant.

7. Participation in off/non- farm activities: This is a dummy variable which takes a value of 1 if the household participates in off/non-farm activities and 0 otherwise. In cases where households or their members participate in any off/non-farm activities, they will generate an additional income which will create an opportunity for households to buy more basic necessities such as food items. In addition to this, various studies have revealed that, keeping other factors constant, the more the income, the more the households will consume foods with higher protein. Therefore, households and their members participation in off/non-farm activities is expected to have a positive impact on the food consumption score of the household.

8. Irrigation: Irrigation is also a dummy variable which takes a value of 1 if the household uses irrigation system and 0 otherwise. Irrigation has a huge impact in the productivity of framers especially in areas with low rainfall like the case of the study areas. Given the study areas' climatic condition, irrigation is expected to have a positive impact on the production yield. In addition to this, irrigation helps farmers to diversify their production which will possibly enhance the consumption pattern of households positively. Thus, it is assumed that food consumption score of a household and irrigation to be positively related.

9. Use of improved seeds: This is also a dummy variable taking a value of 1 if the household employs improved seeds and 0 otherwise. Globally, it has been witnessed that use of improved seeds has boosted up the production yield of farmers. In Ethiopian case also, similar enhancement in the production yield has been seen which on the other hand has enhanced farmers' ability in gaining additional income. Thus, adoption of improved seeds will further increase the chance of having a better access to different varieties of foods.

Accordingly, it is expected that use of improved seeds and food consumptions score to have a positive relation.

10. Production of garden fruits/vegetables: This is also a dummy variable. If the household produces garden fruits/vegetables it will take a value of 1 and 0 otherwise. Two of the food groups incorporated under the food consumption score assessment are fruits and vegetables, and these food groups contain various micro nutrients which are necessary for bodily functions and their production at household level will enhance their consumption directly. Thus, households who are producing fruits and vegetables are expected to have a better food consumption variety which will enhance their nutritional consumption quality. Thus, producing fruits and vegetables is expected to have a positive impact on food consumption score of households.

11. Productive Safety Net Programme participation: this is also a dummy variable which takes a value of 1 if the household is participating in a Productive Safety Net Programme and 0 otherwise. Productive Safety Net Programme directly supports households with some types of food items and cash as an exchange income for the service rendered by the participants for community development works. Thus, households under the support of safety net program are expected to have a better chance of having additional food items in their meal, thereby enhancing their food consumption pattern.

12. Access to extension services: This is also a dummy variable taking a value of 1 if the household has a contact with agricultural extensions and 0 otherwise. As Amdissa T., (2007) stated, access to agricultural extension services enhances households crop production techniques, for improved agricultural inputs as well as other incentives for a better production

which all these will impact food security positively. Therefore, households' access to extension services is expected to be positively related with food consumption score of households.

B. Food Availability

Food availability condition of the smallholding farmers in the study areas varied across different socioeconomic backgrounds of households and agro ecological locations. Majority farmers have one time harvest throughout a year due to their high dependence on the rain fed production system. Initially, a selection of index which can comparatively assess better food availability among the households was done. Accordingly, the index selected was "Months of Adequate Household Food Provisioning (MAHFP)" whereby households were asked the number of months where the household faced food shortage in the past 12 months. In concomitant to this, "The Poisson Regression Model" was selected in its ability to better comparatively capture the significant variables on each monthly food supply adequacy in a household.

The dependent variable is therefore the observable index selected; Months of Adequate Household Food Provisioning (MAHFP). The dependent variable denoted as Y is observable (0-12) where the values range from 0 to 12 representing months starting from January to December with assigned numbers of 1 to 12. The latent variable here is Food availability. Consequently, food availability in a household is taken as a function of Months of Adequate Household Food Provisioning (MAHFP). Months of Adequate Household Food Provisioning (MAHFP) is calculated as;

MAHFP = 12 months minus the total number of months out of the previous 12 months that the household was unable to meet their food needs.

= 12 - Sum (1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 + 11 + 12)

Moreover, food availability of households is affected by various distinct variables and thus assessing the food availability determinants through MAHFP will need to incorporate various independent variables which can possibly impact it. Accordingly, the model specification for the Poisson regression model is given as follows;

Food Availability (FAV) = Months of Adequate Household Food Provisioning (MAHFP) + ϵ

……...1

As said above, food availability is not observable and the observable index which is selected to assess food availability cannot stand alone as an index because of the errors such as representation, recall difficulties in cases of more than one harvest in a given year etc. Therefore, as equation 1 shows, an error term ϵ which is additive is put so as to capture the unobservable factors which can determine the MAHFP. The regressand MAHFP is count type which is the number of months where a given household has adequate food provision for its household members, thus taking a finite number value which ranges from 0 to 12 (discrete value). Specifically speaking, Poisson probability distribution exclusively suites count data and Poisson distribution function is given as follows;

$$f(\mathrm{Y_i}) = \frac{\mu^{\mathrm{Y}} e^{-\mu}}{Y!} \quad \text{…….....2}$$

Where Y= 0, 1, 2, 3,…. N and Y ! is "Y factorial" where Y ! =Y x (Y-1) x (Y-2) x 2 x 1

Accordingly, the Poisson regression model is given by;

$$\mathrm{Prob}(\mathrm{Y_i} = \mathrm{y_i} \,|\, x_i) = \frac{\mathrm{e}^{-\lambda_i}\, \lambda_i^{\,y_i}}{y_i!} \quad \text{……..……3}$$

Where the $\mathrm{Y_i}$ is the count index of months of adequate food availability in a given year among households and $\mathrm{X_i}$ are the independent variables which determine the number of months

where households' will have adequate food supply for their household. Thus, equation 3 reveals that the probability of MAFHS takes a non-negative integer value and the values of MAHFP are independently distributed as Poisson random variables with a mean λ_i for each household. With this in mind, the most common formulation for λ_i is the log-linear model,

$$\ln\lambda_i = x'_i\beta \quad \text{……..……4}$$

In case of Poisson distribution, the variance is the same as the mean value. Subsequently, it can easily be shown that the expected number of months that households will have enough food available at their household in a one year period is given by;

$$E\left[y_i \middle| x_i\right] = Var\left[y_i \middle| x_i\right] = \lambda_i = e^{x'_i\beta} \quad \text{……..5}$$

Therefore, it can be rewritten as;

$$\frac{\partial E\left[y_i \middle| x_i\right]}{\partial x_i} = \lambda_i\beta$$

……...……6

As principle, Poisson regression model is just simply a nonlinear regression. However, it is by far easier to estimate the parameters with maximum likelihood techniques. Thus, the log-likelihood function is given as follows;

$$\ln L = \sum_{i=1}^{n}\left[-\lambda_i + y_i x'_i\beta - \ln y_i!\right] \quad \text{……..……7}$$

Independent variables

X_i's are the independent variables which may possibly determine the MAHFP of households and they are listed and discussed below with their expected impacts as follows;

1. Age of the household head: is a continuous variable and is expected to positively influence food availability of the household. Mostly, rural households devote their time and base their livelihoods on agriculture, and the older the household head, the more the experience he will have in farming techniques, weather forecasting and other hazards. Though in some instances, older people are highly risk averters but still they try to cop up with the situations by diversifying and intensifying their production activities; putting their chance to a higher probability of being food secure. Thus, it is assumed that age of the household head and food availability to be positively correlated.

2. Sex of household head: This is a dummy variable, which takes a value of 1 if sex of the household head is male, and 0 otherwise. In the study areas, the environment and weather conditions highly debilitates farmers making them work hard labor and short time in a day. As a result labor plays an important role and male headed households are assumed to be in a better position to pull together labor force than the female headed households. In view of the fact that women participation both in farm and nonfarm activities is very limited mainly due to cultural and religious impediments, male headed households are expected to make their households in a better food availability condition than their counterparts, female heads.

3. Education level of the household head: Education enhances farmers' ability to perceive, interpret and respond to new technologies and it endows them with the essential knowledge

on how to make a living. Agriculture is a very dynamic occupation and most agricultural production technologies and conservation practices are always coming with a better comprehension. Consequently, the more the household head is educated, he/she will be very open to acquire knowledge of new technologies and advancements such as soil and water conservation techniques, agricultural extension services and supplementary income generating activities. Thus, it is hypothesized that households heads who are more literate are in a better position to enhance the households food availability condition than the less literate ones and is thus expected to have a positive relation with food availability of households.

4. Household size: this is a continuous variable which is a very crucial variable that determines households' food availability condition directly. The larger the member of individuals in the household, the less the food availability, keeping other factors constant. It is factual that as a family size (members living together under the same roof) increases, the number of mouths to feed also increase, which in turn decreases the availability of food in the household. Therefore, it is assumed that household size and food availability to have a negative relation.

5. Dependency ration: Households with higher number of productive members as compared to non-productive members, their probability falling for shortage of food will be less, keeping other things constant. Vice versa, the higher the number of the non-productive age groups (individuals with ages less than 15 years and more than 65 years) in a household comparing to the productive age groups, the higher the probability of the household to be food insecure. Accordingly, households with large number of dependent members are assumed to have less

food availability and thus, it is expected that dependency ratio to be negatively associated with food availability.

6. Total cultivated land: this is a continuous variable and it is the total estimated land size under cultivation. As the size of cultivated land increases, given that other associated production factors remaining the same, the probability getting higher yield will also increase. Even in cases where land holding per adult or per adult equivalent is low, households with larger cultivated land size will have better options to diversify production and to increase their production. Thus, such a household will be in a better position for a better yield and food availability. Accordingly, it is expected that the larger the cultivated land, the higher the chance of a household to have better food availability and thus, a positive relation is expected in between.

7. Land fertility: This is a continuous variable covering the issue of soil fertility based on respondents' perception among; highly fertile, moderately fertile and totally infertile. Various scholars have put land, labor and capital as three most important basic components and factors for an enhanced agricultural production. Land fertility is also a blatant variable which influences the agricultural productivity yield especially in cases like the study areas where the land fertility condition is relatively less fertile. Thus, farmers with a highly fertile land are expected to have a better production output, keeping other factors constant. Thus, the higher the land fertility, the better food availability in a household and therefore, it is expected to have a positive relation with food availability.

8. Total livestock holding: This is the total number of livestock that a household possesses and it is a vital asset which can stand as a security against various predicaments like crop

failure. It is measured in tropical livestock unit. As the total number of livestock possession of the household increases, the household is expected to have a better food availability. This is mainly because livestock directly or indirectly contributes to households' better food availability condition. The direct contributions of having an increased livestock unit includes meat, eggs, milk and other similar dairy products for the direct consumption of a household. The other indirect contributions includes organic manure, drafting power and income from sale of livestock's and their products. As a result, it is expected that livestock holdings will have a positive relation with food availability condition of households.

9. Distance to the main market: This is a continuous variable and stands for the estimated distance between the nearest major market and household's residence. It is assumed as main market distance is far from households' residence, it will be difficult for households to get various fresh food inputs, updated price and quantity demand information. Another feature is the fact that as the distance to main market increases, with less transportation infrastructures, economically weak households will be in a difficult position to engage in various economic activities like petty trading which can enhance their income sources as well as their food stock directly. Hence, it is assumed that the nearer the households' residence to the main market, the better food availability in the household.

10. Access to credit: This is a dummy variable which takes a value of 1 if the respondent has access to a formal credit and 0 otherwise. The more farmers will have access to credit facilities, the more likely they will diversify and enhance their production and income sources. An adequate amount of production is a very significant factor for food availability and in instances where credit facilities are well arranged for farmers, assuming credit will be spent for the intended purpose i.e. production enhancement, it is expected that farmers will

have a better chance of securing their food demand and extend their production. Moreover, in times of severe food shortages, credit facilities may be employed for buying food and important commodities for survival. Therefore, access to credit facilities is expected to have a positive relation with food availability of households.

11. Participation in off/non-farm activities: This is a dummy variable which takes a value of 1 if the household is participating in off/non-farm activities and 0 otherwise. In various occasions around the study areas, crop production yield is insufficient and farmers usually look for other income generating sources than to just solely depend on agriculture. Thus, income earned commencing off/non-farm activities is very crucial variable that can impact food availability of households positively. For this reason, households' participation in off/non-farm activities is assumed to have a positive relation with food availability condition.

12. Food aid participation: This is a dummy variable which takes a value of 1 if the respondent is participating in food aid and 0 otherwise. Food aid is the direct provision of food which is necessary for survival in times of chronic food shortage. Most households in Tigray region are dependent on food aid for several years. As direct food aid will increase the food stock in a household, it is expected to have a positive relation with food availability condition of households.

13. Irrigation: This is also a dummy variable in the model which takes a value of 1 if a household adopts irrigation system and 0 otherwise. In a developing country like Ethiopia, agriculture is a backbone for the country's economy and a base for livelihood of rural communities in general. Given areas with a climatic condition which is not that promising for a sustainable crop production, it would be by far better to supplement the crop production

with irrigation for an enhanced production output. In similar instances in the study areas, there is less and erratic precipitation which curtails the production output per hectare and predestines the study areas' as one of the highly food deficit areas in the country. Thus, given that irrigation is a key technology to enhance productivity, it is expected that food availability and irrigation to be positively related.

14. Use of improved seeds: This is also a dummy variable taking a value of 1 if the household employs improved seeds and 0 otherwise. Different studies have revealed that the use of improved seeds leading to a higher production yield. In similar lines, in the study areas also, households/farmers who employ improved seeds have shown an enhanced production yield and thus it is expected that use of improved seeds to have a positive impact on the food availability condition of households.

15. Number of Oxen owned: This is a continuous variable, and number of oxen owned has a symbolic relation with crop production. In Ethiopia, oxen are very important sources of traction power for majority farmers. In addition to this, they provide organic manure for keeping land fertility. In case of the study areas, manure is often used for garden fruits and vegetables production. Hence, it is expected that the number of oxen owned by the household and food availability condition to have a positive relation.

16. Productive Safety Net Programme participation: This is a dummy variable which takes a value of 1 if the household is participating in a Productive Safety Net Programme and 0 otherwise. Productive Safety Net Programme was mainly initiated in the study areas to support chronically food insecure households to bridge food gaps by assisting with direct food transfers or cash while developing community assets. As Devereux S., (2001) stated,

productive safety net program was launched mainly for food security assurance, prevention of assets depletion, household as well as communal asset building, access to various services and improving natural resource base for an enhanced food security. Thus, safety net program especially in poor communities and food insecure areas signify a transition between emergency reliefs and achievement of long-term development objectives. Thus it is expected that safety net program to have a positive impact on food availability condition of households.

17. Access to extension services: This is also a dummy variable taking a value of 1 if the household has a contact with agricultural extension and 0 otherwise. Farmers having access to frequent agricultural extension services have better awareness on production techniques and output yield management than the farmers who don't have the access or who do not want to have a contact. Thus, households' access to extension services is expected to be positively related with food availability condition of households.

18. Fertilizer: This is also a dummy variable taking a value of 1 if the household adopts fertilizer and 0 otherwise. Farmers who adopt modern fertilizer have better chance of enhancing their productivity due to the enhanced land fertility. In instance such as the study areas with a record of low fertility level of land, fertilizer will have a huge impact in increasing their yield as well as in enhancing their food security status.

C. Utilization

Regarding food utilization of households, a body mass index (BMI) (weight for height) is used as a dependent variable to assess the determinant factors of utilization which is the third component

of food security. For this, the weight and height of the sampled respondents and members of their respective households was measured during the field work as shown in the figure below.

Figure 4.1 Field work for Weight and Height of households

Source: Survey result, 2015

Moreover, the dependent variable here is BMI of household members and it observable with a value which is computed by using the weight and height data.

Table 4.3 BMI classification for Under, Normal and Over weight

Classification	**BMI (Kg/m^2)**
Underweight	**<18.5**
Severe thinness	<16.0
Moderate thinness	16.0 - 16.9
Mild thinness	17.0 - 18.5
Normal range	**18.5 - 24.9**
Overweight	**≥25.0**
Pre-Obese	25.1 - 29.9
Obese	**≥30.0**
Obese class I	30.0 - 34.9
Obese class II	35.0-39.9
Obese class III	≥40.0

Source: WHO, 2014

During the survey, it was observed that no household member was found to have a BMI beyond normal range. Accordingly, a normal Logit model is used to assess the deterring factors of food utilization by assessing through the energy deficiency aspect of households. To explain the characteristics of dichotomous dependent variable, the study chose an appropriate cumulative distribution function. There are no compiling grounds to choose among Logit or Probit, the difference lies on their shape where Logit is flatter at its tail. Therefore, the selection among these two models depends upon the researcher's interest. Accordingly, the dependent variable BMI will take a value of 1 if BMI of a person falls in a normal range and 0 otherwise.

Dependent Variable

As mentioned above, household members will be considered in the group of normal range if they have BMI of 18.5 - 24.9. In the model, BMI of the household which is observable to assess the direct utilization of food in the households was put as a dependent variable. It was regressed with selected independent variables listed below with brief description of variable and their expected impacts. Moreover, the BMI of children in the age group of 'less than 15' was not incorporated in the model as it requires a separate consumption pattern and nutritional impact assessment study.

Assuming, BMI is linear in parameter, it will take the following martix form.

$BMI = X\beta$………. ……………………………………………………………………... 1

However, some of the X's are not observable, thus they are represented by an error term (ε), whereas, all the observed independent variables are presented by the vector X_0.

$BMI = X_0\beta_0 + \varepsilon$ ……………………………………………………………………………. 2

Where X_0 and β_0, represent observed independent variables and their parameters respectively. The error vector (ε) represents the average effect of all unobserved variables. Thus,

$$\begin{cases} \text{If BMI} \geq 18.5 \text{ then P(U)} = 1 \\ \text{If BMI} < 18.5 \text{ then P(U)} = 0 \end{cases} \quad \ldots\ldots 3$$

U represents is the utilization level. BMI of household members is greater than or equal to 18.5 means, they are in normal range of BMI. Using equation 2 on equation 3, equation 4 can be rewritten with their corresponding probability as:

$$P(1) = P(U \geq 0) = P(X_0\beta_0 + \varepsilon \geq 0) = P(\varepsilon \geq -X_0\beta_0) \ldots\ldots 4$$
$$P(0) = P(U < 0) = P(X_0\beta_0 + \varepsilon < 0) = P(\varepsilon < -X_0\beta_0)$$

If we assume the error terms are independently, identically and normally distributed with a mean of 0 and variance of 1, equation 4 can be written as,

$$P(1) = P(U \geq 0) = P(X_0\beta_0 + \varepsilon \geq 0) = P(\varepsilon \geq -X_0\beta_0) = P(\varepsilon < X_0\beta_0) \ldots\ldots 5$$
$$P(0) = P(U < 0) = P(X_0\beta_0 + \varepsilon < 0) = P(\varepsilon < -X_0\beta_0) = [1-P(\varepsilon < X_0\beta_0)]$$

Given they are independent, the Probit likelihood function (LF) is given as,

$$LF = \prod_{i=1}^{n}[P(\varepsilon_i < X_{0i}\beta_0)][1 - P(\varepsilon_i < X_{0i}\beta_0)] \ldots\ldots 6$$

Where i = 1, 2, 3 ……… n represent elements of the sample n size. Taking the natural logarithm of both sides, we will get the log likelihood function (LL),

$$LL = \sum_{Y=1}\ln[P(\varepsilon_i < X_{0i}\beta_0)] + \sum_{Y=0}\ln[1 - P(\varepsilon_i < X_{0i}\beta_0)] \ldots\ldots 7$$

Independent variables

Based on various literatures reviewed and discussion held with stakeholders; local administration officers, Food Security Coordinators, Early Warning Coordinators, Peasant Associations and Development Agents, the explanatory variables for this study were classified broadly as socioeconomic, natural and institutional factors. A range of demographic and socio-economic variables that are expected to influence and determine households' food utilization status are listed below as explanatory variables;

1. Age of the household head: is a continuous variable. Most rural household heads devote their time and base their livelihoods on agriculture, and the older the household head, the more the experience he will have in farming techniques and production of basic household food components for consumption. It is expected that age of the household head and food utilization to be positively related.

2. Sex of household head: This is a dummy variable, which takes a value of 1 if sex of respondent is male, and 0 otherwise. In the study area, the environment highly debilitates farmers making them work hard labor and short time in a day, and as a result labor plays an important role. Furthermore, male headed households are assumed to be in a better position to pull together labor force than the female headed households mainly due to cultural and religious taboos which limit women from engaging in various economic activities. In view of the fact that women participation both in farm and nonfarm activities is highly limited, male headed households are expected to be more food secure.

3. Education level of the household head: Education enhances farmers' ability to perceive, interpret and respond to new events and it endows them with the essential knowledge on how

to make a living better. When it comes to consumption, education will increase their awareness about nutritional contents of food groups and their value of utilization. Thus, it is hypothesized that household heads who are more literate to have better food utilization and thus it is expected to have a positive relation with food utilization of households.

4. Household size: This is the total number of household members living together and is a continuous variable. It is an important variable which determines household's food utilization, where the larger the size of a household, the higher food expenditure and less quality of food consumption. It is factual that as a family size increases, the number of mouths to be fed will also increase which decreases the available food and its optimum utilization in a household. Therefore, it is expected that household size and food utilization to have a negative relation.

5. Dependency ration: Households with higher number of productive or adults groups than the non-productive age groups will have a less chance to fall in food shortage, given that the area provides a better production potential and working atmosphere. Households with large number of dependents are assumed to have a relatively lower food utilization than their counters. As a result, it is expected that dependency ratio to be negatively related with food utilization of households.

6. Total cultivated land: This is a continuous variable which is the total land size under cultivation. As the size of cultivated land increases, given other production factors remaining constant, the probability that the holder gets an enhanced output is high. Higher production yield in turn enhances the food stock and income sources of a household and will have better

options to diversify production and enhance consumption patterns. Accordingly, it is expected that the larger the cultivated land size, the higher the food utilization.

7. Total livestock holding: this is the total number livestock that a household possesses which is measured in total livestock units. Livestock holding has the power to stand as a security in times of crop failure by creating alternative income sources and food consumption. Livestock directly contributes to households' better food consumption pattern with supply of food items such as meat, eggs, milk and other similar dairy products. As a result, it is expected that livestock holdings to have a positive relation with food utilization.

8. Distance to the main market: This is a continuous variable, and is the estimated distance between the households' residence to the main market. This is one crucial factor which is expected to have a negative relation to food utilization status. As majority of the farmers use human power for agricultural hard labor fieldworks as well as to transport their good to the market, the higher the distance means the higher the hardship and higher loss of energy. Moreover, higher distance also limits households from getting access to fresh food consumption ingredients and also limits them from engaging in various petty trading activities. Therefore, it is assumed that the more nearer to the main market, the better food utilization of households.

9. Access to credit: This is a dummy variable which takes a value of 1 if the respondent has access to a formal credit and 0 otherwise. The more farmers will have access to credit facilities, the harder they try to enhance their production, keeping other factors constant. As an adequate amount of production is a very significant one factor for food security, in instances where credit facilities are well arranged for farmers, it is expected that farmers will

have a better chance of utilizing their food at household level. In concomitant to this, in cases of severe food shortages, the credit facilities may be employed for buying food items from market. Therefore, access to credit facilities is expected to have a positive relation with food utilization of households.

10. Participation in off/non-farm activities: This is a dummy variable which takes a value of 1 if the household engages in off/non-farm activities and 0 otherwise. Solely depending on subsistence crop production as one and only way of income generation and consumption source is inadequate and makes households vulnerable especially in times of food shortages. Thus, income earned commencing off/non-farm activities is very crucial variable which can play an important role in the food utilization of households. Thus, households' participation in off/non-farm activities is expected to have a positive relation with food utilization.

11. Land fertility: Apart from farmland size, land fertility is also one crucial factor in the productivity capacity of farming households. Farmers with a relatively higher fertile land invest less time and capital for production as compared to their counterparts. Moreover, they have a better chance to diversify their production as well as their food consumption patterns in their households. Thus, it is assumed that the higher the land fertility, the better food utilization at a household.

12. Food aid participation: this is taken as a dummy variable which takes a value of 1 if the household is participating or if in the past has participated in food aid and 0 otherwise. Food aid has been used as one major intervention mechanism to enhance food availability at household level in many parts of Ethiopia. It is still considered as major way of intervention in times of chronic food shortages through direct provision food supplies which are necessary

for survival. Thus, food aid is expected to have a positive relation with food utilization of households.

13. Irrigation: Irrigation is also taken as a dummy variable in the model which takes a value of 1 if a household adopts irrigation system and 0 otherwise. Modern irrigation technologies are showing promising and positive impacts in the production yield of households especially in areas with challenging climatic conditions. Supplementing crop production with irrigation has been promoted by various institutions and governments of nations for an enhanced production output. Thus, as irrigation is a key technology to boost production of households, it is assumed that irrigation and food utilization to be positively related.

14. Use of improved seeds: This variable is also taken as a dummy variable taking a value of 1 if a household adopts improved seeds and 0 otherwise. Use of improved seeds has shown a positive and promising change in many parts of Ethiopia by enhancing the per hectare productivity of farmers. Its adoption has led to a higher yield which is by far better than the local seed varieties. Thus, it is expected that the use of improved seeds to have a positive impact on the food utilization of households.

15. Number of oxen owned: This variable is taken as a dummy variable; i.e. if a household owns sufficient amount of oxen (two and above) for cultivation will take a value of 1 and 0 otherwise. In Ethiopia, majority farmers use oxen as major sources power for traction. In addition, they provide organic manure for keeping fertility of the land to enhance crop production. Thus, it is expected that the number of oxen owned by the household and food utilization to have positive relation.

16. Productive Safety Net Programme participation: This is also a dummy variable which takes a value of 1 if the household is participating in Productive Safety Net Programme and 0 otherwise. The main purpose of Productive Safety Net Programme is to support the most vulnerable and chronically food insecure households through covering food gaps while enhancing community assets in parallel. Thus, safety net program participation is expected to have a positive impact on the food utilization of households in the model.

17. Access to extension services: This is also a dummy variable taking a value of 1 if the household has a contact with agricultural extensions and 0 otherwise. Farmers' frequent contact with agricultural extension and development agents enhances households' crop production techniques, opens up credit facilities, follow up supports and trainings and etc. which in turn will impact food security positively. Therefore, households' access to extension services is expected to be positively related with food utilization of households.

Scope and Limitations of the Study

The study mainly focused on assessing the food security and livelihood conditions of smallholding farmers in Tigray region covering three *Tabias* in Kilte Awelalo *Woreda*. Geographically, the study is delimited with the three *Tabias* from Tigray Region. Regarding agro-ecology classifications, the study mainly focused on areas with the highest drought recurrences.

Conceptually, the study assessed food security and livelihood resources conditions of the smallholding farmers with a rational selection of limited measurement indices. Moreover, the study assessed selected independent variables which can possibly impact the food security and livelihood conditions of smallholding farmers. In addition to this, in the case of BMI to assess proper utilization of food, the study was limited on adults BMI as children BMI analysis requires

a separate further nutritional analysis. Nonetheless, it would be more consequential if more other areas with different agro climatic condition; additional distinct measurement indices and more independent variables have been included in the study, even so, the study was caught up in between time and cost limitations. Therefore, the findings from the study are limited to the study areas and the conclusions delineated may not possibly represent other areas food security and livelihood conditions. Lastly, the other limitation of the study is the limitation due to non-accessibility of detailed financial transaction records of households; issues such as sell of agricultural products, savings and credit details, where majority households could not recall their financial transaction due to their limited literacy and subsistence way of living. Accordingly, the study was forced to use limited measurement indices of food security and livelihood resources.

Conceptual definitions

This part of the study is used to define key concepts and basis of the study to portray what the variables used in the study mean and how they are taken or perceived in terms of this particular study.

Food Security: Even though, the concept of food security can been perceived from different dimensions, this study has taken it as food availability, accessibility and utilization to meet the basic dietary needs which is nutritious and safe for a healthy life and its stability. In this study, the biological utilization of food is not incorporated.

Livelihood Resources: it is a manner or means of securing the basic necessities of life, and for this study, it covers social and material resources, and the activities exercised by the households as a means of living.

Coping strategies: It is the means through which households strive to protect and guard themselves from abnormal incidents or circumstances such as crop failures, natural dictators mainly shortage in rainfall or other unexpected shocks. For this study, it specifically refers to the mechanisms that rural households in the study areas adopt to protect themselves from abnormal incidents like shortage of food and basic livelihood recourses in a given period of time.

***Woreda* and *Tabias*:** *Woreda* is a local name which can be best substituted with district level of a government system and in Ethiopia and it is the third level of administrative division. *Tabia* or in plural form *Tabias* is also a local name which stands for administrative divisions found under *Woreda*.