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Determinants of Food Security Under Different Land Use Systems: Example of Pastoralists and Agro-Pastoralists in Northeastern Ethiopia

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Abstract: The issue of ensuring food and nutrition security has become a prominent item on the global agenda, particularly for low-income countries with high population growth rates. Despite the implementation of numerous policies and programs with the objective of enhancing household calorie intake, food insecurity is worsening in Ethiopia. It is crucial to comprehend the principal factors influencing food security, as this knowledge is essential for implementing effective interventions to enhance food security. Therefore, this study aimed to estimate the food security status of households, measure the extent and severity of food insecurity, and identify the determinants of food security in Northeastern Ethiopia. The data for this study were collected through key informant interviews, focus group discussions, and a multi-stage sampling method, which involved the selection of 300 households. Descriptive and inferential statistics, the Foster–Greer–Thorbecke (FGT) index, and a probit model were employed to analyze the collected data. The results indicate that 41.67% of the sample households were food secure. By decomposing the results to the two land use systems, 34.62% and 50.69% of the pastoral and agro-pastoral households were food secure, respectively, indicating that agro-pastoral households were relatively more food secure than pastoral counterparts. Furthermore, the gap and severity of food insecurity among the sample households were calculated using FGT indices, resulting in a value of 15.02% and 5.31%, respectively. The probit model revealed that educational attainment, the number of milking cows, cultivated farm size, annual farm income, and participation in off-farm activities were significant predictors of improved household food security status. The findings of this study suggest that policies aimed at addressing food insecurity should consider livelihood diversification, the promotion of education and training, and the strengthening of institutional and technological environments.



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1. Introduction

The term “food security” is defined as a situation where individuals have physical and economic access to the nourishment they require [1]. The FAO [2] and WFP [3] have proposed a definition of food security that encompasses three key aspects: physical, social, and economic access to sufficient, safe, and nutritious food that meets dietary needs and food preferences for an active and healthy life. The level of food security is thus intimately connected to the capacity and access to production factors and resources, as well as their management and ownership structure. The concept of food security has undergone significant evolution since its inception. However, in this investigation, the operational

definition of food security is the ability of households to obtain sufficient food calories of 2550 kcal per adult equivalent (AE) on a daily basis.

The Ethiopian economy is characterized by a high degree of reliance on land legally owned by the state, nations and nationalities. This differs from the typical model of private ownership, whereby land would represent a marketable commodity [4]. The existing land tenure system has been the subject of considerable criticism from commentators who have identified its adverse impact on several key socioeconomic indicators, such as land use sustainability, food security, and self-sufficiency. Additionally, the system has resulted in a slower pace of rural transformation, an inefficient transfer of land from less productive to more productive farmers, and lower crop productivity per unit of land area [5]. Furthermore, the system has led to reduced access to land, tenure insecurity among landholders, and a loss of sense of ownership [6].

Despite the allocation of considerable financial resources by governments, donors, international aid agencies, and multilateral development bodies over several decades, food insecurity remains a significant challenge in Ethiopia and a key priority for policymakers [7]. A considerable proportion of the Ethiopian population is highly vulnerable to food insecurity, particularly in the context of recurrent natural disasters and the intensifying impact of climate change [8]. As indicated by the Global Hunger Index (GHI) report, Ethiopia has a GHI score of 26.2, which categorizes it as a country experiencing severe hunger [9]. In the 2023 Global Hunger Index (GHI) rankings, Ethiopia is ranked 101st out of 125 countries. Additionally, the WFP has indicated that an estimated 20.1 million people in Ethiopia require food assistance [10]. In 2020, approximately 56% of the Ethiopian population was estimated to be food insecure, representing a 7 million increase compared to 2016 [11]. The situation of those experiencing food insecurity and malnutrition is becoming increasingly severe, primarily driven by a confluence of factors, including climate crises (floods and droughts), armed conflicts, diseases, and economic shocks [12].

This is particularly relevant for pastoral and agro-pastoral communities, representing 12% of the total population of the country, herd their livestock in arid and semi-arid areas that are only sparsely populated [13]. Despite contributing over 22% of the country's livestock population, 12–16% of Ethiopia's Gross Domestic Product (GDP), and 30–35% of the agricultural GDP [14], these communities remain largely vulnerable to both natural and policy-induced complex challenges [15]. Nevertheless, they have not received sufficient consideration commensurate with their status in the country's economic development. Historically, they have been marginalized in allocating resources, land transformations, infrastructure development, social service delivery, and economic transformation, jeopardizing their livelihood sustainability and food security [16–18]. In particular, the Afar people derive their livelihood entirely from pastoral livestock farming or a combination of crop and livestock farming. However, the traditional pastoral and agro-pastoral systems are under increasing pressure due mainly to population growth and climate change. The increasing frequency of extreme, climate-related weather events such as droughts, floods, and related disasters, has an increasingly adverse impact on food and nutrition security [19].

The highest percentage of Ethiopia's food-insecure population is concentrated in arid areas, where the combination of harsh climatic conditions, limited water resources, and fragile ecosystems presents a significant challenge to agricultural production. These factors interact in complex ways, creating a vicious cycle of food insecurity for the inhabitants [20,21]. The Afar region in Northeastern Ethiopia is one of the country's most arid and underdeveloped regions. The region is classified as food-insecure with high levels of vulnerability due to recurrent shocks. Notwithstanding the provision of humanitarian assistance and food aid, the prevalence of food insecurity and maternal underweight remains high in the region [22]. WFP and CSA [23] have indicated that approximately 26.1% of the total households in the Afar Regional State are food insecure.

Despite the existence of several empirical studies on the subject of food security among households in different parts of Ethiopia [24–26], including regions in the Northeastern part of the country [27–30], the specific factors that contribute to food insecurity vary from

one area to another [31,32]. Consequently, it is necessary to conduct area-specific research to inform the design of appropriate policies and to enable targeted interventions to be implemented. Furthermore, the study conducted by Moroda et al. [33] indicates that due to the seasonal nature of food insecurity, research may require longitudinal data collection in the same area to confirm the consistency of findings and ensure the efficacy of interventions. Accordingly, our survey aims to address previous studies' shortcomings by investigating the current status of food security among pastoral and agro-pastoral households in the region, the extent and severity of food insecurity, and the underlying factors influencing food security in Northeastern Ethiopia.

2. Review of Relevant Literature

This section presents a selection of the core literature on the subject of the study. It includes a characterization of the dimensions of food security, an analysis of different land use systems, and a detailed discussion of empirical studies on factors that could influence food security.

2.1. Dimensions of Food Security

Several literature sources, including Gross et al. [34], Tawodzera [35], Drimie and McLachlan [36], and Upton et al. [37], identified four dimensions or components of food and nutrition security: availability, access, utilization, and stability.

The term “food availability” is used to describe a situation in which there is a sufficient quantity and quality of food available at all times. This aspect of food security pertains to the supply side and is contingent upon the level of food production, stock levels, and net trade [38]. As stated by Burchi and de Muro [39], food availability represents a significant aspect of food security. While an adequate food supply is a necessary condition for food access, it is not a sufficient one. This is particularly evident when considering the national food supply, which may not guarantee access for individual households unless they possess the necessary resources and purchasing power to access that supply.

The term “food access” denotes that individuals must be in a position to regularly procure sufficient quantities of food through purchase, home production, barter, gifts, borrowing, or food aid [38,40]. Additionally, food access encompasses the capacity to obtain appropriate foods for a nutritionally adequate diet, which is contingent upon income, income distribution within the household, and food prices [39,41].

The third one is focused on “food utilization”, which is commonly understood to encompass the way the body acquires the various nutrients present in food. The adequate intake of energy and nutrients by individuals results from good care and feeding practices, food preparation, and the diversity of the diet and intra-household distribution of food. It encompasses cooking, storage, and hygiene practices, the health of individuals, water and sanitation, feeding, and sharing practices within the household. This determines the food security of household members [38,39].

The final dimension is the stability of the preceding three dimensions over time, even in the event of adequate food intake at the present moment. The stability of food and nutrition security at the individual, household, and national levels is contingent upon the supply at the household level remaining constant over a year and in the long term. Consequently, households may experience food insecurity if they lack adequate access to food items over the long term. Adverse weather conditions, political instability, or economic factors such as unemployment, death, and rising food prices can erode the stability of food and nutrition security at the individual, household, and national levels [42].

2.2. Theoretical Framework

Many theories have been put forth in an attempt to explain food insecurity. In fact, the explanatory power of these theories depends on the time and the existing situation of a particular site. Furthermore, in light of the multiplicity of theories pertaining to food insecurity, it has been posited that no singular theory can be considered dominant or

exclusive of others [43]. Cognizant of this reality, four of the extant theories were employed to elucidate the phenomenon of food insecurity in the study area, including demographic, political-economic, climatic and environmental, and vulnerable livelihood theories.

The primary theoretical perspective on food security is the demographic theory. Under this theory, two distinct and competing theoretical perspectives exist regarding the relationship between population growth and food availability. The initial argument posits that population growth occurs in a 'geometric' manner, whereas the expansion of production and the resources required for sustenance advance only in an 'arithmetic' fashion. It follows that, in the absence of a reduction in population growth, increases in food production will be insufficient to keep pace with it. This notion was originally posited by Thomas Malthus, who advanced the theory that rapid population growth could lead to food shortages and famine. The core argument of neo-Malthusian theories is that the inherent capacity of populations to expand is ultimately constrained by the necessity to secure food and other necessities, the production of which cannot be increased rapidly. Consequently, the pressures of population growth on the limits of productive capacity inevitably result in hunger and other forms of human poverty and misery [44].

Malthus' theory is subject to two distinct forms of criticism. Firstly, the theory does not allow for technological improvements in agriculture, which would enhance agricultural productivity. It has been a considerable length of time since a significant number of countries worldwide have been able to achieve economic growth at a rate that exceeds the rate of population growth. Secondly, Malthus did not anticipate the impact of the transport and communication revolutions [45]. Nevertheless, Malthus' theory retains practical relevance in the context of certain Third World countries, such as Ethiopia. This is why this country is still attempting to issue and implement the neo-Malthusian 'restrictive population policies'.

The other theories posit that large population size is a positive stimulus for growth. In this context, the work of Karl Marx is particularly noteworthy. He investigated the relationship between population and production, although his model is somewhat context-specific to the capitalist mode of production. Marx's perspective diverges from Malthus's in that he identifies the underlying causes of hunger and other forms of human suffering as being intertwined with the structures of production and the associated forms of oppression and exploitation [46]. The neo-Marxist line of thinking that has emerged since 1960 has sought to examine the phenomenon of poverty and the resulting food insecurity by analyzing the structure of society. Boserup [47] put forth a theory that is fundamentally contra-Malthusian. Her theory elucidates the interrelationship between population growth and the transformation of agriculture. Boserup posits that population growth can be a driving force behind the adoption and dissemination of technological innovations that enhance agricultural production, thereby reducing the vulnerability to food insecurity and hunger. Consequently, the two competing theories have remained the pivotal research hypothesis in investigating the link between population growth and food production.

The second principal theory of food security is the political economy explanation, which describes the lack of political conditions for an anti-famine treaty as revolving around anti-democratic tendencies that override any existing democratic rights. This, in turn, hinders timely and effective action to prevent famine and can therefore be said to involve a famine crime [43]. This approach attributes the occurrence of food and nutrition insecurity, regardless of economic or natural shocks, to government incompetence and lack of commitment at best or deliberate action or inaction at worst [48]. All instances of famine are attributed to a combination of technical and political factors. The political factors include poor government policies, the failure of the international community to provide aid and war. For example, the political economy explanation posits that food and nutrition insecurity can occur whenever incumbent government authorities and even donors fail to fulfill their obligations [49]. Similarly, Alamgir [50], Devereux [45], and de Waal [51] put forth the argument that governments contribute to the occurrence of famine in four distinct ways: Inappropriate policies (Sahel famine of 2010), failure to intervene (Chinese famine of

1958–1961 and Bangladesh famine of 1974); by-products such as civil war (Mozambique and Chad in 1980 and Somalia in 1990); and malicious intent or deliberate creation of famine by governments (Soviet famine of 1933 and Dutch famine of 1944).

The third significant theoretical perspective on food security is the climatic and environmental theory. This theory posits that instances of food insecurity and undernutrition are likely to increase in conjunction with the potential intensification and frequency of extreme events, wherein natural hazards are amplified in both magnitude and frequency [52]. Furthermore, it was demonstrated that a combination of arable land lost to population pressure, deforestation, and overgrazing, in conjunction with the potential for a sustained reduction in precipitation in arid regions of Africa and Asia, will result in a decline in crop production and an exacerbation of food and nutrition insecurity [49]. Similarly, it was proposed that this approach considers drought (and occasionally floods) and incorporates recent climate change factors into the explanation of disruption or reduction of food output, which may ultimately result in food insecurity and undernutrition [48].

The fourth theory, Vulnerable Livelihood Theory, concerns the link between food insecurity and vulnerable livelihoods. Accordingly, this theory explains that food insecurity and undernutrition may result when households are unable to secure access to the various forms of assets or when the mediating processes (i.e., institutions, organizations, and social relations at work) are not serving the expected functions and/or a combination of these factors when interacting with the existing context (history, trends, and vulnerability/shock) [53].

2.3. Pastoral and Agro-Pastoral Land Use Systems

Pastoralism and agro-pastoralism represent the predominant land use systems in the arid and semi-arid regions of Ethiopia. Together, these systems encompass one of the most extensive land resources utilized for pastoralism and agro-pastoralism in sub-Saharan Africa, covering almost two-thirds of the local drylands. Together with stationary mixed farming, these two farming systems represent the most dominant land use and management practices in Ethiopia. The primary distinction between these two land-use systems is that pastoralists typically rely on livestock production as their primary economic activity, whereas agro-pastoralists engage in a more diversified agricultural practice, combining livestock rearing with crop cultivation. Furthermore, Ethiopia has the largest number of livestock in sub-Saharan Africa, with up to 70% of local household livelihoods derived from them [31,54]. One of the agrarian policies promoted by the Ethiopian government is the transformation of the current pastoral land use system into an agro-pastoral one. However, pastoralist practices exemplify a migratory agricultural system, whereby fluctuations in rainfall and land ownership are reflected in the movements of people and livestock. This policy is primarily driven by two key issues. The first issue is the potential benefit of agro-pastoralism in terms of food security and livelihoods in general. The second is the increasing conflicts over land tenure that have arisen as a result of growing human populations, which have created competition for land resources. Furthermore, the legal and customary systems of land ownership are not aligned, resulting in disruption and insecurity among pastoralists. They are increasingly turning their attention to common lands, where the legal framework is unclear and weak institutions fail to regulate these areas and protect them from overgrazing [31,55–57].

Notwithstanding the considerable land and livestock resources available, the country has remained one of the most food-insecure countries globally, not just in the region. The underlying cause of this situation is that land use systems under pastoralism and agro-pastoralism are subject to several environmental, socioeconomic, cultural, and political challenges. The combination of prolonged periods of inadequate precipitation and extended intervals of drought, which are now further intensified by climate change, has resulted in a decline in livestock numbers and substantial environmental and livelihood deterioration. Despite poverty alleviation and food security being a primary development objective for Ethiopia, pastoralist and agro-pastoralist households have remained marginalized in

terms of access to logistics, education, healthcare, and investment. Furthermore, not all investments are directed towards large-scale, market-oriented crop production, which is not aligned with the cultural, traditional, and technical capabilities of these households. Consequently, pastoralists and agro-pastoralists continue to represent one of the most impoverished segments of the population. Notwithstanding the economic growth observed over the past decade and the government's efforts to enhance food security, the latter remains a significant challenge [55,57,58].

2.4. Empirical Studies on Determinants of Food Security

A substantial body of empirical evidence from the northern regions of Ethiopia indicates that the majority of households are food insecure, with these regions representing the most food-insecure areas of the country [23]. The proportion of food-insecure households in the Amhara, Afar, and Tigray regional states was 36.1%, 26.1%, and 24.7%, respectively. Additionally, the findings indicated that Dire Dawa was among the most food-secure regions. Furthermore, Ayele [59] evaluated the determinants of food security among households in northern Ethiopia. The study demonstrated that approximately 74.4% of the sampled households were identified as food insecure.

Dubale [60] identified a positive correlation between food security and cultivated land size, annual crop production, and the number of oxen owned, while household size, dependence ratio, and distance from the agricultural office were found to have a negative impact on food security. The study conducted by Dereje et al. [61] indicated that the educational attainment of the household head, access to irrigation systems, livestock ownership, total income, and remittances were positively associated with household food security. Conversely, the age of the household head and distance to the nearest market were found to have a negative correlation with food security.

The study conducted by Mohammed and Abaynew [62] documented the food security status and its underlying determinants among rural households in the Oda Bultum district, located within the West Hararghe zone of the Oromia National Regional State in Ethiopia. The survey results indicated that 38.9% of sampled households were food secure, while 61.1% were food insecure. The Probit regression model revealed that, except for household size, several variables, including the gender of the household head, educational level, ownership of donkeys, income from off- and non-farm activities, annual income from on-farm activities, access to irrigation, frequency of contact with agricultural extension services and production of cash crops, significantly increased the probability of being food secure.

Akukwe [63] evaluated household food security and its determinants in agrarian communities of southeastern Nigeria. The findings indicated that the majority (53.5%) of households were food insecure, while 46.5% were food secure. Furthermore, the logistic regression model results indicated that an elevated level of education among the household head and a higher monthly income were positively correlated with household food security. Conversely, the dependency ratio, marital status, and distance to market were identified as factors that exerted a detrimental influence on household food security.

In a synthesis of the principal factors contributing to household food insecurity in Ethiopia, studies such as Tigistu and Hegena [64] identified various key driving forces, including household size, age, gender, marital status, education level, dependency ratio, credit use, saving habit, total income per adult equivalent, expenditure level (food and non-food), asset possession, access to social services, ownership of homegardens, access to subsidized food, sources of food, availability of food commodities, income from remittance, and supply of food commodities.

3. Materials and Methods

3.1. Study Site Characteristics

The investigation was carried out in the Aysaita district, located in the Afar Regional State of Northeastern Ethiopia. Aysaita serves as the administrative city of the Aysaita

district and Awsa zone, having previously been the capital of the Afar Regional State of Ethiopia before 2007 (Figure 1). Aysaita is situated 655 km to the northeast of Addis Ababa, the capital city of Ethiopia, and 65 km from the capital of the Afar region, Samara. The elevation of the area is approximately 300 meters above sea level. The Aysaita district comprises 13 kebeles, of which two are classified as urban and the remaining 11 as rural. The total number of households in the district is 9740 [65]. The predominant agricultural activities are pastoral and agro-pastoral farming systems. In total, 53% of rural households were engaged exclusively in livestock rearing (pastoralists), while the remaining 47% were engaged in both livestock and crop production (agro-pastoralists) [66].

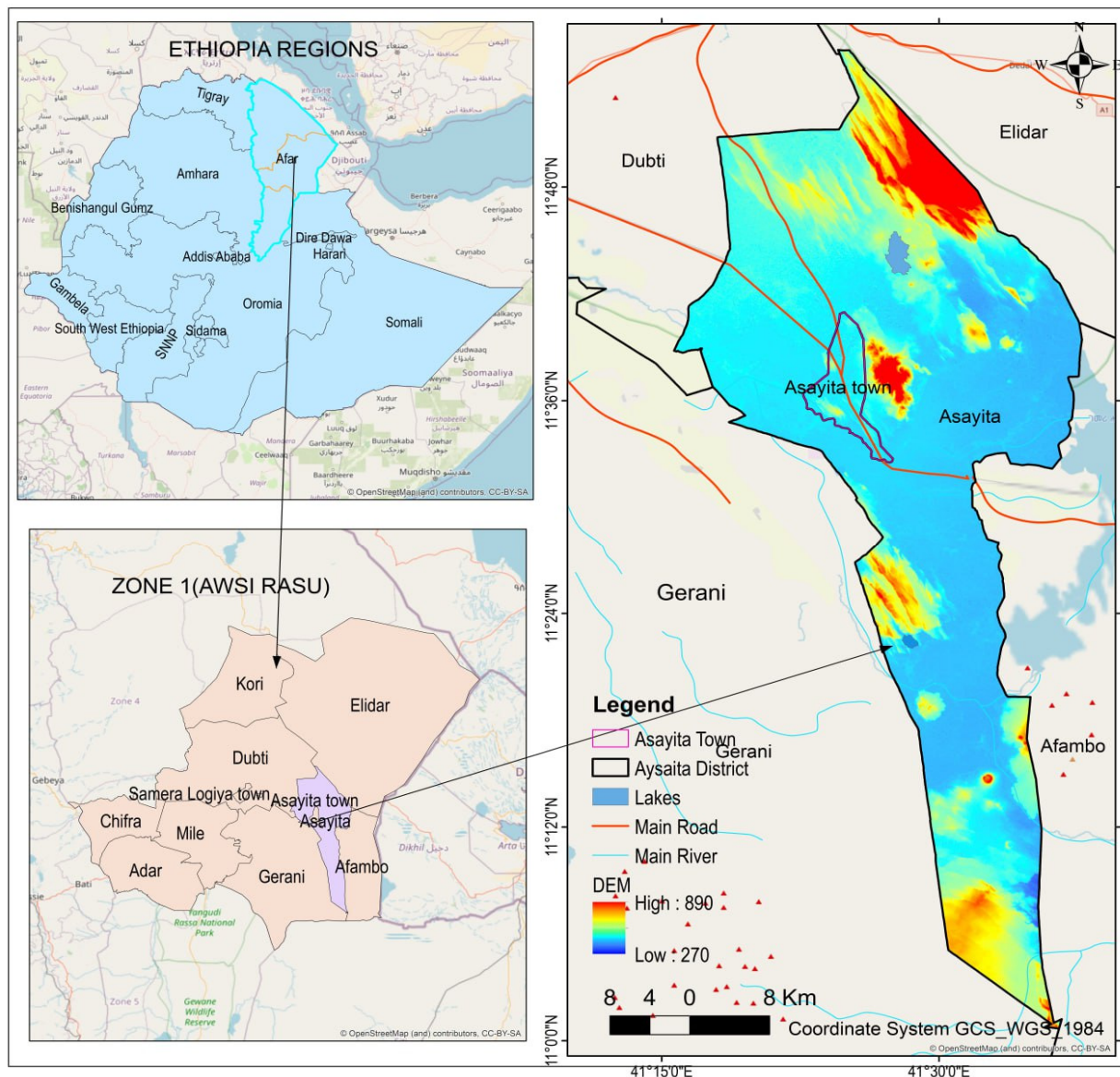


Figure 1. Map of Aysaita district.

Following the report of the Aysaita Woreda Agriculture Office [66], the Aysaita district occupies an area of 1678.28 square kilometers, with the average household in this district/woreda holding 1.78 hectares of land. Of the land under cultivation in this district, 66.21% is planted with cereals such as maize and sorghum. No land was planted with pulses, but 9 hectares were planted with fruit trees, 0.81 hectares with bananas and 0.41 hectares with guavas. Furthermore, Teshome et al. [67] indicated that crop production in the district was undertaken using irrigation water. In terms of land tenure in this district,

66.49% of the population are landowners, 14.09% rent their land, and the remaining 19.42% have other forms of tenure. Moreover, livestock production constitutes a significant aspect of the farming system in the Aysaita district. The majority of households are engaged in livestock rearing to obtain meat, draft power, milk, and milk products for household consumption. However, only a small proportion of households are engaged in livestock rearing for the purpose of market sales and social security, with the majority of households citing these latter two reasons as their primary motivation for livestock rearing. Cattle and shoat are the two most prevalent livestock species reared in the Aysaita district [68].

The Aysaita district represents one of the most vulnerable areas in the Afar region of Ethiopia, facing recurrent challenges related to food and nutrition insecurity. These challenges have proven to be particularly precarious. Notwithstanding the endeavors of the Ethiopian government, the WFP, and other development partners, food insecurity and undernutrition continue to present significant challenges in the Aysaita district. Consequently, the government has designated the district as a pilot area for implementing the Productive Safety Net Programme (PSNP), which commenced in 2005 and continues to the present day [69].

3.2. Sampling Design and Data Collection

This study employs a mixed-methods approach, integrating both qualitative and quantitative data. The data were collected through three primary instruments: a household survey utilizing a structured questionnaire, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs). These instruments were administered by trained enumerators and moderators who possess a comprehensive understanding of the area and are well-versed in the local culture and language. The data were collected via face-to-face interviews, and the fieldwork was conducted in 2022.

At various stages of the sample selection process, both probability and non-probability sampling methods were employed. The Aysaita district was selected for investigation due to its elevated vulnerability to food insecurity in comparison to other regional districts. Secondly, two of the nine rural kebeles in the Aysaita district were randomly selected: Barga and Galifage. Consequently, households in the selected kebeles were stratified into two broad categories based on the land use systems: pastoral and agro-pastoral. Subsequently, a total of 300 households (156 pastoralists and 144 agro-pastoralists) were randomly selected from the lists of pastoral and agro-pastoral households in each kebele, using probability proportional to size.

Given the heterogeneous nature of the population under study (comprising pastoral and agro-pastoral groups), Cochran's [70] formula was employed to determine the sample size. This entailed consideration of a 95% confidence level ($z = 1.96$), an estimated 36% proportion of the attribute in the population (p), and a 5% level of precision (e):

$$n_0 = \frac{z^2 pq}{e^2} \quad (1)$$

where n_0 is the required return sample size, z is the selected critical value of the desired confidence level, p is the estimated proportion of an attribute present in the population, and e is the desired level of precision:

$$n_0 = \frac{(1.96)^2 (0.36) (0.64)}{(0.05)^2} = 354$$

According to Cochran [30], for a sample size exceeding 5% of the population, a correction formula will be used to calculate the final sample size:

$$n_1 = \frac{n_0}{1 + \frac{n_0}{N}} \quad (2)$$

where n_0 = required return sample size, n_1 = final sample size because sample > 5% of population and N = population size.

$$n_1 = \frac{354}{1 + \frac{354}{1966}} = 300$$

3.3. Data Analysis

Descriptive statistics are employed to summarize and present data in a readily comprehensible format. Descriptive statistical techniques, including frequency, percentage, mean, and standard deviations, were employed to estimate the food security status of households surveyed in the study area. Furthermore, inferential statistics, such as the t-test, were employed to ascertain whether there was a statistically significant mean difference between food-secure and insecure household groups concerning calorie intake.

The Foster–Greer–Thorbecke (FGT) index was employed by several researchers [27,59,62,71] to assess the extent, gap, and severity of household food insecurity. This index has been widely used for poverty measurement studies. This study used the FGT index to measure the prevalence and severity of household food insecurity using the Distributive Analysis Stata Package (DASP) version 2.3. The FGT model can be expressed as follows [72]:

$$FGT(\alpha) = \frac{1}{N} \sum_{i=1}^q \left[\frac{Z - y_i}{Z} \right]^\alpha, \text{ if } y_i > z \text{ then } z - y_i = 0 \quad (3)$$

where N is the number of sample households, q is the number of food insecure households, Z represents the cut-off point between food secure and insecure (2550 kcal per AE and day), y_i is a measure of per adult equivalent food calorie intake of the i -th household, and α is the weight attached to food insecurity which is $\alpha = 0$ incidence/headcount ratio, $\alpha = 1$ depth/gap and $\alpha = 2$ severity of food insecurity.

In the final analysis, the Probit model was utilized to uncover factors influencing the food security status of households in the study area. This model is specifically designed for analyzing data with a binomial response variable.

$$y_i = x\beta + U_i \quad (4)$$

where y_i = food security status of the i -th respondent (household), x = vector of determinants of food security, β = vector of parameters of interest, U_i = residuals of the i -th respondent (household). The probit model assumes that the function F follows a normal (cumulative) distribution:

$$F(x) = \Phi(x) = \int_{-\infty}^x \phi(z) dz \quad (5)$$

where $\Phi(z)$ is the normal density function:

$$\phi(z) = \frac{\exp(-\frac{z^2}{2})}{\sqrt{2\pi}} \quad (6)$$

When employing models with a restricted dependent variable, directly interpreting the coefficients of independent variables becomes impractical. Instead, it is advisable to concentrate on their marginal effects [73]. The marginal effect represents the change in the conditional probability of the outcome variable resulting from a unit change in a specific regressor while holding other variables constant [74]. Diagnostic tests were implemented before executing the econometric model to validate the assumptions underlying the probit regression. All data cleaning and analysis were conducted using STATA statistical software, version 17.0.

3.4. Definitions of Variables and Working Hypothesis

The dependent variable employed in the model is the Household Food Security Status (HFSS). The nature of the dependent variable is dichotomous, taking a value of 1 if the household is food secure and 0 otherwise. This study classified the sample households into two groups: food secure and food insecure. This classification was based on the kilocalories (kcal) consumed by each household, as determined through the 7-day recall method. The term “household calorie acquisition” describes the number of calories available for consumption by members of a given household over a specified period of time. The individual primarily responsible for meal preparation was queried regarding the quantity of food prepared for consumption, including purchases, inventory, gifts, and loans over a specified time frame [75]. The average daily caloric intake of a household was calculated based on the average weekly consumption of food. Subsequently, the daily food energy consumption per adult equivalent is calculated by dividing the household’s daily caloric consumption by the number of household members, adjusting for age and gender (i.e., adult-equivalent (AE)), and then compared with the recommended daily calorie intake of 2550 kcal per AE [23]. Therefore, households that consumed 2550 kcal or more per AE were classified as food secure, while those with lower intake were considered food insecure.

Different explanatory variables expected to influence household food security outcomes were identified and included in the model following previous empirical studies done across different contexts. The identified 13 independent variables include a household’s socio-demographic characteristics, institutional factors, and household wealth indicators (Table 1).

Table 1. Description of independent variables and their expected effect on the household food security status.

Variable	Type	Unit of Measurement	Expected Effect	Reference(s)
Household head characteristics				
Gender	Dummy	1 = male, 0 = female	+	Gezimu et al. [76]
Age	Continuous	Years	+/-	Mekonnen et al. [77],
Educational level	Continuous	Years of schooling	+	Goshme [78]
Household characteristics				
Household size	Continuous	Adult Equivalent (AE)	-	Eshetu [79]
Dependency ratio	Continuous	The ratio of inactive (<15 and 65+ years) to active (15–64 years) household members	-	Mohammed and Abaynew [62]
Participation in off-farm activities	Dummy	1 = participate, 0 = otherwise	+	Dula and Berhanu [80], Sisha [8]
Farm characteristics				
Livestock holding (excl. milking cows)	Continuous	Tropical Livestock Unit (TLU)	+	Abebaw and Betru [81]
Number of milking cows	Continuous	Number	+	Ayele [59]
Livestock died in the survey year	Continuous	Tropical Livestock Unit (TLU)	-	Birhanu et al. [82]
Size of cultivated land	Continuous	Hectares (ha)	+	Siraje and Bekeleb [83]
Annual farm income (ln)	Continuous	ETB	+	Dubale [60]
Institutional and biophysical characteristics				
Distance from homestead to market	Continuous	Minutes of walk	-	Moroda et al. [33]
Access to food assistance	Dummy	1 = access, 0 = otherwise	+	Goshme [78]
				Hailu and Amare [84]

Note: The exchange rate at the time of the study was 1 USD = 53.6833 ETB (National Bank of Ethiopia).

Prior research has demonstrated that the characteristics of the household head, including gender, age, and educational level, are strong predictors of household food security. Male-headed households tend to have greater access to resources and fewer responsibilities within the home, which can result in increased engagement in a range of activities. This increased engagement has the potential to enhance income, which in turn can facilitate

the purchase and consumption of a more diverse and nutritious diet [76]. It was therefore hypothesized that male-headed households would have a positive association with the households' food security outcome. Similarly, as the age of the household head increases, a farmer/herder could gain knowledge and experience, and be more likely to be food secure [77]. Conversely, other empirical studies have indicated that younger household heads are more energetic, productive, and more food secure than elderly households [78]. This has led to a debate on the direction of the association between the age of the household head and food security status.

In terms of the educational level of the household head, it can be seen that education plays a role in fostering awareness of the potential benefits of modernizing agriculture through the utilization of technological inputs and the diversification of household income sources. This, in turn, has the effect of enhancing household food availability [79]. In light of the existing evidence, it was hypothesized that there would be a positive association between the educational level of the household head and household food security.

The size of the household, which can be defined as the number of individuals residing under one roof, is a key household characteristic that influences household food security. Larger households often face increased pressure to procure sufficient resources to meet the food calorie requirements of their members, which may present challenges in accessing adequate food [62]. It was hypothesized that larger families would experience lower food security. Furthermore, The dependency ratio encompasses household members who are not fully economically active and, consequently, do not contribute to the family's income. These individuals are solely consumers and, as a result, represent a burden on other household members [3,79]. Therefore, the dependency ratio was hypothesized to be negatively associated with the households' food security status. On the contrary, households engaged in off-farm activities are endowed with additional income, which renders them less likely to face food deficits [81]. Thus, it was hypothesized that households engaged in off-farm activities are more likely to be food secure than those who are not participating.

The household wealth indicators like the total land owned, livestock size (excl. milking cows), and number of milking cows were also identified as key predictors of the household food security. There is a consensus in the relevant literature that the availability of larger cultivated land is associated with an increased potential for the production of foodstuffs for both home consumption and sale [62]. Similarly, livestock holding (excl. milking cows) is argued to be crucially important in improving the households' food security outcomes across contexts. Livestock represents the primary source of livelihood for pastoralist and agro-pastoralist communities in the lowlands of Ethiopia. Households with a greater number of livestock can obtain a greater quantity of meat for direct consumption and generate additional cash income from the sale of live animals, livestock products, and services, which are often used for the purchase of food grains during periods of food shortage [81]. In the same fashion, milking cows represent a significant source of food and income, as these animals provide milk and milk products [82]. Hence, the landholding size, livestock holding (excl. milking cows), and number of milking cows were hypothesized to be positively associated with the households' food security outcome. However, the prevalence of disease represents a significant limiting factor in livestock production, exerting a considerable influence on the food security status of households in dryland areas. The limited availability of veterinary services and facilities in remote areas has resulted in the exacerbation of animal disease incidences, which has, in turn, led to a deterioration in the livelihoods of pastoralists and agro-pastoralists, and has also contributed to an increase in food insecurity [83].

Furthermore, annual farm income represents the annual income of the household obtained from various agricultural activities, primarily the sale of livestock and crop products. Moroda et al. [33] posited that increased on-farm income would lead to improved purchasing power, facilitating the adoption of modern agricultural inputs. This, in turn, would enable farmers to expand their landholdings, diversify their production activities,

and ultimately enhance their food security. Consequently, it was hypothesized that annual on-farm income would have a positive link with household food security.

Moreover, previous studies have highlighted that access to different facilities such as distance from homestead to market and access to food assistance, are important variables that predict household food security. Proximity to market centers facilitates access to additional income streams, including the sale of livestock, livestock products, and crops, as well as employment opportunities. Furthermore, proximity to market centers enables easier access to inputs and outputs, while reducing transaction costs for households [78]. Regarding access to food assistance, households in the study area are particularly susceptible to food insecurity and typically address their food insecurity through the receipt of food assistance. Consequently, food assistance can be an effective means of improving the dietary intake of households [84]. Therefore in this study, it was hypothesized that households located further from markets would experience lower food security, while those with access to food assistance programs would exhibit higher food security.

4. Results

4.1. Household Food Security

Of the 300 respondents, 175 (58.33%) households were found to have insufficient daily calorie intake, while 125 (41.67%) met the minimum daily energy requirement. The maximum and minimum kilocalories consumed by a single adult on a daily basis for food-secure households were 4403 and 2554 kilocalories, respectively, while for food-insecure households, these figures were 2544 and 938 kilocalories. Furthermore, the mean daily energy consumption per adult equivalent among the selected households was 2311 (± 598) kcal, which is below the national average of 3008 kcal and the daily requirement of 2550 kcal per adult equivalent for an active and healthy life (Table 2).

Table 2. Mean differences test of daily calorie intake by food security status.

Daily Energy Available per AE (kcal)	Food Secure Households (n = 125)	Food Insecure Households ((n = 175)
Maximum	4403.08	2543.99
Minimum	2554.36	937.87
Mean	2858.42	1919.96
Standard deviation	330.10	408.97
Mean difference	−938.46	
t-value	−21.192 ***	

Note: *** represents statistical significance at 1% probability level.

Moreover, the mean daily energy consumption per adult equivalent (AE) among food-secure and food-insecure sample households was 2858 and 1920 kcal, respectively. The results of the t-test demonstrated a statistically significant mean difference in per capita calorie intake between food-secure and food-insecure households ($p \leq 0.001$). Consequently, the study area could be classified as food insecure, given that the majority (58.33%) of the surveyed households were unable to meet the nationally recommended daily calorie intake of 2550 kcal.

The results demonstrated that among the 156 pastoral households, 54 (34.62%) were food secure, and 102 (65.38%) were food insecure. Furthermore, of the 144 sampled agro-pastoral households, 71 (49.31%) were food secure, while the remaining 73 (50.69%) were food insecure. The chi-square test yielded a statistically significant difference in food security status between pastoral and agro-pastoral households at the 5% significance level.

4.2. Gap and Severity of Food Insecurity

As demonstrated in Table 3, the food insecurity gap was calculated as the discrepancy between the minimum daily energy requirement (2550 kcal per AE) and the actual energy intake of food-insecure households. The food insecurity gap index (P1) reached 0.1692, 0.1298, and 0.1502 for pastoral, agro-pastoral, and all households, respectively. This

indicates that each food-insecure household requires an additional 383.01 kcal per AE to reach the nationally recommended daily calorie intake level. The findings indicate that, on average, each pastoral and agro-pastoral food-insecure household requires an additional 431.46 kcal per AE (16.92% of the food insecurity line) and 330.99 kcal per AE (12.98% of the food insecurity line), respectively, in daily caloric intake to reach the minimum recommended daily caloric intake level. This suggests that pastoral households require a greater quantity of food energy than agro-pastoral households in order to achieve the minimum recommended daily calorie intake per adult equivalent.

Table 3. Values for gap and severity of food insecurity indices.

Livelihood Strategy	Food Insecure Households	Food Insecurity Gap	Severity of Food Insecurity
Pastoralism	102	0.1692	0.0642
Agro-pastoralism	73	0.1298	0.0411
Total	175	0.1502	0.0531

To ascertain the severity of food insecurity, a higher weighting factor, $\alpha = 2$, was applied to the most food-insecure segment of the sample households. In this regard, the study indicated that the overall severity of food insecurity for the sample households was 0.0531. This indicates that 5.31% of the food-insecure households were experiencing severe food insecurity. In other words, ten of the 175 food-insecure households were in a precarious and severe food insecurity situation. Furthermore, the severity of food insecurity for pastoral and agro-pastoral households was 6.42% and 4.11%, respectively. This indicates that, of the food-insecure households, seven pastoral and three agro-pastoral households were severely food insecure. Therefore, the results suggest that food insecurity was more severe in pastoral households than in agro-pastoral households.

4.3. Factors Influencing Household Food Security

The box plot was employed to identify univariate outliers for each variable. No extreme values were identified in the two independent variables, namely the number of milking cows and the distance from the household to the nearest market. The remaining continuous independent variables (age of household head, education level of household head, household size, dependency ratio, livestock holding excluding milking cows, livestock died in the survey year, size of cultivated land, and annual farm income) were identified as having outlier data, exhibiting observations that were either overestimated or underestimated (Figure 2). Moreover, the 300 observations were also subjected to multivariate outlier screening using the Cook's Distance Statistic. This was conducted for each sample household to ascertain whether any influential cases were unduly influencing the model. The maximum Cook's Distance value for the sample households was 0.0673, which is less than 1, indicating that no significant outlier observation may exert an undue influence on the model. Therefore, it can be concluded that the dataset is free from any issues of multivariate outliers.

Furthermore, the Variance Inflation Factor (VIF) was employed to ascertain the presence of significant multicollinearity between all the independent variables incorporated into the model. The VIF values for all independent variables included in the model were less than 5 (1.03–2.63), indicating that no serious multicollinearity was present. Accordingly, all 13 hypothesized independent variables were incorporated into the model. Finally, the error term of the probit model was also subjected to a test for normality. The kernel density graph for the error term of the probit model demonstrated that the estimated line was not significantly closer to the normal distribution line, indicating that the error term was not normally distributed (Figure 3). The results were also corroborated by the Shapiro–Wilk test, which rejected the null hypothesis of normal distribution ($Z = 7.766$, $\text{Prob} > Z = 0.000$), indicating that the error term is not normally distributed. Consequently, the robust estimator was employed to mitigate the potential bias from non-normality and outliers.

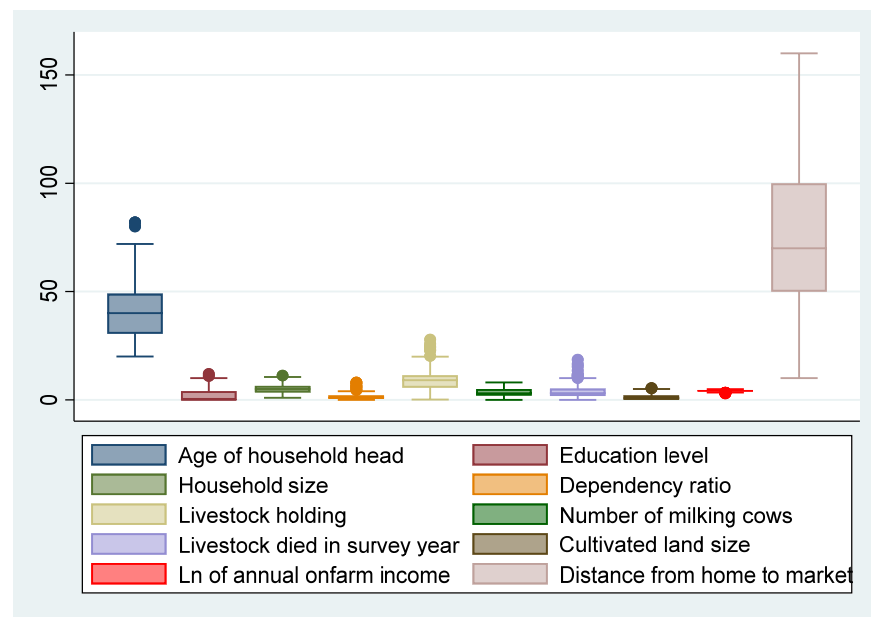


Figure 2. Box plot for numeric independent variables.

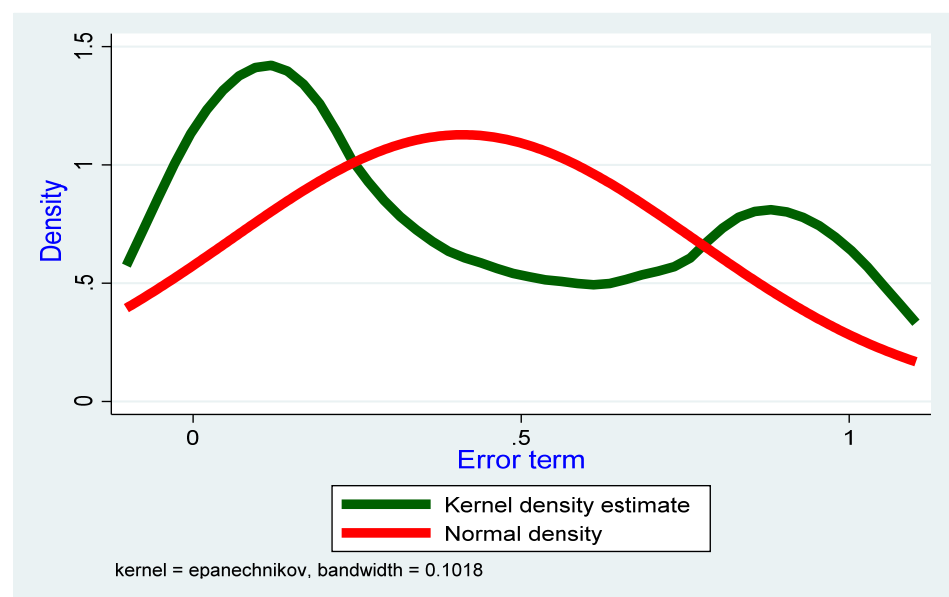


Figure 3. Kernel density estimate.

The Hosmer–Lemeshow test was carried out to decide the suitability of the logit or probit model for identifying the determinants of households' food security status. The outcome of the Hosmer–Lemeshow test ($\text{Prob} > \chi^2 = 0.3814$) demonstrated that the null hypothesis of the model's goodness of fit was not rejected. The results indicated that the error term follows the standard normal cumulative distribution function. Consequently, the probit model was selected over the logit model to fit the dataset.

Table 4 presents the estimated parameters of the variables that are expected to determine the households' food security status. The log-likelihood ratio (LR) test was employed to ascertain the overall significance of the probit model estimation. The results demonstrated that the chi-square value was 100.76 and the $\text{Prob} > \chi^2$ was 0.000, indicating that the chi-square statistic was statistically significant. Therefore, it can be concluded that the null hypothesis, which states that the joint effects of all independent variables included in the model are zero, should be rejected. Furthermore, the Pseudo R² of the model is

0.459, indicating that 45.9% of the variation in the food security status of households can be attributed to those 13 independent variables included, which validates the model's suitability for the dataset.

Table 4. Univariate probit model estimation of factors determining food security status.

Variables	Coefficient	Robust Std. Error	Marginal Effect	Elasticity
Gender	−0.482 **	0.203	−0.182	−0.446
Age	−0.011	0.008	−0.004	−0.555
Education level	0.074 *	0.038	0.028	0.142
Household size	0.021	0.061	0.008	0.140
Dependency ratio	0.030	0.092	0.011	0.052
Livestock holding	0.030	0.029	0.011	0.336
Number of milking cows	0.335 ***	0.060	0.125	0.887
Number of livestock that died in the survey year	−0.042	0.049	−0.016	−0.155
Size of cultivated land	0.340 ***	0.118	0.127	0.340
Annual farm income	1.757 ***	0.410	0.657	8.650
Participation in off-farm activities	0.921 ***	0.210	0.343	0.223
Distance from home to the nearest market	0.004	0.003	0.002	0.407
Access to food assistance	−0.166	0.197	−0.062	−0.082
Constant	−9.466 ***	1.762		
Number of observations	300			
Log pseudolikelihood	−110.312			
Wald χ^2 (13)	100.76			
Prob > χ^2	0.000			
Pseudo R ²	0.459			
Sensitivity ^a	0.744			
Specificity ^b	0.671			

Notes: ***, **, and * represents significance at 1%, 5%, and 10% probability levels, respectively. ^a correctly predicted food secure group based on 0.5 cut value. ^b correctly predicted food insecure group based on 0.5 cut value.

A probit regression model was employed to elucidate the variables that exert an influence on the food security status of households within the study area. The results of the estimation demonstrate that the model exhibited an accurate predictive capacity, correctly classifying 74.4% and 67.1% of the food-secure and food-insecure groups, respectively. This implies that the model has effectively estimated the responses about the variables under examination. Accordingly, the variables posited to exert an influence on the household's food security status were incorporated into the model. Of the 13 independent variables included in the model, six were identified as statistically significant. These were the gender of the household head, the level of education of the household head, the number of milking cows, the size of cultivated land, the annual income generated by agricultural activities, and participation in off-farm activities.

The predicted y-hat represents the estimated probability of a specific event occurring. It is frequently employed in the context of binary outcomes, wherein the outcome is dichotomous, either a success (food secure) or a failure (food insecure). The predicted Y-hat [$Y = \Pr(\text{HHFS} = 1)$] value in this study was 0.360, indicating that the probability of households in the Aysaita district being food secure was 36%. Furthermore, the elasticity of an econometric model quantifies the responsiveness of one variable to changes in another. It is an invaluable instrument for elucidating the interrelationships between variables and for identifying those that exert the most substantial influence on the outcome of interest. In this study, the results of the elasticity analysis among the significant independent variables revealed that annual on-farm income ($ey/ex = 8.650$), number of milking cows ($ey/ex = 0.887$), gender of household head ($ey/ex = -0.446$), size of cultivated land ($ey/ex = 0.340$), participation in off/non-farm activities ($ey/ex = 0.223$) and education level of household head ($ey/ex = 0.142$) were identified as the most influential factors in sequence.

Gender of household head: The gender of the household head emerged as a particularly noteworthy factor in this study. The findings revealed that male-headed households exhibited a lower probability of achieving food security compared to those headed by females, with a statistical significance level of 5%. The marginal effect demonstrated that, when other variables remained constant, the likelihood of male-headed households attaining food security decreased by 18.2% compared to female-headed households within the study area.

Education level of household heads: The study demonstrated that households with more educated heads of household exhibited greater levels of food security, with a 10% level of statistical significance. Therefore, an increase of one year of schooling for the household head is associated with a 2.8% increase in the probability of the household becoming food secure, under the assumption that all other variables remain constant.

Number of milking cows: The findings of the study indicated that households with a large number of milking cows had a high probability of being food secure at a 1% significance level. The marginal effect demonstrated that, with each additional milking cow owned by the household, the probability of the household being food secure increased by 12.5%, while all other factors held constant.

Size of cultivated land: In accordance with the preceding hypothesis, the probit model results revealed that households with more cultivated land exhibited a higher probability of food security, with a probability level of 1%. This suggests that as the cultivated land area increases, the probability of being food secure also rises. The marginal effect results demonstrate that, under constant conditions, an increase of one hectare in cultivated land size is associated with a 12.7% increase in the probability of a household becoming food secure.

Annual farm income: The residents of the study area primarily derive their livelihood from the rearing of animals and/or crop production. As hypothesized, there is a positive correlation between annual farm income and food security. This was found to be statistically significant at the 1% level. Therefore, holding all other variables constant, an increase in annual farm income by 1% is associated with a 65.7% increase in the probability of a household being food secure.

Participation in off-farm activities: The involvement of individuals in activities outside of agricultural work is a key aspect of rural livelihoods. The findings of this study indicate that households engaged in off-farm activities are more likely to be food secure than those who do not participate in such activities, with a statistical significance level of 1%. The marginal effect result indicated that, under the assumption that all other variables remain constant, the probability of achieving food security is 34.3% higher for households engaged in off-farm activities than for those who had not participated in such activities.

5. Discussion

The findings of the survey indicated that households engaged in agro-pastoral activities exhibited a relatively higher level of food security compared to their pastoral counterparts. This result is consistent with the findings of Mayanja et al. [85]. One potential justification is that households engaged in agro-pastoral farming had more productive land use systems, generating a greater diversity of food and income sources than their pastoral counterparts. The primary sources of livelihood for those engaged in agro-pastoral activities are their own crop production and livestock, whereas those engaged in pastoral activities rely primarily on their livestock for income and food. This distinction gives rise to variation in food calorie availability, both from subsistence and market sources. Consequently, the capacity to purchase food is contingent on income level, with pastoralists acquiring fewer food calories than agro-pastoralists.

Moreover, pastoralists in the study area were historically known to migrate from one location to another in search of suitable animal forage. In contrast, agro-pastoralists typically adopt stationary farming and land use systems, given the limitations on wide-ranging movement. This presents an opportunity for agro-pastoral households to engage

in off-farm activities to a greater extent than pastoralists (38.8%), with 42.4% of the former group participating in such activities. Consequently, agro-pastoral households can generate supplementary income, thereby facilitating regular acquisitions of food and superior farm inputs from the local market, which in turn enhances their food security. The diversification of income sources to off-farm activities and increased self-sufficiency in food production contribute to the resilience of households to food insecurity, particularly in the context of fluctuating food prices, increased animal mortality, and the prevalence of drought and other natural disasters in pastures.

Furthermore, households engaged in agro-pastoral farming have been observed to generate higher livestock yields than pastoralists. The milk yield from pastoralist cattle was low due to the limited availability of grazing land, which also presented a significant challenge in terms of animal feed. Conversely, agro-pastoralists utilized crop residues from their agricultural operations as fodder for their livestock, thereby producing a greater quantity of milk. As a result, those engaged in agro-pastoral activities were able to ensure a greater degree of food security for their households.

The probit regression analysis revealed that female-headed households were less likely to experience food insecurity than male-headed households in the study area. One potential explanation for this discrepancy is that female household heads tend to prioritize ensuring the food security of their members to a greater extent than their male counterparts. Moreover, female household heads are less inclined to expend financial resources beyond the farm household system on *khat* consumption, gambling, and other non-essential goods and pastimes. Furthermore, in the study area, women are engaged in different economic activities than men. These include petty trades such as the manufacture and sale of traditional beds (*Oloyita*) and traditional building materials (*Dibbora* and *Sissen*), milk and milk products, dates, and other marketable products. Consequently, female-headed households are more likely to generate higher incomes, which in turn enables them to purchase and consume more food. For the aforementioned reasons, female-headed households are more likely to be food secure than those managed by male. This result is in line with those previously published by Aboaba et al. [86] and Abdiyo [87]. This finding is contrary to those reported by Sani and Kemaw [88], Gezimu et al. [76], and Fadol et al. [89], who found that male-headed households were more likely to be food secure than female-headed households. It is evident that further research is required to gain a deeper understanding of the role of gender in livelihoods, food security, and land use systems.

In general, an increase in the number of years spent in education leads to a greater diversity of options for generating income outside of agriculture. This, in turn, has been linked to higher earning potential, labor productivity, and asset accumulation. Additionally, individuals with more years of schooling are more likely to adopt efficient farming practices and technologies, seek technical advice from extension agents, and demonstrate a higher level of management of farm household systems. These factors collectively contribute to an increased likelihood of a household being food secure [77,90].

The results indicated a positive association between the number of milking cows and food security. The rationale behind this finding is that milking cows primarily provide high-energy foods, such as milk and milk products (e.g., yoghurt, cheese, and butter), which represent the primary sources of food for households in the study area. Furthermore, the sale of milk and dairy products can provide a regular source of income, which could be used to purchase food for household consumption. A previous study by Birhanu et al. [82] similarly reported that households with a greater number of milking cows were more likely to be food secure than those without.

Land serves as an indispensable input for both crop and livestock production systems. An expansion of cultivated land area enables households to increase their food production for both subsistence and commercial purposes. This can mitigate production risks, as larger landholdings can help diversify crop and livestock portfolios. Moreover, the income generated from selling surplus agricultural products can be used to purchase additional food, thereby enhancing household food security. Regarding this, Admasu [91], Dubale [60],

and Amaza et al. [92] lend further support to the assertion that an increase in cultivated land area has a significant positive impact on household food security.

The purchasing power of households in the study region is predominantly determined by their income levels, particularly given their reliance on market-purchased food. An increase in income derived from agricultural activities can stimulate greater investment in improved agricultural inputs, such as improved seeds and animal breeds, fertilizers, fodder, and farm equipment. This, in turn, has the potential to augment farmers' production capacity and productivity, leading to higher agricultural yields and increased household income. Consequently, this could result in increased food availability and a higher likelihood of achieving food security. This finding coincides with those of Ganamo and Anteneh [71], Kabir et al. [93], and Semazzi and Kakungulu [94].

The involvement of individuals in activities outside of the agricultural sector has the potential to exert a considerable influence on the food security status of their households. It is evident that participation in off-farm activities can provide households with additional income, which can be utilized for the purchase of food or the enhancement of agricultural inputs. This can assist in diversifying income sources and reducing reliance on a single source, such as agriculture. A body of evidence demonstrates that augmented income from off-farm activities can facilitate enhanced access to food and mitigate vulnerability to shocks, including crop failures, livestock loss, or natural disasters [80,81,95]. Nevertheless, Holden et al. [96] posited that participation in off-farm activities can diminish the motivation to engage in agricultural activities and the time available for farming and livestock rearing. This can result in a reduction in agricultural production, including the production of food for household consumption, and may potentially lead to a decline in food security.

The findings of this study must be seen in the light of certain limitations. This research excluded urban areas, employed only household caloric acquisition methods, relied on respondents' recall of events (rather than the observational method), and cross-sectional data. Thus, the researchers suggest that due to the spatio-temporal nature of food insecurity, future research may need to be conducted based on longitudinal data and considering both rural and urban areas.

6. Conclusions

Food insecurity and undernutrition represent a reality for millions of households in Ethiopia, though food security is one of the critical concerns and top priorities of the national policy agenda. This suggests that there are still problems that call for action. Therefore, this study was undertaken to analyze the food security status of households in Northeastern Ethiopia with different land use systems (pastoral and agro-pastoral), focusing on identifying its determinants and measuring the gap and severity of food insecurity.

A review of the weekly calorie acquisition data from households in Northeastern Ethiopia revealed that the majority of households (58.33% of those surveyed) were unable to meet the minimum daily energy requirement. This suggests that the area can be classified as food-insecure. Moreover, the prevalence of food insecurity and its associated severity were also considerable, necessitating prompt intervention. Moreover, the prevalence of food insecurity in the Northeastern Ethiopian region was found to be significantly higher among pastoralist households than among their agro-pastoralist counterparts. Moreover, the results of the study indicated that demographic, socioeconomic, and institutional factors exert a considerable influence on the food security status of households. Concerning the determinants of food security, the findings indicated that educational level, number of milking cows, size of cultivated land, farm income, and participation in off-farm activities were positively and significantly associated with the probability of being food secure. Conversely, the gender of the household head was found to have a negative and significant effect on food security status. This indicates that male-headed households were less likely to be food secure than female-headed households.

In light of the study's principal findings, a series of recommendations were put forth, with a specific focus on the advancement of food security within households in Northeast-

ern Ethiopia. The recommendations include the modernization of the agricultural sector through a transition from subsistence to commercialized agriculture, the introduction of high milk yield potential breeds, and the strengthening of small and microfinance enterprises to facilitate increased access to credit, thereby enabling households to procure and own more milking cows. Furthermore, specialized training programs are recommended to raise awareness among men about cultural barriers and assist them in curtailing excessive expenditures. This would facilitate their engagement in business activities and enable them to allocate their resources towards fulfilling the household's food requirements. Moreover, it is recommended that the relevant authorities prioritize the delivery of enhanced agricultural technologies that boost land productivity per unit area, the provision of training on modern farming techniques and agricultural land management, the diversification of household income sources, and the improvement of the education sector through the construction of schools, the reinforcement of school feeding programs and the introduction of mobile schools. It is therefore recommended that government policy and programs designed to combat food insecurity in Northeastern Ethiopia take these factors into account in order to achieve sustainable and more effective outcomes.

The findings of this study provide valuable insights into the status of household food security and its determinant factors among specific groups of farmers, i.e., agro-pastoralists and pastoralists. Consequently, this study provides valuable insights that inform the formulation of appropriate policies aimed at alleviating food insecurity. Furthermore, the findings of this study can inform the design, targeting, and implementation of food security programs by local and international non-governmental organizations (NGOs) and other stakeholders. Furthermore, the novelty of the study lies in its circumvention of the methodological limitations observed in previous studies related to food security assessments in the study area. The results of the study will also contribute to extending the existing body of literature and narrowing the knowledge gap. Previous research has typically focused on a single land use system, either pastoral or agro-pastoral. This approach can inspire other studies and serve as a benchmark for future research in this field of food security and sustainable land use systems.

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