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Factors Affecting Food Security of Expropriated Peri-Urban Households in Ethiopia: The Case of the East Gojjam Administrative Zone

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Abstract: Food insecurity in peri-urban areas is exacerbated by high living costs, limited access to healthy food, and economic inequality. Despite its growing prevalence due to factors like land loss from urban expansion, food insecurity has received limited attention. In Ethiopia, drastic urbanization creates competition for land between agriculture and urban development, which is becoming extreme in peri-urban areas., This study aims to assess the impact of urban expansion on food security among expropriated peri-urban households in Ethiopia. Using a calorie intake-based food security line, we categorize respondents as food-secure or -insecure. The research analyzed data from 350 expropriated peri-urban households through a structured questionnaire, employing descriptive statistics and binary logistic regression. About 67% of the respondents were classified as food-insecure. The binary logit model identified several significant determinants of food security, including compensation amount and type, household head demographics, agricultural land rent participation, irrigation and credit access, off-farm income, and organic fertilizer use. To address food insecurity among expropriated households, policymakers must prioritize these factors. Government attention and policy consideration are crucial to ensure the well-being of these vulnerable populations.

Keywords: urban expansion; food insecurity; calorie intake; expropriation; Ethiopia

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1. Introduction

Food is essential for human existence. Yet, approximately one billion people worldwide lack sufficient food, while another billion suffer from inadequate nutrition [1]. Several definitions of food security are found in the literature [2]. Although the definition of food security is debated [3], it can be defined as "the availability of enough food, whether at the global, national, community, or household level" [4]. Furthermore, food security is denoted as the availability of, access to, utilization of, and stability of food universally over time with the integration of nutritional security [1]. Furthermore, food security is often used as a measure of household welfare, and a household with the ability to acquire necessary food is considered to be food-secure [4].

Numerous crises are challenging the food security of the global population. For example, climate change and worldwide pandemics are threatening and challenging food security [2]. In addition to these, land-use change and competition, population increases, globalization, changing demand in food types and levels of processing, disease, and factors related with under-development, including gender inequity, low resource access, poverty, poor health, and lack of education and stability, are factors affecting food security [1]. Furthermore, urban expansion has an impact on food security [5].

Land, a fundamental resource, directly influences food security. Secure land tenure is crucial for individuals and communities to produce and access food. When people have clear, legally recognized land rights, they are more likely to invest in sustainable agricultural practices, improve land productivity, and adopt innovations that enhance food production. In contrast, insecure land tenure can lead to disputes, displacement, and diminished incentive to invest in land improvements, exacerbating food insecurity.

Expropriation is one of the reasons for insecure land rights [6]. As cities expand, arable land is often converted into urban areas through expropriation, reducing the availability of land for agriculture and potentially leading to lower food production [7–10]. As a result of fast urbanization and population increase, it is becoming increasingly clear that peri-urban areas are now places where many changes and activities are occurring and have become tenure hotspots [10,11].

Urbanization and the increase in population are raising the need for housing, infrastructure, and investment. According to a UN report from 2018, in less than seven decades, the world's urban population has proliferated from 751 million to 4.2 billion from 1950 to 2018. About 55% of the world's population live in urban regions; this ratio is expected to increase to 68% by 2050. Nearly 90% of this expansion is occurring in Asia and Africa [12]. In Ethiopia, the drastic urbanization creates competition for land between agriculture and urban development, which is becoming extreme in peri-urban areas. This increasing demand for urban land is primarily satisfied by expropriation [11]. Expropriation is the government's power to compulsorily acquire private land and real estate for a public purpose [13–16].

Land expropriation and large-scale land transfer to investors in Ethiopia have negative consequences for rural communities' livelihoods [5]. Displacement and dislocation due to land expropriation is significant because most people live in the urban fringes, depending on agriculture with fragmented land holdings [17]. In Ethiopia, land remains the government's property, and the government decides about compensation [18]. It can cause food insecurity if a family loses the land by expropriation that they used to produce food [17,19]. Thus, expropriation is becoming a significant concern in Ethiopia. It affects the livelihoods of different segments of the population in several areas.

In Ethiopia, there have been numerous studies conducted about expropriation, urban expansion, and food insecurity [20–22]. However, there is a dearth of research using an econometrics model to assess the food insecurity of affected peri-urban households. Therefore, in this research, the following questions are answered. What is the food security status of the expropriated peri-urban households? Does any variable exhibit a significant difference between food-secure and food-insecure groups? Which variable has a significant impact on the expropriated peri-urban households?

This study was conducted in the East Gojjam Administrative Zone of Ethiopia, where expropriation for urban expansion has converted fertile agricultural land to urban use. It aims to assess the impacts of urban expansion on the food security of expropriated peri-urban households in Ethiopia.

2. Materials and Methods

2.1. The Study Area

The peri-urban areas of Debre Markos and Bichena in the East Gojjam Administrative Zone were selected as study locations. According to the Amhara National Regional State (ANRS) cities categorization, Debre Markos is a big city, and Bichena is a medium-sized city in the region [23]. These two study areas (Figure 1) represent cities whose urban territory is expanding at an alarming rate.

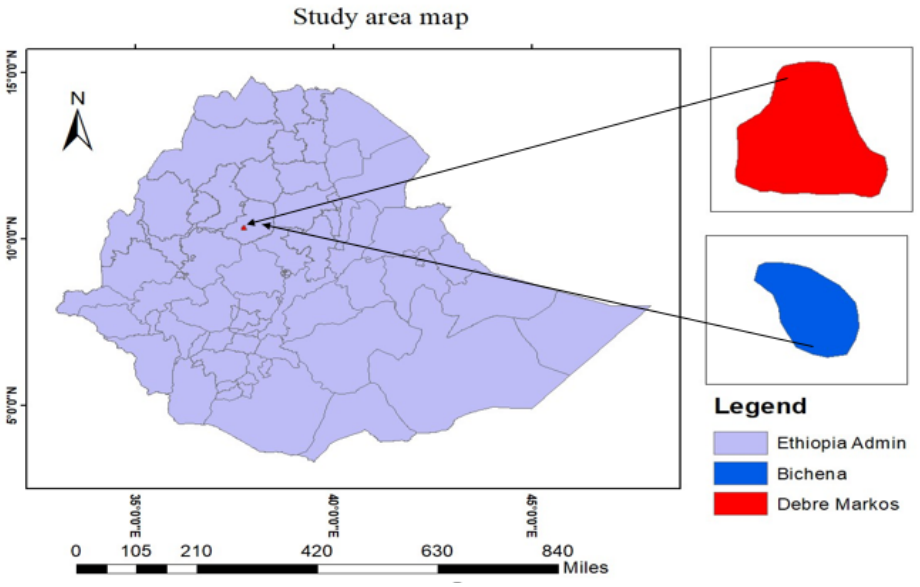

Figure 1. Study area map; source: Ethiopian boundaries—openAFRICA; Google Earth Pro.

2.2. Sampling Techniques and Sample Size Determination

This research employs a mixed approach (qualitative and quantitative) and uses primary and secondary data. Secondary data were collected through a document review, whereas primary data were collected using a pretested standard questionnaire.

The sample frame for this study consisted of peri-urban households expropriated due to urban expansion within the past ten years in both study areas. Expropriated households were identified through relevant institutions, and respondents were then selected randomly using computer software. To ensure equal representation, respondents were selected proportionally from each area.

Cochran's sampling equation was employed to determine the sample size for this study:

$$n_0 = \frac{(t)^2 \times (p)(q)}{(d)^2} \tag{1}$$

$$n_0 = \frac{(1.96)^2 * (0.5)(0.5)}{(0.05)^2} = 384 \tag{2}$$

where

n_0 = the desired sample size for an unknown population.
t = value for a selected alpha level of 0.025 in each tail = 1.96.
$(p)(q)$ = estimate of variance = 0.25.
d = acceptable margin of error for proportion being estimated = 0.05.

Initially, the list of affected households was not all known, and accordingly, it was estimated that we should contact 384 respondents from both study areas. However, in the course of action, the list of affected households recorded increased to 2267 entries. Thus, the sample size was corrected as

$$n = \frac{n_0}{1 + \frac{(n_{0-1})}{N}} \tag{3}$$

$$n = \frac{384}{1 + \frac{(384-1)}{2267}} = 329 \tag{4}$$

where

n = the desired sample size for a known population.
N = the total number of enlisted households.

Thus, it was determined that we should select at least 329 respondents in both study areas. Overall, 350 respondents' data were encoded.

2.3. Data Analysis

After the data were collected, they were encoded and tabulated. For this study, distributive statistics was used to analyze the basic characteristics of the respondents. The *T*-test and chi-square test were employed to understand the difference in the variables across each group. Therefore, the *t*-test was used to test the contentious variables, and the chi-square test was used to test binary variables. Since the dependent variable is binary, the binary logit econometrics model was employed.

The statistical software Microsoft Excel and Stata (14) were used for the analysis. Microsoft Excel was used to tabulate the data, compute food security lines, and perform descriptive statistics (percentage and frequency). Stata[1] (14) software was used for the *t*-test, chi-square test, and logistic regression model.

2.4. Model Specification

The food security status of the expropriated households in the peri-urban area is a dependent variable. It is a dichotomous/dummy dependent variable in the model, with 1 denoting food-secure households and 0 non-food-secure households. By comparing total household expenditure per adult equivalent (AE) per year to the minimum required to ensure survival per AE per year, households are categorized into food-secure and food-insecure. Adult equivalent is defined as follows: "expresses energy requirements on the basis of gender, age and physiological status as a proportion of the energy requirements of an average adult male" [24]. "It is an equivalence scale measures the number of adult males (typically) which that household is deemed to be equivalent to" [25]. The lowest level of expenditure needed per AE is calculated using the number of calories needed per day (2200 kcal/AE/day) [26]. This method has been used multiple times in the literature [27–31]. The dependent variable for this research is household food security status, with a binary 1 if secure and 0 otherwise.

As shown in Table 1, the variables used in this study were derived from the existing literature and Ethiopia's expropriation and compensation proclamation, regulations, and laws.

Table 1. List of independent variables.

No.	Variables	Type	Measurement	Expected Sign
1	Household head age	Continuous	Years	−
2	Household head sex	Binary	1 = male, 0 = otherwise	+
3	Education of household head	Category	1 = illiterate, 2 = writing and reading, 3 = formal education	+
4	Household head marital status	Category	0 = single, 1 = married, 2 = divorced, 3 = widowed	+
5	Off-farm income	Binary	1 = involved in, 0 = otherwise	+
6	Total livestock owned	Continuous	TLU[2]	+
7	Family size	Continuous	adult equivalent	−
8	Use of organic fertilizers	Binary	1 = use to, 0 = otherwise	+

Table 1. *Cont.*

No.	Variables	Type	Measurement	Expected Sign
9	Use of credit	Binary	1 = credit user, 0 = otherwise	+
10	Extension contact	Binary	1 = household visited by extension agents, 0 = otherwise	+
11	Improved seed utilization	Binary	1 = utilize improved seed, 0 = otherwise	+
12	Insect and pest infestation	Binary	1 = pest and insect infested, 0 = otherwise	−
13	Used to irrigation	Binary	1 = access to, 0 = otherwise	+
14	Area of expropriated land	Continuous	Hectares	−
15	Area of residual land from expropriation	Continuous	Hectares	+
16	Type of compensation[3]	Continuous	1 = monetary compensation, 2 = land compensation, 3 = both	−
17	Amount of compensation	Continuous	ETB	+
18	Agricultural risk in last crop season	Binary	1 = there is risk, 0 = otherwise	−
19	Displacement from home	Binary	1 = displaced, 0 = otherwise	−
20	Involvement in land rent	Binary	1 = involved, 0 = otherwise	+

Given the binary nature of the dependent variable, this research employed a binary logistic regression model to identify the key factors determining the food security of expropriated households.

3. Results

3.1. Estimation of Food Security Line

Certain steps were employed to calculate a food security line. Firstly, the minimum calorie requirement per day per AE was determined and used as a baseline. The government of Ethiopia has set the minimum acceptable weighted average food requirement per adult equivalent (AE) per day to be 2200 kcal [26]. This is compared to the calorie intake from the survey data. Secondly, the household data on food consumption and cost of food items were collected. The primary source of the data is from the survey of 350 households. The total consumption of food was collected for the food items through the questionnaire because household surveys were used to estimate household calorie consumption and total expenditure [32]; "Calorie intake is computed from the quantity of food items purchased, borrowed, or as gift" [33].

Thirdly, energy unit costs were calculated. The calorie unit cost is calculated by dividing the total monetary value of consumed food by the total calories consumed. In other words, it is the weighted average of the dietary energy cost of each food item consumed, weighted by its respective share of dietary energy in the total dietary energy consumed [24]. Then, the calories can be converted into monetary values, multiplying calorie unit cost by total calories consumed. Fourthly, household size and composition per capita per day were adjusted. Calorie intake can be obtained by dividing total household calorie intake

by household size [33]. Family composition by age and sex has to be accounted for calorie intake per day [32]. Thus, since the age and sex of the household members were recorded in the survey, adult equivalents were used to estimate the per capita calorie intake [24]. Finally, food security status is determined by comparing the actual calorie intake with the required calorie intake [33]. The actual calorie intake is computed from the survey data converted into monetary value.

The daily caloric intake of 2200 Kcal per adult equivalent (AE) was converted into an annual monetary value. This resulted in a food security line of ETB 26,158.44 per year/AE in 2023. Households with an annual food expenditure exceeding this line were classified as food-secure, while those below the line were considered food-insecure. These categories were used for subsequent logistic regression, t-test, and chi-square analyses.

According to Table 2, expenditure share of the food items, teff took the largest share of expenditure for food. This is because, in the study area, the main dish is Enjera, which is made of teff.

Table 2. Food security line estimation.

No.	Food Items	Kcal per Kg or Lt or Number	Kg, Lit, or Number Consumed per AE per Day	Kcal per Adult per Day After Scaling up	Kcal Share (%)	Mean Price per Kg/Lt/Number (ETB) in 2023	Value of Food Security Line per Year (ETB)	Expenditure Share %
1	Teff	3589	1473.18	1080.72	49.12	65	9738.44	37.23
2	Wheat	3400	218.90	160.58	7.30	50	1174.98	4.49
3	Maize	3751	566.93	415.90	18.90	40	2206.67	8.44
4	Barley	3700	147.14	107.94	4.91	70	1016.05	3.88
5	Bean	3350	33.38	24.49	1.11	80	290.95	1.11
6	Pea	3100	96.01	70.43	3.20	75	847.80	3.24
7	Pepper	933	13.97	10.25	0.47	250	1365.98	5.22
8	Meat	1148	13.76	10.10	0.46	600	2625.23	10.04
9	Butter	7363	25.58	18.77	0.85	650	824.32	3.15
10	Milk	737	3.04	2.23	0.10	60	90.45	0.35
11	Egg	61	0.53	0.39	0.02	10	31.74	0.12
12	Coffee	1103	15.60	11.45	0.52	400	2065.44	7.90
13	Salt	1780	48.07	35.26	1.60	15	147.85	0.57
14	Sugar	3850	68.30	50.11	2.28	100	647.56	2.48
15	Edible oil	8964	206.31	151.35	6.88	200	1680.11	6.42
16	Potato	1037	40.43	29.66	1.35	20	284.59	1.09
17	Onion	713	27.45	20.14	0.92	65	913.53	3.49
18	Garlic	118	0.33	0.25	0.01	200	206.75	0.79
Total		48,697	2998.93	2200.00	100.00		26,158.44	100.00

Source: researchers' computation from the survey data, 2023.

Table 3 shows that approximately 33% of expropriated peri-urban households were food-secure, whereas the remaining 67% were food-insecure. About 65% and 35% of the

food-insecure households were male-headed and female-headed, respectively. In contrast, 54% of the food-secure households were male-headed, and 46% were female-headed.

Table 3. Food security status of households.

			Sex		Total
			Male	Female	
Household food security status	Insecure	Frequency	151	82	233
		% within-household food security status	64.8%	35.2%	100.0%
		% of total	43.1%	23.4%	66.6%
	Secure	Frequency	63	54	117
		% within-household food security status	53.8%	46.2%	100.0%
		% of total	18.0%	15.4%	33.4%
Total		Frequency	214	136	350
		% within-household food security status	61.1%	38.9%	100.0%
		% of total	61.1%	38.9%	100.0%

Source: researchers' survey, 2023.

3.2. Basic Characteristics of the Respondents

Data were collected from 350 heads. As shown in Table 4, about 61% of the households were male-headed, while about 39% were female-headed. Regarding marital status, 6.6% were single, 59.1% were married, 18% were divorced, and 16.3% were widowed. In terms of education, 44.57% of household heads were illiterate, and 55.43% of the respondents were literate and could read and write and held informal education or formal education with different certificates. Regarding basic services, 79.9% of expropriated peri-urban households had access to clean drinking water, but one in five households lacked this essential resource. Additionally, 59.7% had access to electricity, while 40.3% did not. Finally, 93.7% of households had a private toilet.

As shown in Table 5, age was not significantly different between the two groups based on the t-value analysis. However, family size, compensation amount, and types of compensation (monetary, in-kind, both) were found to have significant differences between the groups. Therefore, it can be concluded that household family size, compensation amount, and types of compensation are statistically significant factors differentiating food-secure and food-insecure groups. In contrast, ages, area of expropriated land, and area of residual land from expropriation (land owned) were not significant predictors.

Table 4. Socioeconomic data of respondents.

Characteristics		Frequency	Percent
Household food security status	Insecure	233	66.6
	Secure	117	33.4
	Total	350	100.0
Sex	Male	214	61.1
	Female	136	38.9
	Total	350	100.0
Marital status	Single	23	6.6
	Married	207	59.1
	Divorced	64	18.0
	Widowed	56	16.3
	Total	350	100.0

Table 4. *Cont.*

Characteristics		Frequency	Percent
Household age	Up to 30	26	7.4
	30–60	201	57.5
	Above 60	123	35.1
	Total	350	100.0
Educational status	Illiterate	156	44.57
	Literate	194	55.43
	Total		100.0
Access to phone	Yes	247	71.1
	No	103	28.9
	Total	350	100.0
Access to pure potable water	Yes	278	79.7
	No	72	20.3
	Total	350	100.0
Access to electricity	Yes	204	59.7
	No	146	40.3
	Total	350	100.0
Toilet	Yes	328	6.3
	No	22	93.7
	Total	350	100

Source: researchers' survey, 2023.

Table 5. Mean and *t*-test values of continuous variables differentiating food-secure from food-in secure households (n = 350).

Variable	Food-Secure (n = 117)	Food-Insecure (n = 233)	Total Sample (n = 350)	t-Value
Age	56.5042	53.3390	54.3971	−1.8911
Household family size	2.5367	4.2585	3.6830	7.5633
Area of expropriated land	0.6366	0.6352	0.6357	−0.0267
Area of residual land (owned)	0.5205	0.4792	0.4930	−0.7520
Amount of compensation	5.3657	5.1193	5.2017	−4.0932
Total livestock units	2.2915	2.8329	2.6519	1.3822
Type of compensation	1.1794	1.5064	1.3971	6.1156

Source: derived using Stata from survey data, 2023.

As shown in Table 6, sex, participation in the land rental transaction, use of organic farming, use of irrigation, off-farm income, displacement due to expropriation, credit access and use, use of improved seeds, and pest and insect control were found to have significant differences between the food-secure and food-insecure groups at a 5% significance level. However, agricultural risk during the cropping season was not a significant predictor.

Table 6. Dummy variables differentiating food-secure from food-insecure households (*n* = 350).

Variable	Score	Food-Secure (*n* = 117)	Food-Insecure (*n* = 233)	Total Sample (*n* = 350)	Chi Square	Pr-Value
Sex	0	54	82	136	3.9385	0.047 **
	1	63	151	214		
Participation in land rental transaction	0	32	113	146	14.3550	0.000 ***
	1	85	120	205		
Access to irrigation	0	109	229	338	6.1688	0.013 **
	1	8	4	12		
Off-farm income	0	63	102	185	3.1692	0.075 *
	1	54	131	165		
Displaced due to expropriation	0	113	209	322	5.0116	0.025 **
	1	4	24	28		
Access to credit	0	101	217	318	4.3462	0.037 **
	1	16	16	32		
Extension contact	0	64	130	194	1.0532	0.305
	1	53	103	156		
Use of improved seeds	0	73	120	193	3.7350	0.053 *
	1	44	113	157		
Risk in agriculture	0	84	164	248	0.0748	0.784
	1	33	69	102		
Use of pest control and insecticides	0	72	114	186	4.9749	0.026 **
	1	45	119	164		
Organic farming	0	102	149	251	20.7222	0.000 ***
	1	15	84	99		

*, **, *** indicate significance at 10%, 5%, and 1% probability level, respectively. Source: derived using Stata from survey data, 2023.

3.3. Factors of the Food Security Status of Expropriated Households

A binary logistic model was used to identify determinants of food security status. Prior to analysis, the data were normalized using standard scalar normalization to ensure a mean of zero and a standard deviation of one. Subsequently, a multicollinearity test was conducted using the variance inflation factor (VIF) for continuous variables and the degree of association between dummy variables, as shown in the Table 7. The model was estimated using the statistical software STATA 14.

Table 7. Multicollinearity test of the variables.

NO.	Independent Variables	Collinearity Statistics	
		Tolerance	VIF
1	Sex of the household head	0.492001918	2.032512
2	Age of the household head	0.6134	1.6300
3	Marital status of household head	0.4768	2.0972
4	Educational status of the household head	0.6526	1.5322
5	Area of expropriated land	0.74393	1.3442
6	Area residual land	0.6819	1.4663

Table 7. *Cont.*

NO.	Independent Variables	Collinearity Statistics	
		Tolerance	VIF
7	Type of compensation	0.8497	1.1768
8	Amount of compensation	0.7640	1.3088
9	Participation in agricultural land rent	0.8391	1.1916
10	Use of irrigation	0.9043	1.1057
11	Participation in off-farm income	0.8214	1.2174
12	Displaced from home	0.8428	1.1865
13	Use of credit	0.8264	1.2100
14	Extension contact	0.4916	2.0340
15	Use of improved seeds	0.2358	4.2402
16	Agricultural risk in crop season	0.5439	1.8382
17	Use of pest control and insecticides	0.2108	4.7421
18	Use of organic farming	0.5125	1.9509
19	Total livestock units	0.6365	1.5709
20	Household family size	0.8660	1.1546

Source: derived using Stata from survey data, 2023.

According to Table 8, the overall correct prediction rate was 82.3%. A Hosmer–Lemeshow goodness-of-fit test was conducted to assess the model's fit after the binary logistic regression. As shown in Table 9, the *p*-value of 0.3245 is greater than 0.05, indicating a good fit [34]. To evaluate the model's predictive performance, a confusion matrix was calculated.

Table 8. Confusion matrix for logistic regression.

Classification Report				
Observed		Predicted		
		Household Food Security Status		Percentage Correct
		Insecure	Secure	
Household food security status	Insecure	207	26	88.8
	Secure	36	81	69.2
Overall percentage				82.3

Source: derived using Stata from survey data, 2023.

Table 9. The logistic regression results for the determinants of food security.

Independent Variables	Coef.	Odds Ratio	Margins	Std. Err.	z	*p* > z	[95% Conf.]	[Interval]
Sex of the household head	−0.3026	0.7389	−0.0402	0.2078	−1.46	0.15	−0.7098	0.1046
Age of the household head	0.4959	1.6420	0.0659	0.1982	2.5	0.01 ***	0.1074	0.8844
Marital status of household head								
Married	0.2649	1.3034	0.0353	0.6820	0.39	0.69	−1.0717	1.6017
Divorced	−0.8913	0.4101	−0.1080	0.8313	−1.07	0.28	−2.5206	0.7380
Widowed	−0.1518	0.8590	−0.0197	0.8438	−0.18	0.85	−1.8056	1.5018

Table 9. *Cont.*

Independent Variables	Coef.	Odds Ratio	Margins	Std. Err.	z	$p > z$	[95% Conf.]	[Interval]
Educational status of the household head								
Only can read and write	−0.0491	0.9520	−0.0063	0.0509	−0.13	0.9	−0.1060	0.0933
Formal education (certificate)	0.1330	1.1423	0.0174	0.0722	0.24	0.809	−0.1240	0.1589
Area of expropriated land	−0.0088	0.9912	−0.0012	0.1814	−0.05	0.96	−0.3644	0.3468
Area residual land	0.2342	1.2639	0.0311	0.1776	1.32	0.19	−0.1139	0.5824
Type of compensation	0.2814	1.3250	0.0374	0.1715	1.64	0.10 *	−0.0546	0.6175
Amount of compensation	0.7497	2.1163	0.0995	0.1942	3.86	0.00 ***	0.3691	1.1302
Participation in agricultural land rent	0.6463	1.9084	0.0858	0.1655	3.91	0.00 ***	0.3220	0.9706
Use of irrigation	0.3047	1.3563	0.0405	0.1755	1.74	0.082 *	−0.0392	0.6487
Participation in off-farm income	0.4710	1.6016	0.0625	0.1663	2.83	0.005 ***	0.1450	0.7970
Displaced from home	−0.5705	0.5653	−0.0758	0.2127	−2.68	0.007 ***	−0.9873	−0.1537
Use of credit	0.2745	1.3159	0.0365	0.1517	1.81	0.07 *	−0.0228	0.5719
Extension contact	0.5016	1.6513	0.0666	0.2087	2.4	0.016 **	0.0924	0.9107
Use of improved seeds	−0.1216	0.8855	−0.0162	0.2845	−0.43	0.67	−0.6792	0.4359
Agricultural risk in crop season	0.2888	1.3349	0.0384	0.2037	1.42	0.16	−0.1105	0.6881
Use of pest control and insecticides	−0.5037	0.6043	−0.0669	0.3026	−1.66	0.096 *	−1.0968	0.0893
Use of organic farming	0.7263	1.4837	0.0964	0.2158	3.37	0.001 ***	−1.1492	−0.3034
Total livestock units	0.1859	1.2042	0.0247	0.1909	0.97	0.33	−0.1883	0.5600
Household family size	−1.2084	0.2987	−0.1605	0.1873	−6.45	0.00 ***	−1.5755	−0.8414
_cons	−1.1736	0.3093		0.1715	−6.84	0.00 ***	−1.5097	−0.8375
Independent variables: expropriated peri-urban households' food security status								
Log likelihood = −144.35712						Pseudo R2 = 0.3527		
LR chi2 (20) = 157.31						Number of obs. = 350		
Prob > chi2 = 0								
Logistic model for HHFS, goodness-of-fit test								
number of observations = 350			Hosmer–Lemeshow chi2 (8) = 9.22					
number of groups = 10			Prob > chi2 = 0.3245					

*, **, *** indicate significance at 10%, 5%, and 1% probability level, respectively. Source: derived using Stata from survey data, 2023.

The binary logistic regression model result identified 12 significant explanatory variables out of 20 included. Seven variables (age, compensation amount, land rental participation, use of organic farming, off-farm income, displaced from residence due to expropriation, and family size) were highly significant ($p < 0.01$). One variable (extension contact) was significant ($p < 0.05$), and three (use of irrigation and credit use, type of compensation, and pest and insect control) were moderately significant ($p < 0.1$).

Based on the coefficient and p-value analysis in Table 9, several variables positively influenced the food security status among expropriated households. These include age of the household head, amount of compensation received, compensation type, participation in agricultural land rental transactions, irrigation use, credit access, off-farm income, and organic farming practices. Conversely, family size and displacement negatively affected

food security. The analysis indicates a positive relationship between household age and food security. A one-unit increase in age is associated with a 6.6% increase in the likelihood of the food security, assuming that all other factors remain constant.

Compensation refers to payments or benefits received for expropriated land and can be monetary or in-kind. This study examined the impact of compensation type on food security among expropriated households. The analysis revealed that compensation type significantly influenced food security ($p < 0.1$). The positive coefficient for alternative land suggests that it can enhance sustainability of agricultural production and income of the expropriated households compared to monetary compensation. Households receiving alternative land are 3.7% more likely to have sufficient food access, assuming all other factors remain constant.

As hypothesized, the amount of compensation received significantly positively impacted food security status ($p < 0.01$). The positive coefficient indicates that increased compensation is associated with a higher probability likelihood of food security. The marginal effect analysis reveals that that a one-unit increase in the log of compensation amount is linked to a 9.9% increase in the probability of food security, assuming other factors remain constant.

Agricultural land rental transactions involve a landowner leasing farmland to a tenant for agricultural use. In return, the tenant pays rent to the landowner in various forms, such as in cash, sharecropping, or a combination of both. This agreement allows tenants to farm without owning the land. The analysis indicates that participation in agricultural land rental transactions significantly positively influences food security among expropriated households ($p < 0.01$). The positive coefficient suggests that such participation can enhance agricultural production and household income, thereby increasing the likelihood of food security for expropriated households. The marginal effect analysis revealed that participation in agricultural land rental transactions is associated with an 8.6% increase in the likelihood of food security among expropriated households, assuming other factors remain unchanged.

Irrigation access was found to have a positive impact on food security among expropriated households ($p < 10\%$). The positive coefficient suggests that irrigation can enhance production, increase income, and improve food access, ultimately increasing the likelihood of food security. The marginal effect analysis indicates that irrigation access is associated with a 4.1% increase in the probability of having sufficient income and resources for food security, assuming other factors remain constant.

Access to credit positively influenced food security among expropriated households ($p < 10\%$). The positive coefficient suggests that access to credit can facilitate additional business activities, agricultural land rental participation, and agricultural input purchases, ultimately increasing the likelihood of food security. The marginal effect analysis revealed that a one-unit increase in credit access is associated with a 3.6% increase in the probability of food security, assuming the other factors remain constant.

Organic farming practices significantly positively influenced food security among expropriated households (at $p < 1\%$). The positive coefficient suggests that using organic fertilizers, such as compost, can reduce non-food expenses, thereby increasing the likelihood of food security. The marginal effect result analysis revealed that adopting organic farming practices is associated with a 9.6% increase in the probability of food security, assuming other factors remain constant.

Extension contacts and services positively influenced food security among expropriated households ($p < 0.05$). Access to extension services can enhance the expropriated farmer's knowledge of agricultural production and facilitate land rental transactions, thereby increasing the likelihood of food security. The marginal effect analysis revealed that the extension services are associated with a 6.7% increase in the probability of food security, assuming other factors remain constant.

Off-farm income significantly positively influenced food security among expropriated households ($p < 0.01$). The positive effect suggests that involvement in off-farm activities

can enhance food security. The marginal effect analysis revealed that the involvement of households in off-farm income-generation work increases the probability of food security by 4%, assuming other factors remain constant.

As hypothesized, family size negatively influenced food security among expropriated households ($p < 0.01$). The marginal effect analysis revealed that a one-unit increase in household size is associated with a 16% decrease in the probability of food security, assuming other factors remain constant.

Displacement from the residence significantly negatively influenced food security among expropriated households ($p < 0.01$). The marginal effect analysis revealed that displacement is associated with a 7.5% increase in the likelihood of food insecurity, assuming other factors remain constant.

4. Discussion

The existing literature in Ethiopia has documented food insecurity problems among expropriated peri-urban households. For example, Haile Aboye et al. found that 46% of such households in Jima, a town in Ethiopia, faced food insecurity, influenced by factors like human capital, physical endowments, risk aversion behavior, and institutional barriers [5,35]. In China, rapid urbanization reduced cultivated land, leading to decreased grain production and food insecurity [36,37]. Consistent with these studies, our research revealed that 67% of peri-urban households in the study area, expropriated due to urban expansion, are food-insecure (Table 3), which aligns with these studies. Our study is also supported by the findings of Dires et al., Kefyalew, and Shete and Rutten, which highlighted the negative impacts of urban expansion on food security among displaced populations. The complex relationship between urbanization and food security often involves the loss of agricultural land and disruption of traditional livelihoods, increasing the vulnerability of affected households [5,19,22].

This study identified 20 independent variables that were hypothesized to influence food security status. The binary logit model estimation result revealed that the following variables significantly impacted food security among peri-urban expropriated households: compensation amount and type, household head age, agricultural land rental participation, irrigation access, credit access, off-farm income, extension contact, total adult equivalents, amount of land owned, and organic fertilizer use.

Compensation amount was a critical determinant of food security among expropriated households. This finding aligns with Dires et al., who emphasized the importance of adequate compensation for mitigating food insecurity among displaced populations [5]. Adequate compensation is crucial for enabling households to rebuild their livelihoods and ensure food security [5]. The type of compensation also significantly impacted food security. Households receiving monetary compensation faced food insecurity problems due to rapid consumption. In contrast, those receiving alternative land or business places directly related to food production or income generation reported better food security outcomes [38,39]. These findings suggest that compensation policies in Ethiopia should prioritize supporting the immediate needs of affected households and fostering their post-expropriation sustainability.

The age of the household head was another significant factor influencing food security. Our findings suggest that older household heads tend to be more food-secure, consistent with Pourebrahim et al.'s observation that 56.9% of older individuals are food-secure [40]. However, this contrasts with Sani and Kemaw's findings of an inverse relationship between age and food security [41]. This discrepancy may be due to variations in socioeconomic contexts or research methodologies, underscoring the need for further exploration of the complex relationship between age and food security.

Our findings regarding the impact of family size on food security align with previous research [42]. Mitiku et al. also observed that larger families may struggle to achieve food security due to increased resource demands [42].

Agricultural land rental participation positively influenced food security. This finding highlights the importance of access to land for food production. Policies facilitating land access and promoting agricultural activities are crucial for supporting expropriated households. Moreover, irrigation access was a critical factor influencing food security, aligning with Sani and Kemaw [41]. Irrigation enhances agricultural productivity, leading to improved food availability and household resilience against food insecurity.

Regular contact with agricultural extension services was associated with improved food security, providing households with essential knowledge and resources for effective farming practices. Technical support empowers farmers to adopt improved agricultural practices and increase productivity, which is particularly important in urban expansion areas where traditional methods may be disrupted. The use of organic fertilizers significantly enhances food security status, highlighting the benefits of sustainable agricultural practices in increasing productivity and food availability. This aligns with the growing emphasis on environmentally friendly farming methods.

Our findings regarding the positive impact of credit access and fertilizer use on food security align with Dula and Berhanu [30]. Credit access was a significant factor positively correlated with food security status, corroborating Dula's findings. Access to financial resources enables households to invest in agricultural inputs and improve their overall livelihoods [30]. Moreover, households with off-farm income sources reported better food security, emphasizing the importance of diversified income streams for resilience against food insecurity. Promoting non-agricultural employment opportunities could be a potential strategy to alleviate food insecurity among peri-urban households [43].

5. Conclusions

This study investigates the impact of urban expansion on food security among expropriated households in the peri-urban areas of Debre Markos and Bichena. Using the calorie intake method, we established a food security line to categorize the respondents' food security status. The findings are alarming, as approximately 67% of expropriated households were found to be food-insecure. This indicates that a significant portion of these families struggle to access sufficient food due to land loss and disrupted livelihood, highlighting their vulnerability to poverty as a direct consequence of urban expansion.

The t-test and chi-square test identified several factors that differentiate food-secure and food-insecure households. These factors include the household head's sex, family size, compensation amount and type, agricultural land rent participation, land conflicts, irrigation access, off-farm income, displaced due to expropriation, credit access, and improved seed use. To enhance food security, addressing these factors is crucial.

A logit model revealed several key determinants of food security among expropriated households. These include compensation amount and type, land ownership, extension contact, off-farm activity, household head demographics (age and family size), agricultural land rental participation, irrigation and credit access, and the use of organic fertilizers. Alternative land compensation can enhance food production compared to cash payments. However, adequate compensation is crucial for improving food security. Displacement from residence can negatively impact food security of expropriated households. It is essential to involve expropriated households in development processes. To sustain food security, supporting expropriated households in investing compensation funds and engaging in off-farm activities is crucial. This requires adequate credit access, ongoing extension services, and family planning initiatives.

This study's findings have significant implications for policymakers and stakeholders involved in urban planning and development. The high prevalence of food insecurity among expropriated households highlights the inadequacy of current expropriation, compensation, and rehabilitation strategies. Policymakers must revisit and revise these strategies to effectively address the needs of vulnerable populations. Based on this research, the following recommendations are proposed:

- Develop and implement compensation procedures and rehabilitation strategies that are fair and commensurate with the losses experienced by peri-urban expropriated households.
- It is recommended to provide in-kind compensation rather than monetary compensation. This could include providing replacement land or business opportunities directly supporting food production.
- Create awareness programs to minimize food insecurity among peri-urban households during compensation appropriation and utilization. This initiative should be integrated into the government's rehabilitation strategy for expropriated populations.
- Ensure that expropriated households have access to crucial resources such as credit and irrigation. Supporting alternative livelihoods will be vital in helping these households regain food security and avoid deeper poverty due to urban expansion. The government should consider prioritizing these resources for affected communities.

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Notes

[1] https://www.stata.com/ (accessed on 12 September 2023).

[2] TLU is a reference unit to measure the aggregate species of the livestock owned by the household.

[3] This variable is measured as 1 for monetary, 2 for land compensation, and 3 for both, because it is hypothesized that land compensation is better than monetary compensation.

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