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Determinants of Food Insecurity in Rural Households: The Case of the Paute River Basin of Azuay Province, Ecuador

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Abstract: Eliminating food insecurity is one of humanity's greatest global challenges. Thus, the purpose of this research was to analyze the factors that determine food insecurity in households in the rural area of the Paute River Basin, Azuay Province, Ecuador. Stratified sampling was used as the sampling method, with proportional affixation. Moreover, we employed the Latin American and Caribbean Household Food Security Measurement Scale (ELCSA). We estimated the main determinants of household food insecurity using two binomial logit models and one ordered logit model. For the analysis of the data, the respective statistical and econometric tests were employed. The results show that housing size and access to food security information are the most important determinants of food insecurity in the three predictive models applied in this research. This research contributes to the existing literature on food insecurity and provides important information for policymakers, especially regarding food insecurity in rural areas, which has profound economic and social implications.

Keywords: food insecurity; rural households; ELCSA; binomial logit model; ordinal logit model

1. Introduction

It is a basic right of all people to have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs for an active and healthy life [1–3]. However, there are more than 820 million people in the world who are hungry [4]. The Food and Agriculture Organization of the United Nations (FAO) [5] warns that the number of people in the world suffering from hunger has increased by 11% in the last four years. In 2018, around 2 billion people experienced moderate or severe food insecurity due to poor access to nutritious and sufficient food [4,5]. With regard to Latin America and the Caribbean (LAC), hunger affects 42.5 million people, 90% of whom experience severe food insecurity [5]. In LAC, 30.7% of people live in a state of poverty [6]. Low-income countries in LAC face increases in hunger that are related to food insecurity as a result of the stagnation of economic growth [4,7]. In Ecuador between 2016 and 2018, there were 1.2 million people suffering from severe food insecurity and 3.9 million people suffering from moderate or severe food insecurity [5]. According to the National Statistics and Census Institute of Ecuador (INEC), the food problem in this country, where 23.9% of the population lives in poverty [8], is linked to the difficulty of accessing the basic food basket [6,8]. It has been shown that food insecurity affects many dimensions of well-being and is caused by factors such as macroeconomic imbalances, population growth, poverty, rural–urban migration, inequality, food supply [9], distribution networks [10], and even home interiors, among

others [11,12]. Thus, the second sustainable development goal (SDG), known as Zero Hunger, seeks to end hunger, reduce food insecurity, improve nutrition, and promote sustainable agriculture [7,13]. Indeed, eliminating food insecurity is one of humanity's greatest challenges [4,14–16].

Food insecurity is understood as the limited or uncertain availability of nutritionally adequate or sufficient food [4,14,16]. The inability to acquire or consume a sufficient amount of food is the greatest difficulty faced by many poor subpopulations, despite national economic growth [17]. For part of or the entire year, many people have insufficient food or face the possibility of an inadequate diet in the future [18]. People living in rural areas are at greater risk of food insecurity [19,20], unemployment, poverty, and lack of access to basic services [21,22]. In this context, the eradication of hunger requires a multisectoral public policy approach, due to the multidimensional nature of food insecurity [5]. The Inter-American Development Bank (IDB) [23] is promoting a modern, multisectoral approach that conceives of food insecurity from the perspective of demand and food systems to assess the nutritional status of the population. For this reason, analyzing food insecurity can facilitate the development of public policies for the benefit of vulnerable populations at both the regional and national level [24–26].

The FAO [27] has shown that the assessment and monitoring of household food insecurity can be undertaken through the use of "scales based on household experience" such as the Latin American and Caribbean Food Security Scale (ELCSA), which is a valid tool to assess household food insecurity [15]. Through different methods, food insecurity can be related to demographic, socioeconomic, and environmental variables, among others [28–32].

Some studies have determined the factors that have a significant impact on food insecurity through the assessment of individual, household, and socioeconomic characteristics [14,15,33–36]. In a study conducted by Assefa [37], three factors positively affected household food security in Ethiopia. These were average years of schooling of members of the household, proximity to service centers, and assets and availability of credit services; furthermore, with a logistic regression, the author found that investment in education and rural development could help improve household food insecurity. With a binary logit model, Agidew and Singh [33] found that shortage of farmland, poverty, recurrent drought and climate change, shortage of rainfall, and land degradation are determining factors for such food insecurity. Likewise, variables such as the age of the head of household, family size, number of agricultural labor force, off-farm income, relief support/food aid, farming experience, and agro-ecological zone were key determinants of rural household food insecurity. However, most of the studies that have been carried out so far on food insecurity issues focus on the national, regional, and district levels [38–40].

The main objective of this research was to analyze the determinants of food insecurity in rural households of the Paute River Basin in the province of Azuay, Ecuador, and consequently generate evidence to guide policymakers focused on reducing food insecurity in this area. The main research question posed is, what factors have a significant impact on food insecurity in rural households in this study? Thus, this research contributes to the existing literature on food insecurity, especially in rural areas, with the aim of guiding the implementation of policies to improve the lives of vulnerable populations facing food insecurity. After this introduction, this paper is divided into five sections. Section 2 presents the empirical materials and methods used. Section 3 describes the results. Section 4 presents a discussion of the results obtained, and finally, Section 5 offers some concluding remarks.

2. Materials and Methods

2.1. Location of the Study Area

This research was carried out in the rural area of the Paute River Basin, in the province of Azuay, Ecuador. The Paute River Basin is located between the eastern and western Andes mountain ranges of southern Ecuador. The area includes the provinces of Azuay, Cañar, and Morona Santiago. This inter-Andean region covers an area of approximately 6439 km^2 that ranges between 440 and 4680 m above sea level [41]. The cantons in the province of Azuay selected for this study were Cuenca,

Gualaceo, Paute, Sigsig, Chordeleg, EI Pan, Sevilla de Oro, and Guachapala (Figure 1). These cantons were selected because of their social, economic, demographic, and ecological importance and the different climatic conditions (drought, floods, and landslides, among other natural disasters) they have faced in recent years, which have an effect on food insecurity [42–45], particularly in rural areas [46].

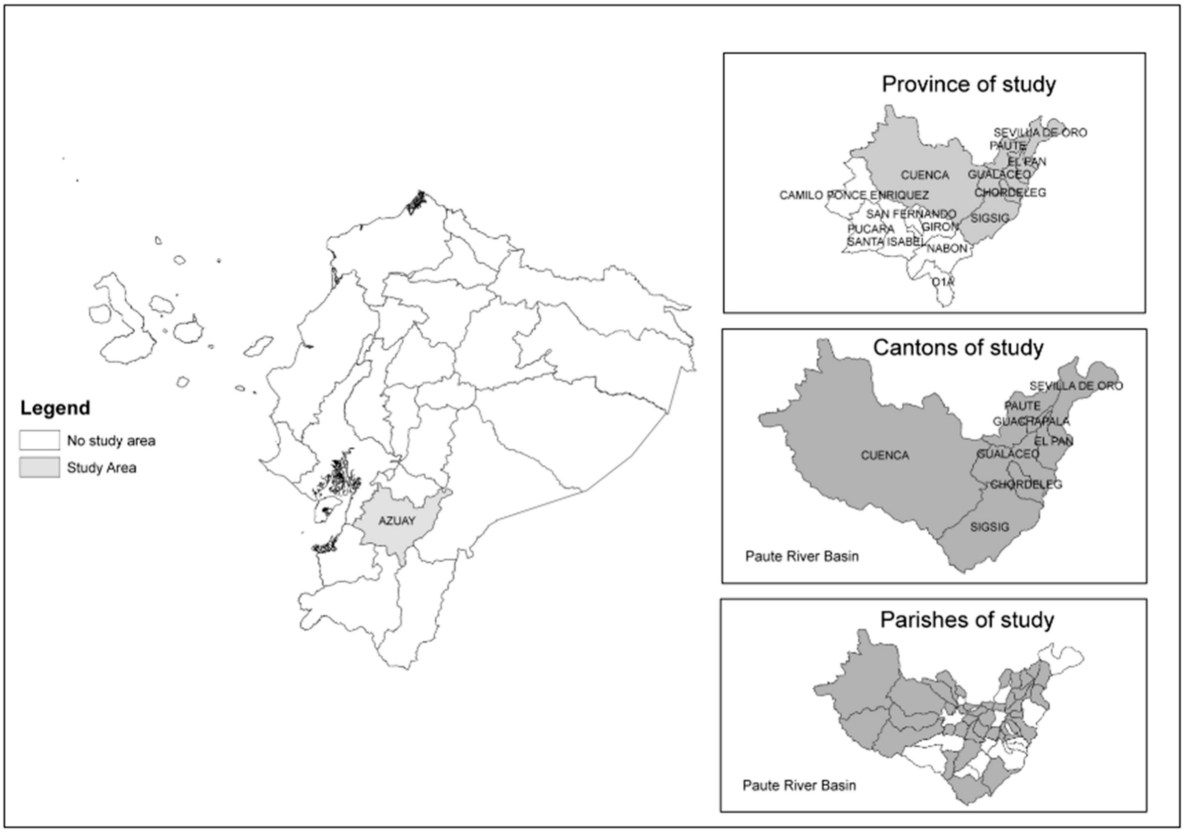

Figure 1. Location of the study area. Source: Authors' own elaboration, 2019.

2.2. Data Collection and Analysis

Communities in the rural area of the Paute River Basin in the province of Azuay were selected using a stratified random sampling method with proportional affixing, according to data from the last census conducted by the National Statistics and Census Institute of Ecuador (INEC) in 2010. The representative sample was made up of 383 surveys distributed in eight rural cantons, with a 95% confidence level and a 5% precision rate. In addition, surveys were distributed randomly within parishes and rural communities. The 383 surveys were distributed in the rural area as shown in Table 1. A pilot study was conducted before the final survey in order to refine the questions contained in the survey. The survey questionnaire was applied directly to ensure timely information and reliable results for the benefit of vulnerable rural communities. The data, collected at the household level, were from primary and cross-sectional sources. Prior to the collection and processing of data, it was essential to ensure the well-being and protection of the rights of participants. The respondents thus gave their consent to participate in the research through an informed consent form in which their full names were requested along with their signature. Moreover, the database of respondents will not be made public, in order to avoid conflicts between parties. The review, evaluation, and ethical approval for this research was granted by the Committee on Bioethics in Health Area Research (COBIAS) of the University of Cuenca, Ecuador.

Table 1. Description of sample size.

Rural Cantons	Frequency	Percentage
Cuenca	250	65.27
Gualaceo	41	10.70
Paute	28	7.31
Sigsig	35	9.14
Chordeleg	13	3.39
El Pan	4	1.04
Sevilla de Oro	8	2.09
Guachapala	4	1.04
Total	383	100.00

Source: Authors' own calculations, 2019.

2.3. Questionnaire

The survey questionnaire was based on socioeconomic, demographic, food, nutritional, and social aspects, among others. The Latin American and Caribbean Household Food Security Measurement Scale (ELCSA) questionnaire was also included in the survey. The questions that make up the ELCSA are related to the quality and quantity of food available and consumed over the three months prior to the date of the survey, according to the resources to which each household had access in that period [27]. It is important to mention than the term "resources" implies the possibility of obtaining or producing food for the household without the need to use money [15]. That is, there is the possibility of obtaining food from one's own production and/or subsistence farming, something very common in rural communities in Ecuador. The ELCSA was used as a measure to construct the dependent variable and analyze the determinants of food insecurity for the rural households in the study area.

2.4. Analysis of the ELCSA

The ELCSA questionnaire (see Appendix A Table A1) consists of 15 questions with dichotomous answers ("Yes" or "No") that are divided into two sections: The first section is composed of eight questions (P1 to P8) aimed at adults and household members in general, and the second section is composed of seven questions (P9 to P15) related to the conditions that affect children and adolescents under 18 years of age in the home [7,27].

A food insecurity variable was constructed according to household perceptions for the estimation of the binomial logit model (BLM *). Food insecurity levels were then constructed using the cut-off points applied to the additive scores of the positive answers of the ELCSA questions: (0) Food security (0 positive responses); (1) mild insecurity (households with adults: 1–3 positive responses, households with individuals under the age of 18: 1–5 positive responses); (2) moderate insecurity (households with adults: 4–6 positive responses, households with individuals under the age of 18: 4–10 positive responses); and (3) severe insecurity (households with adults: 7–8 positive responses, households with individuals under the age of 18: 11–15 positive responses) [27]. The indicator of food insecurity constructed according to the ELCSA questions for the estimation of the binomial logit model (BLM) was a dichotomous variable (1: Mild, moderate, or severe insecurity; 0: Food security). The four levels of food insecurity were used in the ordinal logit model (OLM).

2.5. Evaluation of the Reliability of the ELCSA Using Cronbach's Alpha

One of the measures used to evaluate the reliability and internal consistency of the ELCSA is Cronbach's alpha [47]. The coefficient of this measurement may vary in the range of 0–1; with 0 indicating no internal consistency and 1 indicating perfect internal consistency. When Cronbach's alpha is equal to or greater than 0.80, the answers are considered reliable and indicate good internal consistency of the ELCSA [48,49]. In this research, Cronbach's alpha was approximately 0.87 (Table 2).

The limitation of this measure is that it is based on a linear method that assumes that the change in intensity or difficulty between the questions is constant across the entire scale [27]. X is an $n * k$ matrix of the quantified responses of a questionnaire. Each row in X represents a topic, and each column represents a question. In this case, the quantified responses are on a scale of 0 to 1 [49].

The Cronbach's alpha coefficient formula is expressed as follows:

$$\propto = \frac{k}{k-1}\left[\frac{\sum_{i=1}^{k}\sigma_t{}^2 - \sum_{i=1}^{k}\sigma_i{}^2}{\sigma_t{}^2}\right] = \frac{k}{k-1}\left[\frac{\sum\sum_{i=1}^{k}\sigma_i{}^2}{\sigma_t{}^2}\right] \quad (1)$$

where $\sigma_i{}^2$ is the variance of each column of X, $\sigma_t{}^2$ is the variance of the sum of each row of X, k should be greater than one to have a denominator other than zero, and n should be greater than one to have a non-zero denominator in the calculation of $\sigma_i{}^2$ and $\sigma_t{}^2$. In Equation (1), k is a correction parameter. If there is consistency in the quantified responses, then $\sigma_t{}^2$ will be relatively large, which will lead to α tending to one. Otherwise, the random answers will make $\sigma_t{}^2$ comparable to the sum of the individual variances $\sigma_i{}^2$, which in turn will cause α to tend to zero [26,49].

Table 2. Cronbach's alpha for households assessed using the Latin American and Caribbean Food Security Scale (ELCSA).

Average Interitem Correlation:			**0.3021**			
Number of Items in the Scale:			**15**			
Scale Reliability Coefficient:			**0.8665**			
Item	**Obs.**	**Sign**	**Item-Rest Correlation**	**Item-Rest Correlation**	**Average Interitem Correlation**	**Alpha**
Q_1	383	+	0.4045	0.3038	0.3202	0.8683
Q_2	382	+	0.3149	0.2082	0.3288	0.8728
Q_3	383	+	0.4302	0.3316	0.3177	0.867
Q_4	382	+	0.3652	0.2615	0.3239	0.8703
Q_5	383	+	0.3458	0.2405	0.3258	0.8712
Q_6	383	+	0.5421	0.4549	0.3068	0.861
Q_7	382	+	0.557	0.4713	0.3054	0.8602
Q_8	383	+	0.3849	0.2827	0.3221	0.8693
Q_9	383	+	0.8052	0.7595	0.2812	0.8456
Q_10	383	+	0.8029	0.7567	0.2814	0.8457
Q_11	383	+	0.7829	0.7327	0.2834	0.847
Q_12	383	+	0.8106	0.7659	0.2807	0.8453
Q_13	383	+	0.8045	0.7585	0.2813	0.8457
Q_14	383	+	0.7484	0.6918	0.2867	0.8491
Q_15	382	+	0.7569	0.7019	0.2859	0.8486
Test scale					0.3021	0.8665

Source: Authors' own calculations, 2019.

2.6. Specification of Empirical Models

For the analysis of the determinants of food insecurity, a binomial logit model (BLM) and an ordinal logit model (OLM) were specified. In the estimation of each model, the dependent variable was different. First, for the BLM, a dichotomous variable was used and estimated in two moments: (1) According to household perceptions of food insecurity (FI); and (2) according to the questions of the ELCSA for the construction of an indicator of FI. For the estimation of the OLM, an ordinal variable was used according to the levels of food insecurity (FI) constructed from the ELCSA questions: Food security; mild insecurity; moderate insecurity; severe insecurity. In addition, independent variables were incorporated as determinants of food insecurity in rural households. Based on the literature and observations of the study area, 11 explanatory variables were selected and hypothesized

for the estimation of the models. The cutoff value for statistical significance was 0.70 according to the calculation of the area under the ROC curve of the Stata output. In this context, the parameters of the models were estimated using the maximum likelihood estimation (MLE) method in the Stata/IC15.0® statistical program.

2.6.1. Specification of the BLM

The discrete-choice BLM has two categories, coded 0 and 1 [50,51]. In this modeling approach, food insecurity (FI) as a dependent variable was measured between 0 and 1; where 1 represents food insecurity (FI) (1 = No) and 0 represents food security (FS). The logistic binary specification is suitable for models when the endogenous variables are dichotomous [52]. The logistics distribution function is specified as follows [51,53]:

$$P(Y_i = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_i X_i)}} = \frac{1}{1 + e^{-z_i}} = \frac{e^z}{1 + e^z} \quad (2)$$

where $P(Y_i = 1)$ is the probability that a household experiences food insecurity (FI) and z_i is the function of a vector of n explanatory variables $Z_i = \beta_0 + \beta_1 x_1$. If $P(Y_i = 1)$ is the probability of experiencing food insecurity (FI), then $1 - P(Y_i = 1)$ is the opposite. In this sense, it is easy to verify that as Z_i varies from $-\infty$ to $+\infty$, P_i varies between 0 and 1 [51]. On the other hand, when transformed into the possibilities of success (ODD), the probabilities are no longer in the range of 0 to 1 but of 0 to positive infinity [54]. In this case, the odds ratios are expressed as:

$$o_i = \frac{P_i}{1 - P_i} = \frac{1 + e^{z_i}}{1 + e^{-z_i}} = e^{z_i} \quad (3)$$

Equation (3) constitutes the ratio or probability coefficient. These coefficients show the relationship between the odds of the explanatory variables in relation to the probability of occurrence of the dependent variable [54]. Then, from Equation (3), the natural logarithm is taken as shown below

$$L_i = ln\left[\frac{P_i}{1 - P_i}\right] = Z_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + u_i \quad (4)$$

where L_i is the natural logarithm of the odds ratios; it is linear in the explanatory variables and also in the parameters (from the point of view of the estimate). β_0 is an intercept, β_1, $\beta_2 \ldots \beta_n$ are vectors of unknown parameters to be estimated, x_i is a vector of relevant explanatory variables of the household, and u_i is the stochastic error term. The parameters were estimated using MLE.

2.6.2. Specification of the OLM

In the OLM, the dependent variable is multinomial and ordered in nature [50]. In this case, the ordinary regression analysis is based on a latent regression of ordinal scales, where there is a clear classification between the categories of the dependent variable [53]. The categorical dependent variable (level of food insecurity) takes the values $(0, 1, 2, \ldots, j)$ for some known integer J [55]. In addition, it is a function of a set of explanatory variables.

The latent regression of the level of food insecurity Y_i^* is expressed as [56]:

$$Y_i^* = X_i\beta + \varepsilon_i \quad (5)$$

where Y_i^* is the latent unobservable variable that has more than two ordered or classified categories and denotes the level of FI observed in the home i, X_i is the matrix of a set of explanatory variables that determine the choice made by the household i, β is the vector of parameters to be estimated, and ε_i is a random error term distributed identically and independently.

In the OLM, the ordinal variable Y_i is a function of another variable Y_i^*, according to household choice i between the alternatives $(0, 1, 2, \ldots, j)$ and in relation to several threshold points μ_j $\left(\mu_0 = -\infty\ y\ \mu_j = \infty\right)$, as demonstrated in the following formulas [55]:

$$Y_i = \begin{cases} 0 \text{ si } Y^* \leq \mu_1 \\ 1 \text{ si } \mu_1 \leq Y^* \leq \mu_2 \\ 2 \text{ si } \mu_2 \leq Y^* \leq \mu_3 \\ 3 \text{ si } Y^* > \mu_3 \end{cases} \quad (6)$$

The FI variable is divided into four categories of increasing order and is coded as: 0 = food security, 1 = mild insecurity, 2 = moderate mild insecurity, and 3 = severe mild insecurity. The logistic distribution function of the model is considered by Moon [56]. In this case, the probability of a response for a given household (i) according to the number of categories (j) is expressed as:

$$P[Y_i = j|X_i] = P\left[\mu_{j-1} < Y^* \leq \mu_j\right] = F\left(\mu_j - X_i\beta\right) - F\left(\mu_{j-1} - X_i\beta\right) = \frac{e^{(\alpha_j + X_i\beta)}}{1 + e^{(\alpha_j + X_i\beta)}} \quad (7)$$

where F represents the standard logistic cumulative distribution function (cdf) of ε_i, β are the regression coefficients for X_i, and α_j is the intercept for j logit. The empirical application of the regression of the OLM, following Grimaccia and Naccarato [14], is expressed as:

$$g(Y) = logit(Y) = \alpha_j + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \varepsilon_i \quad (8)$$

The vector of the model parameters was estimated by MLE. The categorical dependent variable (FI levels), measured by the ELCSA score, is analyzed based on observable exogenous variables. The α_j parameters, called thresholds or breakpoints, are in increasing order $(\alpha_1 < \alpha_2 < \ldots)$. Their number is $j = 1,\ 2,\ \ldots,\ j-1$, where j is the number of categories of the ordinal variable [14]. In this research, $j = 4$.

3. Results

In this section, a descriptive and econometric analysis of the continuous and descriptive variables used in the research is presented (Tables 3–5). The original sample consisted of 383 surveys, from which surveys that contained incomplete information were excluded for the estimation of the logistic regression models. Therefore, after taking into account the availability of data on demographic variables, the final sample used for the analysis consisted of 321 surveys, representing 84% of the original sample. Inferential statistics were applied to determine the association between dependent and independent variables of the determinants of food insecurity in rural households.

Table 3. Descriptive statistics of the rural households.

Continuous Variables	Description	Mean	SD/%
Quantitative			
Total Income	Total household income in USD (monthly)	299.79	203.99
Total Expenditure	Total household expenditure in USD (monthly)	226.03	166.25
Household size	Number of household members	3.84	1.65
Age	Age of the head of household	47.20	16.25
Housing size	Number of rooms	4.90	1.59
Discrete Variables			
Qualitative			
Gender:	Gender of the head of household	1.60	0.49
Female			39.69%
Male			60.31%

Table 3. *Cont.*

Continuous Variables	Description	Mean	SD/%
Marital status:	Marital status of the head of household	2.51	1.42
Single			13.05%
Married			61.88%
Widowed			9.40%
Divorced			2.35%
Consensual union			28.00%
Separated			2.35%
Single mother			3.66%
Education level:	Educational level of the head of household	1.19	0.60
Uneducated			7.83%
Primary			67.36%
Secondary			22.45%
Higher			2.35%
Access to water sources:	Household's source of water	1.79	0.76
Public network			32.38%
Board or project water			62.66%
Water well			1.83%
Other (rain)			3.13%
Sanitation service:	Housing sanitation services	1.45	0.81
Connected to public sewage network		64.23%	
Connected to water well—septic		31.85%	
Connected to water well—blind		1.57%	
Direct discharge to the river, lake, or ravine		0.52%	
Latrine		0.26%	
No access			1.57%
Energy for cooking:	Source of fuel or energy for cooking	1.02	0.18
Gas			98.96%
Electricity			0.26%
Firewood or coal			0.78%
Electricity:	Electricity services	1.02	0.13
Access			98.17%
No access			1.83%
Internet:	Internet services	1.53	0.50
Access			46.74%
No access			53.26%
Economic activity	Type of employment		
Self-employed farm worker		0.11	0.32
Yes			11.35%
Employed, salaried farm worker		1.98	0.13
Yes			1.85%
Land measurements:	Crop production by ha	0.60	0.52
None			41.51%
< 1 ha			56.92%
> 1 ha			1.57%
Cultivate corn:	Corn sowing	0.64	0.48
Yes			63.97%
Seed saving:	Household saves seeds	0.73	0.45
Yes			72.83%
Seed consumption:	Household consumes seeds	0.77	0.42
Yes			76.63%
Human Development Bonus (BDH):	Direct money transfer program to households in poverty and destitution	0.13	0.34
Beneficiary			12.89%
Non-beneficiary			87.11%

Note: N = 383; SD: Standard deviation; SD/%: This column refers to the standard deviation (SD) unless otherwise noted (%). Source: Authors' own elaboration from surveys, 2019.

Table 4. Descriptive statistics of food insecurity.

Dependent Variable	Description	Mean	Percentage
Food insecurity perception:	Household perception of food insecurity (BLM *)	0.38	
Food insecurity	0 = No		37.86
Food security	1 = Yes		62.14
Food insecurity indicator:	Household food insecurity indicator (BLM)	0.72	
Food insecurity	0 = No (mild, moderate, and severe insecurity)		71.54
Food security	1 = Yes (Secure)		28.46
Food Insecurity levels:	Household food insecurity level (OLM)	0.89	
Secure	0		28.46
Mild insecure	1		56.66
Moderate insecure	2		12.53
Severe insecure	3		2.35

Note: N = 383; BLM *: Binomial logit model-perception; BLM: Binomial logit model-indicator; OLM: Ordered logit model. Source: Authors' own elaboration from surveys, 2019.

3.1. Descriptive Analysis

Tables 3 and 4 show summary statistics for the demographic variables for the entire sample, as well as for the different food insecurity scenarios. On average, a household is made up of 3.84 members, with an average age of 47 years. The average house size is five rooms. The level of education of the heads of households is low (8% have no education, and 67.36% have primary education). Of the heads of household, 60% are men, while 40% are women, and the majority report their marital status as married (61.88%). With respect to the economic situation, the total monthly income and expenditure of households, on average, is approximately 300.00 and 226.00 US dollars, respectively. The standard deviations for these variables were 203.99 and 166.25, respectively.

According to the results, the provision of basic services in this rural area is low. In terms of water availability, 62.66% of households receive water through a water board or project, 32.38% of households use public network water, and only 1.83% use a well. As for sanitation, 64.23% of people have a sanitation service connected to a public sewer network, 31.85% have a septic tank connected, and 1.57% do not have access to this service. In reference to electricity and internet services, 98.17% of households have access to electricity, and 53.26% of households do not have access to internet services. In addition, only 12.89% of people are beneficiaries of conditional cash transfers through the human development bonus (BDH) program. The BDH payments are conditional on the fulfillment of co-responsibilities by households in terms of health, education, housing, eradication of child labor, and family support. It is worth highlighting that only 11.35% of people surveyed in this research are self-employed agricultural workers, 63.97% sow corn, and on average, 74.73% save and consume the seeds of the last sowing. For 57% of self-employed agricultural workers, the land area for crops is less than one hectare.

According to the perceptions of households in the rural area of the Paute River Basin of Azuay province, Table 4 shows that food insecurity is low at the household level (37.86%). However, when calculating the FI indicator according to the ELCSA questions, this result changes (71.54%). It seems that there is an increase in the level of FI when moving from the perception of households to the construction of an FI indicator. In the analysis of FI levels, most of the rural households (56.66%) have slight food insecurity, and 14.88% have a moderate level of insecurity or severe insecurity. Therefore, 71.54% of households are food insecure.

Table 5. Results of regression analyses (BLM *, BLM, and OLM), showing the determinants of food insecurity in rural households.

	BLM *				BLM				OLM			
Dependent Variable	FI				FI				FI			
Independent Variable	**Coefficients**	**Odds Ratio**	**95% C.I. for O.R.**		**Coefficients**	**Odds Ratio**	**95% C.I. for O.R.**		**Coefficients**	**Odds Ratio**	**95% C.I. for O.R.**	
			Lower	**Upper**			**Lower**	**Upper**			**Lower**	**Upper**
Total income	0.0013 (−0.0013)	1.0013	0.9987	1.0039	−0.0011 (−0.0012)	0.9989	0.9965	1.0012	−0.0006 (−0.0008)	0.9994	0.9978	1.0009
Total expenditure	−0.0024 (−0.0017)	0.9976	0.9943	1.0008	0.0026 (−0.0017)	1.0026	0.9992	1.0059	0.0013 (−0.0008)	1.0013	0.9997	1.0028
Housing size	−0.2426 *** (−0.0926)	0.7846	0.6543	0.9406	−0.2905 ** (−0.1029)	0.7479	0.6113	0.9149	−0.3115 *** (−0.0885)	0.7324	0.6157	0.8710
Household size	0.1664 ** (−0.095)	1.1811	0.9804	1.4227	−0.0242 (−0.1026)	0.9761	0.7982	1.1935	−0.0014 (−0.0926)	0.9986	0.8328	1.1973
Age of head of household	0.0119 (−0.0097)	1.0119	0.9929	1.0313	−0.0233 ** (−0.0104)	0.9769	0.9572	0.9970	−0.0170 * (−0.0087)	0.9832	0.9665	1.0000
Primary education	−0.9844 * (−0.5079)	0.3737	0.1380	1.0111	0.2147 (−0.5343)	1.2394	0.4349	3.5318	−0.3086 (−0.6004)	0.7345	0.2264	2.3824
Secondary education	−1.0785 * (−0.6191)	0.3401	0.1010	1.1445	−0.341 (−0.6557)	0.7111	0.1967	2.5706	−0.8048 (−0.6747)	0.4472	0.1191	1.6778
Higher education	1.0663 (−0.9134)	2.9047	0.4848	17.4028	0.0067 (−1.0448)	1.0067	0.1298	7.8030	−0.8179 (−0.8072)	0.4414	0.0907	2.1473
Self−employed farm worker	0.9554 *** (−0.3669)	2.5998	1.2665	5.3362	0.6762 (−0.4347)	1.9664	0.8388	4.6096	0.3126 (−0.3272)	1.367	0.7198	2.5959
Corn production	−0.6836 ** (−0.3051)	0.5048	0.2776	0.9179	−0.3253 (−0.3242)	0.7223	0.3825	1.3636	−0.296 (−0.2687)	0.7438	0.4393	1.2592
Food security information	−0.9910 *** (−0.2857)	0.3712	0.2120	0.6497	−0.5597 * (−0.2900)	0.5714	0.3236	1.0088	−0.4419 * (−0.2429)	0.6428	0.3993	1.0347
Consumed seeds	0.5109 (−0.3625)	1.6667	0.8189	3.3921	1.4298 *** (−0.3693)	4.178	2.0259	8.6161	1.1152 *** (−0.3571)	3.0502	1.5148	6.1418
BDH program	−0.7610 * (−0.4400)	0.4672	0.1972	1.1067	−0.1116 (−0.3962)	0.8944	0.4113	1.9443	−0.0997 (−0.335)	0.9051	0.4694	1.7450
_cons	0.8591 (−0.8535)	2.3609	0.4431	12.5776	2.6732 (−0.9242)	14.4865	2.3676	88.6363				
cut1	- -				- -	-			−3.2008 (−0.9041)		−4.9728	−1.4288
cut2	- -				- -	-			−0.1385 (−0.9057)		−1.9135	1.6365
cut3	- -				- -	-			1.7984 (−0.9798)		−0.1219	3.7188
Log pseudolikelihood =	−187.34				−168.93				−305.42			
Number of obs =	321				321				321			
Wald chi^2 (13) =	45.93				34.89				37.60			
Prob > chi^2 =	0.000				0.0009				0.0003			
Pseudo R^2 =	0.1191				0.0993				0.0596			
Correctly classified (%) =	71.03				72.90				-			

Note: Significance levels: * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$. Robust standard errors are given in parentheses below the parameter estimates. FI: Food insecurity, BLM *: Binomial logit model—perception, BLM: Binomial logit model-indicator, OLM: Ordered logit model. Source: Authors' own elaboration from surveys, 2019.

3.2. Econometric Estimation Analysis

Table 5 shows the coefficients of the different determinants of food insecurity at the household level, odds ratios, their standard errors, and cut-off thresholds. The estimated models were specified according to household perceptions of food insecurity (FI) and by the construction of an indicator of FI according to the questions of the ELCSA. In general, the main social and economic determinants of food insecurity investigated were the size of housing (number of rooms in the house), the size of the household (number of household members), primary and secondary education, age of the head of household, self-employed agricultural worker status, information on food security, corn production, consumption of seeds, and the human development bonus (BDH) program. With these results, the determinants significantly related to food insecurity at the level of perception and at the level of the FI indicator are compared between the estimated models.

The results of the binary logistic regression of perception show that food insecurity is associated with the following variables: The size of the house, size of the household, level of education of the head of the household (primary and secondary), self-employed agricultural worker status, corn production, access to information on food security, and the BDH program. However, total income, total expenditure, age of the head of the household, and the consumption of seeds from the last planting were not statistically significant in the estimation of the model. Household size and type of employment are the only variables that have a positive impact with respect to food insecurity. The results show that the correctly classified values of the estimated model represent 71.03%. On the other hand, the results of the binary logistic regression of the FI indicator, constructed in accordance with the ELCSA questions, show that the determinants of food insecurity are the size of the dwelling, age of the head of household, access to information on food security, and the consumption of seeds from the last planting. The correctly classified values of this model represent 72.90%. In the estimated robust ordered logistic regression model, it can be observed that the size of the house, age of the head of household, access to information on food security, and consumption of seeds from the last planting are statistically significant and important determinants of the level of household food insecurity. The results of the latter two models also show that the consumption of seeds from the last planting have a significant and positive relationship ($p < 0.01$) with food insecurity. However, total income, total expenditure, and the level of education of the head of household (higher education) were not statistically significant in the estimation of all predictive models.

Specifically, the results of the BLM of perception show that housing size and access to information on food security had a negative and significant effect. This means than the odds of being food insecure for those with larger homes compared to those smaller homes is decreased. Moreover, the same goes for households with greater access to information on food security. The BLM from the construction of the FI indicator also shows that when households have a larger home and have access to information on food security, the odds of FI decrease 0.75 and 0.57 times ($p < 0.05$ and $p < 0.10$), respectively. Similarly, the OLM shows that the probability of presenting FI was 0.73 and 0.64 times ($p < 0.01$ and $p < 0.10$) lower for households with a larger home and for those with access to information on food security, respectively. Table 5 shows the values of cut1, cut2, and cut3, which are the cutoff values that separate the different levels of FI in the OLM. The predicted cumulative likelihoods when the independent variables are equal to zero are indicated by the cutoff thresholds. None of the confidence intervals for the three cutoff thresholds overlapped, demonstrating that the four different levels of food insecurity were significantly different from each other.

4. Discussion

This research analyzed the determinants of food insecurity in households in the rural area of the Paute River Basin, in the Azuay province of Ecuador. Economic variables (income, expenditure, and BDH program), as independent variables, alone do not explain food insecurity since there are also social, demographic, and environmental variables that can explain food insecurity in the estimation of a model. Consequently, there are some studies that analyze the association between dependent

and independent variables of the common determinants of food insecurity, which include individual, household, and socioeconomic characteristics [2,14,15,33,34,40,57].

Productive activities in rural areas are not included in official statistics [58]. The results of this research show that the average income of rural households (USD 300.00) is below the unified basic remuneration (RBU) of USD 394.00. The RBU in Ecuador is a minimum wage that, by law, is set annually and must be paid to workers by an employer. The results indicate that low-income families are forced to cut their food budgets, being more likely to experience chaotic living conditions [59–61]. Furthermore, in Ecuador, a market family basket that contains the products required to meet the basic needs of a household had a cost of USD 718.18 for a four-member household with 1.6 income earners who earned the RBU of USD 394 in the year 2019 (that is, one person earns 1 RBU and another 0.6 of the RBU). These figures were presented by the National Institute of Statistics and Censuses (INEC) in October 2019 [8,62]. Our results indicate a reduction in the purchasing power of households to access and consume a set of goods and services (the 359 products that make up the basket) required to meet the basic needs of the household in terms of food and beverages, living space, clothing, and miscellaneous items [8].

Furthermore, it is important to note that in this rural area, the head of household is most often male. Kraus et al. [63] indicate that women place more importance on healthy and nutritional eating compared to men. Women are responsible for selecting and preparing food, although their efforts to reduce or eliminate household food insecurity is not yet recognized. Moreover, basic services in this rural area are scarce. Our results coincide with the statements of Mahlknecht and González-Bravo [64], who indicate that people living in rural areas tend to not have access to improved water sources and sanitation facilities. In recent years, rural populations have had greater access to electricity services but place a greater value on provisioning services (e.g., food and water) [65]. Likewise, the results of this research, with respect to the average number of members in a household, coincide with the study of Legwegoh and Hovorka [66], who found that the average household size is four, the smallest ones having only one member and the largest, eight. When there are more people to feed in a home, per capita income, per capita expenditure, and per capita food consumption are indirectly reduced, so demand can outstrip the supply of food from the household's own production, which entails family food insecurity [33,35,36,67,68].

On the other hand, the results of the model estimation built according to the perceptions of households show that rural households are less likely to suffer food insecurity when they acquire new knowledge. Knowledge should favor nutritional education; the more educated the heads of the household are, the greater the likelihood of educating family members and improving living conditions [68,69]. Likewise, the highest level of educational attainment increases income and offers a better decision-making capacity for healthy eating [37]. The study of Olabiyi and Mcintyre [39] indicated that food insecurity was significantly lower for households with a baccalaureate education among people whose main income source was self-employment. Furthermore, the age of the head of the household was independent (in terms of sign and significance) with respect to the state of food insecurity [70]. In the current research, however, the age of the head of the household had a negative effect and was statistically significant only in the BLM and OLM models. A study conducted by Bogale and Shimelis [35] also revealed that the age of the head of household has a theoretically consistent and statistically significant effect.

We found that if a head of household is self-employed in agriculture and if the household consumes the seeds of the last sowing, this increases the likelihood of a household experiencing food insecurity. This is an indication that if a household sells its highest-quality agricultural products at market, there is a greater probability that the home will face food insecurity [23]. In part, this could be due to the lack of efficiency of the public sector and coordination between public sectors and local stakeholders [70]. Furthermore, in the current research, the main crop cultivated by the surveyed rural communities is maize. According to our results, when a home cultivates corn, this significantly decreases household food insecurity [71]. Corn is one of the staple foods in homes and is largely produced by small farmers

who obtain their own food needs and supply local markets. Sustainable approaches are needed to ensure their future role in the fight against hunger, food insecurity, and poor nutrition. In general, governments indeed recognize the role that agriculture has in stimulating economic growth and reducing rural poverty [72]. Therefore, the authorities should develop sustainable agriculture and safety nets for the most vulnerable sections of rural populations [26], as agriculture is one of the least-productive sectors but typically involves obtaining food from one's own production and/or subsistence farming [15,73].

The estimation of all econometric models indicated that access to information on food security is a statistically significant variable with a negative effect. Households are less likely to experience food insecurity when they have access to information on how to feed and nourish themselves effectively within the home. This information can be provided through workshops, the training of professionals [74,75], and other activities that may be related to food and nutrition. According to the perceptions of households, our research also found that being a beneficiary of the human development bonus (BDH) program decreases the likelihood of a household experiencing food insecurity. According to Vahabi et al. [38], household food insecurity is highly related to obtaining social assistance and the use of food banks. The results regarding formal economic aid and food and social assistance programs found here are consistent with empirical findings made in many parts of the world [22,76].

As shown by the analysis of the data with the respective statistical and econometric tests, housing size and access to information on food security were the most important determinants of food insecurity in the three predictive models estimated in this research. The goodness-of-fit to the data was better for the binomial logit model built with the ELCSA indicator. Therefore, the results of this model provide a better understanding of the determinants of food insecurity in the rural area of the Paute River Basin in the Ecuadorian province of Azuay. These findings can help policymakers develop effective public policies, plans, programs, and projects to combat food insecurity.

However, there are also some limitations to this research. First, information gathering was only carried out in a specific area in the province of Azuay. Second, the econometric models applied to the survey results only provide an evaluation of positive or negative effects of the determinants of FI and do not provide a monetary evaluation. Therefore, it is difficult to make any generalizations to other rural areas in Ecuador.

5. Conclusions

This research analyzed the determinants of household food insecurity in the rural area of the Paute River Basin in the Azuay province of Ecuador. Information related to household composition, household income, access to resources, and food production was collected. It is crucial to convert policies for reducing household food insecurity into effective and sustainable actions. According to the subjective declaration of the households participating in this research, the average monthly income is approximately USD 300.00, which is below the unified basic remuneration (RBU) of USD 394.00. Households with food insecurity have low incomes, which limits access to food, portion sizes, the number of meals in a day, etc.

Eliminating or reducing food insecurity continues to be a challenge for rural communities. For this reason, eradicating hunger must be a key commitment of local authorities and should be strived for through the management of public policy at all levels and the development of a comprehensive strategic framework focused on promoting greater social inclusion, reducing food insecurity, and improving rural community nutrition. To this aim, this research provides a better understanding of the determinants of food insecurity in rural areas, which has profound sociodemographic implications. The findings obtained here reveal that food insecurity is present in the rural communities of the Paute River Basin, and several determining factors were identified that could improve the food insecurity situation in the study area. These include the size of the house, the age of the head of the household, access to information on food security, and the consumption of seeds from the last sowing. Moreover,

the education of the head of the household is an additional key factor for reducing or eliminating food insecurity.

This research contributes to the literature on food insecurity and provides important information for policymakers regarding food insecurity in rural areas, which has profound economic and social implications. In this challenging scenario, these results allow for the identification of groups of rural households that should be the targeted by public programs and policies implemented by local authorities in order to ensure sustainable development through the availability, access, and stability of the resources of the area and in turn generate inclusive economic development. In addition, public policies, plans, programs, and projects should focus on teaching the importance of leading an active and healthy life, in addition to providing social security subsidies to rural households.

This analysis constitutes a baseline for future research, and for investigations into the determinants of food insecurity in the other cantons of the Azuay province of Ecuador and in other Ecuadorian provinces, with an emphasis on local communities and indigenous people.

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Appendix A

Table A1. Latin American and Caribbean Household Food Security Measurement (ELCSA) questions.

Questions	In the Past Three Months, Because of a Lack of Income or Other Resources:
Q1	Did you ever worry about your household running out of food?
Q2	Did your household ever run out of food?
Q3	Was your household deprived of eating a healthy diet?
Q4	Did you or any other adults in your household ever have an unbalanced diet?
Q5	Did you or any other adults in your household miss breakfast, lunch, or dinner?
Q6	Did you or any other adults in your household eat less than you should?
Q7	Were you or any other adults in your household ever hungry and have nothing to eat?
Q8	Did you or any other adults in your household not eat for a whole day or eat only once a day?
Q9	Were any household members deprived of a healthy diet?
Q10	Did any household members under 18 have an unbalanced diet?
Q11	Did any household members under 18 ever miss breakfast, lunch, or dinner?
Q12	Did any household members under 18 not have enough to eat?
Q13	Did you ever have to cut the size of the meals prepared for any household members under 18?
Q14	Were any household members under 18 ever hungry and have nothing to eat?
Q15	Did any household members under 18 ever not eat for a whole day or eat only once a day?

Source: Food and Agriculture Organization of the United Nations (FAO) [29].

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