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Article

Socioeconomic factors and agricultural production management associated with food insecurity in rural households in the Machángara river basin

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Abstract: The food insecurity and inadequate management of family farm production is a problem that per-sists today in all corners of the world. Therefore, the purpose of this study was to analyze the socioeconomic and agricultural production management factors associated with food insecurity in rural households in the Machángara river basin in the province Azuay, Ecuador. The information was collected through a survey applied to households that were part of a stratified random sample. Based on this information, the Latin American and Caribbean Household Food Security Measurement Scale (ELCSA) was constructed to estimate food insecurity as a function of socioeconomic factors and agricultural production management, through the application of a Binomial Logit model and an Ordinal Logit model, in the STATA® 16 program. The results show that head house a married head of household, living in an informal house, having a latrine, producing medicinal or ornamental plants, and the relationship between expenses and income are significant variables that increase the probability of being food insecure. In this way, this research provides timely information to help public policy makers employ effective strategies to benefit rural household that are food vulnerable.

Keywords: food insecurity; agricultural production; rural households; ELCSA; ordinal logit model

1. Introduction

Every person has the right to adequate food (ONU, 2010), which meets their basic needs, is culturally appropriate, readily available, and does not negatively impact health (Copredeh, 2011). For this reason, food security lies in the availability of necessary food to meet the consumption demand of the global population at any time, including during periods of low production (FAO, 2002).

Additionally, it encompasses the right to both physical and economic access to sufficient, high-quality, safe, and nutritionally acceptable food to lead an active and healthy life (Calero, 2011; Friedrich, 2014; Pastorino, 2020). Conversely, food insecurity is understood as the lack of sufficient availability and access to food (Tadesse et al., 2017), due to social, political, environmental, economic, and financial restrictions (Ayaviri-Nina et al., 2016; Gundersen and Garasky, 2012; Guzmán, 2017).

In response to this issue, the second Sustainable Development Goal aims to

eradicate hunger and ensure access to nutritious food for the entire population, with an emphasis on people in vulnerable situations and those with limited economic resources, in order to reduce food insecurity (ONU, 2023). However, achieving this goal is very challenging, as populations in various parts of the world continue to face high levels of food insecurity (Chakona and Shackleton, 2019), particularly among the groups that experience the most poverty (Calero, 2011).

Currently, around 735 million people worldwide suffer from hunger, a number that increased by approximately 122 million due to the COVID-19 pandemic, which caused significant economic losses that could not be recovered, leading to rising prices of food and agricultural inputs (FAO, 2023b; FAO, 2023c).

Food insecurity is also a significant issue in the Latin America and Caribbean region, where 56.5 million people (8.6% of the population) experienced hunger in 2022 (FAO, 2022). This region not only reports high levels of inequality but also has the highest cost of a sustainable diet compared to the rest of the world, reaching 3.89 USD per person per day, while the global average is 3.54 USD. Consequently, 131 million people were unable to afford such diets in 2022 (FAO, 2022). In South America, the prevalence of undernourishment was 38.6 million people, while in Ecuador, it was 2.7 million, or 15.4% of the population (FAO, 2022). In Ecuador, a significant and concerning per-centage (15.4%) of the population suffers from hunger, equating to 2.7 million out of 18 million Ecuadorians. These statistics position Ecuador as the second most hunger-affected country in South America (FAO, 2022). Additionally, when differentiating food insecurity by continental regions, 37.9% of the population in the coastal region, 33.9% in the Amazon region, and 19.4% in the highland region experienced food insecurity (ONU, 2023).

Food insecurity is impacted by poverty and hunger, issues that remain prevalent worldwide and are influenced by several factors: the lack of food, sanitation, and healthcare; all of which are linked to household income and the ability to use these incomes effectively (Laraia, 2013). Additionally, social, and environmental problems, such as pollution from domestic waste and water sources (Barragán and Ayaviri, 2018); inadequate policies, low commitment from state authorities, lack of employment, incorrect distribution of resources, and the absence of support for the agricultural sector contribute to food instability (Aulestia-Guerrero and Capa-Mora, 2020).

On the other hand, families in rural areas are more susceptible to food insecurity due to high levels of poverty or their geographic location (Calero, 2011). In 2022, moderate or severe food insecurity significantly affected adults living in rural areas at a rate of 33.3%, compared to 26% in urban areas (FAO, 2023c). Therefore, households in rural settings have very limited access to food groups that are expensive but nutritious (Elolu et al., 2023). Women in rural areas face food security challenges, often asking for food from friends, neighbors, or relatives, or buying food on credit, thereby reducing spending on children's education (Elum and Digitemie, 2023). In urban areas, employment can provide a source of income to purchase food, whereas rural households rely more on subsistence production. These households have a high proportion of farmers (Kang et al., 2021), and when the climate is unfavorable for agriculture, they tend to experience greater food insecurity (Rusere et al., 2023). Consequently, government policy interventions can

significantly help control the level of food insecurity in rural areas (Robayo et al., 2020).

The sustainability of agriculture is crucial for meeting the demand for food and contributing to greater food security, while also addressing health and malnutrition issues (Anghinoni et al., 2021; Mwungu et al., 2019). The lack of non-renewable natural resources, water scarcity, and inadequate soil fertility for agriculture contribute to food insecurity (Ayesha et al., 2023). Therefore, it is essential to improve the quality of agricultural production (Hansen et al., 2019). Verde (2014) mentions that crop yields from household farming, necessary for human self-consumption, contribute to food security. For this, quality water is required for acceptable production, which will help harvest nutritious foods that provide a healthier diet (Pérez et al., 2018).

In this context, various studies have been conducted around the world to identify factors associated with food insecurity, some related to the socioeconomic conditions of households and others to agricultural production. Many of these studies have utilized the Latin American and Caribbean Food Security Scale (ELCSA), which aligns with the FAO's (2012) intention to counteract food insecurity globally. This scale has proven to be a valid and reliable tool for monitoring food insecurity (Carmona, 2022; Viveros et al., 2014).

So, the main objective of this research was to analyze the socioeconomic factors and agricultural production management that contribute to food insecurity in rural households in the Machángara River basin in the Azuay province, Ecuador. The primary research question posed was: What are the socioeconomic factors and agricultural production management associated with food insecurity in rural households in the Machángara River basin? Therefore, this study seeks to provide actionable insights contributes to the literature addressing food insecurity, especially focusing on rural sectors, to guide the implementation of public policies aimed at improving the living conditions of vulnerable groups facing food insecurity.

2. Materials and methods

2.1. Location of the study area

This research was conducted in Ecuador, specifically in the province of Azuay, within the rural areas belonging to the Machángara River basin. The Machángara River originates in the Cajas National Park, flowing from north to south, located northeast of the city of Cuenca (Villavicencio and Chávez, 2011). **Figure 1** illustrates the geographical location of the Machángara River basin, which will be the subject of study in this article.

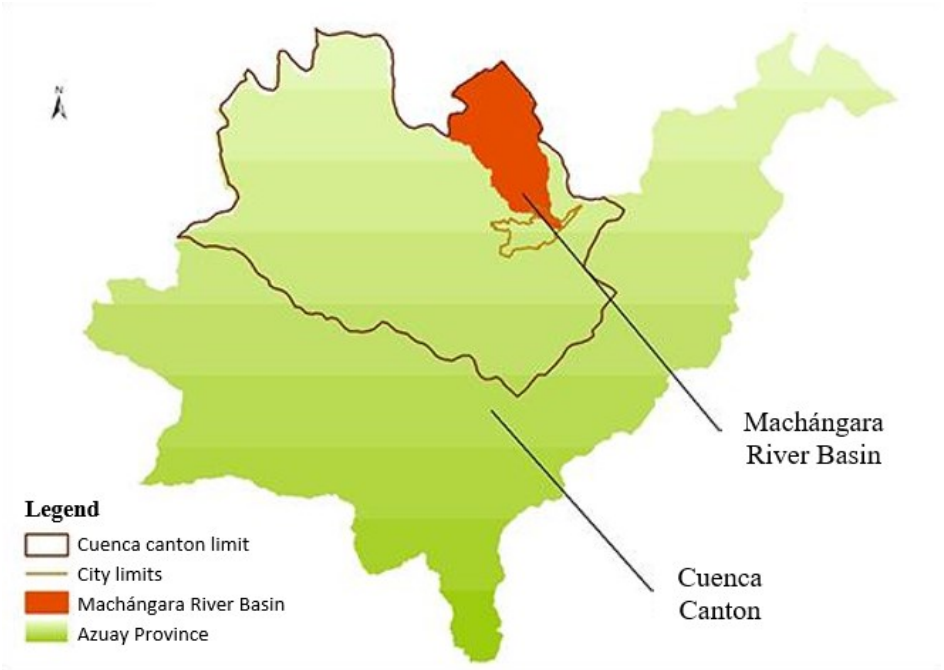

Figure 1. Location of the Machángara river basin on the map of the Azuay province in Ecuador.
Source: (ETAPA, 2023).

The Machángara River basin in southern Ecuador is part of the Santiago hydrographic system, covering an area of 32,500 hectares located in the parishes of Checa, Chiquintad, Sinincay, Sayausí, Nazón, Octavio Cordero Palacios, Ricaurte, and Sidcay (ETAPA, 2023). The Machángara River basin is of great importance for analyzing food security in households, as it is home to a significant rural population dedicated to food production around 3900 users (ETAPA, 2023). This is essential for ensuring food availability in the region. Additionally, this basin supplies water to the entire southern region of Ecuador for domestic, industrial, agricultural, livestock, and electricity generation purposes For example, in the lower basin area there are approximately 133 industries located in the well-known Machángara Industrial Park, which directly receive water supply from the basin. (ETAPA, 2023).

2.2. Data collection

In the framework of this study, a quantitative approach has been implemented, providing guidance on specific aspects of the investigated phenomena. Additionally, it is based on data collection through primary sources, such as surveys (Hernández-Sampieri and Mendoza, 2018). For this purpose, a stratified random sampling method was employed, which involves dividing the population into smaller strata with a common characteristic but different from each other (Hernández and Carpio, 2019). The sample consisted of 455 surveys with a 95% confidence level and a 5% margin of error, distributed across seven rural parishes belonging to the Machángara River basin, as shown in **Table 1**.

Table 1. Description of the sample size of the rural parishes of the Machángara river basin.

Code	Parish	Location area	Frequency	Percentage
010154	Checa	Rural	47	10.33
010155	Chiquintad	Rural	31	6.81
010167	Sinincay	Rural	86	18.90
010165	Sayausi	Rural	39	8.57
010158	Nazón	Rural	23	5.05
010162	Ricaurte	Rural	154	33.85
010166	Sidcay	Rural	75	16.48
TOTAL			455	100.00

Source: Authors.

2.3. Questionnaire

The survey questionnaire covered socioeconomic, demographic, dietary, and social aspects, among others. It also included the Latin American and Caribbean Household Food Security Measurement Scale (ELCSA), which consists of 15 questions related to the quality and quantity of food consumed by the household in the past three months.

The questionnaire was randomly administered to residents of each of the seven rural parishes who were aware of household and community issues or were household representatives, using the mobile application KoboToolbox, developed by the Harvard Humanitarian Initiative.

2.4. Data analysis

Firstly, the ELCSA was used to construct the dependent variable, food insecurity; it consists of 15 dichotomous YES or NO questions, structured in two sections: the first section (P1 to P8) comprises eight questions referring to various situations leading to food insecurity experienced by adults in the households; and the second part (P9 to P15) includes questions related to situations affecting minors under 18 years old in the household (Segall et al., 2012).

Secondly, Cronbach's alpha was calculated to determine the internal reliability of the ELCSA. This coefficient can range from 0 to 1, where 0 represents perfect internal inconsistency and 1 represents perfect internal consistency (Cordero-Ahiman et al., 2020).

Thirdly, the independent variables used to explain food insecurity in rural households in the Machángara River basin are those related to socioeconomic factors and agricultural production management, which are described below **Table 2**:

Table 2. Description of the variables.

Variable	Description	Type
Age	Head of Household Age	Metric

Table 2. (*Continued*).

Variable	Description	Type
Marital status	Marital status of the head of household (1) Singles (2) Married (3) Divorced (4) Common-law marriage (5) widow or widower	Categorical
Level of Instruction	Level of education of the head of household (1) He didn't study (2) Primary (3) High school (4) Superior	Categorical
Overcrowding	Overcrowding in the home (1) Not overcrowded (2) Overcrowded	Dichotomous
Number of bathrooms	Number of bathrooms in the house	Metric
Type of housing	The type of dwelling (1) House/Villa (2) Department (3) Shack	Categorical
Housing Material	Material of the walls of the house (1) Adobe/Tapia (2) Concrete (3) Brick/Block (4) Wood	Categorical
Toilet	Toilet Service (1) With direct discharge to the river, lake, or creek (2) Connected to septic tank. (3) Connected to public sewer network. (4) Latrine	Categorical
Trash Disposal	Trash collection. (1) They dump her in wasteland (2) They bury her (3) They burn it (4) Per Collection Cart	Categorical
Access to water	It has access to water. (1) It doesn't have. (2) Rarely (3) Occasionally (4) Often (5) Always	Categorical
Water Fountain	Home Water Fountain (1) Spring water (2) Well water (3) River water, canal, etc. (4) Drinking water	Categorical
Water Quality	Household Water Quality (1) Very good (2) Good (3) Regular (4) Suitcase (5) Very bad	Categorical
Produce food Buys food Swap Foods	Produce, buy, or trade food. (1) Always (2) Often (3) Occasionally (4) Rarely (5) Never	Categorical

Table 2. (*Continued*).

Variable	Description	Type
Produce cereal		
Produce roots		
Produces legumes	Food production in square meters	
Produce vegetales	(1) Nothing (2) Less than 1000	Categorical
Produce Fruits	(3) More than 1000	
Produce pastos		
Produces medicinal/ornamental plants		
Household Income Level	Household Monthly Income Level (1) 0–450 USD (2) 451–850 USD (3) 851–1250 USD (4) 1251–1650 USD (5) Más de 1650 USD	Categorical
Household Spending Level	Household Monthly Spending Level (1) Spend the same as your household income (2) Spend less than your household income (3) Spends more than your household income	Categorical

Source: Authors.

2.5. Model specification

For the analysis of the socioeconomic factors and agricultural production management associated with food insecurity in rural households in the Machángara River basin, a comparison between the Binomial Logit Model (BLM) and the Ordinal Logit Model (OLM) was conducted, and the model with the highest number of significant variables was chosen. The dependent variable food insecurity is qualitative, denoted by the following expression:

$$Y_i^* = \boldsymbol{X}_i\beta + e_i$$

Y_i^*: the categorical dependent variable food insecurity;

X_i: explanatory variable vector;

β: Coefficients;

e_i: error term.

Two dependent variables were constructed based on the levels of food insecurity (FI) derived from the ELCSA questions.

$$MLB: Y_{1i} = \begin{cases} 0 \; if \; Y_i^* \leq 0 \;\; Food \; security \\ 1 \; if \; Y_i^* > 0 \;\; Food \; Insecurity \end{cases}$$

$$MLO: Y_{2i} = \begin{cases} 0 \;\; if \quad\quad Y_i^* \leq \mu_1 \;\; Food \, security \\ 1 \;\; if \; \mu_1 \leq Y_i^* \leq \mu_2 \;\; Mild \, food \, security \\ 2 \;\; if \; \mu_2 \leq Y_i^* \leq \mu_3 \;\; Moderate \, food \, Insecurity \\ 3 \;\; if \; \mu_3 < Y_i^* \quad\quad Severe \, food \, insecurity \end{cases}$$

The data analysis for this research was conducted using the statistical software STATA® 16.

3. Results and discussion

3.1. Descriptive analysis

Table 3 shows that the average age of the household head in the families of respondents the Machángara River basin is 50 years. Additionally, these households have an average of two bathrooms. It is also evident that nearly half of the respondents have a low level of education, with 49.9% having completed primary education. On the other hand, only 1.1% have attained a postgraduate level of education, and just 3.5% have not studied at all. Among the surveyed household heads, 63.4% report being married. A significant majority of households have good sanitation services, as a high percentage (69.2%) have a connection to the public sewer system, and 95.4% receive garbage collection services.

The water source for of respondents comes from potable water reservoirs, as indicated by 93% of the respondents. Regarding the quality of the water these households receive, it was reported to be in good condition (42.1% good and 39.9% very good). In terms of economic situation, 58.9% of households have an income ranging from 0 to 450 USD, meaning that more than half of the households earn the unified basic salary (UBS 450 USD) as of 2023. However, these incomes are not sufficient to cover their expenses, as approximately 75% spend as much or more than their income.

Table 3. Description of the descriptive results of the variables.

Characteristics	%/Average	Standard Deviation	Minimum	Maximum
Characteristics of the Household Head				
Age	50.0	14.9	18.0	92.0
Level of Education:	1.6	0.8	0.0	3.0
No education	3.5%			
Primary	49.9%			
Secondary	34.1%			
Higher	12.5%			
Marital Status:	1.2	1.0	0.0	4.0
Single	18.5%			
Married	63.4%			
Widowed	7.1%			
Divorced	7.7%			
Common-Law Union	3.3%			
Characteristics of the Household				
Number of Bathrooms	1.5	0.7	0.0	5.0
Type of Housing:	1.2	0.5	1.0	3.0
House/Villa	90.1%			
Apartment	3.5%			
Shack	6.4%			
Building Material:	2.8	0.7	1.0	4.0
Concrete	5.3%			

Table 3. (*Continued*).

Characteristics	%/Average	Standard Deviation	Minimum	Maximum
Brick/Block	81.5%			
Adobe/Rammed Earth	10.6%			
Wood	2.6%			
Overcrowding	6.2%	0.2	0.0	1.0
Basic Services				
Sanitation Service:	2.6	0.6	1.0	4.0
Public sewer system	69.2%			
Septic tank	23.1%			
Direct discharge to the river	7.5%			
Latrine	0.2%			
Waste Disposal:	3.9	0.4	1.0	4.0
Dispose in vacant lot	1.3%			
Bury it	0.4%			
Burn it	2.9%			
By garbage collector truck	95.4%			
Water Source:	3.9	0.5	1.0	4.0
Tap water	93.0%			
Spring water	1.8%			
Well water	0.7%			
River water	4.6%			
Water Quality:	0.8	0.8	0.0	4.0
Excellent	39.9%			
Good	42.1%			
Fair	15.4%			
Poor	1.3%			
Very Poor	1.3%			
Family Economy				
Monthly Income Level:	0.5	0.7	0.0	2.0
0–450 USD	58.9%			
451–850 USD	31.2%			
More than 850 USD	9.9%			
Monthly Spending Level:	1.1	0.8	0.0	2.0
Spends more than earns	39%			
Spends as much as earns	36.5%			
Spends less than earns	24.6%			

Source: Authors.

In **Table 4**, it can be observed that 72.3% of respondents households in the Machángara River basin always purchase food from stores or supermarkets, while 30.8% of households always produce and consume their own food. The data also indicate that bartering is a seldomly practiced activity, as 89.9% of households do not engage in food exchange with their families.

Table 4. Frequency of food production, purchase, and exchange (%).

	Never	Rarely	Occasionally	Frequently	Always
Food Production and Consumption	13.0%	36.3%	7.7%	12.3%	30.8%
Purchase of Food from Stores/Supermarkets	0.7%	2.4%	10.1%	14.5%	72.3%
Exchange of Food with Other Families	89.9%	3.7%	2.6%	2.2%	1.5%

Source: Authors.

In **Table 5**, it is generally shown that of respondents households in the basin plant 56% cereals (such as corn, barley, wheat); 44.4% cultivate vegetables and greens like carrots, spinach, turnips, and cabbages; followed by legumes or grains (38.9%), such as beans, peanuts, fava beans, and peas; with 33% growing grasses; 29.9% cultivate medicinal and ornamental plants. The two least cultivated food groups in households are roots and tubers like potatoes and yams at 27.9%; and fruits at 22.6%.

Table 5. Food cultivated by households (%).

Food Group	Crop
Cereals	56.0%
Roots and tubers	27.9%
Legumes and Grains	38.9%
Vegetables and Greens	44.4%
Fruits	22.6%
Grasses	33.0%
Medicinal or Ornamental Plants	29.9%

Source: Authors.

Prior to the descriptive analysis of the food insecurity variable, the reliability of the ELCSA was assessed through the Cronbach's Alpha coefficient, which was approximately 0.91, indicating excellent internal consistency of the scale (Cordero-Ahiman et al., 2020) (See **Table 6**).

Table 6. Cronbach's Alpha for the ELCSA.

Item	Obs.	Sign.	Correlation	Correlation	Covariance	Alpha
Ad1	455	+	0.6104	0.467	0.03662	0.9182
Ad2	455	+	0.6535	0.5603	0.03718	0.9053
Ad3	455	+	0.8118	0.7576	0.03512	0.8951
Ad4	455	+	0.7677	0.6959	0.03589	0.9002
Ad5	455	+	0.6764	0.6119	0.03908	0.9029
Ad6	455	+	0.7710	0.7048	0.03661	0.899
Ad7	455	+	0.7464	0.6834	0.03765	0.9005
Ad8	455	+	0.6781	0.6211	0.03939	0.9025
M1	266	+	0.7432	0.7023	0.03872	0.9031
M2	265	+	0.7456	0.6974	0.03807	0.9024
M3	266	+	0.6567	0.6157	0.03991	0.9060

Table 6. (*Continued*).

Item	Obs.	Sign.	Correlation	Correlation	Covariance	Alpha
M4	263	+	0.7449	0.7017	0.03852	0.9029
M5	264	+	0.7397	0.6959	0.03855	0.9030
M6	263	+	0.5605	0.5157	0.04063	0.9081
M7	264	+	0.5107	0.4718	0.04121	0.9093
Test Scale					0.0382358	0.9098

Source: Authors.

The **Table 7** shows the description of the proposed dependent variables of food insecurity based on the ELCSA. According to the Binomial Logit Model (BLM), 42.20% of the respondents perceive food insecurity, while for the Ordinal Logit Model (OLM), it is observed that 57.80% of the respondents perceive that there is food security in their homes. Additionally, a third of the population (33.63%) claims to experience mild food insecurity, 6.81% moderate insecurity, and 1.76% severe insecurity.

Table 7. Here are the descriptive statistics for the dependent variable Food Insecurity.

Type of Model	Dependent Variable	Frequency	Percentage
BLM	Food security	263	57.80
	Food insecurity	192	42.20
OLM	Food security	263	57.80
	Mild food insecurity	153	33.63
	Moderate food insecurity	31	6.81
	Severe food insecurity	8	1.76

Source: Authors.

3.2. Comparison of binomial logit and ordinal logit models

Table 8 provides a comparative overview between the Binomial Logit (MLB) and Ordinal Logit (MLO) models. For the MLB, it is noted that the variables determining food insecurity include the type of housing (Shack), access to water, food production, and expenditure level. Shack

Table 8. Results of logit binomial and ordinal models for ELCSA.

Independent Variable	Binomial Logit Model	Ordinal Logit Model
Age	−0.006	−0.006
Marital Status:		
Single Grounding		
Married	0.405	0.540*
Divorced	0.592	0.615
Common-law marriage	0.620	0.637

Table 8. (*Continued*).

Independent Variable	Binomial Logit Model	Ordinal Logit Model
Widowed	0.551	0.509
Education Level:		
Not studied Grounding		
Primary	−0.0748	−0.464
Secondary	0.2880	−0.139
Higher	0.2260	−0.113
Overcrowding	0.6530	0.583
Number of bathrooms	0.0631	0.003
Housing material:		
Adobe/Clay Grounding		
Concrete	−0.255	−0.311
Brick/Block	−0.454	−0.499
Wood	−0.261	−0.217
Housing type:		
House/Villa Grounding		
Apartment	−0.015	−0.181
Shack	1.085*	0.982*
Sanitary Services:		
Public sewer system Grounding		
Septic tank	0.091	0.216
Drainage system	−0.023	0.104
Latrine	17.550	3.357*
Waste Disposal:		
Throw it in vacant lots. Grounding		
Bury it	1.819	3.635
Burn it	0.502	−0.114
By garbage collector	0.350	0.151
Water source:		
Spring waterGrounding		
Well wate	−14.660	−13.430
River or canal wate	0.696	0.579
Potable water	0.372	0.297
Water access	−0.413*	−0.499**
Water quality	−0.112	−0.045
Produces food	−0.285**	−0.257**
Buys food	0.168	0.169
Exchanges food	−0.381*	−0.446**
Cereal production	−0.004	−0.137
Root production	−0.384	−0.192
Legume production	0.116	0.168

Table 8. (*Continued*).

Independent Variable	Binomial Logit Model	Ordinal Logit Model
Vegetable production	−0.447	−0.556*
Fruit production	−0.493	−0.683*
Pasture production	−0.449*	−0.426*
Medicinal/ornamental plant production	0.625*	0.774*
Income level	−0.063	−0.185
Expenditure Level:		
Spends as much as earned Grounding		
Spends less than earned	1.137**	1.179**
Spends more than earned	1.025**	0.907**
Cutoff 1		−2.943*
Cutoff 2		−0.595
Cutoff 3		1.196
N	452	452
Pseudo r2	0.139	0.114

Source: Authors Note: Binomial Logit Model with two categories: food security and food insecurity. Ordinal Logit Model with four categories: food security, mild insecurity, moderate insecurity, and severe insecurity. Significance levels *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$.

While, for the MLO, according to the significance analysis, the determining variables for food insecurity in rural households in the Machángara River basin are marital status (married), a type of Shack, pit latrine, access to water, food production and exchange, vegetable production, fruit production, pasture, and medicinal or ornamental plant production, along with expenditure level. Among these, marital status (married), Shack -type housing, pit latrine for waste disposal, production of medicinal or ornamental plants, as well as expenditure level, have a positive impact on food insecurity.

3.3. Ordinal logit model analysis

The MLB analysis was discarded due to fewer significant variables; therefore, the selected model is the MLO, see **Table 9**. The MLO shows that the probability of experiencing food insecurity is 0.54 times higher for households where the heads are married rather than single. Regarding infrastructure, households living in shack instead of houses have a 0.98 times higher probability of experiencing food insecurity. Households that dispose of wastewater through latrines, rather than direct discharge into rivers, lakes, or streams, have a 3.36 times higher probability of experiencing food insecurity. Cultivating medicinal or ornamental plants increases the probability of food insecurity by 0.77 times. If a family's spending is either lower or higher than their income level, the probability of food insecurity increases by 1.18 and 0.91 times, respectively.

On the contrary, for variables with negative coefficients, households that frequently access water services have a 0.50 times lower probability of experiencing food insecurity. Similarly, households that typically produce or exchange food have a reduced probability of experiencing food insecurity by 0.26 and 0.45 times,

respectively. Likewise, if a household produces vegetables, fruits, and pasture on a larger area of land, the probability of experiencing food insecurity is 0.56, 0.68, and 0.43 times lower, respectively.

Table 9. Results of the ordinal logit model.

Dependent Variable	**0: Food Security** **1: Mild Food Insecurity** **2: Moderate Food Insecurity** **3: Severe Food Insecurity**			
Independent Variable	**Coefficient**	**Odds Ratio**	**[Interval at 95% Conf.]**	
			Lower	**Upper**
Age	−0.006	0.993	0.977	1.011
Marital Status:				
Single BASE				
Married	0.540*	1.725	0.941	3.127
Divorced	0.615	1.849	0.751	4.558
Common-law Marriage	0.637	1.891	0.607	5.894
Widowed	0.509	1.662	0.587	4.707
Level of Education:				
Did not study BASE				
Primary	−0.464	0.624	0.207	1.911
Secondary	−0.139	0.869	0.268	2.824
Higher Education	−0.113	0.893	0.242	3.291
Overcrowding	0.583	1.791	0.783	4.101
Number of bathrooms	0.003	1.002	0.722	1.393
Housing Material:				
Adobe BASE				
Concrete	−0.311	0.733	0.244	2.205
Brick	−0.499	0.607	0.309	1.196
Wood	−0.217	0.804	0.200	3.232
Type of dwelling:				
House/Villa BASE				
Apartment	−0.181	0.834	0.271	2.563
Shack	0.982*	2.671	1.208	5.905
Sanitary services:				
Direct discharge to river, lake, or stream BASE				
Septic tank	0.216	1.241	0.520	2.962
Sewer system	0.104	1.109	0.487	2.526
Latrine	3.357*	28.711	0.851	968.475
Waste disposal:				
They throw it in an open fieldBASE				
They bury it	3.635	37.883	0.425	3376.016
They burn it	−0.114	0.892	0.115	6.903
By garbage truck	0.151	1.163	0.211	6.424

Table 9. (*Continued*).

Dependent Variable	**0: Food Security** **1: Mild Food Insecurity** **2: Moderate Food Insecurity** **3: Severe Food Insecurity**			
Independent Variable	**Coefficient**	**Odds Ratio**	**[Interval at 95% Conf.]**	
			Lower	**Upper**
Water source:				
Spring water BASE				
Well water	−13.430	0.000	0.000	.
River water, canal	0.579	1.784	0.305	10.446
Tap water	0.297	1.346	0.286	6.341
Water access	−0.499**	0.607	0.435	0.848
Water quality	−0.045	0.956	0.745	1.228
Produces food	−0.257**	0.773	0.659	0.907
Buys food	0.169	1.183	0.917	1.528
Exchanges food	−0.446**	0.640	0.485	0.845
Cereal production	−0.137	0.872	0.563	1.351
Roots production	−0.192	0.825	0.498	1.367
Legumes production	0.168	1.183	0.711	1.970
Vegetable production	−0.556*	0.574	0.341	0.965
Fruit production	−0.683*	0.505	0.283	0.902
Grass production	−0.426*	0.653	0.436	0.979
Production of medicinal/ornamental plants	0.774*	2.167	1.200	3.915
Income level	−0.185	0.831	0.587	1.178
Spending level				
Spends as much as earns BASE				
Spends less than earns	1.179**	3.250	1.827	5.779
Spends more than earns	0.907**	2.477	1.373	4.469
Cutoff 1	−2.943*		−5.992	0.106
Cutoff 2	−0.595		−3.626	2.436
Cutoff 3	1.196		−1.870	4.261

Source: Authors Note: Significance levels *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$.

Table 9 shows the values of cut 1 and cut 2, which separate the different levels of food insecurity in the MLO. The confidence intervals for the two cutoff thresholds did not overlap, indicating that the three levels of food insecurity were significantly different from each other.

It's worth mentioning that the variables that were not statistically significant in the model estimation are the age of the head of the household; marital status except married; level of education; overcrowding; the number of bathrooms; the material of the dwelling; apartment-type housing; methods of disposing of water, except for latrines; waste disposal methods; water sources; water quality; food purchases; cereal production, roots, legumes; and income level.

4. Discussion

Regarding the demographic variables in this study, it was found that if a head of household was married instead of single, the risk of experiencing food insecurity increased. This result aligns with the findings of Adepoju and Adejare (2013); Mohamed (2023); Shuvo et al. (2022), who attributed a higher likelihood of moderate or severe food insecurity for households with married heads compared to those with single heads, while authors like Cordero-Ahiman et al. (2021) found a positive relationship between the married marital status of the head of household and the household dietary diversity score (HDDS). All these authors, along with Delgado and Naranjo (2017); Salman et al. (2023), also found that individuals with higher education positively and significantly influenced achieving greater food security in their households compared to heads of households with less education. However, this conclusion contradicts the findings of this study, as the level of education was found to be nonsignificant.

Now, concerning variables related to housing, a positive and significant relation-ship was found between living in a shack and experiencing food insecurity, a result that aligns with Anand et al. (2019), who deduced that households living in a house in an informal settlement have an even higher probability of experiencing food insecurity than if they lived in an individual house. In other words, the type of housing in terms of size and construction material is relevant in reducing food insecurity, as demonstrated by other studies conducted in other countries. For instance, Jonah and May (2020) in South Africa noted that the more formal the type of housing, the lower the probability of experiencing food insecurity. Fuentes (2021) in a study in Mexico indicates that there is a greater impact based on the flooring material of the house.

Regarding sanitation services, it was found that residents in the Machángara River basin who have a pit latrine instead of a bathroom experience higher food insecurity than their counterparts. Authors like Rukundo et al. (2019) assert in their research that not having a proper bathroom increases the likelihood of experiencing food insecurity. Similarly, another study in the country supports this significant finding by mentioning that a household with adequate sanitation facilities will help reduce food-related risks at home (Prieto, 2019).

On the other hand, the lack of adequate access to clean water has a negative impact on the food security of the population, as without it, it is not possible to wash and disinfect both food and utensils, nor to keep their homes clean. Thus, the results of this research indicate that continuous access to clean water promotes food security. This is corroborated by empirical studies by Anand et al. (2019); Mohamed (2023); Rukundo et al. (2019); Shamah-Levy et al. (2021), as they found significant patterns between access to water and levels of food security, as households without access to clean water were more likely to suffer from severe food insecurity; similarly, Bhattacharjee and Sassi (2021) demonstrated that simply not having the possibility to drink treated tap water put food security at risk.

Regarding food provision, although most residents acquire food from local markets, those who produce or exchange food are not affected in their food security. Similarly, Andrade and Ayaviri (2017) found that food security is not altered by low

production, specifically of potatoes, since residents of the study area have continuous access to local markets to meet their food needs. However, in a study conducted in Bolivia by Delgado and Naranjo (2017), it was determined that the priority of households living in rural areas is family subsistence, through food production aimed at self-consumption rather than being sold in the market. This reduces the risk of food insecurity since they are meeting the household's food demand.

Based on this study, households that cultivate vegetables, fruits, and pasture in significant quantities do not perceive the risk of food insecurity, unlike the cultivation of medicinal or ornamental plants. Therefore, as mentioned by Eche (2018) and Romero and Silva (2019), it becomes necessary to apply quality cultivation techniques, access agricultural information to obtain nutritious products, and thereby increase commercialization to reduce levels of food insecurity in the population. Mariscal et al. (2017) and Mohamed-Katerere and Smith (2013) emphasize the importance of agricultural production, as it can address hunger issues and generate a considerable source of income for people residing in rural areas, arguing that peasant production contributes to food sovereignty.

In relation to household spending levels, spending less than what is earned in income may imply accessing less nutritious foods such as processed meats, snacks, and/or fast food, some of which are less expensive than truly nutritious foods such as meat, vegetables, fruits, etc., leading to food insecurity. On the other hand, spending more implies that what is earned is not enough to cover their food needs. This result aligns with the findings of the study conducted by Gundersen and Garasky (2012); Mitu et al. (2022); and Ortega (2018) who found that higher monthly incomes and greater financial management capacity increase purchas-ing power, reducing economic vulnerability and, consequently, levels of food insecurity (EVFI) in a rural context. Similarly affected were households that, due to a drastic change in income, modified their spending on fruits, vegetables, and animal-derived foods (Rodríguez-Ramírez et al., 2021). However, Verduzco et al. (2018) found that nearly one-third of households with incomes above the well-being threshold experience food insecurity in Mexico, suggesting that the problem is also due to labor conditions and not just the amount of income they receive.

Finally, the level of education, the age of the household head, and overcrowding (number of bedrooms per household member) were not determining factors for food in-security in the Machángara River basin. In contrast to these findings, Cordero-Ahiman et al. (2021) in their study of rural households in the Paute River basin found that the level of education and the age of the household head were determinants of food insecurity. Similarly, Abdullah et al. (2019), Arpi and Paredes, (2019), and Mota et al. (2019) determined that households with a higher number of members, those who were illiterate, and older household heads experienced higher levels of food insecurity.

5. Conclusion

This research employed a quantitative approach to analyze the socioeconomic factors and agricultural production management associated with food insecurity in rural households in the Machángara River basin. Primary information was collected

on the characteristics of the household head, housing, household composition, economic data, access to basic services, as well as food production and self-consumption. The results revealed that approximately half of the households in the Machángara River basin experience some degree of food insecurity. The factors that most influence this situation is the use of latrines, expenses exceeding income, precarious housing, production of medicinal or ornamental plants, marital status (married), and lack of access to water.

In this sense, to reduce food insecurity in rural households, it is vital for families to inhabit adequate housing (Valladares et al., 2008). This means guaranteeing citizens the right to have decent housing with basic infrastructure, regardless of the social situation in the country (Goyas et al., 2018). Furthermore, these homes should have quality sanitation systems, allowing residents to live a dignified and safe life, free from contaminants that transmit diseases and jeopardize their food security and health. Therefore, recognizing that poorly constructed housing, such as makeshift shelters known as "Shack," are considered transitional, relevant entities are encouraged to create initiatives for healthy and environmentally friendly housing involving the work of families in the Machángara River basin.

On the other hand, managing household incomes in rural areas is also crucial when it comes to food security, as most household heads earn below the minimum wage (450 USD), limiting economic access to nutritious and quality food. With these incomes, they are unable to cover the cost of the basic Ecuadorian family basket, which exceeds 750 USD (November 2023: 784.65 USD), or even the vital family basket, which surpasses 550 USD (November 2023: 552.02 USD) (INEC, 2023). Therefore, households tend not to consider the nutritional value of food products when making purchases; the priority is simply to satisfy the hunger of those within.

In response to this situation, it is imperative that policymaker's direct efforts towards creating and implementing public policies aimed at economic recovery to generate employment opportunities and improve the purchasing power of households. This includes implementing price regulation mechanisms to reduce the cost of the basic and vital family baskets, supporting the agricultural sector to enhance the availability of sustainable food sources. Additionally, promoting food education is crucial to raise awareness among households that proper nutrition is achievable if resources are man-aged effectively.

Furthermore, access to safe water sources is a universal right for all individuals (ONU, s. f.). It is also of great importance to ensure food production and safety, leading to healthy and nutritious diets. Therefore, it is necessary to manage the Machángara River Basin appropriately to ensure water quality in the present and future. Additionally, issues related to water quality risk and the safety of agricultural products must be addressed to prevent food contamination at its source and reduce exposure to pathogens in water (FAO, 2023b; FAO, 2023c). Likewise, it is imperative to implement policies that promote the recycling and safe use of treated wastewater and responsible irrigation practices or stress-resistant crop cultivation. Similarly, it is necessary, on one hand, to provide agricultural inputs such as seeds, machinery, and labor, and on the other hand, to offer economic incentives for landowners to allocate a portion of their land to the conservation of the Machángara River Basin. According to (FAO, 2023a; FAO, 2023b), governments should

prioritize watershed management approaches for agriculture, aquaculture, and forestry services, allowing for the collective management of these resources.

This research identifies several significant limitations. Firstly, it is noted that the study's approach is solely quantitative, suggesting the need for a qualitative study to gather the perspectives of those involved and validate the obtained results. Secondly, it is acknowledged that the results pertain only to the rural population of the Machángara River Basin, recommending that future research analyze the state of food security in other basins in Ecuador. Finally, the study was conducted only in rural areas, suggesting that research should also be carried out in urban areas to obtain a more comprehensive view of the population, including the measurement of levels of chronic child malnutrition, a priority issue for the Ministry of Health and the Ecuadorian Central Government.

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Appendix

Table A1. ELCSA questions for Food Insecurity Index estimation.

Item	Description
P1	Have you ever worried that food would run out in your home?
P2	Has your household ever run out of food?
P3	Has your household ever stopped having a healthy diet?
P4	Have you or any adult in your household ever had a diet based on a limited variety of foods?
P5	Have you or any adult in your household ever skipped breakfast, lunch, or dinner?
P6	Have you or any adult in your household ever eaten less than you should have?
P7	Have you or any adult in your household ever felt hungry but didn't eat?
P8	Have you or any adult in your household ever eaten only once a day or gone without eating for an entire day?
P9	Has any child under 18 in your household ever stopped having a healthy diet?
P10	Has any child under 18 in your household ever had a diet based on a limited variety of foods?
P11	Has any child under 18 in your household ever skipped breakfast, lunch, or dinner?
P12	Has any child under 18 in your household ever eaten less than they should have?
P13	Have you ever had to reduce the amount served in meals for any child under 18 in your household?
P14	Has any child under 18 in your household ever felt hungry but didn't eat?
P15	Has any child under 18 in your household ever eaten only once a day or gone without eating for an entire day?