

Evaluating Sustainable Livelihood based in Food Security and Resilience of Rural communities in Los Rios, Ecuador

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Abstract: A growing interest emerges concerning food security and resilience due to climate risk and small-scale farmer vulnerabilities. This article explores the farmers' consumption patterns in Los Rios rural communities and its dependence on local production in the agricultural sector to evaluate the livelihood and welfare that farmers and their families could access. It was developed and test a model, which emphasizes the relationship between socio-economic and production variables. A survey was carried using a simple probabilistic sample. The study was designed to collect information about: i) socio-economic and demographic characteristics, ii) production indicators, and iii) food, diet, and welfare. Data was collected from a sample of 133 small-scale farmers in the province of Los Rios. The data was analyzed using i) descriptive statistics, ii) amoeba analysis, and iii) principal components analysis (PCA). The PCA model was obtained using R Studio. The study confirms that farmers mostly consumed what they produced; however, they cannot access several products because they dedicate most of their lands to conventional short-cycle crops destined for sale. Minor farmers present agroecology efforts as small-farms and family gardens.

According to a daily diet, the amoeba graph shows adequate food nutrition and welfare indicators, where farmers present some risk in consumption patterns. Finally, PCA explores the relationship between different variables. Income, education, and hectares produced are essential for covering the farmers' needs and food access. Due to higher production being destined to sell and not to consumption, food security and resilience could be at risk in small-scale farmers' communities. Farmers are vulnerable to price changes and technological access, that stop their product development. We recommend promoting family farming through agroecology, to improve the welfare and food security for small-scale producers and their families

Keywords: Food Security; Rural Livelihood; Food Diversity; Local Production.

1. Introduction

The rural economy shows clear and robust connections between the productive agricultural activity, the natural environment, and the differentiated social component radically ingrained in the territory (Misso, 2012). Romero (2019) explains that food production is one of the biggest challenges worldwide to achieve sustainability, especially when agriculture and livestock generate a high environmental impact. However, food is a fundamental right of the human being; then, food security and nutrition are imperative to reach sustainability.

On the other hand, food diversity is analyzed as the production, processing, marketing, distribution of crops, and livestock products in quantity and quality (Astudillo, 2017). Food diversity provides not only food and raw materials, but also generate employment opportunities to reach the current population needs without compromising future generations.

Agriculture, thus, faces a significant challenge: to achieve the Sustainable Development Goals (SDGs), proposed on the 2030 Agenda for the Sustainable development and adopted by all the members of the United Nations (United Nations, 2015). However, in Ecuador, the highest levels of poverty and extreme poverty are presented in rural areas, approximately 43% of rural people live in poverty while 18.1% in extreme poverty (INEC, 2018).

In this case study, rural populations of Los Rios and Ecuador were selected because of its fertile soil and favorable conditions for agricultural development. Here is where agriculture and livestock activities are the primary sources of income generation (ESPAC, 2017).

Several authors point at agroecology as a provider of scientific bases for sustainable agriculture (Altieri & Nicholls, 2012; Gliessman, 1998). Agroecology aims the researchers to develop farmers' and peasants' knowledge and abilities for identifying the unlimited potential of re-enforcing biodiversity to create useful synergies (Altieri, Funes-Monzote, & Petersen, 2011).

Those are referring to the concept of "sustainable intensification" expressed by FAO (2009) as "the maximization of primary production per area without compromising the ability of the system to sustain its production capacity." To boost the familiar agriculture and agroecology, Altieri (2002) proposed implementing new strategies for natural resource management (NRM) and sustainable production. Thus, beyond diverse conditions where small producers are developed, it must be based on the local means and the know-how of people.

This study aims to analyze the production and consumption patterns of agricultural and livestock resources as a proxy to explore livelihoods and compare them with local agricultural production, analyzing some agroecology efforts. Then, the research question that guides this study is the patterns of food consumption and domestic production supporting the communities' resilience and food security?

The present article includes four main chapters: i) a general overview of the study, including problem and justification, ii) a literature review that supports the research, iii) the methods used for collecting data and analysis, iv) the results obtained and v) main discussion and conclusion including gaps for future research.

2. Literature Review

The concept of sustainability mostly focuses on the ability to develop lifestyles and levels of consumption orientated to the preservation of the resource's stocks. It characterizes for an approach oriented to the conservation of resources and the fulfillment of the present generations' needs without compromising future generations (Borrelli, 2016).

Castellanos (2016) indicates that some of "the fundamental human needs are: health, food, housing, education, and work." Then, when some of the needs are not satisfied, it alters social behavior. People in rural areas are mostly engaged in agriculture, and some of them live with less than a dollar a day, as a result, they face several issues like lack of sanitary systems and drinking water, malnutrition, hunger, among others (FAO, 2014).

Rosso, Wicky, Nessier, & Meyer (2015) indicates "the right to food is necessary for the human being to achieve full development among countries." The objective of "Food security leads an active and healthy life" (FAO, 2020). Still, when territories fail to commit with food security, people face problems such as insufficient food in times of crisis, affection of health, and malfunctioning in society.

Livelihood is made of tangible social resources and activities to live (Barrera, 2017). Territories accomplish food security when there is access to the quantity and quality of food, whether families produce it or buys it to satisfy basic needs. In particular, some factors that help provide enough food are: "fertile soil, sufficient irrigation, easy access to credit, adequate technical assistance, improved seeds, good food storage conditions and the participation of family members in the garden" (Carbajal, 2014).

As reported by Carbajal (2014) the pillars of food and nutritional security are:

- National availability of food for human consumption.
- Purchasing power on people, to buy food, goods, and services they needed to lead an acceptable life.
- Eating behavior then, people make adequate choices and use of the available foods.
- Environmental and health conditions for the biological purpose of food are a determining factor in people's nutritional status.

It is essential to know the nutritional value of food, its preparation, and the most suitable combinations for children and pregnant women in age, sex, size. Likewise, "healthy, strong, and well-fed people are required in agriculture" (Calderón, 2015). Therefore, dietary diversity "has been associated with better nutritional status, regardless of socioeconomic level" (FAO, 2020), which can compensate for the lack of a nutrient in food. When a daily diet is insufficient, people suffer from malnutrition, anemia, obesity, diabetes, and hypertension.

According to Rodríguez, Schneider, & Coelho (2015), when "the individual, family or group of people acquire food or products, it depends on their socioeconomic structure."

That structure includes having no money, following a monotonous pattern of food consumption within the established period, either once a month or within twenty-four hours that they consume the same. Food such as rice, cocoa, orange, cassava, is in the agricultural range and are put up for sale after the harvest since consumption is for the population that requires it day by day. On the other hand, locally grown crops

(agroecology methods) allow growing fresh, tastier food from local varieties throughout the year. People can also eat what they produce, improving their nutrition, income, and welfare. As a result, it avoids some conditions as the displacement of the rural population towards the cities where they receive low wages (Greco, 2015).

Vilches (2014) indicates that “the farmers try to live off their crops, their production, but the money is not enough then, payments and benefits are not fair for small-scale producers. In dry seasons farmers face high costs of seeds, irrigation, fertilizers, and market channels, while in winter, the risk of floods affects production. The production of local food, which farmers cultivate and distribute from their farms or their family gardens, are fresher and good quality (Rodríguez, Torres, & Pérez, 2017). It can contribute to environmental sustainability and local development, safe food, and, therefore, sufficient, stable, and efficient food production to guarantee conservation and regeneration of natural resources. Environmentally sustainable farming could help farmers increase their income and produce healthier crops for consumers and their families, thereby improving their lifestyles (Montoya, 2017)

3. Methods

The study case takes place in Los Rios province, and the research is predominantly descriptive with the objective of support the central hypothesis presented at the beginning of this research.

3.1 Design and Questionnaire

A semi-structured questionnaire was used to gather information about farmer production and consumption patterns. The survey was conducted in the households of participants after they agreed on written consent. This data was obtained from a study conducted across the agriculture producers in Los Rios. The sample was a simple probabilistic random sampling. The survey's primary purpose was to investigate attitudes towards the production activity (farm size and products) and farmer characteristics (demographics), 136 valid questionnaires were obtained, which were carried out randomly in 10 different cities of Los Rios.

The questionnaire had questions regarding the main indicators which are:

Table 1: Indicators of food diversity

Indicators	Measure	Description
Food security (S1):	Main harvested products Main livestock products	Availability of healthy food for members of the community and/or association regarding production and consumption patterns.
Consumption pattern (S2):	Metrics of consumption patterns Amoeba Analysis of Feed	Food that the community consumes daily, regardless of their access to affordable and nutritious food.
Resilience (S3):	Socioeconomic variables Needs and Food covered	Socioeconomic variables as income, education, and gender and its relationship with the farmers' capability to cover needs and food for their families as much as currently and for the future.

3.2 Data Analysis

To analyze the data, we used three different methods for each one of the three core indicators. Descriptive statistics helped to study the food security indicators using tables, describing the primary information to explain appropriately the results obtained from collected data in the field. The consumption pattern was analyzed using an amoeba graph, based on the method designed by Sepúlveda (2008), we adapt it to study the daily habits of consumption of the surveyed families. The eating behavior within 24 hours is in the analysis, along with some core patterns to create its variables.

Table 2: Consumption patterns variables

Daily Diet	Variable	Code
Breakfast	Include carbohydrates	D1
	Only aromatic water and bread	D2
	Include Fruits	D3
Lunch	Just soup	A1
	Always protein	A2
	Always carbohydrate	A3
	Vegetables or fruits	A4
Dinner	Always carbohydrate	C1
	Always protein	C2
	Vegetables or fruits	C3
Beverages	Natural juices	B1
	Always soda	B2
General index	Always greasy	E1
	Mix different carbohydrates	E2
	Children and adults eat similarly	E3

For the third indicator, we are using Principal Correspondence Analysis (PCA) to group the socioeconomic variable with welfare, food access, and nutrition indicators. According to Vyas & Kumaranayake (2006), "PCA is a multivariate statistical technique used to reduce the number of variables in a data set into a smaller number of dimensions. In mathematical terms, from an initial set of "n" correlated variables, PCA creates uncorrelated indices or components, where each element is a linear weighted combination of the first variables."

The goal of introducing the PCA is to obtain a graphical representation of the original data matrix within a few dimensions as possible (Hoffmann & Franke 1986). This powerful method allows us identifying the different factors that correlate and thus can have similar behavior and common origin into the sampled group (Qishlaqi & Moore, 2007). Advanced statistical literature (Slutsky, 1998) describes the theoretical aspects of these analytical methods.

3.3 Study Territory

Los Rios is one of the 24 provinces of Ecuador, located in the coastal region of the country. Its total population is 527,559 people, and its capital is Babahoyo (Naranjo, 2004). In this province, water is a valuable resource, water bathes its lands and makes it the most fertile area in Ecuador, and it is from that it gets its name (Los Rios in Spanish means Rivers).

According to ESPAC (2017), Los Rios stands out for its agriculture in general. For the cocoa, coffee, and rice cultivation, it is one of the provinces with the highest population density. Agricultural then is an essential activity in Los Rios and its primary source of production; it occupies the first place in the republic in cocoa production. It is second on the coast in the production of coffee, other products in this province are bananas, rice, corn, among others (ESPAC, 2017).

The study collected data in 10 different cities of the province, reaching 78 rural communities, between parishes and precincts, where most small-scale agricultural producers are; better presented in Figure 1

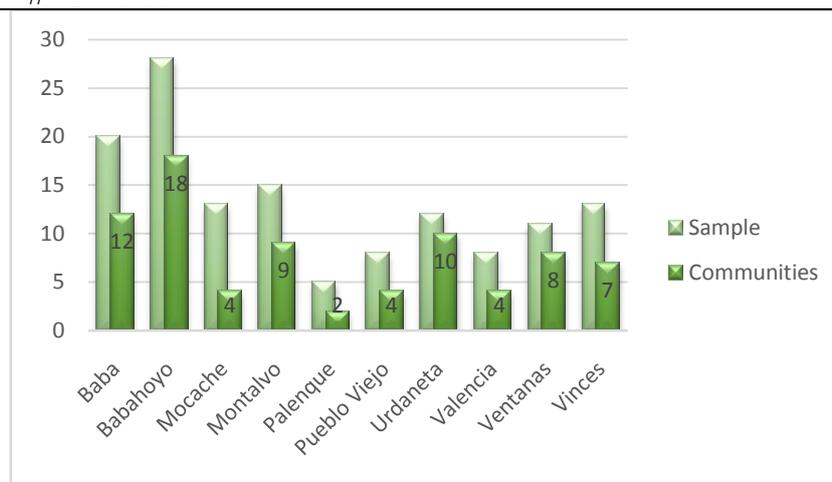


Figure 1: Sample and communities in Los Rios

4. Results

The results show a quantitative and qualitative analysis using descriptive statistics to explain the results obtained from the study population. Mainly, the aim was to support the hypothesis with the data collected in a synthesized way. Initially, Table 3 details the top ten products that were mentioned by small-scale producers, indicating the most produced and also consumed products. The surveyed producers have approximately 1 to 15 hectares, with an average of 6.02 hectares.

Table 3: Top harvested and consumed products

	N	%	N	% Consumed
Produced				
1 Rice	46	18%	58	40%
2 Cocoa	42	16%	1	1%
3 Maize	40	16%	12	8%
4 Banana	26	10%	29	20%
5 Mango	24	9%	7	5%
6 Orange	22	9%	11	8%
7 Lemon	18	7%	9	6%
8 Yucca	14	5%	16	11%
9 Frijol	12	5%	1	1%
10 Soybeans	11	4%	2	1%

Table 1 indicates whether those resources are produced locally or consumed. The rice production represented 18% of the surveyed households, followed by cocoa and corn (16% both). In terms of consumption, rice is preferred by 40% of farmers, while the banana holds 20%. Of the ten agricultural products named in the 133 surveys, they consume 36% of the products. On the other hand, 46.6% of farmers have livestock production, but 100% consumed livestock products. Chickens, pork, hens hold 18%, 21%, and 35% of production respectively; however, hens are more dedicated to direct sales than local consumption. Meat is the most consumed product; thus, it is not highly produced by small-scale farmers.

Table 4: Top livestock products produced and consumed

Product	N	% Produced	N	% Consumed
1 Chickens	11	18%	29	17%
2 Hen	22	35%	4	2%
3 Pork	13	21%	33	19%
4 Egg	6	10%	6	3%
5 Meat	2	3%	69	40%
6 Milk	7	11%	5	3%
7 Fish	1	2%	27	16%

To analyze food consumption patterns, we studied the food that the farmers' families consume daily, determined by their access to affordable and nutritious food. Figures 2 and 3 summarize this data. Based on the variables presented in the Methods section, we use an amoeba figure to detail all this information graphically. It is important to remark that variables with negative relation with adequate feeding were standardized to positive, to create indexes explained between "0" and "1", always being "1" the proper scenario.



Figure 2: Daily feeding based on variables

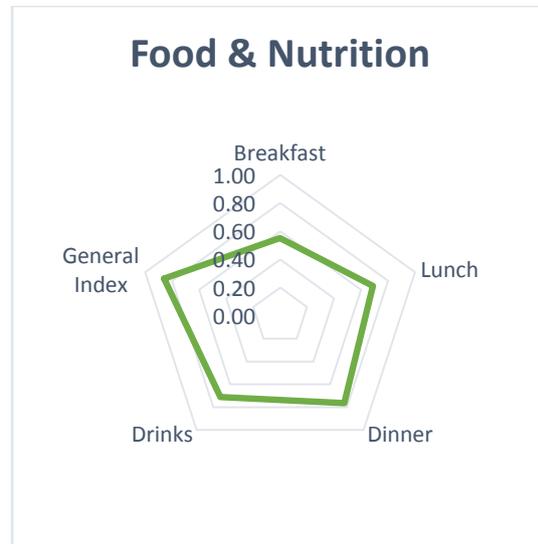


Figure 3: Metrics of adequate food patterns

Figure 2 shows that variables are not entirely adequate to reach the right level of nutrition. Critical variables explain that farmers consume carbohydrates in every daily food, even for breakfast, and sometimes lunch is only accompanied by soup. They do not have a daily consumption of fruits and vegetables, while drinking soda is very common to accompany every food. Breakfast is the critical indicator that farmers need to improve to have better nutrition.

Some variables are also adequate according to our results. Protein is common in farmers' food. Children are adults who are not eating similar, and quality and quantity depend on the ages. To cook food, they do not always use fats; obesity is not a factor presented when the male weight average is 164 pounds and female 139 pounds.

One notable highlight is that farmers cannot feed themselves with their production in Los Rios; they usually have to buy most of this food. Then agroecology is an essential source of development and resilience for those communities that could improve their nutrition and welfare.

Finally, Figure 4 presents the PCA analysis, where different socioeconomic, food, nutrition, and welfare indicators are analyzed through statistical methods.

The length of the vector explains PCA results (the longer it is, the better it explains the model), the angles (closer to 90°, higher correlation), and the direction (opposite direction, minor correlation).

Then, some conjectures we obtain:

- Education, income, and enough-food are the variables that better explain the sample.
- Production and revenue are higher related; thus, higher production represents better income, which could translate into better welfare.
- Some farmers present off-farm activities to generate income (commerce, small community stores, work for more prominent farmers or Agroindustry companies). This variable is highly related to the number of hectares they possess and the income they could gain.
- Higher education levels better the paths to cover farmer needs and have access to enough food for their families and communities.
- Farmers with higher education do not have livestock products. However, farmers with many family members and associated producers produce livestock.
- Gender is not highly relevant for the model; however, it is contrary to needs-cover, enough-food, off-farm activities, and production. Then, we could argue that female farmers are more complicated to generate welfare in the agriculture area than male producers.

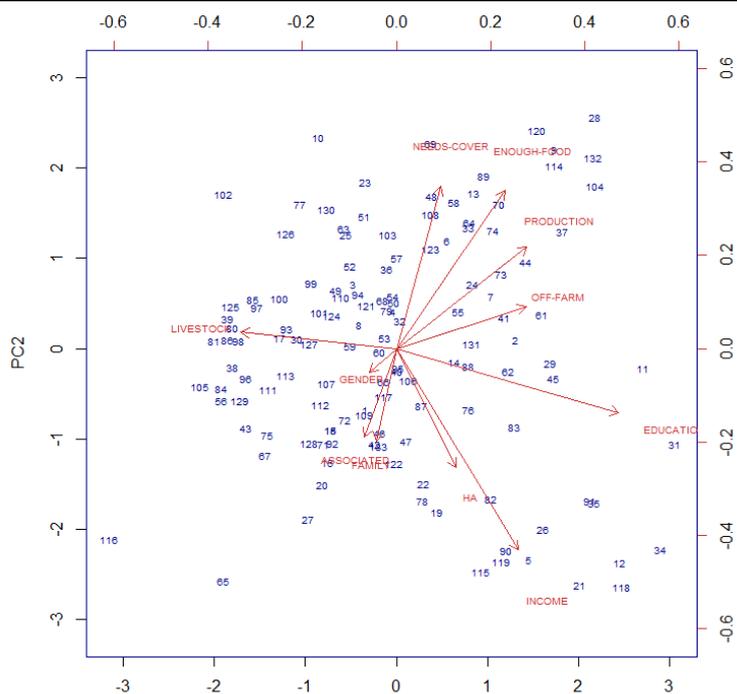


Figure 3: Biplot of PCA Analysis for Socio-Economic Variables

Finally, Los Rios producers can generate resources to cover their basic needs and have adequate production to access enough food for their families and communities. However, farmers' nutrition could be a risk for resilience and food security. They have high potential and resources to generate food and produce what they need. Still, they provide more for sale, more conventional, and short-cycle products. Then, Agroecology efforts are required to improve their livelihood and welfare, as much as for farmers, their families, and communities.

5. Discussion

Although the economy of rural areas is local production, this is not enough to satisfy all needs. The importance of knowing the livelihoods of farmers "plays a crucial role in the economy of a country" (Quinteros, 2017), because it provides food and some sources of work, although it is not well paid. Our survey establishes three factors causing these problems: 1) education; 2) economic income; 3) dietary diversity. According to the results, consumption patterns changed, but food security reached a stable score.

Nevertheless, the participation of families in gardens in one of the factors that can increase food diversity (Carvajal 2014); it is also considered the engine for the community development from an agroecological approach since it is the foundation for sustainable agriculture (Altieri, 2011). Hence, if families' consumption patterns adapt to their natural resources available, they can benefit their communities with a small-scale but highly diversified production, which can bring up the economy and increase the development of their territories (Juarez, 2011). However, context should be analyzed (Schijtman & Berdegué, 2004) the role of the stakeholders along with the strategies to achieve food diversity in rural populations.

Just by using the list method, we know the agricultural resources that they consume and what they buy the most; also, what both the level of education and the economic income is. We obtained a more extensive range of answers, and we learned about their reality (how they live, mass-produce, and consume). It let us remember that dietary diversity "is a qualitative measure that reflects the consumption and access to a variety of foods, as an indirect measure (proxy)" (FAO, 2014).

Then, an alternative way to collect data would be "to ask farmers to report on their activities, for direct measurements" (FAO, 2016). If researchers could understand these challenges, authorities could design public policies to promote improved quality of life, it would be a strong contribution in the right direction towards environmentally sustainable farming.

One of the limitations of this study is that the survey did not include all the cantons of Los Ríos. This can be a point for improvement. Anyhow, the arguments have high validity due to the number of responses, which allowed us to validate the information. Finally, this research provides a striking and innovative vision; it

represents the first step to document part of the dietary diversity and livelihoods in the rural populations of Ecuador.

6. Conclusions

Despite the exploratory nature of this research, it is clear that in the rural areas of the Los Ríos province at the level, it has a stable dietary diversity in the livelihood. Our research supported the hypothesis of this study: Agricultural producers of Los Ríos have appropriate resources to generate products that could improve food security. Small-scale farmers' production is more increasingly destined to sales, forgetting about their local needs. They are consuming a part of their output and buying food from the market, which in some cases, is not adequate to have the right level of nutrition in their daily diets.

Due to their conventional production, sometimes they have less than they need, putting resilience and food security at risk. However, we know that farmers are vulnerable to changes and fluctuations in prices and bargaining power. Production needs such as access to water and financial factors are imperative to develop among requirements to find mechanisms to increase productivity, most appropriate technology, and adequate channels for marketing their products.

Finally, the study concludes that diversified family farming should be promoted and strengthened at the production system level, agriculture, and livestock, with outstanding technical support. These activities can be the potential engine of development in Los Ríos, as long as there are more significant efforts to adopt new techniques and production technologies, keeping in mind that training can unleash an adequate knowledge to producers.

We highly recommend to policymakers and interested organizations to promote family agriculture (through Agroecology) towards a production system integrated into agricultural and livestock activities, using integrated landscape management to improve the resilience and food security (Intriago, Gortaire Amézcuca, Bravo, & O'Connell, 2017).

Future research could be essential to study better ways of accessing local markets, i.e., on the organic production side, through third-party certifications or Participatory Guarantee Systems (Cuéllar-Padilla, 2010; INFOAM, 2013; Meemken & Qaim, 2018; Pino, 2017). We study the resilience of small-scale farmers communities based on the available resources for production. However, it could be vital to consider the level of resistance based on environmental and resource management methods, i.e., natural disasters, infrastructure levels, farmers' illness due to their age ranges, and vulnerabilities due to climate change.

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