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Agricultural Diversification and Economic Growth in Ecuador

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Received: 6 June 2018; Accepted: 26 June 2018; Published: 30 June 2018



Abstract: The purpose of this article is to analyze the relationship between economic growth (measured by economic, social, and financial variables) and the agricultural productive structure, as well as its possibilities for diversification, in Ecuador's 23 provinces in the year 2014. First, we constructed the Shannon-Weaver index. We then used the graphic cartograms method to select relationships between variables. Next, we calculated the Pearson coefficient and the covariance, which revealed the linear association among the study's variables. This methodology led us to conclude that several variables (the gross added value of only agriculture, the average total household income, and the economically active population) have a positive influence on agricultural diversification; each province's overall gross added value, while the level of education, the unemployment rate, and the volume of credit had a negative influence.

Keywords: economic growth; agricultural diversification; land use; Ecuador

1. Introduction

The integration of Latin America into the world economy has been carried out through the export of primary products [1]. Primary production is the means through which Ecuadorian economy maintains its most important link to the rest of South America and the world [2]. In Ecuador's economy, agriculture is one of the key sectors upholding economic dynamics and supplying raw materials to industry, driving industrial expansion by supplying food to the public, and thus guaranteeing the country's food security and sovereignty [3]. Its main effect is reducing hunger and malnutrition, mainly because 59% of production in rural areas is agricultural, so farming can improve people's living conditions by increasing their income and generating employment for the vulnerable groups living in niches of poverty (Food and Agriculture Organization) [4]. These people's needs are priorities for immediate attention and the most effective policy to satisfy their needs is agricultural development, making it imperative to identify this sector's role and contrast it with current economic approaches [5]. The appropriate management of agriculture contributes positively to economic development, understood as a holistic model, which basically reduces the problems outlined in Chapter 14 of Agenda 21 regarding rural development and sustainable agriculture [6]. Sustainable land use is significant, since the current domination by monoculture has caused environmental problems such as soil erosion, rendering land unproductive and damaging the livelihoods of families who directly and indirectly depend on agricultural activity [7].

Thus, diversification can generate an opportunity to conserve soils and reduce the risk of economic losses due to both climatic and market changes [1,8–10].

In this context, analyzing the productive structure as related to the agricultural sector and its possible diversification would be very helpful for the Ecuadorian economy, and could improve both this sector and the environment [4].

To identify the relationship between economic growth and productive diversification, this research will analyze the influence of economic, social, and financial variables on agricultural diversification in Ecuador's provinces by constructing a diversity scale, known as the Shannon index, that will reveal how diverse each province is in terms of agriculture.

There are linear relationships, both positive and negative, between the study variables and agricultural land-use diversification. The variables with a positive relationship are: the gross added value of only agriculture, the average total household income, and each province's economically active population. The variables with a negative relationship are: the gross added value by province, level of education, unemployment rate, and credit volume.

The study is organized as follows. The first part describes the theoretical and empirical review. The second part indicates the methodology that will yield the desired results, describing the Shannon index, cartograms, and indices associating variables. The third part makes a descriptive analysis of the data to be used, the results of constructing the Shannon index, the relationship between variables plotted in cartograms, the results of the association indices, which indicate the linear relationships between the study's variables, and finally the overall research conclusions.

2. Theories of Growth and the Role of Agriculture in Diversification

Early economic theorists endorsed the importance of agriculture's role. Johnson [11] mentions that Adam Smith perceived "a significant relationship between the improvement of agricultural productivity and the wealth of nations". He quotes that, to improve and cultivate land, one family's work can feed two families, so work by half of society is sufficient to provide food for all [5].

The arguments of Kuznets, referring to the 1950s and 60s, called agriculture a marginal factor, mainly because of the steady trend of a falling share in nations' gross domestic product. John Stuart Mill and David Ricardo combined some ideas about labor and specialization while taking into account comparative advantage and trade, ideas that are currently widely accepted. Thus, classical theory began with the combination of land, labor, and capital as basic principles: expanding arable area produced more growth and therefore higher wages. More population was synonymous with more demand [12].

Furtado [13] stated that the agricultural sector has been considered as a supplier of surplus labor, foreign currency, and domestic savings that is destined to boost industrial development, detracting from its role as a growth engine on its own [5].

Malthus [14] associated the negative factors that affect economic growth with excess savings, scarce consumption and population dynamics, pointing out that economic growth does indeed need greater investment, but increased demand must be accompanied by an increase in supply from production.

The report on world development made in 2008 showed the importance of agriculture for the development of agricultural economies and identified four factors that position agriculture as a growth engine in the early stages of development, in which the productivity of agriculture is emphasized, as indicated, basic food crops are fundamental for growth [15].

Ardilla and Palmieri [16] mentioned that for agriculture to develop and reach its full potential, this would require several favorable conditions; one of them is the technological change that contributes to improving productivity. Schumpeter [17] argued that the innovations resulting from scientific research will enhance the accumulation of capital; therefore, science and technology play a very important role in economic growth.

Finally, it is important to emphasize the United Nations' proposal regarding the "Sustainable Development Goals and their origin". The Brundtland Commission defined development as holistic, but the creation of Agenda 21 institutionalized the sustainable use of the Earth as a universal goal, dimensioning development work holistically. Moreover, development is not understood in

terms of using land for agriculture but, at the same time, defines the economic, social, institutional, and environmental analysis within the actions aiming towards sustainability [6].

2.1. Productive Diversification

Diversifying rural production is the process by which families build different livelihoods, using different combinations of resources and assets, in order to be less affected by changes (climate or price decrease) and to ensure permanence in the market [18].

So, if there is strong demographic pressure in a region, but little diversification, the cultivation of low-profitability traditional goods will increase and the farming frontier will expand, driving deforestation and soil erosion [19,20]. Therefore, investing in agricultural diversification can stop environmental degradation by enabling multiple economically viable and more productive products [10].

Nowadays, diversifying agricultural production has become a necessity, precisely because monocropping is predominant. Agriculture must be protected and promoted, especially peasant farming, since it has become less competitive, impoverishing small-farm families [7].

Diversification strategies in all socioeconomic groups combine agricultural and non-agricultural activities, depending on what people can afford [21].

Among arguments promoting productive diversification, the main and most important reason is to generate growth [22]. Diversification is considered to offer an antidote to natural or market risks [8,10,22]. Another argument for diversification is the positive impact on farmers' incomes, lesser environmental impact, occupation of surplus family labor, and greater technical training to manage production [18]. In addition, diversification stimulates manufacturing activity by creating jobs for less skilled workers. At the end of the day, diversification meets people's needs to improve their living conditions [23].

Diversified productive activity yields a series of benefits; the most unquestionable is diversifying risk, by lessening exposure to potential price increases, demand changes, and quickly-shifting technology [8,10,22].

Markowitz [8] focused on diversification in his Portfolio Theory, saying that an investor maintains a portfolio in order to diversify investment risk, by diversifying the securities comprising the portfolio. If there is any change in the market, only some securities will be affected and decline in value while others prosper, so companies' investments will not be so drastically affected [24].

2.2. Diversification as a Strategy for Economic, Social, and Environmental Development

Empirical evidence reveals that development goes hand-in-hand with market expansion, more productive use of funds, and better opportunities for diversification. Buenaventura [25], which enable the progressive allocation of resources to more beneficial uses, increasing productivity endogenously as well as reducing variability in growth [26].

Economic growth in emerging economies is positively influenced by diversifying exports, as long as such diversification expands the country's comparative advantages. There are two channels through which a diversified increase in exports stimulates production growth: the first one tells us that diversifying exports buffers the volatility of exports and therefore of production; and the second refers to the dynamic benefits of measures to diversify comparative advantages [9].

In addition, diversifying exports strengthens a development process, by reducing the volatility of export revenues and boosting the Gross Domestic Product (GDP) and employment [27].

Mora and Cerón [28] found that, in Mexico City, diversification impacted household income significantly: 80% of the sample diversified to survive, and only 20% to accumulate, so policies should target people with lower incomes. Pérez et al. [29] stated that, in Ecuador, farmers who interplant other crops among the cocoa they grow for market improve their own self-supply and their net margin per hectare; that is, their greater profitability means higher incomes.

Diversifying farm productive activities diminishes economic losses, which are an essential element in small-farm systems. Small farmers can produce foods of animal origin in forests without needing to

sacrifice crop area, also diversifying labor inputs. These factors favor agro-silvo-pastoral systems for more sustainable small farms in Latin America [30].

Finally, there is evidence that agro-industrial interest is determined by two factors: adapting agriculture to industrialization, and the degree of diversification and agricultural importance. So, agro-industrial development depends on increasing crop area, diversifying production (accompanied by research), and having a skilled workforce [31].

2.3. Determinants of Diversification

Knowing the factors involved in adequate farmland diversification is a very important basis on which governments can implement policies and projects to improve the agricultural sector, and thus contribute to reducing poverty, particularly for people living in the rural sector, by creating employment, improving wages, and applying fair, equitable labor standards for rural workers [32].

Socioeconomic factors significantly influence adequate agricultural diversification in a region. This is why [33], in a study on factors conditioning land use in Oriente de Tabasco, concluded that the region's deforestation can be reversed through agricultural diversification, as long as the government promotes and supports this process by implementing long-term programs, economic incentives, and technical assistance for Tabasco farmers.

Birthal et al. [34] asserted that small producers have greater potential to diversify than large ones, due to their access to labor at a low opportunity cost. However, they need greater market opportunity and guidance on how to take advantage of the opportunities created by diversification.

A study conducted in Chile concluded that the variables that generate the greatest diversification are gender (if the person engaged in agriculture is a man), family size, agroecological zones, the total number of hectares used, access to credit, and technical advice. Meanwhile, the variables that have a negative effect on diversification are people's age, level of schooling, production for self-supply, and social participation [35].

Agricultural diversification is important to develop countries' rural sectors, but requires large investments in infrastructure, well-trained human capital, investment in research, and in extension work to spread diversification in the region [36].

Anosike and Coughenour [37] found that agricultural diversification is significantly related to farm size, with a positive relationship. That is, the bigger the farm, the greater its diversification, because there is more room where the farmer can grow his crops without creating environmental problems, avoiding soil erosion [38]. Caviglia-Harris and Sills [39] presented one of the factors that curb diversification of commercial crops: farmers' clearing to increase the agricultural frontier, as this renders soils unproductive due to deforestation.

In Latin America, there has been a pattern of upward agricultural export diversification. The econometric analysis reveals variables determining agricultural diversification both positively and negatively. Variables favoring diversification are access to credit, availability of risk-capital investment, and the level of commercial openness; variables hindering it are inflation, the government's share of the GDP, and machinery and fertilizer use [1].

A mechanism to enhance agricultural diversification is to recognize agro-ecological zones, which should have similar climate and soil characteristics. Such recognition will orient and improve the use of the agricultural sector's potential [40].

Another mechanism to diversify the rural economy is to implement rural industrialization, which has become a policy objective in many countries, because this industrialization offers farmers increased income and access to more employment opportunities [41].

Theory and empirical evidence indicate that diversification improves regions' development conditions in different fields of the economy, among which there is evidence of economic growth (thanks to diversifying exports), and improvement in farmers' living conditions (thanks to land-use diversification). There are different mechanisms of diversifying production favor rural growth and curb migration to urban areas. Knowing the factors that promote agricultural land-use diversification

helps establish mechanisms that generate development for farmers. The studies cited above can help identify findings relevant to what our research will now attempt to demonstrate.

3. Methodology

This section shows the variables used, identifies the data sources, and explains the methods used to achieve the proposed objectives.

To analyze the relationship between economic growth and agricultural diversification, we garnered provincial-level economic, social, and financial variables from previous research, as presented in Table 1.

Table 1. Description of the variables to be used in the analysis of the determinants of diversification.

Economic Variables	Source of Information
Gross added value (dollars)	Central Bank of Ecuador (BCE)
Gross added value—agriculture (dollars)	Central Bank of Ecuador (BCE)
Social Variables	
Average total household income (dollars)	Comprehensive System of Social Indicators of Ecuador, 2014 (SIISE)
Economically active population (number of people)	Comprehensive System of Social Indicators of Ecuador, 2014 (SIISE)
Level of education of the total population (years of schooling)	Comprehensive System of Social Indicators of Ecuador, 2014 (SIISE)
Total unemployment rate (%)	Comprehensive System of Social Indicators of Ecuador, 2014 (SIISE)
Financial Variables	
Sector credit volume (dollars)	Superintendence of Banks

Source: Empirical evidence, 2017. Database, 2017.

These variables were selected according to the secondary information available and the empirical evidence used for the present research, and are available from the following sources of information: Central Bank of Ecuador (ECB), the Comprehensive System of Social Indicators of Ecuador (SIISE), the Superintendence of Banks of Ecuador, the National Institute of Statistics and Censuses (INEC), and the Land-Area Survey of Continuous Agricultural Production (ESPAC).

3.1. Methods

In order to attain the objective of analyzing the statistical association between economic, social, and financial variables and provincial-level agricultural land diversification in Ecuador for 2014, we first constructed the Shannon-Weaver index, then selected a list of variables using the graphic method of cartograms. Finally, we calculated the Pearson coefficient and finally the covariance.

3.1.1. Shannon-Weaver Index

Also known as the Shannon index, this enabled us to determine the agricultural diversification of land use for comparison with economic growth in Ecuador's provinces [42]. Shannon is one of the most-used indices to quantify specific biodiversity [43].

This index was created to quantify the uncertainty of guessing a text string, when some initial letters are known. The basic idea is that the more different letters the string has, the harder it is to predict which letter will be next [44].

The Shannon index reflects a community's heterogeneity based on two factors: the number of existing species and their relative abundance [43]. Using this concept for our research, we calculated the Shannon-Weaver index as follows:

$$H = - \sum_{i=1}^S \left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right)$$

where H = Shannon index, S = number of crops, n_i = area of individual crops, N = total area of crops.

The Shannon-Weaver index usually scores from 1 to 4.5, and values above 3 are typically interpreted as diverse [45]. The lowest value the index can have is zero, which occurs when the sample contains only one species; the highest value that can be used is the logarithm of S , which occurs when all S species are represented by the same number of individuals [45].

This index was calculated for each province to analyze the diversification depending on the crops and the dedicated areas of land.

3.1.2. Cartograms

A cartogram is a diagram that shows quantitative data associated with the areas of the study territory. Two-variable cartograms can be used to display, on a single map, how two variables behave at the same time; this also highlights the extreme values of the variables on the map [46].

This graphic method first presents the relationship between economic growth and agricultural land-use diversification, relating the Shannon index with the studied economic, social, and financial variables.

3.1.3. Statistical Indices to Associate Variables

To meet one of the specific objectives (determining the degree of association between the proposed variables), the statistical indices of association between the diversification variable and economic, social and financial variables were calculated, as shown below.

Pearson Correlation Coefficient

The Pearson correlation coefficient is an index that measures the degree of co-variation between different variables; this index quantifies the force of a linear relationship between two quantitative variables [47]. The Pearson correlation coefficient is obtained by applying the following formula:

$$r_{XY} = \frac{\delta_{XY}}{\delta_X \cdot \delta_Y}$$

where r_{XY} = Pearson correlation, δ_{XY} = covariance of (X , Y), δ_X = X standard deviation, δ_Y = Y standard deviation.

The value of the Pearson correlation can range from -1 to 1 . If it is between 0 and -1 , the relation between variables is inverse; if it is between 0 and 1 the relation between variables is direct; if it is 0 there is no relationship between the variables.

This index was used to analyzed the relation between the Shannon index with every single variable per province in Ecuador.

Covariance (δ_{XY})

The covariance is also an index that measures the degree of association between two quantitative variables, assuming that they have a linear relationship. The covariance is calculated with the formula shown below:

$$\delta_{XY} = \frac{\sum (X_i - \bar{X}) \cdot (Y_i - \bar{Y})}{n}$$

where δ_{XY} = co-variance, X = variable X , $\bar{X}$ = average of variable X , Y = variable Y , $\bar{Y}$ = average of variable Y , n = number of the sample.

The expression shown in the numerator is known as the sum of cross products; the covariance can take both positive and negative values. A higher absolute value of covariance indicates a more intense linear relationship between two variables.

A positive value indicates a direct linear relationship, while a negative value indicates an indirect linear relationship, and a value of 0 indicates no linear relationship between the variables.

This covariances were used to analyzed the level of linear association between the Shannon index (diversification measure) and the every single variable (see Table 1) per province in Ecuador.

3.1.4. Research Area

To meet our objective, we used information from Ecuador, a South American country located on the border with Colombia to the north, Peru to the south and east, and the Pacific Ocean to the west. Ecuador occupies an area of 283,561 km² and its population is 16.6 million inhabitants. Geographical distribution was conducted for 24 provinces distributed in the coastal, mountain, and eastern regions (for this research we did not include the province of Galapagos for analysis) [48].

4. Results

The data used are at the provincial level. The province of Galapagos was not considered, as there is no information available from this island region. Only the year 2014 was taken into account for the analysis.

The Shannon index (which indicates the degree of agricultural diversification in land use) uses the number of associated permanent and transient crops, the hectares planted in each crop, and the total planted area in each province. For the total planted area in the province, 7839 units of agricultural production (UPAs) were considered.

4.1. Shannon Index Results

To meet the planned objectives, the agricultural diversification of Ecuador's provinces was first determined, using the Shannon index, and yielding the following results.

Figure 1 shows the Shannon index by province for 2014. The provinces with the most diversification are Imbabura, El Oro, Tungurahua, Cotopaxi, Loja, and Cañar. The provinces with the least diversification are Morona Santiago, Pastaza, Zamora Chinchipe, and finally Santa Elena. Having determined the agricultural diversification of Ecuador's provinces, we measured the degree of association among variables, using the indices mentioned above in the methodology.

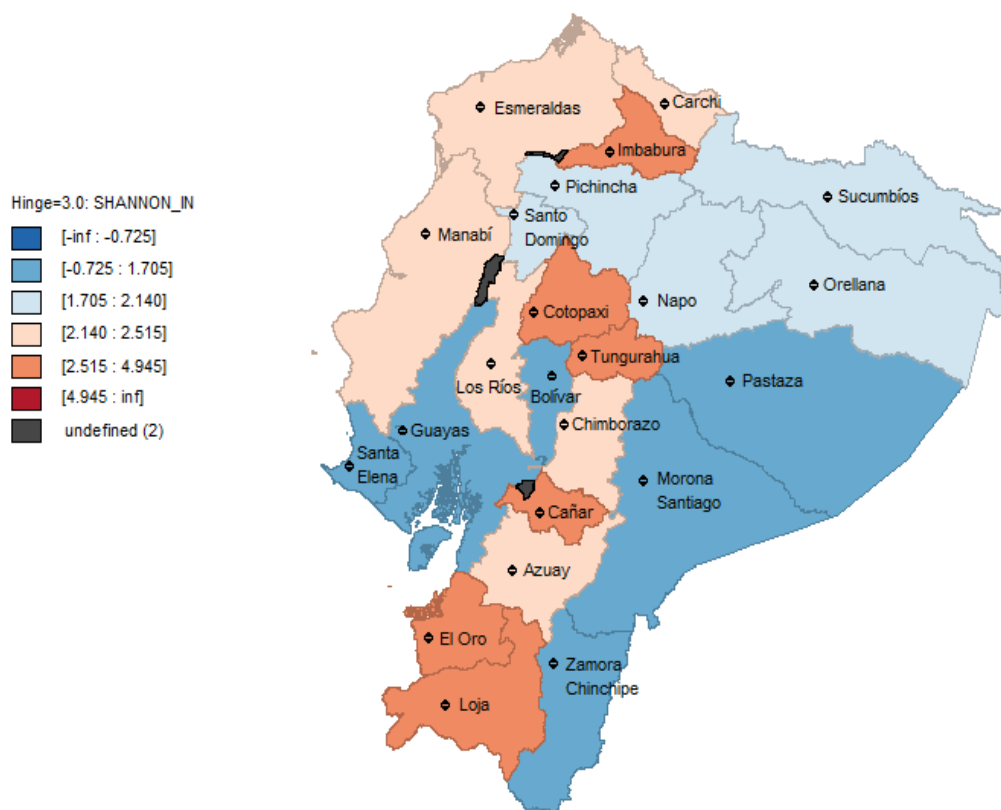


Figure 1. Shannon index by province. Source: [49].

4.2. Cartograms

As explained in the methodology, two-variable cartograms were carried out in order to view the relationships among each of the economic, social, and financial variables representing economic growth, and the Shannon index, which measures the agricultural land-use diversification in each province.

In GeoDa, cartograms were made for two variables. The circle's size represents the economic, social, and financial variables, and the circle's color represents the Shannon index. These circles are located according to the territory; each circle is located where the province is on the map.

Figure 2 shows that, although the provinces of Pichincha and Guayas have the highest amount of Gross Value Added (GVA) in Ecuador, their Shannon Indices are not the highest: Pichincha's is 1.91 and Guayas' 1.69, which are below the median of 2.14. Although the provinces' total GVA is high, this is probably not a factor increasing agricultural diversification.

Figure 3 shows that there are provinces with a high agricultural GVA (e.g., Los Ríos, which has a Shannon index above the median, which is 2.4; the province of El Oro is also highlighted with an index of 2.71, and it is one of the provinces with the highest GVA for agriculture in the country). This suggests that a provincial gross added value in agriculture could increase diversification.

Figure 4 indicates that families' average income does not differ much among the provinces. However, there are more provinces with a high average household income which also have a high Shannon index, as in the case of Cotopaxi, whose average income is 908.3 dollars, with a Shannon index of 2.62; Loja can also be highlighted, with an average income of 844.6 dollars, and El Oro with 834.2 dollars, whose Shannon indices are 2.56 and 2.71, respectively. This may indicate that a high average income can increase diversification.

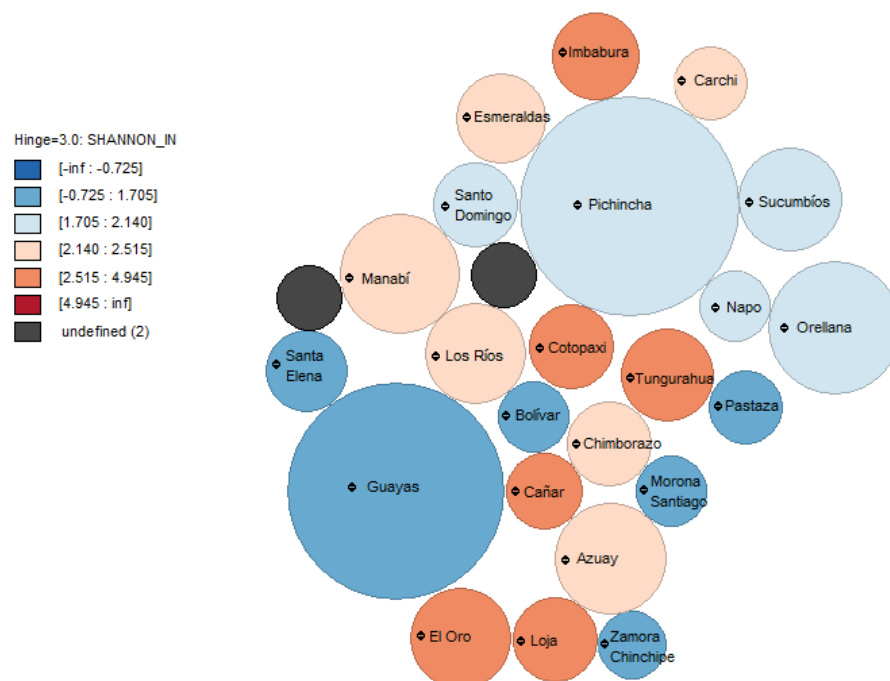


Figure 2. Relationship between total gross value added and the Shannon index, by province. Source: [49,50].

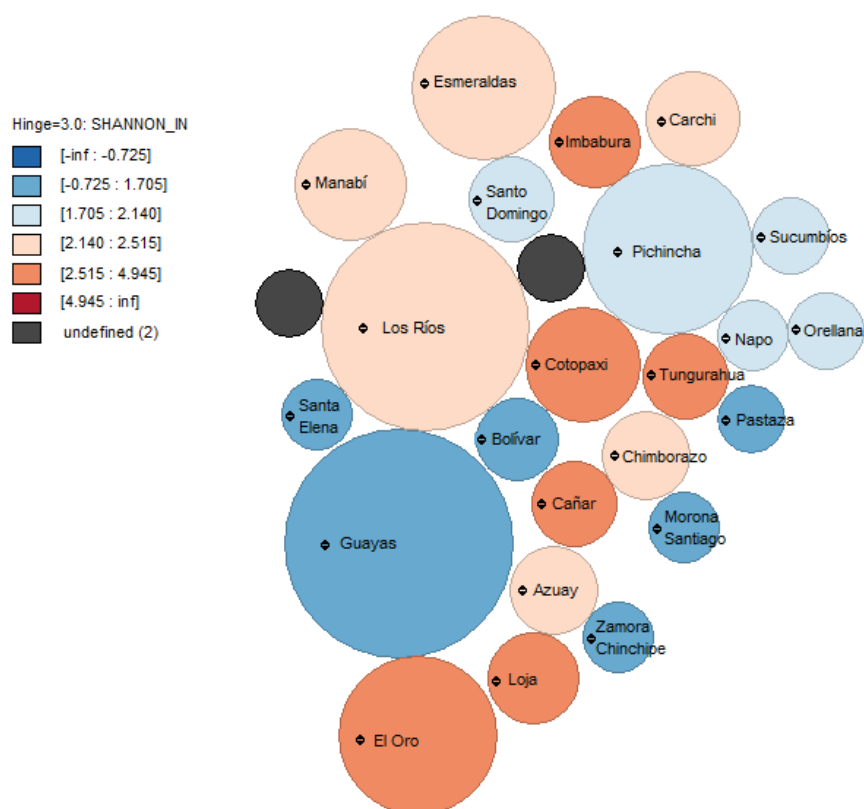


Figure 3. Relationship between gross value added of agriculture and the Shannon index, by province.
Source: [49,50].

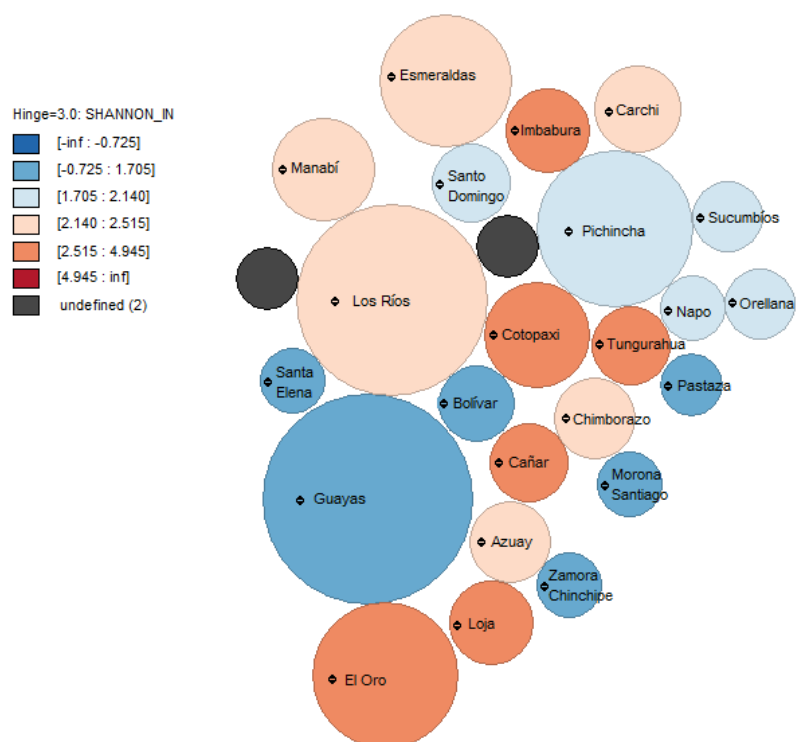


Figure 4. Relationship between average household income and the Shannon index, by province.
Source: [49,51].

Figure 5 shows that there are provinces with a high Economically Active Population (EAP), such as Pichincha and Guayas, whose Shannon index is not very high. Nevertheless, from a general viewpoint there are more provinces with a high EAP which also have a Shannon index above the median. This is the case of Manabí, with an index of 2.48, Azuay with 2.2, and Los Ríos with 2.4, among others. This could indicate that a higher EAP can help provinces reach greater diversification of their agricultural sector.

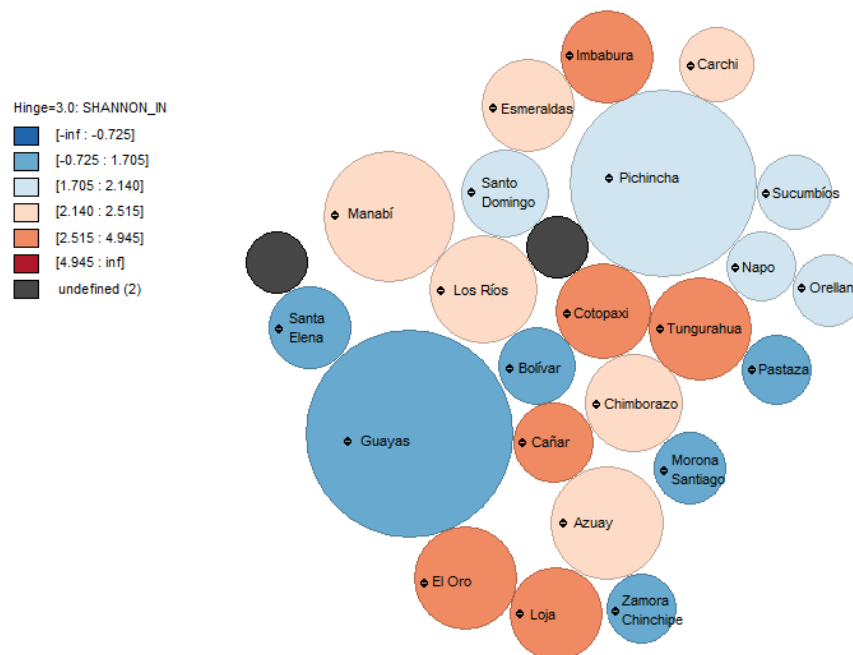


Figure 5. Relationship between the economically active population and the Shannon index, by province. [49,51].

Figure 6 shows no marked differences in the level of education among provinces, ranging from 7.2 to 11.5 years of schooling. However, there are more provinces with a high level of education, that have a somewhat low Shannon index, between 0.49 and 2.14, e.g., Pichincha and Guayas. In addition, Pastaza province has a high level of education (10 years of schooling), but their Shannon index is one of the lowest, 1.45. This could indicate that the level of education does not positively influence agricultural diversification.

Figure 7 shows more provinces with high unemployment rates and a somewhat low Shannon index, with values between 1.71 and 2.14. For example, this is the case of Sucumbíos, whose unemployment rate is one of the highest but has a Shannon index of 1.72; there is also the case of Santa Elena, whose unemployment rate is high but has a much lower Shannon index, between 0.49 and 1.71. Thus, it could be said that, as unemployment decreases, diversification opportunities will increase.

Figure 8 indicates that the provinces of Pichincha and Guayas, despite having the highest credit volume, do not have the highest Shannon indices (1.91 and 1.69, respectively). This indicates that credit volume is probably not a factor increasing agricultural diversification.

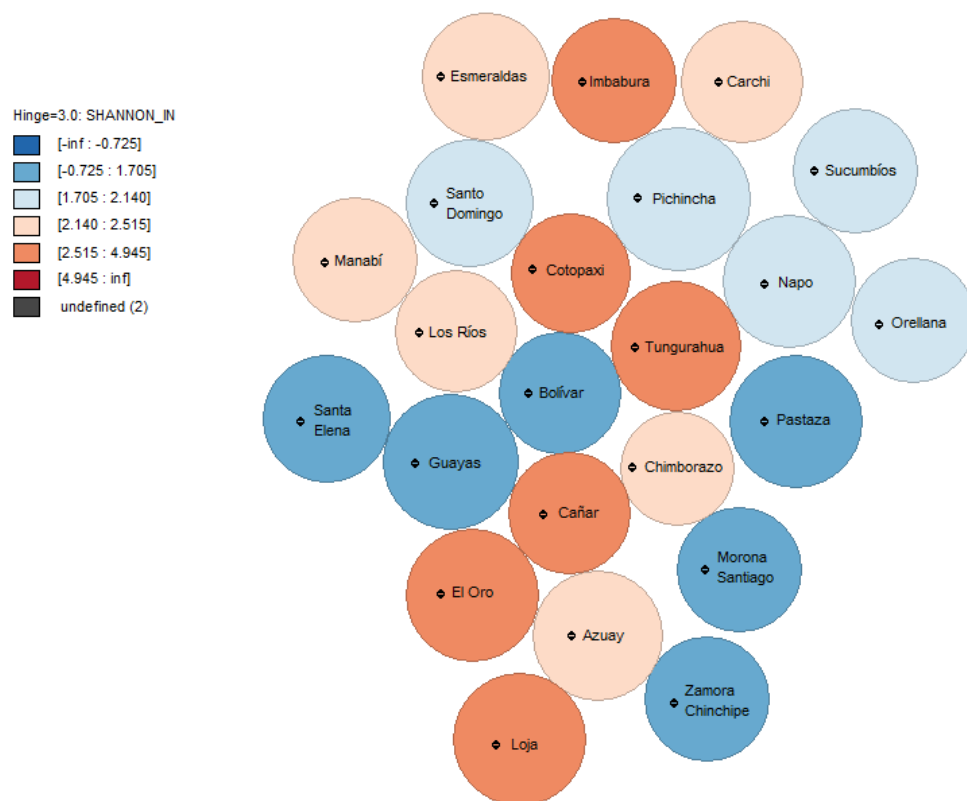


Figure 6. Relationship between the education level and the Shannon index, by province. Source: [49,51].

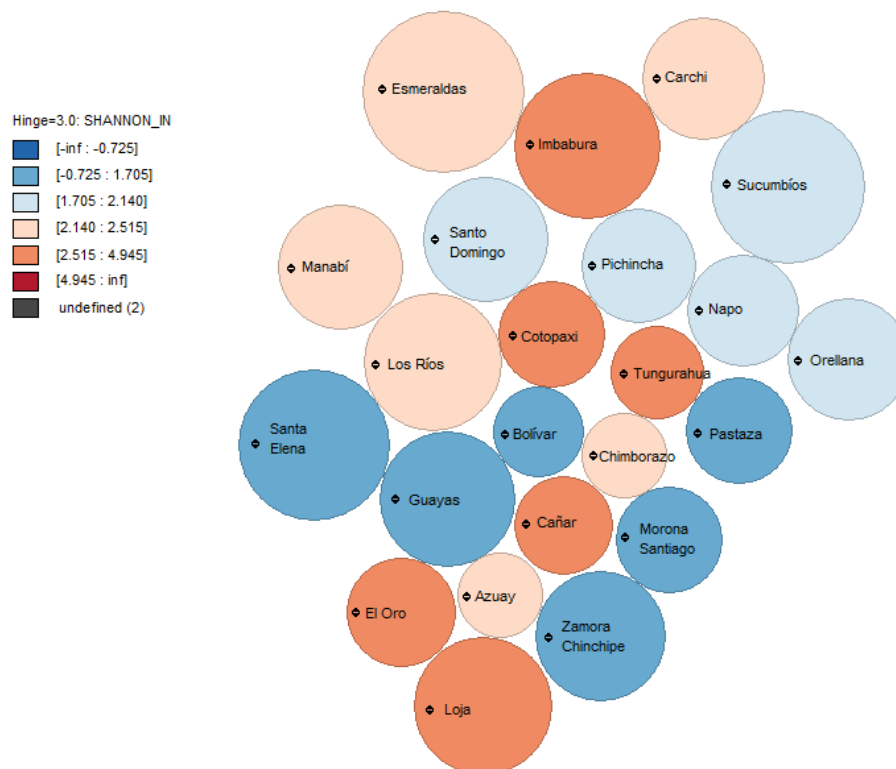


Figure 7. Relationship between the unemployment rate and the Shannon index, by province. Source: [49,51].

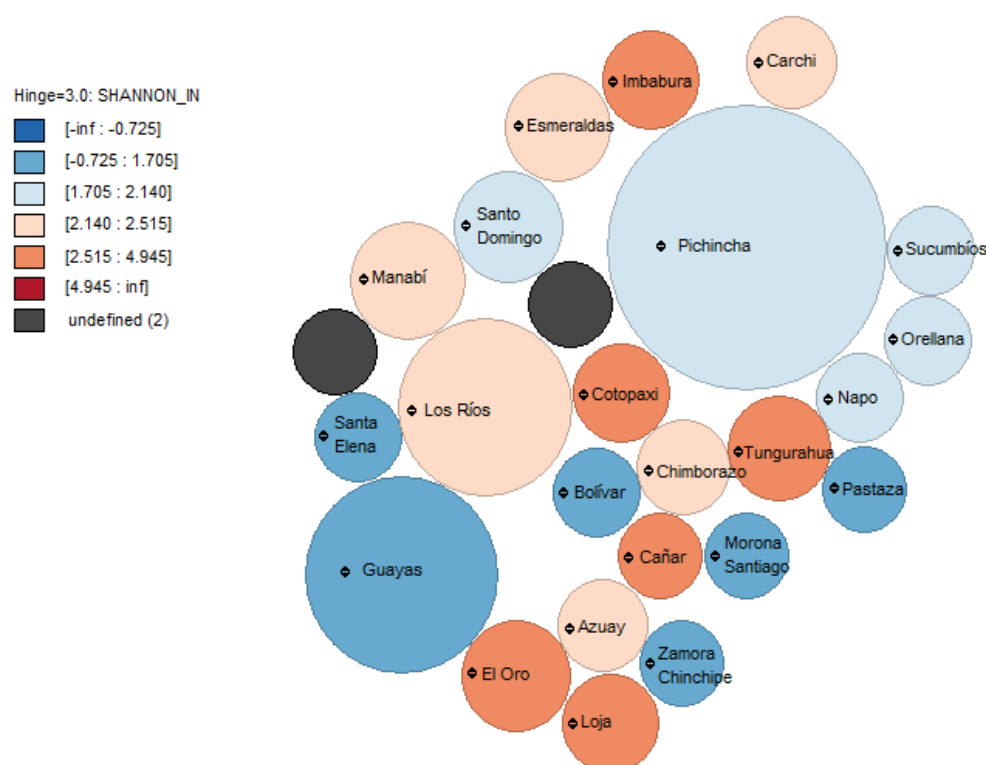


Figure 8. Relationship between the volume of credit and the Shannon index, by province.
Source: [51,52].

4.3. Association Indices

To clarify the vision of these cartograms, two indices of association were established to find the direct or inverse relationship of the study's variables with agricultural land-use diversification.

4.3.1. Pearson Correlation Coefficient

When applying the formula to find the Pearson correlation coefficient, the following results were obtained.

Table 2 shows the Pearson correlation coefficient applied to the study's variables. Several variables (gross value added, level of education, unemployment rate, and credit volume) have a negative correlation: while these variables increase, agricultural diversification increases. On the other hand, the variables that have a positive relationship with agricultural diversification are the gross added value in the agriculture sector, the average total household income, and the economically active population. This means that if these variables increase, agricultural diversification will also increase.

Table 2. Pearson correlation coefficient between the Shannon index and other variables.

Variable	Shannon Index
Gross added value	−0.066
Gross added value—agriculture	0.161
Average total household income	0.119
Economically active population	0.025
Education level (years of schooling)	−0.107
Unemployment rate	−0.177
Credit volume	−0.006

Source: 2017 database.

4.3.2. Covariance

To corroborate these findings, another index was applied to measure the degree of association among variables, yielding the following results.

Table 3 shows the covariance between the study variables, to verify what the correlation findings showed since the covariance results were the same.

Table 3. Covariance between the Shannon index and other variables.

Variable	Shannon Index
Gross added value	−231,802.16
Gross added value—agriculture	31,451.62
Average total household income	7.55
Economically active population	5,552.15
Education level (years of schooling)	−0.05
Unemployment rate	−0.13
Credit volume	−358,517.56

Source: 2017 database.

The covariance indicates that the total gross value added has a very strong indirect linear relationship with agricultural diversification; that is, if the provinces' gross added value increases, agricultural diversification could decrease.

By contrast, the gross added value of agriculture and agricultural diversification have a very intense direct linear relationship, because their covariance is very high in absolute value. This means that if the gross added value in agriculture is higher, diversification could increase as well. Regarding average total household income, this variable has a positive linear relationship with agricultural diversification; this indicates that, if incomes increase, diversification will probably increase as well. The economically active population also has a positive linear relationship with agricultural diversification, so the higher a province's economically active population, the greater the likelihood of agricultural diversification.

The level of education, on the other hand, has an inverse linear relationship with diversification; that is, the more years of schooling a province's inhabitants have completed, the lower the agricultural diversification. The unemployment rate also has an inverse relationship with diversification, which reveals that a decrease in the unemployment rate would have a positive effect on agricultural soil diversification.

Finally, we found that the credit volume has a strong inverse linear relationship with agricultural diversification, so that the greater the volume of credit in Ecuador's provinces, the lower the agricultural diversification would be.

4.4. Discussion of Results

The Pearson association indices and covariance indicated that there is a negative relationship between gross added value and agricultural land-use diversification. This could be explained because each province follows its own production process, which has traditionally defined its economic growth, expressed through the gross added value. Agricultural diversification as the basis of change in a province's productive process is very complex to carry out. This is mainly because it exhaustively uses production factors such as labor, land, and capital, especially in countries such as Ecuador, where farming technology is still basic. Therefore, as the total GVA per province increases due to its economic activities, agricultural diversification will probably be less likely. The empirical evidence presented by Foster and Jara [1] showed that a rich country would be less diverse in the agricultural sector because the marginal effect of per capita income on agricultural activity is negative and probably large, favoring activities that generate greater economic income, such as industry and services. In Ecuador, this is not necessarily because of a successful growth model, but rather because of the marginal agricultural cost implicit in changing the sector. On the other hand, the relationship between the gross value added

of agriculture only and the agricultural diversification expressed by the Shannon index revealed a positive relationship between the variables. Hence, if the GVA of agriculture in Ecuador's provinces increases, this might maintain the trend of expanding agriculture to increase income, so increasing diversification would enable provinces to increase their income. This diversification trend should be applied very carefully.

Basically, the increase in agricultural GVA through diversification does not imply accelerated agricultural marginal income. This is because there are several products which could have an adverse effect at first. Thus, it is first essential to understand this alternative growth through new opportunities on internal or external markets and, above all, from the perspective of sustainable development, making the best use of land. According to [8,10,22], diversification reduces the risk of economic losses caused by changes in both nature and the market, tending to increase diversification in the agriculture sector.

If we deepen the analysis of average total household income and its relationship with agricultural diversification, the positive effect between variables is probably because the higher a family's income, the greater their possibilities of diversifying to improve their production—for example, through buying a greater variety of seeds and investing in soil conservation. When families have a higher income, they can afford to diversify as a means to increase their agricultural yield. This could also be a very typical effect in rural areas, which throughout history have lived by farming. This could be clearly seasonal so, ultimately, if not managed sustainably with supportive public policies, there could be more damage than benefit.

It is no less important to analyze the positive relationship between the economically active population and agricultural diversification. This may be mainly because the more people who join the labor force, and the higher the agricultural investment, the greater the agricultural labor force's liberalization towards other sectors of the economy. More workers will need to find different forms of production to generate income and improve their quality of life. So, agricultural diversification is a reasonable option, as mentioned by [27], who explained that agricultural diversification in Mexico is closely related to income generation, since 80% of the households analyzed in the National Survey are diversified by reason of survival while the rest do so by accumulation.

Therefore, the agricultural sector will be neglected, and it will be difficult to implement diversification as a land-use protection mechanism and income generator, since these rural people are the ones who farm, but cannot afford to invest, including in education. As result, they start farming at an early age and have no chance to develop agricultural diversification. This finding agrees with [34] who, in his study conducted in the province of Linares-Chile, found variables that affect agricultural diversification both positively and negatively. The variables increasing greater diversification are: gender (if the producer is male), family size, agro-ecological zone, total hectares, access to credit, and technical advice. The variables negatively influencing diversification are: age, self-supply, social participation, and schooling—this last variable was the one analyzed.

An important sector for analysis is the labor market, where the unemployment rate and agricultural diversification have a negative linear relationship. This could be because agricultural diversification results from technological growth, which displaces the labor force toward other sectors of the economy, which are not prepared to absorb this extra labor, increasing the overall unemployment rate. A low unemployment rate indicates that people are working, either employed or self-employed, which in Ecuador's smaller provinces usually involves agricultural activities. So, the government could promote agricultural progress through diversification to take full advantage of the land's productivity and profitability, thus enabling increased employment.

Finally, credit volume negatively affects diversification. Not all provinces have the same availability of credit. For example, the credit volume in Pichincha far exceeds that of the other provinces'. An overall analysis suggests that this relationship does not reflect the true effect. There is little financial information on the agricultural sector, preventing any specific conclusion about the impact of increasing credit on the agricultural sector and its diversification. However, these overall

results are the best available indicator and contrast with those of [1,35] whose studies indicated that credit volume has a positive effect on diversification, since an adequate line of credit will benefit farmers, enabling them to earn income and increase diversification as a development mechanism.

Traditionally, Ecuador has been an agricultural country, so these types of studies are valuable to understand its dynamics and its possibilities for growth. This study revealed that diversification can be promoted by a number of variables, not only to generate alternative income. Rather, pursuant to the United Nations' proposal to achieve Sustainable Development, diversification should be one of the proposals to achieve efficient land management. It is imperative to discuss what policies should promote this proposal, since the diversification trend itself is positive. However, it is not necessarily based on sustainable social or economic improvement, as the results show. On the contrary, the third dimension of development proposed by the Brundtland Commission, addressed in Goal 14 of Agenda 21 on rural development and agriculture, stresses that local governments should promote diversified agricultural production models to support sustainable, environmentally-friendly agriculture [6].

Author Contributions: For this research the contributions were made as follows: Theoretical Framework: Jennypher Pacheco and Wilman-Santiago Ochoa-Moreno; Methodology: Jennypher Pacheco and Wilman-Santiago Ochoa-Moreno; Writing-Original Draft Preparation: Jennypher Pacheco, Wilman-Santiago Ochoa-Moreno, Jenny Ordóñez and Leonardo Izquierdo-Montoya; Writing-Review and Editing: Wilman-Santiago Ochoa-Moreno, Jenny Ordóñez and Leonardo Izquierdo-Montoya; Supervision, Wilman-Santiago Ochoa-Moreno.

Funding: “This research received no external funding” but we are grateful to the Private Technical University of Loja who facilitated the installations and the software to do it.

Conflicts of Interest: The authors declare no conflict of interest.

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