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Systemic analysis of the economic sustainability of family agricultural production units in a peasant community of Lebrija, Colombia

Análisis sistémico de la sostenibilidad económica de unidades de producción agropecuaria familiar en una comunidad campesina de Lebrija, Colombia

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Abstract

The complexity of the current problems in the Colombian countryside puts at risk the sustainability of family Agricultural Production Units (UPA for its acronym in Spanish). Consequently, it becomes a fundamental study area for the improvement of the rural economy. For this reason, a documentary, field investigation was developed on a case study located in Lebrija, Colombia, for the systemic analysis of economic sustainability in 10 UPAS promoters of sustainable agriculture. The results allowed to establish the effectiveness of the ES in the Characterization of UPAs. It was identified that the lack of investment in infrastructure and appropriate technologies has made the UPAs to allocate 50% of its total area for inadequate grazing. This distribution of land threatens the sustainability of the economy of local families, given that the production and profitability of livestock are not enough for their livelihood and the maintenance of pastures. The inadequate grazing generates large amounts of manure that pollutes the environment. The above affects the congruence between the productive activities and the philosophical principles of the UPAs.

Keywords: Rual development, systemic approach, organic surpluses, economic sustainability, compost.

Resumen

La complejidad de los problemas actuales del campo colombiano pone en riesgo la sostenibilidad de las Unidades de Producción Agropecuaria (UPA) familiares. En consecuencia, se convierte en un área de estudio fundamental para el mejoramiento de la economía rural. Debido a ello, se desarrolló una investigación documental y de campo sobre un caso de estudio ubicado en Lebrija, Colombia, para el análisis sistémico de la sostenibilidad económica en 10 UPAS promotoras de la agricultura sostenible. Los resultados permitieron establecer la efectividad del ES en la caracterización de UPAs. Se identificó que la falta de inversión en infraestructura y tecnologías apropiadas han hecho que las UPAs destinen más del 50% de su área total para el inadecuado pastoreo de bovinos. Esta distribución de la tierra amenaza la sostenibilidad de la economía de las familias locales, dado que la producción y rentabilidad de la ganadería no son suficientes para su sustento y el mantenimiento de los potreros. El inadecuado pastoreo genera grandes cantidades de estiércol que contamina el medio ambiente. Lo anterior afecta la congruencia entre las actividades productivas y los principios filosóficos de las UPAs.

Palabras clave: Desarrollo rural, enfoque sistémico, excedentes orgánicos, sostenibilidad económica, compost.

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1 Introduction

Farms located in La Cuchilla, municipality of Lebrija Santander, represent a group of family farm units (UPA by its acronym in Spanish), beloging to an association of peasant women called AMMUCALE (Díaz et al., 2011). Its owners promote protection of water, forests, ancestral knowledge, native seeds and food sovereignty, closely related to the principles of biocentrism, alternative economies (barter) and simple life expressed by the objectives of good living (Cubillo and Hidalgo, 2019; Huanacuni, 2010). Although they are a local example of responsible agriculture aligned with some Sustainable Development Goals - SDGs (UN, 2015) according to different studies (ONU, 2015) según diferentes estudios (Díaz et al., 2011; Amaya et al., 2018; Cruz et al., 2018), they experience the problems of the Colombian rural sector.

The distribution and possession of the land shows that 70% of Colombian UPA have less than 5 ha (DANE, 2015), limiting the production capacity of farms (Kalmanovitz and López, 2003). Similarly, issues such as investment in machinery, infrastructure, irrigation systems and technical assistance remain below 15% (DANE, 2015), while the use of artificial fertilizers is 2.83 times higher than the South American average (Banco Mundial, 2019a).This makes it difficult for farmers to keep their production costs stable and puts their economic sustainability at risk.

Since 1950s efforts have been made to improve the conditions of agriculture through development plans (Kalmanovitz and López, 2003), but the results have shown an increase in the inequality gap between the countryside and the city with a Gini (Banco Mundial, 2019b) of 0.45 (DANE, 2019). Some research (Arias et al., 2008; Ruiz and Oregui, 2001), state that one of the main reasons is that agro has traditionally been observed from a reductionist approach, which results in a limited view of the problems. In response, some authors (Bistagnino, 2011; Capra, 1996; Meadows, 2008; Rovaletti, 1989) point to the need to change to a systemic approach – SA for the analysis of complex situations, where different applied research has validated SA for the design of decision-making models (Stamberg, 2015) and sustainable production (Barbero and Toso, 2006).

According to the above, the main objective of the study is to carry out an economic systemic analysis of sustainability in 10 UPA which promote sustainable agriculture. To this end, the specific objectives are proposed: (1) to carry out a systemic analysis of the UPA in relation to the territory based on Bistagnino (2009) Sistemic Desing methodology, (2) to carry out a detailed review of the economic results in terms of production and profitability and (3) to identify systemic problems and their potential opportunities for improvement.

2 Materials and Methods

The data collection through primary and secondary sources, systemic analysis and data interpretation was carried out between May and December 2019 on the basis of a case study, using a qualitative and quantitative analysis.

2.1 Case study

The study area is located in the rural area of the municipality of Lebrija-Santander, north-west of Colombia. In this region, 80% of its inhabitants depend on agricultural activities, mainly from pineapple, Tahiti lemon and cocoa crops. 84.27% of UPA have less than 20 ha (Alcaldía de Lebrija, 2016), as shown in Figure 1. The farms of the territory have approximately 20 ha, whose productive activities are specially based on the cultivation of citrus fruits, vegetables, cocoa and cattle grazing.

Criteria such as: Land extension, crop types, livestock activities, location and sustainability were used for the selection of the case study. 10 UPA located on La Cuchilla vereda were selected, headed by "Tierra Buena" farm. Its managers are women, who are head of the hosehold and belong to AMMUCALE and who are a representative sample of the association.

The selected UPA in this area conduct productive processes that add value to their products. 100% of cocoa is transformed into chocolate and pig feces are used for generating gas from biodigesters. Its income is diversified through 5 livestock and 8 agricultural activities, traded under fair trade practices (Díaz et al., 2011; Amaya et al., 2018; Cruz et al.,

2018). In addition, "Tierra Buena" farm leads the agroecological processes of the area, given its experience at AMMUCALE and the human vision of its owner.

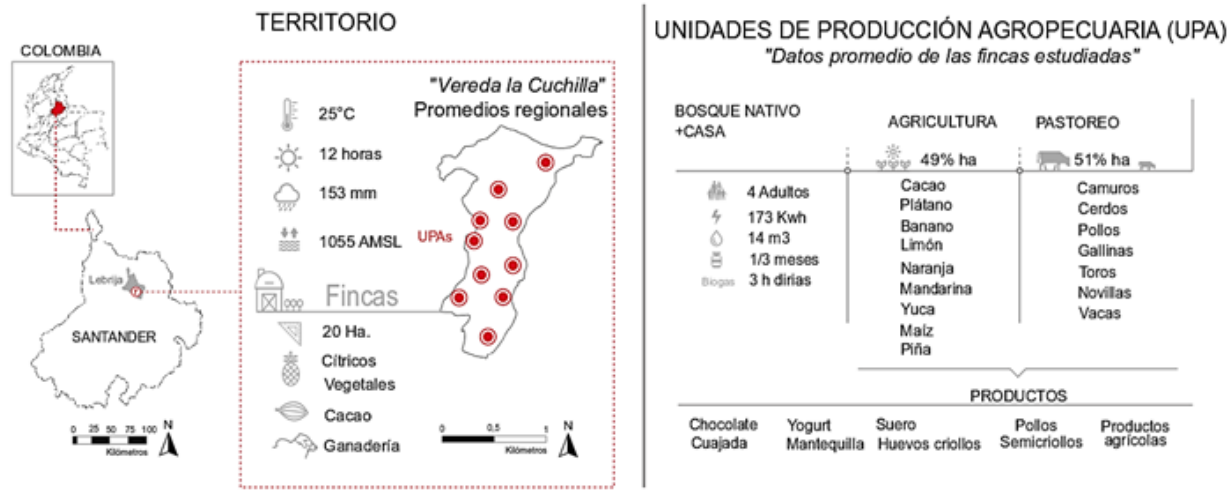

Figure 1. Territory averages and UPA based on Alcaldía de Lebrija (2016) mayor office data.

2.2 Methods

2.2.1 Systemic analysis

SA was applied according to the methodology suggested by Bistagnino (2011), which consists on the analysis of the territory, actors and systems at the different levels (Ceschin, 2014), seeking to identify and characterize quantitatively and qualitatively the inputs, processes, outputs, economic problems (Barbero and Toso, 2006; Bertalanffy, 1968; Bistagnino, 2011; Capra, 1996; Carrá, 1961; Garciandía, 2011; Johansen, 1993; Meadows, 2008; Stamberg, 2015; Rovaletti, 1989) and leverage points (Meadows, 1997) for the improvement of sustainability according to James (2015).

In the first stage, the analysis of the territory was carried out by reviewing secondary sources (articles, books, gray literature, official websites) to obtain data on the cultural, geographical and productive characteristics of the agro.

In the second stage, the analysis of the actors was carried out using a semistructured interview as an instrument of data collection, which was applied to 42 people directly involved in the agricultural activities of the case study, such as their owners, their children and their spouses. The analysis categories correspond to the economic dimension of sustainability based on James (2015), agricultural production, the family economy and transformation processes of raw matter.

In the third and final stage, observation was used as an instrument for the characterization of subsystems; and the system map was used as a tool for structuring and understanding the data (Vargas et al., 2020; Vezzoli et al., 2014). Finally, due to the heterogeneity of the data obtained by SA, three experts in responsible production, ethnobiology and fair trade were interviewed, who provided their interpretation of the results related to agroecology, social structure and informal agricultural trade in the case study.

2.2.2 Analysis of the economic dimension of sustainability

For the analysis of the economic dimension, the profile questionnaire designed by (James, 2015) was adapted, which consists of 49 questions distributed equally on seven topics related to: 1) production and allocation of resources, 2) exchange and transfer, 3) accounting and regulation, 4) consumption and use, 5) work and welfare, 6) technology and in-

frastructure, 7) wealth and distribution. The interview was applied to the owners of the farms, their spouses and their children older than 18, for a total of 42 people. The response options aimed to understand the interviewees' perception of each of the seven topics presented, who in each question chose a single answer that ranged from critical, bad, very dissatisfied, dissatisfied, basic, satisfactory, very satisfactory, good and excellent, which were tabulated in an Excel table and were assigned a value from 1 to 9, where 1 is critical and 9 is excellent. The answers were averaged to obtain the perception of the 49 questions. Subsequently, average satisfaction was calculated for each of the seven topics addressed. Finally, the overall perception of respondents about the economic sustainability of their families was calculated. The results were plotted to observe the levels of the seven themes.

2.2.3 Economic axis profitability analysis

A quantitative approach was applied, which focused on the economic value of goods produced in the UPA. To this end, information was collected on the production of microsystems based on money, and was registered in calculation tables. Economic capacity was assessed by means of net present value (NPV) (Stamberg, 2015), which was found by the formula (1).

$$\text{VAN} = \text{PB} - \text{CI} - \text{D} \quad (1)$$

Where PB is the gross production of UPA in Colombian pesos; CI is the intermediate consumption or the cost of the inputs acquired; D is the sum of the depreciation of the machines, equipment and facilities used in the production of goods and services.

In addition, the agricultural profitability (AP) was found, which allows to know the performance of the business after paying wages (S), bank interest (J), leases (T) and taxes (I) (Stamberg, 2015), thus having a realistic view of the final benefits received by families. For the calculation of AP, Stamberg (2015) formula was applied (2).

$$\text{RA} = \text{VAN} - \text{S} - \text{J} - \text{T} - \text{I} \quad (2)$$

Formulas were applied according to the two activities conducted in the UPA. The first covers all agricultural activities; the second covers livestock activities only. The data were tabulated and analyzed in Excel, where a descriptive analysis of the variables was performed, the formulas were applied and average totals were obtained by type of activity.

3 Results

3.1 Problems identified by SA

By using SA during field observations, it was observed how resources move through the productive systems of the UPA at the micro level; this allowed identifying five common problems in the farms studied, three of them related to inputs, one to processes and one to outputs, problems that are considered a threat for the achievement of a sustainable rural area (Figure 2).

In the inputs, three situations were found whose impacts are negative for the sustainability of the farms studied. The first is related to the lack of fertilizers. Although the owners do not use agrochemicals, the use of organic fertilizers was not evidenced, which in the long term could create agricultural production problems due to the decrease of nutrients in the soil. The second is related to the low profitability of farms, since economic income is not sufficient to cover costs and family needs. The third is based on income outside agricultural production. In 8 out of the 10 UPA studied, most of the economic income comes from urban employment of spouses and children. The latter is beneficial to the household economy, but in the long term it could displace these families into urban areas in search of better opportunities.

Problems related to the maintenance of UPA were identified during processes, specifically in paddocks. It was evidenced that in 7 of the 10 UPA studied, the use of the exclusive soil for cattle grazing is higher than 50%; however, dairy production and the sale of animals do not generate sufficient income to cover the maintenance costs associated with the restoration of posts, fences, the payment of taxes, vaccines, food, among others. Although La Cuchilla is an area that combines agricultural activities with livestock, it was evidenced that the number of specimens corresponds to 1 animal per 1.5 ha in the farms studied.

In the outputs, a problem related to organic surpluses and the environment was evident. From field

observations, it was identified that livestock manure, cocoa pods, household waste water and some wastes have inadequate disposal, thus being a source of environmental pollution. In the case of livestock manure, it was identified that approximately 219.55 t of manure is generated every seven months in the farms studied, which are distributed to the animals without any management. Similarly, during the months of surplus measurement, it was observed that cocoa production generated 53.9 t of pods, which accumulated in piles within the crop and did not receive adequate management. Similarly, it was identified that household wastewater is discharged into the environment without any type of decontamination treatment, the figure of which is unknown due to the lack of aqueduct, accountants and sewerage in the area; but considering the Colombian average consumption per family (EPM, 2020) it is estimated to be about 115.5 cubic meters per household monthly. Finally, it was evidenced that inorganic surpluses such as plastic bags, food wraps, toilet paper, among others, are incinerated by some families, because the urban garbage service does not provide its services in rural areas. Therefore, it was not possible to estimate the pollution level that this practice generates, however, it was considered as a relevant pollution source to be mentioned in the SA results.

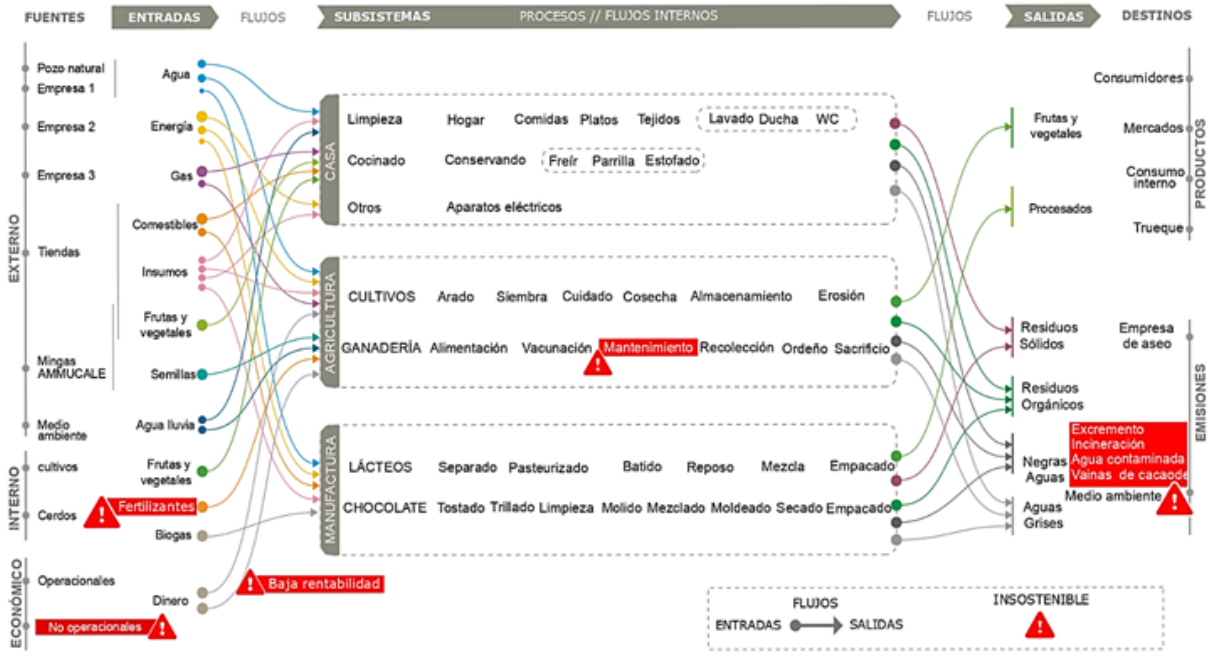

Figure 2. Analysis from the current UPA System Map. Alert symbols show identified sustainability issues.

3.2 Analysis of economic sustainability of UPA

By applying the adaptation of Profile Questionnaire by James James (2015), it was identified that the perception of families toward the economic sustainability is at a basic level. However, by looking at each of its edges, it is possible to note that some of the themes that make up this dimension are at lower levels. As shown in Figure 3, one of the main shortcomings of the UPAs studied and thais is found at a bad level is their lack of accounting strategies and regulation, a subject which, according to the interviewees, makes it difficult to know the amount of money of the family economy and the transparency in how it is used. Likewise, this lack of accounting knowledge prevents families from designing medium and long term plans, limiting them to short term economic exploitation. For its part, the technology and infrastructure edge has a very unsatisfactory level, mainly due to the lack of

endowment and availability of these tools and the proper adaptation of the current infrastructure focused on sustainable development; in other words, the peasants surveyed believe that they have not been able to access new technology or improve the technology they currently possess.

Likewise, according to the results of the interview, edges 7 and 2 related to wealth and exchanges were placed at unsatisfactory level, which implies an informality of people about the opportunities for trading. Finally, edges 1, 4 and 5 related to production, consumption and employment were positioned between the basic and very satisfactory levels.

This means that interviewees have a normal to positive perception of these three issues, mainly because of the work that their owners have done with AMMUCALE for more than 20 year and that has promoted the diversification of production, responsible consumption and the commitment of young people to the countryside.

Figure 3. Profile of economic sustainability of UPA, adapted from (James, 2015).

3.3 Profitability of UPA

The calculation of the net value added and agricultural profitability of each of the UPA studied was carried out to know the economic dimension of sustainability. As can be seen in Figure 4, the results identified the most and least productive activities, as well as the profit generated according to the space required by each.

Although the municipality of Lebrija is not a cattle zone, about 56% of the soil in the UPA studied is used for breeding, in which few animals per hectare are maintained. The sale of cattle is not the most representative economic activity, as cattle are used mainly for the production of milk and dairy products such as yogurt, curd, butter and cottage cheese; instead, cattle is seen as a source of capital savings. Figure 4 shows that the most income-generating livestock activity is pig rearing, followed by the sale of chicken and the marketing of milk. On the other hand, livestock generates an average income of $480.000 per UPA per year, occupying the sixth place in livestock activities and eleventh in general.

In this area, manufacturing projects have been promoted to add value to raw materials, such as chocolate and dairy products. In this regard, chocolate contributes the most to the family economy, reason for which cocoa is transformed and only about 2.831 lbs are sold in grain. Although production by activity and land use makes it possible to understand some aspects of the local economy, it does not fully reflect the reality of households. Table 1 shows the profitability (AP) results, which after subtracting the costs associated with each production system allows identifying how much money the UPA receives and how much is the contribution per hectare according to its use.

The results shown in Table 1 correspond to the average values of the 10 UPA studied. As can be seen, the activities derived from agricultural production have an average NVA of $19'988.115 and an AP of $13'146.944, i.e. profitability per hectare of $4'537.427. However, livestock activities, including livestock and livestock derivatives have an average profitability per hectare of $497.365.
In 8 of the 10 UPA studied, the area used for breeding was greater than the area used for agricultural crops. Despite having more space, the economic benefit received by the family unit as a result of livestock activities is $3'098.579 pesos a year, much lower than the one generated by agricultural activities. This is mainly due to the livestock space and the costs related to food and vaccines that other animals require for their development. On the other hand, it is observed that agricultural activities, including the transformation of cocoa into chocolate, generate an average of $13'146.944 a year, being the main source of income of families in the area.

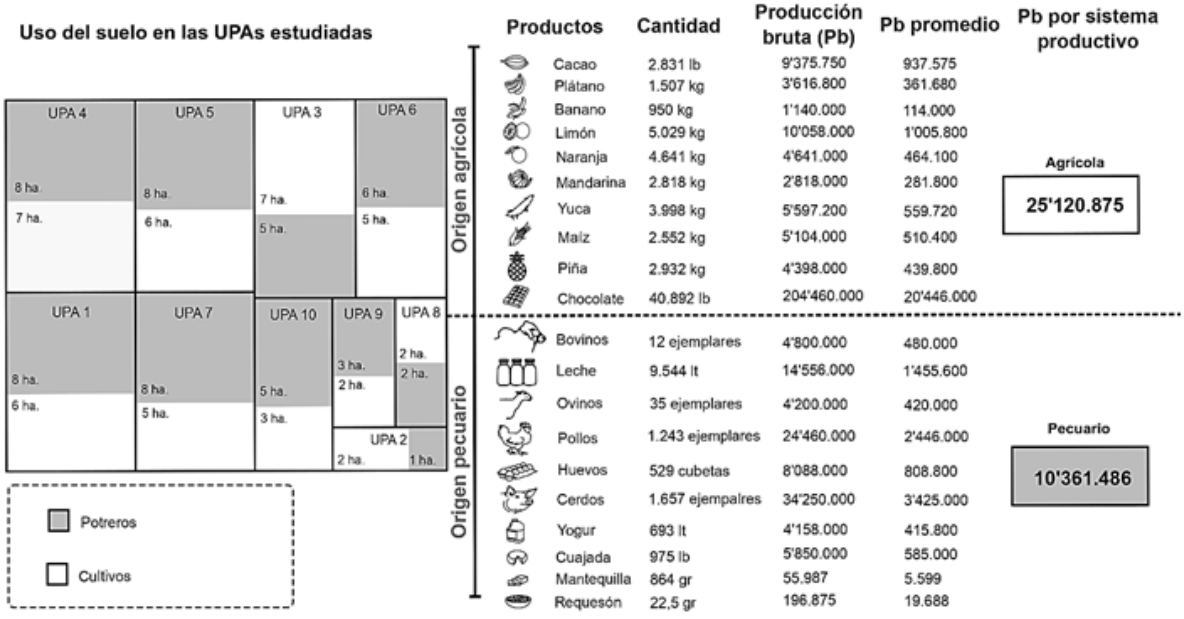

Figure 4. Use of the soil and gross production (Pb) in the UPA studied.

4 Discussion

4.1 SA for analyzing UPA

SA allowed a holistic understanding of the economic situation and the identification of problems associated with the incorrect management of cattle manure and cocoa pods in UPA. This information is based on other research such as Steinfeld et al. (2009) who say that these materials pollute the environment. In addition, Sosa and García (2019) claim that bovine manure produces greenhouse gases and Pinos et al. (2012) and Steinfeld et al. (2009) state that this surplus generates micro and macro nutrients that negatively affect soil and aquifers.

Likewise, SA allowed to identify philosophical differences between the activities carried out by the UPA studied and the principles they claim on sustainable agriculture and environmental protection. This is similar to the results published by Jagustović et al. (2019), in which a community of women farmers in Doggoh-Jirapa, northern Ghana, identified using SA transdisciplinary elements that contradicted their Climate-Smart Agriculture (CSA) principles and allowed them to design improvement strategies. SA also allowed to identify organic surpluses such as cattle manure, cocoa pods and other plant elements that can be exploited by the peasants of the

region in the processing of vermicompost, which is rich in microorganisms (Asadu et al., 2019; Barbero and Toso, 2006; FAO, 2013).This is beneficial for crops because it contains large amounts of nitrogen-fixing bacteria that improves water retention, biological health and soil absorption capacity, storm-water use, enzymatic activity, presence of nutrients, among others (Agegnehu et al., 2016; Argaw, 2017; Rayen et al., 2006; Sharma et al., 2017; Wang et al., 2016), which could become an opportunity to identify pollution problems and to support the development of responsible and sustainable agriculture.

Table 1. VA and AP of the UPA studied

Productive system	Agriculture	Standard deviation	Livestock	Standard deviation	Total of agriculture and livestock
Average Area[1]	4.4	2.2	5.5	2.5	9.9
GP[2]($)	25'120.875	9'373.321	10'361.486	9'826.465	35'482.361
IC[3]($)	3'767.440	1'947.897	6'990.960	6'573.668	10'758.400
GVA[4]($)	21'353.435	7'730.943	3'530.526	3'654.294	24'883.961
DEP[5]($)	1'365.320	444.647	720.870	572.091	2'086.190
NVA[6]($)	19'988.115	7'775.486	2'809.656	3'192.752	22'797.771
DVA[7]($)	6'841.171	5'881.390	366.301	183.605	7'207.472
AP[8]($)	13'146.944	7'340.709	2'443.355	3'098.579	15'590.299
NVA/ha[9]($)	5'869.556	3'220.220	433.122	500.289	6'302.678
AP/ha[10]($)	4'537.427	3'659.267	368.037	497.365	4'905.464

[1] **Average area:** In hectares (ha).
[2] **GP:** Gross production
[3] **IC:** Internal consumption.
[4] **GVA:** Gross value added
[5] **DEP:** Depreciation
[6] **NVA:** Net value added
[7] **DVA:** Other topics related (wages(S), bank interests (J), leases (T), taxes (I)).
[8] **AP:** agriculture profitability
[9] **NVA/ha:** Net value added per hectare
[10] **AP/ha:** Agricultural profitability per hectare

4.2 Economic dimension of sustainability in rural communities

At this point, the study aims to open a debate based on land use and the values of NVA and AP, which suggest the potentialization of agricultural activity over some livestock activities such as cattle. This is similar to the proposal ofStamberg (2015), who advised the potentialization of one activity and the elimination of another based on the results of NVA and AP.

As can be seen, the AP of the livestock system, in the way livestock is currently developed in the UPA studied and compared to agricultural activities, does not generate sufficient income to benefit families; for this rason, it is suggested to continue researching on sustainable ways to use the soil in the rural area, considering topics such as crop diversification, the amount of cattle per hectare and the use of paddocks (Rojas et al., 2013). The latter is based on Fernández et al. (2016) proposal on suitable paddocks that facilitate the management of excreta.

The above also suggests the need to create a complete system of organic surplus management that allows the use of bovine manure, cocoa pods and other plant surpluses through composting processes. For this reason, it is necessary to conduct studies focused on the design of adequate infrastructure and advice on the handling of these materials.

This research is expected to be a tool for the decision-making of the owners of the UPA studied to improve their net income, boost their economic independence, empower them, strengthen their identity and their commitment as peasant women (Botello and Guerrero, 2017); it also serves as the basis for future research related to sustainable rural development and economy.

5 Conclusions

The research provides information on the application of SA to analyze UPA, because this approach concentrates in the flows and their interaction with the actors involved, which allowed to identify the lack of advice on sustainable practices. Also, some limitations inherent in this approach are recognized, since it requires the collection of large amounts of information, and therefore it needs a lot of time, resources and expert advice in multiple disciplines.

The lack of organization and accounting records do not allow the owners of the UPA to know the way the money flows in their businesses, and it is considered a constraint to design improvement plans and strategies, since it normally requires the economic resources that peasant families do not have; moreover, the lack of public investment and the difficult access to credit reduce the possibilities of peasants in obtaining technology, appropriate advice and infrastructure.

Finally, it is concluded that land use in Colombia is a problem observed in the productive distribution applied by the family UPAs, where most of the area is used for cattle grazing, which may have 1.5 ha approximately per animal. The development of sustainable agriculture requires the promotion of efficient methods to improve the family economy and to reduce the gaps in inequality between the countryside and the city to guarantee the increase of agricultural land as a food security strategy for the sustainability of future generations.

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