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Socio-economic factors affecting the use of non-timber forest products in swine production in the Colombian Amazon

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ABSTRACT

In view of the difficulties present in the swine production system to achieve sustainable productivity based on the comparative advantages and potential of the territory of the department of Caquetá, located in the natural region of the Colombian, the aim of the study was to analyze the socioeconomic factors that may influence the use of non-timber forest products (NTFPs) in live-stock feed. For this purpose, the study was carried out with a descriptive-transversal methodology with a non-experimental design and quantitative approach, where the survey was applied to 44 swine production units through a non-probabilistic method. The data were systematized using R software; a principal component analysis was performed and the degrees of relationship of socio-economic factors with the use of NTFPs in animal feed. It was concluded that despite being in a biodiverse territory, social factors related to the level of knowledge about NTFPs and economic factors linked to sources of financing are directly proportional to the degree of NTFP use in swine production in the department of Caquetá. Although NTFPs are found in most production systems in the region, they are not used for animal feed.

Keywords: Amazon region, NTFP, Socio-economic factors, Sustainable productivity, Swine production

INTRODUCTION

Swine activity in Colombia for 2019 reported a growth of 8.8% with a production of more than 4 million tons of pork, distributed in 232,000 lands, assembled in 3,000 farms and with 56 establishments approved by the National Institute of Food and Drug Surveillance (Ortiz *et al*, 2019).Of the total production, 60.9% is produced in technified farms and the remaining 39.1% are backyard animals (Trujillo *et al*, 2019). The producing areas that participate with 63% are assembled in the departments of Antioquia (4.2%), Cundinamarca (17.3%), Valle del Cauca (15.1%), Eje Cafetero (8.7%) and Meta (7%) ; the rest of the country contributes 37% of the national production. Sustaining this production has required the import of raw materials for the production of animal feed, 580 thousand tons of corn, 350 thousand tons of

soybeans (Ministry of Agriculture and Rural Development, 2019). This situation puts Colombia at a disadvantage with other producing contries, due to the fact that the predominant swine production system in Colombia presents different problems: *i)* it is developed on a small scale, *ii)* it has deficient production levels, *iii)* its technological appropriation is insufficient and *iv)* the high costs of inputs for the manufacture of feed needed for the production phase (Muñoz-M, 2015).

Pig farming in Colombia moves $2.6 trillion a year in terms of production and has a share of 1.4% of agricultural GDP and 4.8% of livestock GDP, according to a report presented by Ministry of Agriculture and Rural Development (2020). Although the production of pigs grew, it is not enough to supply domestic demand, increasing imports, reaching 114,000 tons of pork (Ministry of Agriculture and Rural Development, 2020).

In this sense, in the structure of a pig production cost, feed represents between 65% and 70%, where the growth-finishing stage reaches more than 70% of this percentage (Lizardo *et al*., 2002). With the growth of production, the consumption of balanced feed based on feed elaborated with an important ingredient which is corn increases, feed required for pigs because of its contribution as a source of energy and protein (Velayudhan, 2015). During 2019, Colombia presented an approximate consumption of 580 thousand tons of corn, 350 thousand tons of soybean and 1 million tons of concentrate feed to produce 446,602 tons of pork meat (Ministry of Agriculture and Rural Development, 2020).To guarantee good levels of profitability and competitiveness, it is necessary to look for feed alternatives that reduce the high costs represented by the purchase of corn and soybean, which make small-scale swine production unfeasible (Silva *et al*, 2018).

In Colombia, non-timber forest resources (NTFP) are found in great diversity and with potential to be used as raw materials for animal feed (Gonzalez *et al*, 2017). The work carried out by Bessada *et al*. (2019) indicated that the woody perennial fodder plants have been used by different authors highlighting the nutritional quality due to the great contribution of protein and high levels of digestibility, indicating that a high potential in animal feed.

The implementation of sustainable and innovative strategies that contribute to agricultural productivity and planning, which may have a direct relationship with education, training, the organizational structures of the community, and the financial capacity of the same. (Forero *et al*., 2013). Where, it is possible to highlight the generation of social capital for access to markets by the hand of agribusiness and the strengthening of governance (Freitas, *et al*., 2021), which, if not addressed, would cause production systems to present difficulties in the supply of food. Quality and efficient food due to the availability of the ecosystem resources of the territories (Hanisch *et al*., 2019).

From the same perspective, it is stated that the agricultural production systems derive from the non-use of the forest potentialities and another biodiversity of the territory in the low social conditions, the absence of projects for the use of natural resources, the ignorance of the cosmovisions of the population, as well as the lack of economic capital for productive modernization (Hernández *et al*., 2017). Furthermore, there is a high relationship between the use of non-timber forest resources with sex, age, family composition, the importance of the forest, and the productive infrastructure of agricultural systems. (Mushi *et al*., 2020; Walle and Nayak, 2020)

Therefore, the objective of this research was to analyze the socioeconomic factors that affect the use of NTFP as a food supplement in swine production systems in the natural region of the Colombian Amazon. Regions of high biodiversity effective in promoting the sustainability of the territory and the orientation of public policies in rural management from small rural producers and bioeconomy models around the forest. (Ao, *et al*., 2021; Piplani and Smith, 2021).

MATERIALS AND METHODS

In order to achieve the proposed objective, a methodological design was implemented according to the guidelines of Hernandez *et al*., (2018), which was descriptive transectional in scope, where information was collected through a structured survey of 44 units swine production distributed in the municipalities of San Vicente del Caguán (25 units), Cartagena del Chaira (03 units), Albania (5 units), Puerto Rico (08 units) and El Doncello (03 units) belonging to the department of Caquetá (Figure 1). These units were selected using a non-probabilistic method based on selection criteria established by the descriptors of the respective research variables and the characteristics of the small producers.

The selection criteria for the lands were: a) swine production systems, b) the land has at least one (01) ha-1 of forest area, c) 70% of the income comes from agricultural activities, d) 80% of the assets are destined to the development of agricultural activities, and e) Minimum 5 years of experience in the development of agricultural activities.

The data collected from the surveys were systematized around four (04) fixed factors about theNTFPs , which are related to 10 social factors and 42 economic factors that were analyzed from a quantitative approach. Principal component analysis (PCA), using the statistical package "FactoMineR" (Husson *et al*., 2016) and the "factoextra" package (Kassambara and Mundt, 2017) were used to group the dimensions of the respective factors. In the PCA performed for the social and economic factors, only those that presented a significant contribution with a percentage of variance explained greater than 10% of the components were selected (Table 1), which gives 22 economic factors and 10 social factors.

Next, the correlation matrix was constructed to jointly analyze the incidence of the social factors and the economic factors selected in the PCA on the fixed factors that affected the use of the NTFP. Pearson's correlation test (p-value > 0.05) was used for this purpose using the statistical package "corrplot" (Wei and Simko,

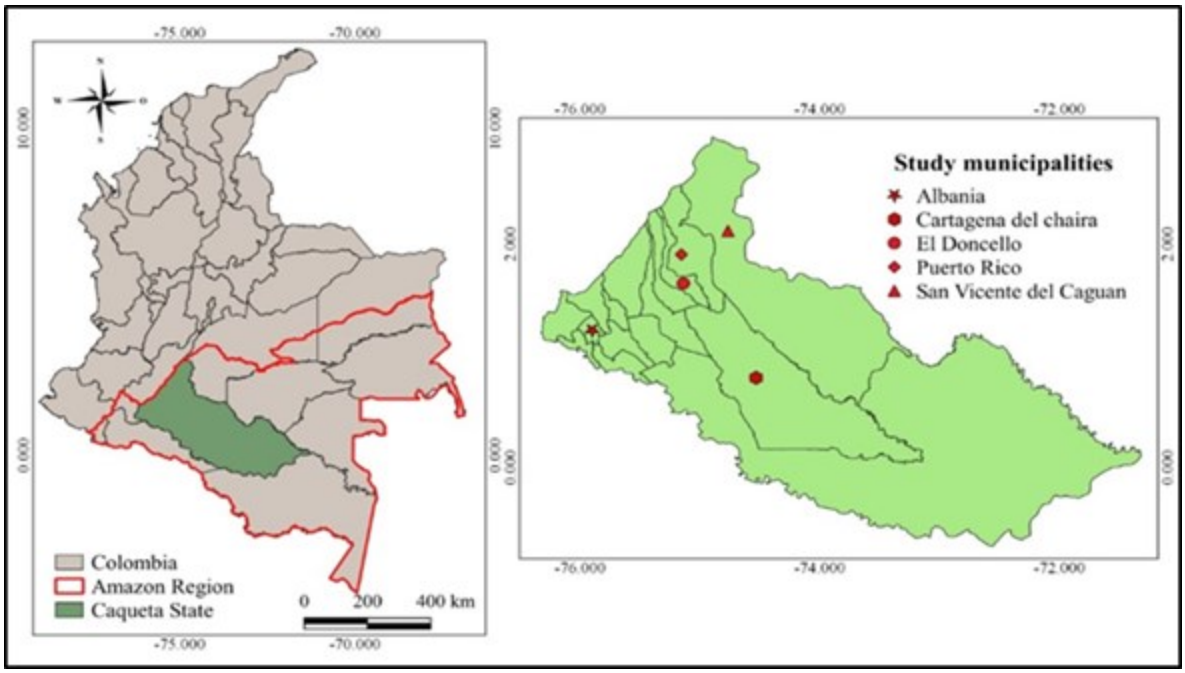

Figure 1. The observation unit of the study was the department of Caquetá located in the natural region of the Colombian Amazon, where five municipalities that concentrate the highest livestock production are prioritized. *Source: Own data from ArcGIS.*

Table 1. Fixed and Socioeconomic Factors of the Swine Production System

Code	Economic Factor	Code	Economic Factor	Fixed Factors
EF1	Total Grouped Hectares.	EF31	Transient Crop Area.	Know about AmazonNTFP.
EF2	Access Road to the Productive Unit.	EF34	Non-Arable Land.	Know about Production Periods of NTFP.
EF7	Type of Assistance Last Year.	EF37	Actions Taken against Environmental Events.	Identified NTFP.
EF8	Technical Assistance Practice.	EF40	Facilities with Ceiling.	Knowledge of NTFP for Animal Nutrition.
EF9	Source of Monetary Resources	EF41	Facilities with Flooring.	
		EF42	Facilities with Divisions.	
EF10	Reason for the Loan.	**Code**	**Social Factor**	
EF11	Loan Amount.	SF1	Health system affiliation.	
EF12	Received Financial Support.	SF2	Land tenure.	
EF15	Irrigation System.	SF3	Time of agricultural activity.	
EF16	Type of Feeding.	SF4	Family composition.	
EF18	Marketing Products.	SF5	No. Minors.	
EF20	Environmental Study.	SF6	Schooling level of producers.	
EF22	Purpose of Production.	SF7	Principal problems productive unit.	
EF23	Income Contribution Level.	SF8	Forest importance in productive unit.	
EF27	Rest Area.	SF9	Attitude towards quality of life.	
EF30	Area of Stubble.	SF10	Forest conservation for water.	

2021). All analyses were performed using R statistical software version 4.0.5 (Team, R. C., 2021), using the programming language Rstudio version 1.3.1 (RStudio Team, 2021).

RESULTS AND DISCUSSION

The main problems of the pig units of the prioritized municipalities in the department of Caquetá are high production costs, environmental problems, livestock diseases and low productivity. This shows the lack of knowledge transfer on the sustainable use of the NTFP and other potentialities of the Amazonregion, causing dependence on commercial inputs and low levels of competitiveness of the sector (Figure 2).

This is different from Rahman and Islam (2021) statement that NTFPs play a vital role in the livelihoods improvement of production systems around forests. Where, the importance of designing sustainable management strategies that link the protection and use of the forest in the supply of ecosystem services, which have a direct relationship with the economy and livelihoods of rural producers, is emphasized. (Strand *et al*., 2018; Talukdar *et al*., 2021).

Social Factors that Affect the Use of NTFP in Swine Production Units.

The principal components analysis (PCA) explained that 33.19% of the cumulative variance of the social factors of the swine production units of the prioritized municipalities of the department of Caquetá. The Figure 3.A and 3.B shows that 68.1% of the units studied have a directly proportional relationship between the main problems of the economic activity (SF7), with the

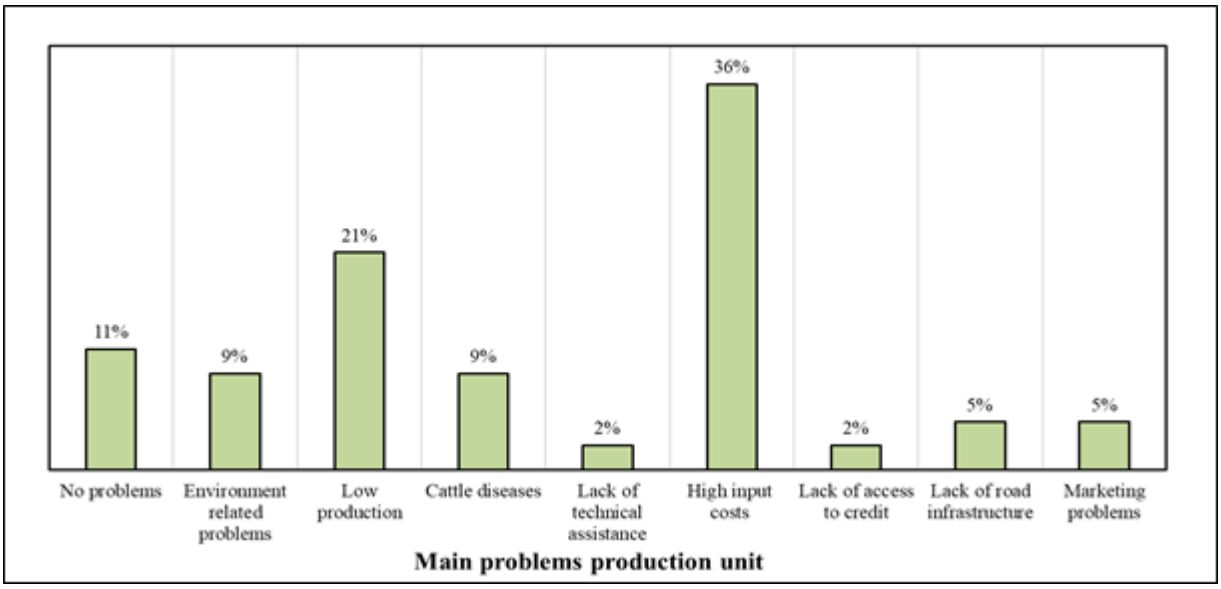

Figure 2. The main problems of the swine units of the prioritized municipalities of the department of Caquetá are high production costs, environmental problems, livestock diseases and low productivity.

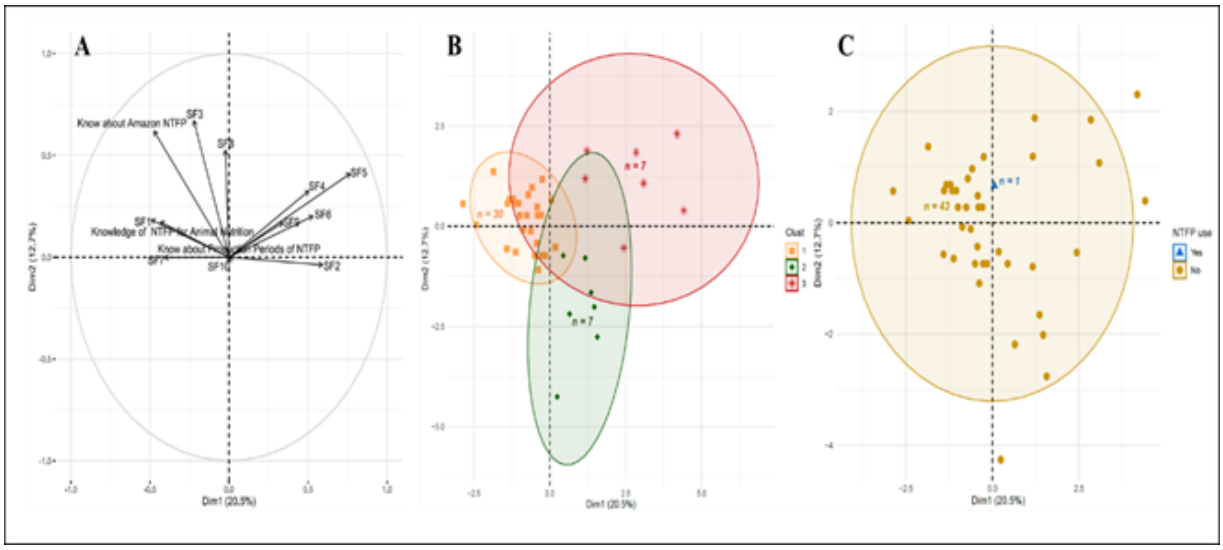

Figure 3. Principal component analysis (PCA) **A.** biplot with selected social factors in swine production system. **B.** Observations grouping by similarity (clustering analysis). **C.** Observations grouping according to NTFP use.

* **n:** number of observations according to each group.

degree of knowledge that the producers have about the nutritional components of the NTFP in animal feed. Likewise, it is evident that the level of knowledge of the production periods of NTP has a positive correlation with the time of agricultural activity (SF3) and the perception of the level of importance of the forest in the respective productive units (SF8). In the face of this, Strand *et al*. (2018) stated that it is necessary to develop training strategies for producers for the conservation and sustainable exploitation of the forest.

At the same time, 15.9% of the production

units expressed the social factors that address the level of formal schooling of producers (SF6), the attitude towards quality of life (SF9), land tenure (SF2) and family composition (SF4). Despite having a positive correlation between them, they do not have a positive correlation with the knowledge and management of NTFP in animal feed.

This highlights that the lack of knowledge or guidance on the nutritional potential of NTFP has generated that 97.7% of swine production units did not use of these forest resources present in the natural region of the Colombian Amazon (Figure 3.C), which is a negative scenario in terms of economic reactivation and sustainable industrialization.

In view of the above, Maua *et al*. (2020) stated that the management of NTFP utilization should systematically and comprehensively consider the general, ecological, harvesting, cultural, social and market factors related to rural productive units. Likewise, Ullah *et al*. (2021) and Alcântara *et al*. (2022) considered that despite the difficulties of community organization, the use of forest resources is highly related to the socioeconomic and environmental benefits of local agricultural production systems.

Economic Factors that Affect the Use of NTFP in Swine Production Units.

With regard to the economic factors, the PCA explains 36.5% of the cumulative variance in the Figure 4.A and 4.B; and 75% of the pig production units in relation with the use and knowledge of the NTFP have a directly proportional relationship (1) to the total hectares of the land (EF1), (2) to the availability of external financing sources (EF10, EF11) and (3) to the type of technical assistance (EF7) relevant to the sustainable development of the economic activity.

On the other hand, there is an inverse correlation between the use of NTFP and the factors related with the management of areas that was not used for pig production (EF27, EF30, EF31, EF34). The level of income contribution (EF23) and the investments promote mitigation actions in the face of environmental events (EF37). As for the factors that deal with the conditions of the swine facilities (EF40, EF41, EF42), they present a null correlation.

From this fact, it can be inferred that pig production units did not take advantage of the NTFP in contexts where the sources of financing (EF10, EF11) and the type of technical assistance (EF7) are limited and insufficient for the implementation of new production practices. In this regard, Lopes *et al.* (2019) and Masoodi *et al*. (2020) stated that agricultural activities carry out exploitation of NTFPs in proportion to the dis-

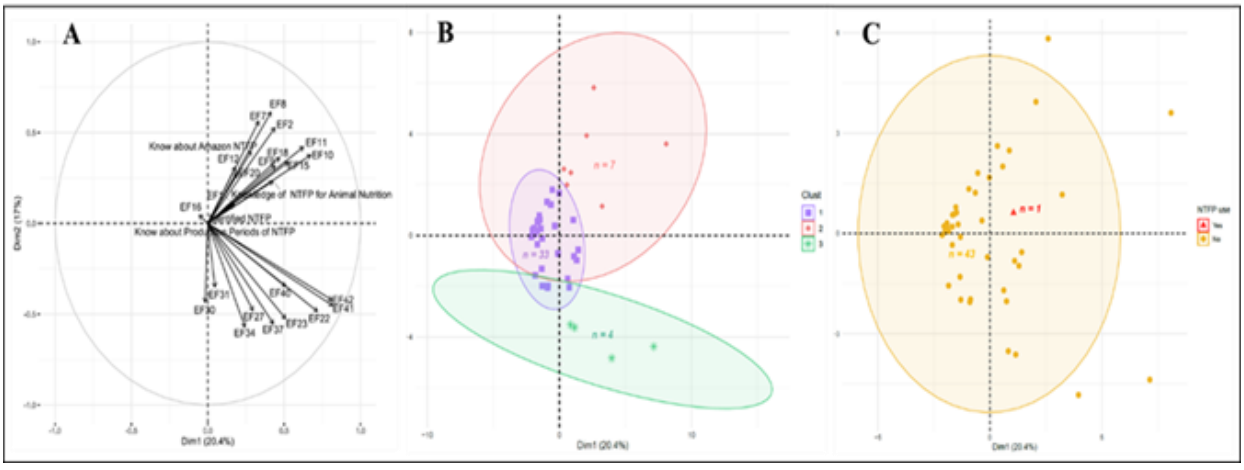

Figure 4. Principal component analysis (PCA) A. biplot with selected ecomomic factors in swine production system. B. Observations grouping by similarity (clustering analysis). C. Observations grouping according to NTFP use.

* n: number of observations according to each group.

tance from the forest, undermining the conservation role of environmentally important areas, where poor and marginal communities lack elements for forest utilization and improvement of living conditions.

NTFP and Relationship with Socio-economic Factors of the Pig Units.

In this way, it is possible to define the relationships between the socio-economic factors and the fixed factors of the use of the NTFP. In the first instance, the knowledge about the NTFP of the natural region of the Colombian Amazon has a high correlation with the identification of these resources by the producers, which is a moderate correlation with the time of exercising the economic activity (SF3), and a very low correlation with the practice of technical assistance (EF8) and the amount of financing through credits (EF11).

At the same time, the identification of NTFP has a moderate correlation with the type of feed provided to pigs (EF16) and the time of economic activity (SF3). Equally, understanding the nutritional components of NTFP in the feeding of livestock shows a moderate correlation with the type of technical assistance received (EF7) and practiced by the producers (EF8).

Thus, the use of NTFP by pig farmers shows a moderate correlation, but not less important, with the economic factors surrounding credit financing (EF10, EF11) and thenon-arable lands (EF34) of the farmers' respective lands (Figure 5).

This can be related to the fact that the lack of trust in the institutional framework and the absence of public policies on NTFP management

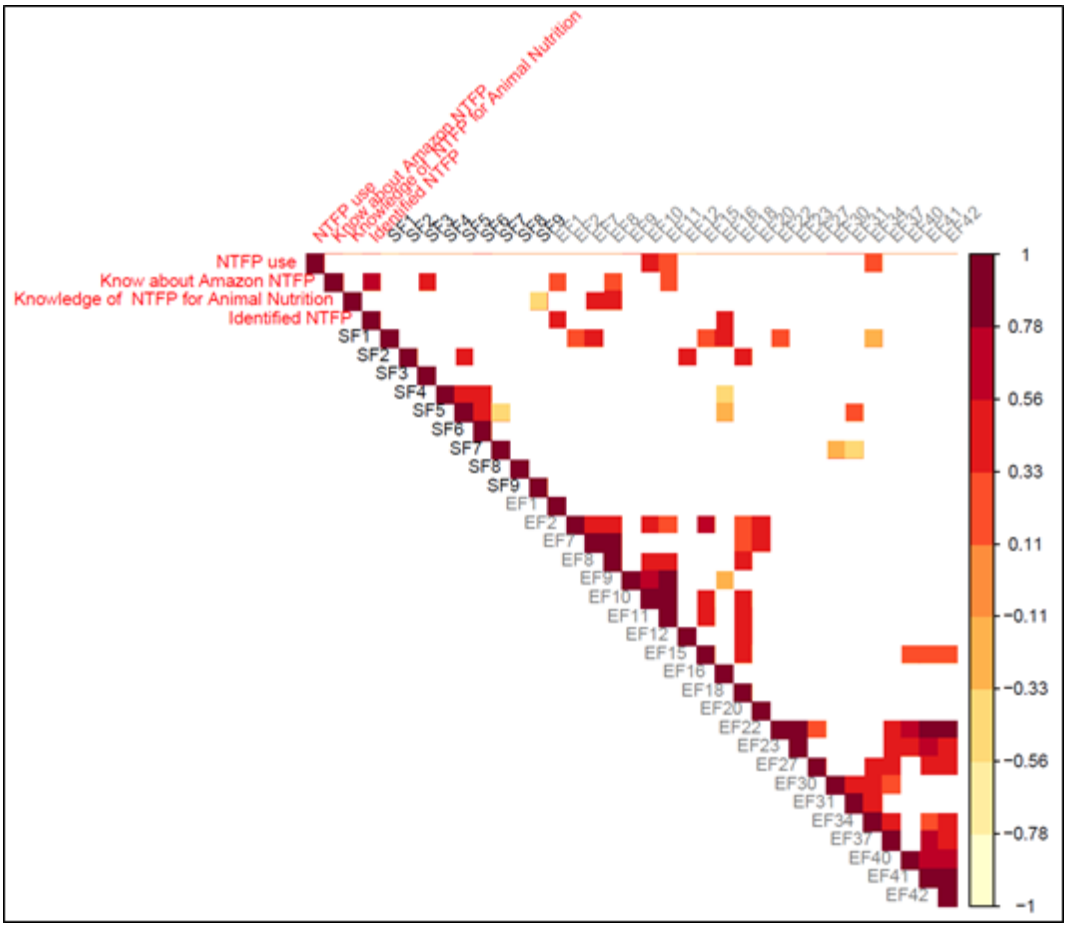

Figure 5. Pearson correlation matrix with socials (red color) and economics (gray color) factors in swine production system, interactions without color are not significant (p-value >0.05).

limit the use of these inputs in pro-social, pro-economic and pro-environmental production systems. (Authelet *et al*., 2021).

Throughout the study, the socio-economic factors that affect the sustainable use of NTFP in animal feed in the farming units of the prioritized municipalities of the department of Caqueta were analyzed. The findings were significant for several reasons. First, the results indicate that the problems are related to the dependence on the supply of inputs for the production of concentrate, which generates high costs in production and wastes the comparative advantages of the territory. Simultaneously, it was found that environmental conditions, production levels and the healthiness of the livestock aggravate the productive efficiency of small pig farmers.

Second, when analyzing the social factors that influence the use of NTFP, it was identified that the level of knowledge that producers have about these resources are directly related to the potential use in livestock feed. This could be considered a significant contribution to pig productivity from a differential and endogenous approach of the territory, even more so when the forest is considered as an important element in the lands and supports the experience of the producers in carrying out this economic activity. Third, it was observed that within the framework of the economic factors, the sources of financing through credits and technical assistance for the use of NTFP in swine feeding are determinant.

CONCLUSION

It is indicated that the problems are related to the dependence on the supply of inputs for the production of concentrate, which generates high production costs and wastes the comparative advantages. Simultaneously, environmental conditions, production levels, and livestock health were found to aggravate the productive efficiency of small-scale pig producers. Next, it is identified that the level of knowledge about these resources is directly related to their potential use in pig feeding. Finally, it is defined that the sources of financing through credits and technical assistance for the use of NTFP in pig feeding are decisive for their use.

Considering the above, it is possible to recommend that the fixed factors that helped in the analysis of the socio-economic factors related to the use of the NTFP should be worked between the technical-scientific knowledge combined with the expertise of local producers that allow an endogenous and sustainable development in reason of the potential particularities of the territory.

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