Factors influencing the use of non-timber forest products in cattle production under humid tropical conditions

Victor Julio Balanta Martínez[*,a], **Gustavo Adolfo Celis Parra**[a],
Marisol González Muñoz[a], **Jhoyner Felipe Ortiz Meneses**[a]

[a] Universidad de la Amazonia, Colombia

Abstract

As more attention is paid to the integral management and the problems of cattle production systems in the achievement of sustainable productivity and competitiveness in the territories of the Colombian Amazon region, it is necessary to determine the socioeconomic factors that affect the use of the potential and comparative advantages of productive units located in the region for nutritional supplementation from local inputs, such as Non Timber Forest Products (NTFP). For this purpose, a descriptive-cross-sectional scope with non-experimental design and quantitative approach study was carried out, applying the collection instrument to the sample size defined in a non-probabilistic way in the municipalities of Albania San Vicente del Caguán, El Doncello, Puerto Rico, and Cartagena del Chaira of the department of Caquetá Colombia. Information was systematized using the R software, where the principal component analysis of the socioeconomic factors with the use of cattle nutrition in the NTFP was carried out. It was found that the factors that have the greatest impact on the use of NTFP are related to the degree of knowledge about NTFP and the strategies for the transfer of scientific knowledge as a complement to the knowledge of the producers.

Article info

* *Corresponding author*: Víctor Julio Balanta Martínez - Universidad de la Amazonia, Florencia, Colombia. E-mail: vjbalanta1904@gmail.com.

Introduction

The challenge for the agricultural sector is to develop sustainable production strategies that improve the profitability of production units by taking advantage of environmental resources that have a positive impact on their competitiveness. Therefore, biodiverse territories such as the Amazon have comparative advantages due to the presence of various non-timber forest products (NTFP) that have potential for animal feed as a sustainable alternative to the unsatisfied nutritional demand of production systems (Stepakova *et al.*, 2019).

It should be clarified that competitiveness is related to the generation of profitability in organizations based on efficiency and effectiveness (Avedaño and Schwentesius, 2005), creating comparative advantages in the markets; evidencing its impact on price and profit. Therefore, bovine productive systems present as a challenge to develop alternative animal feeding strategies based on NTFP that reduce the high costs of feed concentrates (Osorio, 2014) contributing to sustainability from the social responsibility of these actors in the face of environmental challenges that seek to promote responsible productions and consumption (Fonseca *et al.*, 2011). It should be noted that research fosters competitiveness by contributing to technological development based on the innovation of models, processes and use of resources; positively impacting the productivity of agricultural systems by improving their practices, strategic efficiency and financial management (Stellian and Danna, 2017).

It is worth highlighting the role of NTFP in the development of biotrade, generating an attractive and relevant market that can generate substantial income for rural areas through the generation of employment and the creation of companies or business models that take advantage of the potential of these forest resources, generating value in the products and services offered and having a positive impact on the economy and regional development (Weiss *et al.*, 2020). The income that can be obtained from NTFP extraction varies depending on the ecological conditions, social, economic and political structures of the communities (Kar and Jacobson, 2012; Hogarth *et al.*, 2013) from the economic point of view NTFP extraction is perceived as an option to improve the livelihoods of rural communities by diversifying household incomes (Kamaljit *et al.*, 2007), in some cases the income from it can represent up to 39% of net household income (Heubach *et al.*, 2011) and can be constrained by factors such as livestock numbers, size of agricultural and non-agricultural land (Khosravi *et al.*, 2017); however, the effects of economic factors are not necessarily the same in different socioeconomic conditions and geographic locations, as they can vary depending on the scale at which they are measured (Kar and Jacobson, 2012).

Regarding the social implications that determine the use of NTFP, it is common to evidence in rural communities a high incidence of gender socio-cultural barriers (Lakerveld *et al.*, 2015), particularly women are engaged in activities ranging from NTFP collection to NTFP commercialization, this being a secondary economic activity of the household, since the main economic activity of families is livestock and is traditionally carried out by men (Madhusmita *et al.*, 2016); on the other hand, the level of education and age of the head of household determine the economic activities carried out within the household (Khosravi *et al.*, 2017). Other factors such as political structures can incentivize NTFP use within communities with government programs that offer technical accompaniment to make raw material collection and transformation processes more efficient, however, the coverage of these programs is often limited (Gupta *et al.*, 2020; Nassl and Löffler, 2019).

The recognition of the socioeconomic factors that limit the degree of NTFP use is of vital importance to identify the potential resources of the region, promote economic models that promote rural development, generate useful information for the creation of public policies that establish land use patterns, strengthen governance models within the framework of an integral and contextual approach that starts from the recognition of the complexity of the socioecological reality of the regions (Lakerveld *et al.*, 2015). Therefore, the objective of this study is to determine the socioeconomic factors that affect the use of non-timber forest resources in the Colombian Amazon region.

1. Materials and methods

To achieve the objective of the study, a methodological design was implemented according to the guidelines of Hernandez (2018), which was descriptive transectional in scope, where information was collected through a structured survey of 108 units with cattle production distributed in the municipalities of San Vicente del Caguán (25 units), El Doncello (03 units), Albania (5 units), Cartagena del Chaira (03 units), and Puerto Rico (08 units) belonging to the department of Caquetá. These units were selected using a non-probabilistic method based on selection criteria established by the dimensions of the research and the respective characteristics of the small cattle producers.

The units selected as observation units were those that had the following characteristics: a) To have cattle production systems, b) That the land has at least one (01) ha^{-1} of forest area, c) That 70% of the income comes from agricultural activities, d) That 80% of the assets are destined to the development of agricultural activities, and e) To have minimum 5 years of experience in the development of agricultural activities.

Figure 1 - Observation unit of the study
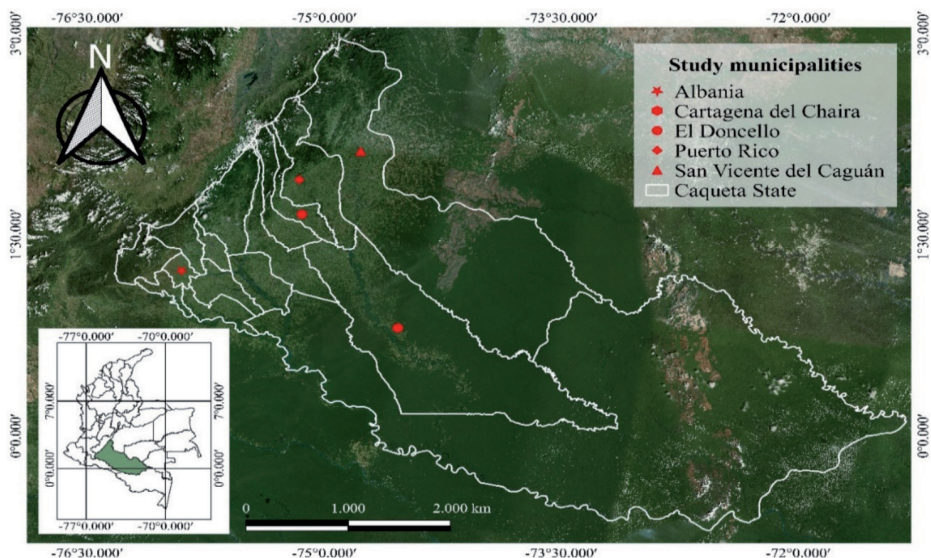
Source: Own data from ArcGIS.

The data collection was based on the measurement of 10 social and 68 economic factors, in reason to 4 fixed factors of the NTFP through a principal component analysis (PCA) using the statistical package "FactoMineR" (Husson *et al.*, 2016) and the package "factoextra" (Alboukadel Kassambara & Fabian Mundt, 2017). Factors with a percentage of variance explained greater than 10% were selected, which centers the analysis in 10 social and 36 economic factors (Table 1).

Subsequently, the correlation matrix is constructed to jointly analyze the incidence of the social and the economic factors selected in the PCA on the fixed factors that influence the use of NTFP in the cattle production systems. For this purpose, the Pearson correlation test was used (p-value > 0.05) using the statistical package "corrplot" (Wei & Simko, 2021), data that were analyzed using the statistical software R version 4.0.5 (R Core Team, 2021), using the programming language Rstudio version 1.3.1 (RStudio Team, 2021).

It should be clarified that the fixed factors on which the analysis of the information is carried out address the technical or popular knowledge that the producers have about the NTFP, as well as the periods of production of NTFP under humid tropical conditions. On the other hand, the visual identification of the NTFP present in the productive units, in addition to the degree of utilization of NTFP in animal feed, was also included.

Table 1 - Fixed and socioeconomic factors of the cattle production system

Cod	Economic factors	Cod	Economic factors	Fixed factors
EF1	Total Hectares	EF39	Grouped Cananguchal Area	Know About NTFP
EF2	Access Road	EF43	Grouped Area Stubble	Know About Production Periods
EF4	Type Of Transportation Access	EF45	Permanent Crop Area	Identified NTFP
EF5	Type Of Organization	EF46	Grouped Wetlands Area	Knowledge Of NTFP for animal
EF6	Benefit Received from Org.	EF47	Grouped Silvopastoral Area	
EF7	Type Of Assistance Last Year	EF48	Grouped Non-Arable Land	
EF8	Technical Assistance Practice	EF49	Environmental Impacts	
EF9	Source Of Monetary Resources	EF50	Severity Environmental Events	
EF10	Reason For the Loan	EF51	Actions Taken Against Environmental Events	
EF11	Loan Amount	EF53	Power Generator	
EF14	Principal Problems	EF54	Tractor Productive Unit	
EF15	Irrigation System Unit	EF55	Cattle Corral	
EF16	Number Of Cattle Grouped Together			
EF18	Milk Production		Social factors	
EF19	Daily Milk Production	SF1	Health System Affiliation	
EF21	Identified Breeds of Cattle	SF2	Land Tenure	
EF24	Load Capacity of The Cattle Unit	SF3	Time Of Agricultural Activity	
EF25	Load Capacity Cattle Grouped	SF4	Family Composition	
EF28	Patch Burn Grazing	SF5	No. Minors	
EF29	Rotational Grazing	SF6	Schooling Level of Producers	
EF32	Crop-Pasture Rotation	SF7	Principal Problems Productive Unit	
EF33	Mixed Pastures NTFP	SF8	Forest Importance in Productive Unit	
EF34	Environmental Study Unit	SF9	Attitude Towards Quality of Life	
EF36	Cattle Income Contribution	SF10	Forest Conservation for Water	

2. Results and discussion

From the information collected in the prioritized municipalities, it was determined that the main problems of the cattle units of the municipalities in the department of Caquetá are the difficulty of transporting and marketing products due to the poor condition of the tertiary roads, the lack of access to credit, the high cost of production inputs, environmental problems, and livestock diseases, in addition to low productivity. This shows that there is little transfer of innovative knowledge about alternatives for sustainable use of the potential of the Amazon territory, causing dependence on commercial inputs and low levels of competitiveness in the sector (Figure 2).

*Figure 2 - Main problems cattle production unit*
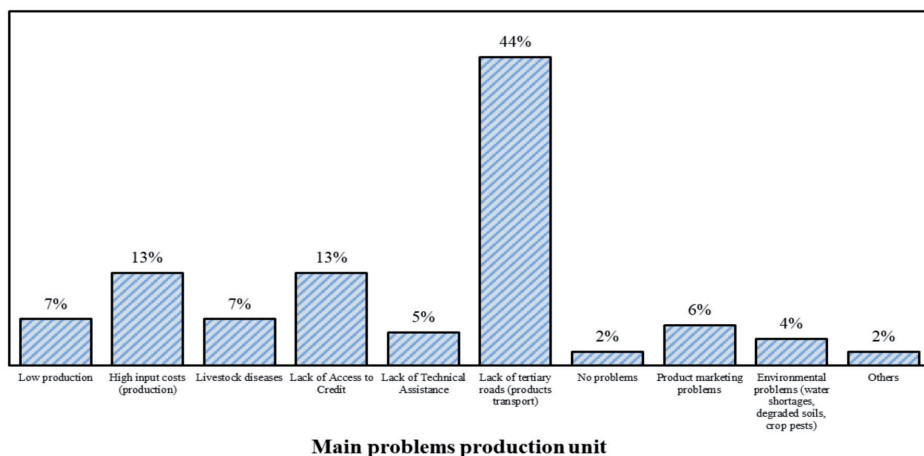
Source: Own data

The principal components analysis (PCA) that explains 28.7% of the cumulative variance of the social factors of the cattle production units of the prioritized municipalities of the department of Caquetá (Figure 3) shows that 80.6% of the observation units (Figure 3B) have a directly proportional relationship between the degree of knowledge of the NTFP with the perception of importance of the forest in the production units (SF8), just as the periods of knowledge about NTFP production have a significant relationship with the type of land tenure (SF2) and the main problems (SF7) present in the cattle production systems. On the other hand, it is evident that despite a negative correlation with the fixed factors, there are positive

correlations in these productive units between the time of agricultural activity (SF3), the perception of quality of life (SF9), water resource conservation (SF10), level of schooling (SF6), and the presence of children in the households (SF5).

From the above, it is possible to intuit that most of the units with cattle production systems have diversity in terms of social factors, which should be taken into account from a systemic approach to define strategies for the transfer of scientific knowledge to promote the use of the potential related to the RNMB in the feeding of livestock, the conservation of biodiversity and the strengthening of public policies that allow for the expansion of local markets to increase community income and generate competitiveness in cattle production systems (Alves *et al.*, 2017).

Figure 3 - Principal component analysis (PCA) A. biplot with selected social factors (SF) in cattle production system. B. Observations grouping by similarity (clustering analysis). C. Observations grouping according to NTFP use
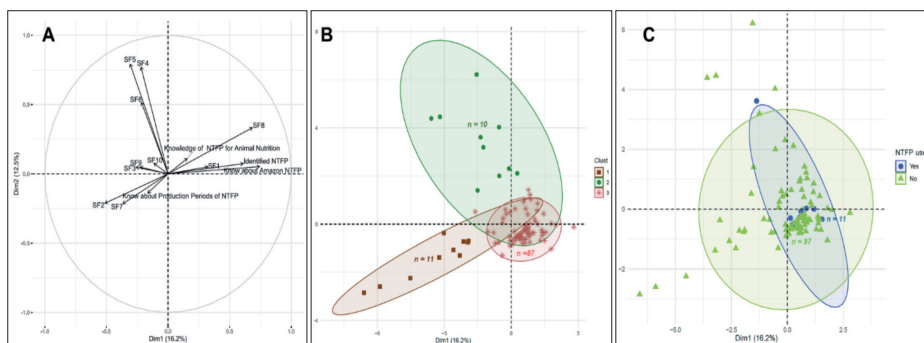
* n: number of observations according to each group.
Source: Own data.

The above scenario based on social factors, which are the result of cultural representations built from community processes has generated that only 10.2% of the cattle production units analyzed make use of NTFP with sustainable alternatives in the nutritional supplementation of livestock.

*Economic factors influencing the use of NTFPs*

As for the economic factors, the PCA, which explains 20% of the cumulative variance shows three groupings according to the fixed variables

of analysis. In the first place, there is a grouping that concentrates 38.9% of the observation units (Figure 4B) that show a high correlation around the knowledge of the production periods of the NTFP. These factors are related to wetland areas (EF46), the realization of environmental studies in the productive unit (EF34), and technical assistance (EF7, EF8), as well as a moderate correlation with the perception of problems (EF14) and access roads (EF2), in addition to a negative correlation with the management of pasture land (EF28) and the type of cattle breed (EF21).

Secondly, 34.25% of the production units (Figure 4B) are grouped according to the knowledge of the nutritional properties of the NTFP, where a high correlation is established with the actions taken to mitigate environmental impacts (EF49, EF51) and the severity of the events as an effect of the productions (EF50). Likewise, there is a moderate correlation with the benefits received by the organizations (EF6) and the equipment of the producers to develop the economic activity (EF53, EF54, EF55).

Lastly, 26.9% of cattle production units (Figure 4B) against the fixed variables of identification and knowledge of Amazonian NTFP have a positive correlation with permanent crop areas (EF45), production levels (EF16, EF18, EF19), availability of financing sources (EF9, EF10, EF11), in addition to a moderate correlation with load capacity (EF24, EF25) and total hectares of production units (EF1).

Figure 4 - Principal component analysis (PCA) A. biplot with selected economic factors (EF) in cattle production system. B. Observations grouping by similarity (clustering analysis). C. Observations grouping according to NTFP use
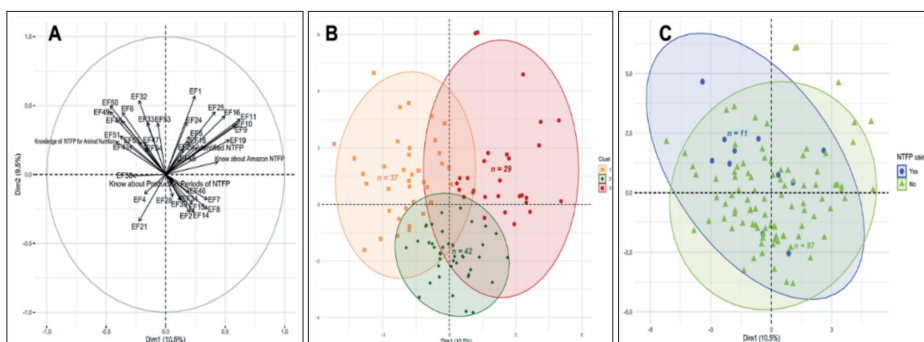
* n: number of observations according to each group.

Source: Own data.

Consequently, 10.2% of the production units (Figure 4C) make use of NTMB in cattle feed, of which 54.5% are concentrated in the second grouping (Figure 4B) that revolve around the fixed factor of knowledge of the nutritional properties of NTFP, which shows a directly proportional relationship with the management and environmental responsibility of the production units with the territory of which it is part.

Relationship of socioeconomic factors with NTFP in cattle units

Regarding the fixed factors, it was generally determined that the use of NTFP has a high correlation with the degree of knowledge that cattle producers have about the nutritional properties of the resources, and the strategies related to mixed pastures (EF33). Likewise, there is a moderate correlation with the total hectares of the productive units (EF1), pasture rotation (EF32), and the availability of machinery (EF54). This shows the importance of transferring scientific knowledge to producers about sustainable production systems, bromatological properties and the competitive advantages that can be generated by taking advantage of the potential of the territory.

From another point of view, it was found that the knowledge about the NTFP of the Amazon region has a significant correlation with the ability to identify the NTFP by the producers, and a moderate correlation with the perception of importance of the forest in the productive units (SF8), the practice of technical assistance (EF8), milk production (EF18) and the load capacity of the land (EF25). In summary, the degree of knowledge for the identification of the NTFP can be attributed to the degree of technical guidance offered to the producers in relation to the productivity of the cattle systems and the integration of alternatives based on the comparative advantages of the productive units.

As a result, the degree of knowledge about the nutritional components of the NTFP is correlated to the type of generally conventional productive practices, where the most significant practices are patch- burn grazing (EF28), crop-pasture rotation (EF32), as well as areas with silvopastoral management (EF47), which are generally introduced with species that are not very efficient or with high implementation and maintenance costs. In addition, the use of stubble areas (EF43), together with the perception of the severity of environmental impacts (EF50) and availability of machinery (EF54).

Figure 5 - Pearson correlation matrix among fixed, social and economic factors in cattle production system, interactions without color are not significant (p-value < 0.05)
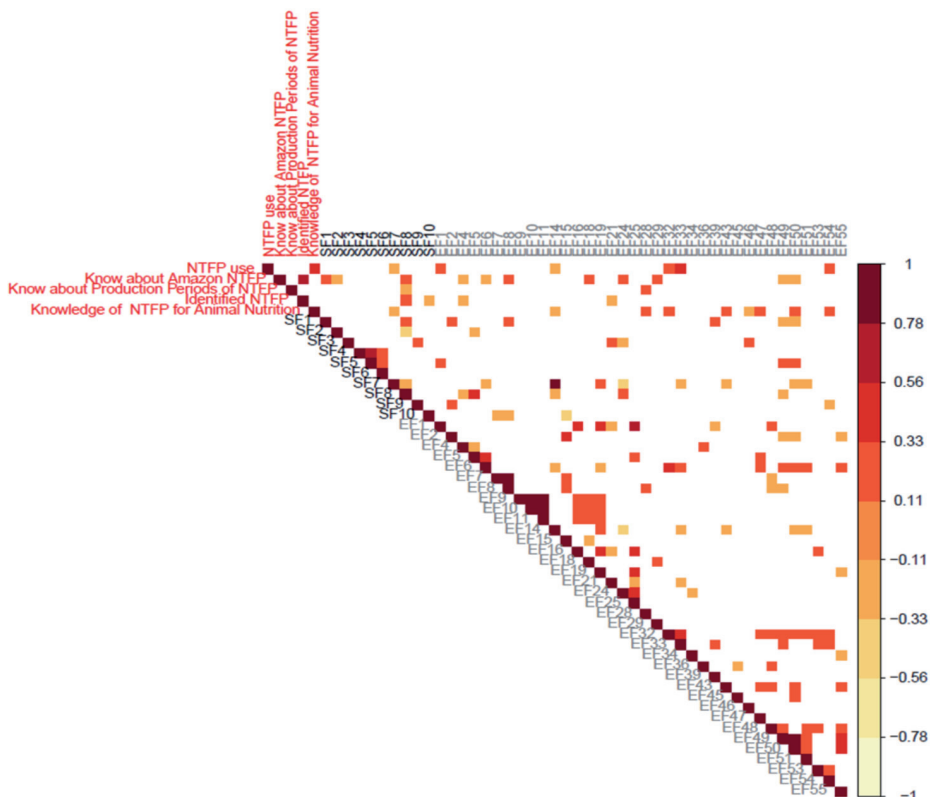
Source: Own data.

Conclusions

Throughout the study, significant results were achieved regarding the analysis of the factors that affect the use of NTFP in cattle production systems under conditions of the Colombian Amazon region. These elements that can guide strategies for the promotion and strengthening of the potential based on the biodiversity of the territory that contribute to sustainable production of agricultural organizations, especially cattle, which are slightly blamed for the negative impacts on forests, as well as for problems related to high production costs, availability of economic resources, environmental problems, low production levels, and lack of infrastructure for competitiveness.

According to the social factors, it can be affirmed that the degree of knowledge about the NTFP is defined by the degree of importance that the forest has in the productive units, which is the social representation constructed from the technical orientations and conventional practices on the economic activity that perpetuate problems that affect the sustainability and competitiveness of these agricultural organizations, in addition to the generation of negative externalities on the various ecosystem services. However, regarding economic factors, the knowledge for the use of the NTFP is determined by the alternatives and strategies of responsible management for the sustainability of the organizations with the territory, in addition to the productive equipment and the degree of organization of the producers.

The research allows us to determine that the socioeconomic factors that influence the use of NTFPs in livestock production units in the Colombian Amazon region are defined by the degree of knowledge of these ecological and regional resources, which requires not only the transfer of scientific knowledge to articulate it with the knowledge of producers and the breaking of production paradigms, but also to facilitate sources of funding for productive innovation relevant to the territory and its potential.

Although the analysis is limited to defining the social and economic factors that influence the use of NTFPs in livestock feed, it presents a great opportunity and orientation for the generation of articulating strategies with producers, government agencies and private organizations that allow the productive strengthening of the region in a sustainable manner, through the implementation of promising resources of the region such as NTFPs as a potential solution to reconcile the different land uses, while promoting biodiversity conservation and the provision of ecosystem services. However, these measures must be implemented with defined strategies that integrate complementary public policies, as sustainable intensification can have negative environmental, economic and social effects.

Acknowledgements

del Chaira, Albania, San Vicente del Caguán, El Doncello, Puerto Rico". Finally, to the Universidad de la Amazonia for being the executing and co-financing entity of the project.

Funding

This work was supported by the OCAD of the Science, Technology and Innovation Fund attached to the General System of Royalties of Colombia that by Agreement No. 78 of August 21, 2019; and the Universidad de la Amazonia.

Disclosure statement

We declare to have no conflict of interest with other parties.

References

Alves-Pinto, H.N., Latawiec, A.E., Strassburg, B.B., Barros, F.S., Sansevero, J.B., Iribarrem, A., & Silva, A.C. (2017). Reconciling rural development and ecological restoration: Strategies and policy recommendations for the Brazilian Atlantic Forest. *Land Use Policy*, *60*, 419-426. doi: 10.1016/j.landusepol.2016.08.004.

Avendaño, R.B., & Schwentesius, R.R. (2005). Factores de competitividad en la producción y exportación de hortalizas: el caso del valle de Mexicali, B.C., México. *Problemas del Desarrollo*, *36*(140), 165-192.

Bawa, K.S., Joseph, G., & Setty, S. (2007). Poverty, biodiversity and institutions in forest-agriculture ecotones in the Western Ghats and Eastern Himalaya ranges of India, *Agriculture, Ecosystems & Environment*, *121*(3), 287-295. doi: 10.1016/j.agee.2006.12.023.

Comité Departamental de Ganaderos del Caquetá (2020). Cifras de Contexto Ganadero Caquetá 2020. -- https://issuu.com/rafaeltorrijos/docs/contexto_ganadero_caqueta_2020.

Dash, M., Behera, B., & Rahut, D.B. (2016). Determinants of household collection of non-timber forest products (NTFPs) and alternative livelihood activities in Similipal Tiger Reserve, India. *Forest Policy and Economics*, *73*, 215-228. doi: 10.1016/j.forpol.2016.09.012.

FAO (2014). El estado de los bosques del mundo. Potenciar los beneficios socioeconómicos de los bosques. 1 ed. Roma (Italia), pp. 20-49.

Fonseca, C.J.A., Muñóz, P.N.A., & Cleves, L.J.A. (2011). El sistema de gestión de calidad: elemento para la competitividad y la sostenibilidad de la producción agropecuaria colombiana. *Revista de Investigación Agraria y Ambiental*, *2*(1), 9-22. doi: 10.22490/21456453.909.

Gupta, D., Lele, S., & Sahu, G. (2020). Promoting a responsive state: The role of NGOs in decentralized forest governance in India. *Forest Policy and Economics*, *111*, 102066. doi: 10.1016/j.forpol.2019.102066.

Hernández-Sampieri, R., & Torres, C.P.M. (2018). *Metodología de la investigación* (Vol. 4). México^ eD. F DF: McGraw-Hill Interamericana.

Heubach, K., Wittig, R., Nuppenau, E.-A., & Hahn, K. (2011). The economic importance of non-timber forest products (NTFPs) for livelihood maintenance of rural west African communities: A case study from northern Benin. *Ecological Economics*, *70*(11), 1991-2001. doi: 10.1016/j.ecolecon.2011.05.015.

Hogarth, N.J., Belcher, B., Campbell, B., & Stacey, N. (2013). The Role of Forest-Related Income in Household Economies and Rural Livelihoods in the Border-Region of Southern China. *World Development*, *43*, 111-123. doi: 10.1016/j.worlddev.2012.10.010.

Husson, F., Josse, J., Le, S., & Maintainer, J.M. (2016). Package "FactoMineR." Multivariate Exploratory Data Analysis and Data Mining, 96, 698. -- https://cran.rediris.es/web/packages/FactoMineR/FactoMineR.pdf.

Kar, S.P., & Jacobson, M.G. (2012). NTFP income contribution to household economy and related socio-economic factors: Lessons from Bangladesh. *Forest Policy and Economics*, *14*(1), 136-142. doi: 10.1016/j.forpol.2011.08.003.

Kassambara, A., & Mundt, F. (2017). Package 'factoextra'. Extract and Visualize the Results of Multivariate Data Analyses, 76. -- https://cran.microsoft.com/snapshot/2016-11-30/web/packages/factoextra/factoextra.pdf.

Khosravi, S., Maleknia, R., & Khedrizadeh, M. (2017). Understanding the Contribution of Non-timber Forest Products to the Livelihoods of Forest Dwellers in the Northern Zagros in Iran. *Small-scale Forestry*, *16*, 235-248. doi: 10.1007/s11842-016-9353-y.

Lakerveld, R.P., Lele, S., Crane, T.A., Fortuin, K.P.J., & Springate-Baginski, O. (2015). The social distribution of provisioning forest ecosystem services: Evidence and insights from Odisha, India. *Ecosystem Services*, *14*, 56-66. doi: 10.1016/j.ecoser.2015.04.001.

Nassl, M., & Löffler, J. (2019). How Societal Values Determine the Local Use of Forest Resources – Findings from the Rural Community Kegong (Northwest Yunnan, China). *Sustainability*, *11*(12), 3447. doi: 10.3390/su11123447.

Osorio, L.F. (2014). *Silvopastoreo. Colombia forestal*, *17*, 73-75.

Pardo, O., Fornaguera, J.E.C., & Hess, H.D. (2008). Efecto de la relación proteína y energía sobre los niveles de amonio ruminal y nitrógeno ureico en sangre y leche de vacas doble propósito del piedemonte llanero, Colombia. *Revista Colombiana de Ciencias Pecuarias*, *21*(3), 6.

R Core Team (2021). R: A Language and Environment for Statistical Computing. -- www.r-project.org.

RStudio Team (2021). RStudio: Integrated Development Environment for R. -- www.rstudio.com.

SMBYC, IDEAM (2018). Sistema de Monitoreo de bosques y carbono -- Recuperado: http://smbyc.ideam.gov.co/MonitoreoBC-WEB/pub/reporteGeoproceso.jsp?id_reporte=7123.

Stellian, R., & Danna-Buitrago, J.P. (2017). Competitividad de los productos agropecuarios colombianos en el marco del tratado de libre comercio con los Estados Unidos: análisis de las ventajas comparativas. *Revista Cepal.*

Stepakova, N.N., Kiseleva, T.F., Koryakina, N.A., Frolova, N.A., & Reznichenko, Y.Y. (2019). Food forest resources as a component of environmental management. IOP Conference Series: Earth and Environmental Science: Earth and Environmental Science, 315, 052046–. doi: 10.1088/1755-1315/315/5/052046.

Wei, T., & Simko, V. (2021). R package "corrplot": Visualization of a Correlation Matrix (Version 0.90). -- https://github.com/taiyun/corrplot.

Weiss, E., Corradini, & Živojinović (2020). New Values of Non-Wood Forest *Products*, *11*(2), 165. doi: 10.3390/f11020165.

Victor Julio Balanta Martínez
Faculty of Accounting, Economic, and Administrative Sciences -
University of the Amazon, Colombia
Calle 2C Este 12 - 48 Altos de laprada, Florencia - Caquetá, Colombia
E-mail: v.balanta@udla.edu.co
Candidate Doctorate in Sustainable Development, Master in Environmental
Education and Sustainable Development, Certified Public Accountant, member
of the Huella Amazónica research group, Macagual Animal Sciences Research
Group, and the Center for Research, Innovation and Development for Sustainability.
His interests are related to the social responsibility of organizations, bioeconomic
models, and eco-accounting.

Gustavo Adolfo Celis Parra
Faculty of Agricultural Sciences - University of the Amazon, Colombia
Vereda la primavera lot 2, Florencia - Caquetá, Colombia
E-mail: g.celis@udla.edu.co
Doctorate in Agrarian Sciences, Master in Agrarian Sciences, Zootenist, member of
the Macagual Animal Sciences research group. His interests are related to animal
nutrition and sustainable production.

Marisol González Muñoz
Faculty of Accounting, Economic, and Administrative Sciences -
University of the Amazon, Colombia
Vereda la primavera lot 2, Florencia - Caquetá, Colombia
E-mail: mari.gonzalez@udla.edu.co
Magister in Taxation, Specialist in Formulation and Evaluation of Projects, Certified
Public Accountant, member of the Huella Amazonica research group. His interests
are related to environmental taxes and green business.

Jhoyner Felipe Ortiz Meneses
Faculty of Agricultural Sciences - University of the Amazon, Colombia
Carrera 11 # 16 - 92 Centro, Florencia - Caquetá, Colombia
E-mail: fel.ortiz@udla.edu.co
Veterinary Doctor and Zootechnician, member of the Macagual Animal Sciences
research group and the Center for Research, Innovation and Development for
Sustainability. His interests are related to animal nutrition and sustainable production.