ISSN: 1692-7257 - Volume 1 – Number 45 - 2025

RCTA
Revista Colombiana de Tecnologías de Avanzada
UNIPAMPLONA

Digital Object Identifier: 10.24054/rcta.v1i45.3342

Innovation model for specialty coffee farms in Colombia

Modelo de innovación para fincas productoras de café especial en Colombia

MSc. Eyder James Ramírez Zuñiga [1], PhD. Hugo Fernando Castro Silva [2], PhD. Ehidy Karime García Cruz [2]

[1] ***Universidad Ean**, Doctorado en ingeniería de procesos, Bogotá, Cundinamarca, Colombia.*
[2] ***Universidad Pedagógica y Tecnológica de Colombia**, Escuela de Ingeniería Industrial. Grupo de Investigación GITYD. Calle 4 A Sur No. 15-134, Sogamoso, Boyacá, Colombia.*

***Correspondence:** hugofernando.castro@uptc.edu.co*

***Received:** july 14, 2024. **Accepted:** december 03, 2024. **Published:** january 01, 2025.*

***How to cite:** E. J. Ramírez Zuñiga, H. F. Castro Silva, and E. K. García Cruz, "Innovation model for specialty coffee farms in Colombia", RCTA, vol. 1, no. 45, pp. 1–9, Jan. 2025.*
Recovered from https://ojs.unipamplona.edu.co/index.php/rcta/article/view/3342

Abstract: This study seeks to analyze the innovation activities within the production, distribution, and commercialization processes of specialty coffee in Colombia, aiming to design an innovation model that highlights key factors necessary for enhancing the sector's competitiveness. The innovation model developed in this research is grounded in a logistic regression statistical framework, which identified critical variables for sustainable coffee production, such as comprehensive waste management across all stages, the adoption of digital technologies, and adaptability to change. This model is intended to advance the sector's knowledge base and foster greater efficiency and benefits for stakeholders throughout the specialty coffee supply chain in Colombia.

Keywords: Innovation, process innovation, agro-industrial innovation, sustainable specialty coffee

Resumen: Esta investigación tiene como objetivo analizar las actividades de innovación desarrolladas en los procesos de producción, distribución y comercialización del café especial en Colombia, con el fin de diseñar un modelo de innovación que permita identificar los factores clave para mejorar la competitividad del sector. El modelo propuesto se fundamenta en un análisis de regresión logística, mediante el cual se identificaron variables críticas para la producción de café sostenible, incluyendo: la identificación y gestión integral de residuos en todas las etapas del proceso, la adopción de tecnología digital y la flexibilidad ante el cambio. Se espera que este modelo contribuya al conocimiento del sector y promueva mayores niveles de eficiencia y beneficios para los actores involucrados en la cadena de suministro de café especial en Colombia.

Palabras clave: Innovación, innovación de procesos, Innovación agroindustrial, café especial sostenible.

1. INTRODUCTION

The coffee sector plays a pivotal role in Colombia's economy, accounting for 22% of the country's agricultural Gross Domestic Product (GDP) and serving as the primary source of income for more than 550,000 Colombian families [1]. The National Federation of Coffee Growers of Colombia [2] identifies coffee as the cornerstone of the economy in the Huila department, as it supports approximately 84,000 rural families who cultivate 144,895 hectares, producing up to two million 60-kg bags of Arabica coffee. These are comprised of various varieties, such as Castillo, Colombia, Caturra, and Bourbon [3].

It is noteworthy that the Huila department holds the distinction of being Colombia's leading coffee producer, supplying both green and dried coffee beans [4]. This achievement can be attributed to policies that effectively align international market demands with local production and commercialization practices [5], thereby underscoring the pivotal role of coffee as an economic and political driver [6].

The coffee production process is hampered by several constraints that negatively impact product quality. For example, green coffee producers are unable to optimize production due to insufficient infrastructure, lack of farmer associations, and limited access to credit [7]. On the other hand, dry coffee producers face challenges in enhancing their product quality as they often do not meet the standards set by marketing cooperatives, the criteria required for global fair-trade certifications, or the stringent demands of key international buyers [7].

A detailed analysis of coffee production emphasizes the close link between this crop and environmental health [8]. The study also cautions that climate change poses a serious threat, as it undermines soil fertility and heightens the risk of pests and diseases that can damage crops and hinder coffee production [8]. Similarly, it has been shown that climate change leads to a decline in both the intention to cultivate coffee and the willingness to recommend areas for its cultivation [9]. Moreover, rising temperatures have been proven to disrupt coffee cherry flowering, ultimately leading to reduced yields [10].

Moreover, research has concluded that inadequate management of the coffee cultivation process leads to unfavorable impacts, particularly in terms of low productivity and substandard coffee quality [11]. Generally, coffee produced under these circumstances is sold at significantly low prices, adversely affecting producers and diminishing competitiveness in the market [12].

These environmental conditions, along with deficiencies in cultivation techniques and the management of coffee marketing and distribution, highlight the necessity for innovative processes to be implemented at all stages of the coffee supply chain. Such innovations are crucial for adapting to the evolving landscape, enhancing resource efficiency, and improving profitability for all stakeholders within the supply chain.

Aligned with these concerns, it is posited that the intricacies of coffee quality are influenced by physical, chemical, sensory, and environmental factors that occur during the pre-harvest phase. Furthermore, it has been demonstrated that coffee quality is impacted by factors related to roasting and milling techniques employed in the post-harvest process [13].

These elements are essential for production efficiency, coffee quality, and commercial recognition, underscoring the urgent need to adopt sustainable practices and to identify and evaluate the factors that determine coffee quality in the current industry landscape [14]. Undoubtedly, the integration of innovative approaches in coffee production processes is crucial for achieving optimal levels of quality, efficiency, productivity, and profitability within the Colombian coffee [15].

In the global coffee market, there is an increasing emphasis on production models that combine fair trade and organic agriculture, as these approaches have been shown to yield superior results, enhance producer incomes, and sustain traditional agroforestry systems [16]. This relevance is heightened by the recent surge in coffee prices, which has led to unprecedented earnings for Colombian coffee growers. This increase has been driven by rising prices on the New York commodity exchange, fluctuations in Colombia's exchange rate, and frost events impacting Brazil's major coffee-producing regions [17].

Figure 1 illustrates the trends in both domestic and international coffee prices over the past decade, revealing a significant correlation between these two pricing dynamics [18]. Notably, Figure 1 highlights a marked improvement in coffee prices beginning in 2020, enabling producers to realize greater profits. This period of elevated coffee prices presents a critical opportunity to promote and implement innovative practices in the coffee production process. Current market conditions facilitate the transformation of coffee into a high-quality specialty product, thus better positioning both producers and marketers to navigate future periods of less favorable pricing.

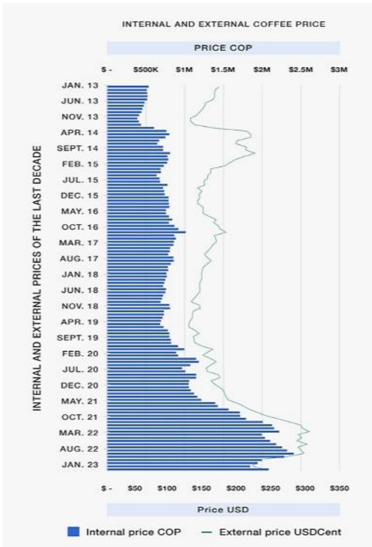


Fig. 1*. Domestic and external coffee prices over the last 10 years.*
Source: *Prepared by the authors based on information from the archive on coffee prices, areas and production [18].*

2. METHODOLOGY

According to the National Federation of Coffee Growers of Colombia (FNC), coffee cultivation in the country is significant due to its substantial positive impact on the social and economic aspects of producing regions, with these benefits also extending to environmental sustainability and the overall health of the territory [19]. Sustainable specialty coffee constitutes 15% of the national market in Colombia [20].

The first phase of the methodology established for this research focused on identifying the types of innovation outlined in the Oslo Manual [21], specifically those related to improvements in business processes (IPN). These innovations are categorized into functional areas, including: 1) product or service development, 2) distribution and logistics, 3) marketing and sales, 4) information and communication systems, 5) management and administration, and 6) product and process development.

In the second phase, we analyzed the most frequently cited innovation criteria in the literature, as well as the elements considered for granting certifications in sustainable and fair-trade coffee. These elements include: 1) the 4C Code of Conduct [22], 2) Starbucks practices [23], 3) Rainforest Alliance [24], 4) Fairtrade [25], and 5) organic certifications from IFOAM [26]. Consequently, we identified and selected the factors and innovation variables most associated with process efficiency and coffee quality.

Subsequently, a survey-based data collection instrument was designed to gather information related to the seven factors of innovation identified in this study: economic, social, environmental, production, knowledge management, technology, and change management. The questions were formulated in a closed format using a four-point Likert scale.

The validation of the data collection instrument was conducted through expert judgment, a method supported by scientific literature [27]. Additionally, the Cronbach's alpha method was employed to validate the instrument, yielding an indicator of 0.97. According to Shi et al. [28], the Cronbach's alpha index is a measure that analyzes data from the perspective of internal consistency; results above 0.7 indicate good reliability of the scale utilized in the validated instrument, which holds true in the context of this research.

For the fieldwork related to data collection, the sampling unit was defined as the special coffee-producing farm in Colombia. Given that Huila is the most significant department for coffee production in Colombia [4], data collection was conducted on coffee farms located in the Guacacallos and Acacos districts within this department.

To determine the composition and size of the sampling frame, the national agricultural census conducted by the National Department of Statistics (DANE) [29] was used as a reference. This census indicates that the Guacacallos district has 169 farms and the Acacos district has 44, totaling 213 coffee-producing farms. Due to the uniformity of the sampling elements, a simple random sampling (SRS) design was employed. Since the selected farms share the common characteristic of coffee production, each element of the population has an equal probability of being selected for the sample in the SRS [30]. To calculate the sample size for this research, Equation 1 was applied [31]:

$$n = \frac{N\ (Z_{1-\alpha})^2 \sigma^2}{Ne^2 + (Z_{1-\alpha})^2 \sigma^2} \qquad (1)$$

Where:
N= Total farm owners = 213.
Z= Confidence level, 95% = 1.96
ϭ (p,q)= Value of proportions = 0.50
e= Error = 10%.

By applying Equation 1 for simple random sampling (SRS), a representative sample comprising sixty-six (66) coffee-producing farms was determined. The owners of these randomly selected farms were administered the data collection instrument in October 2023.

With the collected data, an analysis of the dataset was performed using statistical methods such as Analysis of Variance (ANOVA) and heatmaps to identify variables with a significant impact on the target variable. For this study, the target variable was defined as the probability that each coffee-producing farm would be considered innovative based on its production and marketing practices.

Once the independent variables with the greatest predictive impact on the dependent variable were identified, the regression model that best suited the nature of the data was selected. In this case, the characteristics of the variables led to the choice of a logistic regression model, which is widely recognized as an effective method for data processing in classification and prediction tasks [32]. The statistical analyses required to implement this model on the dataset were conducted using R software.

Subsequently, a quantitative analysis of the results obtained from the proposed model was carried out to generalize the findings to a broader group or segment (the sample) or a larger population [33]. Additionally, the model was validated against its underlying assumptions. Validating these assumptions is crucial to ensuring the reliability and accuracy of the results [34]. The indicators from the validation tests of these assumptions must be significant to confirm that the logistic regression model is robust, thereby ensuring that the prediction results obtained from the model are valid and reliable.

3. RESULTS

The analysis of the literature related to innovation factors in coffee production processes, along with the examination of elements considered for international fair trade certifications in the coffee production and marketing sector, resulted in the identification of a total of seven innovation factors to be addressed in this research: 1) economic factor, 2) social factor, 3) environmental factor, 4) production factor, 5) knowledge factor, 6) technological factor, and 7) management factor. These seven innovation factors are associated with the variables that evaluate the innovative capacity of production processes in coffee farms. A total of 54 variables were identified and categorized within these seven innovation factors. However, variables X5, X11, X20, X28, X44, X49, and X55 were excluded from the statistical analyses, as they are confirmatory variables used in the survey questionnaire for each of the seven innovation factors.

Table 1 presents each innovation factor along with the corresponding variables, including their respective identification labels (Xi), which were utilized for both data analysis and the design of the logistic regression model.

Table 1: *Innovation variables grouped by factors*

Economic factor F1
X1- Long-term profitability and productivity
X2- Record keeping
X3- Market and trade information
X4- Product quality traceability
Social factor F2
X6- Free from discrimination
X7- Freedom from forced and compulsory labour
X8- Child labour and child protection
X9- Freedom of association and collective bargaining
X10- Conditions of employment
Environmental factor F3
X12- Biodiversity conservation
X13- Plant health management
X14- Soil conservation
X15- Soil fertility and nutrient management - Organic matter X16- Water - Water sources
X16- Water - Water sources
X17- Water - Wastewater
X18- Waste identification and management
X19- Climate change management
Production factor F4
X21- Sowing and rotation
X22- Pruning and Tree Crop Renovation
X23- Genetically Modified Organisms
X24- Management of agrochemicals
X25- Management of production practices
X26- Evaluation of conservation areas
X27- Organic production
Knowledge factor F5
X29- Hazardous substances
X30- implementation of improvements to reduce risks from hazardous substances
X31- Soil erosion
X32- Implementation of improvements to reduce soil erosion X33- Fertiliser management
X33- Fertiliser management
X34- Implementation of improvements for proper disposal of fertilisers X35- Sustainable water use
X35- Sustainable water use
X36- Implementation of measures to improve water quality

X37- Wastewater and risks to human health and the environment X38- Implementation of improvements to reduce wastewater risks X39- Use of PPE and other measures to reduce health risks X39- Use of PPE X40- Implementation of improvements for the use of PPE X41- Use of Tools and machinery X42- Implementation of improvements for the use of tools and machinery X43- Emergency management
F6 Technology
X45- Management and monitoring X46- Energy X47- Digital adoption X48- Digital platform
Change management F7
X50- Human resource management X51- Flexibility to change X52- Leveraging resource plans X53- Integrated process management

***Source**: Own elaboration.*

Once the relevant variables were identified, the next step was to determine which of these significantly drive innovation in sustainable specialty coffee production processes on Colombian farms. Figure 2 presents a correlation map, a powerful visualization tool for two-dimensional data that reveals patterns shared by subsets grouped in rows and columns [35]. In this study, the two dimensions represented in the map correspond to each of the identified innovation variables and the likelihood that each coffee-producing farm is regarded as innovative based on its production and marketing practices.

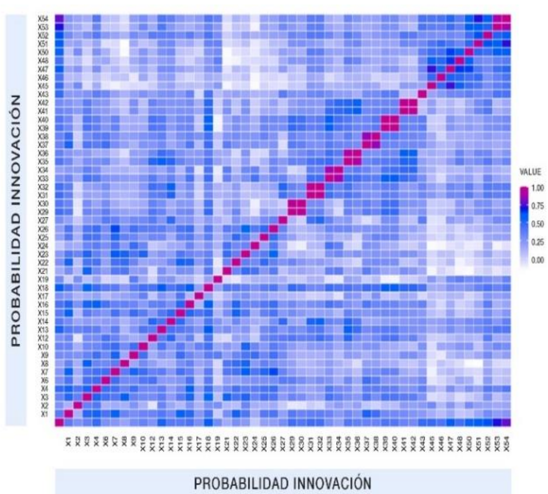


***Fig. 2.** Heat map correlation between innovation variables and the probability of a farm being considered innovative.*
***Source**: Own elaboration using R software R.*

In Figure 2, the innovation variables that most significantly influence the specialty coffee production processes on the Colombian farms participating in the study are highlighted with dark-colored rectangles. These variables are as follows: 1) Product quality traceability (X4); 2) Pesticide application (X13); 3) Comprehensive waste identification and management (X18); 4) Knowledge of first aid (X43); 5) Adoption of digital technology (X47); 6) Human resource management (X50); 7) Flexibility in the face of change (X51); 8) Resource leveraging (X52); 9) Process management (X53); and 10) Internal inspection and self-evaluation (X54).

The results of the correlation analysis were subjected to multivariate statistical analysis to quantitatively determine which variables significantly influence the likelihood of classifying a farm as innovative. This involved conducting an Analysis of Variance (ANOVA), defined by Andrade [36] as a statistical procedure used to compare the means of two or more groups.

Table 2 presents the results of the ANOVA, where the p-value statistically supports the conclusion that the variables 1) comprehensive waste identification and management from the environmental innovation factor, 2) digital technology adoption from the technological innovation factor, and 3) flexibility in the face of change from the change management innovation factor significantly contribute to the likelihood of classifying a coffee-producing farm as innovative. The findings in Table 2 allow for the identification, with 95% confidence, of the three innovation variables that most significantly enhance the potential for innovation in the coffee production processes of the farms.

***Table 2:** Result of the ANOVA analysis of variables with a significant impact on the probability of innovation in a coffee farm.*

Variables	Chisq	Df	Pr(>Chisq)	NS
Identification and integrated waste management	19.451	1	0.000010322	***
Adoption of digital technology	15.16	1	0.000098775	***
Flexibility to change	19.758	1	0.000008789	***

***Source**: Own elaboration using R software R.*

Upon identifying the variables that significantly impact the likelihood of innovation in coffee production processes on the farms, a logistic regression model was proposed. Logistic regression simulates the effects of independent variables on the outcome variable, generating a binary probability [37]. In this research, the binary results enable the prediction of a specific specialty coffee farm's inclination towards innovation, classifying it as either innovative or non-innovative.

RCTA
Revista Colombiana de Tecnologías de Avanzada
UNIPAMPLONA

Table 3 presents the results of the logistic model, utilizing the variables 1) comprehensive waste identification and management, 2) digital technology adoption, and 3) flexibility in the face of change—each of which was statistically identified as having a significant impact on classifying coffee farms with innovative elements in their processes.

The p-value results in Table 3 indicate, with 95% confidence, that these three independent variables included in the logistic regression model exhibit a statistically significant relationship with the dependent variable, specifically the likelihood of classifying a specialty coffee-producing farm as either innovative or non-innovative.

Table 3: *ANOVA analysis of variables with a significant impact on the probability of innovation.*

Description	Estimated	Std. Error	z value	Pr(>|z|)	NS
Intercept	-26.6951	7.939	-3.363	0.000772	***
Identification and integrated waste management	4.861	1.5995	3.039	0.002373	**
Adoption of digital technology	2.1631	0.7833	2.762	0.005752	**
Flexibility to change	2.0838	0.7098	2.936	0.003328	**

Source*: Own elaboration using R software R.*

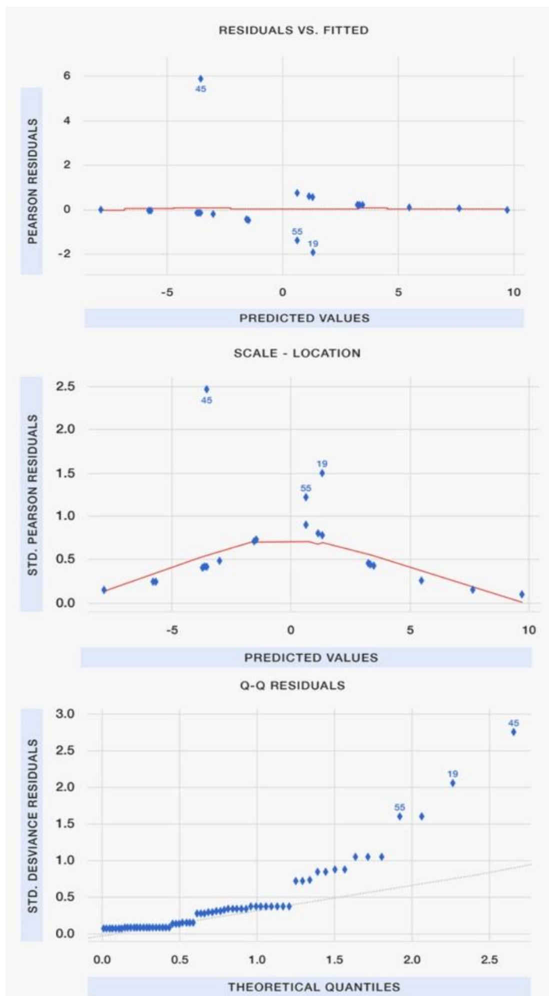
The innovation model to produce specialty coffee, developed through the analyses conducted in this study, facilitates the identification of the innovation variables that coffee farms should integrate into their production processes to generate sustainable specialty coffee. Equation 2 summarizes the innovation model for specialty coffee-producing farms in Colombia, which was derived from this study based on a logistic regression framework.

$$Y = -26.6951 + 4.861 * X18 + 2.1631 * X47 + 2.0838 * X51 \quad (2)$$

Where:
Y = Innovation Probability.
X18 = identification and integrated waste management.
X47 = adoption of digital technology.
X51 = flexibility in the face of change.

The innovation model derived from this research, mathematically represented by Equation 2, indicates that farms producing conventional coffee have an intercept of -26.6951. To enhance their production processes, these farms should prioritize variable X18 from the environmental innovation factor, which has a significant impact on the probability of innovation, quantified at 4.861. Additionally, they should implement variable X47 from the technological innovation factor, which affects the probability of innovation with a coefficient of 2.1631 and adopt variable X51 from the change management innovation factor, which has an impact on the probability of innovation with a coefficient of 2.0838.

Validation of this proposed innovation model is conducted by verifying compliance with the underlying assumptions through a parametric approach. Figure 3 illustrates the results of validating the assumptions of homogeneity, linearity, normality, and independence for the innovation model developed in this study. The outcomes of the parametric validation, presented in Figure 3, indicate that the proposed model demonstrates a robust fit, confirming that its predictions are both reliable and accurate, as evidenced by the absence of discernible patterns and a uniform distribution of residuals.



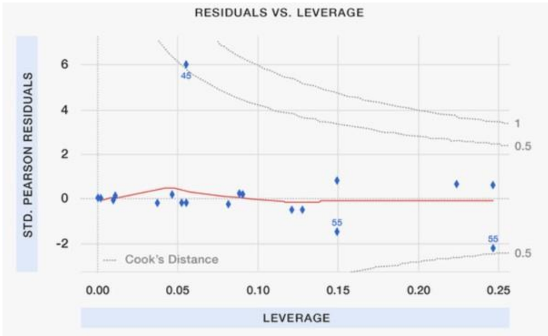


Fig. 3. *Results of validation assumptions using the parametric method.*
Source*: Own elaboration using R software R.*

4. CONCLUSIONS

The innovation model proposed in this research introduces novel, original, and highly relevant insights into the production and marketing processes of coffee. Based on the literature review conducted, no prior contributions have been identified that relate to a model integrating various types of innovation associated with specialty coffees from a sustainable perspective.

The analysis reveals that the primary variables driving innovation in specialty coffee farms in Colombia are: 1) waste identification and management, associated with the environmental innovation factor; 2) digital adoption, linked to the technological innovation factor; and 3) flexibility to change, corresponding to the change management innovation factor. According to the logistic regression model developed in this study, these three variables are pivotal in determining whether a coffee farm can be classified as innovative, particularly with regard to the integration of innovative elements in its production and marketing processes.

The findings of this research indicate that the key innovation factors shared across various international certifications for sustainable trade in the coffee sector are predominantly associated with environmental considerations, technology, and change management. These three factors should be integrated into the supply chain processes of coffee farms to foster innovation and promote the sustainable production of specialty coffee.

REFERENCES

[1] Coffee Behind the Scenes, CBS, (2018), “El Café en Colombia”. Available: http://www.coffeebehindthescenes.com/es/country/colombia

[2] Federación Nacional de Cafeteros - FNC, (2019), “Café de Huila”. Available: https://huila.federaciondecafeteros.org/cafe-de-huila/

[3] C. A. Anacona, B. P. Montoya, E. V. Ramos and A. F. Solis, “Evaluation of cup profile for post-harvest in coffee variety Castillo from Cauca Department”. Tendencias en ciencias, vol. 1, p. 1, Feb. 2021. DOI: 10.48048/tis.2022.4526

[4] C. Manchola, (2022), “Por 12 años consecutivos, Huila es el mayor productor de café”. Available: https://www.lanacion.com.co/por-12-anos-consecutivos-huila-es-el-mayor-productor-de-cafe/

[5] J. Molina, C. Mora and M. Gallardo, “Relations between politics and coffee reality: a case study in Pitalito (Huila-Colombia)”, Revista do Desenvolvimento Regional, vol. 26, pp. 1-12, Apr. 2021. https://doi.org/10.17058/redes.v26i0.17253

[6] A. Alvarez and J. Hurtado, A, “History of Colombian Economic Thought”, vol. 1. Routledge, pp. 1-12, Sep. 2023. https://doi.org/10.4324/9781003289241.

[7] E. J. Ramírez Zuñiga and L. Y. García Muñoz, (2020), “Competitividad en la producción de cafés especiales del departamento del Huila”, M.S. thesis, Univ. EAN. http://hdl.handle.net/10882/10101

[8] I. Laranjeira, (2019), “Café de Calidad y Sostenibilidad Ambiental: ¿Cómo Lograrlos?”. Available: https://perfectdailygrind.com/es/2019/09/12/cafe-de-calidad-y-sostenibilidad-ambiental-como-lograrlos/

[9] Y. Pham, K. Reardon-Smith, and G. Cockfield, “The impact of climate change and variability on coffee production: a systematic review”, Springer Journal, vol. 156, p. 16, Sep. 2019. https://doi.org/10.1007/s10584-019-02538-y.

[10] V. Byrareddy, J. Kath, L. Kouadio, S. Mushtaq, and V. Geethalakshmi, “Assessing scale-dependency of climate risks in coffee-based agroforestry systems”, Scientific Reports, vol. 14, pp. 1-7, Apr. 2024. https://doi.org/10.1038/s41598-024-58790-5

[11] Perfect Daily Grind (PDG), (2019), “¿Cómo Se Compra Y Vende El Café Verde?”. Avaliable:https://perfectdailygrind.com/es/2019/01/15/como-se-compra-y-vende-el-cafe-verde/

[12] K. Tolessa, J. D’heer, J. Duchateau, and P. Boeckx, “Influence of growing altitude, shade and harvest period on quality and biochemical composition of Ethiopian specialty coffee”, Journal of the Science of Food and Agriculture,

vol. 1, pp. 1-13, Oct. 2016. https://doi.org/10.1002/jsfa.8114.
[13] A. Hammed, S. Hussain, M. Umair, S. Ullah, I. Pasha, and H. Rasul, "Farm to Consumer: Factors Affecting the Organoleptic Characteristics of Coffee. II: Postharvest Processing Factors", Comprehensive Reviews in Food Science and Food Safety, vol. 2, pp. 1-8, Jul- 2018, https://doi.org/10.1111/1541-4337.12365
[14] G. Puerta, "Manual del cafetero colombiano: investigación y tecnología para la sostenibilidad de la caficultura", manual cafetero, vol. 3, pp. 80-81, Dec. 2021. https://doi.org/10.38141/cenbook-0026
[15] A. Devaux, M. Torero, J. Donovan, and D. Horton, «Agricultural innovation and inclusive value-chain development: a review, »Current Opinion in Environmental Sustainability, vol. 8, pp. 15-22, Mar. 2018. https://doi.org/10.1108/JADEE-06-2017-0065
[16] Diario Responsable, (2019), "El café, un arma de doble filo para el medio ambiente y los agricultores". Available: https://diarioresponsable.com/noticias/27806-el-cafe-un-arma-de-doble-filo-para-el-medio-ambiente-y-los-agricultores.
[17] Semana, (2021), "Precios históricos del café: ¿a qué se debe el buen momento del grano?". Available: https://www.semana.com/economia/empresas/articulo/precios-historicos-del-cafe-a-que-se-debe-el-buen-momento-del-grano/202110/
[18] Federación Nacional de Cafeteros (FNC), (2023), "Precios, áreas y producción de café, Available: https://federaciondecafeteros.org/wp/estadisticas-cafeteras/
[19] Federación Nacional de Cafeteros - FNC, (2019), "Cafés especiales". Available: https://federaciondecafeteros.org/wp/glosario/cafes-especiales/#:~:text=En%20Colombia%20son%20aquellos%20valorados,mayor%20bienestar%20de%20los%20productores.
[20] L. F. Samper and X. F. Quiñones-Ruiz, "Towards a Balanced Sustainability Vision for the Coffee Industry", Resources, vol. 6, no. 2, p. 17, Mar. 2017. https://doi.org/10.3390/resources6020017
[21] Organización para la cooperación económica y oficina de desarrollo estadístico de las comunidades europeas (OCED), "Manual de Oslo", vol. 4, pp. 15-45, oct. 2018. https://doi.org/10.1787/9789264304604-en
[22] Código de Conducta 4C, (2018), "Código Común para la Comunidad Cafetera (4C)". Available: https://www.4c-services.org/wp-content/uploads/2019/04/4C-Code-of-Conduct_v2.3_ES.pdf
[23] Prácticas C.A.F.E. de Starbucks, (2016), "Tarjeta de puntuación genérica". Available: https://cdn.scsglobalservices.com/files/program_documents/cafe_scr_genericv3.4_esp_030916_1.pdf
[24] Rainforest Alliance, (2023), "Requisitos para fincas". Available: https://www.rainforest-alliance.org/wp-content/uploads/2023/02/SA-S-SD-1-V1.3ES-Rainforest-Alliance-2020-Estandar-Agricultura-Sostenible-Requisitos-para-Fincas.pdf.
[25] Fair Trade, (2019), "Criterio de Comercio Justo Fairtrade para Organizaciones de pequeños productores".Available: https://files.fairtrade.net/standards/SPO_SP.pdf
[26] International Federation of Organic Agriculture Movements – IFOAM, (2019), "The Common Objectives and Requirements of Organic Standards. Available: https://ch.ifoam.bio/sites/default/files/2020-04/coros_2011_spreadsheet_final_5.xls
[27] D. F. Polit and C. T. Beck, "Nursing Research: Generating and Assessing Evidence for Nursing Practice, »Kluwer health, vol. 31, pp. 770-784, Aug. 2017. https://doi.org/10.1016/j.iccn.2015.01.005
[28] H. Shi, Y. Ren, J. Xian, H. Ding, X. Liu, and C. Wan, "Item analysis on the quality-of-life scale for anxiety disorders QLICD-AD (V2.0) based on classical test theory and item response theory", Health and Quality of Life Outcomes, pp. 1-12, May. 2024. https://doi.org/10.1186/s12991-024-00504-2
[29] Departamento Nacional Administrativo de Estadísticas - DANE,(2014), "Censo Nacional Agropecuario". Available: https://www.dane.gov.co/files/CensoAgropecuario/informacion-veredas.xls
[30] R. Hernández-Sampieri, C. Fernández, y M. Baptista. "Metodología de la investigación". Mcgrawhill education, vol. 6, pp.170-180, Aug. 2014. ISBN: 978-1-4562-2396-0
[31] S. Rahi, "Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues, and Instruments Development", International Journal of Economics & Management Sciences, vol. 6, pp. 1-13, May. 2017. https://doi.org/10.4172/2162-6359.1000403
[32] X. Zou, Z. Tian, Y. Hu, and K. Shen, "Logistic Regression Model Optimization and Case

Analysis”, IEEE Xplore Digital Library, p. 1-2, Oct. 2019. DOI: 10.1109/ICCSNT47585.2019.8962457

[33] R. Hernández-Sampieri, C. Fernández, and M. Baptista, “Metodología de la investigación”. Mcgrawhill education, vol. 6, p.6, Aug. 2014. ISBN: 978-1-4562-2396-0

[34] D. Alita, A. Putra, and D. Darwis, "Analysis of Classic assumption test and multiple linear regression coefficient test for employee structural office recommendation," Indonesian Journal of Computing and Cybernetics Systems, vol. 15, No 3, pp. 290-297, Jun. 2021. https://doi.org/10.22146/ijccs.65586

[35] Z. Gu and D. Hubschmann, “Make Interactive Complex Heatmaps in R”, Bioinformatics, vol. 38, pp. 1445-1460, Mar. 2022. https://doi.org/10.1093/bioinformatics/btab806.

[36] C. Andrade, «Understanding Factorial Designs, “Main Effects, and Interaction Effects: Simply Explained with a Worked Example”, Indian Journal of Psychological Medicine, vol. 46, no 2, pp. 1-11, Mar. 2024. https://doi.org/10.1177/02537176241237066

[37] T. Islam, A. Sheakh, S. Tahosin, H. Hena, S. Akash, Y. Yardan, G. F. Wondmie, H. Nafidi, and M. Bourhia, “Predictive modeling for breast cancer classification in the context of Bangladeshi patients by use of machine learning approach with explainable AI”, Scientific report, vol. 14, pp. 1-7, Apr. 2024. https://doi.org/10.1038/s41598-024-57740-5