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Hans H. Ruthenberg Award for Graduates 2024

Paloma Acosta Rivera “Climate-Smart and Circular Practices for Coffee Farming in Antioquia and Caldas, Colombia”, Technical University of Munich, 2024

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Problem Statement

Coffee is one of the most valuable agricultural commodities globally, and its relevance extends beyond economic dimensions to cultural and environmental aspects. The continuous expansion of the coffee market, supported by rising global demand, particularly for high-quality coffee in international markets, underscores its economic significance (Vegro & de Almeida, 2020). This growth highlights the coffee industry as a crucial player in the global economy, with coffee production predominantly occurring in tropical regions like Colombia, Brazil, Vietnam, and Indonesia. Colombia, the third-largest coffee producer worldwide (FNC, 2021), is particularly notable in the coffee industry for its high-quality Arabica beans. The country's unique geographical features, including its mountainous terrains and tropical climate, create ideal conditions for coffee cultivation, allowing Colombia to produce coffee with distinctive flavors that are highly prized on the international market. The nation's coffee industry not only plays a vital role in its economy but also in the socio-economic development of its rural areas. Over half a million families in Colombia depend directly on coffee farming for their livelihoods, out of which 96% are small-holder farmers (Lacambra et al., 2020; Sectorial, 2022), making it a critical sector for rural development and poverty alleviation.

However, the coffee value chain exhibits significant inequalities. While coffee production primarily takes place in developing countries, the majority of the economic benefits accrue in developed consuming countries. This imbalance results in producers receiving disproportionately low prices for their coffee compared to the final retail prices in consumer markets. Moreover, adverse impacts on agriculture due to climate change (CC) are especially alarming for smallholder farmers in developing countries as they frequently lack information about alternative choices to adapt their production systems and face limited access to use technologies and financial services (FAO, 2013). The environmental impact of coffee farming is a pressing concern, with challenges such as deforestation, soil erosion, and biodiversity loss. These issues, coupled with the threats posed by CC, including increased pest and disease risks and unpredictable weather patterns, require exploring sustainable practices that can mitigate these adverse effects while reducing the negative environmental impacts.

Objective of the Research

This research is focused on studying Climate-Smart Agriculture (CSA) and Circular Economy (CE) practices in Colombia, which aim to address environmental challenges while improving economic outcomes for farmers. Despite Colombia's ongoing efforts to implement more environmentally friendly practices, most of the initiatives have been directed to the production phase of the value chain, leaving a gap in understanding the economic and environmental effects of implementing such practices in the post-harvesting stage. Studying these practices in Colombia's key coffee-producing regions of Antioquia and Caldas, which are significant players in the national coffee industry, provides valuable insights into how sustainable farming practices can be implemented effectively.

Hence, this study seeks to broaden the knowledge regarding coffee production and processing practices with a focus on these regions. The primary purpose is to evaluate the current practices implemented in the production and processing phases within the frameworks of CSA and CE, respectively. Once the practices are determined, the study intends to (i) identify the factors influencing the farmers' adoption of CSA and CE practices and (ii) assess the economic impact for the farmers of adopting these practices. Additionally, the study aims to compare the adoption rates in both regions, oriented toward understanding the factors driving these differences. Finally, the study seeks to provide recommendations to the relevant stakeholders involved in the production and processing stages of the coffee value chain.

Methodological approach

The study included a thorough literature review to identify the most relevant CSA and CE practices in coffee production and processing. This review was pivotal in grounding the empirical research within the existing body of knowledge and ensuring that the practices examined were pertinent to the current challenges and opportunities in sustainable coffee farming.

The literature review's findings were essential for designing the study's survey and data collection instruments, ensuring that the research focused on practices that were both theoretically grounded and practically significant in the field of coffee production and processing. The data collection approach included developing a survey tailored to the specific context of the coffee production and processing stages in Colombia, as well as a sampling strategy that combined both random and non-random sampling techniques. Additionally, qualitative instruments were integrated through unstructured interviews to supplement the quantitative survey data, providing a more comprehensive view of both the environmental and economic impacts of CSA and CE practices.

The research design was developed in two stages to address the selection bias problem arising from farmers' self-determined adoption of practices. This implies that unobserved factors can affect both the outcome of interest and the decision to adopt. The first stage involved using a multinomial logistic model to identify the factors that influence the adoption of CSA and CE practices among the 110 coffee farmers surveyed. The model expanded the binary approach (adoption vs. non-adoption) to incorporate different levels of treatments. In the second stage, the estimated probabilities of adoption from the multinomial logit model were used to assess the impact of these practices on the farmers' coffee income using a maximum likelihood estimation method.

Results

The study found that agricultural practices were adopted to different degrees between regions. At the production stage, the practices of permanent shade, temporary shade, and cover crops showed the most significant differences between Antioquia and Caldas. These differences could be attributed to altitude variations as the areas in Antioquia are located at lower elevations, requiring shade cultivation due to higher temperatures. In contrast, cooler regions in Caldas do not require as much shading. Some farmers were reluctant to adopt shade trees due to concerns about decreased productivity and the desire to grow more coffee trees to increase yields. The lower adoption of cover crops in Antioquia compared to Caldas was mainly due to time constraints, as cultivating other crops required additional efforts. At the processing stage, significant discrepancies were observed in adopting wastewater treatment systems (STAM), with a higher adoption rate in Antioquia compared to Caldas. This disparity could be attributed to stringent environmental regulations, active promotion by local authorities and coffee cooperatives, and government aid packages post-disaster. While Caldas showed a preference for artisanal filters to treat wastewater, no literature was found to evaluate their efficacy. Overall, farmers in both regions tended to adopt multiple practices simultaneously, indicating a preference for integrated approaches.

The findings of the multiple logistic regression analysis revealed a strong positive correlation between climate change perception and the likelihood of adopting shading systems and STAM, suggesting that farmers who have observed changes in the weather over the past 1520 years are more likely to adopt these practices. Additionally, the location of farms, particularly in Antioquia, exhibited significance in adopting only the STAM or the STAM combined with shading systems. The results from the second stage estimation showed that implementing shading systems (including permanent and temporary shade) at the production stage and wastewater treatment systems at the processing stage can benefit the farmer's coffee income. This underscores the potential economic benefits of adopting sustainable practices that extend beyond their environmental impact, suggesting a dual benefit of enhanced profitability and improved sustainability.

The implications of the study's findings for theory, practice, and policy development emphasized the need for sustainable practices at both production and processing stages. Practitioners are urged to adopt innovative approaches to enhance economic outcomes for coffee producers while minimizing environmental impact. However, financial and informational barriers must be addressed, necessitating additional resources and institutional support. Future research should focus on diverse and larger sample sizes, explore the potential of biodigesters in Colombian coffee farming, and delve into stakeholder dynamics within the coffee value chain to ensure that sustainability efforts are tailored to the real challenges faced by coffee producers.

In conclusion, this study provides robust empirical evidence supporting the economic and environmental benefits of CSA and CE practices in coffee fanning. lt also advocates strongly for policy interventions to facilitate the widespread adoption of these practices. Such interventions are crucial for ensuring the sustainable thriving of the coffee industry in Colombia, a key player in the global coffee market.

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