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Key Factors for Adaptation to Climate Change of Colombian Coffee Growers[a]

Factores claves para la adaptación al cambio climático de los caficultores colombianos

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RESUMEN

Climate change could have a negative impact on global coffee production. In Colombia, the current climate variability impacted coffee activity negatively in 2010-2011. Thus, the adaptation measures implemented by coffee growers will be crucial to assure the future of coffee production. This study pursues to identify which are the factors that encourage coffee growers to implement adaptation strategies to climate change. The vulnerability approach is used to analyse the growers´ adaptation prospects to climate variability. The research relies on the critical analysis of secondary information, mainly from the National Agricultural Census 2014. Some important findings were revealed; factors such as ethnicity, level of education, literacy, associativity, access to credit, size of the farm, living conditions, and land tenure, are decisive for implementing adaptation strategies. Thus, the analysis performed in this document could be an alternative for policymakers to design programs and policies that consider growers´ characteristics to reduce their vulnerability to climate change.

KEY WORDS: adaptation; climate change; coffee growers; vulnerability.

ABSTRACT

El cambio climático podría tener un impacto negativo sobre la producción global de café. En Colombia, la variabilidad climática actual impactó negativamente la actividad cafetera en 2010-2011. Así, las medidas de adaptación implementadas por los caficultores serán cruciales para asegurar el futuro de la producción. Este estudio pretende identificar cuáles son los factores que alientan a los caficultores a implementar estrategias de adaptación al cambio climático. El enfoque de vulnerabilidad se utiliza para analizar las perspectivas de adaptación de los productores a la variabilidad climática. La investigación se base en un análisis crítico de información secundaria, proveniente del Censo Nacional Agropecuario 2014. Los principales hallazgos son que factores como el grupo étnico, nivel de educación, alfabetización, asociatividad, acceso al crédito, tamaño de la finca, condiciones de vida y tenencia de la tierra, son elementos decisivos para la implementación de estrategias de adaptación. Así, el análisis desarrollado en este documento podría ser una alternativa para que los hacedores de política diseñen programas o políticas que tengan en cuenta las características de los cultivadores para reducir su vulnerabilidad al cambio climático.

PALABRAS CLAVE: adaptación; cambio climático; caficultores; vulnerabilidad.

Introduction

Coffee is produced in more than 50 tropical and subtropical countries and provides income for approximately 25 million farmers, especially smallholders (Samper et al., 2017). In Colombia, more than 550,000 families are involved in coffee cultivation (FNC and Universidad EAFIT, 2017). Several studies have demonstrated that climate change represents a real threat to coffee crops. In fact, current climate variability has distressed coffee crops. For this reason, some adaptation strategies have been developed, such as the use of resistant varieties, shade management, soil conservation, soil improvement, protection of water sources, crop diversification,

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animal husbandry, access to technical assistance, among others. The implementation of these strategies could depend on the demographic, social or economic characteristics of growers. Furthermore, this study uses the vulnerability approach to analyse the growers´ adaptation prospects to climate variability.

To further understand the elements that can influence the implementation of adaptation strategies, this study is framed as a qualitative analysis that aims to answer the research question: Which are the factors that determine the climate change adaptation strategies among coffee growers in Colombia?

The analysis is based on the National Agricultural Census 2014 (DANE, 2016). In Colombia, the decisive characteristics of coffee growers for the implementation of adaptation strategies are the educational attainment, size of the farm, access to credit, belong to an ethnic group, belong to any growers' association, grower living conditions and land tenure. Moreover, the participation of stakeholders and the policy design could be crucial to reduce the producers' vulnerability.

Background

According to Field et al. (2014), the future climate will depend on the expected warming produced by past emissions, as well as future emissions and natural climatic variability. The change in the global average surface temperature for 2016-2035 with respect to 1986-2005 will be in the range of 0.3 ˚C to 0.7 ˚C; this scenario is similar for all emission generation paths. However, the projected climate change for 2050 and 2100 will be affected by these trajectories. The increase of global mean surface temperature by 2081-2100 compared to 2016-2015 will be from 0.3 ˚C to 1.7 ˚C under low emission scenarios, 1.1 ˚C to 2.6 ˚C under medium emission scenarios, 1.4 ˚C to 3.1 ˚C under high emission scenarios and 2.6 ˚C to 4.8 ˚C under very high emission scenarios.

Climate change could manifest rapid and recurrently through hazards, generally related to an increase in the frequency and intensity of storms, extreme precipitation events, and heat waves. Furthermore, slow onset changes may occur, which may have adverse effects in the long term, these are associated with the consequences of the increase in the trends and variability of the meteorological variables, change in seasons, the disruption of the El Niño Southern Oscillation (ENSO), melting ice, the acidification of the oceans, sea level rise, among others. Those can contribute to increasing the vulnerability of people and communities and affecting their livelihoods (Boyd and Tompkins, 2010).

The consequences of climate change will vary depending on the region of the planet, and the economic sector (Smit and Wandel, 2006; Boyd and Tompkins, 2010). For Latin America, Samaniego et al. (2015), suggest that in agriculture the main economic risks might be a reduction in production and quality, lower-income and higher prices. CIAT (2014) maintain that in the Andean region of Colombia, Ecuador and Peru, the increase in temperature will cause the loss of land suitable for some crops, such as coffee, so those crops could move to higher latitudes.

Field et al. (2014) sustains that coffee is sensitive to climate variability, and it is expected the increase in the incidence of pests and diseases in the presence of climate variability. Besides, climate change could cause the loss of land suitable for coffee cultivation, which will affect livelihoods, especially of smallholders. In consequence, adaptation strategies are crucial, and some structural changes are required, such as encouraging sustainable agriculture and climate-smart agriculture (FAO, 2018).

In Colombia coffee is a traditional crop, in 2017 this sector represented 12 % of the agricultural Gross Domestic Product (GDP) and about 25 % of the rural population was engaged in this crop, that was approximately 550,000 families (FNC and Universidad EAFIT, 2017). The IDEAM et al. (2017) suggests that Colombian coffee sector is one of the most vulnerable to climate change, and different tools for adaptation have been consolidated through the associations of growers. The adaptation strategies for coffee have been related to the transformation of production systems, management of shady coffee plantations, reforestation and the protection of water and soil. The Colombian Coffee Growers Federation through the National Coffee Research

Centre (CENICAFE in Spanish) generates early weather warnings and provides crucial information for farmers decision making (FNC, 2017a).

One of the events that may have an impact on crops in the country is the disruption of the ENSO that causes the El Niño and the La Niña event. Between 2010-2011, the La Niña event caused heavy rains and floods, with significant economic impact in Colombian sectors, such as infrastructure, habitat and agriculture. In the last one, the most affected crops were rice, coffee and sugarcane. This situation showed the risk of the country to extreme weather events, which could be accentuated in a climate change scenario (ECLAC, 2012). As reported by the FNC (2012), coffee production in 2011 was 7.8 million bags, 12 % less than in the previous year, due to excessive rainfall and humidity, and lower solar energy associated with the La Niña event 2010-2011.

The La Niña event 2010-2011 prompted the Federation of growers to orient its sustainability policy to reduce the vulnerability of producers with adaptation strategies, the strengthening of a communication system to generate timely information for decision making, and the adoption of Climate Smart Coffee Growing (FNC, 2012). For the development of these strategies the following actions have been established, planting of varieties resistant to rust, review of the spatial distribution of coffee plants, renovation of coffee plantations, phytosanitary crops management, adequate soil nutrition, shade management, soil conservation, early warnings and scientific research related to climate change. Another strategy that has been implemented was the management of environmental resources with activities, such as waste management, environmental education, and protection of water sources and forests (FNC, 2015)

Moreover, according to Avelino et al. (2015), the Colombia rust crisis from 2008 to 2011 reduced coffee production by about 31 % compared with the average of 2007. This harvest reduction had an impact on the livelihoods of coffee farmers and workers. In a climate change scenario, the epidemics by coffee rust could be more frequent. Thus, actions such as the development of resistant coffee seeds, the creation of a warning system, better crop management practices, and training should be positive options for farmers.

Coffee growers in Colombia have started applying some strategies for adaptation to climate variability. The CIAT and CVC (2016), through a participatory approach identified some of these practices in the north of the Valle del Cauca region, related to water management, soil conservation, land use, resistant seeds, crops diversification, shade management, education and training, community participation, among others. Similarly, Turbay et al. (2014), explored the experience of 70 growers in the Chinchina and Porce rivers located on the central Andes in Colombia related to current climate variability adaptation. They recognized the use of some agricultural practices for facing this situation, such as shade management, resistant varieties, vegetation cover, soil conservation, crops diversification, preservation of water sources, staggered production, good use of fertilizer, and some social and economic strategies, such as reducing food consumption, family labour force reorganization, participation in growers' associations, income diversification and community support.

The analysis in this paper explores some adaptation strategies consider in this section and how the coffee growers' characteristics could determine their implementation. In the next section the document explains the analytical framework of vulnerability and how this supports to explain the coffee producer's adaptation decisions.

Analytical framework

This document uses the conceptual framework of vulnerability; this concept is complex and encompasses several elements. Gupta et al. (2010) affirms that the determinants of vulnerability are adaptive capacity, exposure, and sensitivity. Gallopín (2006) points out that even if a system is vulnerable, it will not present problems if this system is not exposed to perturbations. Meanwhile, Smit and Wandel (2006) find that the vulnerability of a system is related to the exposure and sensitivity to hazardous situations, as well as the ability of that system to cope, adapt or recover from the consequences of those situations. In general, if a system is more exposed

to climate-related shocks, that system will be more vulnerable. But if that system has the more adaptive capacity, its vulnerability will tend to decrease.

The definition used in the document is given by Parry et al. (2007, p. 21) "vulnerability to climate change is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."

To understand a context of vulnerability it is necessary to consider its components. Thus, adaptive capacity is "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (Parry et al., 2007, p. 21). Exposure is "the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected" (Field et al., 2014, p. 5). And sensitivity that is "the degree to which a system is affected, either adversely or beneficially, by climate variability or climate change" (Parry et el., 2007, p. 881).

Following Baca et al. (2014), the elements that frame vulnerability, such as exposure, sensitivity, and adaptive capacity, can be used to analyse the interaction between climate change and the availability of resources for coffee producers in Colombia. The exposure can be described in relation to the impact of climate change on producers and their livelihoods. Sensitivity and adaptive capacity can be associated with the producers' resources, such as human, natural, social, physical and financial capital (CIAT, 2014; Baca et al., 2014). For Colombia and according to the National Agricultural Census 2014 (DANE, 2016), the human capital could be related to the growers' educational level, literacy or access to the health service. The social capital with the association capacity of the producers. Physical capital might be connected to poverty levels, the material of floors and walls, access to public services and the size of the farm. Meanwhile, the financial capital with access to credit and natural capital with access to water sources, natural forests and the area planted with crops.

Finally, the vulnerability of the Colombian coffee growers, their livelihoods and their production systems, following the definitions of Parry et al. (2007), will depend on the nature, magnitude and speed of climate change and the variation to which they are exposed, their sensitivity and their adaptive capacity. Thus, the coffee growers will be considered vulnerable if they have high exposure, high sensitivity, and low adaptive capacity. Alternatively, the adaptive capacity that includes natural, human, social, physical and financial capital, could be improved with broad access to these resources, such better knowledge and training for farming practices or use of water, supporting association of growers, access to finance, among others (Baca et al., 2014; Fischersworring et al., 2015).

Methodology

To address the research question: Which are the factors that determines the climate change adaptation strategies among coffee growers in Colombia? The study uses the vulnerability approach to analyse the social and economic characteristics of coffee growers and their households. Then this identifies the adaptation strategies that coffee producers are using and the factors that are influencing the implementation of these strategies.

The growers' characteristics and the adaptation practices are defined using the National Agricultural Census 2014 (DANE, 2016). This Census covered the dispersed rural area of Colombia, according to DANE 112 thousand hectares were reached. Of this total 40.6 % were for agricultural activities. For this study, coffee growers were selected from the Census 2014, following the criterion that the producers were living on the farm, thus, 174,673 resident producers were identified. Then, these producers were characterised according to their age, sex, ethnicity, educational level, literacy, if they have access to health service, if they recognize themselves as poor, if they have access to credit, the region where they reside and if they belong to any farmers association, also the size of the farm and land tenure status were considered.

The activities considered as adaptation in this document, and that can be identified in the Agricultural Census 2014 are:

The use of coffee varieties resistant to rust. In Colombia, CENICAFE has developed four varieties with these characteristics, the Colombia variety introduced in 1983, the Tabí variety in 2002, the Castillo variety in 2005 and in the the Cenicafé 1 variety released in 2016 (Rendón, 2020).

Soil conservation practices: These were classified as technical, cultural or none. Technical practices include minimum tillage, zero tillage, manual sowing, vegetation coverage, conservation practices, preparation of substrates to form the soil or crop rotation. Practices that can be considered as cultural are prayers, rites or indigenous rituals. None, if the producers do not perform any soil conservation practice.

Protection of water sources, similar to the previous one, the activities related to vegetation conservation, tree planting, artificial drinking facility, hydrographic rounds management, water reuse and wastewater treatment were classified as technical practices. The cultural were prayers, rites, indigenous rituals and the management of sacred sites. None, if the producers do not perform any practice. Not water sources, if the farm does not have water sources.

Soil improvement: The application of chemical or organic fertilizers, correction of soil acidity and burning. The cultural once again encompasses prayers, rites and indigenous rituals. None, if the producers do not perform any improvement practice.

Crop diversification, if one or more of the following products are grown in the coffee production unit, cereals, fruits and nuts, vegetables, edible roots and tubers, and oilseeds and seeds.

Animal husbandry: if the producer has animals for sale or self-consumption, including cattle, pigs, chickens, buffalo, sheep or goats.

Technical assistance, if the producer received technical advice on issues related to good agricultural and livestock practices, environmental management, soil management, postharvest management, commercialization, associativity, credit and financing, business management or traditional or ancestral knowledge.

The adaptation strategies consider suitable for soil conservation, protection of water sources and soil improvement are those classified as technical practices.

Subsequently, the implementation of these strategies will be analysed according to the characteristics defined for the producers, which could be related to the five types of capital, human, natural, social, physical or financial, that in turn can be associated with the sensitivity and adaptive capacity of the growers. The existence of differences in the use of these strategies will be explored, for example between men and women, by levels of education, literacy, farm size, poverty status, associativity, access to credit, age and regions. This analysis will allow greater clarity on which are the factors that determine the use of adaptation strategies to climate change in the coffee sector, and if the policies related to climate change that the government or the Federation have designed could help to improve the growers' adaptation.

Analysis

Producer characteristics: most of the Colombia coffee producers are small farmers

For this analysis, 174,673 coffee growers were identified in the Census 2014. Traditionally coffee regions in Colombia are found in the Andes Mountain. The coffee farms are small, about 70 % of them have less than 5 hectares (ha), and the average area planted with coffee is 1.87 ha. Most form of landholding is private, 74 %, the houses inhabited by coffee growers have mostly walls with adequate materials, 82 %, while the percentage of houses with adequate floors is lower, 69 %. Access to public services is almost total for the electricity, 99.6 %, but very low for the aqueduct, 44 %, and sewerage, 7 %. Thus, approximately 72 % of producers are recognized themselves as poor (DANE, 2016).

A total of 67 % of the coffee producers are men. The average age is 50 years and 46 % is in the range between 25 and 50 years, 79 % of producers claim that do not belong to any ethnic group, while 19 %

recognise themselves as indigenous. A total of 96 % of these producers have access to health services. Most growers, 66 %, only reached the primary level of education and only 2.5 % have tertiary education. The percentage of those who cannot read or write is 14 %. Only 35 % of resident producers say that belong to producer associations, unions, cooperatives, research centres or community organizations, while 23.3 % have access to credit (DANE, 2016).

Adaptation strategies: belonging to a growers' association could be positive for climate change adaptation

Some adaptation strategies for coffee crops have emerged from technical and scientific research. But others are the natural response of farmers to current climate variability. Thus, it is important to know if coffee growers in Colombia are using any of them and which factors determine the use of these strategies. For example, agroforestry or shade management, is an important practice to protect coffee plantation for the sun and high temperatures and is generally considered like a good practice against climate change (Avelino et al., 2015). According to Farfán et al. (2004), partial or total shade was implemented in approximately 37 % of the Colombia coffee plantations.

The other adaptation strategies to be considered here are those that are identified from the National Agricultural Census 2014. A total of 68.5 % of resident producers used rust resistant coffee varieties. For the protection of water sources, 71.6 % employed some of these practices, vegetation conservation, tree planting, artificial drinking facility, hydrographic rounds management, water reuse or wastewater, but 19 % did not have access to water sources. In the case of soil conservation, 72.5 % of the farmers used minimum tillage, zero tillage, manual sowing, vegetation coverage, conservation practices, preparation of substrates to form the soil or crop rotation, and 25.1 % did not use any soil conservation practice.

To improve soil, 70 % of growers applied chemical or organic fertilizers or corrected the acidity of soils, and 27.4 % did not use any practice. Meanwhile, the diversification of crops was practiced by 69.9 % of producers, that cultivated cereals, fruits and nuts, vegetables, edible roots and tubers, or oilseeds and seeds for self-consumption or sale, and the animal husbandry was practiced by 77.6 % of them. Besides, 60.6 % of producers received technical advice.

In order to analyse the factors that affect the use of the adaptation strategies considered in this study, it must identify what of the characteristics of the producers are essential. One of the critical factors is if the producer belongs to an ethnic minority (Figure 1) this influences negatively almost all the strategies considered in this document. In contrast, if the producer belongs to any growers' association (Figure 2), this influences positively the adaptation strategies, especially to obtain technical assistance, the use of resistant varieties, animal husbandry and the improvement of soils. Meanwhile, access to credit encourages producers to use more adaptation practices related to the protection of water sources, animal husbandry, access to technical assistance, and the conservation and improvement of soils (Figure 3).

The size of the farm is significant (Figure 4) for the improvement and conservation of soil if the farms are small, and for crop diversification, animal husbandry and access to water sources if the farms are large. Private land tenure is a positive factor for the implementation of adaptation strategies, such as protecting water sources, receiving technical assistance, planting improved varieties, and improving soils (Figure 5).

The level of education is another crucial factor for using adaptation strategies, if producers have some level of education, they do more activities related to the protection of water, improvement of soil, technical assistance and soil conservation (Figure 6). Likewise, the literacy of farmers has a similar effect for implementing adaptation strategies (Figure 7). Finally, if the producers recognize themselves as not poor, it is important for obtaining technical assistance and using crop diversification (Figure 8).

The analysis carries out in this study could be an alternative point of view for policymakers and stakeholders, considering the grower characteristics like an element for designing programs and policies to reduce the producers' vulnerability.

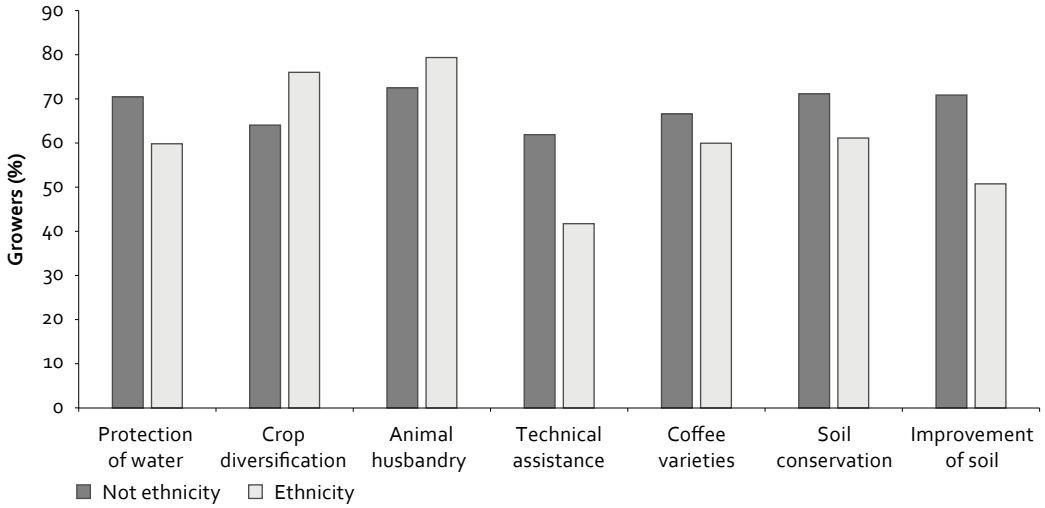

Figure 1. Belong to an ethnic minority. *Source*: National Agricultural Census 2014

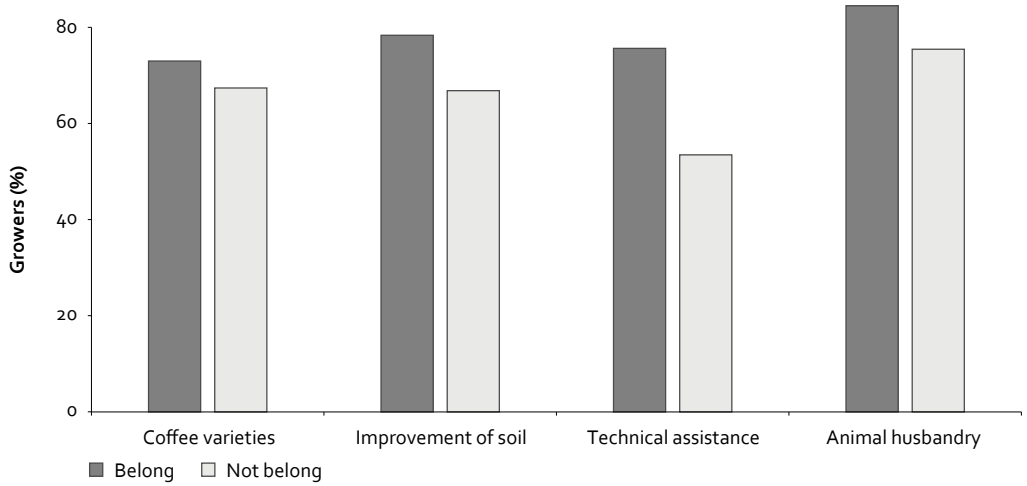

Figure 2. Belong to a famer's association. *Source*: National Agricultural Census 2014

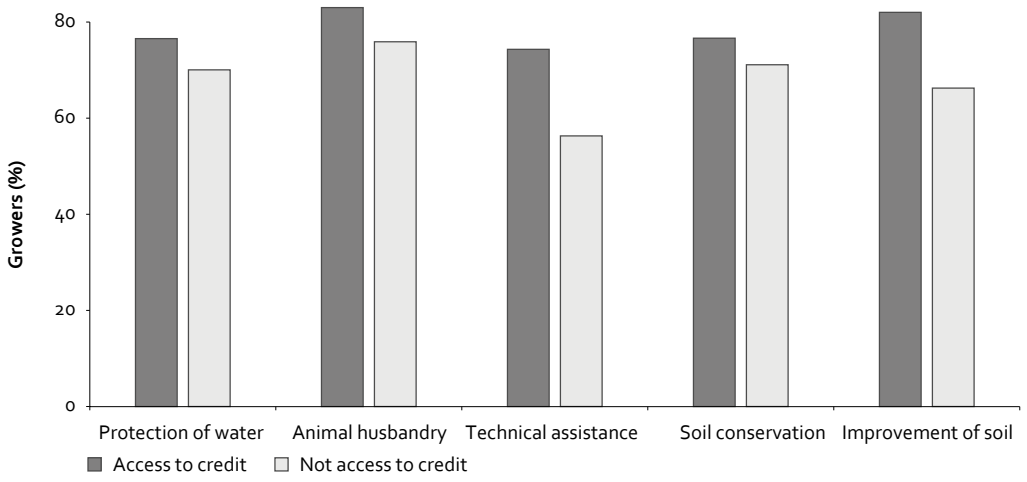

Figure 3. Access to credit. *Source*: National Agricultural Census 2014

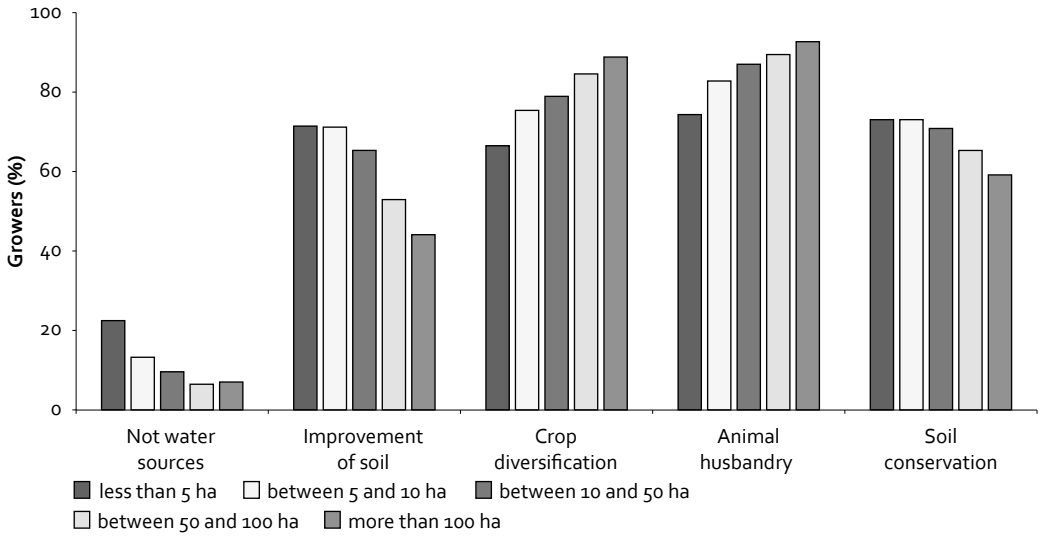

Figure 4. Size of the farm. *Source*: National Agricultural Census 2014

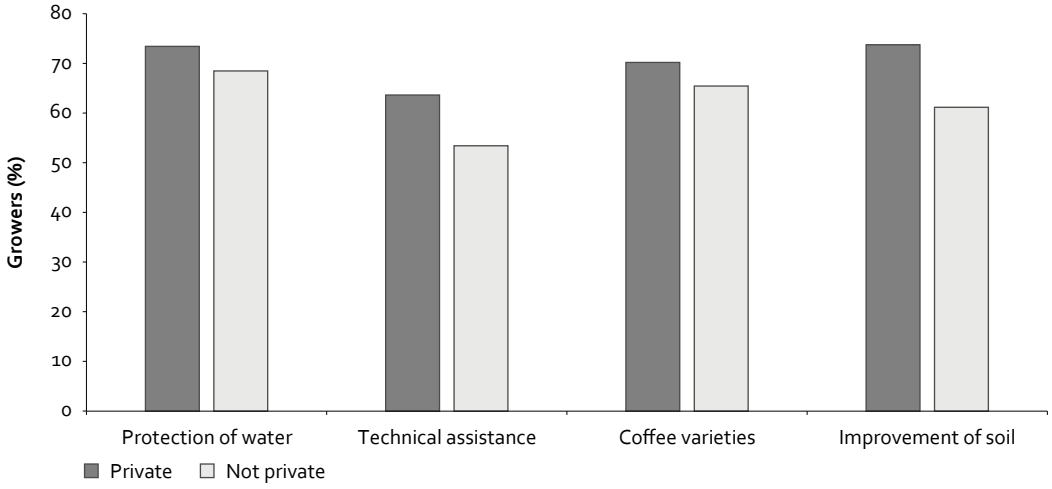

Figure 5. Land tenure. *Source*: National Agricultural Census 2014

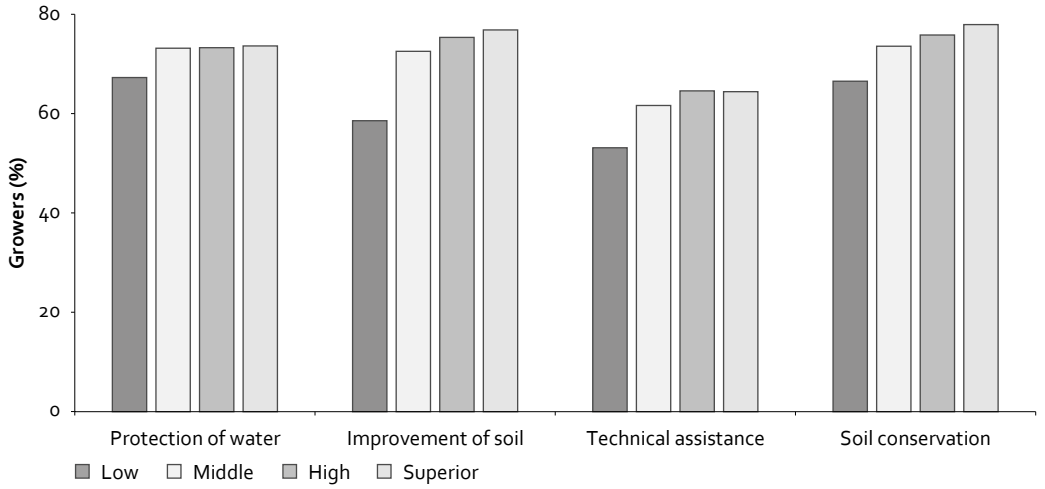

Figure 6. Level of education. Source: National Agricultural Census 2014

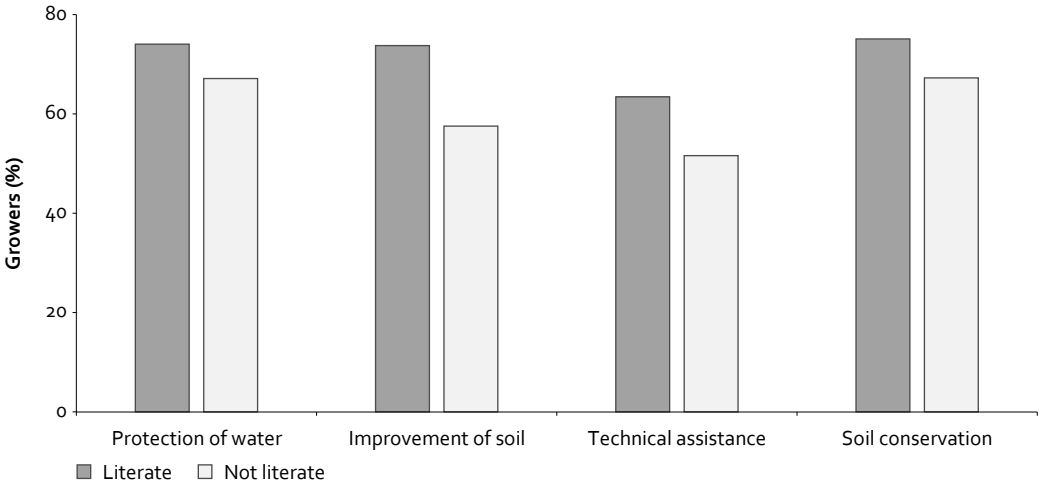

Figure 7. Literacy. *Source*: National Agricultural Census 2014

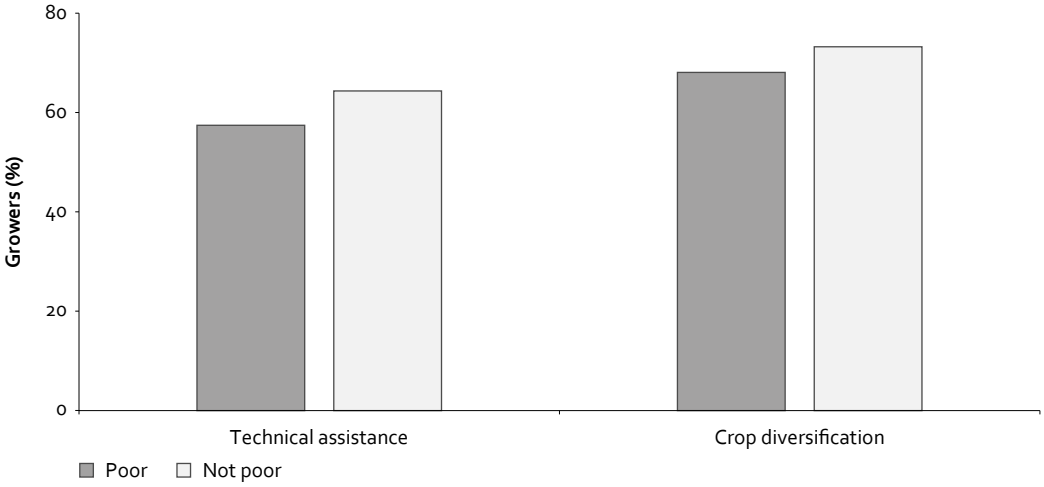

Figure 8. Poverty status. *Source*: National Agricultural Census 2014

Growers' associations could play a key role for tackling climate change

In Colombia, climate change represents a challenge for social and economic development. For instance, the emergency generated by the La Niña event between 2010-2011 encouraged to strengthen and organise the Disaster Prevention and Attention System, which constitutes the institutional public response to deal with environmental risks (Acosta et al., 2012). Thus, the National Development Plan 2010-2014 included a chapter on environmental sustainability and risk prevention. Meanwhile, document 3700 of the National Council for Economic and Social Policy (2011), guides the coordination of the institutions involved with the climate change strategy under the National Climate Change System (created under decree 298 of 2016), to integrate into the planning and investment processes of the sectors and territories, the challenge to economic and social development caused by climate change (DNP, 2011).

And the last National Development Plan 2018-2022 urges the construction of a resilient country. Colombia is committed with two strategies, risk management and adaptation to climate change (DNP, 2019).

The Third National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), highlights that the integration of the problem of climate change in sectoral and territorial planning is just beginning. For instance, the

agricultural sector that is one of the most vulnerable to climate change has been one of the leaders in proposing different lines of action. The Ministry of Agriculture and Rural Development has proposed to strengthen growers' associations, with technology and information transfers and the improvement of the sector adaptive capacity (IDEAM et al., 2017).

One of the most important growers' association in the country has been the National Coffee Growers Federation. For this institution, the economic, social and environmental sustainability has become a central issue. In particular, the federation has considered two components for the environmental management, climate-smart coffee growing, which seeks to make this activity more sustainable and profitable, through mitigation and adaptation to climate change, and the management of environmental resources, which promotes preservation of biodiversity and natural resources, through environmental education, waste management and the protection of water sources and soils (FNC, 2015).

Discussion

In Colombia, the aging of the population dedicated to agriculture is one of the problems for the sector (DNP, 2015). In the case of coffee growing, the producers' average age is 50 years. Moreover, coffee growers are mostly (70 %) owners of small farms of less than 5 ha with an average planted area of less than 1 ha. The living conditions of the resident coffee growers reflect the precariousness of the rural life, as noted by the Mission for Rural Transformation (DNP, 2015), since the access to public water services (44 %) and sewerage (7 %) is low, and the walls and floors are constructed with inappropriate materials in coffee farmers' households (DANE, 2016).

Similar results were reported in a study developed by the Federation, which calculated the adjusted Multidimensional Poverty Index for coffee growers, based on data from the National Agricultural Census 2014, this revealed that around 46 % of the coffee population lived in a poverty situation. However, this was lower than the national rural poverty that was 48.1 % (FNC, 2017b).

Additionally, Colombian coffee production is exposed to the risks of climate variability, it was evidenced by the La Niña event 2010-2011. As Ramirez-Villegas et al. (2012) state that in a scenario of climate change Colombian coffee cultivation will experience yield reductions and increase production costs. Thus, strategies such as crop migration to higher altitudes in the Andes is an option, but the economic, social and environmental sustainability of the crops should be guaranteed. For this reason, it is crucial to analyse other adaptation strategies, which have been already implemented by coffee producers and were discussed in the previous sections, to determine the factors that could contribute to their use.

The analysis of vulnerability to climate change in this document considers the five types of capital, physical, human, natural, financial and social. They are associated with sensitivity and adaptive capacity (CIAT, 2014; Baca et al., 2014). Likewise, it is important to examine whether the sociodemographic characteristics of the producers have any influence on the implementation of the selected adaptation strategies.

One of the sociodemographic factors decisive for the implementation of the adaptation strategies for climate change was belonging to an ethnic minority, although in a negative way. In the Colombian case belongs to an indigenous community (18.6 %) or to be Afro descendant (2.3 %). Producers who identify themselves as ethnic minorities are concentrated in four producing departments. The Federation emphasizes that indigenous peoples have a great respect for Earth, and they are communities of collective rights. Thus, indigenous coffee is an activity promoted by these communities with the aim of improving their living conditions. In the department with the greatest participation of indigenous producers, the Federation provides technical assistance services using radio broadcasting to reach indigenous communities (CCC, 2017). But it is still insufficient since the information from the Census 2014 revealed that only 44 % of these ethnic growers received technical assistance. In contrast, 65 % of non-ethnic producers have access to this service.

In general, ethnic groups produce coffee without chemical fertilizers (El Espectador, 2016), this is one of the reasons to implement fewer practices of soil improvement, compared to growers who do not belong to an ethnic group. Indigenous people do not consider coffee growing as a mono-crop, thus, the average coffee area cultivated by indigenous growers is smaller, 1.2 ha, compared to not indigenous growers, 2 ha. However, the former carries out more activities, such as animal husbandry or crop diversification in relation to the others.

Another important feature is the land tenure, the possession of the land by ethnic groups is private, 46 %, collective property, 23 %, and adjudication, 20 %. In contrast, farmers that do not belong to ethnic groups mostly have private property, 82 %. Thus, the adaptation practices regarding land ownership have some similarities to the practices implemented by ethnic groups, that is, if the land ownership is not private, they use fewer strategies for protecting water sources and improving soils, receive less technical assistance and plant fewer improved varieties.

The educational attainment reached by the producers is low since the majority only have primary education, 66 %, in many cases it was not completed, in the same way, the percentage of the cultivators without education or with just pre-primary is large, 15 %. Likewise, people who cannot read and write, 14 %, is a high result, considering that in 2014 this rate was 5.8 % at the national level and 3.9 % in the urban area (DANE, 2015). It is observed that the educational attainment and literacy, indicators related to human capital, are important factors in the implementation of adaptation strategies since if the producers have a higher level of education and are literate, they tend to use better practices to protect water, improve and conserve soils, and receive more technical assistance.

Consequently, policies for access to education in the rural area, especially at the higher levels, are necessary. According to the Ministry of Education, the gross coverage in the rural area at the upper secondary level in 2014 was 62 %, and in 2017 it continued low at 67 %, compared to access in the urban area that was 86 % (MEN, 2014, 2017). Meanwhile, access to tertiary education is limited since most universities are in the urban area, especially in the main cities. In addition, rural literacy programs for adults should be promoted to improve the human capital of farmers.

The ability for association understood in this context as social capital has become an important determinant to implement some of the strategies considered. Thus, the associated growers applied better practices, such as planting varieties resistant to rust, improving soils, receiving more technical assistance and practicing animal husbandry. The Federation is a participatory organization, but not all growers can be federated and have the right to vote because they should complete some requirements (FNC and Universidad EAFIT, 2017). However, everyone can obtain the benefits that the Federation offers. According to the Census 2014, only 35 % of resident producers acknowledged belonging to some type of association. This percentage of participation is considered low since for that year the Federation had a registry of 374,540 federated growers (FNC, 2014b), although not all of them are resident producers.

The role plays by the Federation is highlighted by some authors, such as the FNC (2014a), which indicates that the Federation was the executor of the policies, that the government performed for the sector between 2010-2014. Echavarría et al. (2017) mention that the Federation has promoted subsidy and credit policies to improve crops. In addition, the extension service of this institution carries out technical, social, economic and environmental programs. Nonetheless, its final goal has been to improve the quality of life of coffee growers, with the adoption of appropriate practices to produce excellent quality coffee, in a cost-effective and sustainable way (FNC and Universidad EAFIT, 2017). Through the extension service the Federation provides the producer with information on the financing alternatives (FNC, 2012; FNC, 2015), hence according to the Census 2014, those who belong to some type of association have better access to credit, 33 %, than those who do not belong, 18 %. Furthermore, the producers that have access to credit implement more adaptation strategies.

The sustainability approach that has been present in the programs of the Federation was consolidated with the strategies of climate-smart coffee

and the management of natural resources, adopted since 2011, after the impact of the phenomenon of La Niña event (FNC, 2012). Over the years these strategies have been a priority, with practices such as the planting of varieties resistant to rust, the spatial management of the crop, the renovation of coffee plantations, the improvement and conservation of the soils, the management of the shady, the early warning systems and the scientific research on climate change (FNC, 2015).

Meanwhile, the size of the farm, which corresponds to physical capital, is an important element for the implementation of some strategies. It is remarkable that larger farms, from 50 ha to 100 ha and more, perform fewer practices for conservation and improvement of soils. However, the explanation may be in the programs of specialty coffees and sustainable coffees, those are sponsored by the Federation and generally are developed in small farms. Large and medium-sized growers produce coffee by volume and do not concentrate on quality (Fernandez, 2017). In addition, as the Federation states, most coffee growers are smallholders, so accessing the market individually is difficult, for this reason, the Federation and its logistics operator, Almacafé, play a key role in developing programs of specialty coffee (FNC and Universidad EAFIT, 2017). These products have gained ground in the world market, which has allowed growers to protect themselves from the low prices of standard coffee (Velásquez and Trávez, 2019).

In Colombia, the specialty coffees program was created in 1986 by the Federation, with the objective of identifying and selecting coffees from specific regions, with special characteristics. These were divided into three large groups, coffee of origin, brewing coffee and sustainable coffee. To obtain quality certifications, farms should follow a process, which requires the proof of the use of biodiversity conservation practices, proper practices for improvement and conservation of soils, reduction of agrochemical use, conservation of water resources, better use of natural resources, fair treatment, and good conditions for workers, among others (Farfán, 2007). In fact, specialty coffees are a positive option to improve practices, which benefit adaptation to climate change and is an opportunity to obtain better living conditions for small producers, since the price of these coffees is higher than the price of standard coffee

On the other hand, the Federation has promoted the sowing of complementary crops such as maize and beans, these are considered a fundamental part of the food of peasant families. Similarly, coffee can be interspersed with fruit trees (FNC, 2012; FNC, 2015). However, the information obtained from the Census 2014 showed that the most widely grown crop in coffee farms is tubers, 49 %, which includes cassava and potatoes. Then there are fruits, 28 %; cereals, 15 %, which includes maize; and vegetables, 12 %, which includes beans.

In the analysis section the crop diversification covered several products, cereals, fruits, vegetables, tubers, and seeds, with the condition that one or more of these were carried out on the farm, the result was that in 70 % of the farms there are any of these crops. Furthermore, the largest farms diversify their crops more than the smallest. For instance, 89 % of farms with more than 100 ha use this practice compared to the 85 % of those with 50 ha to 100 ha that implements this practice.

Moreover, it is crucial to recognize the vulnerabilities of different groups, especially ethnic minorities, that participate in coffee production. It is necessary to consider their beliefs, norms of behaviour and the organization of their communities, in order to include them to the services provided by the Federation and to the programs of climate change, in all regions where these communities are settled. In addition, 72 % of resident coffee growers are recognized as poor according to the Census 2014 and they receive less technical assistance and diversify their crops less.

As noted in the background section, poverty reduction policies in rural areas can improve the living conditions of coffee farmers and benefit the adaptation to climate change (FAO, 2018; Turbay et al., 2014). In Colombia, the reduction of rural poverty has been gradual, in the last 10 years, approximately 1.7 million people have gotten out of this condition. However, the gap between the urban and rural areas is still significant, so the government should do greater efforts for improving the living conditions of the countryside population.

The Federation has represented the producers since 1927. The coffee growers can benefit from the services provided by the Federation, the most important of these is the extension service (FNC and Universidad EAFIT, 2017). Therefore, it is important to strengthen this activity with technical assistance related to climate change, risk management, land use and management, irrigation systems, prevention and control of pests and diseases, incorporation of agricultural innovation technologies, privilege the conservation of natural coverage, the restoration of degraded areas, the implementation of agroforestry systems, the reduction of deforestation, among others.

Additionally, the Federation should integrate its programs with national and territorial policies, headed by the Ministries of Agriculture and Rural Development, the Ministry of Environment and Sustainable Development, and the Regional Autonomous Corporations. Similarly, alliances for research in relation to climate change issues should be a priority for the government, promoting the association of the Federation Research Centre (CENICAFE), with universities especially those located in coffee regions, with Regional Autonomous Corporations, other national institutions such as the Colombian Agricultural Research Corporation (AGROSAVIA in Spanish) or the National Training Service (SENA in Spanish), international centres such as the Research Centre for Tropical Agriculture (CIAT), among others.

Conclusions

This document has analysed the Colombian coffee growers' features, that determine the implementation of strategies for climate change adaptation. In the case of coffee, the adaptation is related to change in precipitation patterns, loss of suitable land, dissemination of pests and diseases, possible disruption of the ENSO among others. To deal with current climate variability, some adaptation practices have been implemented, such as shade management, conservation and improvement of soils, protection of water sources, use of resistant varieties to coffee rust, crop diversification, animal husbandry, access to technical assistance, among others, these could be useful in a climate change scenario

The analysis from the National Agricultural Census 2014 has revealed some important findings. For instance, most coffee growers in Colombia are men, their average age is 50, smallholders, poor and with primary education. Some groups like indigenous producers (19 %) implement fewer adaptation strategies compare with not indigenous producers. Furthermore, the human capital associated with level of education and literacy; the social capital with associativity; the financial capital with access to credit; and the physical capital with the size of the farm, living conditions and land tenure were important factors for implementing adaptation practices, in the sense that if the growers have more of these resources, they use better practices.

The vulnerability analysis encompassed three components, exposure, adaptive capacity, and sensitivity. As (Baca et al., 2014; Fischersworring et al., 2015) affirm that the exposure could be difficult to reduce, but the adaptive capacity could be easier increased, by improving the access to natural, human, social, physical and financial resources. Therefore, the adaptation policy should incorporate this type of analysis to identify the resources that should provide and the groups that should prioritize to increase adaptive capacity. In the Colombia case, the programs should be concentrated on indigenous communities, and to promote better education, provide access to credit, reduce rural poverty and increase associativity.

However, in Colombia adaptation policies are recent, most of them were established in 2017. And as the Third National Communication under the UNFCCC highlights that the integration of climate change matter in sectoral and territorial planning is just beginning. In the coffee sector, national and sectoral policies should be integrated. The Federation has performed a decisive role for the coffee sector representing the producers, executing the policies and promoting sustainable programs, such as the specialty coffees, sowing of complementary crops, climate-smart coffee growing, access to credit, research on climate change, among others. Thus, the Federation should articulate their programs with the national policies headed by the Ministries of

Agriculture and Rural Development and the Ministry of Environment and Sustainable Development, and with the Regional Autonomous Corporations programs.

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