RESR Revista de Economia e Sociologia Rural
ISSN 1806-9479
ARTICLE

Representations of Colombian Andean farmers on climate change and mitigation and adaptation strategies

Representações dos produtores andinos colombianos referentes às mudanças climáticas e estratégias de mitigação e adaptação

José de Jesús Núñez Rodríguez[1], Julio César Carvajal Rodríguez[1], Darcy Margarita Carrero[2], Luisa Lorena Ramírez Novoa[1], José Vicente Sánchez Frank[1]

[1]Universidad de Santander, Cúcuta, Colombia. E-mails: jo.nunez@mail.udes.edu.co; julices63@hotmail.com; lulorano1971@gmail.com; jvsfrank@gmail.com

[2]Universidad Nacional Experimental del Táchira, San Cristóbal, Venezuela. E-mail: darcycarrero@gmail.com

How to cite: Núñez Rodríguez, J. J., Carvajal Rodríguez, J. C., Carrero, D. M., Ramírez Novoa, L. L., & Sánchez Frank, J. V. (2021). Representations of Colombian Andean farmers on climate change and mitigation and adaptation strategies. Revista de Economia e Sociologia Rural, 59(2), 2021. https://doi.org/10.1590/1806-9479.2021.220439

Abstract: This article presents the findings of research conducted in a rural community located in Norte de Santander Department, Colombia, on farmers' representations of the impacts of climate change. The analysis of the behavior of temperature and average rainfall in the period 1985-2015 was put together concerning the local knowledge of the farmers. The approach was developed through 56 multiple choice questions surveys done to 144 producers intentionally selected from a group of 1,933 farmers, analyzed with descriptive and inferential statistical techniques. The findings indicate a broad opinion by farmers of the effects of climate change due to the gradual increase in temperature that causes changes in the bimodal system and intensity of rainfall; reduction in agricultural and livestock production, product quality and quantity; intensification of pest and disease attacks; reduction in water sources and water quality; extinction and migration of species of flora and fauna; and effects on the family's comfort during work and rest hours, health and hygiene. Likewise, local strategies and the participation of public institutions in the mitigation and adaptation to climate change are evident.

Keywords: agriculture, climate change, social representations.

Resumo: O artigo apresenta os resultados de uma pesquisa realizada em uma comunidade rural localizada no Departamento Norte de Santander, Colômbia, sobre as representações dos produtores em relação aos impactos das mudanças climáticas. Foi avaliado e analisado o comportamento da temperatura e da precipitação média no período 1985-2015, bem como sua relação com o conhecimento dos agricultores. A abordagem foi desenvolvida por meio de 56 questões de múltipla escolha feitas a 144 produtores, selecionados de um universo de 1.933 produtores, que foram analisadas por intermédio de técnicas estatísticas descritivas e inferenciais. Os resultados indicam uma ampla percepção dos produtores sobre os efeitos das mudanças climáticas em razão do aumento gradual da temperatura, causando mudanças no regime bimodal e na intensidade das chuvas; redução da produção agrícola e pecuária, e da qualidade e quantidade de produtos; intensificação no ataque de pragas e doenças; diminuição de fontes de água e qualidade da água; extinção e migração de espécies da flora e fauna; efeitos no conforto da família durante a jornada de trabalho e a folga, na saúde e na higiene. Além disso, estratégias locais e participação de instituições públicas na mitigação e adaptação às mudanças climáticas são evidentes.

Palavras-chave: agricultura, mudanças climáticas, representações sociais.

1. INTRODUCTION

The purpose of this article is to present the main findings of an investigation carried out in a Colombian Andean region of farmers' social representations on the implications of climate change on agricultural production, environmental resources, the rural family, and the strategies implemented for its mitigation and adaptation.

In Latin America and the Caribbean, a large part of food production comes from family farming, which accounts for some 17 million productive units (75%-90%), 60 million people (Sabourin et al., 2014) and, it is also the protector of the planet's rich reservoirs of biodiversity, such as water sources, soils and species of fauna and flora, due to the knowledge and experience of farmers in their conservation (De Boef et al., 2007). However, despite its great importance in the agri-food sector, few studies have been carried out on the impacts of climate change in this highly vulnerable social, ecological, and productive sector.

Exploring the implications of the environmental changes in their productive, environmental and social systems from the opinion of the social representations of the farmers is an epistemic strategy of reconstruction of meanings of this phenomenon in their everyday lives to generate theoretical constructs that allow their understanding and interpretation and, at the same time, enalbe researchers elements built “in situ” that are useful for the study of the impacts of climate change contextualized at the level of small-scale agriculture.

In the search for the knowledge of the farmers to rebuild their social representations, we started from the questions: What do they know about the changes in temperature and precipitation? how do climate variations affect agricultural production, environmental resources, and their family environment? what strategies have they implemented to adapt or mitigate their effects? and what has been the participation of public institutions in the rural community studied?

The Colombian Andean mountain range is a region that is fragile to climate change because of its geological and orographic conditions and because its slopes and intermountain valleys are home to a large segment of the population, especially those engaged in small-scale agriculture (Food and Agriculture Organization of the United Nations, 2014). Likewise, the rich biodiversity of local phylogenetic resources (Caetano et al., 2015), the multifunctionality of its rural territories (Pérez, 2016), and its important role as water reservoirs and regulators (Daza Torres et al., 2014) are given a strategic purpose.

In the agricultural scenario, extreme weather in Colombia, with prolonged droughts and intense rainfall, have caused large losses in agriculture (Fondo Financiero de Proyectos de Desarrollo, 2013) due to the effects of the Niño and Niña phenomena (Southern Oscillation, ENSO), especially in the period 2010-2011, due to its highly rainfall-dependent nature and vulnerability to thermal variability (Pierre & Tirado, 2007) and because of its dependence on structural family farming (Avellaneda-Torres et al., 2014).

Multiple factors in the agricultural sector are associated with climate change and range from the elevation movement of crops in search of better weather conditions (Rodríguez de Luque et al., 2016) to the emergence of new opportunities in high latitudes for agricultural business for rural workers (Peltonen-Sainio et al., 2016). One of the effects caused by the increase in temperature and the reduction in precipitation is related to the decrease in crop yields and product quality (Rodríguez de Luque et al., 2016; D'Agostino & Schlenker, 2016; Esperbent, 2017; Lachaud et al., 2017; Wang et al., 2017; Nendel et al., 2018) of agricultural products in vulnerable rural regions.

The consequences of climate change on agriculture are multidimensional and escape the analysis of internal factors related to the agronomic processes of food or agro-industrial product production. The double exposure approach (Leichenko & O'Brien, 2008; Bellante, 2017) is useful in understanding farmers' vulnerability to climate change and globalization policies. Particularly, in the context of the environmental problems generated by variations in temperature and rainfall, it is necessary to involve collateral issues such as the effects of yields on prices, product quality, and food security of the population (Valenzuela & Anderson, 2011; Rodríguez de Luque et al., 2016; Peixoto et al., 2017; Bee, 2014) and; the relationship between community capacities, extreme events, and poverty of farming families (Iglesias et al., 2011).

Likewise, adaptation and mitigation practices have been implemented to guarantee the sustainability of the agricultural sector, among which are: conservation agriculture (Steward et al., 2018), climate-smart agriculture (Engel & Muller, 2016; Saj et al., 2017; Confalone et al., 2016; Andrade et al., 2014), the 4‰ soil carbon sequestration initiative (Chabbi et al., 2017) and local responses to climate change (Sada et al., 2014).

The relevant aspects of the research results presented are put together with the help of empirical data on climate behavior in the area under study over 36 years with the farmers' knowledge on the changes observed in their environment, attributed to climate variations, and the local responses of farmers to mitigate and adapt to climate change.

2. THEORETICAL UNDERPINNINGS

Social representations

Addressing farmers' representations on climate change and mitigation and adaptation strategies require linking three disciplinary areas around the effects of climate on agricultural production, environmental systems, and the social environment of farmers.

The concept of social representation, as an approach to research in rural settings, is relevant because of its character of in-depth thinking, in which the anthropological acquires relevance and facilitates access to the meanings of social life. Piñero (2008) develops the study of social representations from the notion of collective representations proposed by Durkheim (2000), who states that the phenomena have their origin in the network of social relations that individuals build in society.

The theory of Social Representations (SR) rethinks the relations between the individual-society, the subject-object, and of social interaction in the reconstruction of social and common-sense knowledge (Casado & Calonge, 2001). Moscovici (1979) establishing that social representations are an organized body of knowledge through which people understand and interpret physical and social realities, integrate and exchange information and experiences from their daily life. This body of common-sense knowledge allows Moscovici and his followers to elaborate the notion of social representations (Sancovschi, 2007), establishing a vision of the common, shared, and organized reality of a given social or cultural group (Jodelet, 1986).

Social representations institute a social thought that is differentiated from other forms such as science, myth, or ideology (Piña & Cuevas, 2004), enabling to establish differences between social representations around a diversity of social objects or facts, by individuality, that is, their subjectivity, and according to the uniqueness of their socio-cultural context (Ibáñez, 1994). This individual and subjective character connects the social representations of rural actors and their perception of the variations of climate change and its economic, environmental, and social impact. Rural scenarios give social representation a shared character as an agreement between individuals that is manifested by the similarity between responses, and interests or, in terms of Doise et al. (2005).

In rural culture, social representations are a vital guide to social behavior, practices and produce a system of anticipation and expectation (ABRIC, cited in Doise et al., 2005) around the family-work-belief triad (Núñez, 2016), about the infinite number of objects that surround them, which, when they become habits which are going to be the supports and guides of rural social practices.

In the system of representations of the farmers, sufficient mental schemes are configured to explain the local and external realities of their daily lives. In the noise of their daily life, they learn from their natural and social environment how to construct mental maps, which are becoming increasingly complex, of how to act in their natural ecosystems, the norms of social behavior, the beliefs and superstitions of the spiritual world and the social practices related to production. The knowledge is built in the theoretical-empirical planes under rationality characterized by the deep overlap of the worlds (natural, social, and spiritual) objectified and anchored as cultural features of the rural social groups (Núñez, 2004).

Studies on the particular nature of farmers' social representations reveal that the responses to climate risks are predominantly social, emotional, and symbolic (Joffe, 2003); with a tendency to deny their behaviorto avoid guilt feelings about their responsibilities in the destruction of the environment, making a selectivity of perspectives and a selective interpretation of their immediate economic and family interests (Norgaard, 2006); developing cognitive and social processes for adaptation to climate threats through the perception and understanding of risks (Litre & Bursztyn, 2015); through a selective and temporary opinion, in the short term, that does not allow for the anticipation of long-term actions (Rodrigues et al., 2016; Brondizio & Moran, 2008) and; which allows them to develop territorial and socio-cultural resilience to cope with climate pressures (Gaivizzo et al., 2019).

3. METHODOLOGY

The research was carried out between 2017 and 2018 in the municipality of Bochalema, a mountain area located at 1,051 meters above sea level, with an average temperature of 20°C and an average annual rainfall of 1,200 mm, in the department of Norte de Santander in the Republic of Colombia, on the eastern border with Venezuela. In this entity, about7,042 people are predominantly engaged in small-scale agricultural activities such as coffee, cocoa, pasture, dual-purpose cattle raising, fruit trees (avocado and citrus), panelera sugar cane, vegetables (tomato and paprika), bananas, and minor animal species (chickens, pigs, ducks). Most of the rural properties are owned and some are leased, with 80% of the areas less than 10 hectares, dedicated to polyculture, and with the use of low technology levels (Bochalema, 2016). It is a region characterized by abundant natural biodiversity, water wealth, agro-tourism importance, and high vulnerability to extreme events (landslides).

The methodological approach was descriptive and cross-sectional, using a survey consisting of 56 multiple-choice questions, with categories related to the impacts of climate change on agricultural production, environmental resources, the family social environment, mitigation and adaptation strategies, and the actions of public institutions on climate change. From a group of 1,933 farmers in the municipality (Bochalema, 2016), 144 producers were selected at their convenience according to the criteria of geographical location, the experience of the farmers, and favorable references from community leaders. The instruments were applied by three professionals in the areas of agronomy and agricultural administration, residents of the study area.

The results of the surveys were analyzed using descriptive statistics and included the calculation of absolute and relative frequencies for the organization and presentation of information using graphs and tables that allowed trends to be detected. Likewise, for the climatological data an inferential model we used two ways: firstly, to cover all aspects related to the estimation of parameters, real population values, obtaining estimators with desirable properties, and; secondly, hypothesis testing.

In the hypothesis tests, the following was used for the difference of proportions: 1) Confidence Interval, which allowed to find the range of effective values for the real difference of two proportions (parameter difference) and at the same time to figure out the existence of significant differences and; 2) Hypothesis Contrast, for the difference of population proportions, to obtain a better understanding, validation of the results given by the estimation of Confidence Intervals and to confirm the trends shown by the use of descriptive statistics.

The analysis of temperature and rainfall trends was based on the report “Technical guidelines for climate change management and low-carbon and climate-resilient development” produced by the North-Eastern Border Regional Autonomous Corporation (CORPONOR) and the Francisco de Paula Santander University (UFPS) in 2018. The study covered the climate records for the period 1980-2015 (36 years), of 15 weather stations located in the department of Norte de Santander, belonging to the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM).

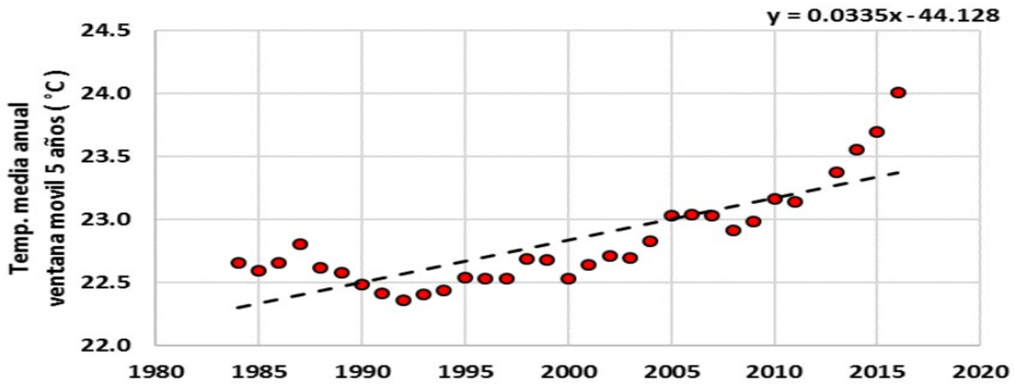
We estimated the trends in average temperatures and precipitation through scatter plots with trend lines, using a Simple Regression model, by linking the values of the 36 years of climate records. To determine the behavior of the climatic variables in the municipality of Bochalema, we selected the stations located in the municipality of Salazar de las Palmas, code

1602503, coordinates 7745283 latitudes and 72.830556 longitudes, located at 860 meters above sea level, for the analysis of temperatures and; the Francisco Romero station, identified with code 1602506, coordinates 7.76667 latitudes and 72.80000 longitudes, located at 1000 meters above sea level, for the analysis of precipitation.

4. Results and Discussion

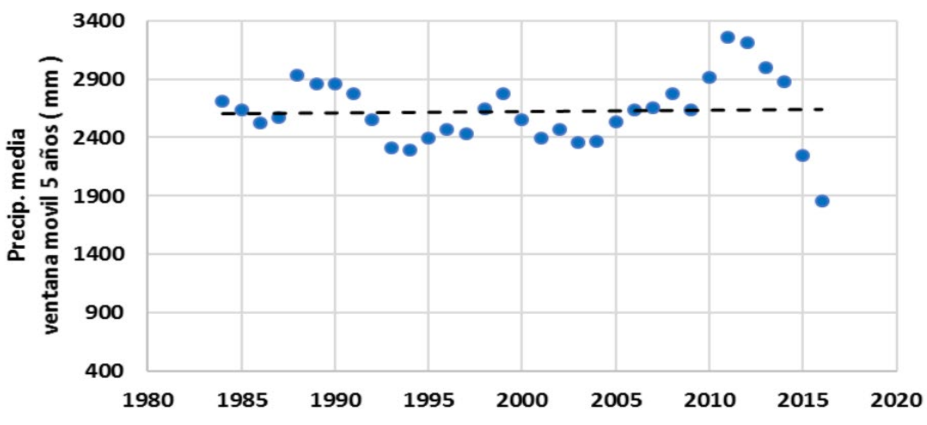
4.1 Climatological behavior in the study area.

Trends in average annual temperatures and precipitation are presented in Graphs 1 and 2, respectively.



Graph 1. Average annual temperature trends. Source: Colombia (2018)

The scatter plot shows a direct or positive association trend of the time and temperature variables, with significant increases in the average temperature over the 36 years of recording, estimated according to the regression model at a gradient of 0.0335 °C per year.



Graph 2. Trends in average annual rainfall. Source: Colombia (2018)

The scatter plot and the dotted trend line do not show trends of association between weather and rainfall, i.e. there are no significant changes in the amount of rainfall over the 36 years of record.

By figuring out the empirical data on temperature trends with farmers' opinions and local strategies for mitigation and adaptation, there is consistency with the perception of the increase in temperature and drought and their impact on agricultural production, water resources, soil preservation, family comfort and responses to them. However, although rainfall records do not reveal significant variations over time, in farmers' experience the intensity and bimodal system have changed with the occurrence of contingent, extreme and unexpected rainfall and long periods of drought that affect production cycles, work schedules, and natural resources.

The trends in temperature increases are in line with the climate change scenarios projected for Colombia in 2100, analyzed by Instituto de Hidrología, Meteorología y Estudios Ambientales (2012) and Intergovernmental Panel on Climate Change (2014), which estimate an average increase of 2.1°C and a decrease of between 10% and 30% in average annual rainfall by the end of the century. These findings correspond to the propensity for rapid growth in global warming that shifts temperature into higher ranges, especially in the dry seasons, and are implanted in the opinions of older people, who can recall the changes in climate that have occurred in recent decades (Hansen et al., 2012)

The effects of ENSO in its warm phase, known as El Niño Phenomenon (Misra, 2009), have caused recurrent periods of drought that affect crops, characterized by increases in temperatures, increased heat waves (López et al., 2018), and decreased rainfall (Paredes & Guevara, 2010) which negatively affect plants due to thermal stress in the processes of plant growth and reproduction (Gourdji et al., 2013; Deis et al., 2015; Sun et al., 2018), biomass production and loss of fertility (Nendel et al., 2018) and leaf fall due to stress (Silveira et al., 2016).

Climatic variations generate negative impacts on agriculture since increases in average temperatures of 1°C are harmful to crops (Peltonen-Sainio et al., 2016) and increases in minimum nocturnal temperatures influence coffee production since it is estimated that for every 1°C increase in minimum nocturnal temperature (T min) it will cause annual yield losses of 137 ± 16.87 kg ha-1 (Craparo et al., 2015).

Likewise, effects have been found on crop yields and productivity (D'Agostino & Schlenker, 2016; Moreira et al., 2018), on the decline of soil fertility and coverage (Cortez et al., 2011; Candelaria-Martínez et al., 2014), and in pest and disease infestation (Fernández & Cordero, 2007; Čačija et al., 2017; Chloupkova et al., 2018). As announced, average temperature increases above 1°C can cause harmful effects on crops and, in some cases, can benefit the development of others (Peltonen-Sainio et al., 2016) according to their adaptive capacities, resilience, and agronomic management of the crops.

In the case of the La Niña phenomenon, farmers said that it had contributed to the loss of soil fertility due to the washing away of the top layer (20.8%), landslides due to torrential downpours, and waterlogging of flat land (30.6%). These indicators were significant at the level of the hypothesis test conducted.

The high sensitivity of the soils to extreme rainfall-dry events, especially those on the slopes of the Colombian Andes and dedicated to family agriculture in the production of coffee, fruit, vegetables, and pasture (Avellaneda-Torres et al., 2014), generates in the periods of prolonged droughts the loss of their vegetation cover by vegetation fires or plant death, making them vulnerable to erosion processes (Camargo et al., 2017), reducing the natural fertility for agricultural production (Candelaria-Martínez et al., 2014) and, therefore, affecting the quantity and quality of fertile land (Wang et al., 2017).

On the other hand, in the presence of intense rainfall, the soils lose their agricultural conditions due to the washing of the organic horizon and nutrients, mass removal of cultivated land (Salazar & Hincapié, 2010), and destruction of agricultural infrastructure and services (Colombia, 2014; Gourdji et al., 2016).

4.2 Farmers' representations of climate change

The analysis of farmers' social representations on climate change was divided into five categories: a) implications for agricultural production, b) impacts on environmental resources, c) effects on the family environment, d) mitigation and adaptation strategies, and e) actions by public institutions. Within each category, the impacts, the social representations of the surveyed, and the answers are broken down.

4.2.1 The implications of climate change on agricultural production

In the agricultural work of the farms, the climatic variations of the last years have configured a set of negative effects in the production of the crops by the prolonged droughts, intense rains, high incidence of plagues and diseases, and deterioration in the quality of the harvests (Table 1).

Table 1. Implications of climate change on agricultural production

Impacts	Farmers' representations	Percentage (%)
Effects on crop production	Decrease in production	51.4
Effects on livestock production	Decrease in grassland	51.0
	Decrease in animal production	42.0
Effects of droughts	Loss of soil fertility	67.4
	Soil erosion	36.1
	Vegetation Fires	7.4
Effects of flooding	Landslide	51.4
	Waterlogging of soils	30.6
	Soil fertility wash	20.8
Attack of pests and diseases	High incidence of the coffee berry borer	80.0
	Coffee rust damage	40.0
Effects on crop quality	Decrease in product quality	70.1

Source: Own elaboration (2018)

The repetition of prolonged droughts, derived from the El Niño phenomenon, is considered by farmers to be responsible for the loss of soil fertility (67.4%) and soil erosion (36.1%), determining a rejection of the null hypothesis (in favor of the alternative. there is a difference in averages) at a significance level of 5%. These farmers' assessments are consistent with the analyses of the area's rainfall records, which show a trend towards fewer days of rain and an increase in the volume of rainfall per unit of time.

Likewise, farmers have observed high infestations and aggressiveness of pests and diseases in crops, especially in coffee, in the low altitudes (less than 1,200 meters above sea level) by the coffee berry borer (*Hypothenemus hampei*, Ferrari) and coffee rust (*Hemileia vastatrix*, Berk. & Broome) due to new humidity and temperature conditions that favor their reproduction and virulence. In fruit and vegetable crops, farmers reported attacks of pests and diseases that decrease yields and crop quality, attributed to the effects of climate change (Sada et al., 2014).

In this regard, Čačija et al., (2017) found a direct relationship between temperature increases and the reproduction of pests, and Aragón & Lobo (2012) studied the distribution patterns of pests in vulnerable agricultural areas, showing an increase in the potential range of reproduction (Gutiérrez & Ponti, 2014), the reproduction and movement of insects and diseases to higher altitudes, where they did not occur, as is the case of the coffee berry borer and coffee rust (Galindo et al., 2013).

The quality of the crops was valued by the farmers surveyed, who in a fairly high proportion (70.1%) said that their products harvested have deteriorated because of climate change in the area. This proportion contrasts with those who say that quality has improved or been maintained with 5.6% and 24.3%, respectively. The rejection of the null hypothesis indicates that the relation of farmers who declared a loss of quality of their harvested products due to the effects of climate change experienced in the region differs significantly at the level that is greater than those who reported increase or permanence of the quality of their crops.

In the case of coffee, variations in moisture content and temperature during the stages of reproduction, formation, filling, and ripening of the beans predispose the plants to infection by fungi and, consequently, to fermentations that alter the chemical composition and quality of the beans (Peixoto et al., 2017), and there is evidence in Colombia of significant impacts on this category of floating and immature grains (Ocampo Lopez & Alvarez-Herrera, 2017) which, when added to the effects on the generality of crops, generate alterations in agricultural markets and food security (Rodríguez de Luque et al., 2016).

In the area of farmers' opinions and representations of climate change, the above results are consistent with studies carried out in various countries. Soares & Murillo-Licea (2013) in research conducted in Yucatan (Mexico found a high and positive perception by farmers of changes in climate due to increases, and extreme changes, in temperatures and rainfall, decreased rainfall, increased periods of drought, and impacts on the daily life of families. In the Amazon (Dubreuil et al., 2017) the perceptions of farmers are varied and are related to the regions with the greatest shortage of rainfall; or the unusual presence of hot or cold "load" seasons in recent years (Hansen et al., 2012), which are recalled by farmers.

Similarly, in Africa, Kgosikoma et al. (2018) in Botswana describe that farmers perceived increases in average annual temperature, increases on hot days, decreases in rainfall and rainy days and; Sada et al. (2014) in Nepal state that people have begun to feel the impacts of climate change through decreased water sources, loss of crops and the attack of new pests, diseases, and weeds on their fields.

4.2.2 Environmental impacts of climate change

Farmers' opinions on water availability on the farm, variations in rainfall, and effects on local biodiversity (Table 2) resulting from changes in climate patterns were grouped in this category.

Table 2. Environmental impacts of climate change

Impacts	Farmers' representations	Percentage (%)
Reduction of water resources	Decrease in water source flows	80.6
	Decrease in the amount of water reaching the farm	61.0
	Improved drinking water quality	50.0
Changes in rainfall patterns	Variations in rainfall intensity	82.0
	Variations in the bimodal rainfall regime	79.0
Effects on local biodiversity	Extinction of species of wild flora and fauna	65.3
	Migration of new species of flora and fauna	47.0

Source: Own elaboration (2018)

There is great concern among farmers about the situation of water resources in the communities studied, as seen in the answers given in the surveys carried out. Eighty-one percent consider that water sources have diminished their flow and many of them have dried up, so the amount of water that reaches their farms has decreased (61 percent) and the quality of water for human consumption has deteriorated (50 percent), especially in extreme periods of drought and heavy rainfall. The inferential analysis rejected the null hypothesis between the proportion of farmers who declared that the water sources had dried up and those who reported that the water sources continued to produce water, as they differed significantly from the level of $p < 0.05$.

The decrease in the water supply is associated with rainfall patterns that occur in rural communities. In the particular case of the farmers consulted, it is evident that the intensity of rainfall has varied through time (82%), with episodes occurring with high volumes of precipitation in short periods that cause damage to crops and support infrastructure, and alterations in the bimodal rainfall system (79%), modifying the historical processes of planning and development of their agricultural activities, as heat and rainfall without temporal spacing appear in their agricultural calendar.

Related studies indicate that reduced water availability in agriculture affects crop growth more than heat waves (Bauweraerts et al., 2014) by causing physiological drought in plants and ecological impacts from changes in precipitation and water loss systems (Gu et al., 2016). Water resources constitute a factor that limits, by deficit or excess, agricultural production in climate change scenarios.

In periods of severe drought, the reserves and availability of freshwater decrease (Martin-Ortega, 2011; Esperbent, 2017) to cover the physiological and reproductive demands of cultivated plants, with rain-fed crops suffering the greatest water deficits (Gourdji et al., 2016) due to their exclusive dependence on the rainy season. In the opposite case, during the presence of La Niña phenomenon, severe and intense rains cause damage to plants due to waterlogging of the soil (Martin-Ortega, 2011), presence of pests, diseases, and weeds (Sada et al. 2014) and by hindering agronomic cultivation practices (Peltonen-Sainio et al., 2016), so extremes of drought-rain cause large losses in agriculture in countries vulnerable to climate variability (Pierre & Tirado, 2007).

Local biodiversity is another resource that farmers believe has been affected by climate variations. In those surveyed, 65.3% said that the effects of heat or intense rainfall have caused the disappearance of species in flora and fauna. In the inferential analysis, the null hypothesis was rejected, which indicates that the proportion of farmers who declared the disappearance of species due to the effects of intense heat or rain experienced in the region, differs significantly at the level of $p < 0.05$, from the proportion of those who reported that these conditions of weather, heat, and rain, have not caused variations in the flora and fauna.

Among the species mentioned by the farmers that are in the process of disappearing are ferns, mosses, lulo, some vegetables and fruit trees of temperate climate, and; armadillo, squirrels, and sloth bears are rare in the farms of the communities studied. Also, they reported the presence of animal species from warmer climates, such as herons, hawks, ducks, waders, and ticks, among others.

The effects of climate change on biodiversity are generated by pressure on the conditions of the environmental ranges of survival and reproduction of species, displacing climatic niches, forcing the species to adapt or disappear according to its phenotypic plasticity, the capacity of evolution, and accommodation in the same place or dispersion towards colder areas (Herzog et al., 2010).

However, the uncertainty in the trend of current environmental changes does not allow us to effectively assess the rates of displacement, adaptation, and phenotypic plasticity of flora and fauna species (Matesanz & Valladares, 2013) to mitigate their disappearance and regeneration. Likewise, alterations in the temporality of climate cycles are generating gaps in the patterns of flowering, pollination, reproduction, and hatching of species in food webs (National Reseach Council, 2012), which lead to the alteration of interactions between species in disturbed scenarios (Hannah & Bird, 2018) due to the degeneration of symbiotic relationships, the disappearance of natural enemies of control or the invasion of new species and pests.

4.2.3 Effects of climate change on the family social environment

Farmers' families are beginning to perceive the effects of temperature increases and variations in rainfall on their food security and family comfort (Table 3), which alter the daily lives of rural residents.

Table 3. Effects of climate change on the family environment

Impacts	Farmers' representation	Percentage (%)
Food security	Decrease in the food supply	59
	Low food quality	78
Family comfort	Heat, pests and water shortage	88
	Incidence of diseases	81

Source: Own elaboration (2018)

The safe and quality provision of food for the farming family becomes noticeable during periods of prolonged drought or heavy rainfall as the pantry of farm-harvested "bread" products is reduced, and local markets become more expensive due to the decline in the supply of fresh or processed products. In this sense, 59% of farmers consider that the amount of food that reaches their tables has diminished or has lower quality (79%) due to small sizes, sunburn, less weight, damage by pests and diseases, or loss of the organoleptic characteristics of the products, especially those related to color and flavor.

In agriculture-dependent on environmental conditions, food supply is subject to climate variability, so a drastic decrease in rainfall would increase the food poverty indicators (Olayide & Alabi, 2018) of the population, affecting the supply chain of sufficient, healthy, and nutritious food (Fanzo et al., 2018). In a changing climate, food security is subject to the exposure of people and production processes to environmental troubles (Brown et al., 2017), making them vulnerable to market supply and demand, with greater implications in poor regions of the world.

Also, the welfare of farming families in their homes has been affected in recent times by heatwaves, the presence of pests, the shortage of drinking water, and the incidence of disease. Within these factors, 67.4% of the respondents said that there are many pests, 41% indicated that the heat has intensified and is a nuisance to sleep, and 16% said that there is not enough water to have a shower.

In the statistical analysis, 95% of the confidence intervals determined that between 32.9% and 49% establishes the real proportion of farmers who say they are affected by climate change as evidenced by the discomfort of sleeping due to intense heat, reflecting an important aspect for the overall hygiene of the family. In the case of the group that declares the existence of many pests, the estimated confidence interval, according to the sample, has a range of 59.7% to 75%.

Another factor in family comfort associated with the effects of climate change is the incidence of diseases that attack family members, resulting from temperature conditions conducive to vector reproduction, water scarcity, or accumulation. Among the diseases highllighted by farmers are high rates of diarrhea, dengue, zika, chikungunya, and allergies in general, with 66.7%, 43.1%, 34%, 40.3%, and 27.1%, in that order. Other diseases have a low incidence, but create discomfort in the members of the family group are attacks of lice (23.7%), ticks (13.2%), and scabies (16.7%).

Human health is one of the dimensions most vulnerable to climate change. The occurrence of alterations in temperature, humidity, rainfall, and seasonality are determining factors in the reproduction of pests and transmission of infectious diseases (Waits et al., 2018; Tjaden et al., 2017), increasing the reproduction of vectors and, therefore, the incidence of viral diseases and exponentially multiplying health problems in vulnerable populations (Wu et al., 2016), living in communities with limited drinking water and primary health care services.

4.2.4. Climate change mitigation and adaptation strategies

The experiences lived by farmers and their families in the the new climate scenarios that are disrupting the daily life of the Andean mountain region are prompting them to generate local responses to mitigate the effects of heatwaves or intense rainfall and to adapt their production systems to preserve agricultural enterprises, water sources, soils, biodiversity and their comfort and health (Table 4).

Table 4. Local Strategies for Mitigation and Adaptation to Climate Change

Farmers' strategies	Percentage (%)
Mitigation strategies	
Reforest water sources with native species	36.8
Do not hunt wildlife	36.8
Planting trees for shade on coffee plantations and pastures	15.3
Making efficient use of water for irrigation and livestock activities	15.3
Adaptation strategies	
Adapting working hours to climatic conditions	29.2
Fumigation against crop pests	30.6
Protecting the family from the attack of the mosquitoes	26.4
Implementing good crop management practices	18.1
Wearing clothes appropriate for the weather	14.6
Preventing risks of disease in the family	21.5

Source: Own elaboration (2018)

Among the farmers' strategies for mitigating climate change, water conservation has been a priority for farmers because of its vital importance for farm work and family consumption. Consequently, the actions began to revolve around the reforestation of water sources (36.8%) with native species (tartar and bamboo); the reduction of hunting of wild animals (36.8%); planting tree species to shade coffee crops and pastures (15.3%) and; making good use of the water to irrigate crops and livestock activities.

Likewise, within the adaptation responses of farmers to high temperatures, variations in precipitation and the decrease in water supply, the adaptation of fieldwork schedules (29.2%) and the use of clothing appropriate to the climate (14.6%) stand out; fumigation of crops to protect them from pests and diseases (30.6%); protection with mosquito nets from attack by mosquitoes (26.4%); implementation of good agricultural practices in their crops (18.1%) and; establishing activities for the prevention of climate-related diseases in families (21.5%).

Rural areas have become vulnerable to increases in temperature. This is affecting the capacity of water sources to maintain their flows and, therefore, users of the resource due to supply constraints (García et al., 2012). These recent episodes of decline in the flows of water sources is a strange circumstance and are not part of the collective memory of farmers, historically accustomed to the abundance of water in their communities to meet their daily needs, so that the rural communities are exposed to their lack and face difficulties in their daily lives (Mussetta & Barrientos, 2015), generating a high impact on the lives of families and their productive processes (Esperbent, 2017).

The new climate reality and inefficient public policies in rural areas have pushed farmers to take action to mitigate and adapt to impacts using their skills and traditional knowledge (Sada et al., 2014), by shading their coffee plantations with trees to buffer high temperatures (Silveira et al., 2016; Andrade et al., 2014), and thus, preserving yields and grain quality, planting improved crop species, adapting cropping patterns and planting dates, using water, and soil conservation techniques, and improving irrigation systems (Wang et al., 2017; Kgosikoma et al., 2018).

4.2.5 Actions of public institutions in rural communities on climate change

The implementation of programs and projects aimed at preparing rural communities for climate change mitigation and adaptation has been incipient and low-impact (Table 5).

Table 5. Actions of public institutions on climate change.

Main actions	Frequency (%)
Risk and disaster management programs	15
Health campaigns for climate-driven epidemics	15
Technical studies on climate change	11
Early warning systems	6
Economic studies on climate change	5
Climate change education programmes	4
Engineering studies on climate change impacts	2

Source: Own elaboration (2018)

The farmer's opinion is that the participation of public organizations related to the agricultural and environmental sectors has been scarce in the development of intervention programs that prepare the communities on the impacts of climate change. In the perception of those surveyed, 15% claim to know the risk and natural disaster management programs, 15% of health campaigns in climate-driven epidemics, 11% of climate-related technical studies, 6% of early warning systems, among others.

In the effort to reduce the risks of climate change in rural communities, public policies are essential, in line with cultural roots, to strengthen the adaptive capacity and resilience of farmers (Gaivizzo et al., 2019) for sustainable food production with the least environmental damage (Sabourin et al., 2017). Actions should be focused on solving concrete problems by previously assessing, based on short-term planning, the vulnerability of the population's environmental quality and life (Rodrigues et al., 2016). Charting society's future trajectories in the climate change scenario is the result of a combination of public policies generated by multidisciplinary agreements between social and natural scientists (Lever-Tracy, 2008), institutional authorities, and rural social actors.

5. CONCLUSIONS

Analysis of the climatological records of temperature and average rainfall over 36 years of data revealed significant increases in temperature (0.0335 °C/year) and non-significant variations in rainfall values. It is interesting to establish that in the farmers' representations temperature increases are appreciated as one of the main factors affecting agricultural production, natural resources, and family comfort. However, despite the invariable trend in rainfall records, farmers expressed the occurrence of a contingent, extreme, and unexpected rainfall during recent years.

Farmers' knowledge of the impacts of climate change on agricultural production includes decreases in crop and livestock production; impacts on rangelands; loss of fertility, landslides and soil erosion; vegetation fires; increased incidence of pests and diseases; and deterioration of the quality of agricultural products. These findings are important in planning agricultural mitigation and adaptation actions to reduce the vulnerability of agro-ecosystems and the agricultural food security of the population.

Concerning the effects of climate change on environmental resources, farmers consider that there has been a reduction in water resources in their communities, represented by a decrease in water flows and in the quality of the water that reaches the farms; changes in the bimodal system and intensity of rainfall; and effects on local biodiversity as a result of the extinction and migration of species of fauna and flora in their rural areas. Local responses by farmers to preserve these resources are essential to ensure environmental sustainability and reduce the vulnerability of rural territories.

The family of the Colombian Andean farmer considers that climate change is affecting their daily life mainly in the aspects related to food security by the decrease in the supply and quality of products, especially in periods of drought and; in the family comfort by the increase of heat in the day and night hours, intensification of pests and diseases and water shortage in the dry season. These aspects have been little studied in research on climate change, so it is a priority line of work to understand the processes of mitigation, adaptation, resilience, vulnerability, and sustainability of farming families to environmental changes.

Farmers' responses to changes in temperature and rainfall operate through a set of empirical strategies to mitigate negative impacts and adapt to new climate scenarios. Among the mitigation strategies developed on their farms are reforestation of water sources with native plant species, we highlight not hunting wild animals or cutting down trees near water sources, fumigation against crop pests and diseases, planting shade trees on coffee plantations and pastures, preventing the risk of disease in the family, and efficient use of irrigation water, among others. In strategies to adapt to climate change, farmers have adapted their schedules to the weather conditions, protect families with mosquito nets to avoid attacks by mosquitoes, implement good crop management practices, and use clothing appropriate to the state of the climate, among many others.

The participation of public institutions related to rural and environmental development for farmers is incipient in the absence of information on programs and projects that promote capacity building for mitigation and adaptation of the agricultural sector to climate change.

The approach to climate change representations of farmers in Colombia is scarce. Therefore, the results found in the research are preliminary and open countless spaces for new research to deepen empirical observations and theoretical discussions in comparative studies of physio-graphic landscapes, gender, rural family, technological levels, and methodologies.

REFERENCES

Andrade, H., Marin, L., & Pachon, D. (2014). Fijación de carbono y porcentaje de sombra en sistemas de producción de café (*coffea arábiga* L) en el Libano, Tolima, Colombia. *Revista Bioagro*, *26*(2), 127-132.

Aragón, P., & Lobo, J. (2012). Predicted effect of climate change on the invasibility and er6666distribution of the Western corn root worm. *Agricultural and Forest Entomology*, *14*(1), 13-18. http://dx.doi.org/10.1111/j.1461-9563.2011.00532.x

Avellaneda-Torres, L. M., Torres Rojas, E., & León Sicard, T. E. (2014). Agricultura y vida en el páramo: una mirada desde la vereda El Bosque (Parque Nacional Natural de Los Nevados). *Cuadernos de Desarrollo Rural*, *11*(73), 105-128. http://dx.doi.org/10.11144/Javeriana.CDR11-73.avpm

Bauweraerts, I., Ameye, M., Wertin, T., Mcguire, M., Teskey, R., & Steppe, K. (2014). Water availability is the decisive factor for the growth of two tree species in the occurrence of consecutive heat waves. *Agricultural and Forest Meteorology*, *189-190*(1), 19-29. http://dx.doi.org/10.1016/j.agrformet.2014.01.001

Bee, B. (2014). Si no comemos tortilla, no vivimos: women, climate change, and food security in central Mexico. *Agriculture and Human Values*, *31*(4), 607-620. http://dx.doi.org/10.1007/s10460-014-9503-9

Bellante, L. (2017). La doble exposición de campesinos: políticas públicas y cambio climático. *Revista La Jornada Ecológica*. Retrieved in 2019, February 25, from file:///C:/Users/Usuario/Downloads/La_doble_exposicion_de_campesinos_politi%20(1).pdf

Bochalema. Alcaldia del Municipio. (2016). *Bochalema Plan de desarrollo 2016-2019*. Retrieved in 2019, February 25, from http://www.sisubregionalns.gov.co/files/sid_Desarrollo_territorial/PMD/SurOriental/PDM_BOCHALEMA_2016-2019.pdf

Brondizio, E., & Moran, E. (2008). Human dimensions of climate change: the vulnerability of small farmers in the Amazon. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *363*(1498), 1803-1809. http://dx.doi.org/10.1098/rstb.2007.0025

Brown, A., Graffeo, M., Richler, J., & Simpkins, G. (2017). Agriculture mitigation through food Agric. *Ecosyst. Environ. Nature Climate Change*, *7237*, 234-241.

Čačija, M., Kozina, A., & Basrcic, J. (2017). Linking climate change and insect pest distribution: an example using *Agriotes ustulatus* Shall. (Coleoptera: Elateridae). *Agricultural and Forest Entomology*, *20*(2), 288-297. http://dx.doi.org/10.1111/afe.12259

Caetano, C., Peña, R., Maigual, J., Vásquez, L., Caetano, D., & Caetano, R. (2015). Mejoramiento participativo: herramienta para la conservación de cultivos subutilizados y olvidados. *Acta Agronomica*, *64*(3), 307-327. http://dx.doi.org/10.15446/acag.v64n3sup.50550

Camargo, C., Pacheco, C., & López, R. (2017). Erosión hídrica, fundamentos, evaluación y representación cartográfica: una revisión con énfasis en el uso de sensores remotos y Sistemas de Información Geográfica. *Revista Gestión y Ambiente*, *20*(2), 265-280. http://dx.doi.org/10.15446/ga.v20n2.63917

Candelaria-Martínez, B., Ruiz-Rosado, O., Pérez-Hernández, P., Gallardo-López, F., Vargas-Villasmil, L., Martínez-Becerra, A., & Flota-Bañuelos, C. (2014). Sustentabilidad de los agroecosistemas de la microcuenca Paso de Ovejas 1, Veracruz, México. *Cuadernos de Desarrollo Rural*, *11*(73), 87-104. http://dx.doi.org/10.11144/Javeriana.CDR11-73.sdam

Casado, E., & Calonge, S. (2001). *Conocimiento social y sentido común* (1. ed.). Caracas: Fondo Editorial de Humanidades y Educación, Universidad Central de Venezuela, .

Chabbi, A., Lehmann, J., Ciais, P., Loescher, H., Cotrufo, M., Don, A., San Clements, L., Schipper, J., Six, P., & Smith y Rumpel, C. (2017). Aligning agriculture and climate policy. *Nature Climate Change*, *7*(5), 307-309. http://dx.doi.org/10.1038/nclimate3286

Chloupkova, J., Svendsen, G., & Zdechovsky, T. (2018). A global meat tax: from big data to a double dividend. *Agricultural Economics*, *64*, 256-264. https://doi: 10.17221/270/2016-AGRICECON

Colombia. CORPONOR. Universidad Francisco de Paula Santander – UFPS. (2018). *Documentos de lineamientos técnicos para la gestión del cambio climático y un desarrollo bajo en carbono y resiliente al clima*. Retrieved in 2019, February 25, from http://corponor.gov.co/corponor/PICCDNS/Plan_Integral_de_Cambio_Climatico_Departamento_Norte_de_Santander.pdf

Colombia. Ministerio del Ambiente y Desarrollo Sostenible. (2014). *ABC: adaptación bases conceptuales marco conceptual y lineamientos del plan nacional de adaptación al cambio climático*, Colombia: MADC. Retrieved in 2019, February 25, from http://www.minambiente.gov.co/images/cambioclimatico/pdf/Plan_nacional_de_adaptacion/1._Plan_Nacional_de_Adaptaci%C3%B3n_al_Cambio_Clim%C3%A1tico.pdf

Confalone, A., Vilatte, C., Lázaro, L., Roca, N., Mestelan, S., Aguas, L., Navarro, M., & Sau, F. (2016). Parametrización del modelo CROPGRO-soybean y su uso como herramienta para evaluar el impacto del cambio climático sobre el cultivo de soja. *Revista de la Facultad de Ciencias Agrarias*, *48*(1), 49-64. Retrieved in 2019, February 25, from http://www.redalyc.org/pdf/3828/382846012013.pdf

Cortez, A., Rodríguez, M., Rey, J., Lobo, D., Parra, R., Ovalles, F., & Gabriels, D. (2011). Análisis de la agresividad y concentración de las precipitaciones en Venezuela. II. Región Noroccidental. *Revista Bioagro*, *23*(1), 13-18. Retrieved in 2019, February 25, from http://www.ucla.edu.ve/bioagro/Rev23(1)/2.%20An%C3%A1lisis%20de%20la%20agresividad.pdf

Craparo, A., Van Asten, P., Läderach, P., Jassogne, L., & Grab, S. (2015). *Coffea arabica* yields decline in Tanzania due to climate change: Global implications. *Agricultural and Forest Meteorology*, *207*(15), 1-10. http://dx.doi.org/10.1016/j.agrformet.2015.03.005

D'Agostino, A., & Schlenker, W. (2016). Recent weather fluctuations and agricultural yields: implications for climate change. *Agricultural Economics*, *47*(S1), 159-172. http://dx.doi.org/10.1111/agec.12315

Daza Torres, M. C., Hernández Flórez, F., & Triana, F. A. (2014). Efecto del uso del suelo en la capacidad de almacenamiento hídrico en el páramo de Sumapaz – Colombia. *Revista Facultad Nacional de Agronomía*, *67*(1), 7189-7200. http://dx.doi.org/10.15446/rfnam.v67n1.42642

De Boef, W., Thijssen, M., Ogliari, J., & Sthapit, B. (2007).*Biodiversidade e agricultores fortalecendo o manejo comunitário*. Porto Alegre: L&PM Editores.

Deis, L., Rosas, M., Malovini, E., Cavagnaro, M., & Cavagnaro, J. (2015). Impacto del cambio climático en Mendoza: variación climática en los últimos 50 años. Mirada desde la fisiología de la vid. *Revista de* *la Facultad de Ciencias Agrarias*, *47*(1), 67-92. Retrieved in 2019, February 25, from http://www.contingencias.mendoza.gov.ar/web1/pdf/Deis%20et%20al.%202015.pdf

Doise, W., Clèmence, A., & Lorenzi-Cioldi, F. (2005). *Representaciones sociales y análisis de datos*. México D.F: Instituto Mora.

Dubreuil, V., Funatsu, B., Michot, V., Nasuti, S., Debortoli, N., de Mello-Thery, N. A., & Le Tourneau, F.-M. (2017). Local rainfall trends and their perceptions by Amazonian communities. *Climatic Change*, *143*(3-4), 461-472. http://dx.doi.org/10.1007/s10584-017-2006-0

Durkheim, E. (2000). Representaciones individuales y representaciones colectivas. In *Sociología y filosofía* (pp. 27-58). Madrid: Miño y Davila.

Engel, S., & Muller, A. (2016). Payments for environmental services to promote "climate-smart agriculture". Potential and challenges. *Agricultural Economics*, *47*(1), 173-184. http://dx.doi.org/10.1111/agec.12307

Esperbent, C. (2017). El cambio del clima deja su huella en la agricultura. *Revista de Investigaciones Agropecuarias RIA-INTA*, *43*(2), 108-112. Retrieved in 2019, February 25, from http://ria.inta.gob.ar/sites/default/files/nota2cambioclimatico.pdf

Fanzo, J., Davis, C., McLaren, R., & Choufanic, J. (2018). The effect of climate change across food systems: Implications for nutrition outcomes. *Global Food Security*, *18*, 12-19. http://dx.doi.org/10.1016/j.gfs.2018.06.001

Fernández, S., & Cordero, J. (2007). Biología de la broca de café Hipothenemus hampei (Ferrera) (Coleoptera: Curculionidae: Scolytinae) en condiciones de laboratorio. *Revista Bioagro*, 19(1), 35-40. Retrieved in 2019, February 25, from http://www.redalyc.org/articulo.oa?id=85719105

Fondo Financiero de Proyectos de Desarrollo – FONADE. Instituto de Hidrología, Meteorología y Estudios Ambientales – IDEAM. (2013). *Efectos del cambio climático en la producción y rendimiento de cultivos por sectores, evaluación del riesgo agroclimático por sectores*. Colombia. Retrieved in 2019, February 25, from http://www.ideam.gov.co/documents/21021/21138/Efectos+del+Cambio+Climatico+en+la+agricultura.pdf/3b209fae-f078-4823-afa0-1679224a5e85

Food and Agriculture Organization of the United Nations – FAO. (2014). *Agricultura familiar en América Latina y el Caribe: recomendaciones de política*. Chile: FAO.

Gaivizzo, L. H., Litre, G., Lopes Ferreira, J., Gomes Pereira da Silva, R., Nogueira Soares, D., Moraes Reis, R., Almeida, A. C., Bernal Davalos, N. E., Almeida Gonçalves Mendes, P. D., Pereira Lindoso, D., Michels Brito, A., Rodrigues-Filho, S., & Hiroo Saito, C. Resiliência à mudança climática em Comunidades de Fundo de Pasto na região semiárida do Estado da Bahia, Brasil, 2019. DOI: http://dx.doi.org/10.14393/SN-v31-2019-46331

Galindo, L., Villegas, G. C., Mantilla, J. G., Gilligan, T., & Florez, C. P. (2013). Lepidópteros perforadores de los frutos del café. *Revista Apuntes Técnicos de Cenicafe*, *434*. Retrieved in 2019, February 25, from http://biblioteca.cenicafe.org/bitstream/10778/471/1/avt0434.pdf

García, M., Piñeros, A., Bernal, F., & Ardila, E. (2012). Variabilidad climática, cambio climático y el recurso hídrico en Colombia. *Revista de Ingeniería*, (36), 60-64. Retrieved in 2019, February 25, from ttp://www.scielo.org.co/pdf/ring/n36/n36a12.pdf

Gourdji, S., Mesa-Diez, J., Obando-Bonilla, D., Navarro-Racines, C., Moreno, P., Fisher, M., Prager, S., & Ramirez-Villegas, J. (2016). *Simulated Near-term Climate Change Impacts on Major Crops across Latin America and the Caribbean* (abstract id. GC53F-06). American Geophysical Union, Fall General Assembly.

Gourdji, S., Sibley, A., & Lobell, D. (2013). Global crop exposure to critical high temperatures in the reproductive period: historical trends and future projections. *Environmental Research Letters*, *8*(2), 1-10. http://dx.doi.org/10.1088/1748-9326/8/2/024041

Gu, L., Pallardy, S., Hosman, K., & Sun, Y. (2016). Impacts of precipitation variability on plant species and community water stress in a temperate deciduous forest in the central US. *Agricultural and Forest Meteorology*, *217*(15), 120-136. http://dx.doi.org/10.1016/j.agrformet.2015.11.014

Gutiérrez, A., & Ponti, L. (2014). The new world screwworm: prospective distribution and role of weather in eradication. *Agricultural and Forest Entomology*, *16*(2), 111-215. http://dx.doi.org/10.1111/afe.12046

Hannah, L., & Bird, A. (2018). Climate change and biodiversity: impacts. In *Reference Module in Earth Systems and Environmental Sciences 4: Encyclopedia of the Anthropocene* (Vol. 3, pp. 249-258). http://dx.doi.org/10.1016/B978-0-12-409548-9.09970-X

Hansen, J., Sato, M., & Ruedy, R. (2012). Perception of climate change. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(37), E2415-E2423. http://dx.doi.org/10.1073/pnas.1205276109

Herzog, S., Jørgensen, P., Martínez, R., Martius, C., Anderson, H., Hole, D., Larsen, T., Marengo, J., Ruiz, D., & Tiessen, H. (2010). *Efectos del cambio climático en la biodiversidad de los Andes tropicales: el estado del conocimiento científico. Resumen para tomadores de decisiones y responsables de la formulación de políticas públicas*. São José dos Campos: Instituto Interamericano para la Investigación del Cambio Global (IAI).

Ibáñez, T. (1994). Representaciones sociales: teoría y método. In *Psicología social construccionista* (pp. 153-216). México: Universidad de Guadalajara.

Iglesias, A., Quiroga, S., Diz, A., & Garrote, L. (2011). Adapting agriculture to climate change. *Revista Economía Agraria y Recursos Naturales.*, *11*(2), 109-122. http://dx.doi.org/10.7201/earn.2011.02.05

Instituto de Hidrología, Meteorología y Estudios Ambientales – IDEAM. *Indicadores que manifiestan cambios en el sistema climático de Colombia (años y décadas más calientes y las más y menos lluviosas)*. Subdirección de Meteorología. 2012. Retrieved in 2019, February 25, from http://www.ideam.gov.co/documents/21021/21138/Indicadores+de+cambio+climatico+en+el+pa%C3%ADs.pdf/5ac540b8-e3f7-4076-91fe-d876f31101f9

Intergovernmental Panel on Climate Change – IPCC. (2014). *Cambio climático: impactos, adaptación y vulnerabilidad: quinto informe*. IPCC. Retrieved in 2019, February 25, from https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_es.pdf

Jodelet, D. (1986). La representación social: fenómenos, concepto y teoría. In S. Moscovici (Ed.). *Psicología social II: pensamiento y vida social: psicologíasocial y problemas sociales* (pp. 469-494). Barcelona: Paidós.

Joffe, H. (2003). Risk: From perception to social representation. *British Journal of Social Psychology*, *42*(1), 55-73. http://dx.doi.org/10.1348/014466603763276126

Kgosikoma, K., Lekota, P., & Kgosikoma, O. (2018). Agropastoralists' determinants of adaptation to climate change. *International Journal of Climate Change Strategies and Management*, *10*(3), 488-500. http://dx.doi.org/10.1108/IJCCSM-02-2017-0039

Lachaud, M., Bravo-Ureta, B., & Ludena, C. (2017). Agricultural productivity in Latin America and the Caribbean in the presence of unobserved heterogeneity and climatic effects. *Climatic Change*, *143*(3-4), 445-460. http://dx.doi.org/10.1007/s10584-017-2013-1

Leichenko, R., & O'Brien, K. (2008). *Environmental change and globalization: double exposures*. England: Oxford Scholarship. http://dx.doi.org/10.1093/acprof:oso/9780195177329.001.0001

Lever-Tracy, C. (2008). Calentamiento global y sociología. *Current Sociology*, *56*(3), 445-466. http://dx.doi.org/10.1177/0011392107088238

Litre, G., & Bursztyn, M. (2015). Percepções e adaptação aos riscos climáticos e socioeconómicos na pecuária familiar do bioma pampa. *Ambiente & Sociedade*, *18*(3), 55-80. http://dx.doi.org/10.1590/1809-4422ASOC668V1832015

López, H., West, R., Dong, S., Goni, G., Kirtman, B., Lee, S.-K., & Atlas, R. (2018). Early emergence of anthropogenically forced heat waves in the western United States and Great Lakes. *Nature Climate Change*, *8*(5), 414-420. http://dx.doi.org/10.1038/s41558-018-0116-y

Martin-Ortega, J. (2011). Costs of adaptation to climate change impacts on fresh-water systems: existing estimates and research gaps. *Economía Agraria y Recursos Naturales Agricultural and Resource Economics*, *11*(1), 5-28.

Matesanz, S., & Valladares, F. El papel de la plasticidad fenotípica en la respuesta de la vegetación mediterránea al cambio climático. In *Biodiversidad* (Cap. 32). España: MAPAMA, 2013. Retrieved in 2019, February 25, from https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/cap32-elpapeldelaplasticidadfenotipicaenlarespuesta_tcm30-70234.pdf

Misra, V. (2009). The amplification of the ENSO forcing over equatorial Amazon. *Journal of Hydrometeorology*, *10*(6), 1561-1568. http://dx.doi.org/10.1175/2009JHM1108.1

Moreira, S., Pires, C., Marcatti, G., Santos, R., Imbuzeiro, H., & Fernandes, R. (2018). Intercropping of coffee with the palm tree, *macauba,*can mitigate climate change effects. *Agricultural and Forest Meteorology*, *256-257*(15), 379-390. http://dx.doi.org/10.1016/j.agrformet.2018.03.026

Moscovici, S. (1979). *El psicoanálisis, su imagen y su público*. Buenos Aires: Editorial Huemul.

Mussetta, P., & Barrientos, M. (2015). Vulnerabilidad de productores rurales de Mendoza ante el Cambio Ambiental Global: clima, agua, economía y sociedad. *Revista de la Facultad de Ciencias Agrarias*, *47*(2), 145-170.

National Reseach Council. (2012). *Climate change: evidence, impacts and choices*. US: National Academies Press.

Nendel, C., Rötter, R., Thorburn, P., Boote, K., & Ewert, F. (2018). Introduction to the Special Issue "Modelling cropping systems under climate variability and change: impacts, risk and adaptation". *Agricultural Systems*, *159*, 139-143. http://dx.doi.org/10.1016/j.agsy.2017.11.005

Norgaard, K. (2006). People want to protect themselves a little bit: emotions, denial, and social movement nonparticipation. *Sociological Inquiry*, *76*(3), 372-396. http://dx.doi.org/10.1111/j.1475-682X.2006.00160.x

Núñez, J. (2004). Los saberes campesinos: implicaciones para una educación rural. *Revista de Investigación y Postgrado*, *19*(2), 13-60.

Núñez, J. (2016). Tejido Fronterizo Rural: una tipología de los campesinos tachirenses en La Frontera y su Tejido Social, Caracas. *Universidad Pedagógica Experimental Libertador*, *978-980*, 251-267.

Ocampo Lopez, O. L., & Alvarez-Herrera, L. M. (2017). Tendencia de la producción y el consumo del café en Colombia. *Apuntes del Cenes*, *36*(64), 139-165. http://dx.doi.org/10.19053/01203053.v36.n64.2017.5419

Olayide, E., & Alabi, T. (2018). Between rainfall and food poverty: Assessing vulnerability to climate change in an agricultural economy. *Journal of Cleaner Production*, *198*, 1-10. http://dx.doi.org/10.1016/j.jclepro.2018.06.221

Paredes, F., & Guevara, E. (2010). Desarrollo y evaluación de un modelo para predecir sequias meteorológicas en los llanos de Venezuela. *Revista Bioagro*, *22*(1), 3-10.

Peixoto, J. N. S., Nunes, M., Baliza, D. P., Pereira, S. P., & Rosa, B. T. (2017). Cafeicultura familiar e as boas práticas agrícolas. *Coffee Science, Lavras*, *12*(3), 365-373. http://dx.doi.org/10.25186/cs.v12i3.1298

Peltonen-Sainio, P., Pirinen, P., Mäkelä, H. M., Hyvärinen, O., Huusela-Veistola, E., Ojanen, H., & Venäläinen, A. (2016). Variación espacial y temporal en eventos climáticos críticos para la agricultura boreal: I Temperaturas elevadas. *Agricultural and Food Science*, *25*(1), 44-56. http://dx.doi.org/10.23986/afsci.51465

Pérez, S. (2016). El valor estratégico del turismo rural como alternativa sostenible de desarrollo territorial rural. *Revista Agronomía Colombiana*, *28*(3), 507-513.

Pierre, F., & Tirado, M. (2007). Efecto del ENOS sobre la precipitación en la cuenca del rio Yacambu y la depresión de Quibor, Estado Lara, Venezuela. *Revista Bioagro*, *19*(1), 41-52.

Piña, J., & Cuevas, Y. (2004). La teoría de las representaciones sociales: su uso en la investigación educativa en México. *Perfiles Educativos*, *26*(106), 102-124. Retrieved in 2019, February 25, from http://www.redalyc.org/pdf/132/13210605.pdf

Piñero, S. (2008). La teoría de las representaciones sociales y la perspectiva de Pierre Bourdieu: una articulación conceptual. *CPU-e: Revista de Investigación Educacional*, *7*. Retrieved in 2019, February 25, from http://www.uv.mx/cpue/num7/inves/pinero_ representaciones_bourdieu.html

Rodrigues, S., Lindoso, D., Bursztyn, M., & Nascimento, C. (2016). O clima em transe: políticas de mitigação e adaptação no Brasil. *Revista Brasileira de Climatologia*, *19*, http://dx.doi.org/10.5380/abclima.v19i0.48874

Rodríguez de Luque, J. J., Gonzalez Rodríguez, C. E., Gourdji, S., Mason-D'Croz, D., Obando Bonilla, D., Mesa Diez, J., & Prager, S. D. (2016). Impactos socioeconómicos del cambio climático en América Latina y el Caribe: 2020-2045. *Cuadernos de Desarrollo Rural*, *13*(78), 11-34. http://dx.doi.org/10.11144/Javeriana.cdr13-78.iscc

Sabourin, E., Patrouilleau, M., Le Coq, J., Vásquez, L., & Niederle, P. (2017). *Políticas públicas a favor de la agroecología em América Latina y El Caribe* (412 p.). Rome: FAO.

Sabourin, E., Samper, M., & Sotomayor, O. (2014). *Políticas públicas y agriculturas familiares en América Latina y el Caribe Balance, desafíos y perspectivas*. Santiago de Chile: CEPAL.

Sada, R., Shrestha, A., Kumar Shukla, A., & Melsen, L. (2014). People's experience and facts of changing climate: impacts and responses. *International Journal of Climate Change Strategies and Management*, *6*(1), 47-62. http://dx.doi.org/10.1108/IJCCSM-04-2013-0047

Saj, S., Torquebiau, E., Hainzelin, E., Págès, J., & Maraux, F. (2017). The way forward: an agroecological perspective for climate-smart agriculture. *Agriculture, Ecosystems & Environment*, *205*(1), 20-24. http://dx.doi.org/10.1016/j.agee.2017.09.003

Salazar, G., & Hincapié, G. (2010). *Manejo de suelos y aguas para la prevención y mitigación de deslizamientos en fincas cafeteras* (Avances Técnicos, No. 401, pp. 8). Colombia: CENICAFE.

Sancovschi, B. (2007). Sobre a noção de representação em S. Moscovici e F. Varela. *Psicologia e Sociedade*, *19*(2), 7-14. http://dx.doi.org/10.1590/S0102-71822007000200002

Silveira, H., Santos, M. O., Silva, V. A., Venturin, R. P., Volpato, M. M. L., Dantas, M. F., Carvalho, G. R., Setotaw, T. A., Moreira, F. C., Barbosa, J. P. R. A. D., & Resende, M. L. V. (2016). Impacts of water deficit in ecophysiological and spectral responses of coffee intercropped with woody species. *Coffee Science*, *11*(3), 318-328. http://dx.doi.org/10.25186/cs.v11i3.1085

Soares, D., & Murillo-Licea, D. (2013). Gestión de riesgo de desastres, género y cambio climático: percepciones sociales en Yucatán, México. *Cuadernos de Desarrollo Rural*, *10*(72), 181-199.

Steward, P. R., Dougill, A. J., Thierfelder, C., Pittelkow, C. M., Stringer, L. C., Kudzala, M., & Shackelford, G. E. (2018). The adaptive capacity of maize-based conservation agriculture systems to climate stress in tropical and subtropical environments: a meta-regression of yields. *Agriculture, Ecosystems & Environment*, *251*(1), 194-202. http://dx.doi.org/10.1016/j.agee.2017.09.019

Sun, T., Hasegawa, T., Tang, L., Wang, W., Zhou, J., Liu, L., Liu, B., Cao, W., & Zhu, Y. (2018). Stage-dependent temperature sensitivity function predicts seed-setting rates under short-term extreme heat stress in rice. *Agricultural and Forest Meteorology*, *256-257*(15), 196-206. http://dx.doi.org/10.1016/j.agrformet.2018.03.006

Tjaden, N., Caminade, C., Beierkuhnlein, C., & Thomas, S. M. (2017). Mosquito-borne diseases: advances in modelling climate-change impacts. *Trends in Parasitology*, *34*(3), 227-245. http://dx.doi.org/10.1016/j.pt.2017.11.006

Valenzuela, E., & Anderson, K. (2011). Climate change and food security to 2030: a global economy-wide perspective. *Economia Agraria y Recrusos Naturales Agricultural and Resource Economics*, *11*(11), 29-58. https://doi.org/10.7201/earn.2011.01.02

Waits, A., Emelyanova, A., Oksanen, A., Abass, A., & Rautio, A. (2018). Human infectious diseases and the changing climate in the Arctic. *Environment International*, *121*(Part 1), 703-713. http://dx.doi.org/10.1016/j.envint.2018.09.042

Wang, S., Lee, W., & Son, Y. (2017). An assessment of climate change impacts and adaptation in South Asian agriculture. *International Journal of Climate Change Strategies and Management*, *9*(4), 517-534. http://dx.doi.org/10.1108/IJCCSM-05-2016-0069

Wu, X., Lu, Y., Zhou, S., Chen, L., & Xu, B. (2016). Impact of climate change on human infectious diseases. *Empirical Evidence and Human Adaptation*, *86*, 14-23. http://dx.doi.org/10.1016/j.envint.2015.09.007

Submitted on: 25/Feb./2019
Accepted on: 09/Aug./2020
Clasificación JEL: O13; Q01; Q54