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Farmers' Perception of Climate Change: A Review of the Literature for Latin America

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Global climate is changing rapidly, and it is not clear if agricultural producers in developing countries will be able to adapt fast enough in order to mitigate its negative effects. In order to be willing to take adaptation measures, farmers need to perceive that the climate is changing or could change, and they need to attribute enough weight to this perception to take action. During the last two decades, the literature that examines farmers' perception of climate change has gained ground, but it is still scant. This is particularly true for Latin America, which is highly vulnerable to climate change. Based on a review of original research articles published between 2000 and 2020, this article presents the status of knowledge about the topic in the region to identify research gaps and inform future research. The review found that the available research has been based mostly on qualitative analyses of case studies for a few countries. More research that identifies causal relationships is necessary. Data from surveys that are representative at the national or subnational levels, as well as longitudinal data, will be very helpful to better understand farmer's perceptions. Finally, the use of field experiments and choice experiments can complement the use of observational data.

Keywords: perception, climate change, adaptation, Latin America, farmer, agriculture

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INTRODUCTION

Throughout human history, farmers have adapted to changing environmental, social and economic conditions (Kurukulasuriya and Rosenthal, 2013). Nonetheless, it is not clear if agricultural producers will be able to keep up with the unprecedented speed at which climate is expected to change in the coming years (Jones et al., 2012). The negative effects of these changes will be higher for agricultural producers that practice rainfed agriculture, as well as for those with limited access to credit and insurance, and those that are disconnected from regional or national markets (Skoufias et al., 2011; Quiroga et al., 2015; IFAD, 2016; Castells-Quintana et al., 2018). In order to ameliorate these negative effects, public policies and interventions to promote and facilitate adaptation will be needed (Howden et al., 2007; Kumar et al., 2020). Nonetheless, in order to be willing to implement adaptation measures, farmers need to be aware of climate change (Silvestri et al., 2012; Simelton et al., 2013; Meldrum et al., 2018). In that sense, the perception that farmers have about climate change not only informs their planting decisions, but also determines the adoption of adaptation measures (Meldrum et al., 2018; De Matos Carlos et al., 2020). Therefore, understanding farmers' perceptions about climate change can be seen as a condition for the design and successful implementation of

adaptation policies in agriculture (Hansen et al., 2004; Silvestri et al., 2012; De Matos Carlos et al., 2020).

The number of studies that focus on understanding farmers' climate change perception has been increasing, but it is still scant. This is particularly true for Latin America (Dang et al., 2019; Karki et al., 2020), a region highly vulnerable to climate change (López-Feldman and Hernández Cort). This phenomenon is expected to have serious negative impacts on the income, consumption and health of agricultural producers in the region (Reyer et al., 2017; IPCC et al., 2018), leading to increases in poverty and inequality (Skoufias et al., 2011; Harvey et al., 2018; López-Feldman and Mora Rivera, 2018). Given this scenario, the lack of research on the determinants of climate change perception is worrisome. The objective of this work is to present an overview of the studies on this topic available for Latin America while identifying research gaps and potential paths for future research.

CLIMATE CHANGE PERCEPTION

Climate change perception is a complex process that encompasses a range of psychological constructs such as knowledge, beliefs, attitudes and concerns about if and how the climate is changing (Whitmarsh and Capstick, 2018). Perception is influenced and shaped, among other things, by the individuals' characteristics, their experience, the information that they receive, and the cultural and geographic context in which they live (van der Linden, 2015; Whitmarsh and Capstick, 2018). Therefore, measuring climate change perception and trying to find its determinants is not an easy task.

The variability that local weather can have from one day to the other, from one season to the next, and between years, is one of the many challenges that a person faces when trying to distinguish between normal short-run variations and climate change manifestations (Hansen et al., 2012). In fact, local short-term variations tend to be more salient than long-term trends and hence can have a key impact on the formation of climate change perceptions (Lehner and Stocker, 2015). Although the perception of those that directly depend on the weather for at least part of their income, such as farmers, tend to be more accurate than that of their counterparts, they might still have problems using their own experience with weather variables to correctly interpret changes as being big enough as to feel worried and compelled to do something about it (Weber, 2010; Whitmarsh and Capstick, 2018).

Life experiences influence perception, individuals who have been directly affected by extreme climatic events tend to report that the probability of such event happening again is relatively high (Patt and Schröter, 2008; De Matos Carlos et al., 2020). Furthermore, the perception that a person has about climate change can be influenced or modified by the information that she receives (Weber, 2010). Finally, it should be noted that perception is in part a subjective phenomenon, therefore, different people in the same locality might construct different perceptions of climate change even though they experience the same weather patterns (Simelton et al., 2013).

THE LINK BETWEEN PERCEPTION AND ADAPTATION TO CLIMATE CHANGE

In order to protect the livelihoods of the population that directly depends on agriculture, adaptation of the agricultural sector to the adverse effects of climate change is crucial (Asfaw et al., 2016). In a world with perfect information, complete markets, and adequate incentives, the decision to adopt or implement a particular adaptation measure would simply be a matter of evaluating the net benefits of said measure. That is certainly not the setting in which small and subsistence farmers in developing countries operate (Castells-Quintana et al., 2018). Therefore, the adoption of adaptation measures is not an automatic or smooth process, quite the contrary. The evidence has shown that factors like inadequate access to insurance or credit, limited information about adaptation alternatives, and incomplete property rights, constitute barriers that small and subsistence farmers face in relation to technology adoption (Asfaw et al., 2016). Furthermore, the decision to adopt a new technology or production method frequently entails cognitive processes, like mental accounting (Thaler, 1999), loss aversion (Kahneman and Tversky, 1979), and hyperbolic discounting (Laibson, 1997), which can lead to suboptimal levels of adoption (Zilberman et al., 2012). This is particularly relevant for adaptation to climate change, as even farmers with access to weather information and climate forecasts face considerable levels of uncertainty (Silvestri et al., 2012). Under these conditions, the perception that farmers have about climate change is a key component to understanding their adaptation decisions (Clarke, et al., 2012).

Adaptation requires not only that individuals perceive that something is changing or could change, but also that they attribute enough weight to this perception to be willing to take action and try to do something about it (Eakin et al., 2014). In this sense, perceiving that the climate is changing can be seen as a pre-condition for the adoption of agricultural adaptation measures (Simelton et al., 2013; Makuvaro et al., 2018). Furthermore, the successful implementation of public policies aimed towards the promotion of adaptation requires, among many other things, the cooperation and participation of the intended beneficiaries. If their perception about the consequences or immediacy of climate change is different from that of the policy makers, then it is likely that the implementation of the policy will fail (Patt and Schrö).

CLIMATE CHANGE PERCEPTION OF FARMERS IN LATIN AMERICA

Hansen et al. (2004) were the first to analyze the climate perceptions of farmers in a Latin American country (Argentina). The literature on this topic has slowly grown since then, although it is still scarce compared to that from Africa and South-East Asia (Altea, 2020; Karki et al., 2020). Here we briefly summarize some of the main findings of the studies about Latin America published, in either English or Spanish, during the period 2000–2020. The articles' selection process was based on some of the steps used in systematic reviews,

TABLE 1 | Basic information for studies regarding climate change perception in Latin America.

Authors	Methods	Climate related variables	Sample size	Study area	Language
Hansen et al. (2004)	Qualitative analysis (Mental models)	Temperature, precipitation, *el Niño* and *la Niña*	215 farmers (200 in Argentina and 15 in the US)	Argentina	English
Boillat and Berkes (2013)	Qualitative analysis (Semi-structured interviews)	Temperature, precipitation and wind	28 households	Bolivia	English
Jacobi et al. (2015)	Qualitative analysis (Focus groups)	Temperature (extreme heat) and droughts	30 farmers and 5 experts	Bolivia	English
Meldrum et al. (2018)	Quantitative analysis (Focus groups and multifactor analysis)	Temperature, precipitation, hail and frost	193 households	Bolivia	English
Valdivia et al. (2010)	Qualitative analysis (Participatory research)	Temperature, precipitation, droughts, floods, hail and frost	330 households	Bolivia	English
De Matos Carlos et al. (2020)	Quantitative analysis (Logit)	Temperature, precipitation and droughts	289 farmers	Brazil	English
Funatsu et al. (2019)	Quantitative analysis (Descriptive statistics and bivariate analysis)	Precipitation	747 households	Brazil	English
Roco et al. (2015)	Quantitative analysis (Probit)	Temperature, precipitation and droughts	274 farmers	Chile	English
Barrucand et al. (2017)	Qualitative analysis (Structured and semi-structured interviews)	Temperature, precipitation and wind	37 households	Colombia	English
Leroy (2019)	Qualitative analysis (Structured and semi-structured interviews)	Water Scarcity, temperature, and precipitation	56 farmers (24 Venezuela y 32 Colombia) and 17 strategic actors	Colombia and Venezuela	English
Pinilla et al. (2012)	Qualitative analysis (Structured and semi-structured interviews)	Precipitation	487 farmers	Colombia	Spanish
Eakin et al. (2014)	Qualitative analysis (Descriptive statistics)	Droughts, torrential rainfall and hurricanes	1,267 households (Costa Rica:399; Guatemala:399; Honduras:161; Mexico:164)	Costa Rica, Guatemala, Honduras, and Mexico	English
VanderMolen (2011)	Qualitative analysis (Semi-structured interviews)	Temperature and precipitation	90 farmers	Ecuador	English
López-García and Manzano (2016)	Qualitative analysis (Semi-structured interviews)	Temperature, precipitation and droughts	35 persons	Mexico	Spanish
Meli et al. (2015)	Qualitative analysis (Participatory research, semi-structured interviews)	Temperature and precipitation	93 persons (57 ejidatarios, 14 elders and 22 local authorities)	Mexico	English
Orduño et al. (2019)	Quantitative analysis (ANOVA, Principal Component analysis)	Precipitation, droughts, floods and frost	370 farmers	Mexico	English
Sánchez-Cortés and Lazos (2011)	Qualitative analysis (Semi-structured interviews)	Temperature and precipitation	69 persons	Mexico	English
Quiroga et al. (2015)	Quantitative analysis (Ordered probit)	Water available for irrigation	274 farmers	Nicaragua	English
Altea (2020)	Qualitative analysis (Semi-structured interviews)	Temperature, precipitation, hail and frost	23 farmers and 13 regional institutions	Peru	English
Gurgiser et at. (2016)	Quantitative analysis (Semi-structured and narrative interviews)	Precipitation	37 farmers, 16 representatives of communities and 26 representatives of public institutions and NGOs	Peru	English
Fourment et al. (2020)	Qualitative analysis (Semi-directed interviews)	Precipitation (with strong winds)	38 winegrowers and 3 technical advisors	Uruguay	English

Source: Own elaboration.

in particular we followed Karki et al. (2020) and Dang et al. (2019). For our search, we used the following combinations of keywords or closely related words: *climate change* (climate, climate variability, global warming, temperature, rainfall), *extreme weather events* (droughts, hurricanes, tropical storms), *perception* (understanding), *Latin America* (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela, North America, Central America, South America), *family farms* (farms, small producers, farmers, subsistence farms, household, communities, villages), *indigenous* (indigeneity). In our search, in addition to *Science Direct* and *Web of Science*, we also used *Google Scholar*. It has been shown that *Google Scholar* has a very good coverage in areas where *Web of Science* does not (Martín-Martín, et al., 2018), therefore, by using these three

databases we have a comprehensive coverage of the literature. The title and abstract of 112 published papers that resulted from the search were analyzed to check if at least one of the objectives of the paper was to empirically analyze the climate change perceptions of farmers in a Latin American country; if that was the case, the paper was included in the revision. We focused on research published in peer-reviewed journals, the only exception was (Hansen et al., 2004) which was published as a technical report and was the first study to analyze the topic in a Latin American country. At the end of this procedure, 21 scientific articles met the pre-established criteria.

As **Table 1** shows, the existing studies come from a limited number of countries in the region; Mexico being the country with the highest number of studies available with five. Case based analysis was conducted for most, allowing for a more in depth understanding of local actors and weather (Funatsu et al., 2019), while excluding generalizations at greater scales. Only two studies (Eakin et al., 2014; Leroy 2019), covered more than one Latin American country. The studies are based on small samples; the average sample size of the papers included in **Table 1** is 240, with a range of 23–1,267 observations. Most of the studies are qualitative, only three use an econometric approach as part of the analysis. Latin America's diversity in terms of ecosystems, climate, and agricultural production systems is reflected in the studies. The papers in **Table 1** analyze farmers in settings that go from semiarid environments to high mountain ecosystems, intertropical alpine ecosystems (*páramos*), and tropical forests, and, although the majority of them are of subsistence farmers, there are also studies that look at small commercial farmers, such as winegrowers. Coffee is the crop that farmers were planting in most of the studies, followed by maize, banana, cacao, potatoes, sugar cane, beans, tomatoes, and cocoa.

The papers reviewed look at the perception that farmers have about changes in, among other climate and weather-related variables, temperature, precipitation, and droughts. Results show that most of the farmers have in fact perceived changes in these variables. A common approach used in many of the studies is to compare farmers perceptions with the actual measured variations in the respective variables. In this way, in addition to testing if farmers perceive changes in climate-related variables, it is also possible to test if farmers perceptions coincide with actual changes. The reported results are mixed, in some cases there is a clear correspondence between changes reported by farmers and actual changes (Pinilla et al., 2012; Roco et al., 2015; Fourment et al., 2020), while in other contexts, farmers' perceptions are less aligned with observed changes (Valdivia et al., 2010; Gurgiser et at., 2016; Funatsu et al., 2019). However, even in those cases where farmers disagree in the direction in which weather variables are changing (e.g., more or less precipitation), they tend to agree in reporting that there is more variability and in mentioning that a less reliable and more unpredictable weather complicates their farming related decisions (Eakin et al., 2014; Meli et al., 2015; López-García and Manzano, 2016). Nonetheless, in some cases even when farmers perceive climate variability, they do not attribute it to climate change as they see it as a future and long-term issue (Fourment et al., 2020).

Even though the focus of this review was not farmers' adoption of adaptation practices, the articles that do look at adoption show that, in general, farmers try to adapt to the changing environmental circumstances that they are facing (Eakin et al., 2014; Jacobi et al., 2015; Gurgiser et al., 2016; Meldrum et al., 2018; De Matos Carlos et al., 2020). Particularly relevant for the focus of this review is the result reported by De Matos Carlos et al. (2020) showing that there is a positive correlation between the adoption of adaptation practices and perceiving a change in climate.

The literature for Africa and Asia has shown that factors such as age, gender, education, and culture, play an important role in the processes that determine farmers' perception of climate change (Karki et al., 2020). This seems to be the case in Latin America as well. Results for Chile show that younger and more educated household heads tend to have a perception of climate change that is more aligned with the observed changes in weather variables than the perception of their older and less educated counterparts (Roco et al., 2015). Nonetheless, there is also evidence showing that, in other contexts, farmers might have similar perceptions of climate change irrespective of their age; that is the case for Southern Mexico (Meli et al., 2015). Meanwhile, results for Brazil (Funatsu et al., 2019), Peru (Altea, 2020), and Mexico (Sánchez-Cortés and Lazos, 2011; Orduño et al., 2019) show that women are less involved than men in agricultural activities and in general in decision making. Furthermore, they tend to be less perceptive of climate change, and, at least according to the evidence for Brazil and Peru, when they perceive it, they do not think of it as an anthropogenic phenomenon. Similarly, some indigenous farmers in Bolivia see climate change as a punishment of God to inappropriate human behavior (Boillat and Berkes, 2013). Results from an analysis of indigenous farmers in Mexico, show another relevant cultural aspect behind climate change perception; the Zoques in Chiapas use biological indicators (e.g., ants, birds and some plants), in addition to their observation of weather variables, to explain perceived changes in climate variability (Sánchez-Cortés and Lazos, 2011).

In addition to the aforementioned characteristics, agroclimatic conditions can also play a relevant role as a determinant of climate change perception (Karki et al., 2020). In Chile, for example, farmers living in dryland areas, where rainfall is always marginal, seem to be more aware of climate change than those located in places where irrigation infrastructure is widely available (Roco et al., 2015). Something similar, although less conclusive, is reported for Ecuador (VanderMolen, 2011). Altea (2020) presents evidence suggesting that in Peru perception of climate change varies with the altitude in which the agricultural land is located. Meanwhile, in the case of Brazil, although droughts affect farmers located in the tropical rainforest as well as those living in shrubland areas (characterized by low and irregular levels of precipitation), rainforest farmers seem to be less aware of the effects of climate change (De Matos Carlos et al., 2020). Farmers' location can be related to perception for another reason: access to meteorological information. This seems to be the case of Chilean farmers, those located close to the regional capital are more aware of the actual changes in weather

(Roco et al., 2015). Finally, perception could be affected by recent experience with climate events. Barrucand et al. (2017) report that the perception of changes in precipitation could be biased upwards when farmers have been recently affected by a weather phenomenon; La Niña occurred a few months before farmers participating in their case study were interviewed.

DISCUSSION, RESEARCH GAPS AND OPPORTUNITIES FOR FUTURE RESEARCH

The "finite pool of worry" hypothesis proposes that climate change concern is a finite resource, that is, it diminishes as other worries rise in prominence (Weber, 2006; Weber, 2015). Other than the work from Hansen et al. (2004), this is something that has not been carefully studied for Latin American farmers. Understanding how the presence of more immediate threats (e.g., violence) might hinder concern, and therefore action, about the implications of climate change is crucial in a region with high levels of poverty, inequality and social unrest. In particular, it has been shown that exposure to violence can induce higher levels of risk aversion, which in turn hampers productive investments (Moya, 2018). Given the relatively high levels of violence experienced by rural populations in many Latin American countries, understanding the effects that exposure to violence can have on climate change perceptions, as well as on adaptation decisions, is crucial for the successful adaptation of farmers in the region.

The studies available for Latin America are mostly qualitative in nature and based on case studies and small samples. While these studies provide abundant information in terms of the local context, it is desirable to complement them with quantitative studies, in particular with econometric studies. Econometric studies have the potential to identify the main factors behind climate change perceptions as well as the relationship between perception and adaptation. Furthermore, given the adequate data and the correct identification strategy, econometric tools can help establish causal relationships. Moreover, data from surveys that are representative at the national or sub-national levels are necessary to obtain results that can be generalized and used to scale-up adaptation policies and programs. Ideally, these data should be longitudinal in order to better understand how information and the occurrence of extreme climatic events affect perception and adaptation over time. The national statistical offices of all Latin American countries should regularly collect information on perception of climate change and adoption of adaptation mechanisms.

The use of *field experiments* and *choice experiments* is an alternative approach which can complement the use of observational data. These tools are used widely in behavioral, environmental and experimental economics, among other disciplines. The use of hypothetical scenarios, a characteristic of these two methods, allows for the construction of mental simulations of the negative effects of climate change. By being based on hypothetical scenarios, these methods have an important advantage over observational studies: they can be used to analyze policies before they are actually implemented. These methods could also be useful to test how successful different policies might be in terms of promoting adoption of adaptation measures. Furthermore, they can help us analyze the effect that different approaches to communicate climate change information has on perception. The issue of the perception of climate change in a context where concern is in fact a finite resource could also be analyzed using these methods. Applying field and choice experiments to study perception and adaptation to climate change in Latin America is a very promising agenda from a purely academic perspective, but, more importantly, it could be very relevant in terms of providing valuable information that could aid in the design and successful implementation of public policies.

The complexity behind the analysis of farmers' climate change perception implies that the collaboration between researchers from different disciplines, such as economics, geography, meteorology, psychology, and sociology, among others, is almost a necessity. If such collaboration is successfully achieved, the results could generate recommendations for the design of adaptation policies that are better tailored to local conditions, less costly, more efficient, and conducive to rural development.

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