



Climate change perception, vulnerability, and readiness: inter-country variability and emerging patterns in Latin America

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Abstract

In Latin America, there is scarce comparative research on variables associated with the perception of climate change. This hinders the ability of governments to take mitigation and adaptation measures in the face of the phenomenon, as well as the ability of the population to cope with its effects. In order to fill that void, this research studies the relationship between climate change perception, vulnerability, and readiness in 17 countries of the region. To that end, perception indicators included in the *Latinobarómetro* 2017 survey are analyzed, contrasted with vulnerability and readiness indexes provided by the University of Notre Dame's Global Adaptation Index. The analytical strategy includes the statistical description of the variables associated with the perception of climate change in countries of the region, clustering together those countries that display similar behavioral patterns in relation to their vulnerability and readiness indicators, as well as crosstabs with climate change indicators. The key findings indicate that it is possible to identify 3 patterns of behavior regarding the countries' vulnerability and readiness, which account for high, intermediate, and low levels in those variables. These patterns indicate cross-cutting trends concerning variables such as the level of education and affinity for the market economy, as well as particularities differentiating each country from the rest. The main conclusion is the existence of a negative association between the affinity people express for the market economy and their acknowledgment of climate change as a relevant problem.

Keywords Climate change perceptions · Vulnerability · Readiness · Latin America · ND-Gain · *Latinobarómetro*

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Introduction

During the last decades, environmental issues have been gaining increasing saliency in the global community. A growing corpus of scientific evidence has been stressing that human activities are about to produce or are already producing substantial and long-lasting shifts in biophysical equilibria, with unpredictable but deep consequences (Steffen et al. 2007). Significant transformations in the way we organize our societies are required (Feola 2015; O'Brien 2012). Climate change, in this context, raises particular concerns: on the one hand, the phenomenon requires urgent action, its effects being already visible in several parts of the globe, and bound to get much worse beyond the threshold of 1.5 °C above pre-industrial levels, which would unleash cascade effects with possibly catastrophic outcomes (IPCC 2014a, 2018). On the other hand, while international efforts have been devoted to fighting the phenomenon (UNFCCC 2015; United Nations 2015), the commitments agreed until now fall short of the standards demanded by science and stand deeply threatened by the current negationist fad engaged by several governments including the USA, which is, at the same time, one of the largest contributors in greenhouse gas emissions (Global Carbon Atlas 2018).

It is also well-known that the phenomenon is bound to produce diversified impacts on different populations and territories, depending on both their exposure to climate-related trends or events (either "natural" or human induced) and on their specific vulnerability to said hazards. The latter includes the intrinsic sensitivity or susceptibility to damage of specific individuals and communities, as well as of the goods, infrastructures, processes, services that are considered of value for these, and their lack of capacity to cope with and adapt to said hazard (Adger et al. 2011; CR2 2018; GIZ 2017; IPCC 2014b).

In Latin America, in particular, the impacts of climate change are significant and already manifest in several territories, including significative and negative variations in the availability of hydrological resources (CEPAL 2015) and increasing frequency and intensity of extreme climatic events. This will likely result in growing economic costs for the affected populations (CRED and UNISDR 2018; Germanwatch 2018). Jointly, these trends are causing significant impacts in the agricultural sector (FAO 2017), affecting the livelihoods and food security of millions of people in the region (FAO 2015). Moreover, significant impacts are projected in terms of human health, heat stress, economic development, and poverty rates, among others (CELAC, FAO, and UNISDR 2018; IPCC 2018, 2014b; Reyer et al. 2017; Romero-Lankao et al. 2012; Scott and Verkoeyen 2017; Team and Manderson 2011). Growing concerns regard the possible security risks associated with the increase in human conflict and social-political unrest triggered or enhanced by climate change

(UNFCCC 2017; Rüttinger et al. 2015), which may worsen the already fragile socio-political situation of the Latin American region.

Studies performed in the region tend to highlight persisting income inequalities, which in turn are worsened by their intersectoral association with other forms of socioeconomic and gender- or ethnical-based discrimination (CEPAL 2016, 2017). This results in enhanced climate vulnerability among the most disadvantaged groups (Anderser et al. 2014; Burns and Patouris 2014; Kaijser and Kronsell 2014; Montana et al. 2016; Smith and Romero 2016).

Climate vulnerability, in sum, is closely related to the political, cultural, economic, and territorial conditions of affected communities and the territories they occupy (Eakin and Luers 2006; Krellenberg et al. 2017; Cutter et al. 2003; Engle 2011; Smit and Wandel 2006), including the institutional and social ability to react and preemptively adapt to these hazards.

In turn, public perceptions about the phenomenon play a key role in defining the coping and adaptive capacity of a population. These perceptions contribute to mediate the effective predisposition and overall ability of each given population (Owusu et al. 2019; Cannon and Müller-Mahn 2010; Qin et al. 2015; Torres et al. 2015) and the corresponding socio-ecological systems to anticipate and transform their structures to dangers and stress that may arise in the future (Berman et al. 2012; Folke 2016; Urquiza and Cadenas 2015; Urquiza and Billi 2018). Perceptions can also influence support for public policies, including the adoption of effective and sustainable strategies to tackle climate vulnerability (Azócar 2018; Gifford et al. 2011; Leviston et al. 2013).

It is, therefore, a cause of enduring concern that, despite the growing visibility acquired by climate change in the last years, there appears to persist a strong degree of apathy, doubt, skepticism, or even negation with respect to the phenomenon (Engels et al. 2013; Nisbet et al. 2015; Whitmarsh et al. 2011; Zhou 2015).

A meta-analysis developed by Brechin and Bhandari (2011) across surveys including climate change items between the 1990s and 2010s has noted that public perception on the matter tends to vary deeply across countries, significantly correlating with development level and the degree of impact on informants. Studies like this stress the need to deepen our knowledge of the influence played by cultural differences, and to extend the analysis to regions outside the developed world, which remain relatively understudied as of yet.

Latin America, particularly, has received scarce attention at this respect. Existing scholarship has focused almost exclusively on high-risk groups such as indigenous communities and farmers, mostly through qualitative and/or participative approaches (Forero et al. 2014; Sapiains and Ugarte 2017). According to these studies, while there appears to be a growing acknowledgment of changes in the climate and biophysical systems, people tend to manifest scarce awareness and

understanding of the scientific evidence on climate change, as well as of possible pathways to adapt and/or anticipate its effects (Forero et al. 2014; Olmos et al. 2013; Roco et al. 2016).

There remains a lack of comparative research attempting to explicitly connect climate perceptions and vulnerability across countries and cultures. This is a problem because, as discussed above, public perceptions of climate change affect the ability of a population and its institutions to cope with and adapt to the consequences of the phenomenon, which can increase vulnerability. At the same time, a lack of knowledge or awareness could correlate with already existing inequalities, thus locking people up in a downward spiral of vulnerability.

Aiming to fill this gap, this paper offers a comparative analysis of climate change perceptions across the Latin American region. We analyze a set of variables derived from the *Latinobarómetro* 2017, a public opinion survey conducted annually on a sample of 20,000 people from 18 Latin American countries. We contrast the prevailing climate change perceptions in each country with its specific degree of vulnerability and readiness in the face of the phenomenon, relying on the University of Notre Dame's Global Adaptation Index (Chen et al. 2015). With this, we intend to report on the particularities in the public perceptions on climate change dominant in different countries of the region and how these relate to the specific degree of vulnerability and coping/adaptation capacity of each country. More specifically, we aim to (a) describe how this perception varies in different countries, (b) identify behavioral patterns common to groups of countries, and (c) compare said groups of countries to establish features of interest for climate change decision-making process.

It is necessary to point out that this research represents a preliminary approach to the comparative study of perceptions of climate change in the region. In this sense, they show general trends across the region, based on a limited number of indicators, that were included for the first time in the *Latinobarómetro* 2017 survey. This paper, therefore, should be considered the first step in a series of deeper studies in this area.

The paper is structured as follows. We begin by reviewing a number of studies on climate change perceptions in different regions around the world, sustaining our claim that the diversity of results obtained depends on the particularities of the populations studied. In the methodological section, we explain the information sources, variables, and techniques used, as well as the stages implemented to carry out the analysis. Subsequently, we present and discuss our results: in countries with greater vulnerability, the proportion of people that acknowledge the existence of climate change, as well as those who consider it an urgent problem that needs to be addressed and tackled, is lower. On the other hand, vulnerability appears associated with low levels of education, with a positive

valuation of the market economy, and with the use of television as the primary source of information. We conclude by summarizing our main results and delineating brief conclusions.

Studies on the perception of climate change

Environmental psychology and affiliated disciplines have been conducting studies on public perceptions of environmental issues and climate change for several decades (Bell et al. 2001), but the results have not always been concordant. The literature on this subject can be divided into at least three groups, depending on the kind of variables studied: (a) studies on mental models and their influence on climate change perceptions, (b) studies focusing on the ways in which people become informed and learn about the consequences of climate change, and (c) studies focusing on socioeconomic and demographic variables associated with climate change perceptions.

Climate change perceptions have been linked to different types of mental models (Weber and Stern 2011). These models correspond to the set of beliefs about the environment that influence the different ways in which people respond to problems caused by climate change (Sterman 2008). In this context, it has been suggested that adaptation policies based on good practices require readjusting a person's mental models through effective communication and learning processes (Otto-Banaszak et al. 2011) or adjusting the communication to the different perceptions that persons have of the problem (Hine et al. 2016; Dewulf 2013; Bain et al. 2012). Along these lines, de Boer et al. (2016) point out that people manage to trade off the information they receive about the consequences of this phenomenon with their previous beliefs about the weather in their area, thus generating adaptive behaviors that integrate both types of knowledge. There is a tendency to think that people who are more aware of the consequences of climate change or with favorable attitudes towards taking care of the environment are those who adopt adaptive mental models; however, it has been demonstrated that a greater commitment to the environment or to climate change is not necessarily associated with ecological motivations (Xiao and Buhrmann 2019; Stern et al. 1999).

When we focus on the ways in which people become informed and learn about the consequences of climate change, multiple variables have been identified, with different results. Evidence has been found that personal experience is a determining variable in the perception of the risks associated with climate change since it increases knowledge about its consequences (Botzen et al. 2009; Lindell and Hwang 2008). Experience, however, may be less of a determining factor than the knowledge gained through education when adaptation measures are adopted (Madisson 2007). On the other hand, access to information can generate sensitivity and concern for

this issue but does not guarantee effective responses. The role of social networks and media in informing people about climate change has also been studied. There is evidence of the importance of the media and especially the Internet in spreading knowledge about this phenomenon (Masud et al. 2017; Shepherd et al. 2012). Literature shows that becoming informed and raising awareness about a problem such as a climate change do not guarantee that adequate responses will be adopted. Multiple psychological, social, and cultural barriers intervene between the concern about climate change and the decision to take action to address it (Gifford et al. 2011; Leviston et al. 2014). Moreover, the increasing visibility and knowledge of environmental issues in general and the scientific consensus regarding the anthropogenic character of climate change (Cook et al. 2013) have proved insufficient to change the perception of important sectors of society: in countries such as the USA (Howe et al. 2015) and Australia (Leviston et al. 2014), levels of skepticism regarding the origin of climate change remain quite high.

A further strand of scholarship has connected climate change perceptions with socioeconomic and demographic variables. The results vary according to the geographical characteristics and the particularities of the populations under study. Again, multiple variables have been considered by these studies with somewhat contradictory results.

With regard to gender, some studies indicate that women are more aware of climate change than men (Smith 2018; Akompab et al. 2013; Shepherd et al. 2012; Lindell and Hwang 2008). On the other hand, evidence has been found that women living in urban areas are less aware of its consequences and therefore more vulnerable to it (Owusu et al. 2019; Botzen et al. 2009).

Concerning age, certain studies indicate that younger people are more sensitive to the risks associated with climate change, especially if these risks relate to recent events (Roco et al. 2015; Botzen et al. 2009; Frewer 2003). Conversely, there is research indicating that age has a positive association with the perception of risks associated with climate change, and, in this sense, older people give more importance to its consequences (Shepherd et al. 2012).

With respect to the level of education, studies also show mixed findings. On the one hand, a negative association has been found between the level of education and the perception of risks associated with climate change (Botzen et al. 2009; Hori and Shaw 2012), and, on the other, positive associations have been identified that indicate that people with a higher level of education are more aware of the consequences of climate change (Hamilton and Keim 2009; Owusu et al. 2019). In addition, research on specific populations in developed countries has found no relation between people's level of education and the perception of climate change (Akompab et al. 2013; de Boer et al. 2016).

Interesting results have been found regarding income. Research indicates that higher-income people are less aware of climate change and its risks (Hamilton and Keim 2009; Akompab et al. 2013; Lindell and Hwang 2008; Masud et al. 2017). Along the same lines, it has been underscored that lower-income people are more vulnerable and therefore more aware of the effects of climate change on their lives (Hori and Shaw 2012). Conversely, some studies have found a positive association between income levels and climate change perceptions and have marked high earners as more sensitive to its consequences (Vulturius et al. 2018).

Considering the literature above, two observations can be made: first, that while there exists a significant relationship between climate change perceptions and the adoption of, or support for, climate adaptation, this relationship is far from linear. The ability and willingness of individuals, groups, and authorities to cope with or adapt to climate change depend on multiple variables, among which number climate perceptions. Accordingly, climate perceptions are not a sufficient condition for governments to apply effective mitigation and adaptation actions, or for the population to effectively cope with the phenomenon, but at the same time, they are arguably a necessary one to favor the adoption, timeliness, and effectiveness of adaptation measures. No climate adaptation would seem to be possible in the lack of sufficient awareness, belief, relevance, and urgency about the phenomenon. This makes it highly relevant to deepen our understanding of cross-cutting factors influencing public perceptions of climate change and, by this token, guide possible policy responses aiming to intervene in such perceptions as a way to promote adaptation.

On the other hand, the literature review also shows that climate perceptions are complex, diverse, and context specific. In effect, the contrasting findings on the role played by socioeconomic and demographic variables could be due to the particular hazards considered in each given study, as well as the geographical, social, and cultural differences of the populations covered. Observed populations vary from farmers, women living in urban slums, people exposed to flood risks, people exposed to heatwaves, and droughts, among other risks. Most are extracted from delimited populations of European countries or in the USA and Australia. Other previous results seem to corroborate the idea that climate change perceptions are strongly dependant on the context and the way in which it is measured or studied. Thus, for example, evidence has been found of the relationship between political identification and religion with the perceived effects of climate change (Hamilton and Keim 2009), and a negative correlation seems to link climate change perceptions with the fact of living alone (Akompab et al. 2013).

It follows from that that it may be counterproductive to approach risk perceptions reductively, without taking duly into account the heterogeneity of socioeconomic and socio-cultural contexts in which these perceptions arise. In this

context, comparative research has the potential to help illuminate both country-specific patterns and emerging common trends characterizing climate change perceptions in the Latin American region and connect these with the different levels of vulnerability and adaptive capability of the different countries in the region.

Vulnerability and resilience to climate change

A large part of the research on climate change has focused on the conditions under which systems and populations face the risks and hazards associated with this phenomenon. This has led to an increasing interest to map the exposure, vulnerability, and resilience of these populations and systems to climate change.

While the concept of exposure simply refers to the existence of people or goods they value in areas potentially affected by climate change threats (IPCC 2014a), vulnerability focuses on the susceptibility of different communities and territories to suffer the impacts of these threats (Adger 2000; Eakin and Luers 2006). More precisely, it signals the propensity or predisposition of a community or territory to be negatively impacted by climate hazards (CR2[Centro de Ciencia del Clima y la Resiliencia] 2018; IPCC 2014a), which in turn depends on the sensitivity of specific individuals and territorial process to the climate hazards to which they are exposed, as well as on the overall resilience of the community or territory in the face of said hazards. This propensity is closely related to the political, cultural, economic, and geophysical-ecological conditions of affected territories and communities (Krellenberg et al. 2017; Engle 2011; Smit and Wandel 2006).

Resilience, on the other hand, refers to the capacity of a system to maintain or resume operations that were disrupted by events in their environment (Meerow et al. 2016). It may be understood as a form of resistance to change, protecting against disturbances that could affect the operation of a system (Adger 2000). But it may also reflect the system's capacity to anticipate and transform their structures to dangers and stress that may arise in the future (Folke et al. 2016; Berman et al. 2012). Both dimensions of resilience—reactive and proactive—relate to the resources and readiness of communities and political institutions to manage the risks associated with climate change (Kelly and Adger 2000). Using resilience as a guide, it is possible to develop innovative responses that consider the lessons learned about the consequences that climate change-related events have had in the past (Urquiza and Cadenas 2015; Urquiza and Billi 2018). In fact, it has increasingly been argued that effective responses to climate change should go beyond adaptation and resilience, to embrace a thorough transformation of key structural aspects of society and of its relationship with the environment which acts at once

as a cause of the phenomenon and as amplifiers of its effects (Chaffin et al. 2016; Feola 2015; O'Brien 2012; Pelling 2011).

Interventions seeking to reduce the vulnerability of populations exposed to climate change require, at least, understanding the causes and impacts of the phenomenon (Azócar 2018), as well as the available capacity within each territory and community to respond or adapt to said impacts. The same can be said about attempts to put in force more transformative solutions to the problem. In turn, this demands a deep understanding about how the causes and impacts of the phenomenon, as well as the ability to respond, are perceived within the population and how these perceptions vary across different socioeconomic and demographic groups (Owusu et al. 2018).

Within the framework of this research, we will use the definitions of “vulnerability” and “resilience” developed by the Global Adaptation Program of the University of Notre Dame. Within this index, vulnerability is defined as the “propensity or predisposition of human societies to be negatively impacted by climate hazards” (Chen et al. 2015: 3), combining elements related to each country's geographical exposure, sensitivity, and adaptive capacity towards climate change. The “readiness” index, in particular, seeks to measure the preparedness of a country to make use of available international funding to anticipate and/or adapt to future impacts of climate change. In this regard, it may be considered a proxy of a country's climate resilience.

As we will show, climate change perceptions are strongly linked with vulnerability and resilience across Latin American countries, while also displaying specific patterns of behavior in each individual country.

Methodology

The study focuses on 18 Latin American countries, covered by the *Latinobarómetro* survey conducted between June and August 2017. For each of these countries, we collected data from the aforementioned survey, along with indicators of vulnerability and readiness to climate change as measured in the Global Adaptation Index developed by the University of Notre Dame (ND-GAIN). Data from both sources were analyzed independently and cross-checked in a three-stage process.

The first stage consisted of the analysis of variables related to climate change perceptions, included in the *Latinobarómetro* survey. This survey is carried out using a face-to-face questionnaire with representative samples of the total population of 18 Latin American countries. The samples are nationally representative for each of the countries under study and vary between 1000 and 1200 cases, representing a 3% margin of error at the domestic level (Cooperación Latinobarómetro 2017). The 2017 measurement included four variables associated with climate change perceptions: acknowledgment of the problem, attributing

cause, the level of urgency with which the problem must be addressed, and priority given to the fight against climate change. The first two variables are ordinal (Likert), and the remaining two are single nominal variables. The behavior of these variables was analyzed through descriptive statistics.

In a second stage, we worked with the vulnerability and readiness indices of the Global Adaptation Index (ND-GAIN), of the University of Notre Dame. ND-GAIN data are obtained from international organizations whose sources are public and reliable and which carry out regular quality controls and address a high proportion of United Nations member countries (Chen et al. 2015). ND-GAIN comprises two major indices: the vulnerability index is organized into 36 indicators organized into 3 sub-indices (exposure, sensibility, and coping capacity) and 6 cross-cutting sectors. It measures the “propensity or predisposition of human societies to be negatively impacted by climate hazards” (Chen et al. 2015: 3). The readiness index consists of 9 indicators, reflecting “a country’s ability to leverage investments to adaptation actions” (Chen et al. 2015: 4). More precisely, the readiness index captures the ability of a country to catalyze national and international investments and convert them to adaptation actions, mediated by the suitability of the country’s economic regulation and general economic climate to attract adaptation investments, the appropriateness of the governance arrangement to capture this investment and turn it into effective adaptations (including the country’s political stability and lack of violence, the degree of corruption, regulatory quality, and rule of law), and the adequacy of the social structure and socio-technical infrastructure to support effective adaptation investment.

Using this data, we created a cluster classifying all the countries covered by the *Latinobarómetro* survey according to their levels of vulnerability and readiness. Clusters were identified by applying Ward’s Hierarchical Clustering Method, which seeks to identify the structure of the data by locating similar entities in a reduced number of groups (Hair et al. 1999; Cea 2004). Ward’s method is an agglomerative classification technique that seeks to minimize dispersion within groups, offering a solution that emphasizes the similarity of entities in the same cluster (Murtagh and Legendre 2014).

As a result of this process, a typology of 4 groups was obtained. It is worth noting that the classification identified a group comprising a single country (Venezuela), which exhibits an atypical behavior pattern. We tried different cluster analysis techniques and in each of them, Venezuela seems isolated. Because the objective of this document is to find groups of countries that show internally homogeneous behavior, we decided not to consider this country in the analysis. On the other hand, we believe that the results are probably associated with the precision of the data obtained in Venezuela, which reinforces our decision not to consider them. Only the

remaining 3 groups were analyzed, which yielded results for 17 of the 18 countries covered by *Latinobarómetro*. It is important to note that the statistical homogeneity observed within these groups of countries in the vulnerability and preparedness indicators fails to reflect the important differences in climate change policies carried out by these countries. That is why the results should be interpreted with caution. The groups, however, show common patterns in the levels of vulnerability and preparedness of the countries that include them. These patterns are related to the way in which these countries perceive climate change, which is the focus of the analysis.

The third stage of the analysis consisted of joint analysis, using crosstabs, of the variables of climate change perception with the 3 vulnerability and readiness clusters. We particularly focused on how, within each cluster, the climate change perceptions associate with different sociodemographic variables, with how people access to information, the perception of the country’s economy, and with their political-economic views (namely, the preference for a market system over a centralized one).

In order to further elaborate on their characterization of each cluster, we decided to select three countries, each representing one of the clusters, in order to investigate their distinctive features. We selected those countries which showed a distribution in perception with the highest similarity to the one proper to the cluster to which they belong. Focusing on the analysis of these countries delivers a parsimonious reading of each cluster, with a simpler and more understandable description of the perception patterns than would result from considering the aggregate data of each cluster. For these representative countries, we analyzed the relationships between climate change perceptions and sociodemographic variables (age and level of education), variables related to the perception of the country’s economy (perception of the economy’s progress and preference for the market economy system), and to the information sources most widely used by each country’s residents.

Before reviewing the results, it is important to note that the *Latinobarómetro* survey included, for the first time, 4 indicators of perception of climate change. As will be shown below, these indicators offer the possibility of identifying different groups of countries with similar results and comparing them with each other. However, the available sample size only gave account of general trends in these indicators. Therefore, our results should be considered as a first approximation to this issue in Latin America. We hope that our paper may serve to guide the development of further research in the region or individual countries, based on surveys with a greater degree of representativeness.

Results

Our results indicate that climate change perceptions differ widely across Latin American countries. Acknowledgment of the existence of climate change, particularly, ranges from 87% in Uruguay to a meager 42% in Ecuador (see Table 1).

On the other hand, the identification of the primary cause of the phenomenon displays much less dispersion, the general trend being attributing it mainly to human activities, an opinion expressed by at least two-thirds of each country's population. Likewise, most of the survey respondents consider climate change to be an urgent problem that needs to be addressed today, an opinion ranging from 56 in Guatemala and the Dominican Republic to 79% in Colombia. In the same vein, the general opinion is that, regardless of its negative consequences, the fight against climate change is a priority, a view shared by 59% of respondents in Honduras and 84% in Colombia (see Table 1).

It is striking that in countries like Ecuador, a high proportion of the population does not recognize that climate change exists, and, in turn, most of it believes in anthropogenic causes of climate change and in the need to face it. The countries that present this inconsistency, as we will see later, integrate the cluster with higher levels of vulnerability and lower levels of readiness. Our hypothesis is that this incoherency is an indicator of these high levels of vulnerability and lack of readiness.

More detailed results appear when we group countries into clusters, based on their relative levels of vulnerability and readiness to climate change. Importantly, these clusters are relative to the reality of the region, and these results can be compared with the behavior of other regions and countries around the world in future researches. Table 2 resumes the composition of the 3 clusters, which were named based on the comparison between their vulnerability and readiness levels.

The first cluster consists mainly of Central American countries with high climate change vulnerability levels and low readiness levels to face this phenomenon. Therefore, the cluster was dubbed "highly vulnerable countries." The second group consists of "countries with medium vulnerability and readiness," i.e., its members are neither the most vulnerable countries nor the most prepared ones. These countries display a medium level of risk since they are susceptible to the consequences of climate change but lack the necessary resources to confront it. With the exception of Mexico and Panama, most are South American countries. The third cluster, comprising only 3 countries, is also characterized by medium vulnerability, but the readiness levels are much higher: thus, the cluster was called "highly ready countries." Two of these countries are in South America and one is in Central America.

Crosstabs comparing climate change perceptions across the 3 clusters confirm internal homogeneity and cluster

Table 1 Climate change perception in Latin American countries

Country	% agree + strongly agree with: climate change exists	% agree + strongly agree with: human beings are the main cause of climate change	% climate change is an urgent problem that we have to address today	% the fight against climate change must be a priority, regardless of its negative consequences
Uruguay	87%	91%	74%	73%
Argentina	76%	88%	69%	69%
Colombia	73%	87%	79%	84%
Brazil	73%	86%	70%	73%
Mexico	69%	85%	74%	73%
Paraguay	66%	80%	62%	70%
Venezuela	64%	82%	72%	64%
Bolivia	64%	82%	71%	74%
Peru	63%	79%	64%	67%
Costa Rica	63%	91%	77%	73%
Chile	60%	85%	69%	79%
Panama	54%	80%	67%	66%
Honduras	51%	77%	59%	59%
El Salvador	51%	83%	70%	72%
Guatemala	50%	74%	56%	60%
Nicaragua	50%	85%	69%	66%
Dominican Republic	46%	73%	56%	60%
Ecuador	42%	79%	74%	80%

Source: Prepared by the authors based on the *Latinobarómetro* 2017 survey

Table 2 Vulnerability and readiness clusters

		Vulnerability		
		High	Medium	Low
Readiness	High			
	Medium		Cluster 2: Argentina Brazil Colombia Mexico Panama Paraguay Peru	Cluster 3: Chile Costa Rica Uruguay
	Low	Cluster 1: Bolivia Dominican Republic Ecuador El Salvador Guatemala Honduras Nicaragua		

Source: Prepared by the authors based on the ND-GAIN Global Adaptation Index

differentiation (see Table 3). Both within “countries with medium vulnerability and readiness” and “highly ready countries,” the majority of the population acknowledges climate change as a problem (68% and 70%, respectively). On the other hand, this figure drops to 51% within “highly vulnerable countries.”

This pattern is also observed for the rest of the climate change perception indicators. The high-readiness cluster presents the strongest agreement on the notion that climate change is caused primarily by human beings, on it being a problem that requires urgent attention, and on making a priority of addressing it. Inversely, high-vulnerability countries feature the lowest levels of agreement across all three variables (see Table 3). All the differences observed are statistically significant ($p < 0.005$).

The countries selected to represent each cluster and to explore in more detail patterns associated with climate change perceptions are, respectively, Honduras, Mexico, and Uruguay.

Honduras was selected to exemplify “highly vulnerable countries.” In Honduras, 51% of the population acknowledges that climate change exists. Education positively associates with the acknowledgment of climate change: only 43% of illiterate persons acknowledge the existence of climate change, a figure that rises to 70% in the group of people with higher education. On the other hand, the acknowledgment of climate change is the lowest among people who consider that the country’s economic growth is a priority (43%) and those who positively value the market economy (46%). Likewise, there is a lower perception of climate change among those who report television as their primary information medium (53%).

Mexico was selected as representative of “countries with medium vulnerability and readiness.” In México, 69% of the population acknowledges the existence of climate change. Age is one of the variables most associated with the perception of climate change: 75% of people between the ages of 16 and 25 agree that this problem exists, something that is only observed in 59% of adults aged 61 and older.

Climate change perceptions also correlate with the level of education, but in this case, the trend is more pronounced than that observed in Honduras, ranging between an acknowledgment rate of 51 among illiterate people and 87% in the group with higher education. There is also a negative association between those who value the market economy and those who acknowledge the existence of climate change (3%). On the other hand, there is a greater acceptance of the existence of climate change among people who mostly use the press (80%) and the Internet (83%) as their primary sources of information.

Uruguay was chosen to illustrate “highly ready countries.” In this country, 92% of the population acknowledges the existence of climate change. In this case, age does not seem to influence climate change perceptions, while, as in the previous clusters, the level of education level is positively associated with it. Variables related to the perception of the economy are also relevant: 85% of the people who consider that the country’s economic growth is stagnant and 89% of those who do not value the market economy acknowledge the existence of climate change. In this country, there is no relationship between the means of information mostly used by the informants and the perception of climate change.

Table 3 Cluster by variables of change climate perception

		Cluster 1: Highly vulnerable countries	Cluster 2: Countries with medium vulnerability and readiness	Cluster 3: Highly ready countries
The climate change problem does not exist	Strongly agree	9.8%	4.9%	8.4%
	Agree	34.2%	20.0%	14.6%
	Disagree	40.7%	44.8%	44.3%
	Strongly disagree	9.9%	23.3%	25.9%
Humans are primarily responsible for climate change	Strongly agree	27.2%	35.0%	43.5%
	Agree	52.1%	48.7%	45.0%
	Disagree	14.7%	9.3%	6.1%
	Strongly disagree	2.3%	1.9%	1.7%
Which of the following affirmations do you agree with the most?	Climate change is an urgent problem that we have to address today	65.5%	69.2%	73.3%
	It is not an urgent problem yet, but it will be in the future	14.2%	13.9%	14.4%
	It is an urgent problem, but nothing can be done, it is too late to act	7.2%	5.7%	7.3%
	It will never be a problem that requires addressing	6.1%	3.9%	2.0%
Which of the following affirmations do you agree with the most?	We must give priority to the fight against climate change, regardless of its negative consequences	67.8%	71.9%	74.9%
	We must give priority to economic growth, regardless of its negative consequences	23.8%	16.8%	14.7%

Source: Prepared by authors based on the *Latinobarómetro* 2017 survey

Noticeably, while the 3 countries have signed and ratified the Paris Agreement (United Nations 2020), they are quite heterogeneous in terms of CO2 emissions, ranging from 3.8 in México to 1.0 t CO2/person in Honduras (Global Carbon Atlas 2018), emission reduction committed as part of each country’s Nationally Determined Contributions, roughly 25% in Uruguay and México, and just 1% in Honduras (UNFCCC 2020); number of recorded environmental conflicts per inhabitant, from roughly 0.82 in México to 2.08 in Honduras (Temper et al. 2015); and number of environmental/climate laws and policies, 9 in Honduras, 14 in México, and 17 in Uruguay (Grantham Research Institute on Climate Change 2020).

Discussion

By clustering Latin American countries according to their levels of vulnerability and readiness to confront climate change, we were able to reveal three types of behavior in the region. In this regard, it is important to note that there is a positive relationship between the level of readiness of the countries in these clusters and the 2018 Human Development Index (HDI). The countries in the cluster of least readiness are mostly among those countries with the lowest HDI in the region; conversely, the countries in the highly ready cluster are those with a high HDI.

By relating the behavior of clusters with the perception of climate change, we demonstrate that the least ready countries, and therefore the most vulnerable, are those where a lower percentage of the population acknowledges the existence of climate change. This corroborates previous evidence on a negative association between vulnerability and perception of climate change (Safi et al. 2016; Krellenberg et al. 2017) but contrasts with other studies (Brechin and Bhandari 2011) that suggest that people in poorer countries are more concerned about this phenomenon than people in developed countries since the latter can count on greater resources to address it.

The results indicate that belief in the existence of climate change is not a generalized opinion in all Latin American countries. Levels of skepticism in clusters 1 and 2 are particularly high and raise doubts as to the motivations behind these answers. These questions need to be studied in-depth in future studies, considering that these clusters include the most vulnerable countries of the region.

However, the answers to other perceptual items reveal a larger consensus about the notion that climate change is primarily caused by human activity, of the need to address it, and on it is a policy priority—answers that, apparently, would imply an implicit acceptance that climate change is happening.

To interpret this apparent inconsistency, we deem it necessary to consider the relevance that climate change has acquired

over the last few decades, reflected in the frequent political and scientific discussions on this subject in the media. It is possible that this generates a social desirability effect on answers regarding the existence and importance of climate change. There is evidence to suggest that the frame delivered by the media associates climate change with anthropogenic causes and a sense of urgency (Boykoff and Boykoff 2007; Boykoff 2011; González 2015). Evidence of the influence of this type of frame has been found showing that the phenomenon can be declared a priority both by people who are convinced of its existence and by those who remain skeptical (Gavin 2018). Our results seem to corroborate this.

Another key finding refers to the heterogeneous factors that seem to influence climate change perceptions within different clusters of countries of the Latin American region. In countries with low readiness, although the proportion of people who perceive climate change is tendentially low, we observe a positive association between education levels and climate change perceptions, contrasting previous research, which had found a negative association between these variables (Botzen et al. 2009; Akompab et al. 2013). In these countries, the influence of television on the perception of climate change is less than that of other media such as social networks and the Internet.

This negative association between education levels and climate change perceptions is also evident in countries with a medium level of readiness. On the other hand, these countries are consistent with previous studies that indicate that age is negatively associated with the recognition of the existence of climate change and its risks (Botzen et al. 2009; Roco et al. 2015; Hamilton and Keim 2009). In these countries, mass media such as the press and the Internet seem to have the highest influence on the perception of this phenomenon.

High-readiness countries stand out in that age, and the media seem to have no influence on climate change perceptions. Noticeably, all these are economically developed countries displaying high HDI values.

An additional key finding of the study regards the existence of a negative relationship between climate change perceptions and a positive valuation of the market economy, i.e., in most Latin American countries, those who value the market economy least acknowledge the existence of climate change. This result is consistent across the three clusters. It may be associated with people's political ideology—something similar to what was observed in the USA (Benegal 2018; Kahan et al. 2012) and Australia (Leviston et al. 2014). People concerned about climate change tend to coincide with those that value caring for the environment more than the economic development of their nations. It should be noted that we are talking about countries with stable economies and better prepared to face the effects of climate change, which seems to have repercussions on the opinions of their inhabitants on the current relevance of this phenomenon. In this sense, a more in-depth

study on countries that are more detached from the market model may shed light on educational strategies regarding the consequences of climate change, which in turn could help to enhance the resilience of their populations.

Conclusions

The increasing evidence on climate change and its impacts urge us to reach new and stronger agreements to fight the phenomenon, while promoting the ability of countries and their residents to cope with and adapt to these impacts, particularly focusing on the most vulnerable groups, which are bound to suffer the worst effects of the phenomenon. As we argued, while public perceptions are likely insufficient to promote effective responses and adaptations, they are a necessary precondition mediating the adoption of protective and adaptive measures on the part of the population and in fostering an active climate and environmental agenda on the part of the national and sub-national governments. As such, improving public perceptions on the matter is necessary to reduce vulnerabilities and increase adaptation in the face of climate change.

Within this context, this research aims to improve our understanding of factors associated with the public perceptions of climate change and how these vary across different cultures. The Latin American region is an especially important case study because of both the severity and heterogeneity of the impacts expected in its different territories and the high variability in the degree of social and institutional preparation to deal with the phenomenon and for the relative lack of comparative and quantitative studies in the region.

Our research shows that, while the public perception of the climate change displays a high heterogeneity across the Latin American region, it is possible to identify stable patterns of behavior which associate said perceptions with the specific levels of readiness and vulnerability of each country with respect to the phenomenon. In general terms, public perceptions of climate change—and, particularly, belief that humans are primarily responsible for the phenomenon, that climate change is an urgent problem that we have to address today, and that this should take priority with respect to the promotion of economic growth—tend to be stronger within countries displaying a high readiness in the face of the phenomenon and weaker in less ready and more vulnerable ones. Strangely, belief on the actual existence of climate change seemed to show an opposite pattern of correlation (stronger in the most vulnerable countries and weaker in the most prepared ones), creating an apparent inconsistency that requires further research.

In addition, our analysis reveals cross-cutting trends that, to varying degrees, are presented in the three clusters: a direct relationship between people's level of education and the

acknowledgment of the existence of climate change and a negative association between the level of affinity for the market economy and the perception of this phenomenon.

On the other hand, each group also seems to feature specific behavioral patterns, as was made manifest by analyzing the countries that represent these clusters' behavior. Honduras, a vulnerable country, presents a clear negative association between the perception of the existence of climate change and the use of television as the primary means of information. Mexico, a country in the intermediate cluster, stands out for the relationship between people's age and their perception of the existence of climate change, with a greater proportion of younger people recognizing this phenomenon. In Uruguay, we find that people who consider that the country's economy is stagnant are those who most acknowledge the existence of climate change.

In a context of scarce comparative research on climate change perception, vulnerability, and readiness, this study is a first approximation to the behavior of Latin American countries regarding this problem. It corroborates the idea that the results of studies on the perception of climate change are diverse and depend on the particularities of the geographical locations in which they are conducted, providing evidence on behavioral patterns that can be observed in Latin America. On the other hand, our results can be contrasted with studies developed in other regions around the world, aiming to identify universal trends and to single out the distinctive features that characterize Latin American countries.

Prior literature did not count on studies correlating the perception of climate change with the assessment of a country's economic system, a variable that is considered in this study. This is especially relevant if we consider that the capacities to adapt and respond to the effects of climate change imply allocating resources for preventive and mitigating actions, something which is not always compatible with the market economy system that predominates in different regions around the world. For this reason, verifying the existence of a negative association between the affinity expressed by people from different Latin American countries for the market economy and the perception of climate change is considered significant, especially when this relationship indicates that countries with the highest readiness levels are those with high human development indicators, which consequently present positive economic development forecasts. As we discussed above, climate action has to do as much with adaptation, as with transformation, and it does not seem surprising that climate perceptions are lower in those with a closer affinity to the traditional way of development, which is often pictured at the core of what should be transformed to achieve more sustainable and climate-sensitive development.

A series of projections and challenges emerge from these results. On one hand, Venezuela's behavior in relation to its vulnerability and readiness indicators needs to be studied

further, seeking plausible explanations for its behavior as a statistically atypical case. Along with this, the statistical data analyzed here needs to be supplemented with qualitative and documentary studies to examine the discourses and argumentative lines behind the different perceptions of climate change in the region. Finally, variables related to the perception of climate change need to be permanently included in quantitative and longitudinal studies such as the *Latinobarómetro*, in order to analyze trends and changes over time in relation to a phenomenon that has progressively gained ground and relevance in the region's political agendas.

In closing, it is relevant to note that, as it was argued in the paper, changing climate change perceptions, while an important step to pave the way towards the adoption of adaptive, and even transformative, initiatives, is bound not be enough, particularly in contexts of severe and/or chronic socioeconomic deprivation, or in the presence of weak political institutions, or ones that are indifferent or overtly hostile to the changes required by these initiatives. This makes it all the more relevant that, on the one hand, climate perceptions seem to correlate positively with a country's degree of human development and preparedness in the face of climate change, meaning that vulnerable populations could be prone to get stuck in a negative loop of poverty, under-awareness, under-preparation, and more severe climate impacts, circularly reinforcing each other. On the other hand, the negative association that we found between climate perceptions and the preference for a market-oriented economic system suggests that the problem of cultivating the public opinion on the issue does not reduce to creating and diffusing evidence and information but has also a prominently political, and even ideological, facet, which is sadly exemplified in the enduring campaign of several administrations to discredit and undermine the declarations of climate experts and international commitments on the matter.

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