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Perceptions of climate trends among Mexican maize farmers

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ABSTRACT: Farmers around the world are among the groups most vulnerable to the effects of climate variability and change. Accurate perceptions of climate variability and change can help farmers take effective measures to protect their livelihoods against threats from local environmental change; conversely, understanding how farmers perceive threats from climate change (or not) can help policy-makers anticipate the diversity of strategies and behaviors that will ultimately shape the vulnerability of agriculture in the coming decades. Nevertheless, perceptions of climatic variability and change are influenced by far more than direct experience with and observations of weather and climate; thus, farmers' perceptions may not always accurately reflect observed climatic trends. We analyzed Mexican maize farmers' perceptions of change in drought frequency as a proxy for their perceptions of climate variability and change. Through statistical analyses of survey data collected from 1092 maize-producing households in Sinaloa, Chiapas, and the state of Mexico, we identified factors associated with the perception of change in drought frequency. Results showed that indigenous identity and receipt of credits or loans were the variables that most strongly influenced, either positively or negatively, perceptions of change in drought frequency. These results suggest that climate adaptation policies will need to go beyond focusing on agronomic options to consider the social and institutional contexts of farmers' decision-making as important influences on their risk perception and adaptation strategies.

KEY WORDS: Mexico · Drought · Climate change · Perceptions · Adaptive capacity

1. INTRODUCTION

Farmers' perceptions of climate variability and change reflect cognitive factors, objective local realities, and first-hand experiences of climate impacts (O'Connor et al. 1999, Leiserowitz 2006, Etkin & Ho 2007, Crona et al. 2013). Perceptions influence people's decisions to act, and affect how individuals decide what adaptive measures they should take (Grothmann & Patt 2005). While empirical knowledge of climate variability or change may be influential in decision making, perception is more often based on people's personal observations, experiences, and surroundings (Tobin & Montz 1997, Slovic 2000, Dessai et al. 2003, Weber 2010).

Across the world, farmers are among the groups most vulnerable to the effects of climate variability and change (Slegers 2008, Apata et al. 2009, Fosu-Mensah et al. 2012, Bryan et al. 2013). Accurate perceptions of climate variability and change can help farmers take effective measures to protect their livelihoods against threats from local environmental change; conversely, understanding how farmers perceive threats from climate change (or not) can help policy-makers anticipate the diversity of strategies and behaviors that will ultimately shape the vulnerability of agriculture in the coming decades. Studies have shown that in some cases, farmers' perceptions of climate variability and change are shaped more by their personal experience than by empirically meas-

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ured climate patterns (Weber 2010, Bryan et al. 2013). Moreover, while farmers' perceptions are based in part on a lifetime of observations, several studies have suggested that farmers tend to emphasize recent observations and local experience in forming their perceptions of climate risk and making decisions about their own adaptive behavior (Weber 2010). But farmers' perceptions are also often in sync with climate trends in their regions (see for example Vedwan & Rhoades 2001, Apata et al. 2009, Wiid & Ziervogel 2012, Li et al. 2013).

Our goal was to determine to what extent maize farmers' perceptions of trends in climate hazards align with what climate scientists are observing and predicting. We also wanted to know what factors most influenced those perceptions. We surveyed over 1000 maize-farming households in Sinaloa, Chiapas, and the state of Mexico, using socioeconomic, demographic, and agronomic indicators as independent variables. Our study was motivated by literature documenting a range of factors associated with farmers' perceptions of climate, including education, gender, farming experience, farm size, access to credit and loans, land tenure, soil fertility, public support programs, and access to climate information (Gbetibouo 2009, Fosu-Mensah et al. 2012, Li et al. 2013). Our study tested the degree of influence that such factors have on perceptions of drought trends among maize farmers in the 3 states, using farmers' perceptions of drought trends as a proxy for climate change.

2. LITERATURE REVIEW

2.1. Perceptions and adaptation

Environmental perception research has a long history in hazards geography and risk analysis (Tobin & Montz 1997). Climate change science has reinvigorated this legacy, highlighting the role of public perceptions of climate variability and change in adaptation (e.g. Leiserowitz 2006, Etkin & Ho 2007, Patt & Schröter 2008, Fosu-Mensah et al. 2012, Halder et al. 2012), including how people recognize, understand, and respond to climate-change risks based on their social, cultural, and economic attributes (Crona et al. 2013). Collectively, this research has underscored the relationship between perception and behavior, and thus the salience of perception in understanding why and how society responds to environmental change.

'Risk appraisal' and 'adaptation appraisal' are 2 processes that explain why individuals adapt differently to climate change risks (Grothmann & Patt 2005). Risk appraisal, which occurs first, is how 'individuals assess a threat's probability and damage potential to things she/he values, under the condition of no change in her or his own behavior' (Grothmann & Patt 2005, p. 203). In the adaptation appraisal process, 'a person evaluates her or his ability to avert being harmed by the threat, along with the costs of taking such action' (Grothmann & Patt 2005, p. 203). Whereas the cognitive process of risk appraisal results in risk perception, the result of adaptation appraisal is a specific perception of one's own adaptive capacity or self-efficacy. An individual will respond to a threat by either preventing damage if adaptive capacity is high (adaptation), or by choosing a maladaptive strategy such as denial, wishful thinking, or fatalism. Those who choose an adaptive response form an 'adaptation intention' to take action, but this is different from actual behavioral adaptation because people often have intentions that they do not carry out. An intention to adapt can be unproductive if individuals objectively lack adaptive capacity (e.g. lack time, money, staying power, knowledge, entitlements, social or institutional support). For example, in the Commune of Madiama, Mali, Crane et al. (2011) found that Marka and Fulani farmers' intention to adapt to drought depends heavily on constructs of ethnic identity. Although both groups experience the same socio-economic pressures, their intention to adapt is ultimately shaped by their social status. Because each group adapts according to the actions permitted in its social stratum (Crane et al. 2011), the intention of one group to adapt might be limited or unproductive in comparison to the other.

In this analysis, we focused on the factors associated with risk appraisal among farmers. Clearly, one of the most salient factors is an individual's personal experiences that communicate risk about environmental change (Weber 2010). Drought is a livelihood risk for farmers. Events that create vivid memories such as significant losses in yield, as well as events that have occurred recently, are often judged by those who have experienced them to be likely to happen again (Crocker 1981, Grothmann & Patt 2005, Kahneman et al. 2016). Because exposure to environmental risk promotes self-protective behavior among farmers (Weinstein 1989, Vaughan 1993), their risk perception and risk appraisal may be more in tune with perceived fluctuations in climatic variables rather than general trends. For example in Kenya, farmers' perceptions of long-term decreases in rainfall were found to be based more on their experiences with shifts in timing and distribution of rainfall than on average annual rainfall (Bryan et al. 2013). However, other studies have shown that farmers' perceptions of climate variability and change are in sync with climate trends in their regions (Vedwan & Rhoades 2001, Apata et al. 2009, Wiid & Ziervogel 2012, Li et al. 2013). For example, farming communities in the Sahel have a clear memory of extreme climatic events, but also a good understanding of regional climatic changes (Mertz et al. 2009). In other cases, farmers' perceptions of climatic variables are a mix of scientific facts and personal experiences. In Southwest Uganda, for example, farmers perceived changes in temperature, seasonality, distribution within seasons, amount of rainfall, and increased intensity of rainfall, but scientists have only recorded changes in regional temperature (Osbahr et al. 2011). In other cases, farmers' perceptions may be influenced by access to scientific information in news media or information from farm organizations through a process of 'social amplification of risk' (Weber 2010).

Beyond the influence of direct experience and observations of climatic impacts and change, researchers have analyzed a diversity of 'situational' variables (those related to socio-economic factors that limit a person's range of choices) that also influence perceptions among farmers, including education level, farm size, access to credit and loan, access to irrigation water, and soil fertility, among others (Slegers 2008, Gbetibouo 2009, Fosu-Mensah et al. 2012). Public support and extension services, for example, may provide farmers with access to information about climate risks and adaptation strategies available in the market (Fosu-Mensah et al. 2012). While a better understanding of both risk and adaptation might help farmers make decisions that would shield them from current and future climate risks, farmers who receive public support might feel protected from risk and thus take no action to adapt. Financial support may also affect risk perception indirectly, by giving individuals greater access to information via the supplier of credit, and help to make adaptations (i.e. making intention to act 'actionable'). It may directly affect risk perception by making households more financially sensitive to the possibility of loss (particularly if households are in precarious economic circumstances). Household crop and economic diversity also likely affect risk: the greater the dependence on climate-sensitive income or climatically sensitive crops, the more sensitive a household is likely to be to climatic impacts (Eakin 2000, Brush & Perales 2007, Eakin & Bojorquez-Tapia 2008). In Mexico, for example, one might assume that rainfed farmers would be more perceptive of climatic variability than farmers cultivating under irrigation; however, rainfed maize farmers also often plant criollo varieties that are well-adapted to local agro-climatic conditions, which may reduce the farmers' sensitivity to climate (Eakin 2000).

Personal socio-demographic attributes also influence risk perception. For example, perception is strongly associated with worldviews, and although worldviews can vary at the individual level, there is also a shared cultural component to perceptions about human–environment relationships (Slegers 2008). The cultural values held by an individual are determined, at least in part, by that individual's ethnicity. Cruz-López (2011) suggests that in some cases, ethnic belief systems can enhance awareness of environmental variability. Ethnic identity in Chiapas has been found to be associated with how information on risk was received by coffee farmers (Frank et al. 2011). The range of relevant factors that influence perceptions varies by country, region, and social group.

2.2. A brief overview of maize production and climate change in Mexico

In Mexico, maize can be considered a 'keystone crop' with deep significance for food security, national political stability, culture, and the environment (Sweeney et al. 2013, Eakin et al. 2014a). Maize is grown throughout the year during 2 seasons: spring/summer (April to October) and fall/winter (October to February) (Dewes 2013). Although it is produced across the country under a wide range of agro-climatic conditions, 8 Mexican states (Sinaloa, Jalisco, México, Chiapas, Michoacán, Guerrero, Guanajuato, and Veracruz) are the major producers, accounting for about 70% of the total production.

Before the 1990s, central and southern Mexico were the primary areas of maize production, largely under rainfed conditions. However between 1989 and 2006, the state of Sinaloa in the northwest increased its output of irrigated maize (produced in the winter season) from 6.9 to 21.3% (Appendini 2014). Today, the state of Sinaloa alone accounts for over 70% of the fall/winter irrigated production — nearly one-quarter of Mexico's annual production of white maize (Eakin et al. 2014a). However, irrigation is not invulnerable to climate impacts. While, for example, Sinaloa's farmers enjoy the benefits of irrigation, their success still depends on seasonal rainfall accumulation to recharge the reservoirs that supply water to the irrigation systems. And the country as a whole still relies on rainfed maize: three-quarters of Mexico's maize is still produced during the spring/summer growing season, and 65% is grown on non-irrigated farmland, primarily in Central and Southern Mexico (Sweeney et al. 2013). Seasonality determines the rate of plant growth in both production regimes because even when water availability is controlled through irrigation, temperature is the main driver of crop development.

Scholars of climate trends and climate change projections anticipate that recent and future changes in climate will challenge the production of maize in Mexico. Between 1950 and 2008, Mexico's climate changed, although not uniformly across the country (Groisman et al. 2004, Dewes 2013, Conservacion Internacional Mexico 2009). Dewes (2013) found that in the states of Sinaloa and Chiapas, temperatures and annual number of dry days increased and total precipitation decreased. Meanwhile, the state of Mexico has experienced a decrease in total precipitation concomitant with an increase in heavy precipitation events (Table 1) (see also Groisman et al. 2004).

Climate projections suggest that Mexico will experience a decrease in precipitation combined with increasing average temperatures and more frequent and intense extreme events (IPCC 2014; see Table 1), with droughts as a major risk for maize farmers (Conde et al. 2006). The majority of land in maize is rainfed. Farmers have developed maize varieties that have enabled cultivation in a wide variety of different growing conditions (Ruiz Corral et al. 2008). Nevertheless, continued cultivation of rainfed maize is threatened by changing climate conditions (Perales et al. 2003). Lower yields might lead to abandonment of maize cultivation, or make maize farmers dependent on irrigation (Feng et al. 2010, Thornton 2012). Concern over the vulnerability of Mexico's agricultural sector has incentivized the government to

Table 1. Historical and projected climatic changes in Mexico

State	Past and current trends	Future trends
Sinaloa	Delayed start of the rainy season at a rate of 0.3–1.4 d yr^{-1} Decrease in precipitation at a rate of 5 mm yr^{-1}, which threatens water discharge from rivers that fill Sinaloa's dams Increase in the number of dry days at a rate of 0.3–0.7 d yr^{-1}, and 0.5–1.5 d yr^{-1} along the Gulf coast (Dewes 2013)	Projected increase of ~1.5–2.5°C and reduction of precipitation between 15–20 mm (Monterroso Rivas et al. 2012, Flores et al. 2012, INECC 2017)
Mexico	Substantial precipitation decrease in the last 30 yr, but heavy precipitation events increased during the same period (Groisman et al. 2004)	Projected increase of ~1.3–1.5°C and reduction of precipitation between 15–20 mm (Monterroso Rivas et al. 2012, INECC 2017)
Chiapas	An increase of 1.8°C in average temperatures and a decreased of 500 mm in annual precipitation Increase in heat/high temperature events (of at least 6 consecutive days) (Conservacion Internacional Mexico 2009	Temperatures projected to increase between 1.5–2°C, and decrease of precipitation between 20–50 mm (Monterroso Rivas et al. 2012) Increase of 2.1–2.2°C and decrease in precipitation between 80–85 mm (4 or 5%) (Schroth et al. 2009) Variation in precipitation between +10 and −10%, and an increase in average annual temperature between 1.0–2.0°C (INECC 2017) **2015–2039 trends:** Increase in maximum temperatures of 3–3.6°C, and of 2.5–2.8°C in minimum temperatures Dry spells are projected to last 30–50 consecutive days in the near future (Gobierno del Estado de Chiapas 2011) **By the end of the century** Increase in precipitation >0.7 mm d^{-1} for Soconusco area and a reduction of 0.7–1 mm d^{-1} for the Altos, Sierra, Fronteriza and Selva

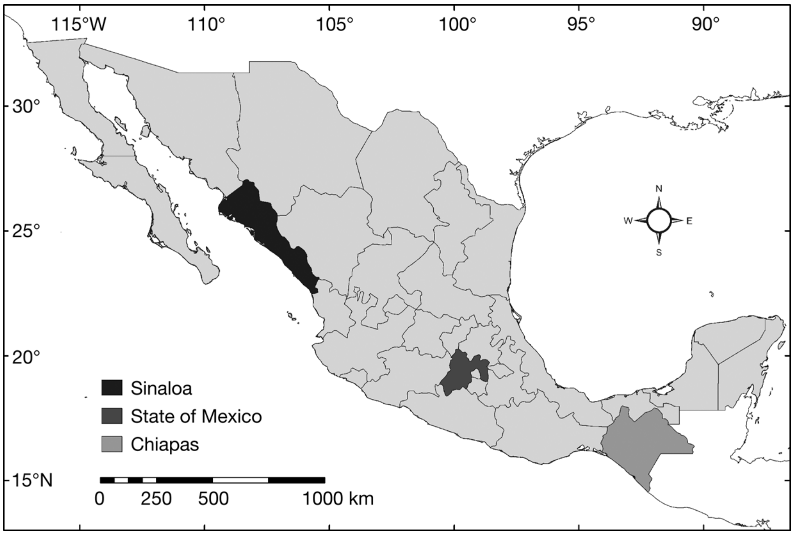

Fig. 1. The 3 states of Mexico studied: Sinaloa, Mexico, and Chiapas

invest in a 'Special Program for Climate Change' (Programa Especial de Cambio Climático), focused largely on irrigation and resource use efficiency, insurance, and phytosanitary techniques.

3. RESEARCH SITES AND DESIGN

3.1. Research sites

Our analysis used household data on maize farmers in the states of Sinaloa, Mexico, and Chiapas (Fig. 1, Table 2). Maize farmers in the states of Mexico and Chiapas are typically small-scale (2 to 5 ha) and largely produce under rainfed conditions (Eakin et al. 2014a). The state of Mexico, which surrounds Mexico's capital, the Ciudad de Mexico, is the most populous state in the country (INEGI 2011). In 2012 the total volume of maize produced in the state was 1.6×10^6, representing 7.1% of the national production (SHCP 2014). Chiapas is among the most impoverished states in Mexico and contains about 13.5% of all of Mexico's indigenous population. Agriculture contributes 15.2% to the state's GDP. In 2012 the total volume of maize produced in the state was 1.4×10^6, which represented 6.4% of the national production (SHCP 2014).

One important difference among the study sites must be noted. Small-scale farmers in Mexico often lack access to financial support from formal lenders (e.g. public banks). These small farmers (note that all households surveyed in Mexico state and Chiapas were small farmers) thus rely on informal lenders, such as moneylenders, traders, landlords (large farmers), or friends and relatives (Chaudhuri & Gupta 1996, Campero & Kaiser 2013). The flexibility of these informal lenders and rapid access to loans are some of the most attractive characteristics for those who seek loans from these sources. However, these positive features may be negated by the high interest rates typically charged by informal credit institutions or credit agents (Chaudhuri & Gupta 1996, Campero & Kaiser 2013). In Chiapas, as across the country, 'agiotistas' (money lenders) are notorious for their high interest rates (as high as 20% mo^{-1}), and their demands for collateral in the form of land titles and car deeds, for example. The discontent among borrowers who feel deceived by agiotistas make headlines in regional newspapers and are a topic of discussion of online blogs. According to such sources, many borrowers complain of high interest rates, charges above the amounts agreed on, and that the agiotistas threaten to report them to the authorities for nonpayment.

Maize production in Sinaloa is predominantly large-scale and irrigated with surface water (Gonzales et al. 2010). Agriculture occupies 20% of the state's

Table 2. Demographic, economic, and ecological attributes of the study sites. MT: metric tonnes. Source: CONAPO (2017), SIAP (2012)

State	Land area (km^2)	Population (millions)	Indigenous population (%)	Annual average min. and max. temperatures (°C)	Annual average precipitation (mm)	Contribution to national GDP (%)	Maize produced in 2012 (MT)	Planted area of maize under irrigation in 2012 (%)
Sinaloa	57 365	2.8	0.9	11–36	790	2.1	3 646 875	65
Mexico	22 499	15.2	2.8	12–18	700	9.2	1 575 300	17
Chiapas	73 311	4.8	27.2	18–28	1200	1.9	1 404 679	4

landscape (SIAP 2012) and represents 14.9% of Sinaloa's GDP. Here most farmers have access to commercial loans from private banks to support their capital-intensive production strategies. Maize production in the state started in the late 1980s and expanded rapidly from 140 727 ha planted in 1989 to a peak of 606 917 ha in 2008. This expansion is the result of federal neoliberal economic reforms in the late 1990s, the rapid adoption of high-yielding seed varieties, and irrigation availability. Today, Sinaloa's winter maize harvest contributes over 20% of national maize production (Eakin et al. 2014a).

3.2. Data collection

We used data from 1092 surveys of maize-producing households (Chiapas: n = 603; Mexico: n = 407; and Sinaloa: n = 449) (Eakin et al. 2014). The surveys were administered in person by teams of technical assistants hired and trained for the research project, following the institutional review board (IRB) human subject protocols. Households were surveyed about socioeconomic characteristics, sources of livelihood, agricultural practices, yield and crop choice, changes in land area over the previous decade, in-house maize consumption, maize marketing strategies and targets, and perceptions of climate variability and climate change.

In Mexico and Chiapas, we purposely selected rural development districts (DDR) that were representative of the agro-climatic conditions, land area, and production volume typical of maize production in the state. Within each DDR, farm communities were randomly selected from the publicly available database of beneficiaries of the agricultural support program, Programa de Apoyos Directos al Campo (PROCAMPO). In each community, households were selected using a systematic random sampling approach. In Sinaloa, 4 irrigation modules within the Culiacán irrigation district were randomly selected for sampling, and within each module a random sample of respondents was selected from the registry of irrigation users. In Sinaloa, households that had produced maize at any time between 1990 and 2009 were surveyed, including those that had ceased production at any point over that period. In Chiapas and Mexico, data was collected from November to February, and questions pertained to the 2009 spring crop that had just been harvested. In Sinaloa, the surveys took place in January 2010 and targeted the winter crop from the prior year (harvested May/June 2009), as well as the spring/summer crop that would have been harvested just prior to the survey (for more information, see Eakin et al. 2014a). The dependent variable was perception of change in drought frequency. This variable was measured using a question from the survey that asked participants who reported having been affected by drought, 'How do you think drought has changed in the last 10 years?' The answer options were 'has not changed,' 'decreased,' or 'increased.' For statistical analysis purposes, we recoded this variable and made it a binomial variable with the values 'has not increased' and 'increased.'

The independent variables were selected from 8 survey questions to reflect different theoretical propositions on how socioeconomic and situational factors might affect perception. These explanatory variables included indicators of ethnicity (language), public support, access to credit (from formal or informal sources), agricultural income dependence, use of irrigation (due to the survey design all households surveyed in Sinaloa had access to irrigation), cultivation of non-commercial maize varieties, access to news media and information, and direct experience of crop losses (Table 3).

Information was also collected about gender, age, household size, and number of adults contributing to income in the surveyed households (Table 4). Note that most of the farmers surveyed in all 3 states were male, but in the state of Mexico the proportion of female farmers was higher (24%). Farmers in Chia-

Table 3. Explanatory variables and their meaning based on the household survey

Independent variables	Survey question (simplified for presentation)
Language	Do you speak a language other than Spanish? If so, what language?
Irrigation	Do you use irrigation water to grow maize?
Agprimary	Does your primary income come from agriculture-related sources?
Support	Do you participate/have you participated in a support program?
Credit	Do you receive/have you received loans or credits?
Infolevel	Do you have _______ asset? (TV, internet, computer)
Criolla	Do you grow criolla varieties of maize? (grow some, all, or none)
Yield	Have your maize yields changed in the last 20 years? (decreased, increased, remained the same)

Table 4. Demographic characteristics by state. Results are presented as percentages or means

	Chiapas (n = 476)	Mexico (n = 377)	Sinaloa (n = 239)
Male	406 (85%)	286 (76%)	214 (96%)[a]
Age	48.6	51.7	53.7[b]
Household size	3.7	4.1	3.5[b]
Number contributing to household income	3.1	3.6	2.1[b]

[a]Significant difference between states at the 5% level, according to chi-squared test
[b]Significant difference between states at the 5% level, according to 1-way ANOVA

pas were slightly younger than farmers in Mexico and Sinaloa. Average household size was 4 members per household in all 3 states.

3.3. Data analysis

We focused first on qualitative analysis of current temperature and precipitation trend patterns in Mexico. We reviewed information from multiple authors (see Table 1) and compared their findings on trends in climatic variables with our own analysis of responses to survey questions that asked farmers if they had experienced various weather and climate events (drought, heat/high temperatures, hail, cold/frost, changes in seasons/wet days, and floods), and how they perceived the frequency of these events (have they increased, decreased, or not changed).

Second, we measured the effect of each independent variable on perception of change in drought frequency, using 2 different statistical methods: a chi-squared test and a logistic regression model. The chi-squared test was used to assess the bivariate association between each independent variable and the perception of changes in drought frequency; those with $p < 0.05$ were considered to be associated. A logistic regression model was used to determine the combinations of independent variables that most influenced the perception of drought in each state. In testing combinations, we extracted the variable with the highest p-value and ran the model again. Doing so enabled us to see how the p-values of the remaining variables changed. We repeated this procedure until we had a reduced list of variables with $p < 0.05$. To explain these results, we analyzed additional survey questions about sources of financial support, and characteristics of farmers with and without loans in Sinaloa and Chiapas.

4. RESULTS

The descriptive statistics associated with the statistically significant independent variables are shown in Table 5. In Sinaloa, all respondents reported Spanish as their only language, all respondents had irrigation water (according to the survey design) and none grew criolla varieties. Thus for Sinaloa, we used 5 independent variables in our analysis: credit, agprimary, support, yield and infolevel. In contrast, non-Spanish speaking populations were present in both Mexico and Chiapas, and while some households had access to irrigation, the majority did not. In Mexico, irrigation is used primarily as an auxiliary source of water, allowing farmers to plant prior to the start of the rainy season. In Chiapas, a small percentage of households in the Central Valley have more regular access to irrigation water during the entire growing season.

4.1. Are perceptions aligned with scientific data?

Farmers from all 3 states reported that maize production was more affected by drought than other events (Table 6). In Chiapas and Mexico, more than

Table 5. Responses of households by variable. (–) No change; ↓ decreased, ↑ increased. *Significant difference between states at the 5% level, according to chi-squared test

Variables	Chiapas (%) No	Chiapas (%) Yes		Mexico (%) No	Mexico (%) Yes		Sinaloa (%) No	Sinaloa (%) Yes	
Language	75.8	24.2		55.4	44.6		100	0*	
Irrigation	87.4	12.6		53.1	46.9		0	100*	
Agprimary	48.3	51.7		71.6	28.4		5.9	94.1*	
Support	98.1	1.9		95.1	4.9		1.7	98.3*	
Credit	76	24		96.1	3.9		7.5	92.5*	
Infolevel	58.4	41.6		58.3	41.7		20.6	79.4*	
Criolla	None	Some	All	None	Some	All	None	Some	All
	76.5	23.5	0	2.5	91.9	5.7	99.8	0.2	0*
Yield	–	↓	↑	–	↓	↑	–	↓	↑
	13.9	68.1	18	1	88.1	10.9	2.8	9.2	88*
Perception of drought	–	↓	↑	–	↓	↑	–	↓	↑
	27.5	1.7	70.8	6.4	4.2	89.4	19.7	72.4	7.9*

Table 6. Percentages of households that suffered/did not suffer a climatic event. *Significant difference between states at the 5% level, according to chi-square test

Climatic events	Chiapas (%) No	Chiapas (%) Yes	Mexico (%) No	Mexico (%) Yes	Sinaloa (%) No	Sinaloa (%) Yes
Drought	18.7	81.3	7.6	92.4	46.5	53.5*
Heat/high temperatures	31.2	68.8	81.8	18.2	74.6	25.4*
Hail	77.6	22.4	84.3	15.7	98.2	1.8*
Colds/frost	78.9	21.1	67.6	32.4	75.3	24.7*
Changes in seasons/wet days	67	33	79.9	20.1	88.6	11.4*
Floods	75.6	24.4	57	43	78.6	21.4*

80% of the farmers surveyed had experienced drought, while in Sinaloa only 53.4% of farmers reported this experience. In Chiapas, 68.8% of farmers had also experienced heat and high temperatures events; in the other 2 states these events were much less frequently reported. Collectively, other climatic events (i.e. hail, frost, floods, etc.) were far less frequent: together these events were reported by an average of 22% of farmers across the 3 states (see Figs. 2 & 3).

The perception of drought as 'increasing' was higher in the states of Chiapas and Mexico, where 70.8 and 89.4% of the farmers who had experienced drought reported this perception (Fig. 2). On the other hand, in Sinaloa, while over half of farmers had experienced drought, only 7.9% said that drought was increasing. In all 3 states a majority of farmers who experienced heat/high temperatures perceived this phenomenon to be increasing, with the highest percentage (90.5%) in the state of Mexico (Fig. 3).

In summary, perceptions of climate variability depend on farmers' locations. In Sinaloa, although scientific data indicates that the state is experiencing and will continue to experience a decrease in annual precipitation totals, an increase in dry days, and increasingly delayed starts of the rainy season (Monterroso Rivas et al. 2012, Dewes 2013), the majority of farmers surveyed in that state did not perceive drought as increasing, even though almost half of them reported being affected by it. On the other hand, although there is little available empirical evidence as yet that the state of Mexico has experienced significant changes in climatic parameters (especially drought events), farmers there perceived drought to be increasing, along with floods and cold/frosts. In Chiapas, there has been an increase in the number of dry days and heat-stress days, and farmers there accurately perceived drought and heat/high temperatures to be increasing (although historical climatic trends indicate a shift towards an earlier start to the rainy season, which is associated with a longer growing season).

4.2. Factors that influence perception of drought

Based on the chi-squared tests, 7 of the 8 independent variables were statistically associated with the perception of drought, but not all 7 were associated in every state. In Sinaloa, only credit and support were associated with the perception of drought; in Mexico, language was the only associated variable. In Chiapas, 6 variables were associated with the perception of drought: language, irrigation, criolla, credit, yield, and infolevel. However, when collinearity was controlled for, the logistic regression model showed only 2 statistically significant independent variables: credit and language (Table 7).

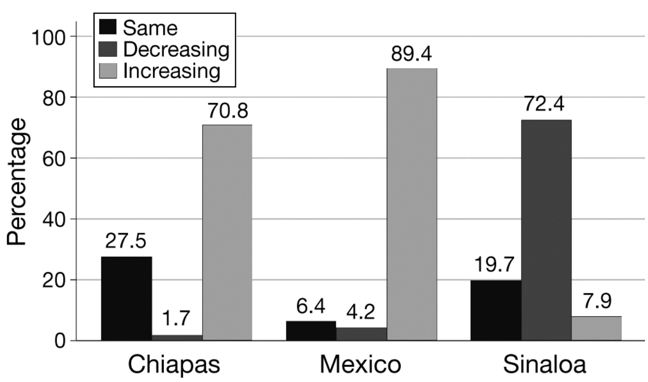

Fig. 2. Perceptions of drought in the states of Chiapas, Mexico, and Sinaloa

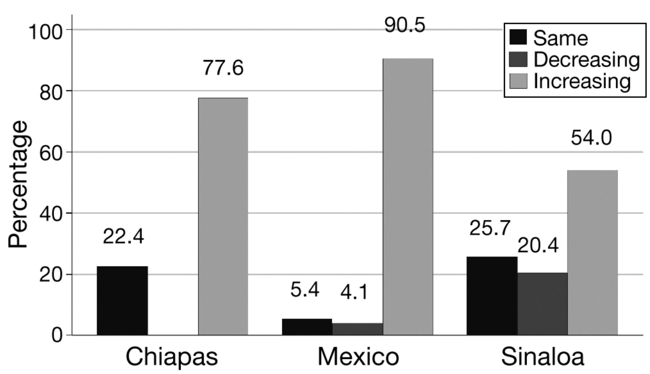

Fig. 3. Perceptions of heat/high temperatures by state

Table 7. Odds ratios (OR) and p-value for independent variables influencing the Mexican farmers' perception that drought is increasing

	Chiapas (n = 476) OR	p	Mexico (n = 377) OR	p	Sinaloa (n = 239) OR	p
Spanish, no credit	1.00					
Native language, no credit	0.069	<0.001				
Spanish, credit	3.16	0.007				
Native language and credit	1.06	0.943				
Native language (with or without credit)			0.392	0.007		
Credit (all Spanish speakers)					0.176	0.003

In Chiapas, language and credit affected perception of drought. The model showed that in Chiapas among people who did not use credit, native speakers were less likely to believe drought was increasing than those who only spoke Spanish (odd ratio = 0.69, p < 1). In this sample, 81% of Spanish speakers without credit believed drought was increasing in comparison with only 23% in the native group. In addition, Spanish speakers who received credit or loans were more likely to believe drought was increasing than native speakers with credit or loans (odd ratio = 3.16, p = 0.007; and odds ratio = 1.06, p = 0.943, respectively). Among these households, 93% of the Spanish speakers believed drought was increasing in comparison with 82% in the native speaker group (Fig. 4).

In Sinaloa, perception of drought was influenced only by receipt of credit or loans (Table 7). Those who received credit or loans were less likely to believe that drought was increasing than those who did not receive them. In Sinaloa, 28% of those without credit believed drought events have been increasing in the last 10 yr, whereas only 6% of those who received credit and loans believed this (Fig. 4). Of the 90.9% of Sinaloan farmers who received credit or loans, 49.9% received them from parafinancieras and 38.9% from public banks. These results suggest that credit and loans act as a buffer against the impacts of drought, affecting risk and adaptation appraisal, and consequently, adaptive capacity.

In the state of Mexico, perception of drought was influenced only by language (odds ratio = 0.392; p = 0.007), and households in which Spanish was the only language spoken were more likely to believe that drought was increasing. In the state of Mexico, 93% of Spanish speakers perceived drought as increasing, whereas only 85% of native speakers perceived the same (Fig. 4).

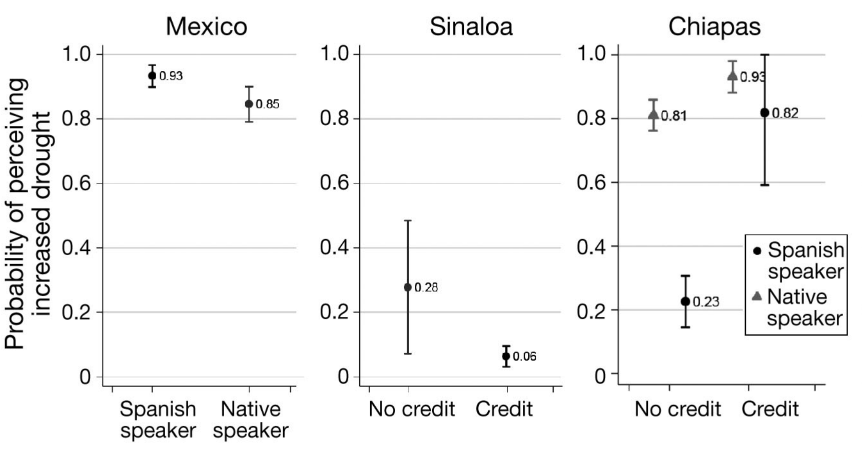

Fig. 4. Probability of perceiving increased drought by state, with 95% confidence intervals

4.3. Further analysis for Sinaloa and Chiapas

In Sinaloa, the difference in perception of drought between those who received credit or loans and those who did not was especially interesting because of the relative homogeneity of the sample of farmers. All surveyed farmers in Sinaloa were commercial farmers who use irrigation water and for whom agriculture was the primary source of income. The most significant differences among Sinaloan survey respondents who received or did not receive credit were in production of maize under contract, purchasing insurance against weather contingencies, and technical assistance (Table 8).

Regarding insurance, in Sinaloa, those who received credit might have more means to acquire insurance against weather contingencies, since 94.6% had insurance compared to only 22% of those who did not receive credit or loans. The purchase of insurance is associated with access to credit or loans in Sinaloa (odds ratio = 62.38384, p < 0.001) but not with the perception of drought (odds ratio = 0.3544776, p = 0.090). These results suggest that recipients of credit or loans are not likely to have bought insurance based on their perception of climatic risk; rather, many may have been required by parafinan-

Table 8. Household attributes of farmers with and without credit or loans in Sinaloa (%)

	Without credit (n = 41)	With credit (n = 408)
Own land	58.5	69.6
Rent land from others	41.0	30.4
Produced maize under contract?	56.3	83.9
Did you buy insurance against climate events for your production?	22.0	94.6
Received technical assistance for your production?	29.3	80.1
Has anyone in the household been part of a farmer's organization?	62.9	78.8

Table 9. Summary of sources of credit mentioned by farmers in Chiapas

Credit type	Percentage of people with this credit type
Informal lender	65.0
Civil association	5.1
Public bank	0
Commercial bank	5.1
Parafinaciera	23.1
Other	1.7

cieras and banks to purchase insurance as a way to guarantee their credit or loans.

Unlike in Sinaloa, the relationship of credit access to risk perception was different in Chiapas. In Chiapas, it is farmers who have credit who are more likely to believe drought frequency is increasing. The percentage of farmers in Chiapas who received credit or loans was the second highest among the 3 states studied, but it was a very small percentage (20.2%) compared to Sinaloa, where 90% of farmers surveyed reported receiving credit or loans. In Chiapas, credit was associated with ethnicity: 27.6% of Spanish-only speaking farmers received credit or loans, while only 5.6% of farmers who spoke a native language in addition to Spanish received credit or loans. Also, most of those who received credit in Chiapas obtained it from informal lenders (65%), with a smaller percentage from parafinancieras (23.1%); none received it from public banks (Table 9). This suggests that the farmers did not meet the requirements of formal banks and lenders (e.g. land size, yields, etc.) for receiving credit and loans and that they therefore resorted to informal credit agents.

As explained above, the distinction between Spanish and native speakers also influenced the perception of drought. While 92.8% of Spanish speakers experienced drought events, only 58.2% of native speakers experienced it (Table 10). Spanish speakers also have more access to resources such as irrigation, credit, sources of information about the climate (Table 11).

Table 10. Responses to the question 'Which climate events affected your production in the last 10 years?' in Chiapas

Climate event	Spanish speakers (%)	Native speakers (%)
Drought	92.8	58.2
High temperatures	90.3	25.9
Hail	14.7	37.8
Cold/frosts	7.9	47.3
Change in seasonality	31.6	35.8
Floods	28.1	16.9

5. DISCUSSION AND CONCLUSIONS

While this study only covered a sample of the households that produce maize in Mexico, we found that farmers' perceptions of climate events are not always aligned with scientific observations. For example, farmers in Sinaloa were generally not cognizant of the observed warming and drying trends. While drying trends were perceived in Chiapas and the State of Mexico, farmers were less observant of rising temperatures and changes in rainfall intensity in those states (see Table 1 & 6). Issues of temporal and spatial scales, resolution of climatic analyses, and farmers' observations may explain in a large part the differences we found. Nevertheless, it is also clear that other cultural, agroecological, and institutional factors play a role in farmers' perceptions.

Our logistic regression analysis for Sinaloa suggests that credit and loans act as a buffer against the

Table 11. Resource access and climate perception among Spanish speaking-only households and native households in Chiapas

Household attributes	Spanish speakers (%)	Native speakers (%)
Use irrigation	17.6	0.0
Agriculture primary income	50.5	48.8
Participate in support programs	1.8	1.0
Receive credit/loans	27.6	6.6
Have more than 1 source of information	46.3	25.6
Yields decreased in the last 20 yr	83.9	31.3
Perceive drought as increasing	84.5	27.8

impacts of drought, affecting risk and adaptation appraisal, and consequently, adaptive capacity. According to the literature, receipt of credit should enhance the adaptive capacity of farmers to climate variability and change (Gbetibouo 2009, Fosu-Mensah et al. 2012). Theoretically, a higher adaptive capacity encourages farmers to take action against the effects of drought in their production. In this study, the adaptive capacity of Sinaloan farmers was heavily influenced by their dependence on federal financial resources and public agricultural support programs. Farmers' reliance on public adaptation (i.e. public sector actions to manage risk on behalf of farmers) may have negatively affected their risk appraisal, and thus their expectation of being exposed to drought and their evaluation of a drought event's potential to reduce their production (Grothmann & Patt 2005). Consequently, farmers with the means (i.e. credit) to mitigate the effects of drought on their production may be less concerned about, and therefore less attentive to, drought events.

In the state of Mexico, perception of drought was influenced only by language, whereby households speaking a native language in addition to Spanish were less likely to believe that drought was increasing. No other socio-economic attribute of the surveyed farmers explains why language was the only variable that influenced perception of drought in the district and why those who spoke another language in addition to Spanish (in this case, Mazahua) were less likely to believe drought is increasing. One possible explanation could be in the survey respondents' interpretation of the word 'drought' (in Spanish 'sequía') in the question 'How has drought changed in the last 10 years?' Qualitative research on flood risk undertaken in Mazahua communities in the state found that some respondents interpreted sequía as the 'dry season' and not as anomalous dry spells during the rainy season (Eakin & Guadarrama 2008). If this interpretation was prevalent in the survey responses of the Mazahua-speaking farmers, this may have influenced their perception that drought had not increased. However, a study of a maize-farming Mazahua community in the municipality of San Felipe del Progreso (within the DDR where the survey was implemented) found that farmers there did, in fact, perceive changes in the regional climate, and the Mazahua's knowledge about climate patterns appeared to be accurate (Cruz-López 2011). Mazahua farmers understand the changes in precipitation patterns in the region (late start of the rainy season) and they have taken adaptive measures to cope with the change (Cruz-López 2011).

In Chiapas, both language and credit affected perception of drought. The higher risk appraisal among Spanish speakers was unexpected; however, one or both of 2 factors might explain it. First, language may be serving as a geographic proxy. Farmers who spoke only Spanish reported higher exposure to or experience with drought, perhaps because these farmers tend to live in the lowlands while indigenous farmers are concentrated in the highlands, and climate differs according to altitude. Second, a higher percentage of Spanish speakers reported decreases in yields (see Tables 10 & 11). Throughout the states, ethnicity and financial capital proved to be significantly associated with risk perception, and thus these factors are likely to affect adaptive capacities. These findings are novel for Mexico, and potentially provide insights into issues of importance for adaptation policy in other nations. The significance of ethnicity, for example, suggests that efforts to enhance rural adaptive capacities must go beyond simply translating recommendations and other salient information into native languages. Cultural and ethnic identity permeates human–environment relationships, and reflects worldviews and the ways that individuals mobilize to independently or collectively manage risk.

Mexico has over 60 ethnic groups. In other places, such as sub-Saharan Africa and southeast Asia, the different ethnic groups within a country's boundaries can number in the hundreds. Many of these populations derive their livelihoods from agriculture, underscoring the need to pay greater attention to how ethnic identity mediates risk and adaptation appraisal and thus, vulnerability. In Mexico, the public sector, in close collaboration with civil society groups and local representatives, could support culturally specific strategies to help ethnic communities manage climatic risk effectively. Such investments would not only be an issue of mitigating agricultural losses and risk to farm livelihoods, but also an issue of sustaining the cultural practices that make ethnic livelihoods meaningful.

The relationship of credit to risk perception is clearly complex, and merits further research and analysis given the differences in the sign of the relationship between the central and southern states and Sinaloa. Nevertheless, the significance of credit underscores the multi-stressor nature of risk: households are perceiving risk from climate in relation to livelihood strategies that are subject to financial stress. In places like Chiapas, credit may be a proxy for livelihoods already in precarious economic balance. Here, resorting to credit (often on unfavorable terms) may only amplify a household's risk appraisal.

In contrast, in Sinaloa credit appears to represent access to institutional support and security, potentially enabling adaptive capacities.

This latter finding has potentially important implications for the role of safety-net programs and insurance in mobilizing individual adaptation, as captured in recent work on generic and specific capacity tradeoffs in adaptation (Eakin et al. 2014b). High dependence on formal risk-protection institutions, while an important feature of many more industrialized economies, can potentially diminish incentives for individual investment in adaptation. Under circumstances of significant environmental change, those institutions can be fallible; in such cases, the lack of individual capacity for risk management can potentially create circumstances of high vulnerability, or a 'safe development paradox' (Eakin et al. 2014b). In contrast, other households may lack reliable access to formal institutional supports; their efforts to cope alone — perhaps relying on less regulated institutions such as informal money lenders — can exacerbate their circumstances, creating 'poverty traps' (Eakin et al. 2014b).

The complex institutional landscape within Mexico's agricultural sector suggests that once again (see for example Frank et al. 2011 or Eakin & Bojórquez-Tapia 2008) the role of specific 'situational factors' in risk perception and adaptive capacity must be considered in relation to the specific cultural and geographic context of farmers' livelihoods. Where technical support, insurance, or credit may serve to enhance risk management in one location, similar institutional mechanisms may exacerbate risk in others. Local consultation and collaboration in the development of appropriate support programs is clearly needed to ensure that mechanisms such as credit are functioning to build adaptive capacity among vulnerable farmers rather than to exacerbate risk. In summary, these findings highlight how risk perception is affected not only by internal factors, such as cognition and identity, but also by external or 'objective' attributes of decision-makers. In our case, both were significant, and together with the social context in which these factors emerge, appear instrumental in risk perception.

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LITERATURE CITED

Apata TG, Samuel KD, Adeola AO (2009) Analysis of climate change perception and adaptation among arable food crop farmers in south western Nigeria. In: Proceedings of the 27th Conference of the International Association of Agricultural Economists. 16–22 August 2009, Beijing

Appendini K (2014) Reconstructing the maize market in rural Mexico. J Agrar Change 14:1–25

Brush SB, Perales HR (2007) A maize landscape: ethnicity and agro-biodiversity in Chiapas Mexico. Agric Ecosyst Environ 121:211–221

Bryan E, Ringler C, Okoba B, Roncoli C, Silvestri S, Herrero M (2013) Adapting agriculture to climate change in Kenya: household strategies and determinants. J Environ Manage 114:26–35

Campero A, Kaiser K (2013) Access to credit: awareness and use of formal and informal credit institutions. Working Papers, 2013-07, Banco de Mexico

Chaudhuri S, Gupta MR (1996) Delayed formal credit, bribing and the informal credit market in agriculture: a theoretical analysis. J Dev Econ 51:433–449

CONAPO (Consejo Nacional de Población) (2017) Indicadores de la dinámica demográfica 1990-2010 y de proyecciones de población 2010–2030 de México y las entidades federativas. www.conapo.gob.mx/es/CONAPO/Mexico_en_cifras (Accessed May 31, 2017)

Conde C, Ferrer R, Orozco S (2006) Climate change and climate variability impacts on rainfed agricultural activities and possible adaptation measures. A Mexican case study. Atmosfera 19:181–194

Conservacion Internacional Mexico (2009) Programa de acción ante el cambio climático del estado Chiapas. www.conservation.org/global/mexico/iniciativas/Pages/paccch.aspx

Crane TA, Roncoli C, Hoogenboom G (2011) Adaptation to climate change and climate variability: the importance of understanding agriculture as performance. NJAS Wagening J Life Sci 57:179–185

Crocker J (1981) Judgment of covariation by social perceivers. Psychol Bull 90:272–292

Crona B, Wutich A, Brewis A, Gartin M (2013) Perceptions of climate change: linking local and global perceptions through a cultural knowledge approach. Clim Change 119:519–531

Cruz-López M (2011) Comparación del ciclo agrícola actual con el de hace unos diez años en San Juan Jalpa, municipio San Felipe del Progreso estado de México: evidencia de adaptación al cambio climático. Ra Ximhai 7:95–106

Dessai S, Adger WN, Hulme M, Turnpenny J, Köhler J, Warren R (2003) Defining and experiencing dangerous climate change. Environment 64:11–25

Dewes CF (2013) Understanding climate impacts on Mexican rainfed maize. PhD dissertation, University of California at Santa Barbara, Santa Barbara, CA

Eakin H (2000) Smallholder maize production and climatic risk: a case study from Mexico. Clim Change 45:19–36

Eakin H, Bojórquez-Tapia LA (2008) Insights into the composition of household vulnerability from multicriteria decision analysis. Glob Environ Change 18:112–127

Eakin H, Guadarrama X (2008) Impactos de las inundaciones y percepción del riesgo. In: Appendini K, Torres-Mazuera G (eds) ¿Ruralidad sin agricultura? Perspectivas multidiciplinarias de una realidad fragmentada. El Colegio de Mexico, Mexico, p 151–168

Eakin H, Bausch JC, Sweeney S (2014a) Agrarian winners of neoliberal reform: the 'Maize Boom' of Sinaloa, Mexico. J Agrar Change 14:26–51
Eakin HC, Lemos MC, Nelson DR (2014b) Differentiating capacities as a means to sustainable climate change adaptation. Glob Environ Change 27:1–8
Etkin D, Ho E (2007) Climate change: perceptions and discourses of risk. J Risk Res 10:623–641
Feng S, Krueger AB, Oppenheimer M (2010) Linkages among climate change, crop yields and Mexico–US cross-border migration. Proc Natl Acad Sci USA 107: 14257–14262
Flores Campaña LM, Arzola-González JF, Ramírez-Soto M, Osorio-Pérez A (2012) Global climate change impacts in the Sinaloa State, México. Rev Colomb de Geogr 21: 115–129
Fosu-Mensah BY, Vlek PLG, MacCarthy DS (2012) Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environ Dev Sustain 14:495–505
Frank E, Eakin H, López-Carr D (2011) Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. Glob Environ Change 21:66–76
Gbetibouo GA (2009) Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa. Discussion paper 00849, International Food Policy Research Institute, Washington, DC
Gonzalez CA, Juarez B, Ford M (2010) Mexico grain and feed annual corn production forecast to rebound. Gain Report. Global Agricultural Information Network. https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_Mexico%20City_Mexico_3-12-2010.pdf
Groisman PY, Knight RW, Easterling DR, Karl TR, Hegerl GC, Razuvaev VN (2004) Trends in intense precipitation in the climate record. J Clim 18:1326–1350
Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change. Glob Environ Change 15:199–213
Halder P, Sharma R, Alam A (2012) Local perceptions of and responses to climate change: experiences from the natural resource-dependent communities in India. Reg Environ Change 12:665–673
INECC (Instituto Nacional de Ecología y Cambio Climático) (2017) www2.inecc.gob.mx/cgacc/escenarios_cu/
IPCC (2014) Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge
Kahneman D, Tversky A, Kahneman BYD, Tversky A (2016) Prospect theory: an analysis of decision under risk. Econometrica 47:263–292
Leiserowitz A (2006) Climate change risk perception and policy preferences: the role of affect, imagery, and values. Clim Change 77:45–72
Li C, Tang Y, Luo H, Di B, Zhang L (2013) Local farmers' perceptions of climate change and local adaptive strategies: a case study from the Middle Yarlung Zangbo River Valley, Tibet, China. Environ Manage 52:894–906
Mertz O, Mbow C, Reenberg A, Diouf A (2009) Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. Environ Manage 43:804–816
Monterroso Rivas A, Conde Álvarez C, Gay García C, Gómez Díaz J, López García J (2012) Indicadores de vulnerabilidad y cambio climático en la agricultura de México. In: Rodríguez Puebla C, Ceballos Barbancho A, González Reviriego N, Morán Tejeda E, Hernández Encinas A (eds) VIII Congreso Internacional AEC, Publicaciones de la Asociación Española de Climatología, Serie A, No. 8. AEC, Salamanca, p 881–890
O'Connor RE, Bord RJ, Fisher A (1999) Risk perceptions, general environmental beliefs, and willingness to address climate change. Risk Anal 19:461–471
Osbahr H, Dorward P, Stern R, Cooper S, Osbahr BH (2011) Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmer perceptions. Exp Agric 47:293–316
Patt AG, Schröter D (2008) Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. Glob Environ Change 18:458–467
Perales RH, Brush SB, Qualset CO (2003) Landraces of maize in Central Mexico: an altitudinal transect. Econ Bot 57:7–20
Ruiz Corral JA, Durán Puga N, Sánchez González JDJ, Ron Parra J, González Eguiarte DR, Holland JB, Medina García G (2008) Climatic adaptation and ecological descriptors of 42 Mexican maize races. Crop Sci 4:1502–1512
Schroth G, Laderach P, Dempewolf J, Philpott S and others (2009) Towards a climate change adaptation strategy for coffee communities and ecosystems in the Sierra Madre de Chiapas, Mexico. Mitig Adapt Strategies Glob Change 14:605–625
SHCP (Secretaria de Hacienda y Crédito Publico) (2014) Panorama del Maíz. http://infosiap.siap.gob.mx/aagricola_siap_gb/icultivo/index.jsp
SIAP (Servicio de Información Agroalimentaria y Pesquera) (2012) Anuario Estadístico de la Producción Agrícola. http://infosiap.siap.gob.mx/aagricola_siap_gb/icultivo/index.jsp (Accessed 19 October 2014)
Slegers MFW (2008) 'If only it would rain': farmers' perceptions of rainfall and drought in semi-arid central Tanzania. J Arid Environ 72:2106–2123
Slovic P (2000) The perception of risk. Earthscan Publications, London
Sweeney S, Steigerwald DG, Davenport F, Eakin H (2013) Mexican maize production: evolving organizational and spatial structures since 1980. Appl Geogr 39:78–92
Thornton PK (2012) Recalibrating food production in the developing world: global warming will change more than just the climate. CCAFS Policy Brief No. 6, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Denmark
Tobin GA, Montz BE (1997) Natural hazards: explanation and integration. Guilford Press, New York, NY, p 132–164
Vaughan E (1993) Chronic exposure to an environmental hazard: risk perceptions and self-protective behaviour. Health Psychol 12:74–85
Vedwan N, Rhoades R (2001) Climate change in the Western Himalayas of India: a study of local perception and response. Clim Res 19:109–117
Weber EU (2010) What shapes perceptions of climate change? WIREs Clim Chang 1:332–342
Weinstein ND (1989) Effects of personal experience on self-protective behavior. Psychol Bull 105:31–50
Wiid N, Ziervogel G (2012) Adapting to climate change in South Africa: commercial farmers' perception of and response to changing climate. S Afr Geogr J 94:152–173

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