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EXPERIENCES AND PERCEPTIONS OF HUMAN VULNERABILITY TO CLIMATE
CHANGE IN CALAKMUL, MEXICO

by

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A Plan B report submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Geography

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ABSTRACT

Experiences and Perceptions of Human Vulnerability to
Climate Change in Calakmul, Mexico

by

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Utah State University, 2017

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This report explores how residents of Calakmul, Mexico perceive and experience their own vulnerability to climate change, and how these perceptions and experiences are differentiated among communities, households, and individuals. Fifty-five semi-structured interviews in 2013 and 45 follow-up interviews in 2016 provide data on familiarity with climate change and perceived effects of climate-related stressors on livelihood activities, health, and experiences of hunger. We found that coping responses to the effects of climate change often require cash inputs, and communities are differentiated in their experiences of vulnerability, based in part on their access to wage labor and importantly governmental support.

(29 pages)

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INTRODUCTION

Human vulnerability to climate change is a pressing concern. It is a global issue present in various geographical regions and cultural contexts, but climate change vulnerability in rural areas of developing countries elicits special attention due to structural inequities and development goals related to social justice (Mearns and Norton, 2010). According to the Intergovernmental Panel on Climate Change (IPCC, 2014, 1452), “Mexico is one of five countries in the world that is projected to experience the highest increases in poverty due to climate-induced extreme events.” The same report summarizes research that observes recent increases in the number of hot days and warm nights, and projects further increases in hot days and warm nights along with increasing dryness and more frequent heat waves. These changes will lead to greater agricultural risks in already-marginal growing areas (IPCC, 2014). In addition to climate-related risks, farmers in rural Mexico continue to face economic challenges from ongoing neoliberal reforms started in the 1980s and 90s, as well as low levels of agricultural support for smallholders from the state in research and technological assistance (Eakin, 2006, Schmook et al., 2013). These challenges are observed on the Yucatan Peninsula in a recent study by Mardero and colleagues (2015), who analyze the “double exposure” (O’Brien and Leichenko, 2000) of smallholder maize production to climate change and agricultural policy. They found that “Current climate characteristics make traditional maize cultivation more economically marginal” (25) in a situation where there is a lack of agricultural support programs (Mardero et al., 2015).

This paper contributes to knowledge about climate change vulnerability in southeast Mexico by discussing what residents experience and perceive as key sources of their

vulnerability and how people are differentiated in these experiences and perceptions. The study of experiences and perceptions is important to knowledge about climate change vulnerability because it grounds “expert” conceptions of vulnerability in people’s lived experience and wellbeing (Hulme, 2009). A mix of local and global factors makes the human-environment relationship in southeast Mexico an interesting case for this analysis. The study site of Calakmul—a municipality in the state of Campeche—borders a 723,185-hectare protected area of seasonal tropical forest. Common livelihood strategies include rain-fed semi-subsistence agriculture, receipt of state transfer payments, regional and transnational labor migration, and involvement in conservation projects. By Mexican state indicators, Calakmul has been categorized as economically highly marginal in recent years (Anzaldo and Prado, 2006; Haenn, 2011; Radel et al., 2016).

Theoretically, our study contributes to recent scholarly work emphasizing human perceptions and experiences as important sources of knowledge about various dimensions of climate change. Recent work details how culture interacts with climate change as a scientific concept and as an idea, and how social science can contribute to global environmental change research (Adger et al., 2013; Hulme, 2009; O’Brien, 2011). Beyond its existence as a physical phenomenon, “Climate change has become an idea that now travels well beyond its origins in the natural sciences. And as this idea meets new cultures on its travels and encounters the worlds of politics, economics, popular culture, commerce and religion—often through the interposing role of the media—climate change takes on new meanings and serves new purposes” (Hulme, 2009, xxvi). Because climate change exists as an idea shaped by human experiences and culture, climate change vulnerability needs to be defined not only externally—by experts—but by the

people experiencing changes, considering their overall wellbeing and lived experiences. Our investigation of these questions follows sections on background literature, methods, and results describing people's familiarity with climate change.

LITERATURE REVIEW

Climate change vulnerability studies

Vulnerability is an important feature in the climate change discourse. Within this discourse, Adger's (2006, 268) characterization of vulnerability as "the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt" stands as one of the most commonly cited definitions.

Vulnerability assessments and indices with foci on environmental or social change are often complex and difficult to create because vulnerability and its functions (such as exposure, sensitivity, or adaptive capacity) have multiple definitions and are not directly measurable phenomena (Hinkel, 2011). Hinkel writes, "'Measuring vulnerability' should be avoided, as this is impossible and raises false expectations" (2011, 206). However, some studies have successfully limited their analyses to specific variables or sets of variables determined representative of context-specific vulnerability (e.g., Luers et al., 2003; Eakin and Bojórquez-Tapia, 2008) and other studies (Birkmann et al., 2013; Grothmann and Patt, 2005; Kuruppu and Liverman, 2011), as noted in a recent IPCC report (2014), have increasingly included human experiences and perceptions: "Perceptions and cognitive constructs about risks and adaptation options as well as cultural contexts influence adaptive capacities and thus vulnerability."

People's experiences affect their risk perceptions, and familiarity with adverse conditions may lead to smaller perceptions of risk (Weber, 2010). Experiences are inextricably linked to people's daily lives and livelihood activities. For that reason, a framework of contextual or human-security vulnerability underpins our analysis. This framing is different from but

complementary to framings of outcome or scientific vulnerability which tend to focus more on biophysical factors and general circulation model scenarios (O'Brien et al., 2007).

Finally, this paper complements recent research on vulnerability in Calakmul by Ruiz-Mallén and colleagues (2015), whose findings suggest that resource management regulations associated with the Calakmul Biosphere Reserve are perceived as a source of vulnerability, due in part to the failure of the reserve to include residents in management decision-making (Ruiz-Mallén et al., 2015).

Climate change in southeast Mexico

Calakmul's history is shrouded by uncertainties surrounding the collapse of the ancient Mayan civilization. The collapse is an unparalleled event in the region's human-environment interactions and it left the landscape without widespread human population until the early 20th century (Haenn, 1999). The ancient Mayans appear to have reached the threshold of their human-environment system, resulting in its collapse (Turner and Sabloff, 2012). The Maya who survived collapse were greatly reduced in number and shifted to the northern Yucatan Peninsula. This allowed the seasonally dry tropical forest to grow untended for nearly a thousand years, leading to narratives emphasizing great biological value, wildness, and danger (Haenn, 1999). Local narratives highlight this resilience of the forest as a tenacious entity that "always grows back," while conservation narratives emphasize the forest's fragility and the necessity of conservation regulations (Haenn, 2006). Calakmul is a place with marginal agricultural land due to the lack of dependable water sources and irrigation infrastructure, shallow soils, and the vulnerability of swidden—or "slash and burn" agriculture—to rain timing and hurricanes; yet, the ancient Maya experienced agricultural success (Faust, 2001; Turner, 1974). They maintained

a highly complex human-environment system with intensive resource use and large-scale landscape alterations, including terracing and raised fields (Turner, 1974). Modern agriculture in the region lacks the infrastructure and financial and technical support to rival the success of ancient Mayans.

Previous work on climate variability and human responses to climate change in the southern Yucatan region reveals mechanisms of adaptation including agricultural adjustments, water storage, and livelihood diversification (Mardero et al., 2015). In their analysis of data from weather stations in the southern Yucatan, Mardero and colleagues (2015) found trends of highly variable annual precipitation along with overall decreases in annual precipitation at some stations from 1957 to 2007. The area in their study farthest inland and closest to the Calakmul Biosphere Reserve was drier than areas closer to the Caribbean coast (Mardero et al., 2015).

Climate change perceptions in Mexico

Cognitive factors and familiarity with climate change and its effects contribute to people's actions in mitigating, adapting to, and coping with climate change. Perceptions of and familiarity with climate change sit within the broader context of environmental perceptions and experiences. A high regard for nature and biodiversity exists among the public in Mexico (Fernandez Moreno, 2008), and the results of a nationally-representative survey conducted in 2011 show that 80 percent of people think global warming affects the country a lot, instead of only some, a little, or not at all (Fernandez Moreno, 2008). This percentage is an increase from the same survey results in 2007 (64%) and 2010 (73%) (Latinobarómetro, 2013). However, the effects of climate change compete with other important issues for people's attention.

Even if most Mexicans are aware of global warming in some form or another, it is not viewed as one of the most important problems in the country. Crime (28%), economic problems (13%), unemployment (21%), political crisis (9%) and corruption (6%) were chosen by the largest percentages of people as the most important problem in the country in a 2013 survey (Latinobarómetro, 2013). Global warming was chosen as the most important problem by zero percent of the sample (Latinobarómetro, 2013). This awareness crowded out by other concerns is also visible in the federal approach to climate change. In a 2014 New York Times piece (V. Burnett, 11/29/14), a public policy analyst at the Mexican Center for Environmental Law was quoted as saying, “‘Mexico put on the climate change T-shirt because it was in vogue,’ [...] ‘We are the champions of the climate change fight—the good boy who does his homework—but the resources dedicated to climate change are few.’”

In the southern Yucatan, most (92%, or 138 of 150) farmers interviewed by Mardero and colleagues (2014) perceived that climate patterns had changed over the previous 15 years. The majority of these farmers reported the changes as decreased rainfall, increased temperatures, or increased variability in rainfall (Mardero et al., 2014). To face these changes, farmers reported adaptations including changing the dates of agricultural activities such as burning and planting,

Methods

Study region

The municipality of Calakmul is part of the state of Campeche and sits just north of Guatemala on the southcentral end of Mexico’s Yucatan Peninsula. The peninsula is made up of limestone bedrock which holds very little surface water. Scarce surface water and minimal water infrastructure result in dependence on rainwater for domestic and agricultural purposes. In times

of drought, drinking and household water is delivered for purchase. One major east-west highway (Federal Highway 186) bisects Calakmul and connects the area to the cities of Chetumal, Quintana Roo and Escárcega, Campeche. The highway goes through Calakmul's municipal seat of Xpujil. Calakmul is a young municipality, created in 1996 following the contentious declaration of the Calakmul Biosphere Reserve (Haenn, 2002). Many of the current 28,424 residents (INEGI, 2015) or their forebears moved to the region in the 1960s and 1970s from more densely populated states such as Veracruz or Tabasco and founded new *ejidos*. *Ejid*os are communities defined by common property practices instituted through agrarian reform dating back to the Mexican Revolution. Since the 60s and 70s, infrastructure has slowly improved. Roads that connect the 159 small villages to each other and the municipal seat are now mostly paved. Over the past couple decades most houses have received concrete floors (in place of dirt) through government assistance, and there are increasing numbers of concrete houses or rooms which offer increased protection during hurricanes and other storms. Electricity services are available in today's *ejidos* and Internet service is spreading rapidly. *Ejid*os typically have a small clinic, with either a resident nurse or clinic assistant and regular community visits by a doctor. There is also a small hospital in Xpujil. Communities have a *cocina ejidal* (ejidal kitchen) where reduced-cost breakfast is cooked by a group of women (on a rotating schedule) and available for children and others (Olvera et al., 2017). Agriculturally, there are few extension agents in the region (Schmook et al., 2013), but there are several state-run support programs and payments for farmers that provide small but critical income or supplies. The Calakmul Biosphere Reserve incentivizes some conservation-related projects for communities near the reserve by providing

payments for activities such as holding land in conservation or participation in activities deemed sustainable (e.g., reforestation).

Livelihood activities in Calakmul have varied over time. The Yucatan Peninsula was influenced by the “Mexican Miracle” era between the 1940s and 1980s, which coincided with the post-World War II rise of a global development agenda (Boyer, 2012; Klepeis, 2003; Rist and Camiller, 2014). During that time, Calakmul saw logging by international forestry companies and para-statal organizations, as well as chicle extraction and large agricultural projects (Klepeis, 2003). Many new *ejidos* (small agricultural communities) were also formed in the 1970s and 80s. The period from 1982 to present in Mexico is marked by neoliberalism and characterized as an era of “savage decentralization” (Boyer, 2012). Events and changes in Calakmul generally align with this characterization. Land use has diversified, farm gate prices have decreased, food prices have increased with the lack of subsidies, cash crops became more common, international investment came alongside the establishment of the Calakmul Biosphere Reserve, and there are trends toward privatization of land (Klepeis, 2003).

Site selection

Three *ejidos* were selected for qualitative interviews. Selections were intended to capture some diversity in the make-up of *ejidos* based on their geographic location relative to a northwest-southeast rainfall gradient, migration history, and livelihood activities. These *ejidos* are Los Alacranes, Nuevo Becal, and San Antonio Soda. They were selected based on their inclusion in a 227-household survey conducted in 2010 in 15 Calakmul *ejidos*. The survey data provided information on the *ejidos* to guide selection—particularly regarding livelihood activities. Methodology for the 2010 survey is published by Radel et al. (2016). *Ejidos* where the

primary spoken language is indigenous (e.g., Ch'ol) were excluded due to logistical limitations. Thus, a limitation of this study is that results may not be generalizable to indigenous Calakmul *ejidos*. Participants included *ejidatarios/as* (community members who hold land rights under Mexico's communal land tenure system and have a recognized voice in the ejidal assembly that governs the community) and *pobladores/as* (community members who do not hold a right to land or have a voice in the ejidal assembly, though they may use borrowed land).

Los Alacranes was founded in 1979 by migrants from Veracruz and is the smallest of the three study *ejidos*, with 36 households and 22 *ejidatarios/as* at the time of interview in 2013. It is situated in the southeast corner of Calakmul and the state of Campeche, near the international border with Belize. Because annual precipitation increases from northwest to southeast on the peninsula, Alacranes typically receives the highest rainfall of the three communities. It is also farthest from the main highway in the region. Parcel sizes in Alacranes typically range from 60 to 80 hectares, and chili peppers have historically been an important crop in addition to milpa. Nuevo Becal was founded in 1970 by chicleros from a community in the northwest corner of the peninsula. It is the northernmost *ejido* of the three and has the largest average parcel size at 300 hectares. Each ejidal right is associated with an additional 300-hectare forestry plot. There were just under 100 households and approximately 84 *ejidatario/as* on the record, but only 60 to 70 of the *ejidatarios/as* were resident in Nuevo Becal at the time of interview in 2013. Milpa is the primary agricultural activity, and some residents also engage in logging, have cattle, make charcoal, or keep bees. Labor migration to the United States is a historically prevalent activity in this *ejido*. Nuevo Becal has been the site of many conservation projects in the past three decades.

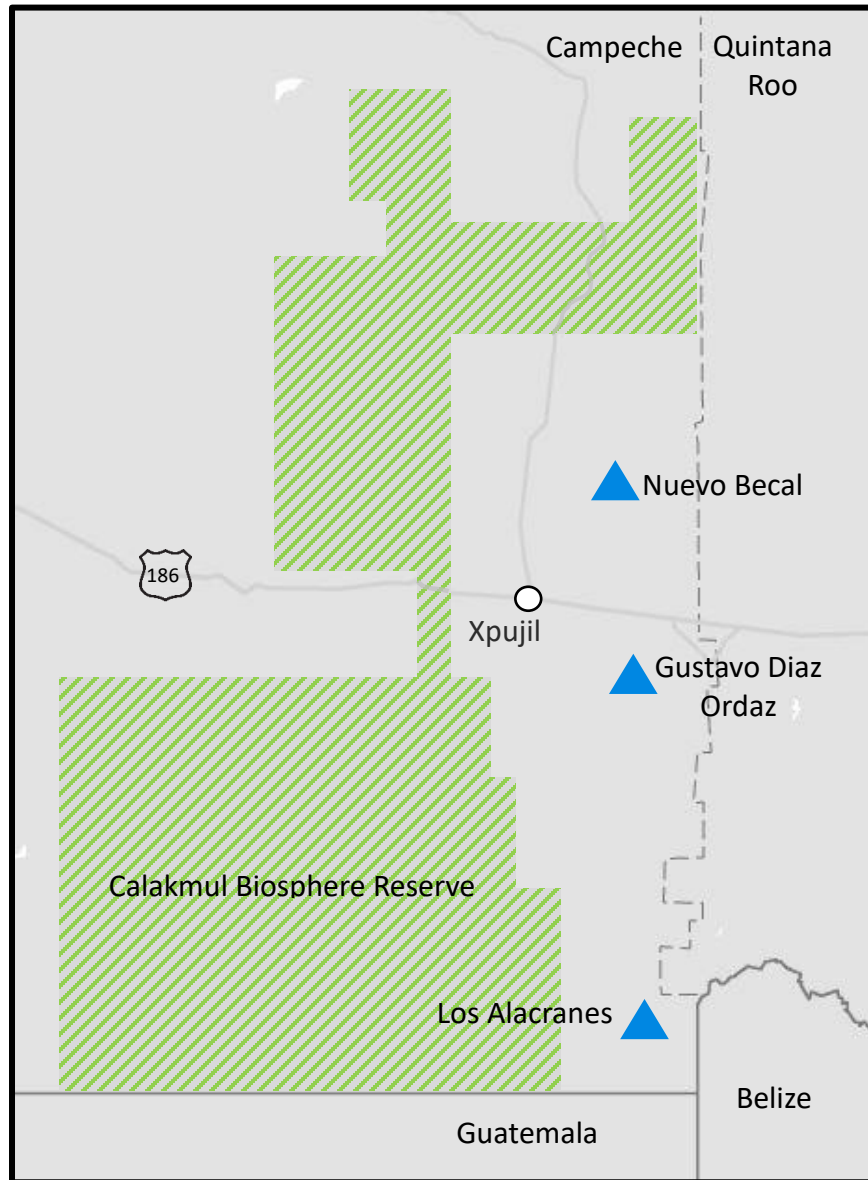


Figure 1. Study *ejidos*.

San Antonio Soda (also known as Gustavo Díaz Ordaz) is located about nine kilometers south of Highway 186, and is therefore considerably closer to the main highway than the other two *ejidos*. With a longer history as a logging town, San Antonio Soda is the oldest community of the three but it did not become an *ejido* until around 1970. It is the most populated of the three

communities, with approximately 200 households and 150 ejidatarios/as. Most parcels are approximately 100 hectares, and livelihood activities include milpa, cattle, beekeeping, and chile. Proximity to the highway and other larger communities in the municipality (which are often also situated near the highway), combined with community size and history, appears to give the *ejido*'s residents improved access to off-farm employment and markets for agricultural products.

Data collection and analysis

The dataset for this research consists of two sets of semi-structured interviews, conducted with the goal of understanding differentiation in experiences and perceptions of vulnerability to climate change across communities, households, and individuals. The first set of interviews is on the topics of subsistence and commercial agriculture, livelihood-related activities and assets, migration, food sources, hunger-related coping responses, receipt of state transfer payments, and involvement in conservation projects. In the first set, interviews were conducted with both male and female heads (separately, when possible) of 37 households for a total of 55 interviews (27 men, 26 women, 2 with both present) from June through August 2013. For these interviews, a snowball sampling technique was followed in each community. At the end of an interview, the respondent was asked if they could refer the researchers to friends or neighbors who engaged in particular livelihood activities. This purposive technique also included selecting participants with differences in apparent material wealth (e.g., the appearance of housing or vehicles). Twelve households were selected in Los Alacranes (representing about 33% of the community), 12 in Nuevo Becal (representing about 12% of the community), and 13 in San Antonio Soda (representing about 7% of the community). Nine households (of 37 total in 2013) were *poblador* households without an *ejidal* right. The number of households selected for participation in each

community (12 or 13) provided a satisfactory amount of diversity in livelihood activities and saturation in terms of the quality of responses, in spite of the differences in community size. Nine additional interviews were conducted with key informants and local leaders to gather ejidal-level information. The interviews lasted between 15 minutes and one hour, with the majority ranging from fifteen to thirty minutes. The second set of interviews were carried out with 45 people in January and February 2016 and covers the topics of climate change familiarity and perceptions of the effects of climate change. These interviews were conducted as follow-up with the original interviewees, if available, in addition to a few other residents who showed interest. The follow-up interviews were intended to place people's concerns about the vulnerability of their livelihood activities in the context of their broader knowledge of the concept of climate change because respondents were not directly questioned about their knowledge or perceptions of climate change in 2013—instead they were asked about their experiences with some particular effects of climate change (e.g., late rains or hurricanes). The follow-up interviews were also intended to compare Calakmul residents' climate change perceptions with nationwide perceptions. As in 2013, male and female heads of household were interviewed separately when possible. Conversation included: if and what they had heard about climate change and from what source, in what ways and to what extent they think climate change affects Mexico, their self, and their family, and what overall threats or benefits result from climate change. They were also asked about their coping responses to any threats. Interviews from both 2013 and 2016 were recorded and transcribed before responses were coded by category in QSR NVivo. Categories were created to represent answers to specific questions (e.g., “does not recognize,” “does not recognize but describes concept,” “recognizes but does not describe,” or “recognizes and describes” for a

question about recognition of the term or concept of climate change) and to account for common themes across answers (e.g., “lack of money or employment”). Categories were then searchable in NVivo on their own or by demographic classifications.

Results and Discussion

Findings are presented beginning with the 2016 interview results in order to provide greater context for the more detailed, event- and livelihood-specific interviews conducted in 2013.

Climate change familiarity

During the interviews in 2016, respondents were asked if they had heard of the word or theme “*cambio climático*,” and if their answer was positive, they were then asked to describe what it meant. Sometimes the words “*calentamiento global*” were substituted or added in this question. The question followed a lead-up inquiry about whether they had heard of the Conference of Parties in Paris one month prior. This was used as a priming question because it was a climate change subject recently in the news. The majority (71% or 36 people) recognized the term, and about half (53%) described it somewhat accurately, whether or not they recognized the term or concept. If the respondent did not recognize the term, the interviewer gave a brief explanation of climate change. The explanation was not standardized, but included descriptions of a mix of local or global effects and causation.

Table 1. Recognition and description of the concept of climate change

		Recognizes	
		Yes	No
Describes accurately	Yes	18	9
	No	18	6

Among the 18 people who recognized the term and described some aspect of climate change correctly, understandings often related to conservation and forests. These understandings come from their communities' existence in and around a large tropical forest and the local importance of conservation discourse, centered around the Calakmul Biosphere Reserve. Using forest conservation language is valuable when applying for governmental or NGO funds and participating in conservation projects. In this category of respondents, some were forthright about what they saw as the impacts of their small-scale farming compared to larger-scale industrial actions. Miguel (a pseudonym), a man from Nuevo Becal, is well-versed in the potential and rhetoric of forest conservation but is skeptical of climate change mitigation at the expense of farmers' livelihoods.

“You notice I am one of the people that [cut down trees]—yes, it harms us to devastate the forests, but we are also harmed by the big companies' pollution. It's worthless when farmers are held down and forced to understand, to comprehend, when [cutting down trees is] their job. The business man, because he has money, he can make deals with the government offices so he can keep on producing and polluting even more than farmers. That's what I always tell my wife, what use is there in prohibiting us that much, when we

produce more than those business men and factories? For example, I see Peña Nieto on the news talking about the tons of cars sold by Mexico, which gives income to our country. If he could see us, we produce 10 tons of maize, it should bring income for the country too. To produce 10 tons, I devastated 2 hectares.”

There were 18 people who recognized the term *cambio climático*, but did not seem to understand its scientific meaning. Their answers were coded as “recognizes but does not describe.” Among these, the most common response by far was that the term referred to day-to-day or seasonal changes in weather. Some others seemed to know that climate change was an environmental issue and mentioned similar issues such as contamination or deforestation, but did not state any connection between these issues and climate change. Therefore, their answers were coded conservatively as “recognize but does not describe.” Perhaps more people in this category would have provided accurate descriptions, or spelled out the effects of deforestation to include links to climate change if the phrase “*calentamiento global*” (global warming) had been used more consistently in the questioning. *Cambio climático* is frequently understood as day-to-day changes in weather. Nonetheless, the responses reveal information about people’s lived experiences and perceptions of climate change vulnerability.

Nine people did not state recognition of the term, but described its local or global effects in conversation with some accuracy. This fit with results from the 2013 interviews, where the overwhelming majority of respondents (29 people) perceived that heat had increased over the time period of their residence in the *ejido*. They reported either increasing high temperatures, a longer duration of the hot season, or the simultaneous occurrence of both. Mardero and

colleagues (2014) also found residents of southern Yucatan ejidos to report increasing heat. In our study, these changes were described in the context of daily activities such as sleeping and working, as follows:

“Yes, the heat lasts longer. Right now, [when I go to bed at] night, you can’t sleep because of all the heat there is. And before, no. I slept in the hammock or you could sleep in the bed with the mosquito net. Now you can’t sleep in the bed because it’s hot. There is more heat, even at night.”

“The truth is, I’ve felt more heat. Before there wasn’t much. Right now, you go to the field, you don’t work past 1 or 2 p.m.”

People also described the increasing variability in rainfall, which complicates the timing of agricultural activities. Traditionally, farmers take the arrival of spring rains around the beginning of May as their cue to begin planting (Mardero et al., 2012). One man shared:

“Sadly, right now the weather we have is variable. Sometimes, in the summer it rains when it shouldn’t. You are clearing the vegetation, and the planting rains come. But you don’t have the land ready yet. Because these are the traditions we have for planting maize. We know what time we can plant, but [right now we have a] dry period. We plant when the rains fall, the maize doesn’t grow, or it’s pulled out by the birds, or it dies from

being dry because there is no rain. That's the problem we have in Nuevo Becal—it hasn't rained [enough] for two years.”

As with those who recognized the term but did not accurately describe elements of the scientific concept of climate change, the six people who did not recognize the term sometimes described day-to-day changes in weather—even after hearing a general description of the scientific concept from the interviewer.

Experiences, perceptions, and differentiation of vulnerability

In addition to familiarity, perceptions and experiences of climate change vulnerability reveal important differences in lived experiences and wellbeing, and affect people's actions in mitigation, adaptation, and coping (Weber, 2010). In the 2013 interviews, respondents were asked how the expected and observed phenomena of climate change (i.e., droughts, late rains, and hurricanes) affected each of their livelihood activities, and what they are already doing to cope with these effects (Table 2). They were also asked—in separate segments of the interview—about the effects of climate change on health, and about recent experiences of hunger, as this can be an important negative outcome for semi-subsistence farmers under global warming. For various perceptions of vulnerability, some differentiation is evident. In our study, this differentiation was primarily along the lines of participants' *ejido* of residence and land tenure status.

In Table 2, activities are divided into on-farm and off-farm to highlight differences in vulnerability perceptions between the two. On-farm activities are generally more vulnerable to climate change, given the importance of favorable, predictable weather conditions. These

vulnerabilities include a decreased availability of food and water for livestock, epidemics and infestations, low or no yield of some or all crops, livestock mortality, damages to equipment such as beehive boxes, and a decreased availability of agricultural wage labor. Agricultural wage labor—where people hire others in the community to work in their fields for a daily wage—is disrupted by the same climatic events, thereby limiting local employment opportunities when they are needed most. Most of the coping responses for these effects require cash purchases of some necessary item. Animal feed and water must be purchased when pasture and maize does not grow, and household staple foods must be purchased if crops do not produce. Vaccinations, pesticides, or herbicides must be purchased when conditions lead to epidemics and infestations for livestock or crops, respectively. Several cattle owners mentioned needing to buy expensive vaccines for their cattle in times of drought because the cattle are not as well-fed and able to fend off rabies carried by vampire bats. Besides being subject to epidemics during droughts, livestock are also at risk during flood events that come with hurricanes or other strong storms, and must be moved to higher ground, which may require hiring extra help. Purchasing goods or services is made especially difficult during unfavorable climate conditions because one of the common sources of cash in Calakmul is wage labor completed for neighbors based on the same on-farm activities. A frequent refrain when asked what happens when the rains are late or there is a drought was that, “There is no work. There is nothing.”

In contrast, off-farm livelihood activities were seldom reported as directly vulnerable to droughts, late rains, or hurricanes. One can hypothesize how these activities might also be affected. For example, a hurricane could damage roads that drivers rely on or lead to decreased employment opportunities for labor migrants in the nearby tourist corridor between Cancun and

Table 2. Reported effects of and coping responses to climate-related stresses

Activity type	Activity	Climate-related stress	Effect	Coping
On-Farm	Beekeeping	Drought and late rains Hurricanes	Fewer flowering plants Bees cannot leave hive boxes Boxes damaged	Feed bees Feed bees Reinforce boxes
	Livestock other than cattle	Drought and late rains	Decreased food availability Epidemics Animal mortality	Buy feed Vaccinations Move animals to high ground
		Hurricanes and flooding		
	Cattle	Drought and late rains	Decreased food availability Decreased water availability Epidemics Loss of grass to flooding Animal mortality	Buy feed Transport or buy water Vaccinations Buy feed Move animals to high ground
		Hurricanes and flooding		
	Chili peppers	Drought and late rains	Low or no yield Pests	None Purchase pesticides
Hurricanes and flooding		Difficult to access land	Access by horse or foot	
Day labor	Drought and late rains Hurricanes and flooding	No available work No available work	Search for work outside <i>ejido</i> Search for work outside <i>ejido</i>	
Milpa	Drought and late rains	Low to no yield Pest infestations	Buy food for family and livestock Purchase pesticides	
	Hurricanes and flooding	Low to no yield	Buy food for family and livestock	
Off-farm	Teaching	Indirect	Little effect	
	Shop-keeping		Sell goods on credit	Wait for payment
	Handicrafts		Little effect	
	Driving		Little effect	
	Construction		Little effect	
	Labor migration		Little effect	
	Cattle buying and selling	Drought	Business increases	N/A

Tulum. However, these potential effects were not at the forefront of people's minds. The two exceptions in our sample are with shop-keeping and cattle buying. Shopkeepers of small corner stores choose to sell goods on credit, depending on the trust they share with customers. It becomes difficult for people to have enough cash to purchase food items when climatic conditions prevent them from earning money from their on-farm activities. These debts are typically paid off with Prospera payments. Prospera is a social welfare program at the federal level, from which parents—typically mothers—receive cash payments in exchange for meeting conditions such as having their children enrolled in school and receiving regular health check-ups (Radel et al., 2016). Therefore, Prospera payments are not dependent on climatic conditions. The payments are a significant source of cash for participants in this study, and the program has the unintended effects of supporting semi-subsistence maize production (Radel et al., 2016). It also appears to lessen some gender gaps in agriculture (Radel et al., 2016). The other off-farm activity that was reported to be affected by climate stressors—cattle buying and selling—sees the immediate effect of an increase in business. The only individual we interviewed in this study who engages in this activity reported that people are more likely to sell their cattle during droughts because they lose the ability to provide feed and water, and may have an increased need for cash from the sale.

At the *ejido*-level, people appear somewhat differentiated in their experiences and perceptions of vulnerability. Interviewees in San Antonio Soda were more frequently engaged in off-farm employment outside the household that benefits from close proximity to the major east-west highway (e.g., as a road construction worker, grocery distribution driver, cattle buyer and seller, or regional transportation provider). These livelihood activities were less frequently reported as vulnerable to climate change, as explained above. Also, some *ejidos*, such as Nuevo

Becal, have a more robust history of involvement with conservation-related income-generating opportunities. This history is partially a result of the character of land in the ejido. Nuevo Becal has larger parcels than most *ejidos*, allowing greater opportunities for forestry- and wildlife-based conservation.

The health effects of climate change were also an important aspect of people's experiences of vulnerability. Two lines of discussion affirmed this in our interviews. If respondents asserted that heat had increased during their time in the *ejido*, they were asked how this affects household members' health. The more general question, "How does climate change affect you and your household?" also revealed health concerns. The most frequent answer regarding how climate change affects health was that rapid shifts between hot and cool weather causes people—especially children—to become ill with the flu or a cold. Respondents also described several other health effects of climate change, including skin cancer, illness from excessive heat, respiratory problems from contaminated air, and the spread of viral diseases transmitted by infected mosquitoes. Chikungunya and zika were prevalent in the greater region during the January and February 2016 interviews, and chikungunya had made its way through Calakmul, as described by a woman from San Antonio Soda:

“Well right now, many times in the past year a lot of illness occurred from this chikungunya. They say, by the mosquito, it's by the wind that...for other countries there are illnesses, there are deaths. They are brought by the air.”

Hunger is one of the eventual outcomes of droughts, late rains, and hurricanes. One quarter to one third of all interviewees reported experiencing hunger in the past two or three

years. *Pobladores/as* were especially likely to report hunger. Almost all *pobladores* in the study reported experiencing hunger in the past two or three years. Only one quarter of *ejidatarios* interviewed in 2013 reported experiencing hunger. Both *ejidatarios* and *pobladores* described similar circumstances leading to and surrounding their experiences of hunger. Typically, it occurred when there was no harvest or the harvest did not last throughout the year and there was no employment available on neighbors' farms. In such cases and in situations where a household enacted coping strategies to avoid hunger, three respondents reported reliance on Prospera payments, not only as a source of money to buy food, but as collateral for credit at corner stores where basic foodstuffs are purchased. This information arose in the context of conversation and was not revealed through a direct question, and more informants would have likely reported the same for Prospera and other governmental programs if asked directly.

Overall, *pobladores* have less access to some of the resources that help prevent hunger, such as governmental subsidies and land with more advantageous characteristics. They generally hold a second-class status compared to *ejidatarios*. Navarro-Olmedo and colleagues (2016) find this status difference evident in access to land and other resource-based assets in spite of efforts on both sides toward "mutual respect and the fulfilment of social obligations," (163). Related to these differences in access to resource-based assets, extremely localized topographical differences play a subtle but critical role in the differentiation of Calakmul residents' experiences and perceptions of vulnerability. Among *ejidatarios*, positive and negative land characteristics were described in conversations about on-farm livelihood activities. For example, three separate Alacranes residents said their cattle were not affected in the last hurricane because their land includes hills where the animals could avoid flood danger. Other advantageous land characteristics noted by interviewees included a stream for use in droughts (in Nuevo Becal) and

having a house plot on high ground which prevented house flooding (in San Antonio Soda). Lowlands were mentioned by residents of each *ejido* as a concern in times of flooding, and one resident had lost cattle in a flood event. Other negative characteristics included having land that was “pure sascab” (decomposed limestone) and not being able to access borrowed land in the rainy season because the land is far from the *ejido* and the path becomes impassible. *Pobladores* only described disadvantageous conditions in relation to the land they worked or borrowed, suggesting a perception of increased vulnerability. For example, one *poblador* in San Antonio Soda has a house plot in the lowland by the river, and his house is subject to flooding. He knew of the availability of government assistance to provide a sturdier concrete house to replace or augment his wooden one, but told us he was denied the assistance by ejidal leadership due to his status as a *poblador*. Additionally, no *pobladores* in our study owned cattle at the time of interview. Many households rely on cattle as a relatively liquid asset in times of financial stress, so the lack of ownership signifies increased vulnerability to a variety of climatic and non-climatic stressors.

Aside from livelihood activities, health, and hunger, people experience vulnerability due to shortages of water for household use. A considerable number of the early migrants in the 1960s and 1970s moved away from Calakmul before government assistance in the provision of water (Haenn 2002). Despite this assistance in the form of community wells and piping to houses, shortages are still commonplace. This is observable on the physical landscape, where various governmental and non-governmental organizations have sponsored the construction of *piletas* (Fig. 2)—large water storage tanks that collect rainwater from house roofs. Piped water is unreliable and households must also collect rainwater and occasionally purchase water that is delivered by truck for domestic use. Older residents talk about how much easier it is to live in

Calakmul today than when they moved to the frontier 30 or 40 years ago and there was less infrastructure to ensure a year-round water supply. However, with more frequent droughts and less annual precipitation, water shortages remain a source of vulnerability.



Figure 2. A *pileta*, with a pipe to direct rainwater from the house roof.

Conclusion

Our approach follows the trend toward greater inclusion of human perspectives through a qualitative examination of people's familiarity with climate change and their experiences and perceptions of its effects in their lives and on their livelihoods.

Calakmul residents, like Mexicans in general, have a high awareness of climate change. It has multiple profound consequences in their lives and livelihoods through outcomes related to on-farm and off-farm activities, human health, hunger, and the availability of water. The interview data above reveal differences in experiences of vulnerability according to livelihood activity profile, community of residence, and land tenure status. Most coping strategies

mentioned by residents require cash purchases, and the shortage of cash and opportunities for employment are perceived as important problems.

Given the environmental history of the nation and region, and the current neoliberalism and “savage decentralization,” the outlook is not particularly exciting for semi-subsistence farmers in Calakmul. They have experienced some advantageous changes in recent years with government investment in electricity, housing upgrades, and small improvements in water infrastructure and medical services. However, much of the population continues to live in poverty and faces a demoralizing lack of agricultural support.

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