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# Factors that Influence Climate Change Mitigation and Adaptation Action: A Household Study in the Nuevo Leon Region, Mexico

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**Abstract:** Household-level mitigation and adaptation actions are important because households make a significant contribution to greenhouse gas emissions and are severely affected by climate change. However, there is still very little understanding of the factors that influence household-level mitigation and adaptation action. From a review of literature, we identified the factors that potentially influence climate mitigation and adaptation actions of households, which we then tested using survey data from 622 households in Nuevo Leon, Mexico. Nuevo Leon is a major emitter of greenhouse gasses and is a state where climate-related disasters are recurrent and expected to increase in frequency and severity. Results from ordinal regression analyses showed that perceived knowledge and financial self-efficacy greatly influenced the extent of household-level action taken. To a lesser extent, the age and educational level of the respondent also affected action. Respondents pointed out the need to know about different aspects of climate change. An implication of our study is the value of recognizing the importance of perceptions, as mitigation and adaptation actions are shaped by perceptions of climate change alongside socio-demographic characteristics. This may have significant implications for policies and campaigns promoting household-level action to increase resilience to climate change.

**Keywords:** Mexico; climate change awareness; household action; perceived knowledge; climate change beliefs; climate and development

## 1. Introduction

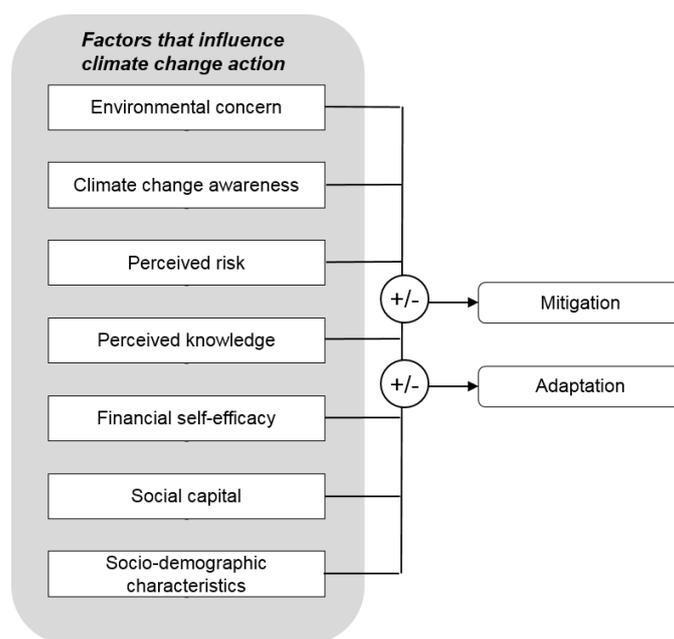
Climate change is creating challenges for society and the environment. Increasing greenhouse gas (GHG) emissions have already affected typical climatic conditions and the magnitude and frequency of climatic events. It is predicted that the effects of climate change on social systems will be substantial, especially for developing countries where populations are most at risk and have least opportunities for change [1]. Consequently, policy-makers need to encourage the reduction of GHG emissions and stimulate adaptation to reduce vulnerability to climate change. Traditionally, the scientific community and policy-makers have emphasized the research, design, and implementation of mitigation measures over adaptation strategies [2,3]. However, there has been a shift toward a more balanced approach between mitigation and adaptation in climate research during the last decade or so. Given many challenges at varying spatial and temporal scales, a variety of approaches is necessary to reduce and manage risks [1,3]. Therefore, to support the planning and implementation of climate-resilient measures for sustainable development, understanding the factors that influence mitigation and adaptation actions has emerged as a crucial part of climate change research.

The success of climate change strategies depends on the extent of cooperation within social systems and across scales [1]. There have been many studies that focus on developed countries, but far fewer studies have been done elsewhere. This lack of studies across all regions of the world is a matter of concern, as factors that influence action are based on local contextualities [4]. There is also a paucity of literature on the factors that influence household-level action [5]. This gap is critical, since not only does household behavior drive climate change, with households being responsible for two thirds of GHG emissions [6], they are also greatly affected by it [7,8].

This study examines the factors that influence mitigation and adaptation actions at the household level. Using relevant literature, we describe the conceptual theory about the factors that have been found to influence mitigation and adaptation action. We then present our study in Nuevo Leon, in which we operationalized, collected, and analyzed empirical data by conducting statistical and qualitative analysis of open-ended questions. The final section discusses the findings and draws conclusions.

## 2. Factors that Influence Household-Level Mitigation and Adaptation Action to Climate Change

To establish the factors that influence mitigation and adaptation actions among households, from the literature we developed a theoretical model that includes a combination of perceptions and socio-demographic characteristics that potentially have an effect on action (see Figure 1). These factors include awareness of climate change and environmental issues; perceived risk; perceived knowledge; perceived self-efficacy; social capital; and various socio-demographic characteristics. We describe these factors below.



**Figure 1.** Factors that influence household-level mitigation and adaptation to climate change.

### 2.1. Environmental Concern

Pro-environmental attitudes are related to a greater intention to act against climate change [9]. People with higher environmental awareness use less air conditioning in the summer and less heating in the winter than people with lower environmental awareness [9]. Similarly, Nauges and Wheeler (2017) found that among pro-environmentally motivated households, environmental concern resulted in reduced water and electricity use [10]. Environmental concern has also been observed to be positively related to purchasing behavior, such as willingness to pay for green products [11,12] and support for public policies that promote mitigation strategies [13].

## 2.2. Climate Change Awareness

While there is awareness and acceptance of climate change amongst the public generally, most people believe its effects will only occur in the future [14,15]. This creates a distance between their contemporary everyday lives and the perceived future impacts of climate change [16]. Therefore, improving their understanding of what causes climate change would increase their awareness of the connections between their activities and the changing climate and thus their support for climate change action [17]. Fleming and Vanclay (2010) and Arbuckle et al. (2013) found that farmers who believed climate change was attributable to human activities were more likely to support climate change action [18,19]. They suggested that those who believed in human-caused climate change were more likely to be aware of the importance of reducing their emissions.

## 2.3. Perceived Risk

People who perceive that climate change is likely to impact their household are more willing to address climate change [9] and support climate change policies [20]. For example, Smith and Mayer (2018) found that people who believed climate change was a threat to their nation were more willing to support climate change policies [21]. Nevertheless, not all people perceive climate change as a major risk. For instance, people in developing countries generally perceive climate change to be a greater risk to themselves and their families than do people in developed countries [22].

## 2.4. Perceived Knowledge

Knowledge can impact people in different ways, for example, by affecting their concern, willingness to take action, or acceptance of climate policies. Shi et al. (2015) found that action-related knowledge was positively associated with willingness to change behavior [23]. Abrahamse et al. (2007) demonstrated that households saved energy after being presented with tailored information concerning their energy use [24]. This indicates that information and understanding about climate change could be an important factor to facilitate action, and that people who do not engage in climate change action may not do so simply because they lack adequate information.

## 2.5. Financial Self-Efficacy

Several studies have shown a positive relationship between self-efficacy and willingness to address climate change [25]. Ung et al. (2015) found that greater perceived self-efficacy is associated with both anticipatory and reactive adaptation to natural disasters [26]. Self-efficacy also applies to a financial management context, referring to the perceived ability to accomplish a financial goal [27]. Thus, it can be expected that, as the household's financial self-efficacy increases, so does their confidence to execute measures related to climate change, despite their objective level of financial resources.

## 2.6. Social Capital

Individuals and households are embedded within social networks comprised of relationships between family members, friends, neighbors, and others [28]. Social capital has gained importance in the climate change literature as these social relationships provide support, knowledge, and security, in addition to facilitating collective action among households [29–31]. Reliance upon family and local networks is key during and after natural disasters [32], as they may facilitate faster recovery by facilitating information and sharing resources [33].

## 2.7. Socio-Demographic Characteristics

Many studies have identified various socio-demographic variables related to climate change action, such as gender [34], age [35,36], level of education [34,35], income [36], household size [36], and location in terms of rural or urban setting [37].

### 3. Materials and Methods

Our research was conducted in Nuevo Leon, a state in northeastern Mexico, which has a population of over 5.1 million people who occupy around 1.3 million households. This region was selected because it is prone to weather-related events such as storms, floods, droughts, and high temperatures [38,39]. Climate change is also expected to increase the frequency and severity of these climatic events [1,38]. The Monterrey Metropolitan Area, which includes Monterrey, the capital of Nuevo Leon and 12 surrounding municipalities, is one of the biggest emitters of GHG in Latin America [40]. However, Nuevo Leon has set a goal to reduce its GHG emissions [41], with mitigation and adaptation being needed at a household level.

Data was gathered using a survey of households in the State of Nuevo Leon. A pilot study was first conducted by using a paper questionnaire. The results of the pilot study revealed logistical issues, which led to the decision to adopt an online survey, alongside a paper questionnaire to ensure maximum survey response and to minimize sample bias. Recruitment for the web-based survey took place from August 2016 to January 2017 using popular social media platforms (i.e., Facebook and Instagram). Potential participants were sent an invitation and link to a Qualtrics survey. Data collection for the paper questionnaire was undertaken during field work in Nuevo Leon from November 2016 to January 2017. Potential respondents were approached in major public spaces, with questionnaires being participant-completed.

Descriptive analysis was used to describe the characteristics of the sample. Statistical assumptions were checked for violations, including multicollinearity, with no violations existing. Ordinal regression analyses were performed using two regression models, one to examine associations between the independent variables on reported household-level mitigation, and one for household-level adaptation. The analyses were performed using various independent variables (indicated in Figure 1): environmental concern, climate change belief, awareness of causes, climate change timing, perceived risk, knowledge of effects, knowledge of responses, financial self-efficacy, social capital, household setting, household income, household size, number of working members, respondent educational level, gender, and age.

Each dependent variable was measured using a 5-point Likert scale from “strongly disagree” to “strongly agree.” Mitigation action was measured by agreement with the statement: “My household reduces the level of climate change.” To measure adaptation action, we asked to what extent households agreed with the statement “My household is prepared to respond to climate change and its effects.” This wording was chosen rather than using the terms “mitigation” and “adaptation” to avoid possible misunderstanding.

The factors that potentially influence mitigation and adaptation actions that were identified from the literature review were converted into measurable variables for inclusion in the questionnaire. The first question elicited general information about the main concerns of the household and was used to determine whether participants prioritized any environmental issues. This was later recoded into the nominal variable, environmental concern. The factor, climate change awareness, was measured by three variables, belief, awareness of causes, and timing. For climate change belief, respondents rated their belief in climate change (strongly disagree to strongly agree). The variable, awareness of causes, examined what respondents thought were the causes of climate change (nominal). We then asked about climate change timing, specifically whether they thought climate change was already occurring or not, and if it will happen in the future (nominal).

The variable, perceived risk, asked what respondents thought the effects of climate change would be on their household, ranging from beneficial effects to very serious consequences. Although this variable originally had five categories, it was later recoded into three to have an adequate sample size per category. Two variables were used to assess perceived knowledge. Knowledge of effects measured their agreement with the statement that their household was well informed about climate change and its effects (strongly disagree to strongly agree). Originally having five categories, this variable was recoded into four categories to have a sufficient sample sizes in each category. Knowledge of

responses measured how strongly they believed their household is informed about how to respond to climate change (strongly disagree to strongly agree). Financial self-efficacy asked to what extent they thought their household had the ability to find economic resources to overcome the effects of climate change (strongly disagree to strongly agree). Social capital asked to what degree they believed their household could rely on the help of family and friends to overcome the effects of climate change (strongly disagree to strongly agree).

Background socio-demographic information was collected at the end of the survey. The variable, household setting, measured rural or urban location. Household income was measured in increments, which were re-categorized into seven classes, including “rather not say” to avoid losing these cases for the regression analyses. Household size measured the number of household members. The variable, working members, recorded the number of actively working members in the household (grouped). One category recorded households where people had other sources of income and there were no actively working members in the household. Other data collected included educational level, which was classified as ordinal; gender, classified as nominal; and age, recorded in years.

For some of the analyses, we split the cases into four categories: households who reported agreeing with high levels of mitigation and low levels of adaptation ( $n = 111$ ); those who reported agreeing with high levels of adaptation and low levels of mitigation ( $n = 56$ ); those who reported high levels in both mitigation and adaptation ( $n = 281$ ); and those who reported low levels of mitigation and adaptation ( $n = 174$ ).

In addition to the statistical analyses, a qualitative analysis of an open-ended question was conducted. The open-ended question asked what they thought would motivate them to take (further) action to address climate change in their household. There were 307 responses to this question. It was analyzed using a predetermined list of thematic codes derived from the theoretical framework: environmental concern, belief in climate change, awareness of causes, perceived risk, perceived knowledge about effects, perceived knowledge about responses, financial self-efficacy, and social capital. Additional codes were added to the list if they appeared in reasonable frequency, specifically being part of the curriculum (at different educational levels) and governmental assistance. The distribution of coded themes across different subgroups of households was considered. The qualitative analysis of the open-ended question was intended to validate the relative importance of the factors that influence climate change action proposed in the theoretical framework of this study and to identify further factors that may not have been included.

## 4. Results

### 4.1. Overview of the Sample

In total, 622 surveys were received, 229 online and 393 by paper questionnaire. Figure 2 reveals that the distributions for household mitigation and household adaptation action are similar across the response categories. Furthermore, there is not much difference in the distributions between the extent to which households take mitigation action and adaptation action. Some 33% of households agreed to some extent with the statement, “My household reduces the level of climate change.” Another 29% were neutral and 33% considered that they did not carry out mitigation action. As for adaptation action, 30% agreed to some extent that their household was prepared to respond to climate change and its effects, 25% were neutral, and 42% disagreed to some extent.

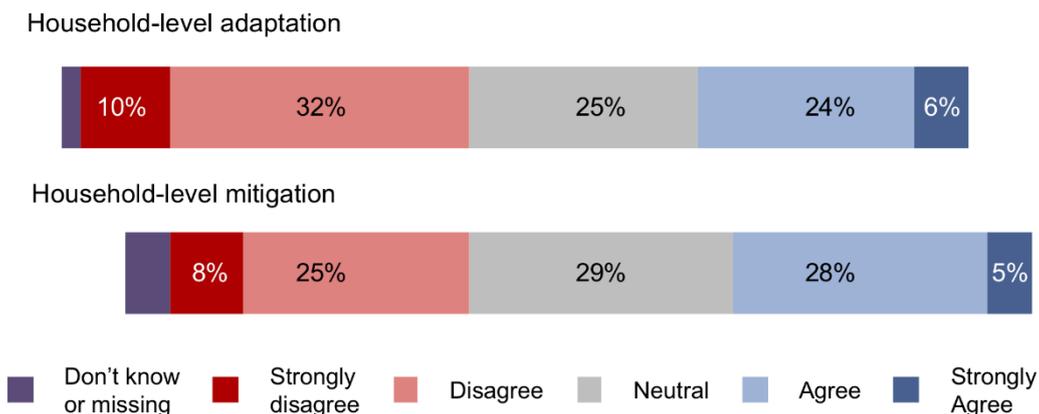


Figure 2. Overall distribution of responses to household-level mitigation and adaptation action.

Table 1 summarizes the findings about household views on climate change. Only 17% of responses indicated an environmental issue as a main concern, primarily mentioning pollution (67% of these responses). Non-environmental issues were mentioned more frequently, including economic matters (35%), criminality (31%), and corruption (29%). The majority of households (91%) agreed that they perceive climate change to be a real phenomenon, and there is an agreement by 88% of participants that climate change is already occurring. The majority (81%) believed that climate change will have serious effects on their households. This indicates that although most households perceive non-environmental problems to be more important, the majority still see climate change to be a serious issue.

Table 1. Summary of household views on climate change (n = 622).

Dependent Variables	Question Wording	Classes	%	n
Mitigation	How much do you agree with: "My household reduces the level of climate change"?	Strongly disagree	8	47
		Disagree	25	157
		Neutral	29	183
		Agree	28	176
		Strongly agree	5	33
		Don't know/missing	4	26
Adaptation	How much do you agree with: "My household is prepared to respond to climate change and its effects"?	Strongly disagree	10	60
		Disagree	32	208
		Neutral	25	153
		Agree	24	148
		Strongly agree	6	36
		Don't know/missing	3	17
<b>Independent variables</b>				
Environmental concern	What is the main concern in your household?	Did not mention any	83	518
		Did mention at least one	17	104
Climate change belief	How much do you agree with the statement "Climate change is real"?	Strongly disagree	0	2
		Disagree	1	6
		Neutral	6	37
		Agree	27	171
		Strongly agree	64	399
		Don't know/missing	1	7
Awareness of causes	What do you think are the causes of climate change?	Human activities	52	323
		Natural causes	6	255
		Both	41	39
		Don't know/missing	1	5

Table 1. Cont.

Dependent Variables	Question Wording	Classes	%	n
Climate change timing	When do you think climate change will occur?	Already happening	88	550
		In the future	10	62
		Don't know/missing	2	10
Perceived risk	What do you think will the effects of climate change be on your household?	Very beneficial effects	0	2
		Beneficial effects	1	7
		No effects	10	61
		Serious consequences	52	324
		Very serious consequences	29	178
Knowledge of effects	How much do you agree with the statement: "My household is informed on climate change and its effects"?	Don't know/missing	8	50
		Strongly disagree	2	14
		Disagree	13	82
		Neutral	25	156
		Agree	38	236
		Strongly agree	20	126
Knowledge of responses	How much do you agree with the statement: "My household is informed on how to respond to climate change"?	Don't know/missing	1	8
		Strongly disagree	9	54
		Disagree	25	155
		Neutral	23	144
		Agree	31	195
		Strongly agree	9	58
Financial self-efficacy	How much do you agree with the statement: "My household has the economic resources to overcome climate change and its effects"?	Don't know/missing	3	16
		Strongly disagree	13	83
		Disagree	33	205
		Neutral	25	154
		Agree	20	125
		Strongly agree	4	30
Social capital	How much do you agree with the statement: "My household can rely on the help of family and friends to overcome climate change and its effects"?	Don't know/missing	4	25
		Strongly disagree	5	34
		Disagree	13	79
		Neutral	20	124
		Agree	40	250
		Strongly agree	18	115

Some 58% agreed to some extent that their household was informed about the effects of climate change and 40% indicated that they were informed about how to respond to climate change. However, only 24% agreed that their household had the financial resources to overcome the effects of climate change. As for social capital, 58% indicated that they could rely on the support from their family and friends to overcome the effects of climate change.

A comparison was made between the socio-demographic characteristics of the sample against the Nuevo Leon population [42] (Table 2). The gender distribution was roughly representative of the overall population, with 56% being female. The age distribution revealed a slight under-sampling of the over 60 age group. As for education, 46% of respondents had at least a bachelor's degree, far more than the 24% of the Nuevo Leon population. Unfortunately, the way income is reported by the census means that it was not valid to compare income. Household size is representative of the state population, with a median of 3.7 members per household. The percentage of respondents living in an urban setting is roughly representative of the Nuevo Leon population, with 91% living in the Monterrey Metropolitan Area.

**Table 2.** Household and respondent profile.

Variable	Classes	Household Sample (%)	Nuevo Leon Population (%)
Household profile			
Household setting	Urban	91	95
	Rural	7	5
Household income (MXN per month)	Rather not say	14	
	Less than \$5000	15	
	\$5,000–10,000	17	
	\$10,000–20,000	18	–
	\$20,000–30,000	15	
	\$30,000–40,000 More than \$40,000	9 12	
Household size	Median	3.7	3.7
Household working members	1	28	–
	2	43	
	3	14	
	4 or more	9	
	Other sources of income	4	
Respondent profile			
Gender	Male	44	50
	Female	56	50
Age (Years)	18–25	29	23
	26–30	19	11
	31–40	16	21
	41–50	16	17
	51–60	11	12
	>60	8	16
Education	Less than high school	13	53
	High school	41	23
	Bachelor	33	24
	Graduate	13	–

## 4.2. Factors Influencing Mitigation and Adaptation

### 4.2.1. Mitigation Action

Table 3 presents the findings from the ordinal regression models. As seen in the variable, environmental concern, the odds ratio (OR) of having reported mitigation action is significantly greater (OR = 1.410,  $p < 0.10$ ) in households who reported a concern related to the environment than those who did not. Regarding knowledge of effects, respondents who agreed (OR = 1.690,  $p < 0.05$ ) or strongly agreed (OR = 2.952,  $p < 0.001$ ) were more likely to take mitigation actions compared to those who disagreed. Similarly, for the variable knowledge of responses, the odds of having taken mitigation action was greater among those who were neutral (OR = 2.209,  $p < 0.05$ ), agreed (OR = 4.422,  $p < 0.001$ ), or strongly agreed (OR = 8.352,  $p < 0.001$ ). An increase in financial self-efficacy also raised the odds of mitigation action amongst those who were neutral (OR = 1.964,  $p < 0.05$ ), agreed (OR = 1.720,  $p < 0.10$ ), or strongly agreed (OR = 5.176,  $p < 0.001$ ) with the statement.

Concerning socio-demographic variables, an increase in the number of household members was associated with an increase in the odds of reporting higher levels of mitigation (OR = 1.120,  $p < 0.10$ ). Nonetheless, regarding the number of working members in the household, the odds decreased when the household had other sources of income, such as a pension (OR = 0.444,  $p < 0.10$ ).

**Table 3.** Ordinal regression results in factors influencing the implementation of mitigation and adaptation actions among households in Nuevo Leon, Mexico (N = 622).

		Mitigation Action			Adaptation Action		
		Estimate	Odds Ratio	Sig.	Estimate	Odds Ratio	Sig.
Environmental concern	Did not mention	Ref.	1.000	–	Ref.	1.000	–
	Mentioned	0.343	1.410	0.095 *	–0.092	0.912	0.662
Climate change belief	Disagree	Ref.	1.000	–	Ref.	1.000	–
	Agree	–0.407	0.666	0.266	–0.699	0.497	0.058 *
	Strongly agree	–0.556	0.573	0.123	–0.957	0.384	0.009 ***
Awareness of causes	Natural causes	Ref.	1.000	–	Ref.	1.000	–
	Human activities	–0.487	0.614	0.227	–0.560	0.571	0.158
	Both human and natural	–0.429	0.651	0.290	–0.535	0.586	0.179
Climate change timing	Future	Ref.	1.000	–	Ref.	1.000	–
	Already occurring	0.150	1.161	0.601	0.191	1.210	0.520
Perceived risk	Beneficial or neutral effects	Ref.	1.000	–	Ref.	1.000	–
	Serious consequences	–0.084	0.919	0.716	–0.244	0.783	0.304
	Very serious consequences	0.027	1.027	0.917	–0.385	0.681	0.149
Knowledge of effects	Disagree	Ref.	1.000	–	Ref.	1.000	–
	Neutral	0.408	1.504	0.129	–0.538	0.584	0.060 *
	Agree	0.525	1.690	0.046 **	0.077	1.080	0.779
	Strongly agree	1.083	2.952	0.001 ***	0.349	1.418	0.283
Knowledge of responses	Strongly disagree	Ref.	1.000	–	Ref.	1.000	–
	Disagree	0.096	1.101	0.763	1.190	2.288	0.001 ***
	Neutral	0.792	2.209	0.016 **	3.213	2.484	0.000 ***
	Agree	1.487	4.422	0.000 ***	3.738	4.016	0.000 ***
Financial self-efficacy	Strongly agree	2.122	8.352	0.000 ***	5.737	8.024	0.000 ***
	Strongly disagree	Ref.	1.000	–	Ref.	1.000	–
	Disagree	0.396	1.486	0.144	0.630	1.877	0.027 **
	Neutral	0.675	1.964	0.018 **	0.942	2.566	0.002 ***
Social capital	Agree	0.542	1.720	0.078 *	1.437	4.209	0.000 ***
	Strongly agree	1.644	5.176	0.001 ***	1.774	5.896	0.001 ***
	Strongly disagree	Ref.	1.000	–	Ref.	1.000	–
	Disagree	0.050	1.051	0.896	0.183	1.201	0.647
Household setting	Neutral	0.004	1.004	0.992	0.552	1.737	0.146
	Agree	0.356	1.428	0.303	0.778	2.177	0.032 **
	Strongly agree	0.467	1.595	0.232	0.904	2.470	0.025 **
	Rural	Ref.	1.000	–	Ref.	1.000	–
Household income	Urban	–0.304	0.738	0.379	0.154	1.166	0.661
	Not reported	–0.188	0.828	0.545	0.208	1.231	0.518
	Less than \$5000	0.463	1.590	0.145	–0.070	0.932	0.827
	\$5,000 to 10,000	Ref.	1.000	–	Ref.	1.000	–
	\$10,000 to 20,000	–0.167	0.846	0.559	0.609	1.838	0.043 **
	\$20,000 to 30,000	0.196	1.216	0.527	0.649	1.914	0.044 **
	\$30,000 to 40,000	–0.288	0.750	0.418	1.118	3.057	0.002 ***
More than \$40,000	0.127	1.135	0.713	0.559	1.749	0.117	
Household size	Continuous	0.114	1.120	0.067 *	–0.051	0.951	0.433
	1	0.134	1.143	0.510	0.098	1.103	0.643
Household working members	2	Ref.	1.000	–	Ref.	1.000	–
	3	0.267	1.306	0.302	0.348	1.416	0.191
	4 or more	–0.506	0.603	0.110	0.048	1.049	0.883
	Other sources of income	–0.812	0.444	0.075 *	–0.276	0.759	0.564
Educational levels	Middle school or less	Ref.	1.000	–	Ref.	1.000	–
	High school	0.119	1.126	0.698	–0.387	0.679	0.209
	University	0.287	1.332	0.376	–0.687	0.503	0.038 **
	Postgraduate	–0.726	0.484	0.063 *	–1.165	0.312	0.004 ***
Gender	Female	Ref.	1.000	–	Ref.	1.000	–
	Male	–0.140	0.870	0.429	0.260	1.296	0.154
Age	Continuous	0.036	1.037	0.000 ***	0.012	1.013	0.073 *
	n	543			552		

\* p < 0.1; \*\* p < 0.05; \*\*\* p < 0.01.

Unexpectedly, in terms of educational levels, relative to those who had low levels of education, those who held a postgraduate degree were less likely to take mitigation action (OR = 0.484,  $p < 0.10$ ). An increase in age (OR = 1.037,  $p < 0.001$ ) was associated with an increase in the odds of reporting mitigation action. Non-significant variables associated with mitigation were belief in climate change, awareness of causes, climate change timing, perceived risk, social capital, household settings, household income, and gender.

#### 4.2.2. Adaptation Action

Somewhat surprisingly, for the variable, climate change belief, respondents who “agree” (OR = 1.037,  $p < 0.001$ ) or “strongly agree” (OR = 1.037,  $p < 0.001$ ) were less likely to have taken adaptation actions. As for knowledge of effects, those who reported feeling “neutral” (OR = 0.584,  $p < 0.10$ ) were less likely to report adaptation actions than those who “strongly disagree.” An increase in knowledge of responses increased the odds of implementing adaptation actions among those who responded “disagree” (OR = 2.288,  $p < 0.001$ ), “neutral” (OR = 2.484,  $p < 0.001$ ), “agree” (OR = 4.106,  $p < 0.001$ ), and “strongly agree” (OR = 8.024,  $p < 0.001$ ). An increase in financial self-efficacy increased the odds of having reported adaptation actions among those who responded “disagree” (OR = 1.877,  $p < 0.05$ ), “neutral” (OR = 2.566,  $p < 0.05$ ), “agree” (OR = 4.209,  $p < 0.001$ ), and “strongly agree” (OR = 5.896,  $p < 0.001$ ). As for social capital, an increase in one ordinal level of the categories “agree” (OR = 2.177,  $p < 0.05$ ) and “strongly agree” (OR = 2.470,  $p < 0.05$ ) raised the odds of reporting adaptation actions.

With regard to income, the odds of reporting higher levels of adaptation increased for those who answered within the MXN \$10,000 to 20,000 (OR = 1.838,  $p < 0.05$ ), \$20,000 to 30,000 (OR = 1.914,  $p < 0.05$ ), and \$30,000 to 40,000 (OR = 3.057,  $p < 0.01$ ) brackets, when compared to those with an income of \$5000 to 10,000 MXN per month. In addition, an increase in age increased the odds of reporting high levels of adaptation actions (OR = 1.013,  $p < 0.10$ ). Although this is significant at the  $p < 0.10$  level, the odds ratio is small, meaning that age does not substantially contribute to the outcome of the regression analysis. In relation to educational levels, respondents who reported holding a bachelor’s degree (OR = 0.503,  $p < 0.05$ ) or a postgrad degree (OR = 0.312,  $p < 0.01$ ) were more likely to report lower levels of adaptation. Non-significant variables in the model associated with adaptation were environmental concern, awareness of causes, climate change timing, perceived risk, household setting, household income, household size, working members, and gender.

#### 4.2.3. Qualitative Analysis

Of the 622 surveys received, 307 (49%) responded to the open-ended question: “What do you think motivates or would motivate your household to take action to address climate change?” Recoding the answers yielded nine main themes (Table 4). Five themes were covered by the theoretical model (Figure 1) and four emerged as new perception themes, namely “general knowledge,” “financial resources,” “government assistance,” and “education”. Financial self-efficacy was removed and the “financial resources” theme was created. This theme included components such as economic incentives and fines.

We split the respondents into four groups of households based on their stated climate change action. Across all groups, the most frequently mentioned theme was knowledge ( $n = 93$ ), followed by social capital ( $n = 56$ ) and climate change awareness ( $n = 49$ ). A closer inspection of Table 4 reveals that households who agreed with statement, “My household reduces the level of climate change,” mainly mentioned things related to knowledge, social capital, financial resources, and governmental assistance. For households who agreed with the statement, “My household is prepared to respond to climate change and its effects,” the highest frequencies were regarding knowledge, social capital, and awareness. This was also the case for the households who agreed with both statements and for those who disagreed with both statements.

**Table 4.** Respondents' perspectives regarding factors that motivate climate change action (n = 307).

Tags	Agreed with Statement "My Household Does Enough to Reduce Levels of Climate Change"		Agreed with Statement "My household is Prepared to Respond to Climate Change and Its Effects"		Agreed to Both Statements		Disagreed with Both Statements		Total n
	n	Illustrative Quote	n	Illustrative Quote	n	Illustrative Quote	n	Illustrative Quote	
<i>Themes derived from conceptual framework</i>									
Climate change awareness	6	"Become aware that we are already living with climate change." (R.521)	6	"Be more aware of our use of resources." (R.449)	8	"Be more aware of the reality of climate change." (R.398)	29	"We need extensive population awareness through media." (R.526)	49
Perceived risk	2	"Teach the consequences and how they could affect our home." (R.87)	2	"Gain consciousness of what can happen to us if we don't take measures." (R.529)	3	"Show us what happens when we do not help the planet." (R.418)	19	"Report on the risks that climate change entails." (R.85)	28
Knowledge of effects	3	"Know its causes and effects." (R.528)	3	"Have ideas on how we can help." (R.427)	7	"Informing us more about climate change." (R.235)	12	"Describe what we should specifically do." (R.13)	25
Knowledge of responses	3	"Know what you can do in those cases." (R.489)	8	"Learn about strategies that can be taken to tackle this problem." (R.8)	6	"Study the topic and learn about sustainable living practices." (R.448)	12	"Report on the causes of the damage." (R.89)	29
Social capital	9	"Participation of my family and community." (R.208)	7	"Teamwork as a family." (R.495)	10	"Mainly change and encourage my family to do the same." (R.532)	30	"Let the family cooperate!" (R.503)	56
Education	5	"Activities and workshops on environmental education focused on climate change." (R.582)	2	"Better education." (R.403)	6	"Encourage environmental education, especially among children." (R.514)	12	"Education and awareness in schools." (R.542)	25
<i>Emerging themes</i>									
General knowledge	11	"Better information." (R.32)	8	"Have digestible information at hand, something easy to understand." (R.533)	9	"Information of an urgent nature." (R.520)	65	"Provide information to create habits." (R.212)	93
Financial resources	8	"Finance households with energy-efficient products." (R.157)	6	"Have access to energy saving systems at a low price." (R.435)	7	"Subsidize the expenses of households that use clean energy." (R.215)	19	"Have access to products with low ecological footprint at lower cost." (R.95)	40
Government assistance	8	"Let the government get involved through sanctions." (R.193)	2	"Ask the government for help." (R.156)	5	"Communication and programs by the government." (R.12)	9	"The government secretariats related to this should help." (R.221)	24

1. Quotes were translated from Spanish to English. 2. The number in parenthesis represents the identification number of the survey.

Some respondents indicated that better information would lead them to make better decisions. For example, 29 respondents pointed out that they would like to know specific, relatively easy actions they can take to reduce the effects of climate change. The quality of information is important: "Offering better information in terms of truthfulness and quality" (R.522). Social capital and media play a key role in knowledge exchange: "First I would like to inform myself about what else I can do and then give that example to my family" (R.445).

Raising awareness was also considered important to address climate change: "If people were constantly reminded of the effects of climate change, they would be self-motivated" (R.456). Additionally, 15 responses reflected on the importance of climate change gaining more attention with the use of "awareness campaigns." When discussing motivators to take action, one respondent reflected that: "Programs to raise awareness to motivate the change of certain habits" (R.491). This is interesting, as our regression analysis showed that awareness does not contribute to taking more action.

A total of 26 responses reflected on themes related to perceived risk. Responses mostly centered on the need to recognize and understand what the risks related to climate change mean to their family, household, and community. Six responses reflected on the importance of addressing climate change in a timely manner, for instance: "We need to take early precautions" (R.531). Households also suggested the importance of financial resources ( $n = 40$ ). A few expressed concerns about their inability to pay for costly products, such as solar panels. A few other responses reflected on the extent to which respondents believed that the more economic resources they have (spanning from incentives and subsidies to having better employment), the more motivated they would be to address climate change: "Some discount vouchers that motivate the change of certain habits" (R.490).

The analysis also puts forward the notion that social capital is important to taking action. Participants stated that reliance on family, friends, and neighbors would enable them to take on climate change. Social capital was seen to play an important role even in households where there is no family relationship between members: "It really depends on the people I have for roommates, since many don't help at all" (R.438). However, a few responses also captured the impact of social capital acting as a barrier. For example, a few described a range of negative emotions as a reaction to the lack of support from other household members: "Because I don't bear any responsibility at home, nobody pays attention to my suggestions, so they are not important" (R.90).

Some 24 households emphasized that governmental authorities play a crucial role in combating the issue of climate change. For example, the government can help in the successful implementation of measures because they can promote the necessary changes in behavior, for example, by promoting technology: "Government subsidies to encourage the use of renewable energies" (R.415). A few openly criticized the lack of support from governmental authorities: "Authorities do not inform you, they think that nothing will happen or maybe they are just too busy" (R.172).

Another theme that emerged from our analysis was education. Participants acknowledged education was a necessary tool to address climate change and alluded to its value, especially for children of school age. Education was also usually connected to other themes, mainly awareness and knowledge, as they believed it would help children to understand and address climate change and its effects. A few described formal and informal approaches they believed would be helpful, such as the integration of environmental activities into academic curricula and neighborhood workshops.

## 5. Discussion

Perceived knowledge was a significant factor in explaining the extent to which households addressing climate change differentiated in terms of type of knowledge (climate change physics and how to respond). The importance of knowledge was not only shown by the regression analysis, but was also demonstrated in the qualitative analysis, with knowledge being the most mentioned theme among participants. All groups of households pointed out the need for more and better information about the principles of climate change and action they could take. This means that, if policymakers seek to motivate action among households, it is important to improve the accessibility of information that

focuses on the climate change phenomenon, its consequences and possible responses, and that this information is targeted at the household level.

The importance of financial self-efficacy was evident, as our results showed that households were more likely to take mitigation and adaptation actions if they felt it was within their financial capacity. This indicates that financial self-efficacy may be used to simultaneously promote mitigation and adaptation actions. To the best of our knowledge, this study is one of the first to bring financial self-efficacy into the climate change literature.

Age is another relevant factor for climate change action, as older household members are more likely to have taken part in both mitigation and adaptation measures. It may be that older household members benefit from having accumulated sufficient financial means that can facilitate the implementation of actions, even though research has found that younger people tend to be more concerned about the environment and express greater intended behavior [43].

Regarding education, our study identified that educated households were less likely to have reported taking climate change action. This is counterintuitive, as other evidence suggests that education is usually associated with climate change action [35]. This relationship may be partly explained because educated household members may recognize their own limitations. They may assume that they are doing less in comparison to the growing body of knowledge about mitigation and adaptation measures that can be used to limit the magnitude of climate change, therefore reporting doing less than what they are actually doing. Another possible explanation could be that they simply have a better living environment, which is less vulnerable to climate change. From our qualitative data analysis, many respondents were of the opinion that education level does play a role in taking climate change action. Further research is needed to explain this result.

Regarding environmental concern, the majority of household members listed issues that are more pressing in their lives, although the environment was still a concern among a few. These results concur with studies that demonstrate climate change is less of a priority to the general public compared to other issues such as the economy [17,44]. Nonetheless, our study provides evidence that those who hold environmental matters as a main concern are more likely to take mitigation action.

An increase in the number of people in the household would generally translate into a higher resources demand. Nonetheless, some mitigation measures appear to be affected positively by having additional members in the household. This could be due to a “household economies of scale,” in which emissions decrease with household size, as household members tend to share appliances and living space [45]. In contrast, a negative relationship was found between mitigation actions and households who do not have any members actively working, in other words, households in which there are other sources of incomes such as government pensions. This relationship might be explained by the fact that the majority of households that reported having other sources of income belong to single pensioners or pensioner couples.

One unexpected finding was that households who agreed that climate change was real were more likely to report low levels of adaptation. However, this anomaly can perhaps be attributed to the skewed distribution of responses, meaning that a high number of respondents already believed in climate change, when compared to those who did not believe in climate change or feel neutral about it.

Social capital was found to have a positive influence on household adaptation. In other words, a household’s reliance on family and friends significantly facilitates the adoption of adaptation measures against climate change. Our findings are in accordance with previous work that observed that social capital facilitates the adoption of adaptation measures by promoting exchange of information and resources [33,46]. This is validated by our qualitative analysis, as one of the main themes among responses was the importance of other household members to assist in taking action.

From the statistical analysis, we can observe that middle income households were taking adaptive actions. Middle income households were likely to carry out adaptation measures compared to lower income households as they have more assets to protect themselves against climate-related disasters.

Although the current study provided important insights into the influencing factors of household-level mitigation and adaptation, a few limitations should be noted. First, a methodological limitation was the use of the online survey. By using the online survey, we intended to reach segments of the population that would have been difficult to reach otherwise. However, if we assume that more educated and higher income households generally have better access to online resources, we may have a slight bias, as we have noted an over-representation of educated households and high-income households. Nonetheless, we decided to keep the online survey data because we believe we would be losing valuable data otherwise. Future research should pay more attention to the sampling of households. Second, a self-reported questionnaire was used to determine the levels of mitigation and adaptation, which may differ from observed measures of actual behavior. We focused on the stated behavior at the household level, but extra research would be required to establish the revealed actions. Related to this, our findings may be subject to under-report or over-report because respondents might not recognize that their actions are related to mitigation and adaptation.

## 6. Conclusions

Our study highlighted a range of factors that motivate mitigation and adaptation actions. We showed that apart from socio-demographic factors (i.e., age and education), perceptions are more prominent in influencing climate change action among households. We showed that perceived knowledge and financial self-efficacy are most important. Climate change awareness did not appear to be significant in taking climate change action, which we explain by the fact that the vast majority of the households were already climate aware. For our study among households in Nuevo Leon, Mexico, we can confirm our theoretical model (as proposed in Figure 1), which shows that perception variables are substantial factors in stimulating climate change action. The importance of the perceived risk of climate change was not revealed through regression analysis; however, it was regarded as important through our qualitative analysis. We also identified several themes from the open-ended question that were not covered by the theoretical model, including that some household members indicate that they perceive their educational level, general knowledge, financial resources, and government assistance to be important in their decision to take action or not. The ready availability of supportive infrastructure (e.g., recycling, public transport) was also important to taking climate change action [47].

For policy makers, this could suggest that focusing on perception factors rather than targeting specific socio-demographic groups might be effective at promoting climate change action. It means that providing information about different dimensions of climate change can be used in the development of plans and programs to facilitate action. It also means that improving confidence in economic management can be advantageous for households. This is important, as this is often overlooked. For local and state policy makers, efforts to reach target groups should not be only based on household socio-demographics, but should also take into account household perceptions of climate change.

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