

CLIMATE CHANGE AND INHABITANTS' PERCEPTION OF FLOOD RISK: PEÑÓN DE LOS BAÑOS, VENUSTIANO CARRANZA, MEXICO CITY, MEXICO

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ABSTRACT

Climate change represents a long-term variability, namely decades of state of the climate, as identified by means of a statistical analysis containing a record of weather changes over time. These climate changes, which include temperature and precipitation mean values, may arise from natural processes within the same climate system or from anthropogenic events. Therefore, it is a mistake to attribute any temperature changes or variations to climate change without having some records or other comparable climate studies, as climate change entails a change in all climate features as determined by meteorological variables. Both in Mexico and worldwide, weather changes have occurred and have been attributed to climate change. However, in populations where floods are recurring, it is worth learning what population understands by climate change, if they find it to be a cause of floods, and why. To this end, a population was sampled (the town of Peñón de los Baños, in Mexico City), and semi-structured interviews on flood causes were used to ask people about the connection of floods with climate change. The importance of this research was not only to learn whether climate change is a cause of floods, as compared to the science behind what climate change is, but what the population is suggesting that should be done to solve the problem of floods, and to take local actions that contribute directly to control climate change.

Keywords: climate change, perception, floods, mitigation, prevention.

1 INTRODUCTION

In the 1970s, people began to focus on problems caused by environmental degradation together with the possibility of seeing the natural resources essential to human beings reduced in the near future. Some of these problems include phenomena such as the creation of urban heat islands, extreme droughts, sea level rise, as well as hydrometeorological phenomena such as hurricanes, tornadoes, rains, and issues related to these, such as floods. According to Quiroz [1], all this made the studies on climate change and environmental issues a priority by the end of the twentieth century.

Due to these facts, scientists began to discuss climate changes from two different perspectives: the first one states that climate changes are due to anthropogenic activities, while the second one states that such changes are due to the climate variability that our planet develops periodically. Scientists who support the first perspective establish that global warming is the result of the Industrial Revolution that began in the middle of the 18th century. And to study the climate change phenomenon, the IPCC (Intergovernmental Panel on Climate Change) was created by the UNEP (United Nations Environment Program) and the WMO (World Meteorological Organization) in 1988.

In Mexico, climate change can be seen in ocean and land warming, as well as in the variation of rainfalls, changes in wind patterns, and increase in the occurrence and intensity of extreme hydrometeorological phenomena.

Mexico City is a particularly floodable zone because of it was established on a lake. And as a result of this, many boroughs and areas of the city experiment floods repeatedly.



For this reason, research on the causes of such floods was carried out in a case study: Peñón de los Baños in the borough of Venustiano Carranza. Since climate change is a global issue, it was considered relevant to ask the people from this borough how they would define climate change, and whether they consider it to be the cause of floods. All this was to know whether they have any proposals regarding this issue.

2 CLIMATE CHANGE IN MEXICO

A clear example of the point of view stating climate change as due to anthropogenic causes is a study of Cancún. Fig. 1, taken by the NASA Earth Observatory [2], shows urban sprawl in Cancún from 28 Mar. 1985 to 11 Apr. 2019. The study also states that this has caused environmental costs such as water pollution and beach erosion.

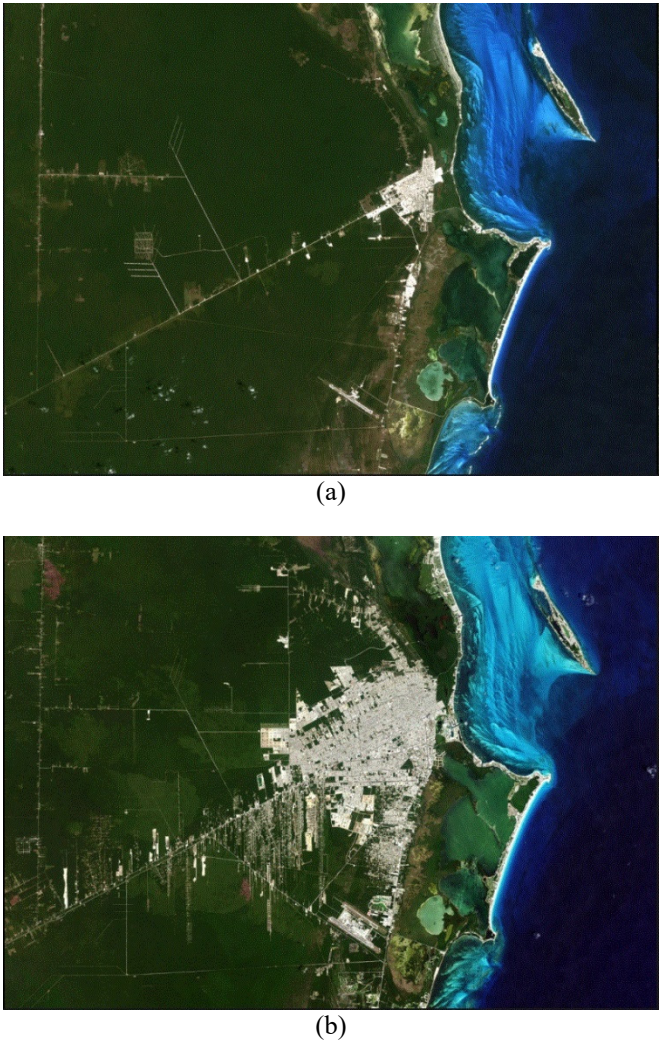


Figure 1: Urban sprawl in Cancún, Mexico. (a) 28 Mar. 1985; and (b) 11 Apr. 2019.

Another effect of climate change is rain that causes winds and sea level to rise and, at the same time, leads to floods. Mexico's National Water Commission (CONAGUA (Comisión Nacional del Agua)) establishes a wet season of 8 months, with the rainiest months being June, July, and August. But cyclic events such as the hurricane season and longer incidence intervals, e.g., the ENSO (El Niño-Southern Oscillation) phenomenon, may extend the wet season, as well as rainfall intensity and frequency.

Using accumulated precipitation maps from Mexico's National Weather Service (SMN (Servicio Meteorológico Nacional)) and the CONAGUA [3], we compiled Table 1, which shows that rainfalls in Mexico City have increased from 2013 to 2020 by more than 20 mm per year.

Table 1: Monthly accumulated precipitation in Mexico City, Jan. 2013–Jan. 2020.

Accumulated precipitation	
Year	mm
2013	0.5–5
2014	0–0.5
2015	0–0.5
2016	10–20
2017	0–0.5
2018	10–20
2019	0.5–5
2020	20–35

According to Trucco [4], areas to the east and west of the city stand out, as maximum rainfalls within a 24-hour period have reached 100 mm. These intense and short-duration rainfalls usually cause more flood damage in poorly planned streets or where drainage is insufficient, because initially it was not planned for the amount of water running through the pipelines. Heavy rains also cause unstable mudslides on the mountainside, where there usually are regular or irregular human settlements in Mexico City.

Tools such as forecasting models are needed to study climate change. And to that effect, Martínez et al. [5] indicate that, for using and developing any other kind of model, it is important to take into account the multidecadal variability of the climate system regarding its practicability, since it may influence anthropogenic activities.

Basic instruments for climate forecasting are atmosphere–ocean general circulation models (AOGCMs). In Mexico, information for such models is available, e.g., CMIP3 and CMIP5 (Coupled Model Intercomparison Project). From these two, the CMIP5 is slightly superior because it allows a better explanation of seasonal periods, among other scientific aspects regarding the weather on a time scale of decades, according to Taylor et al. [6] and Knutti and Sedláček [7].

Martínez et al [5] also point out that other relevant models to study the climate in Mexico are the regional climate models. These provide more detailed information and increase spatial resolution of the regional climate. These models show the climate change associated over regions with complex orographic and continent–ocean characteristics only shown in high resolution models [8]. There are also intermediate-complexity models more frequently used by some Mexican meteorologists. Some of the regional models are Mann–Kendall test and Sen's slope estimator, which are non-parametric methods used to spot important trends within the long-term temperature and precipitation time series.



These forecasting models aim for strengthening the coordination and communication within the General Office of the SMN and the CONAGUA, for the staff to know the country's weather situation and, as a result, perform its functions based on the institutional requirements.

The SMN has 189 automatic weather stations (AWSs) throughout the Mexican territory, which provide information to make FV3-GFS numerical forecasting models where the accumulated precipitation and the surface wind are measured (example in Fig. 2). These models can be used to monitor ambient temperature (C), wind speed (km/h), surface pressure (hPa), accumulated pressure per hour (mm), and solar irradiance (W/m²) regionally. And meteograms per region are obtained as a result of all these models.

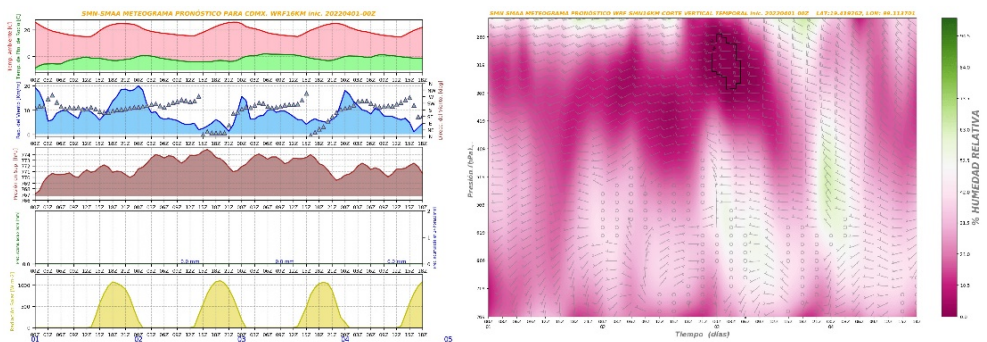


Figure 2: Meteograms – Venustiano Carranza, Mexico City [9].

Three factors could explain the reasons for which there are few studies on climate change in Mexico, like the ones mentioned herein. The first factor is the weather information registered throughout the country. It is related to the fact that huge differences exist among the equipment used in large cities compared to those used in small towns or villages where the equipment is limited. The second important factor is methodological and refers to the kinds of models used to perform the different analyses: mainly general circulation models for studies at the planetary level and regional climate models. However, all types of models pose problems related to the inclusion of data and the complex behavior of the climate variability processes observed in our planet decade after decade, as well as the climate variability levels generated by anthropogenic activities such as combustion and greenhouse gas (GHG) emissions.

It is essential to compare Mexico's law and regulations related to the strategies of mitigation and adaptation to climate change to the public policies that have the same goals regarding climate change strategies and programs established at federal and local (Mexico City) levels.

Climate change plans and programs currently in force in Mexico City are: 2014–2020 Mexico City Climate Action Program, focused on improving the quality of life and sustainable development with a low-carbon intensity in the City and 2019–2024 Mexico City Environment and Climate Change Program, which consists of seven main lines: (1) replanting: country and city; (2) saving rivers and bodies of water; (3) sustainable water management; (4) zero waste; (5) integrated strategies for a sustainable mobility; (6) air quality; and (7) solar city.



3 PERCEIVING CLIMATE CHANGE AS THE CAUSE OF FLOODS

In order to know what people think about climate change and its relation to the recurrence of floods, a study case was chosen: Peñón de los Baños (divided into three districts: Los Reyes, El Carmen, and La Asunción), shown in Fig. 3. This district is a 1.59 km² area with 8,700 inhabitants in the Venustiano Carranza borough within Mexico City (a 33.42 km² area), according to Mexico's National Institute of Statistics and Geography (INEGI (Instituto Nacional de Estadística, Geografía e Informática)) in 2010.

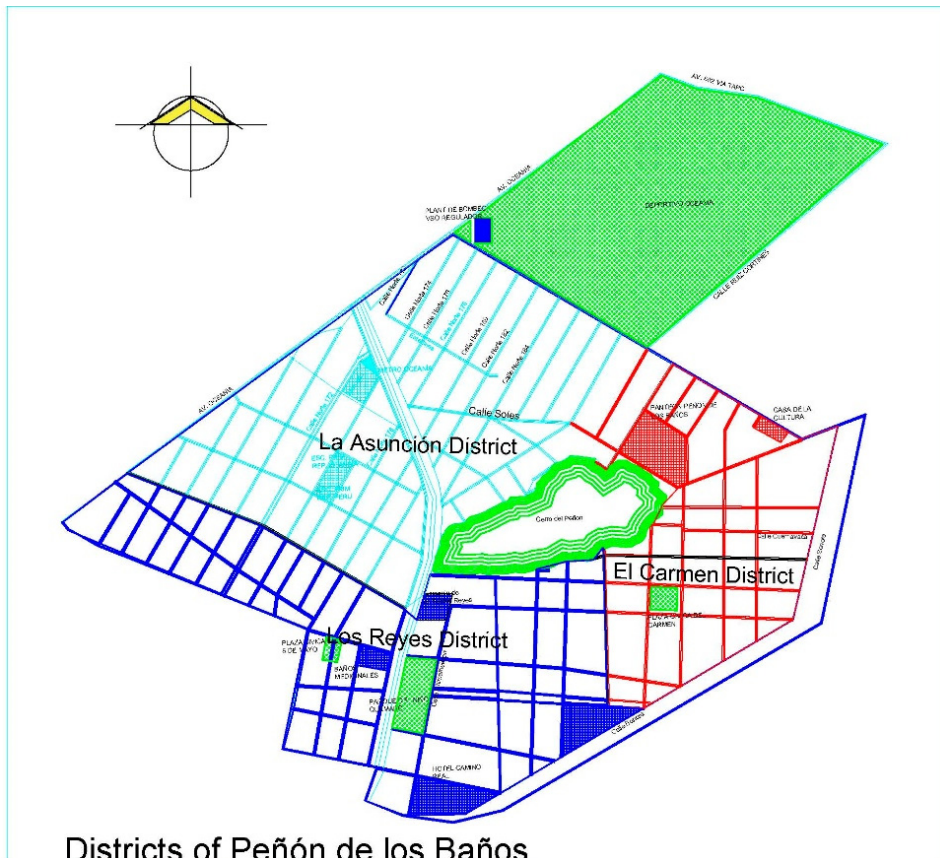


Figure 3: Districts of Peñón de los Baños.

Due to the COVID-19 pandemic worldwide, a total of six semi-structured interviews were conducted on representatives of the different districts of Peñón de los Baños. Since the sample population is located in a zone of frequent floods, and the general project is about climate change and risk, seven questions regarding this problem were asked to the population so as to know their perception of climate change and its relation to flood risk, i.e., how people currently understand climate change and whether they see it as a cause of floods in Peñón de los Baños. The questions asked are:

1. How would you define climate change?
2. Do you think that floods are caused by climate change?

3. Do you think that rains are caused by climate change?
4. If you believe that climate change is something unavoidable, what would you do to adapt to it?
5. Do you think you can help reverse climate change? If so, what would you have to do to help mitigate climate change?
6. Would you like to know what climate change is?
7. Would you like to receive information on climate change? How would you like to receive the information (workshops, leaflets, etc.)?

4 RESULTS AND ANALYSIS

For the purpose of obtaining the results, Peñón de los Baños was divided into three zones depending on the flood levels. Native neighbors representing each zone who know the rest of the population were interviewed. In turn, they asked the interview questions to the population of their corresponding zone.

Fig. 4 shows the location of zones and interviews: In Zone 1, where waters reach up to 1.20 m high, one interview was conducted. In Zone 2, where waters reach up to 1.00 m high, two interviews were conducted. In Zone 3, where waters reach up to 0.50 m high, three interviews were conducted. And a neighbor from the upper part of Peñón de los Baños was also interviewed because, even if this person's home does not flood, the low part of the area is affected by the floods, and the access to this person's home is through the flooded zones.

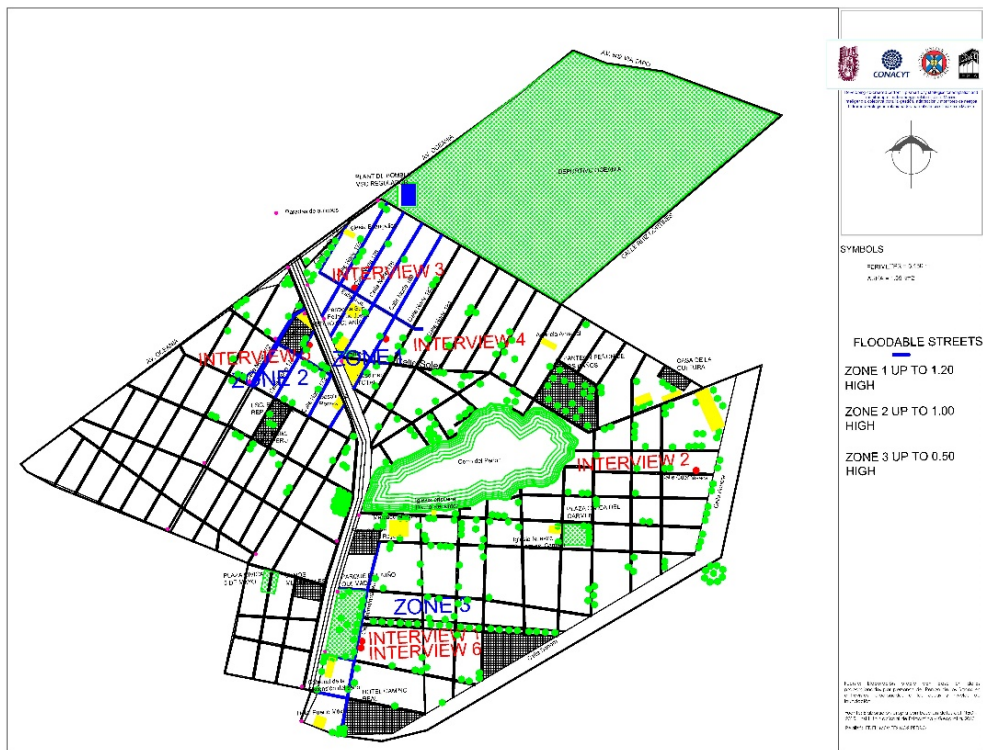


Figure 4: Localization of zones and interviews conducted in Peñón de los Baños.



5 INTERVIEWS

5.1 Merchant (Zone 1)

“Climate change is a change in natural phenomena such as rains and earthquakes”.

5.2 Retired person (Zone 2)

“Climate change is something we all pay attention to when it affects us. We know that we are facing floods because climate change causes the Earth’s poles to melt, then, water levels start rising. So, climate change manifests through rains and poles melting. I think that we haven’t faced climate change at its full extent. And hurricanes are also part of this problem that we are seeing now, but we haven’t paid as much attention to this as we should. Climate change is due to all that we have done to damage our planet and the environment. Factories and water pollution are things we have done to destroy our planet. Climate change should be addressed because, if we wait more time, there will be no turning back. Starting with the presidents, who cannot agree on this matter, such as the President of the United States, who is looking at things from an economic point of view, or Korea and all those countries, dropping bombs and all. I think that, far from being helpful and rational, they’re not thinking in doing good things but wrong things. They are being materialistic, but we need to start becoming self-aware”.

5.3 Teacher (Zone 2)

“Climate change is ruining our world because of all the factories, cars, garbage, trash, and spray products that we consume. All these have contributed to affect the atmosphere and we will continue to deplete our natural resources, flora, and fauna. In the end, we are depleting all our resources. Even fires come out of nowhere, and everything is coming to an end. Climate change is the result of human beings”.

5.4 Town chronicler 1 (Zone 3)

“Climate change is very important. Time is running out for us and climate change is here. It is a natural phenomenon. Our president is not doing anything to fix it, and all that impacts the system, such as health, water system, and weather system. For example, a sign of climate change is what happens in Mexicali during May when the temperature is 60°C at midnight, or right now during the rainy season in Oaxaca’s isthmus or Chiapas where the temperature is 42°C day and night during the hurricane season. Climate change is here, and the Federal Government and the Local Government haven’t done anything. As an expert on the environment, the current Secretary of Environment got sucked into controversy with the President on this matter, but the President does not worry about it. It’s sad! Nowadays all Mexicans should sit down and do self-analysis; live consciously and apply preventive measures because climate change is coming, and it is coming strong. Let’s not forget that we have coastlines and, in this case, two oceans, gulfs, and rivers, but the authorities don’t care. They are ignorant and unmoved on the matter. Yesterday, the newspaper ‘La Jornada’ published a piece of news saying that the city will face a 30-day water shortage. There have been no rains, and the dams in the Peñón (de los Baños) town don’t have enough water. The Head of Government hasn’t worried about the water shortage. The Government is more concerned with supplying water to hotels and the airport than to the citizens. I live here, and here I see and hear people saying that climate change prevention programs are needed,



starting with food programs such as: teaching people how to eat healthy, balanced, but there is no empathy on the part of the government. Watch out! Because if we don't implement something to fight climate change soon, there will be trouble".

5.5 Town chronicler 2 (Zone 3)

"Climate change is related to environmental matters, cleanliness, not littering. It is also related to geological changes and changes in rains caused by different elements, such as pollution. Not only pollution caused by waste, but the one caused by carbon dioxide and other kinds of particles that are affecting the atmosphere, i.e., changes during the rainy season and during droughts as well. And obviously, this impacts the quality of life of human beings".

5.6 Postdoctoral person (Zone 3)

"Climate change is how human beings have intervened in the normal environmental cycle. They have affected it in such a way that they have altered the seasons of the year and wet season, increasing heat waves and deforestation".

5.7 Interview analysis

In general, people who were directly or indirectly interviewed connected climate change to the increase in rainfalls and, subsequently, to the cause of greater floods. Besides, depending on their surroundings, they identified four problems (Table 2) related to flood risk. When they were asked about potential solutions, they mentioned things that are directly related to littering.

Litter causes floods because it accumulates and blocks drains. And the solution does not depend on the authorities, but on the population that recognizes their responsibility of keeping their neighborhoods clean. Besides the litter issue, people suggest promoting citizen participation and the adoption of awareness-raising campaigns, beginning with teaching about climate change and the role that litter play. They are aware that making environment education campaigns would help mitigate both problems: floods and climate change.

People notice the weather changes such as the increase in temperature and distressing phenomena such as unusual rainfall. For this reason, they suggest working together with the authorities, since, on the one hand, they face floods and, on the other hand, they face water shortages at home. In view of that, they suggest recycling rainwater and invite again the relevant authorities to work together with them, since they need the government to authorize the resources required to have adequate infrastructure.

People are asking to be heard and to be able to participate with the government in programs focused on climate change since they can brainstorm ideas to take local actions and contribute to controlling climate change and stopping our planet's destruction.

6 CONCLUSION

Although climate change is a phenomenon currently affecting the globe, it is understood as long-term climate variability and can be seen from two different scientific perspectives: (1) the climate variability caused by the life cycle of the planet; and (2) the climate variability directly related to anthropogenic activities.

In countries such as Mexico, climate change affects the ocean and land temperatures, which are monitored by the NASA Earth Observatory. At the same time, to study this issue, the SMN and the CONAGUA conduct tests and implement models such as Mann-Kendall's and Sen's.



Table 2: Problems and proposals of the inhabitants of Peñón de los Baños (Venustiano Carranza borough, Mexico City), related to climate change and flood risk.

Problems	Inhabitants' needs	Possible inhabitants' suggestions
Regulating reservoir	1. To be informed of the amount of water in the reservoir and if it will collect more water 2. Someone who monitors its maintenance 3. Someone in charge of it	Someone in charge trained with the knowledge and the tools necessary to be on the alert for anything and inform the corresponding people or entities
Litter	1. To pick up the leaves of the trees 2. Not to litter 3. To clean the drainage 4. To know if the drainage capacity is enough	Campaigns for collecting litter and maintaining the drainage
Infrastructure	1. To follow up on health issues arising after floods 2. To follow up on material losses 3. To give advice and warn about floods 4. Government economic aid for housing maintenance 5. Prevention programs 6. Road improvement	Use of social media, cameras, workshops
Additional comments	1. Roads are blocked by customs transportations 2. There is a water shortage, so there is a need for recycling water	Citizen participation

More locally, in Mexico City, there are two significant programs regarding climate change: the 2014–2020 Mexico City Climate Action Program (expired) and the 2019–2024 Mexico City Environment and Climate Change Program (in force). These programs aim to address the issues by involving citizens.

However, to address the issue, it is necessary to know at a micro-local level whether the population affected by floods understood what climate change is, whether they knew it existed or not, and whether they related it to floods.

At a government level, strategies are presented with the aim of addressing the climate change issue downward, i.e., the issues are not addressed along with the population – perhaps because it is believed that they do not understand what climate change is. However, results show just the opposite: The population associates climate change with floods and they also understand that it is caused by man, which is the first scientific perspective, i.e., the one that relates climate change to anthropogenic activities.

The key is that population not only understands what climate change is, but they are aware of the problem and make proposals to address this issue. These proposals are related to climate change dissemination and workshops in which they are willing to take part and are

formulated by them along with the government, as they understand that the government is the one having the necessary resources to carry out such dissemination and workshops.

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