GeoJournal
https://doi.org/10.1007/s10708-023-10978-4

# Exploring climate change perceptions, climate trends and the level of knowledge on the subject in farmers from Guasave, Mexico

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Accepted: 20 October 2023


**Abstract** Climate change has adverse consequences for socioeconomic activities such as agriculture, as it can affect crop yields and production costs. Farmers' adaptation to the impacts caused by this phenomenon may be limited because they do not perceive the problem, have limited knowledge of the subject or by lack of willingness to change certain behaviors. In this way, the objectives of this research were to know the farmers' perception of climate change, if what they perceive match with the trends of the climate records of temperature and rainfall, as well as to assess the level of knowledge that farmers have about climate change. This with the purpose of laying the foundations for the adaptation to climate change in the municipality of Guasave, Sinaloa, Mexico. A structured survey was applied in 1111 agricultural households selected at random and proportionally in 153 communities. The results show that 43% of respondents have an acceptable level of knowledge about climate change and that 89.4% perceive changes in climate, mainly in temperature, but this is not statistically corroborated with climate records. Likewise, 52.2% attribute the problem to anthropogenic causes, mainly pollution. They point out that this phenomenon could decrease agricultural production; generate higher electricity consumption and a higher incidence of diseases. The vast majority of respondents is willing to implement actions to minimize the problem and its impact on the region; however, an awareness-raising program is needed about the problem (causes, impacts, and the way to face it).

**Keywords** Adaptation · Agriculture · Climate change · Knowledge · Perception

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## Introduction

Climate change is currently one of humanity's biggest challenges (Abera & Tesema, 2019; Arbuckle et al., 2013; Harun et al., 2014). According to scientific evidence, this change in climate is occurring due to human influence by the execution of activities such as the burning of fossil fuels, industry, deforestation, changes in land use, among others (IPCC, ). This phenomenon is causing the modification of stable weather patterns, which are now unpredictable and increasingly threatening (Findlater et al., 2018; Ricart et al., 2018). Climate change has significant adverse

Published online: 04 November 2023

consequences for the world's ecosystems and societies, by affecting socio-economic activities, health, livelihoods, and food security (Amjath-Babu et al., 2016; Ayanlade et al., 2017; IPCC, 2022). Although this is considered to be a global phenomenon, the severity of its effects differs significantly between regions, countries, and socioeconomic levels (Abera & Tesema, 2019). In such a way, developing countries are likely to be more affected, due to their socioeconomic status and their inability to face the impacts of climate change (Adger et al., 2003; Ajuang et al., 2016).

Mexico is potentially vulnerable to climate change due to its geographical position and the socio-economic conditions of its population (González et al., 2019). The impacts of this phenomenon are expected to be distributed heterogeneously in the country, depending on factors such as climate, the distribution of natural resources, and economic development (Sosa-Rodríguez, 2015). Evidence shows that rural livelihoods in this country are being affected by climate change through droughts, desertification, hurricanes, and floods. It is even estimated that 28 million people in Mexico are exposed to a high risk of disasters such as hurricanes and floods (Banco Mundial, 2013).

Among the most sensitive livelihoods to climate change agriculture can be considered, since changes in the climate can affect crop yields, production costs, and indirectly relative crop prices (Attavanich et al., 2014; Dinesh et al., 2018; IPCC, 2022). In this sense, climate change becomes a new challenge for rural communities, especially those dependent on agriculture, because it enhances existing vulnerabilities and it also can contribute to worsening the poverty conditions of the population (Gallardo-Milanés & Hardy-Casado, 2016). In view of this situation, there is a need to adopt adaptation strategies focused on reducing the impact of climate change. However, adaptation to the impacts and risks caused by this phenomenon may be limited, among other factors, by a lack of knowledge about the causes and effects of climate change, as well as by the unwillingness of the population involved to change certain behaviors (Adger et al., 2009; Niles & Mueller, 2016).

According to Adiyoga (2018), and Ali and Rose (2021), the adaptation process to reduce the impacts of climate change in the agricultural sector also requires that farmers can perceive that the climate is indeed changing. In this way, Das (2009) reported that it is very important to understand farmers' perception of climate change, as this would know their willingness to consider some adjustments to their production practices. Similarly, Briggs (2013), and Asare-Nuamah and Botchway (2019) agreed that local knowledge and perception are important as tools for the design of policies focused on improving development.

Therefore, the objectives of the present research were: (1) to know the farmers' perception of climate change, (2) to identify if what farmers perceive match with the trends of the climate records of temperature and rainfall, (3) to assess the level of knowledge that farmers have about climate change. The study area was Guasave, Sinaloa, Mexico, a municipality with livelihoods based primarily on agriculture. The study's findings provide a basic contribution to the design of climate change awareness and adaptation programs in the region; however, additional research is required.

## Literature review

According to the IPCC (2007), climate change is a change in the state of the climate that can be identified as long-term trends in the mean of climate variables over decades or long time periods. This change can be attributed directly or indirectly to human activity, which alters the composition of the global atmosphere, through the generation of greenhouse gases (GHG). Mitigation, understood as the implementation of policies to reduce GHG emissions and improve sinks (IPCC, 2014), could be the best way to deal with climate change; however, a lot of time and financial resources are required to have satisfactory results with this strategy (Ali & Rose, 2021). Therefore, it is necessary to complement mitigation with adaptation, in this sense, adaptation to climate change is defined as the process of adjustment to the real or expected climate and its effects to reduce or avoid damage or take advantage of its beneficial opportunities (IPCC, 2014). Among the adaptation actions that are applicable for agricultural activity and that are most reported by the literature, it is possible to mention change crops, improvement of irrigation infrastructure, use of improved seed, changes in the crop calendar, and contracting of agricultural insurance (Ricart et al., 2018;

Orduño-Torres et al., 2019; Viguera et al., 2019a; Biswas et al., 2020; Tessema & Simane, 2021).

It is argued that all societies can be adaptable; however, their perception, education, and knowledge about climate change is critical (Ali & Rose, 2021). Perception is a form of information processing whereby automatic tasks related to sensory reflexes are coupled with more controlled tasks related to cognitive activity (Riviere-Honegger et al., 2015). People's perception of climate change can affect how they will respond and adapt to its multiple impacts (Woldeamlak, 2012). In this way, for the population to be able to take adaptation measures to climate change, they must first recognize it. Education fosters the development of appropriate awareness, knowledge, attitude and capacity to change farmers' perception of participating in activities focused on preventing or mitigating climate change (Eneji et al., 2020).

Studies around the world have suggested the relevance of local perceptions and local knowledge in climate change research. Likewise, they have also reported the perception of changes in the climate by farmers (Abera & Tesema, 2019; Asare-Nuamah & Botchway, 2019; Ayanlade et al., 2017; Oluwatimilehin & Ayanlade, 2021; Ricart et al., 2018; Shi-yan et al., 2018; Soares et al., 2018; Tessema & Simane, 2021; Viguera et al., 2019a, 2019b; Waibel et al., 2018).

With reference to the studies that compare farmers' perception of climate change with meteorological data, most of the articles reviewed indicate that the population has observed changes in temperature and precipitation; however, in many of them the statistical analyzes carried out on the climatic data do not corroborate these observed changes (Asare-Nuamah & Botchway, 2019; Atube et al., 2022; Niles & Mueller, 2016; Panda, 2016). Among the authors who found consistency between the climatic data and the farmers' observations, it is possible to mention Ayanlade et al. (2017) and Limantol et al. (2016), the first authors found match in precipitation and the second in temperature.

Ayanlade et al. (2017) reported that some scientists perceive that rural farmers' knowledge of climate change is insufficient for reliable adaptation. This is the case of several studies that report that although, farmers recognize climate change; their explanations of the causes that generate it contrast with the scientific explanation of the problem (Abera & Tesema, 2019; Ishaya & Abaje, 2008; Munthali et al., 2016; Ozor et al., 2015; Soares et al., 2018).

In this context, concern arises to evaluate these aspects in the municipality of Guasave, Sinaloa, Mexico, whose economy is mainly based on agriculture.

## Materials and methods

### Study area

The study was carried out in the municipality of Guasave located in the North of the State of Sinaloa, Mexico (Fig. 1). This municipality has a total population of 289,370 inhabitants (INEGI, 2021) and a surface area of 3464 $km^2$. The economically active population (EAP) represents 29% of the population and the main livelihood are based on primary activities, mainly agriculture (H. Ayuntamiento de Guasave, 2022). The average annual temperature of the municipality is 25.5 °C and the average annual rainfall is 423 mm (CICESE, 2022). The types of climate that occur are very dry, very hot, and warm (51.95%); dry, very hot, and warm (43.58%); and semi-dry, very hot, and warm (4.47%). The dominant soil types are Kastañozem (62.6%), located mainly in the agricultural area and Solonchack (21.7%), distributed in the coast area (INEGI, 2009).

It is important to mention that Guasave was chosen to develop this study, because it is considered the agricultural heart of Mexico. The economy of this municipality is based mainly on agriculture, since this activity is carried out in 70% of the municipal surface (H. Ayuntamiento de Guasave, 2022). In this region are located two of the largest irrigation districts in Mexico (075 and 063), which occupy the first and sixth place in irrigated physical surface, and the first and eighth place with respect to the economic value of agricultural production (CONAGUA, 2018).

### Study techniques and methods

Primary and secondary data were used to conduct the study. Primary data were collected through a face-to-face household survey and secondary data were obtained from two weather stations located in the project's area of influence. The face-to-face survey data was used to know people's perception of climate change, assess their understanding of the

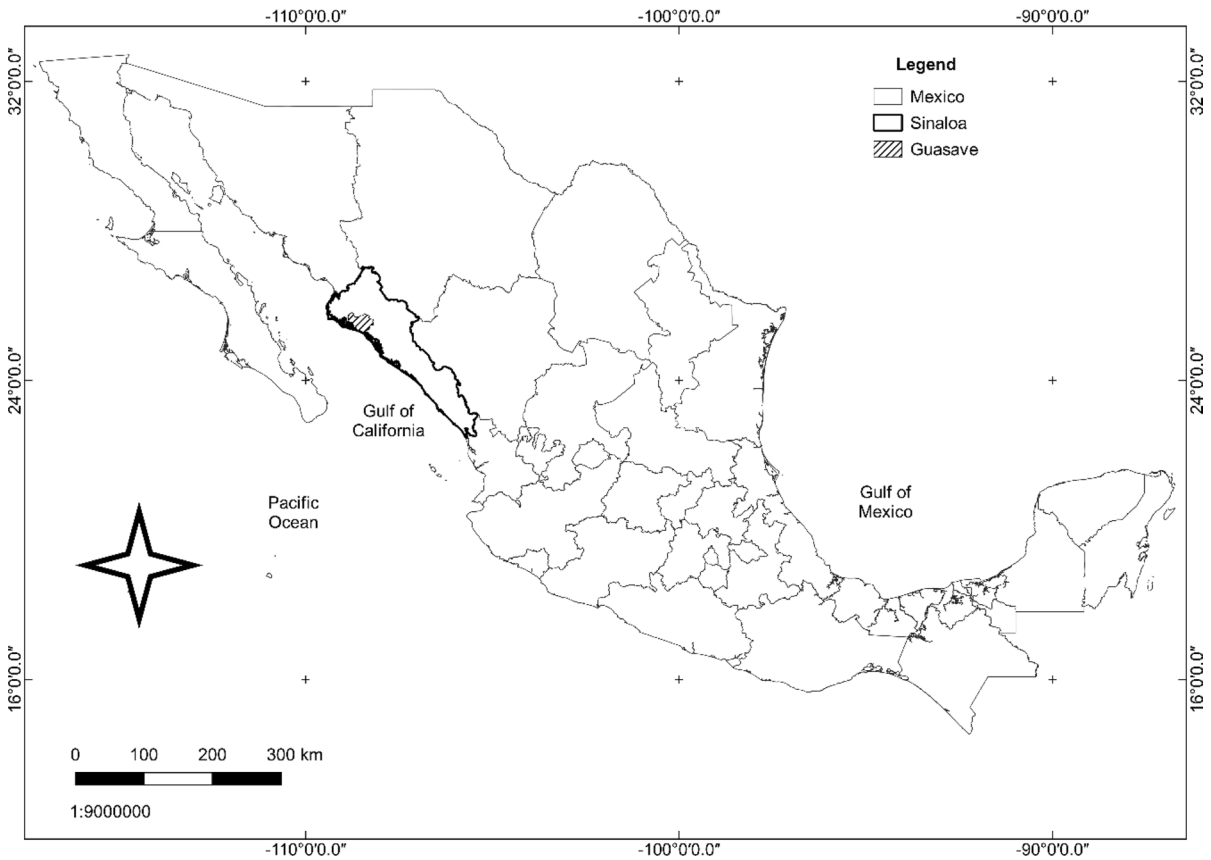


**Fig. 1** Location of the municipality of Guasave, Sinaloa. Source: Elaborated by the authors

issue, as well as measure the level of future commitment that farmers assume to be part of solving the problem.

For the application of the survey, a stratified random sampling was used of those households that had income from agriculture. In total, 1111 surveys distributed in 156 rural communities were applied in the period from June to December 2019. This sample size was determined based on the formula of finite populations, with a confidence level of 96%, a supported error of 3% and a success probability of 0.5. As already mentioned, the survey was face to face and the interviewer was the one who filled out the survey with the responses of the farmers. Special care was taken to protect the personal information of the respondents and even the people's name was not requested. In order to verify the consistency and logical flow of the questions, a pilot test was carried out; from this, some adjustments were made to the questionnaire to make it more coherent. In addition, the instrument was shared with expert colleagues in the field to seek validation.

The first part of the questionnaire focused on issues relating to the farmer's age, type of housing, household income-generating activities, and damage to housing due to climate issues. The second part addressed the issue of farmers' perception of climate change. This section of the questionnaire consisted of two questions, the first to know if farmers perceived climate change, with a dichotomous answer of yes or no. In this way, those who said they perceived climate change were asked in what climatic variables they perceived this changes. This last question was open-ended to the respondent; however, the interviewer had four options in which he or she could locate the answer, including temperature and rainfall.

The third part of the survey addressed the level of knowledge that the farmers have about climate change and the repercussions that this phenomenon would has in the region. In this section, six questions were

used, the first one to know if farmers had heard the term climate change and the next was to determine with what aspect they related this phenomenon. In the third question, they were asked whether they understood that term; in case their answer was affirmative, they were asked what they understood by climate change. The last two questions in this section focused on the causes of climate change and the impacts that it could cause in the region. Most of the questions were open-ended to the respondent, but each of them had options with which the interviewer related the answers. At the end of this section and based on the responses issued by the farmer, the interviewer determined whether this person had full knowledge about the nature and concept of climate change.

Finally, the last part of the questionnaire referred to the level of commitment that the farmers may have to face the problem in the near future, including questions regarding their willingness to implement mitigation and adaptation measures. They were also asked if they had implemented any adaptation measures to be less affected by climate change and what kind of measure.

In relation to the climatic records, average annual temperature and average annual precipitation data for 30 years from the period 1985–2014 (the most current data available) from GUASAVE (DGE)-SIN and ZOPILOTE-SIN weather stations were used. These records were obtained from the national climatological database (Sistema CLICOM) (CICESE, 2022). These data were analyzed in Excel 2013 and XLSTAT 2022 to detect trends, as well as to verify if what people perceive agrees with reality. To detect linear trends in the temperature and precipitation time series, the nonparametric Mann–Kendall test was used with a confidence level of 95%, many researchers have used this test with this type of data (Alencar & Silva, 2017; Asare-Nuamah & Botchway, 2019; Limantol et al., 2016; Panda, 2016;). It is important to mention that among the techniques used to perform trend analysis, the Mann–Kendall test is the one recommended by the World Meteorological Organization (WMO) (Alencar & Silva, 2017), likewise, for Berger (1986), this test is the most appropriate method to analyze climatic trends.

With the data collected from the survey, descriptive statistics were calculated to analyse the demographic information of the farmers and their homes, their level of knowledge about climate change, their perception related to it; as well as their level of commitment to deal with the problem in the near future. Finally, from the results it is inferred about some actions that could be developed to minimize the impact of climate change in the study region.

## Results

### Characteristics of farmers and of their housing

Most of the surveyed farmers were older than 50 years (56.6%) with several years of experience in agricultural activity; the female sex represented 17% of the sample. Most households reported income from agricultural activity only; however, 3.1% reported income from other primary activities (fishing and livestock) and 16.2% also receive income from other economic activities (commerce, education, transport, industry, among others). In this way, of the total economic income received by the surveyed farmers, 60% comes from primary activities.

In relation to housing, 1% is considered to be in very good condition (according to the number of rooms and the quality of walls, floors, and ceilings), 51% in acceptable condition and 48% in precarious condition. Of these, 26% have suffered some type of damage due to weather-related phenomena, especially those homes located near riverbeds, streams or flooded areas.

### Farmers' perception of climate change

Regarding to farmers' perception, the first question posed focused on identifying whether farmers had perceived changes in the climate in recent years. As a result, 89.4% of those surveyed responded that they had noticed some type of change in the region's climate. Of the farmers who reported perceiving a change in the climate, the vast majority (96.6%) reported an increasing trend in temperature.

In relation to precipitation, 58.6% of respondents who say they perceive changes in the climate have also noticed some kind of change in rainfall. They mention that perceive a decrease in precipitation, they also observe a delay of the rainy season, in addition, to the fact that there is a decrease in rain events; however, the amount of rain for each event is regularly greater in relation to past times.

Temperature and precipitation trends

The trend line of the average annual temperature of the period 1985–2014 recorded at the GUASAVE (DGE)-SIN weather station indicates a small increase over the years (Fig. 2). However, the Mann–Kendall test indicated that this trend is not significant ($p=0.061$). The average annual temperature for this period was 25.5 °C, the highest temperature occurred in 2014 with an annual average of 26.35 °C, while the lowest was recorded in 1985 with an annual average of 24.65. In the case of the ZOPILOTE-SIN weather station, the trend line of the average annual temperature recorded for the same period also indicates a small increasing trend (Fig. 2), but it is not significant either ($p=0.066$). For this station, the average annual temperature was 24.6 °C, the highest average temperature was also recorded in 2014 (25.7 °C), while the lowest took place in 2004 (23.57 °C).

The trend line of the average annual precipitation in the GUASAVE (DGE)-SIN weather station for the period 1985–2014 shows a slight decrease over the years (Fig. 3). However, according to the Mann–Kendall test, this decrease is not significant ($p=0.121$). The average annual rainfall for this

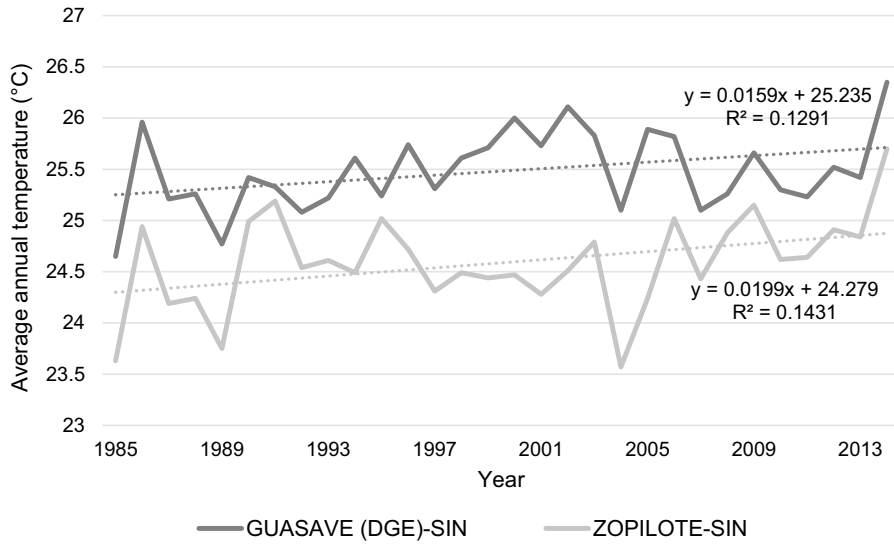


**Fig. 2** Average annual temperature trends. Source: Elaborated by the authors with data from CICESE (2022)

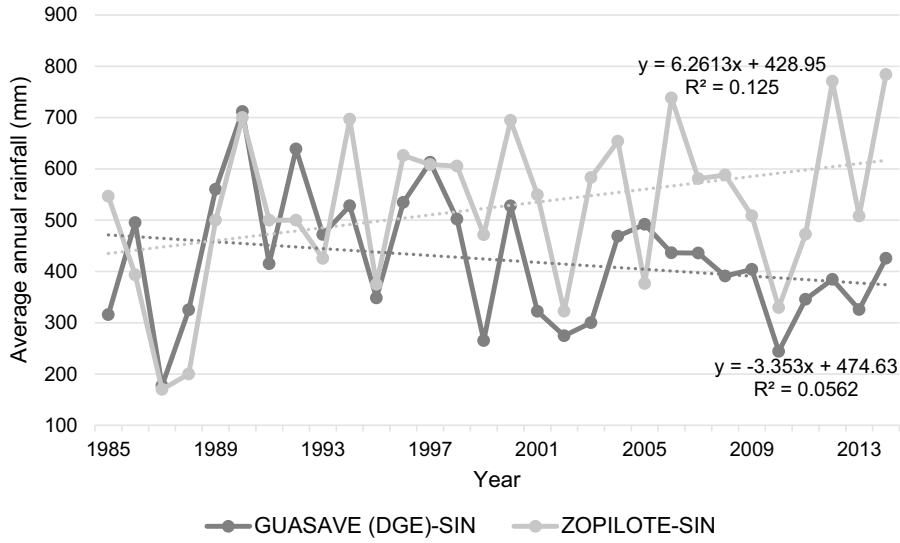


**Fig. 3** Average annual rainfall trends. Source: Elaborated by the authors with data from CICESE (2022)

period was 422.7 mm, the highest average rainfall was recorded in 1990 (711 mm), and the lowest in 1987 (177.4 mm). In the case of the ZOPILOTE-SIN weather station, the trend line shows a slight increase in average annual precipitation (Fig. 3) without being significant ($p=0.134$). The average annual rainfall for the period evaluated in this station was 526 mm, the highest value was recorded in 2014 (784 mm), and the lowest value in 1987 (170 mm).

## Understanding of climate change

Most of the surveyed population (81.2%) reported having heard the term climate change, mainly on television; however, only 66.5% answered understand it. To get a conclusion about the level of knowledge based on the answer to the question is the term climate change understood by you? Could be very misleading as it's a very general question. In this way, those who answered whether to understand what climate change is were asked a series of questions to corroborate whether they really understood it. Thus, only 43% provided a coherent explanation of the nature and the concept of climate change.

Respondents relate climate change to heat, cold, rainfall variation, climate variation, and polar ice melting, heat being the most cited option (34.2%). It is important to mention that 14.2% of the surveyed farmers did not know how to relate climate change to any aspect (Fig. 4).

In relation to the drivers of climate change, just over half of the farmers surveyed attributed it to anthropogenic activities (mainly pollution), a small percentage attributed it to natural causes, and a minimum percentage to the combination of both (Fig. 5). As can be seen in Fig. 5, a high percentage of the sample could not answer what are the causes that generate climate change.

Regarding the impact or effects that climate change could have on the region's livelihoods, 5.2% of respondents argued that it would have no impact and 39.2% said that they did not know how it might affect them. Of those who reported repercussions (55.6%), the vast majority indicated that it would affect agricultural production (77.6%), 11.5% said that it would generate greater electricity expenditure, and 10.9% reported that it would bring a higher incidence of disease.

## Commitment to minimize climate change and its impact

To help minimize climate change and its impact on the region, 90% of respondents expressed their willingness to implement actions to reduce GHG emissions in their activities in the near future, as well as to implement adaptation actions. Among the actions that they identify and that they could implement to reduce their emissions can be mentioned: reducing pollution by not burning garbage in their homes, nor the agricultural shears of their crops, reforesting in their home and on their farmland, and reducing the consumption of electrical energy.

Regarding adaptation, only 12% of respondents mentioned having carried out this type of action in their agricultural activity; however, there is a lack of

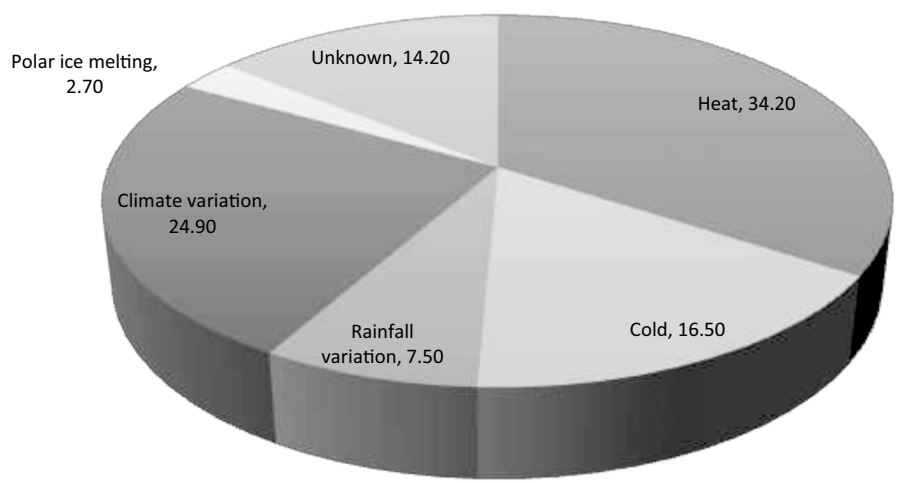


**Fig. 4** Aspects to which farmers relate climate change. Source: Elaborated by the authors

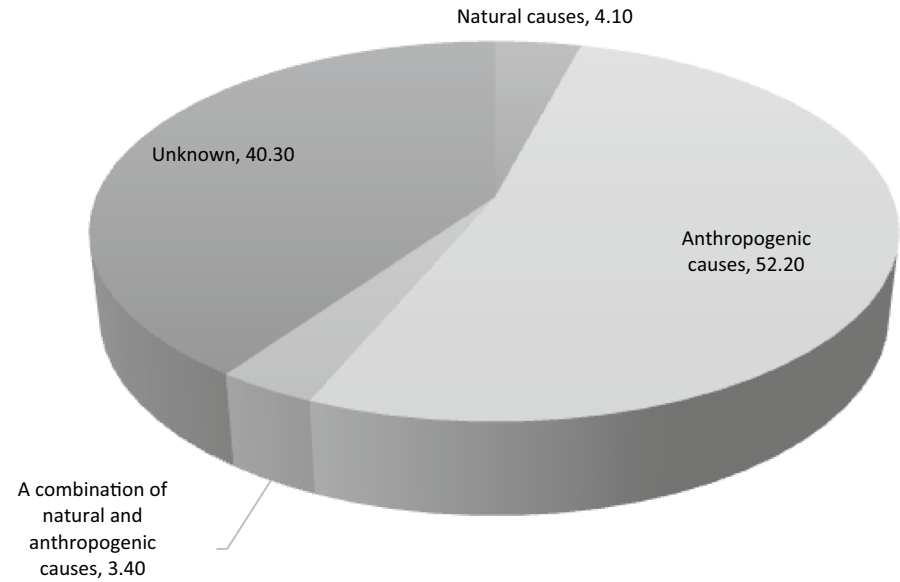


**Fig. 5** Drivers of climate change. Source: Elaborated by the authors

knowledge of the subject, since it was found that most farmers in the region carry out this type of action without knowing it. Therefore, it is likely that these actions are the result of a trend attributable to other reasons, and not necessarily as a result of a conscious change in attitude towards climate change. Among the most implemented adaptation actions are, the use of improved seed, changes in the crop calendar, and the contracting of agricultural insurance.

## Discussion

According to IPCC (2014, 2022), it is likely that primary activities will be the most affected by climate change in the future. Given this situation, the fact that 60% of the households surveyed only receive economic income from this type of activity could represent a problem. For this reason, it is important to manage for the implementation of adaptation strategies focused on the creation of a greater diversity of economic activities that are not dependent on primary ones, an action that was already recommended by Ahumada-Cervantes et al. (2018) for this region.

According to Banco Mundial (2013), floods are one of the impacts of climate change in rural areas of Mexico, which is corroborated in this research, since 26% of the households surveyed have suffered some type of damage from climate-related phenomena, mainly floods. To minimize these impacts, it is recommended to implement actions focused on the identification of risk areas to prohibit the construction of infrastructure and human settlements in them, or where appropriate, manage support for the relocation of existing ones.

Diverse researches have reported that most people in different regions perceive or have noticed changes in climate in recent years (Asare-Nuamah & Botchway, 2019; Atube et al., 2022; Ayanlade et al., 2017; Biswas et al., 2020; Hundera et al., 2019; Oluwatimilehin & Ayanlade, 2021; Shi-yan et al., 2018; Tessema & Simane, 2021; Viguera et al., 2019a), which is similar to the result of 89.4% found in this research. It is important to emphasize that 96.6% of those who observed changes in climate, perceived them in temperature. This is similar to the findings of several authors, who report that a large part of the population studied by them perceived an increase in temperature in different regions of the planet (Ricart et al., 2018; Soares et al., 2018; Abera & Tesema, 2019; Asare-Nuamah & Botchway, 2019; Viguera et al., 2019a; Biswas et al., 2020; Oluwatimilehin & Ayanlade, 2021; Tessema & Simane, 2021). In this regard, IPCC (2013, 2021) points out that the global temperature of the planet is increasing. In the case of Mexico, in the last 50 years average temperatures have increased by 0.85 °C, there is also an increase in the number of extreme warm days and an increase in warm nights (INECC & SEMARNAT, 2018).

The farmers' perception that the region's temperature has shown an increase in recent years is not corroborated by the results of the statistical analysis of the data from two weather stations located in the area of influence of the study, since the trend lines shows a slight increase (Fig. 2), but not significant.

In relation to precipitation, 58.6% of respondents who say they perceive changes in climate have also perceived changes in precipitation, for example: decrease in the amount of rainfall, delay of the season, decrease in rainfall events and more torrential rain events. According to INECC and SEMARNAT (2018), the amount of precipitation has not changed in the last 50 years; however, its distribution is changing differentially in the Mexican territory. In other regions of the planet, farmers have also observed changes in precipitation (Asare-Nuamah & Botchway, 2019; Atube et al., 2022; Ayanlade et al., 2017; Hundera et al., 2019; Shi-yan et al., 2018; Soares et al., 2018; Tessema & Simane, 2021; Viguera et al., 2019a).

The farmers' perception that precipitation has decreased does not correspond to the climatic data, since although the line of the average annual precipitation trend of the GUASAVE (DGE)-SIN station is shown to be downward, this trend is not statistically significant. In relation to the precipitation data of the ZOPILOTE-SIN station, it does not correspond to what was observed by the residents, since the average annual rainfall shows a small increasing trend; however, it is not significant either. This non-correspondence between the recorded precipitation data and that observed by the villagers is also reported in the research of Limantol et al. (2016), Panda (2016), and Asare-Nuamah and Botchway (2019).

Changes in climatic variables such as temperature and precipitation can influence crop yields (IPCC, 2014; Dinesh et al., 2018; Ricart et al., 2018). In the case of Mexico, it is expected that most crops will be less suitable for production with a scenario of temperature increase between 2.5 and 4.5 °C, and a decrease in precipitation between 5 and 10% (DOF, 2014). Faced with such scenarios, it is essential to implement adaptation actions that help farmers to minimize the impact of climate change in the study region, some actions that could contribute to this purpose are those recommended by Ahumada-Cervantes et al. (2018) for this municipality, as well as those studied by Orduño-Torres et al. (2019) for irrigation district 076, also located in the state of Sinaloa.

Like authors such as Niles and Mueller (2016), González-Martínez et al. (2017), Soares et al. (2018), Abera and Tesema (2019), and Viguera et al. (2019b), this research also documented that the majority of surveyed farmers attribute climate change to anthropogenic activities. In addition, they agree that climate change will adversely impact agricultural production and will bring with it an increase in diseases. In this way and supporting what the population studied thinks or perceives, it is very likely that the production of most crops in Mexico will decrease in the face of the expected climate change scenarios (DOF, 2014); an increase in gastrointestinal, heat stroke, and vector-borne diseases is also possible (INECC and SEMARNAT, 2018).

Similar to the findings of Ozor et al. (2015), Soares et al. (2018), and Hundera et al. (2019), it was found that the majority of the surveyed population is unaware of what climate change is, does not identify the causes of this phenomenon and does not know the effects it could have in the region. They have generally heard the term climate change, mainly on television or on the radio; however, only 4.3% have received some type of sensitization on the subject. Those who received awareness, received it through talks, workshops or brochures, mainly aimed at those who receive government support through social programs and support for the field or fishing. According to the research carried out by Ali and Rose (2021), the lack of information and knowledge about climate change is one of the limitations for adaptation to take place. Given this, the design and implementation of an awareness program that describes the problem, its causes and consequences is recommended.

Most farmers are willing to contribute to the minimization of climate change and to adapt to the changing conditions generated by this phenomenon; however, very few mention having developed adaptation strategies in their activity. It is important to mention that the agricultural activity of the municipality of Guasave has been reported with high adaptive capacity by Ahumada-Cervantes (2017) and Ahumada-Cervantes et al. (2017), since the hydro agricultural infrastructure seems to be sufficient and is preserved in functional conditions. In addition, most farmers implement actions such as the use of improved seed, changes in the crop calendar, the contracting

of agricultural insurance, among others. This actions have also been reported by authors such as Ricart et al. (2018) in Europe, Orduño-Torres et al. (2019) in Mexico, Viguera et al. (2019a) in Guatemala, Biswas et al. (2020) in India, and Tessema and Simane (2021) in Ethiopia.

Even when the adaptive capacity of regional agriculture is considered good, it would be important to reinforce it, since under climate change scenarios it is estimated for the near future temperature increases greater than 2 °C in the north of the country and between 1 and 1.5 °C for most of the Mexican territory. Regarding precipitation, a decrease of between 10 and 20% is expected in general for the entire country (INECC & SEMARNAT, 2018). For the distant future, changes in these climate parameters could be more significant with all the economic, social, and environmental consequences that it would bring.

## Conclusions

The economic sustenance in the study region is based on primary activities, especially agriculture. Farmers perceive changes in climate in recent years, mainly in temperature and precipitation; which is not statistically corroborated by the climatic records in the study area. Most of the farmers involved in the study do not know or have little understanding about climate change, they do not know its causes and possible repercussions; they have heard the word, mainly in the media, however, only 4.3% of them have received some kind of awareness about it. Of those who show good knowledge of the subject, most attribute climate change to human activities that generate pollution, with effects such as the decrease in agricultural production, higher energy expenditure and higher incidence of diseases.

The population is committed to face the problem by future implementation of actions to reduce its ecological footprint and to adapt to new situations; however, guidance is required in this regard. In this way, it is necessary to implement an awareness program about the problem, evidencing the causes that generate it, its possible effects in the region, and the way to face it.

In the region, the implementation of adaptation measures in agricultural activity is observed, especially the use of improved seed, changes in the crop schedule, and the contracting of agricultural insurance; however, it is necessary to strengthen adaptive capacity by implementing more and better strategies aimed at the expected changes and for the conditions of the study region, under a strict analysis of relevance. To do this, agricultural policymakers must generate incentives in this regard and guide them in the process.

The limitations of the present study have to do with the unwillingness of people to answer the survey, possibly due to their distrust of providing personal data and due to their lack of knowledge on the subject. As research proposals that could complement this study, it is possible to mention the agricultural vulnerability studies developed with information obtained from updated databases, in addition to that generated through surveys applied to farmers. In this way, knowing the most vulnerable areas and the factors that influence their vulnerability, it is possible to design adaptation strategies to reduce the impacts of climate change. It is also necessary to develop studies to evaluate the relevance of the recommended adaptation strategies, making a cost–benefit analysis of their implementation, in addition to exploring if farmers are willing to implement them.

**Acknowledgements** The authors thank the students of the Environmental Engineering Educational Program of the Universidad Autónoma de Occidente of Guasave Regional Unit for their support in the collection of field data. Thanks to the anonymous reviewers who helped improved the manuscript.

**Funding** No funding was received for conducting this study.

**Declarations**

**Conflict of interest** The authors have no competing interests to declare that are relevant to the content of this article.

**Human or animals and informed consent** This research did not experiment with humans or animals. Prior informed consent of respondents was sought before the data collection process.

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