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PERCEPTION AND STRATEGIES FOR ADAPTATION TO CLIMATE CHANGE IN AGRICULTURAL CROPS IN MEXICO

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Abstract: During the last decades, climate change has been the main threat faced by human beings, currently significantly affecting agricultural production, having direct repercussions on soil health, lack of water, increase of pests, diseases, as well as social and economic effects. These changes are clearly perceived by humans, and drastically affect food production, modify prices and, ultimately, our food security. This paper is a review of research and studies that show actions to address this problem in Mexico, with the objective of identifying the perceptions and social strategies of adaptation and mitigation to climate change related to the effects on cropping systems that contribute to food security in Mexico. The review consisted of an analysis of 21 scientific works carried out and published during the last 10 years in the country, with an exploratory, descriptive and qualitative approach. The review shows that farmers identify and perceive anomalies in terms of variability in the distribution, intensity and durability of temperature and precipitation, affecting the yield and agricultural productivity of their crops. Consequently, the strategies they have implemented are productive, social and economic. It is concluded that adaptation strategies generate adaptability and resilience to climate change in order to ensure food production.
Keywords: Social adaptation, Adoption, Climate, Perception

INTRODUCTION

Social perception is the capacity of human beings to capture, analyze and make sense of the information received through the five senses in order to cognitively understand the meaning of things. Franco-Coffré (2020) point out that man connects with the external world and creates information or knowledge. In general, these interpersonal relationships or in various situations of different kinds, make people create interpretations or inferences of everything they see, hear or experience. Hernández-Salamanca (2020) argues that an important part of human behavior is linked to this fact, which depends on the way in which the social environment and other people are perceived, some actions will be privileged over others.

Society is currently affected by the phenomenon known as climate change, which is perceived through different anomalies in weather patterns such as distribution, intensity and durability. The social perception of climate change refers to the way in which people can understand and value the effects of climate change on their lives. This perception is linked to people's beliefs, values, and norms. Naturally, this phenomenon is generated by global warming, originated by the retention of the sun's rays due to the effect of greenhouse gases generated by anthropogenic actions, which give rise to long-term modifications manifesting in the typical or average climate of a region (Santos and Bokhshoodeh, 2021). Mexico, due to its geographic location, climatic conditions and orography, is exposed to extreme hydrometeorological phenomena with serious effects, mainly on mountain slopes, coastal areas and flood-prone areas, especially affecting the agricultural sector (Zamora-Martínez, 2025).

Nowadays, climate change is a problem of global dimension, which has a direct impact on economic and social development, and has become even more accentuated in recent decades. The main problems of climate change related to the low level of social perception are linked to global and local ecological problems such as: depletion of non-renewable resources due to high consumption, excessive pollution, destruction and deterioration of the environment, whose solution requires the support of society in general (Vivanco and Bravo-Benavides, 2022). As mentioned by Heras (2013),

this problem has become a topic of special relevance in the active state of people, in their daily social activities , given its influence on the level of agricultural productivity and competitiveness, several international organizations show irrefutable evidence of the effects of climate change on the quality of life and human health.

One of the scenarios of greatest impact and consequently of greatest affectations has been the countryside, directly due to changes in climate patterns, it is unknown how these changes translate into agriculture, how they affect small farmers, their security, economic income and which adaptation strategies are the most appropriate to minimize the impacts (Donatti et al., 2018). The objective was to know the perceptions of farmers on climate changes and modifications on their crops, as well as the strategies they are implementing in response to these, is a relevant input to promote the adaptation of the agricultural sector to changes in temperature and precipitation patterns, through efficient adaptation measures.

METHODOLOGY

The methodological perspective of the work focused on the phenomenological-hermeneutic method through a review of bibliographic and documentary information. Through this method, human experiences are described with respect to the peasant perception in the context of the effects of climate change, how it has affected agricultural production and productivity in their local food security in different states of Mexico. As well as adaptation and mitigation strategies to counteract and ensure the production of different crops that contribute to their food. The above, in order to understand the context of research findings that have published case studies focused on the problems affecting the country.

A search was conducted in academic databases such as Redalyc, Google Scholar, Science Direct and Scopus, using keywords such as "perception", "climate change", "food security" and "adaptation strategies". Priority was given to studies published between 2020 and 2025. A documentary population of 21 scientific articles was obtained.

RESULTS AND DISCUSSION

Figure 1 shows the studies found by state. These are the states that have been most affected and where farmers have had the greatest perception of the effects of climate change. The most affected studies were found in the state of Puebla with 3, followed by the state of Guerrero, Oaxaca and Veracruz with 2 studies, while only 1 study was found in the rest of the states. The results obtained in this study reflect relevant aspects on the social perception in rural areas, mainly of farmers and their farming systems for their food subsistence. The strategies they are implementing as a means of resilience and adaptation to the phenomenon of climate change, which can be contrasted with future research that addresses similar factors.

Therefore, Mexico is considered vulnerable to the effects of climate change; socioeconomic conditions such as poverty, inequality, fragility of natural ecosystems and the geographic and climatic characteristics of our country make it more prone to these effects. (2022), who report that other states of the republic do not reflect negative impacts of climate change, however, it puts them in a state of greater vulnerability of socio-ecological systems. The present study showed that the state of Puebla located in the center of the country shows studies where currently the greenhouse effect of the city, urbanization, human activities and industry are the main factors contributing to this phenomenon. The states of Guerrero, Oaxaca and Veracruz, within the Mexican Republic, are considered the states with the highest

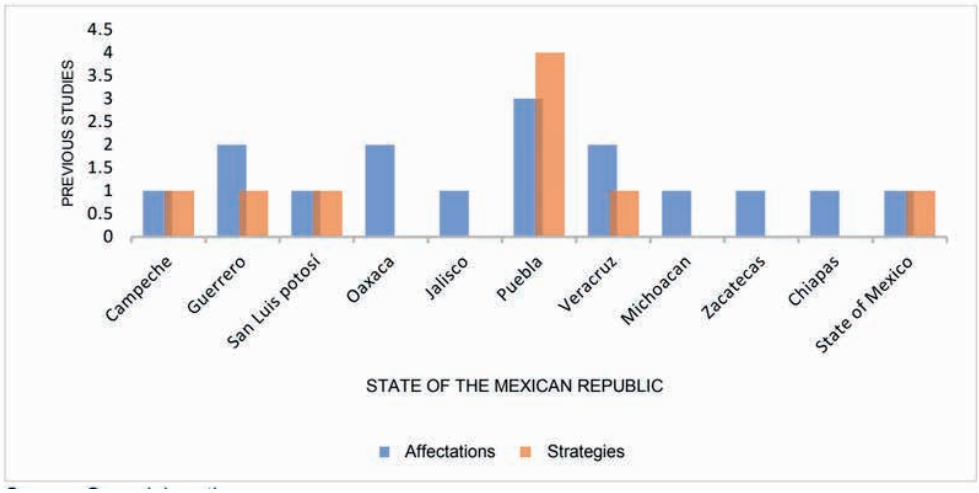

Figure 1. Studies found by state, most affected and strategies implemented by climate change.

Source: Own elaboration.

Author	Cultivation	Relevant findings
Rosales-Martínez et al., 2021.	Lemon	In a sample of 65 citrus growers in the state of Campeche, 1.5% consider that they do not perceive a change, 28.8% have perceived a little change and 69.6% perceive a greater change. Forty-three percent believe that the climate is modified by human causes, 27.6% attribute it to natural causes; however, 24.6% consider that these two factors influence CC.
Hernandez-Castan and Tapia-Hervert, 2023	Coffee	Out of a total of 80 coffee growers in Guerrero, 88% of them reported drought, followed by torrential rain with a percentage of 82%. Other perceived effects are landslides, delayed rains, frost and fires.
Chávez-Acuña et al., 2022	Corn	Farmers in San Luis Potosí perceive scarcity of precipitation as a recent phenomenon. Reduced corn yields for self-consumption, introduction of commercial monocultures, and increased livestock activity.
Cruz-Hernández et al., 2021.	Corn, beans	In Oaxaca, 97.78% have perceived that there is a change in the climate and having a direct impact on food security, it was determined that 52.59% of the population indicate that they have experienced a strong concern for the lack of food.
Mirenda, 2020	Corn, beans and squash	In Jalisco, farmers perceive hurricane intensity, which generates future risks for the production of their basic grains.
Jaramillo-Villanueva et al., 2022	Coffee	The perception of the main effects of climate change in the state of Puebla was an increase in pests and diseases; 87%, excess rainfall; 74% in Mazateca and 60% in Cuetzalan and droughts 71% in the Mazateca region and 61% in Cuetzalan.
Gallardo-López et al., 2021	Beekeeping	In Veracruz, 66.4 % considered climate variation to be affected, followed by the variation in flowering seasons. Regarding the concept of climate change, 30.2 % said that it is "a problem of seasonal difference", another 24 % as "changes in natural cycles due to deforestation", 13.5 % responded that they "do not know" and 12.5 % mentioned "global warming".
Orozco-Bolaños et al., 2019.	Corn	Farmers in Puebla, highlight through observation the delay of rains (21%), prolonged droughts (18%) and frost (16%).

Munguia-Aldama et al., 2021	Corn	In Guerrero, 56% of the farmers perceive that the temperature has increased strongly, that the hot days in winter are stronger than before, 66% affirm that there is a gradual increase of cold days, 41% estimate a drastic reduction of the period.
Hernandez-Sanchez and Travieso-Bello, 2021	Coffee	In Veracruz, 55.2% of UPByE and 45.7% of VIDA members report an increase in temperature; in addition, 31.0% in UPByE and 35.7% in VIDA identify sudden changes in temperature. 65% in UPByE and 79% in VIDA consider that changes in temperature and precipitation affect the crop, as they cause wilting of the coffee plant, flower and fruit.
Gonzáles-Martínez et al., 2017.	Corn	In Michoacán, farmers perceive delays in planting dates and early frosts.
Cid-Rios et al., 2022	Bean	In Zacatecas, farmers perceive that the lack of yields due to the effects of climate change has led to the substitution of native seeds for improved seeds (transgenic).
Juárez-Sánchez et al., 2022	Corn	Farmers in Puebla perceive changes in rainfall patterns, increased heat, affecting rainfed corn crop yields.
Maldonado-Méndez et al., 2024	Coffee, sugarcane, corn, corn, beans	In Chiapas, they perceive the presence of extreme events that were not common before 2010, an increase in temperature and a decrease in precipitation and loss of crops or harvests.
León-Rojas et al.,2020	Bean	Farmers in the state of Mexico, perceive climate change, impacts of conventional agriculture and economic problems.
Miguel- Velazco et al., 2022	Peanut and pumpkin	Farmers in Oaxaca mentioned perceiving differences between current crops and those of a few years ago, a decrease in crop quality and quantity, and delays or advances in planting.

Table 1. Social perception of climate change.

Source. Own elaboration.

Author	Cultivation	Adaptation Strategies/State
Rosales-Martínez et al., 2021.	Lemon	In Campeche, strategies have been used for floods such as: drains and canals. In the event of drought: irrigation systems, wells, taking care of the water and leaving stubble on the ground to maintain humidity, in the event of winds: planting trees that serve as windbreaks and placing supports for the plants.
Hernández-Castán and Tapia-Hervert, 2023	Coffee	**Guerrero** - Terracing application - Application of contour lines - Application of mowing and fertilizing - Application of drip irrigation techniques - Water savings - Application of biological controls.
Chávez-Acuña et al., 2022	Corn	**San Luis Potosi** - Opening new spaces for planting - Promote and apply ethnoclimatic and ethnometeorological knowledge, - Forced migration - Credit management for the field.
Orozco-Bolaños et al., 2019.	Corn	**Puebla** - Modification of planting dates - Selection of drought resistant seeds - Organic fertilization - Establishment of natural barriers - Establishment of jagüeyes

Hernandez-Sanchez and Travieso-Bello, 2021	Coffee	**Veracruz** - Renovation of coffee plantations with varieties tolerant to pests and diseases. - Coffee diversification - Modification of the agricultural calendar - Coffee shade management - Soil and water conservation practices - Diversification of income sources - Differentiated marketing - Social organization
Gonzáles-Suárez et al., 2019.	Corn	**Puebla** - Establishment of MIAF system on terraces - Value added to fruit products - Vegetable production - Open field flower cultivation - Backyard animal husbandry (chickens and sheep) and the cultivation of fruit trees and medicinal plants. - Sowing of native seeds
Apodaca-González et al., 2023.	Coffee	**Puebla** - Reduce and modify their work in the agricultural cycle. - Inclusion of pest and disease resistant varieties - Use of shade trees - Crop diversification
Ramírez-Huerta et al., 2022	Corn	**Puebla** - Incorporation into social programs Liconsa (Social Milk Supply Program), Diconsa (responsible for the timely supply of basic and complementary products at accessible prices in rural localities of high and very high marginalization), prospera and senior citizens.
Lluch-Cota et al., 2024	Corn	**State of Mexico** - Cultivar development and variety selection - Crop rotation and agroforestry systems - Transformation from rain-fed, rain-dependent to irrigated crops - Efficient irrigation and wastewater use - Participatory plant breeding
Cruz-González et al., 2024.	Corn	**State of Mexico** - Regional and exotic-adapted germplasm management - Change of planting date - Application or increase of organic mulch - Migrate to new areas of opportunity for this activity and maintain investment costs

Table 2. Adaptation strategies to climate change. The size of the table title is too small in relation to the content, it should be the other way around, just like the previous one, right?

Source. Own elaboration.

poverty and marginalization indexes, factors that make the rural population more vulnerable to social, economic and environmental problems such as climate change. These factors coincide with López Medina *et al.* (2023), who indicate that the geographic characteristics of Mexico and the states where more studies on the subject were found are prone to extreme meteorological phenomena, given that their geographic location is in a territory where hurricanes occur in both the Atlantic and Pacific oceans.

Table 1 shows the results of different studies on farmers' perceptions of the effects of climate change in different states of Mexico. Studies were found in which the main perception is linked to phenomena generated by the effect of climate change, referring to anomalies and extreme climatic events in terms of modification of climate patterns such as: distribution, durability and intensity of temperature and precipitation, resulting in direct effects on different crops of food importance within the states of the Mexican Republic.

Hernández-Castán and Tapia-Hervert (2023) found that torrential rains have caused flooding and the death of lemon trees, threatening farmers in the state of Campeche. In contrast, Chávez-Acuña *et al.* (2022) found that farmers in the state of San Luis Potosí have observed water shortages for irrigation of maize crops, which has led to changes in agricultural production from milpa for self--consumption to commercial monocultures such as sugarcane.

Cruz-Hernández *et al.* (2021) identified that farmers in the states of Oaxaca and Guerrero have perceived that there is a change in the climate and that this has a direct impact on food security in terms of maize and bean production. Barahona-Mejía *et al.* (2022) mention that this affectation generates an increase in the agricultural frontier, given that the increase in average temperature is real, globally generating a reduction in precipitation and an increase in periods of drought, affecting productive yields, the family economy and increasing migration. Jaramillo-Villanueva et al. (2022) identified in coffee growers of Oaxaca and Puebla, the increase of pests and diseases in their coffee plantations, as well as an increase in precipitation, with a loss of bean production for the process of ground coffee. 87% of the population has perceived the increase of pests and diseases and 74%, excess rainfall, which has drastically affected coffee production. Munguia-Aldama et al. (2021) and Gonzáles-Martínez *et al.* (2017) and Cid--Ríos et al. (2022) point out that farmers perceive a delay in the rainy season, which has directly impacted the dates and seasons for planting rainfed corn. Cid-Ríos *et al.* (2022) identified low yields among bean farmers due to the effects of climate change, which led to the substitution of native seeds for improved seeds (transgenic). As can be seen in all the studies analyzed, climate change has generated instability in production, development and production in different cropping systems, having a direct impact on food security, this perception is well defined on climate alterations with respect to temperature variation and precitation generated in different territories.

Table 2 shows the strategies found in different studies carried out in Mexico and in different cropping systems; subsequently, the productive, social and economic actions and strategies are described.

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PRODUCTION STRATEGIES

Modifying sowing dates and selecting seeds resistant to extreme climates are strategies implemented by farmers to ensure harvests, since this germplasm requires less water in the face of global scarcity and thus be able to obtain yields that can ensure food throughout the year. Orozco-Bolaños *et al.* (2019) and Hernández--Castán and Tapia-Hervert (2023) indicate that using organic fertilizers, crop renewal and crop rotation are strategies to improve and conserve soil properties, as well as to reintegrate nutrients that contribute to better fertility, helping plant development for optimal production and yield, generating food security for farmers throughout the production cycle.

As strategies for water use and conservation, studies show that efficient irrigation and drip irrigation techniques are useful for supplying water and nutrients directly to plant roots. In addition, it improves water efficiency resulting in less waste and improves crop quality, which is an attractive option for farmers. The negative effects of climate change affect crop yields and this has caused farmers to look for other sources of food. Similar to what was reported by Gonzáles-Suárez *et al.* (2019), indicating that the production of vegetables and backyard animals, contributes as a food strategy, since they are the second option for food in rural areas as they function as a source of self-consumption for food and to generate economic income through their sale.

The establishment of living barriers using timber or fruit trees, such as the Milpa Intercalado con Árboles Frutales (MIAF) system, is another environmental and productive strategy that serves a dual purpose for farmers. Rosales-Martínez et al. (2021) and Gonzáles-Suárez *et al.* (2019) report that these strategies contribute to more rain, especially because "planting more trees equals more water", while the combination of MIAF has served to contain soil erosion, delimit plots and diversify production for self-consumption and sale.

SOCIAL STRATEGIES

Migration to other states of the republic or to northern countries, participatory plant breeding, incorporation into social programs that boost the local economy, credit management for the countryside and promoting social organization were the strategies found in different studies in the country. Migration as a family option in search of new opportunities to generate income to meet family needs in the face of the lack of agricultural production due to climate change. Lluch-Cota *et al.* (2024) emphasize that participatory plant breeding is a strategy that facilitates interaction between the indigenous component and the traditional knowledge of farmers with scientific research to generate socio-ecological adaptation and climate pressure. Ramírez-Huerta *et al.* (2022) indicate that inclusion in social programs serves as a strategy to contribute to food security, given the loss of their crops and the erosion of their land, the programs are a means to generate economic income for the purchase of food. Hernández-Sánchez and Travieso-Bello (2021) consider that in the face of climate change, social organization is an opportune strategy to generate an exchange of knowledge among peers and to be able to access different supports managed with governmental institutions and non-governmental organizations. This is a strategy to counteract crop losses and thus gain access to technology packages, machinery, plants and fertilizer for crops, access to training and technical advice.

ECONOMIC STRATEGIES

Faced with low productivity and the disappearance of species resistant to the effects of climate change, farming families opt to seek new sources of income to cover household expenses. Similar to Hernández-Sánchez and Travieso-Bello (2021) who identified that a diversification of income sources and differentiated commercialization serve as adapta-

tion strategies to supplement their income, face price fluctuations and the sale of products and by-products to generate income from other sources and supplement expenses to cover basic family needs. Access to markets that pay fair prices allows farmers greater economic stability and enables them to recover from damages caused by changes in climate. Cruz-González *et al.* (2024) mention that maintaining investment costs is another strategy that helps the farmer to continue with the crop in order to achieve food security without economic losses due to the negative effects of climate change.

CONCLUSIONS

The main crops that have been affected by the effects of climate change were coffee and corn, in the states of Mexico, Oaxaca and Veracruz, all under rainfed conditions. Based on the bibliographic analysis, it is evident that climate change has generated a variation in climatic patterns in terms of temperature and precipitation. In terms of distribution, it has generated droughts and a delay in the rainy season. Intensity, having in some regions of the country torrential rains and hurricanes that hit with greater intensity, as well as longer cold seasons. Durability, with hotter seasons increasing the average temperature, which has affected crops, such as an increase in pests and diseases, yields and forest fires, which will put society at risk in future years with greater food production losses due to extreme events caused by climate change.

Farmers have implemented environmental strategies such as contour lines through the introduction of the Milpa Intercalada system with fruit trees, use of organic fertilizers, modification of planting dates and selection of seeds that are more resistant to high and low temperatures.

Economically, the main strategy generated is the management of credits for field support and crop diversification to generate additional income.

On the social side, migration is a forced strategy due to the lack of production and employment in rural communities, participatory plant breeding to encourage joint organization and participation to improve agricultural germplasm.

The need for and dependence on food has made it necessary to employ adaptation actions and strategies that lead to resilience to improve the capacity of farmers to adapt, recover and survive in the face of future threats, disasters and crises in their farming systems. This will allow them to maintain their way of life, limit impacts, reduce vulnerabilities and increase resilience to climate change in order to avoid food dependence due to increased imports of products and higher import costs.

This review identifies the main challenges and gaps in information, which will allow us to generate future efforts and research in terms of scientific research and dissemination of results related to the climate change phenomenon for future decision making.

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