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Article

## Impact of climate change on corn price, a current analysis

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### Abstract

Climate change is a problem that has worsened in recent years, its effects have spread to all economic sectors, extreme events are becoming more frequent and their intensity has increased. The agricultural sector is one of the sectors that has had the most negative impacts due to the effects of climate change, in addition to being a sector that potentially contributes to the generation of greenhouse gases, making the problem chronic. In order to measure the effects of climate change on corn price, it was analyzed how changes in temperature and precipitation over a broad time horizon (1992-2022) have physically affected corn yields and what is their effect on the price of this crop in Mexico through a two-stage least squares model; it was found that, without taking into account climatological variables, in the face of an increase in yield, the price shows a decrease of 5.7%; nevertheless, when including the effect of climate change, the reduction in the price is 2%; using the IPCC climate change scenarios, it was concluded that, in the long term, these variations in the price of corn would cause distortions in the market, negatively impacting the dynamics of inflation and, consequently, making the minimum consumption basket more expensive.

## **Keywords:**

climate change, corn price, impacts.



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# Introduction

It is of utmost importance to differentiate between the definitions of the concepts of climate change, climate, and weather, in order to delimit why within this analysis climate change is considered as a variable that affects the price of corn. While weather refers to the short-term conditions of the atmosphere, climate is defined as the average weather of a specific region over a long period of time. The Intergovernmental Panel on Climate Change (IPCC) defines climate change as the variation in the state of the climate identifiable (e.g., through statistical testing) in variations in the mean value or in the variability of its properties, which persists over long periods of time, usually decades or longer periods (IPCC, 2013).

It is important to note that, although its effects are physical (intense droughts, water scarcity, serious fires, rising sea levels, floods, melting of the poles, catastrophic storms, and decrease in biodiversity), its impacts reach the entire population economically, socially, and geographically, the consequences of the intensity and frequency of extreme events are transferred to many areas and one of them is agriculture, because crop yields modify the availability of food, affecting the supply chain, modifying demand and generating distortions in markets that lead to price volatility, and this can even translate into inflationary pressures, affecting access to food.

Agriculture is extraordinarily vulnerable to climate change, its impacts manifest in the form of lower agricultural yields and more frequent extreme weather events, affecting crops and livestock equally. Kim and Lee (2023) indicated that corn is very sensitive to extreme events, and it can suffer from drought stress, which has the most devastating effect on crop yields during the reproductive or growth stage. In corn, hot, dry weather during pollination and fertilization can have negatively affect yield. In particular, drought stress can reduce overall plant size, ear size, and number of grains.

At the same time, the agricultural sector has an important impact on the problem of climate change. According to the Banco Mundial (2025a), in 2012, agriculture generated between 19% and 29% of total greenhouse gas (GHG) emissions. Nonetheless, food production generates emissions of methane, carbon dioxide, and other greenhouse gases, and causes deforestation and land clearance for agriculture and grazing, livestock feed, fertilizer production and use, and fertilizer used for crops. All this makes food production one of the sectors that contribute the most to climate change.

According to FAO (2020), in 2018, emissions from agriculture and related land use accounted for 17% of global GHG emissions from all sectors, a figure below the 24% recorded in the 2000s; the United Nations Environment Program PNUMA (2024) indicated that agriculture was responsible for 11% of global emissions, 6% of which was attributed to livestock and 5% to the burning of biomass, soils, and rice.

According to the INECC-National Institute of Ecology and Climate Change-2024, from 1990 to 2021, emissions from the agricultural and livestock sector have had an average annual growth rate (AAGR) of 0.6%, considering the national inventory of greenhouse gas and compound emissions from 1990 to 2019, the agricultural and livestock sector has presented rapid growth in recent years due to the increase in its own activities.

Other studies, such as Ritchie's (2024), have mentioned that plants can benefit from higher levels of CO2 in the atmosphere; what is called 'carbon fertilization'; however, crops are affected by higher temperatures and water availability; this can increase or decrease yields depending on the type of crop and where in the world it is grown; for example, wheat and rice are crops that can benefit significantly from a higher amount of CO2. Corn, millet, and sorghum, on the other hand, benefit very little, except under drought conditions.

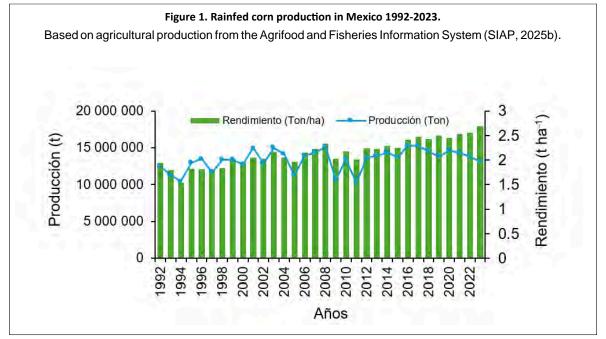
Since corn benefits little from carbon fertilization and is often grown in warmer regions, global warming directly reduces the world's productivity of corn. And when yields decrease, if the supply law is considered, prices are expected to increase; therefore, this analysis exposes how changes in climatological variables generate negative impacts on the price of corn.



This study focuses on the analysis of the effects of climate change on corn prices, since it is one of the most important cereals for both human and animal consumption, grown as grain and forage. It is one of the staple grains for food and an industrial raw material worldwide, consequently, variations in its price impact consumers; therefore, in Mexico, it is a component of the minimum consumption basket.

## Materials and methods

Due to the nature of this research, the information analyzed is focused on grain corn data in the agricultural year, with an open-field rainfed production system and with a conventional type of production. Figure 1 showed that rainfed corn production has had an irregular behavior from 1992 to 2023, although yield showed a sustained increase; nevertheless, within the analysis carried out on other variables, it was found that the SIAP reports a decrease in the planted area, as from 1992 to 2023, the area planted for rainfed corn production fell by 25%.



Nonetheless, it is important to note that the yield exhibits an upward behavior; Figure 1 showed that the yield in 2023 at the national level was 2.7 t ha-1, but since 2017, the increase has been noticeable; however, production has fallen since 2020, which may be due to different situations, one of which may be climatic phenomena associated with the decrease in the area that is sown because although the yield has increased, the reduction in the sowing area does not allow an increase in the final production.

Now, for this study, it is important to note that regression is an analysis that practically supports econometrics, which, according to Gujarati and Porter (2010), indicated the dependence of a variable (dependent variable) on one or more variables (explanatory variables) in order to estimate or predict the population mean of the first variable in terms of the known or fixed values of the second variables. As Gujarati and Porter (2010) mention, the Gauss model, the classical or standard linear regression model (CLRM), is the foundation of most econometric theory. Its mathematical form is as follows:  $Y_i = \beta_0 + \beta_1 X_i + u_i$ . The ordinary least squares model is one of the methods for estimating the parameters of a linear regression model, it consists of minimizing the sum of the squared residuals of the variables entered the model. Their estimates possess some ideal or optimal properties contained in the Gauss-Markov theorem, which considered that an estimator must be linear, unbiased, with the least variance among all linear and unbiased estimators to be considered the best linear unbiased estimator (BLUE).



Nevertheless, the variables in a model are exogenous (determined outside the model) and endogenous (determined within the model), by using an OLS model, correlation was identified in one of the variables, violating the assumption of strict exogeneity in the variables, causing biased and inconsistent estimates, which translates into an endogeneity problem. To address this problem, the two-stage least squares (2SLS) model is used, which, as the name indicates, the method comprises two successive applications of OLS.

The structural model represents an equation where it is intended to measure the causal relationship between the variables and the attention is focused on the regressors (#i). Model 1 is a multiple linear regression with two explanatory variables: Y2 and Z1. Model 1:  $Y_1 = \beta_0 + \beta_1 Y_2 + \beta_2 Z_1 + U_1$ . If Z1 is an endogenous variable, it is essential to eliminate the endogeneity problem in the model, so it is necessary to use instrumental variables that allow explaining the response variable and are related to it. To eliminate the probable correlation between Y1 and u2, in stage one, a first OLS regression is performed for Y1 including the instrumental variables, thus, the following is obtained from model 1:  $Y_1 = \beta_0 + \beta_1 Z_2 + \beta_2 Z_3$ . Where: Z2 and Z3 are the instrumental variables and Y1 is an estimate of the mean value of Y1 conditional of the fixed X's. The result of this estimation yields predicted values of Y1, which are used in stage two of the model, thus obtaining the following: model 2:  $Y_{1.1} = \beta_0 + \beta_1 Y_2 + \beta_2 Z_1$ .

As indicated by this two-stage procedure, the basic idea behind 2SLS is to 'purify' the stochastic explanatory variable Y1 from the influence of the stochastic perturbation u1. This objective was achieved by performing the reduced regression of Y1 on all the predetermined variables in the system (stage 1), obtaining the Y1 estimates and replacing Y1.1 in the original equation with the Y1 estimated, and then applying OLS to the equation thus transformed (stage 2). The estimators thus obtained are consistent; that is, they converge towards their true values.

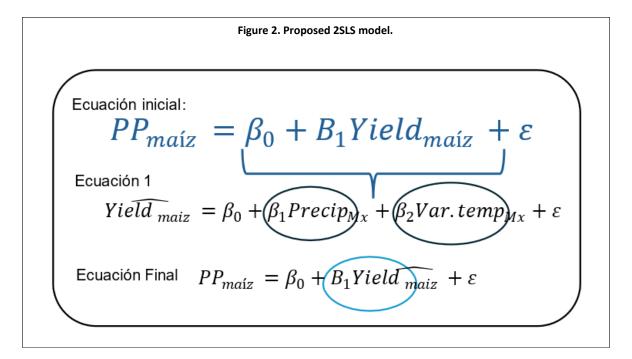
It is necessary to mention the supply and demand model, since this part of economic theory is the basis that supports the research because it exposes the reason for the variables used and the hypothesis raised. The demand function is as follows:  $Q_d = D(P)$ . Where: the quantity demanded is inversely proportional to the price, as indicated by the law of supply and demand, so the higher the price, the lower the quantity demanded. The supply function has the following form:  $Q_s = D(P)$ . Where: the quantity supplied is a function of the price of the goods at which the suppliers are willing to sell, consequently, the relationship between them is direct. Supply can be modified by changes in the prices of production factors and inputs, changes in the technology used, even by changes in the number of suppliers of the same good or service. According to economic theory, the price of a good or service is determined when supply and demand are in equilibrium, this means:  $Q_d = D(P) = Q_S = D(P)$ . To find the equilibrium, the equality is solved for P, which results in:  $P = Q_{ds}$ . In this sense, it is mathematically proven that the price of a good is determined by the quantity of supply and demand for a good or service; it can be then stated that supply is an endogenous variable within the model since it affects the price and this, in turn, affects the supply.

Since the objective is to explain the incidence of climate change on the price of corn, different models were tested to achieve the objectives set and as a result, the two-stage least squares model was used, which was selected for two reasons. The effects of climate change are physical (intense droughts, water scarcity, severe fires, rising sea levels, floods, melting of the poles, catastrophic storms and decreased biodiversity) (Commisión Europea, 2024); this physically impacts crops yields, in this case corn. The literature reviewed showed that it is not accurate to take climatological variables as explanatory variables for a response variable that is indirectly related to them, so the relationship between the variables must first be reviewed to make accurate measurements and inferences.

Understanding that yield is the amount of t ha-1 sown and when added together the total production is obtained, it is assumed that yield is the supply component within the initial model, so there is a problem of endogeneity and to solve it, it is necessary to make use of instrumental variables. It is worth noting that in order to talk about a climate change analysis, the temporality of the information plays a fundamental role, since according to the Intergovernmental Panel on Climate Change (IPCC), climate change is the variation in the state of the climate identifiable in the variations of the average value and in the variability of its properties, which persists for long periods of time, usually decades or longer periods, so the study period is from 1992 to 2022.

The data sets used are: producer price. It is the value at which each unit of a good or service is marketed, without considering any type of taxes or transportation charges that were not incorporated in the production price. In dollars, obtained from FAOSTAT. It is the world's largest database of agricultural and food statistics. Grain corn yield (t ha-1) at the national level and by state, obtained from SIAP (2025a and 2025b). Average rural price of corn at the national level and by state, obtained from SIAP. Producer price index, according to primary activities, agriculture, animal raising and farming, forestry and fishing, obtained from the National Institute of Statistics and Geography (INEGI, 2025). National producer price index for Mexico in dollars, obtained from FAOSTAT. Exchange rate, obtained from Databank. DataBank is an analysis and visualization tool that contains collections of time series data on a variety of World Bank topics. Annual precipitation for Mexico, obtained from CRU TS 4.07. Maximum temperature for Mexico, obtained from CRU TS 4.07.

The time series (TS) gridded data version 4.07 of the Climatic Research Unit (CRU) are month-to-month variations of climate over the period 1901-2022, provided in high-resolution grids (0.5 x 0.5 degrees), produced by the CRU at the University of East Anglia and funded by the UK's National Centre for Atmospheric Sciences (NCAS), a NERC collaborative center. As shown in Figure 2, the first model proposes the price of corn as a function of its yield, but as already seen, yield is assumed as the supply component, so, to remove the endogeneity problem, a 2SLS model was made using instrumental variables.



## **Results and discussion**

Derived from the methodology presented and the exploratory analysis of the data series used, the following is proposed: The structural model:  $PMR_{maiz} = \beta_0 + B_1 Yield_{maiz} + \varepsilon$ . In the first stage:  $Yield_{maiz} = \beta_0 + \beta_1 Precip_{Mx} + \beta_2 Temp_{max}_{Mx} + \varepsilon$ , and in the second:  $PP_{maiz} = \beta_0 + B_1 Yield_{maiz} + \varepsilon$ . Where: PMR maiz= is the average rural price of corn in Mexico deflated in the period 1992-2022. Yield maiz= corn yield in Mexico in the period 1992-2022; Precip= precipitation in Mexico in the period 1992-2022; Temp.max= maximum temperature in Mexico in the period 1992-2022. The data used are presented on different scales due to their nature, so standardization was carried out. It is the process of transforming data so that they have consistent scale and distribution. To standardize,



the meaning is subtracted from each value of the original variable and the resulting value is divided by its standard deviation (Tezen, 2024) in order to facilitate the analysis.

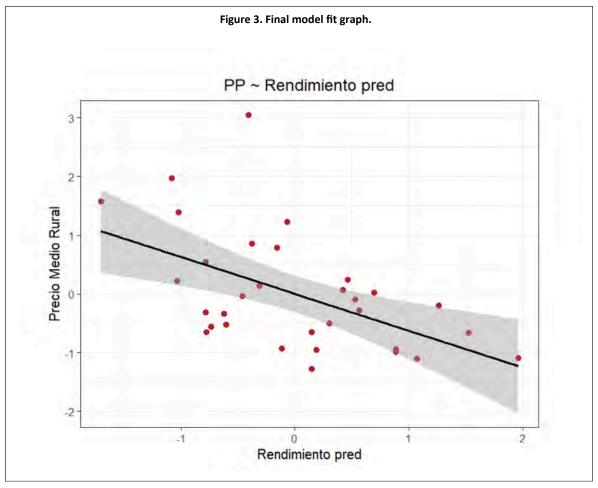
The R studio program, version 4.3.3, was used to perform the regression for the structural model using the PMR of corn deflated with the INPP and the national yield, obtaining the following:  $PMR_{maiz} = -0.00004907 - 0.5701Yield_{maiz} + \varepsilon$ . These results yield an R2 of 0.3025, so the model explains 30% of the PMR by the yield, now with a *p*-value: 0.0006343 (< 0.05), this study reports that the explanatory variable affects the dependent variable; however, considering the R2 of the model, the endogeneity problem and that autocorrelation was found in the model, it was concluded that it is not the optimal model.

Returning to the explanation that yield is a component of supply and therefore is an endogenous variable, the 2SLS model was used with instrumental variables, so the model analyzed in stage one has the following form:  $Yield_{maiz} = \beta_0 + \beta_1 Precip_{Mx} + \beta_2 Precip_{Mx}^2 + \beta_3 Tempmax_{Mx}^2 + \beta_4 Tempmax_{Mx}^2 \varepsilon \ .$  Once the first regression was run, the values that form the mathematical equation were obtained:  $Yield_{maiz} = 0.02057 + 0.39512 Precip_{Mx}^2 - 0.11597 Precip_{Mx}^2 + 0.79177 Tempmax_{Mx}^2 - 0.09468 Tempmax_{Mx}^2 \varepsilon .$ 

In this result, it should be noted that both precipitation and maximum temperature were used in their linear and quadratic form, derived from the fact that, by nature, there is a maximum yield point at a given level of precipitation and temperature, so, when the crop obtains either more temperature or less precipitation or vice versa, the yield decreases, so the use of linear variables alone is incorrect. In this model, it can be seen that keeping everything else constant, in the face of an uncontrolled increase in precipitation, the yield would decrease by 11.5%; regarding temperature, when it increases precipitously, the yield of corn would increase at a lower rate, this with the data used until 2022. The R2 of this model is 0.6688, so the model explains almost 67% of the yield by the climatological variables chosen; therefore, the explanatory variables affect the dependent variable.

The results obtained were used to validate the model and to generate the predicted values of the yield to be used in the equation:  $PP_{maiz} = \beta_0 + B_1 Yield_{maiz} + \varepsilon$ . The following is obtained:  $PP_{maiz} = -0.06233 - 0.02074 Yield_{maiz} + \varepsilon$ . The model explains 46% of the PMR of corn by its yield, but now this variable already has the effects of climatological variables. For its part, the Durbin-Watson test yields a value of 1.90943, very close to the value that indicates no correlation (2), even the *p*-value (0.6684) of the test confirms that there is no autocorrelation in the residuals of the model. The variance of errors is constant, therefore, errors are homoscedastic. Finally, the model obtained showed a better fit than the initial one, which can be seen in Figure 3, in which the data are closer to the line compared to the initial model.





When testing the normality of the residuals, it can be observed that, although they behave normally, there are some atypical data that do not conform to the line, this is derived from the nature of the data. That said, as the model went through the statistical tests, it was concluded that the effects of climatological variables do have physical impacts on corn yields, these in turn affect the price of corn, since in the initial model, an increase of one tonne of corn decreased the price by 5.7%; nevertheless, when the effects of climate change are introduced, in the event of an increase of one ton of corn, the price only decreases by 2%.

It is not enough to conclude that the effects of climatological variables cause changes in price, it becomes necessary to use climate change scenarios that the IPCC defines as follows: a climate scenario is a plausible and sometimes simplified representation of the future climate, based on an internally coherent set of climatological relationships explicitly defined to investigate the possible consequences of anthropogenic climate change and which can be introduced as incoming data in impact models. To know the effects of changes in climatological variables in the long term, the Caladapt RCP 4.5 and RCP 8.5 scenarios were considered; Cal-Adapt has been developed by the Center for Geospatial Innovation at the University of California, Berkeley, with funding and advisory supervision from the California Energy Commission and the California Strategic Growth Council (2025); these are two climate change scenarios that are used to model the future. These scenarios are part of representative concentration pathways (RCPs), which are a set of possible scenarios that are used to project climate change. RCP 4.5 is a scenario in which greenhouse gas (GHG) emissions are stabilized and was achieved thanks to the implementation of adaptation measures. RCP 8.5 is a scenario in which very high levels of GHG emissions are maintained, the world's economies are considered to be based on the burning of fossil fuels.



Data from the IPCC, 2025, were used to estimate the effects of changes in maximum temperature and precipitation on corn yield, so that this result could be used to determine the effect on price. The results obtained were the following: under RCP 4.5, based on the period 1995-2014 and at the regional level; that is, Mexico and Central American countries, the information is shown in Table 1.

Table 1. Results of climate change analysis under the RCP 4.5 scenario.						
Period	Change in max. temperature (oC)	Change in precipitation (%)	Yield	Price		
2021-2040	0.8	1.2	-0.081	0.061		
2041-2060	1.3	0.2	-0.179	0.066		
2081-2100	2.1	-1.4	-0.436	0.071		

There it can be confirmed that, in each period shown by the scenario, the yield has different impacts that lead to the rise in the price of corn; for the period 2021-2040, a change in temperature of 0.8 degrees is expected with an annual increase of 1.2% in precipitation, the yield began to decrease whereas the price experiences a slight increase; however, as the periods progress, the effects of climate change generate losses in yields, increasing the price.

For its part, in RCP 8.5, which is the most critical scenario (Table 2), it was identified that the loss in yield is more accelerated, as is the increase in price; even in this scenario, for the period 2081, the price of corn doubles since yields are practically lost and dependence on imports is what would sustain domestic demand.

Table 2. Results of climate change analysis under the RCP 8.5 scenario.						
Period	Change in max. temperature (oC)	Change in precipitation (%)	Yield	Price		
2021-2040	0.9	-0.1%	-0.096	0.06		
2041-2060	1.7	-2.3%	-0.291	0.183		
2081-2100	4.2	-8.8%	-1.683	1.057		
	Based on inform	mation from the IPCC inte	eractive atlas.			

The analysis under climate change scenarios allows us to identify what would happen, since environmental policy measures are currently aimed at complying with the commitment to generate fewer GHG emissions, as well as to transition to more sustainable production practices and reduce and even eliminate the use of fossil fuels; so it was extremely useful to know that the effects of climate change reach absolutely the entire population.

## **Conclusions**

Assuming that all other factors involved in corn production remain constant, the study was able to demonstrate that changes in climatological variables (temperature and precipitation) over time have negative physical effects on rainfed corn yields as they are fully exposed to the environment; therefore, lower yields imply less availability of the product, which in turn, caused changes in the price of the crop.

The literature reviewed confirmed that, with a broad time horizon, it is possible to estimate and determine the impacts of climate change on crop yields, since such changes can only be measured in the long term. Likewise, under different scenarios, there could be problems to cover domestic demand derived from a decrease in production, so resorting to imports would generate an increase in the price of both grain corn and final goods that use this product as an input, affecting people with lower incomes.



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