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Statistical evaluations of the agricultural input price index in relation to monthly precipitation levels in Colombian territory

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Abstract
The objective of this research was to determine if there is a significant linear variation between the total receipt recorded each month in Colombia and the changes in the agricultural input price index recorded each month. Using information obtained from secondary sources, such as the official pages of the National Open Data Platform of Colombia, the monthly accumulated rainfall levels and the inter-monthly changes in the agricultural input price index values across Colombia from January to October 2024 were examined, running a classification analysis through R Studio. Using the Shapiro-Wilks normality test, it was verified that the data obtained for the variables "Total precipitation" and "Variation in agricultural input prices" fit a normal distribution, so the Pearson weighting test was used to determine the level of evaluation between both variables. The p-value of the statistic obtained is 0.01353, which is significantly lower than the significance level of 0.05, confirming that there is a significant linear evaluation between the monthly accumulated rainfall in the country and the fluctuations in the price index of Colombian agricultural inputs. The calculated correlation coefficient is 0.7444429, which indicates that there is a considerable positive correlation between the variables. These results show that it is plausible to state that monthly fluctuations in the agricultural commodity price index tend to be positive as monthly accumulated precipitation increases, while they tend to be negative as accumulated precipitation decreases. This does not mean that there is a causal relationship between the two, since many factors can influence this dynamic. Therefore, it has been concluded that more research is needed to better understand the causes of changes in the agricultural commodity price index in Colombia and how climatic conditions influence this process.
Key words: climatic conditions, agricultural development, price variation, rainfall, correlation.

Introduction

The main problems of the Colombian agricultural sector are due to variations in input costs, driven by multiple factors, mainly related to the climate (Lachaud et al., 2022). The reasons for changes in the measurement of agricultural input costs are multiple, but so far, the most influential has been climate variation, particularly rainfall, which does not directly generalize crop production due to lack of water or sufficient irrigation, but rather indirectly affects almost all stages of crop development, the unexpected appearance of diseases and pests, and the supply and price of all types of inputs such as fertilizers and pesticides (Hoogenboom, 2024).

Therefore, the total monthly receipt is an important determinant that can be used to interpret the conditions of supply and demand for agricultural inputs. Excessive rainfall can also lead to greater soil degradation and therefore greater use of fertilizers, which increases the price of the latter (Liu et al., 2021). On the other hand, prolonged dry periods reduce agricultural production and increase the demand for additional inputs, such as water and irrigation equipment, which increases their price (Wang et al., 2022).

In Colombia, rainfall variation not only directly affects crop cycles and agricultural production, but also has enormous repercussions on the supply chain of inputs and other agricultural materials. Both lack and excess of rainfall can alter distribution logistics, affecting the accessibility of fertilizers, seeds and pesticides, which will change their prices, which will have to be borne by farmers (Mishra, 2023). In addition to this, changing rainfall patterns may lead to the need to change agricultural practices, such as the selection of crops that are more resistant to drought or floods or more sophisticated irrigation systems; therefore, operational costs are increasing (Toromade et al., 2024). These climatic changes would also exacerbate some pests and diseases that would require much more specialized and expensive inputs for their control, emphasizing the complexity of the link between climate economics and agriculture in Colombia.

In response to the above, this research investigates the strength of the direct relationship between changes in the agricultural input price index and monthly total precipitation in Colombia through a statistical correlation analysis (Aggarwal and Ranganathan, 2016). The objective is to explore the possible impact of this specific meteorological factor on changes in the aforementioned index. This was achieved by studying information from January to October 2024 that was collected from external sources, including the Colombian government's National Open Data Platform, which collects information from the Rural Land Planning, Land Adaptation and Agricultural Uses Unit (UPRA).

The results of this research can not only be applied to Colombia, but can also serve as a guide to examine similar links in different countries and areas. In the context of scientific research, this can be particularly valuable, as understanding how climate and agricultural economics are related can help create more robust and flexible strategies in response to climate change.

Materials and methods

Through a correlation analysis, this work studies the interrelation between the accumulated precipitation at the end of each month in the Colombian territory and the variations recorded in the agricultural input price index in the Republic of Colombia. First, data were extracted from the Meteoblue meteorological archive (2024) recorded between January and October 2024 to form the variable "Total precipitation". In turn, from data collected from the Official Page of the National Open Data Platform of the Republic of Colombia (UPRA, 2024), the agricultural input price index was obtained between December 2023 and October 2024; with this data, the variation in the price index recorded between each month was calculated, thus forming the data for the variable "Variation in agricultural input prices". Once the data was collected, a correlation analysis between both variables was run using the statistical software RStudio Team (2020).

At the beginning of the correlation analysis, both variables were evaluated using the Shapiro-Wilk test, in order to check whether both fit a normal distribution. The choice of this test corresponded to the fact that the sample size was less than 50 observations (Mendivelso, 2021). The normality test was based on the hypotheses shown below (D’Agostino, 2017):

H_0: “The variables ‘Total precipitation’ and ‘Variation in agricultural input prices’ fit a normal distribution.”

H_1: "The variables 'Total precipitation' and 'Variation in agricultural input prices' do not fit a normal distribution."

In the event that the p-value obtained by the Shapiro-Wilk test yielded a value lower than the significance level of the study ($\alpha = 0.05$), the null hypothesis (H_0) would be rejected by virtue of the alternative hypothesis (H_1), allowing it to be concluded that the variables did not conform to a normal distribution; for this result, a Spearman correlation analysis would be performed (Mendivelso, 2021). On the contrary, if the p-value obtained by the Shapiro-Wilk test yielded a value higher than the significance level of the study ($\alpha = 0.05$), it would be determined that there was insufficient evidence to reject the null hypothesis (H_0) by virtue of the alternative hypothesis (H_1), allowing it to be concluded that the variables did conform to a normal distribution; for this other result, a Pearson correlation analysis would be performed (Demir, 2022).

In any case, both correlation analyses are aimed at determining the same thing: the magnitude and direction of the correlation between these variables and the level of significance of said correlation (Katebi et al., 2022). Regarding the magnitude and direction of the correlation between the variables, these would be defined by the correlation coefficient, which can vary from − 1.00 to 1.00, and according to their proximity to both ends of the scale, the result obtained for the correlation coefficient of the variables included in the present study would be classified as follows (Hernández-Sampieri and Mendoza, 2018):

- "− 1.00" = "Perfect negative" correlation
- "− 0.90" = "Very strong negative" correlation
- "− 0.75" = "Considerable negative" correlation
- "− 0.50" = "Medium negative" correlation
- "− 0.25" = "Weak negative" correlation
- "− 0.10" = "Very weak negative" correlation
- "0.00" = "There is no correlation between the variables"
- "0.10" = "Very weak positive" correlation
- "0.25" = "Weak positive" correlation
- "0.50" = "Medium positive" correlation
- "0.70" = "Considerable positive" correlation
- "0.90" = "Very strong positive" correlation
- "1.00" = "Perfect positive" correlation.

Finally, as in the normality test, the p-value obtained by the correlation analysis would be what would determine the existence or not of a significant correlation, based on the corresponding hypotheses (Washima, 2022):

H_0: "There is no significant correlation between the variables 'Total precipitation' and 'Variation in agricultural input prices'."

H_1: "There is a significant correlation between the variables 'Total precipitation' and 'Variation in agricultural input prices'."

Only if the p-value obtained by the correlation analysis had a value lower than the significance level of the study ($\alpha = 0.05$) would the null hypothesis (H_0) be rejected by virtue of the alternative hypothesis (H_1), allowing us to conclude that there was a statistically significant correlation between the variables studied (Ramírez et al., 2023).

Results

Below is a summary of the data on the agricultural input price index recorded in the Republic of Colombia between December 2023 and October 2024, which were consulted through the Official Open Data Page of Colombia, linking to a database provided by the Rural Land Planning Unit, Land Adaptation and Agricultural Uses (UPRA, 2024).

Table 1

Agricultural input price index information between January 2023 and October 2024.

Month	Agricultural input price index
Dic-2023	148.43
Ene-2024	146.01
Feb-2024	144.01
Mar-2024	140.63
Abr-2024	137.63
May-2024	134.75
Jun-2024	134.78
Jul-2024	135.82
Ago-2024	135.92
Sep-2024	136.21
Oct-2024	136.96

Note: Data taken from the Rural Land Planning, Land Adaptation and Agricultural Uses Unit (UPRA, 2024).

Once the data concerning the agricultural input price index in Colombian territory was collected, it was necessary to calculate how much said index varied between one month and the next to obtain the observations of the variable "Variation in agricultural input prices" through the following operation:

[illegible]

Once these values have been calculated, Table 2 provides a detailed description of the total accumulated precipitation data at the national level between January and October 2024 and the values of the variation in the agricultural input price index corresponding to the same months, thus forming the variables "Total precipitation" and "Variation in agricultural input prices".

Table 2

Information on the variables "Total precipitation" and "Variation in agricultural input prices" between January and October 2024.

Month	Variation in agricultural input prices	Total Precipitation (mm)
Ene-2024	-2.42	0.5
Feb-2024	-2.00	7.75

Mar-2024	-3.38	2.9
Abr-2024	-3.00	1.5
May-2024	-2.88	24.15
Jun-2024	0.03	85
Jul-2024	1.04	34.75
Ago-2024	0.10	52.5
Sep-2024	0.29	47.45
Oct-2024	0.75	36.7

Note: Prepared by the authors (2025) based on changes calculated in the Colombian agricultural input price index for 10 months from January to October 2024 (UPRA, 2024), together with data on total accumulated precipitation each month at the national level (Meteoblue, 2024).

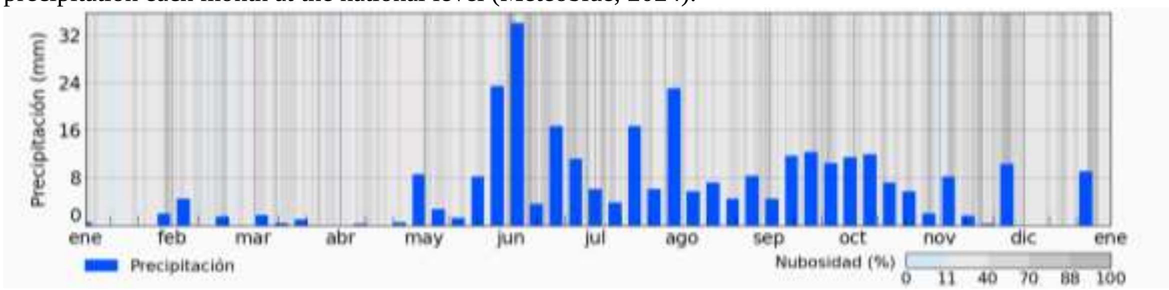

Figure 1. *Total accumulated precipitation levels observed in Colombian territory during the year 2024. Source: Meteoblue (2024).*

Table 2 shows fluctuations in the agricultural input price index and total accumulated precipitation each month at the national level during the period described. This data set is important to understand how changes in agricultural input prices can relate to monthly accumulated precipitation levels in a country over time, which can have important economic consequences. Once the data for each variable was collected, the Pearson correlation analysis was carried out, as shown in the following paragraphs.

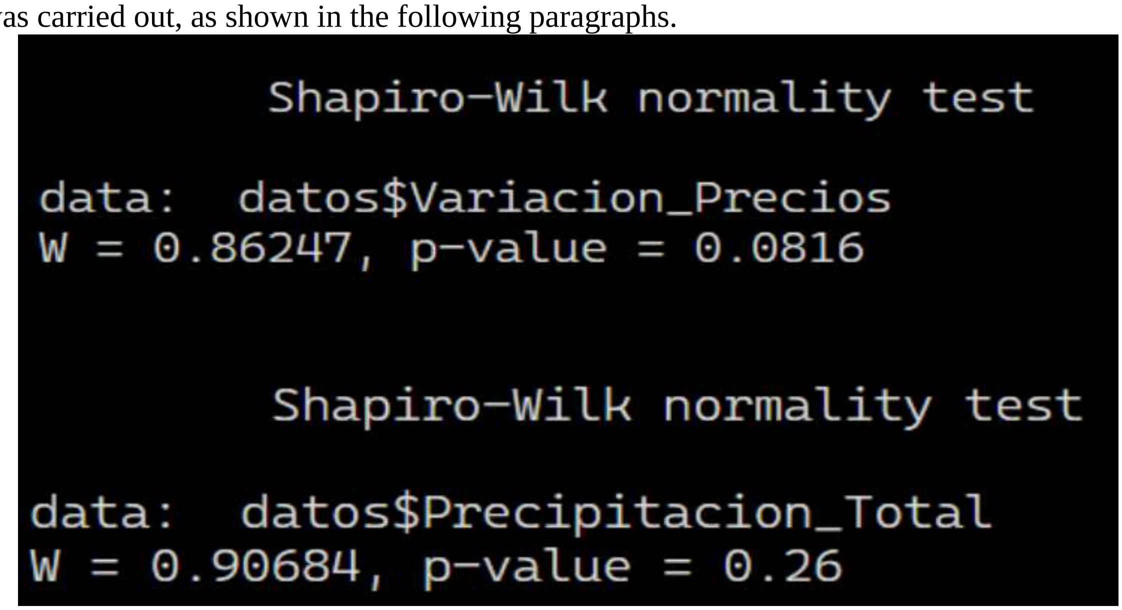

Figure 2. *Results of the Shapiro-Wilk normality test, performed in RStudio.*

The results of the normality test for the variables "Total precipitation" and "Variation in agricultural input prices" are shown in Figure 2. Both p-values obtained are greater than the significance level of 0.05, indicating that there is insufficient evidence to reject the assumption of normality. Therefore, it has been determined that the Pearson correlation coefficient is the most suitable to run the correlation analysis between the monthly accumulated precipitation and the changes calculated for the agricultural input price indices recorded in the Colombian territory between January and October 2024, the results of which are shown below.

```
> print(correlacion_pearson)
[1] 0.744429

[1]
> print(test_pearson)

        Pearson's product-moment correlation

data:  datos$Variacion_Precios and datos$Precipitacion_Total
t = 3.1534, df = 8, p-value = 0.01353
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.2160838 0.9355512
sample estimates:
     cor
0.744429
```

Figure 3. *Results of the Pearson correlation test performed in RStudio.*

The hypothesis test of the correlational analysis yielded a p-value of 0.01353, as shown in Figure 3. Therefore, the null hypothesis is rejected in favor of the alternative, which states that there is sufficient statistical evidence to conclude that there is a significant correlation between the variables "Total precipitation" and "Variation in agricultural input prices", since the p-value obtained is less than the significance level of $\alpha = 0.05$.

The verification of a significant correlation between the variables included in the present study was accompanied by the determination of the Pearson correlation coefficient, which, as shown in Figure 3, had a value of 0.744429, which allowed us to conclude that there is a considerable positive relationship between the variables "Total precipitation" and "Variation in agricultural input prices". The cross-correlations can be clearly seen in Figure 4.

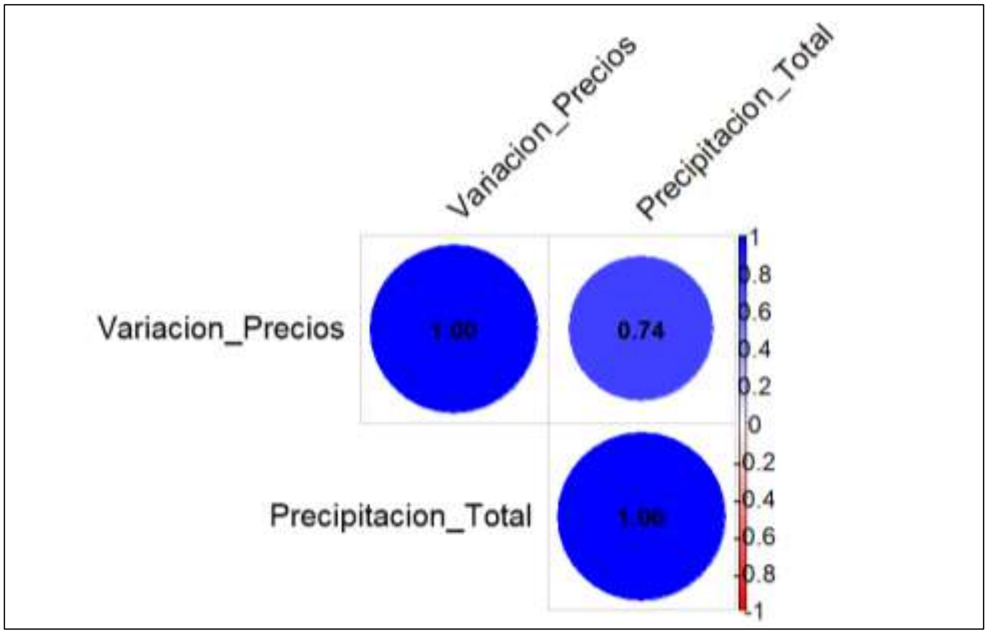

Figure 4. *Pearson correlation between the variables "Total precipitation" and "Variation in agricultural input prices".*

From a practical point of view, it is plausible to affirm that the increases and decreases in the accumulated precipitation recorded at the end of each month at the national level in Colombia, correspond from a statistical point of view with the increases and decreases in the price indices of agricultural inputs recorded in the Colombian agricultural sector.

Conclusions

As mentioned in the previous sections, this study conducts a correlation analysis to investigate the relationship between monthly accumulated precipitation and monthly changes in the agricultural input price index in Colombia from January to October 2024. The results show that the variables "Total precipitation" and "Variation in agricultural input prices" follow a normal distribution, which allowed the Pearson correlation coefficient to be used to determine the magnitude and direction of the variables.

Once the assumption of normality was confirmed, the Pearson correlation analysis showed that there was a statistically significant relationship between the variables analyzed with a p-value of 0.01353, which was below the significance level of the study ($\alpha = 0.05$). This suggests that changes in accumulated precipitation are associated with changes in agricultural input prices, although this is not necessarily a causal relationship. According to the statistical evidence obtained, there is a considerable positive correlation between the monthly accumulated rainfall recorded in the Colombian territory between January and October 2024 and the changes in the price index of agricultural inputs, according to the interpretation of the correlation coefficient obtained of 0.744429.

The analysis highlights the importance of incorporating climate variables, such as rainfall, into agricultural resource planning and management. The results are particularly important for developing strategies to mitigate the negative impacts of climate on agricultural economies, especially in countries where the agricultural sector plays a key role in food security and economic development. However, it is important to note that the analysis period covered only ten months, which limits the generalizability of the results to other contexts, locations, and time periods. In addition, other economic, social, and environmental factors not considered in this study may also influence the volatility of agricultural product prices. Future studies should expand the temporal sample and examine interactions with other relevant variables (such as supply and demand of agricultural products or transportation costs), but for the purposes of this paper, there is a significant relationship between rainfall and changes in commodity prices recorded from January to October 2024, which allows theorizing that climate phenomena should be considered a key factor in agricultural planning and public policy development in Colombia.

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