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CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

How vulnerable is Cali's food system to climate shocks?

A historical perspective

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Introduction

Climate variability events such as El Niño and La Niña (related to heavy rains and droughts), have had historically diverse effects associated with changes in the atmosphere and ocean, which manifest themselves in detrimental impacts on the population and their livelihoods such as agriculture, livestock and fisheries (1)(2). Consequently, they threaten food systems and their sustainability.

Some of the main consequences of the presence of these phenomena in global food systems are: Problems in food production, increased prices and increased food and nutritional insecurity (3)(4). It should be noted that in general terms the agricultural sector and food security are affected by climatic anomalies associated with El Niño and La Niña phenomena, since under the influence of La Niña rains flood crops and reduce their yields, while under El Niño events, the scarcity of rain and droughts reduce the production of different crops (5)(6).

In Colombia, El Niño phenomenon usually occurs during the months of July - September, while La Niña occurs during the months of November - March. There is no consensus as to the period in which it is repeated; however, experts worldwide agree that the most approximate cycle is between four and seven years and that its duration varies from 3 months to two or more years, and that its intensity can be mild, moderate or severe (7).

According to studies conducted by the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), when El Niño phenomenon occurs, precipitation volumes tend to be low in relation to the season, especially in large sectors of the Caribbean, Andean and Pacific regions; on the contrary, when La Niña is present, these same areas experience excessive precipitation. However, it should be emphasized that the occurrence of these phenomena does NOT suppress seasonality, i.e., El Niño does not suppress rainy seasons, nor does a Niña suppress dry or less rainy seasons (8).

Generally, when El Niño occurs, the crops most affected historically have been, in order: fique, cassava, African palm and barley, followed by rice, potato, corn, cotton, sugarcane, banana, cocoa and beans. It should be noted that the impact on agriculture varies from one country

to another, due to several variables such as the intensity of climatic effects at the local level and the specific conditions of the production systems, life cycles, among others (2)(9).

Two of the main effects on the supply system of a city in the agricultural sector due to climatic variations in the agricultural sector are related to the reduction of food supply and the impact on food prices (10). Knowing how much El Niño/La Niña climatic phenomena affect the agricultural sector that supplies food to a city, municipality or country will help to plan strategies to mitigate these impacts, the fragility of food systems and the protection of the most vulnerable.

In this sense, we are interested in knowing to what degree the supply system of the city of Cali is vulnerable to this type of phenomena, a city in which 1 out of every 2 inhabitants suffers from food insecurity, 1 out of every 2 people is poor and more than 50% of the population has nutritional deficiencies (11).

Finally, it is important to note that Cali is not a food-producing city; 80% of the products that reach the city are imported or come from other regions of the country. Thus, the objective of this study is to observe how climatic variations affect or threaten the city's food supply, but not how they influence local agricultural activity.

Methodology

To assess the vulnerability of historical climate shocks on Cali's food system, an exploratory time series analysis was developed where the following were studied:

1. The monthly supply[1] to Cali (total amount of food entering the Santa Elena and CAVASA supply centers) in percentage terms, by food and municipality of origin. It is worth highlighting that food information with the highest temporal information coverage (2013-2020) was used, this corresponds to a limited number of cities that report complete and continuous supply information
2. The ONI[2] (*Oceanic Niño Index*) that measures temperature anomalies (difference from the mean) in the surface waters of the Pacific Ocean in the central-eastern region, using a three-month moving average, which allows quantifying the El Niño-Southern Oscillation climate pattern. Values above 0.5 indicate the occurrence of the El Niño phenomenon, while values below -0.5 indicate La Niña conditions (in at least 5 consecutive months).

In Colombia, El Niño is associated with low rainfall and high temperatures, while La Niña corresponds to above normal rainfall conditions.

The main objective of the analysis was to determine whether there is any causality between the ONI index and the time series of monthly food supply by food and municipality of origin to determine:

a. List of foods (and their municipality/department of origin) impacted to some extent by El Niño or La Niña events.

b. Number of months (lags) following the development of an El Niño/La Niña event where an impact occurs in the food supply time series.

[1] Data source: https://www.dane.gov.co/index.php/en/servicios-al-ciudadano-2/servicios-de-informacion/sipsa#componente-abastecimiento

[2] Data source: https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

The Granger causality statistical test was used to determine whether the ONI index can predict changes or alternations in the food supply time series with a given number of months prior to the event.

The ONI index time series was defined as the predictor variable and the food supply time series was used as the response variables. As a time-window for evaluation, lags of 1 to 24 months were tested, given that the influence of ocean surface temperature warming does not translate immediately into an alteration of food supply, but takes a certain number of months to reflect this impact.

To determine the statistically significant lags, a significance level of α=0.05 was used. Thus, significant lags correspond to months where the p-value of the Granger test is less than α. In other words, the statistical test detects that with a certain number of months after the occurrence of an El Niño or La Niña phenomenon, there is some important alteration in the supply time series.

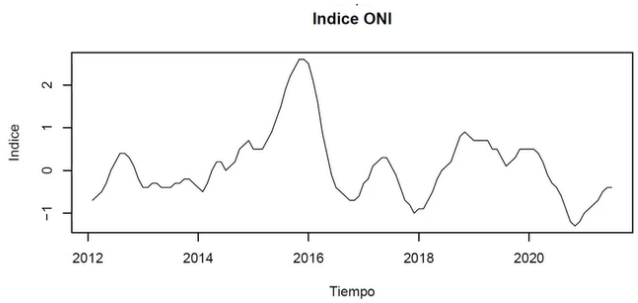
Finally, for each municipality (and using the information of all the foods in that municipality), the median number of subsequent months in which the food was affected by climatic shocks (El Niño/La Niña) was calculated.

For the selection of foods that could have been affected by the Niño or Niña phenomenon, two main criteria were considered: a) Foods with the highest amount of food supply to Cali, which could mean a higher consumption and redistribution of these foods, b) Foods with a higher nutritional value, whose absence could represent an impact on the health and nutritional status of the population. To categorize the foods, the different food groups contemplated in the National Dietary Guidelines for Colombia - GABA were considered and the first two of each group were prioritized according to their nutritional value (12).

In the case of fruits and vegetables, the content of vitamin A and vitamin C was considered, and in the case of cereals and meats, the contribution of carbohydrates and protein. There are some unique foods per group such as milk, sugar, avocado. The knowledge of consumption in the region was also considered to assign the priority.

Results

According to the graph, the ONI series indicates that in Colombia there have been effects of the La Niña phenomenon in some months of the years 2012 - 2014, 2017 - 2018 and 2020 - 2021, while the El Niño phenomenon has occurred mainly in the years 2015 - 2016 and 2018 - 2019. The greatest severity of El Niño occurred during 2016 and the greatest severity of La Niña occurred in late 2020 and early 2021.

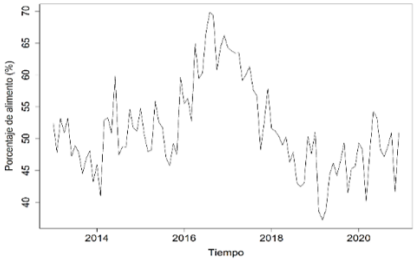


From an initial list of 30 foods that arrive in the city of Cali, 10 foods were prioritized according to the largest quantities supplied to the city and which in turn have a higher nutritional value.

Food	City/State of origin (mainly)	Period of time (ONI variable) – Significant lags
Beef	Yumbo (Valle del Cauca) Candelaria (Valle del Cauca)	5 – 10, 18, 20 – 24 months No significant lags
Carrot	Bogotá DC Tuquerres (Nariño)	15 – 17 months 14 – 24 months
Tree tomato	Medellín (Antioquia) Santa Rosa de Osos (Antioquia)	4 – 8 No significant lags
Plantain	Belén de Umbría (Risaralda) Sevilla (Valle del Cauca)	No significant lags No significant lags
Milk	Restrepo (Valle del Cauca) Yotoco (Valle del Cauca)	19 months 9 months
Chicken	Candelaria (Valle del Cauca) Ginebra (Valle del Cauca)	20 – 22 months No significant lags
Corn (mazorca)	Pradera (Valle del Cauca) Palmira (Valle del Cauca)	No significant lags 2 months
Tangerine	Caicedonia (Valle del Cauca)	1 – 20 months
Avocado	Armenia (Quindío)	20 y 22 months
Rice	Ibague (Tolima) Espinal (Tolima)	No significant lags

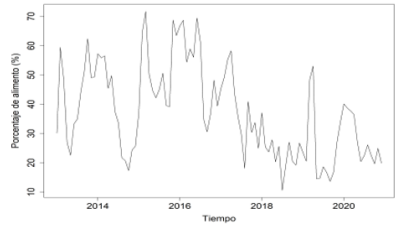
In addition, for each of the 10 foods listed, supply trends were observed for the period of 2013-2020.

Beef



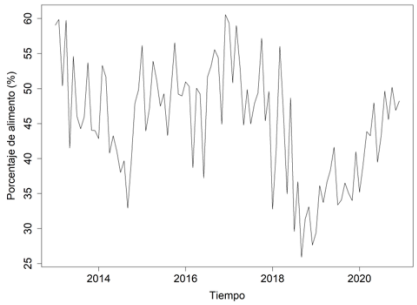
Average: 500,431 kg/month. During 2013 - 2016 between 50 - 65% came from Yumbo.
Variation: Increasing during 2016-2017
Trend: Downward

Carrots



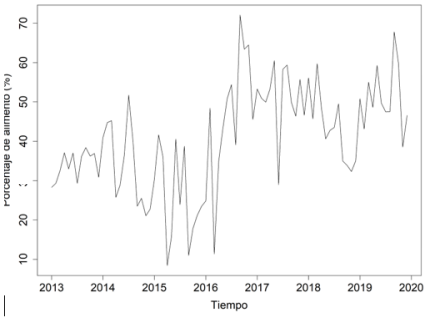
Average: 469,982 kg/month, with about 40 - 60% arriving from Bogota during 2013 - 2016 and decreasing by half during 2018-2020.
Variation: High variation
Trend: Downward

Corn



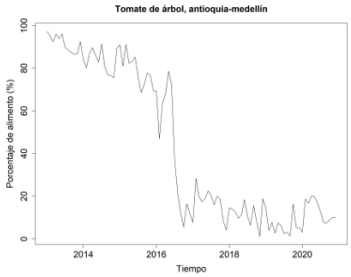
Average: 169,736 kg/month. Between 45 - 55% of corn supply comes from Pradera - Valle.
Variation: Sharp declines in 2014-2015 and 2018-2019 periods.
Trend: Relatively constant for most of the period evaluated, with an upward trend.

Tangerine



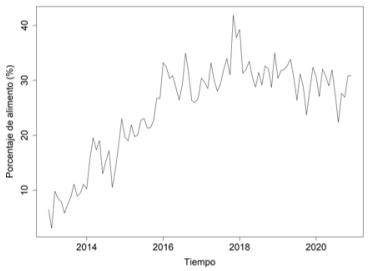
Average: 73.494 kg/month.
Upward trend during the whole period. High variation during 2015-2017. This period coincides with the presence of a mild El Niño phenomenon.

Tómate de árbol



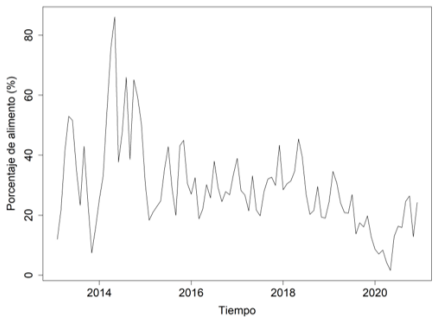
Average: 233,809 kg/month. With around 80% - 90% of supply coming from Medellín during 2013 - 2016, while between 50-60% came from Santa Rosa de Osos (Antioquia) during 2017-2020.
Trend: Downward
Variation: High between 2016 - 2017, which coincides with a mild La Niña phenomenon.

Plantain



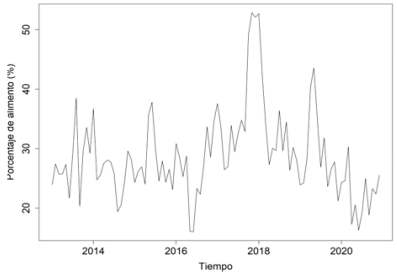
Average: 475,606 kg/month. About 30% of the plantain arriving in Cali came from Risaralda.
Trend: Upward

Milk



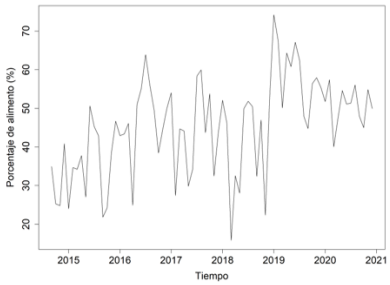
Average: 107,143 kg/month
Variation: Increases and decreases during 2014 - 2015.
Trend: Constant during most of the period.

Chicken



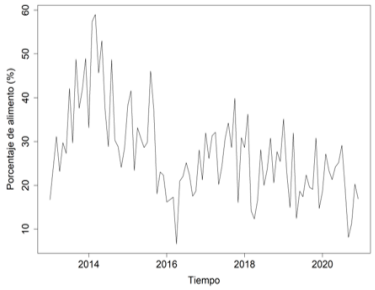
Average: 131,701 kg/month
Variation: In 2018 a rise, which declined rapidly.
Trend: Constant with a downward trend.

Avocado



Average: 76,363 kg/month. Around 30 -50% of the feed comes from Armenia, with strong variations during 2018-2019, which coincides with the presence of a mild El Niño phenomenon.

Rice



Average: 386,775 kg/month. About 30% of the rice that supplies Cali comes from Ibague, showing a downward trend and variations between 2015 and 2016, which coincides with the presence of an intense El Niño phenomenon.

In addition, the occurrence and intensity of El Niño or La Niña events during the period 2002 – 2021 are shown.[3]

El Niño		
2002 - 03	Moderate	June 2022 – March 2003
2004 - 05	Mild	August 2004 – February 2003
2006-07	Mild	October 2006 – February 2007
2009-10	Moderate	August 2009 – May 2010
2014-16	Severe	May 2014 – Jun 2016
2016-17	Mild	December 2016 – March 2017
2018-19	Mild	October 2018 – Jun 2019
2019-20	Mild	October 2019 – April 2020

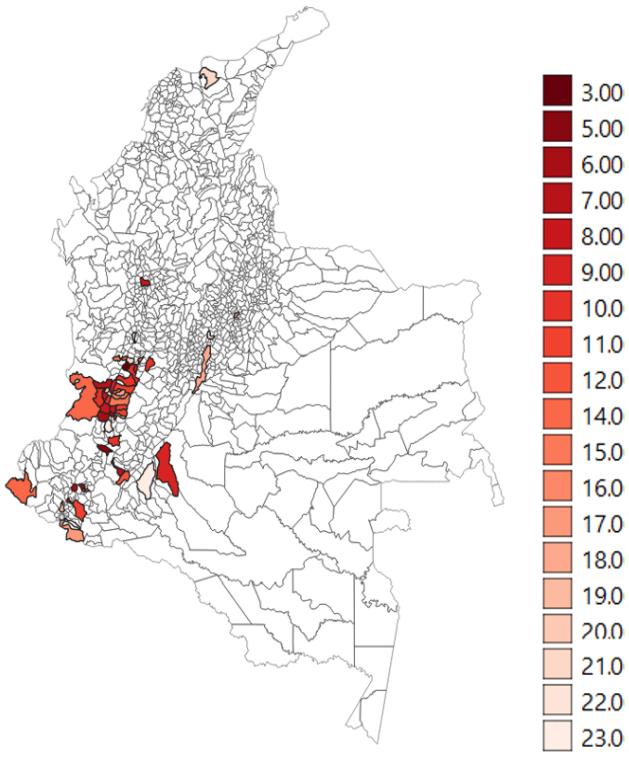
[3] El Niño and La Niña events in the 21st century. Available at :https://es.wikipedia.org/wiki/Anexo:Eventos_de_El_Ni%C3%B1o_y_La_Ni%C3%B1a_en_el_siglo_XXI

La Niña		
2005 - 06	Mild	August 2004 – February 2003
2007-08	Moderate	September 2007 – July 2008
2009	Mild	January – April 2009
2010-11	Severe	August 2010 – May 2011
2011-12	Mild	October 2011 – April 2012
2016	Mild	July – November 2016
2017-18	Mild	October 2017 – March 2018
2020-21	Severe	October 2020 – May 2021

Event

El Niño	Mild	Moderate	Severe	Very intense (Mega Niño)
La Niña	Mild	Moderate	Severe	

In addition, the municipalities/department of origin impacted by El Niño or La Niña phenomena in Colombia during the period studied are shown:



These results indicate that cities located in the departments of Valle, Cauca and Nariño were affected more quickly by El Niño/La Niña events, i.e., between 3 and 8 months, while cities located in the departments of Boyacá, Cundinamarca, Caquetá and Magdalena were affected more distantly, generally between 15 and 23 months.

Conclusions

This is a descriptive analysis, which does not allow us to observe causality to determine whether El Niño/La Niña climatic effects have any influence on Cali's food system and the diet of its population. However, the impact of El Niño/La Niña climatic phenomena on certain departments and their cities and what this may mean for their food production and distribution processes in the city is not negligible.

The city is highly dependent on other areas for its supply and there is a downward trend in some of the foodstuffs reported. Although this may indicate several situations, not only of climatic origin, but it can also be deduced that what most reaches the city may be threatened by different events, whether social, climatic, related to the production characteristics of the place, among others.

Limitations

Some foods do not have reported values of supply for each month to be considered for the time series, in this sense the temporal period (2013 - 2020) for each food may vary.

Although the supply of some products such as soft drinks has an important load in the supply to the city of Cali, this was not considered because it is not a food that contains a great nutritional contribution. Therefore, this type of products (beverages, sugars, sweets,

confectionery) were not considered in the analyses.

The abrupt changes that can be observed in these graphs are not necessarily related to climatic impacts (it may be that there was a truck strike or some other event that produced such a change. Therefore, interpretations are cautious. In this sense, it is not possible to determine whether the changes in supply were the result of climatic variability or other factors.

The time series can only show the temporal pattern (ups and downs) of the supply of certain food to Cali.

The Granger statistical test only allows us to identify whether the ONI index time series in any way affects the supply time series. Basically, the answer of the test is binary: yes, there is affectation or no affectation. But it does not tell us at what point in the time series it occurred. That is, we cannot see it graphically.

The databases of the National Administrative Department of Statistics (DANE) were used as a secondary source of information, which reports official information in a defined period of time, this may vary from the amounts reported by the food supplies centers involved (CAVASA and Santa Elena). Additionally, changes in the methodology of data gathering could produce not very precise quantities, moreover those quantities can be underestimated due to not all the producers sell through supply centers.

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