Annex to iTAP Response (Annex iTAP-A)

Question 7c

Based on our review of existing studies, the following trends can be summarized for Colombia:

- Temperature and precipitation trends. Figure 1 shows temperature change as anomalies for the period 1901–2020 with respect to the 1971–2000 period, based on the Berkeley Earth dataset (taken from https://showyourstripes.info). Whereas temperature shows a clear signal, including into the 21st century (also see IDEAM, 2015), historical precipitation trends are more difficult to understand and generalize, as they vary spatially and temporally.
- IDEAM's analysis of the precipitation is one of the most recent and comprehensive analyses to date of precipitation trends in Colombia (IDEAM-UNAL, 2018). We have used this document as the basis to respond the comment. Hence, we recommend iTAP to peruse such document if further clarity is needed (for example, on the methods they used). We summarize the main trends, but refrain from providing a more comprehensive summary of the document since the document is freely available online.
- Figure 2 shows precipitation trends for each of IDEAM's stations throughout the Colombian territory. Most stations show a small increasing trend (up to 19 mm/year). Conversely, a minority of stations show a strong increasing trend (up to 140 mm/year). Decreases in annual precipitation are seen only in specific spots throughout the territory.
- Figure 3 shows the same trends but for the peak dry (January, July) and wet (April, October) periods of the year. From these it can be seen that precipitation chances can be highly variable depending on the month. For January, precipitation decreases are concentrated toward the south-west of the country. Conversely, Orinoquia experiences the most drying for July. Between the two wet periods, October is seen to experience the most significant drying trends. The lower-Cauca (departments of Cordoba, Sucre) show decreases in precipitation. For April, the Santanderes and the areas around Guajira, Atlantico, and Magdalena, experience precipitation decreases.
- Other studies that analyze hydro-climatic trends in Colombia are Carmona and Poveda (2014), and Pabon (2012), both cited in the main response.

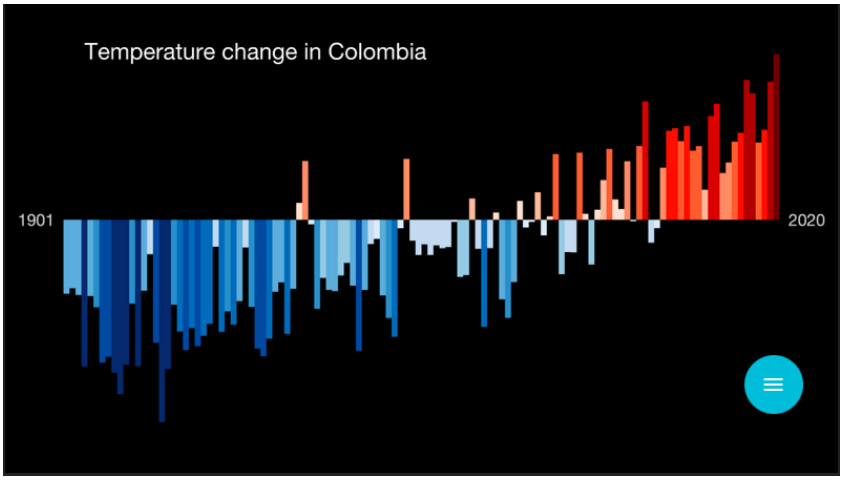

Figure 1 Temperature trends for Colombia displayed as anomalies with respect to the period 1971–2000. Taken from https://showyourstripes.info

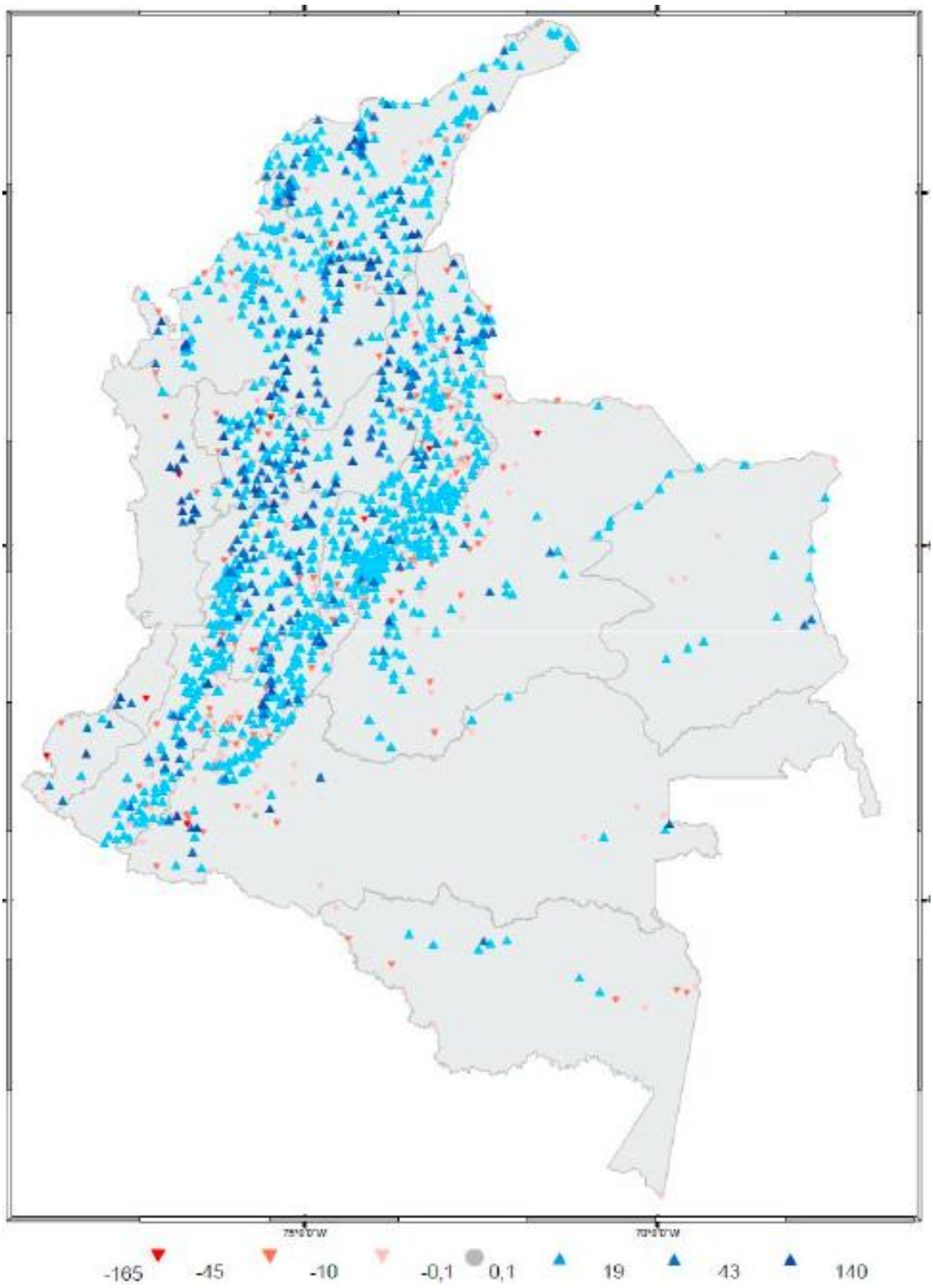

Figure 2 Trends (in millimeters) in precipitation for Colombia for the period 1980–2011. Taken from IDEAM-UNAL, 2018.

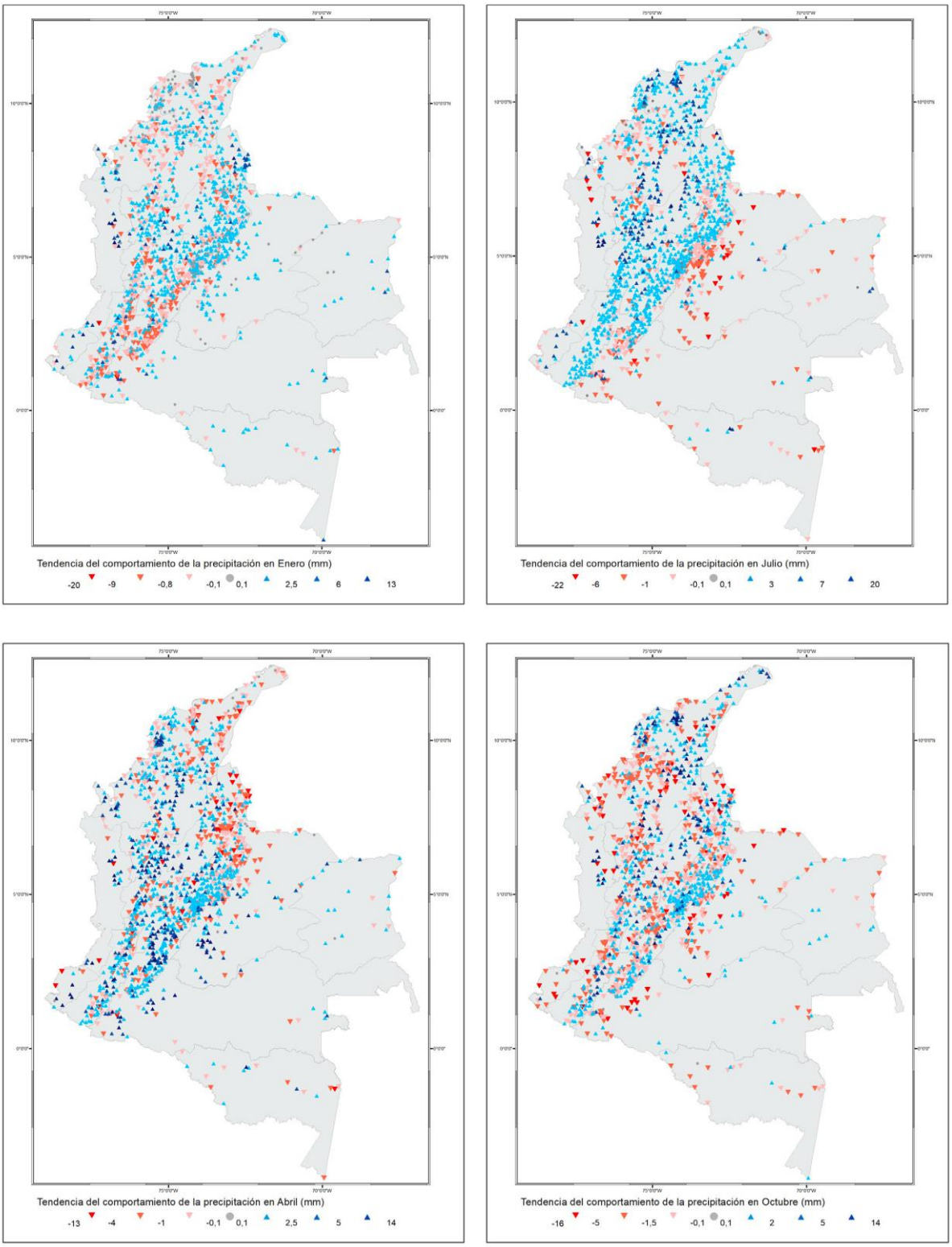

Figure 3 Trends (in millimeters) in precipitation for Colombia for the period 1980–2011 for January (top-left), July (top-right), April (bottom-left), and October (bottom-right). January and July are considered as dry periods, whereas April and October wet periods. Taken from IDEAM-UNAL, 2018.

ENSO affects the hydro-climatic variability of Colombia, which in turn affects agriculture. IDEAM-UNAL (2018) provide an analysis of anomalies for different ENSO phases (positive –El Niño, and negative –La Niña) and intensities. Their maps are shown in Figures 4 and 5. Their analysis shows that during positive ENSO phases, temperatures are warmer, and rainfall is generally less than the long-term average (Fig. 4). The converse is true during La Niña events, whereby temperatures are cooler and precipitation higher than the long-term average (Fig. 5). Bedoya-Soto et al. (2019) analyze the hydro-climatic variability during the 2009-2011 extreme ENSO phases in Colombia. These authors report that ENSO effects extend from the diurnal cycle to interannual timescales, and from glaciers to rivers along the Caribbean lowlands of the Magdalena-Cauca river basin.

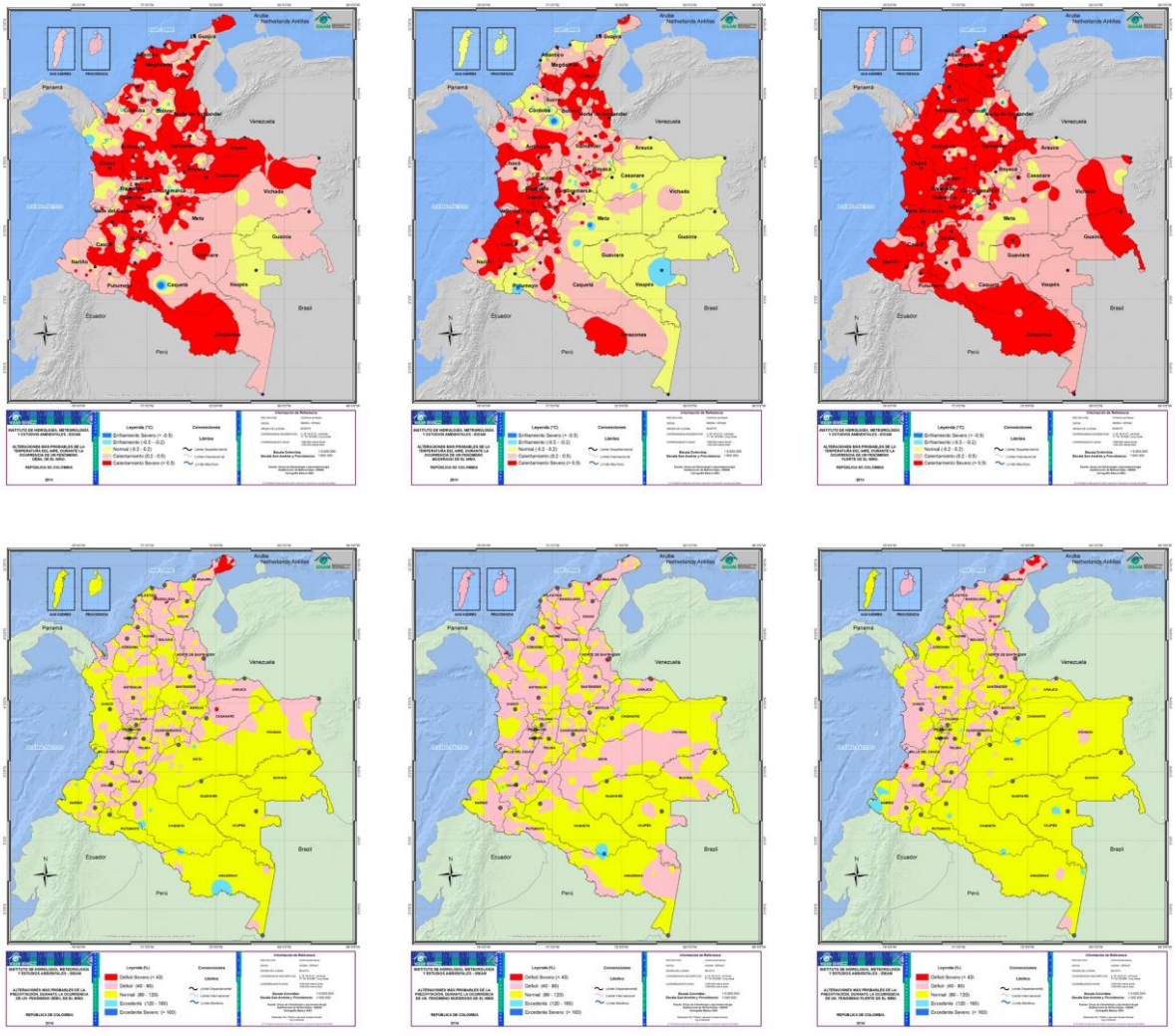

Figure 4 Spatial distribution of temperature (top maps) and precipitation (bottom maps) anomalies observed during weak (left), moderate (middle), and strong (right) El Niño (i.e., positive ENSO phase) events. Taken from IDEAM-UNAL, 2018.

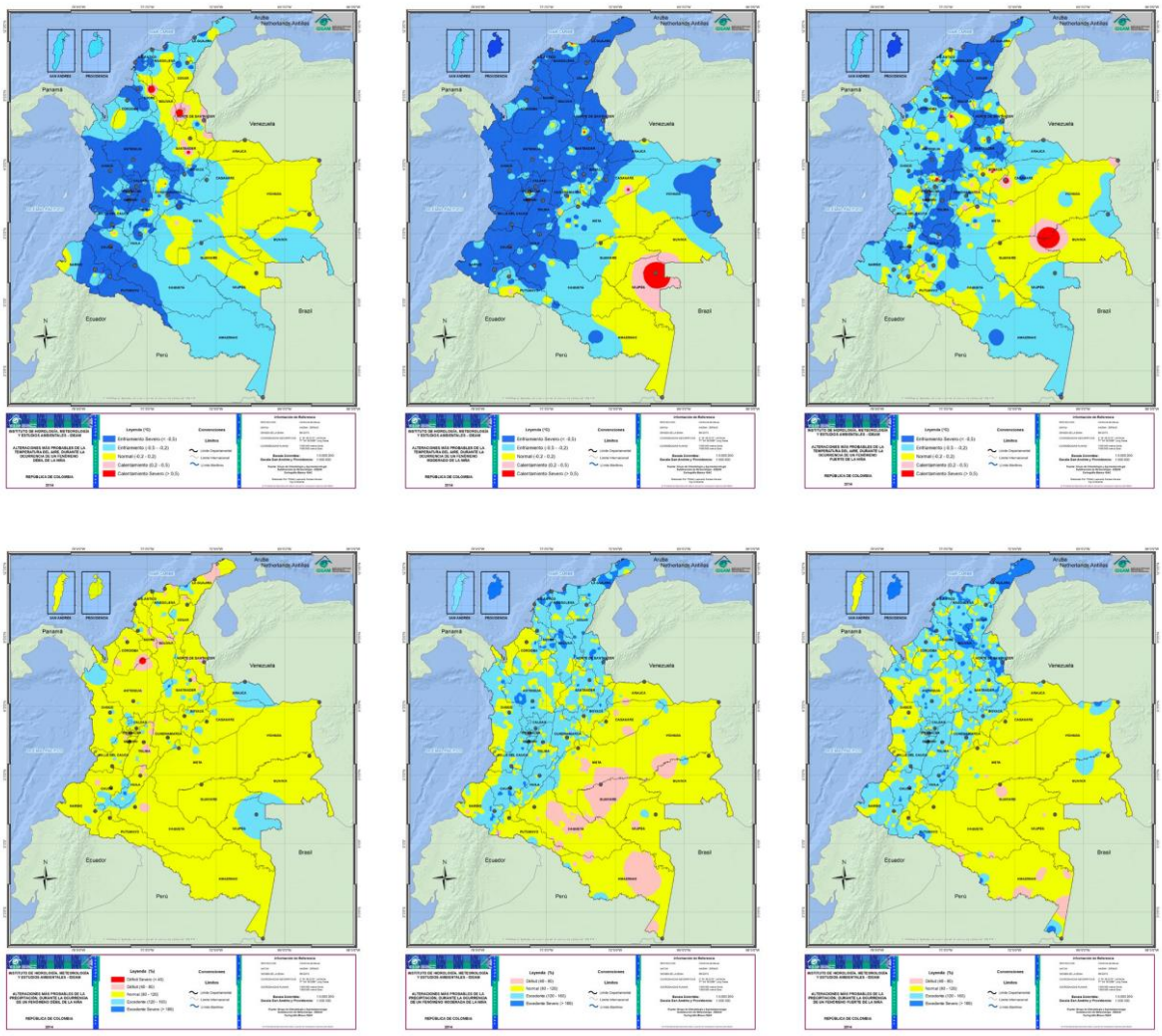

Figure 5 Spatial distribution of temperature (top maps) and precipitation (bottom maps) anomalies observed during weak (left), moderate (middle), and strong (right) La Niña (i.e., negative ENSO phase) events. Taken from IDEAM-UNAL, 2018.

ENSO-driven variations affect agricultural production in many ways. For example, they may lead to direct yield reductions due to high temperatures or less rainfall (which induces drought stress on crops), cause outbreaks of pests and diseases, or delay or impede certain field operations (e.g., planting, harvesting), resulting in economic loss. There is substantial anecdotal evidence of the effects of ENSO in Colombian agriculture[1]. However, there are not many studies that analyze the effect of ENSO on agricultural production. We highlight three studies that have analyzed the ENSO and agriculture in Colombia:

- Barrios-Perez et al. (2021) shows that the yields of rice generally (but not always) decrease during El Niño events and increase during La Niña events, for the Magdalena Valley region (one of the main

[1] https://www.eltiempo.com/archivo/documento/CMS-16397785
https://www.portafolio.co/economia/finanzas/nino-pasa-cuenta-cobro-produccion-agricola-33332
https://reliefweb.int/report/colombia/intensa-sequ-tiene-alimentos-por-las-nubes

rice-producing regions in the country). Figure 6 shows areas of positive (green) and negative (red) yield changes.

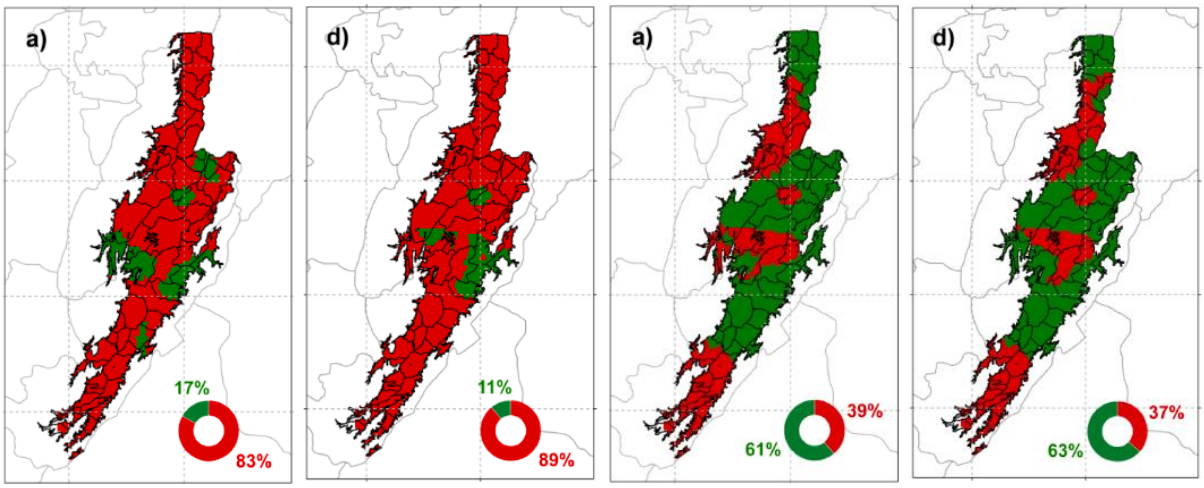

Figure 6 Spatial variation of rice yield changes during positive ENSO phases (El Niño), and for negative ENSO phases (La Niña), from left to right: El Niño effect on first growing season; El Niño effect on second growing season; La Niña effect on first growing season; La Niña effect on second growing season. Taken from Barrios-Perez et al. (2021).

- Ruiz and Pabon (2013) analyze ENSO events for the Atlantico department, and find that "*sesame and banana yields increase when rainfall is above average (usually under La Niña conditions) during the short dry season and both the first and second rainy seasons. The above-average rainfall in the dry season has a positive impact on cassava yields. Corn yields increase if the recorded rainfall in the short dry season is above average and decrease under above-average precipitation in the second rainy season. Bean yields decrease when rainfall is above average during the first and second rainy seasons and increase when rainfall is above average in the short dry season. Cotton yields decrease in cases of above-average rainfall in the second rainy season, while sorghum does not present noticeable responses to precipitation anomalies.*"
- Bonilla et al. (2003) report sugarcane yield decreases of 6.5% (El Niño) and 4.3% (La Niña) due to ENSO-driven climatic variations. They estimate an increase in the 'societal benefit' of 9.59 million USD stemming from the accurate prediction of ENSO.